

HRS DOCUMENTATION RECORD COVER SHEET

Name of Site: Millsboro TCE

EPA ID No.: DEN000306645

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Contact Persons

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Pathways, Components, or Threats Not Scored

Surface Water Migration Pathway

The surface water pathway was not scored. The ground water pathway was sufficient to list the site.

Soil Exposure Pathway

The soil exposure pathway was not scored. The ground water pathway was sufficient to list the site.

Air Migration Pathway

The air migration pathway was not scored. The ground water pathway was sufficient to list the site.

WORKSHEET FOR COMPUTING HRS SITE SCORE

	S pathway	S² pathway
Ground Water Migration Pathway Score (S _{gw})	100	10,000
Surface Water Migration Pathway Score (S _{sw})	NS	NS
Soil Exposure Pathway Score (S _s)	NS	NS
Air Migration Score (S _a)	NS	NS
$S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2$		10,000
$(S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2)/4$		2,500
$/(S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2)/4$		50.00

Notes:

NS Not scored

HRS Table 3-1 –Ground Water Migration Pathway Scoresheet

Factor Categories and Factors	Maximum Value	Value Assigned
Likelihood of Release to an Aquifer:		
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	
3. Likelihood of Release (higher of lines 1 and 2e)	550	550
Waste Characteristics:		
4. Toxicity/Mobility	(a)	10,000
5. Hazardous Waste Quantity	(a)	100
6. Waste Characteristics	100	32
Targets:		
7. Nearest Well	50	50
8. Population:		
8a. Level I Concentrations	(b)	25,500
8b. Level II Concentrations	(b)	
8c. Potential Contamination	(b)	
8d. Population (lines 8a + 8b + 8c)	(b)	
9. Resources	5	
10. Wellhead Protection Area	20	
11. Targets (lines 7 + 8d + 9 + 10)	(b)	25,550
Ground Water Migration Score For An Aquifer:		
12. Aquifer Score [(lines 3 x 6 x 11)/82,500] ^c	100	100.00
Ground Water Migration Pathway Score:		
13. Pathway Score (S_{gw}), (highest value from line 12 for all aquifers evaluated) ^c	100	100.00

(a) Maximum value applies to waste characteristics category.

(b) Maximum value is not applicable.

^c Do not round to nearest integer.

REFERENCES

1. U.S. Environmental Protection Agency (EPA). Hazard Ranking System: Final Rule. 40 Code of Federal Regulations (CFR) Part 300, *Federal Register*, Volume 55, No. 241. December 14, 1990. 138 pages.
2. EPA. Superfund Chemical Data Matrix (SCDM). January 28, 2004. 13 pages. A complete copy of SCDM is available at <http://www.epa.gov/superfund/sites/npl/hrsres/tools/scdm.htm>.
3. U.S. Geological Survey (USGS). 7.5-Minute Series Topographic Map for Millsboro, Delaware, Quadrangle. 1992. 1 page.
4. Tetra Tech EM Inc. (Tetra Tech). 4-Mile Radius Map Millsboro TCE. March 2009. 1 page.
5. Delaware Geological Survey. Thickness and Transmissivity of the Unconfined Aquifer of Eastern Sussex County, Delaware: Report of Investigations No. 70. 2006. 26 pages.
6. Reference reserved.
7. EA Engineering, Science, and Technology, Inc. (EA). Draft Well Installation and Groundwater Monitoring Report for Millsboro TCE Groundwater Contamination Site (a/k/a Millsboro Public Well TCE Site), DE-1361, Millsboro, Delaware. September 2008. 206 pages.
8. EA. In Situ Chemical Oxidation Pilot Study Work Plan, Millsboro Public Well Trichloroethene Site (a/k/a Millsboro Public Well TCE Site), (DE-1361), 225 West Dupont Highway, Millsboro, Delaware. October 2008. Excerpt. 51 pages. (Appendix A is included as Reference 52.)
9. Delaware Geological Survey. Geologic Map of Southern Delaware: Open File Report No. 32. 1990. 1 page.
10. Delaware Department of Natural Resources and Environmental Control (DNREC). Final Plan of Remedial Action, Millsboro TCE Groundwater Contamination Site. DNREC Project No. DE-1361. December 2007. 22 pages.
11. USGS. A Surficial Hydrogeological Framework for the Mid-Atlantic Coastal Plain: Professional Paper 1680. 2005. 49 pages.
12. DNREC. Well Completion Reports. Water Resources Section – Groundwater Allocation. Various Dates. 101 pages.
13. DNREC. Site Fact Sheet for Millsboro Public Well TCE Site, DE-1361. September 2008. 2 pages.
14. Tetra Tech. Electronic Mail Regarding Millsboro Water Supply Wells. From Kenneth S. Eden, Environmental Scientist/Hydrogeologist. To Robert Asreen, Hydrologist, Delaware DNREC. March 5, 2009. 1 page.
15. Severn Trent Laboratories (Severn Trent). Analytical Report for Job No. W573 – Millsboro DE-1361. September 27, 2006. 75 pages.

16. EPA. Ground Water Issue, Dense Nonaqueous Phase Liquids. EPA/540/4-91-002. March 1991. 21 pages.
17. Tetra Tech. Electronic Mail Regarding Groundwater Elevation for Millsboro Water Supply Wells. From Kenneth S. Eden, Environmental Scientist/Hydrogeologist. To Robert Asreen, Hydrologist, Delaware DNREC. March 10, 2009. 3 pages.
18. Environmental Data Resources, Inc. (EDR). The EDR Radius Map with GeoCheck for Millsboro DE-1361, 225 West Dupont Highway, Millsboro, DE 19966, Inquiry Number: 1635559.2s. March 17, 2006. Excerpt. 17 pages.
19. Test America Laboratories. Analytical Report for Grab Water Samples Sample Job # -W146, (MW-10S, -10D, -6D, -6S). July 23, 2008. Excerpt. 19 pages.
20. Tetra Tech. Millsboro TCE Aerial Photograph from Google© Earth. March 17, 2009. 1 page.
21. EA. Final Soil Addendum Focused Feasibility Study for Millsboro Public Well TCE Site (DE-1361). August 2007. 61 pages.
22. EA. Figure 1-5: 2005 – 2006 Sample Locations and Associated TCE Results at 225 West Dupont Highway (TCE Source Site), Millsboro, DE. March 2006. 1 page.
23. EA. Final Focused Feasibility Study for Millsboro Public Well TCE Site (DE-1361). February 2007. 304 pages.
24. Hardy and Son, Inc. Letter Regarding the Removal and Disposal of TCE Impacted Soil with Attachments. To Robert Asreen, DNREC-Site Investigation and Restoration Branch (SIRB). July 27, 2006. 23 pages.
25. Hardy Environmental Services. Letter Regarding Removal of Septic/Separator Tank with Attachments. May 12, 2006. 3 pages.
26. Hardy Environmental Services. Letter Regarding Removal of Anomalous Subsurface Debris with Attachments. May 30, 2006. 4 pages.
27. Lancaster Laboratories. Analysis Report, Analytical Results, Town of Millsboro, Sample Group 1097666. June 30, 2008. 24 pages.
28. Severn Trent. Millsboro TCE, Data Sheets, W575. October 22, 2006. 37 pages.
29. Severn Trent. Millsboro TCE, Laboratory Data Sheets. October 2, 2006. 21 pages.
30. Severn Trent. Laboratory Results, Job No. S106 – Millsboro Public. June 20, 2006. 13 pages.
31. DNREC. Logbook Notes Regarding Removal. March 23, 2006. 48 pages. (24 sheets).
32. Severn Trent. Laboratory Results, Job No. U463 – Millsboro Public. August 22, 2006. 17 pages.
33. Severn Trent. Laboratory Results, Job No. U455 – Millsboro DE-1361. August 22, 2006. 16 pages.

34. Tetra Tech. Record of Telephone Conversation Regarding Millsboro TCE. From Alicia Shultz, Hazard Ranking System (HRS) Specialist. To Robert Asreen, Hydrogeologist, DNREC. March 18, 2009. 1 page.
35. Tetra Tech. Record of Telephone Conversation Regarding Millsboro TCE. From Alicia Shultz, HRS Specialist. To Jamie Capacy, Project Manager, Test America. March 18, 2009. 1 page.
36. Severn Trent. Millsboro TCE Soil Analysis. September 8 and 9, 2006. 2 pages.
37. Severn Trent. Millsboro TCE Soil Analysis. September 7, 2006. 1 page.
38. EPA. Second Five Year Review Report for NCR Corporation Superfund Site, Millsboro, Sussex County, Delaware. June 2005. 36 pages.
39. Tetra Tech. Record of Telephone Conversation Regarding Millsboro TCE. From Alicia Shultz, Hazard Ranking System (HRS) Specialist. To Robert Asreen, Hydrogeologist, DNREC. June 8, 2009. 1 page.
40. Test America Laboratories. Laboratory Results for Samples Received June 25, 2008. Job No. W210 – Millsboro Public. (MW-9S, MW-4S, MW-4D, MW-7S, MW-7D). July 22, 2008. Excerpt. 14 pages.
41. Test America Laboratories. Laboratory Results for Samples Received June 26, 2008. Job No. W262 – Millsboro Public. (MW-3S, MW-3D, MW-2S, MW-2D, MW-1M, MW-1D, MW-1S). July 25, 2008. Excerpt. 21 pages.
42. Test America Laboratories. Laboratory Results for Samples Received June 24, 2008. Job No. W146 – Millsboro Public. (MW-10S, MW-10D, MW-6S, MW-6D). July 23, 2008. Excerpt. 18 pages.
43. DNREC. Division of Water Resources, Source Water Assessment and Protection Program. Public Water Supply Source Water Assessment for Millsboro Water, PWS ID: DE0000622. December 15, 2003. 26 pages.
44. DNREC. Standard Operating Procedures for Analytical Program Under Hazardous Substances Cleanup Act (HSCA). September 27, 2006. 151 pages.
45. DNREC. Hazardous Substances Cleanup Act Guidance Manual. October 1994. 112 pages.
46. Tetra Tech. Letter Regarding Millsboro TCE Site – Data Quality Report. Data Packages W146, W210, and W262. June 23, 2009. 2 pages.
47. Tetra Tech. Letter Regarding Millsboro TCE Site – Data Quality Report. Data Packages S106, U455, U463, W572, W573, and W575. June 23, 2009. 4 pages.
48. Wyoming Department of Environmental Quality, Solid and Hazardous Waste Division. Response to Public Comments for Remedial Investigation Work Plan – Final Draft. December 3, 2007. Excerpt. 2 pages. (Document available at: http://deq.state.wy.us/volremedi/downloads/Web%20Notices/Windsor%20Well_Clark/DEQ%20Response%20to%20Comments%20120307.pdf).

49. Delaware Health and Social Services, Division of Public Health. Public Drinking Water Annual Compliance Report and Summary. 2005. Excerpt. 2 pages. (Full text available at: <http://dhss.delaware.gov/dhss/dph/hsp/files/acr2005report.pdf>).
50. Agency for Toxic Substances and Disease Registry. Trichloroethylene Fact Sheet. July 2003. 2 pages.
51. Tetra Tech. Conversions. July 6, 2009. 1 page.
52. ISOTEC. Pilot Study Work Plan, Millsboro TCE Site, Millsboro, Delaware. August 22, 2008. 69 pages.
53. EA Engineering. Logbook notes Millsboro TCE Project. Various dates. 53 pages. (26 sheets).
54. Tetra Tech. Letter Regarding Millsboro TCE Site – Data Quality Report. Data Package ATF19. July 20, 2009. 2 pages.
55. Tetra Tech. Record of Telephone Conversation Regarding TCE in PW-1 and PW-2 Prior to 2005. From Alicia Shultz, HRS Specialist. To Kevin Cottman, Delaware Department of Health, Information Specialist. July 15, 2009. 1 page.
56. EPA. Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses. April 1993. 31 pages.
57. EPA. Innovative Approaches for Validation of Organic Data Standard Operation Procedures. June 1995. 220 pages.

SITE SUMMARY – MILLSBORO TCE

Millsboro TCE includes an area of trichloroethene, also called trichloroethylene, (TCE) contamination located at 225 West Dupont Highway, Millsboro, Sussex County, Delaware (Ref. 23, p. ES-1). Millsboro TCE includes the location of a former poultry vaccine manufacturing facility located at 225 West Dupont Highway, Millsboro, Sussex County, Delaware (Ref. 10, p. 4; Ref. 21, pp. 1-1, 1-3; Ref. 23, p. ES-1). The manufacturing building was demolished in December 2000 (Ref. 13, p. 1). TCE was used for an unknown period of time as a heat transfer medium within a closed refrigeration system (Ref. 23, p. 1-7). TCE contamination was found in underground storage tanks (USTs) beneath the property (Source 1) and soil across the property (Source 2) (Ref. 10, p. 5). TCE-contaminated soil was detected at various locations on the property on which the sources of the Millsboro TCE ground water contamination are located (Ref. 22 and Table 3 of this documentation record). Reference 22 shows the locations of the tanks (Source 1) and areas of soil contamination (Source 2). TCE from Sources 1 and 2 impacted ground water under the privately owned properties in between the source areas and public supply wells PW-1 and PW-2 in the Town of Millsboro, Delaware (Ref. 10, pp. 4, 9). The Town of Millsboro supply wells are located approximately 0.25 mile north of Millsboro TCE (Ref. 4). The approximate extent of the plume is shown in Reference 7, Figure 2-1. The two public supply wells are completed in the upper most aquifer, the unconfined aquifer (Columbia Aquifer), in the Town of Millsboro's well field (Ref. 12, pp. 1; Ref. 23, pp. 1-4, 1-5, and Figure 1-2 following p. 1-4; Ref. 43, pp. 1, 4, 5). The TCE ground water plume expands approximately 1,500 feet in length by 300 feet in width beneath a mixed light commercial and residential area within the Town of Millsboro, Sussex County, Delaware and encompasses the Town of Millsboro well field. The Millsboro TCE source areas are located in what is currently an open, vacant lot (Ref. 10, pp. 4, 9, 10).

Poultry vaccine manufacturing operations began at the property on which the sources of the Millsboro TCE ground water contamination are located in 1952 with the establishment of Delaware Poultry Laboratories, Inc. Sterling Drug purchased Delaware Poultry Laboratories sometime in the 1960s and operated the property as Sterwin Laboratories until 1984. In 1984, International Minerals and Chemical (IMC) purchased Sterwin Laboratories from Sterling Drug. Between 1984 and 1997, the operating company name changed to IMCERA, Pitman-Moore, and then to Mallinckrodt Veterinary, Inc., without a change of ownership (Ref. 13, p. 1).

On June 30, 1997, Schering-Plough Corporation (Schering Plough) acquired the animal health business including the property of Mallinckrodt, Inc., and Mallinckrodt Veterinary, Inc., through a stock purchase agreement. Schering Plough conducted poultry vaccine manufacturing operations on the property until August 1999. Schering Plough sold the property to a private entity on June 29, 2001. Since that time, the private entity has owned the property but has not operated any business on it (Ref. 13, p. 1).

During the week of October 17, 2005, the Delaware Division of Public Health (DPH) Office of Drinking Water (ODW) conducted routine drinking water sampling in the Dagsboro area, located southeast of Millsboro. This sampling identified TCE contamination in water sampled from the Town of Millsboro's public water supply wells. As a result, DPH issued a public notice requiring the contaminated supply wells be taken offline and that affected residents of Millsboro and Dagsboro, Delaware use bottled water supplied by the municipality. In November 2005, granular activated carbon (GAC) treatment systems were installed at the impacted Millsboro water supply wells (PW-1 and PW-2). The public notice was lifted by the DPH in late November and early December 2005 (Ref. 10, p. 5).

In December 2005, a consultant for Delaware Department of Natural Resources and Environmental Control (DNREC) initiated a site investigation (SI) to determine the source of the TCE contamination in the Millsboro supply wells. SI sampling began with the collection of ground water grab samples from multiple depths at locations throughout the Millsboro Water Plant property, which is located on Church

Street, northeast of the property on which the sources of the Millsboro TCE ground water contamination are located. Ground water grab samples were then collected from multiple depths at upgradient sampling locations east, west, and south of the impacted water supply wells (PW-1 and PW-2). An exceptionally high concentration of TCE was found in the shallow ground water sample collected from a property that was later identified as Millsboro TCE (Ref. 10, p. 5; Ref. 24, p. 1). The impacted supply wells are approximately 0.25 mile north of Sources 1 and 2 (Ref. 4). A geophysical survey was conducted in the area where the sources of the Millsboro TCE ground water contamination are located (Sources 1 and 2), and several anomalies (physical changes in the subsurface) were identified, investigated, and subsequently removed as part of an interim action. Two USTs that may have served as dry wells and/or septic systems were identified and very high concentrations of TCE were found in the sludge collected from the USTs as well as in the surrounding soils. Approximately 209 tons of contaminated soil and storage media (including these tanks and piping) were subsequently removed as part of an interim action. Four-hundred gallons of liquid were removed from a below grade septic/separator tank. Additional ground water samples were also collected in the vicinity of Sources 1 and 2 to further delineate the source of the TCE ground water contamination (Ref. 10, p. 5; Ref. 23, p. 1-9 and Figure 13- following p. 1-9; Ref. 24, p. 1; Ref. 25, p. 1; Ref. 26, p. 1).

In August 2006, four indoor air samples were collected by a consultant to DNREC from the residence adjacent to the TCE source areas to determine whether volatilization of TCE from ground water would pose an unacceptable human health risk to the occupants. There was no TCE or any degradation products detected in any of the indoor air samples collected (Ref. 10, p. 6).

Based on analytical results of the SI sampling, DNREC determined that sludge and surface and subsurface soils in Sources 1 and 2, respectively, were contaminated with TCE. DNREC further determined that unless the source area contamination is remediated, it could pose an unacceptable human health risk to residents at or near the TCE source areas or construction workers who would perform redevelopment activities at the property on which the sources of the Millsboro TCE ground water contamination are located. Ground water flowing beneath the TCE source areas towards the Town of Millsboro supply wells is contaminated with TCE and poses an unacceptable human health risk to people drinking the water (Ref. 10, pp. 5, 6).

Ground water collected from monitoring wells sampled during the SI contained TCE at concentrations as high as 17,000 micrograms per liter ($\mu\text{g/L}$) (Ref. 7, p. 6-3a, Table 6-1). Ground water samples collected from the Town of Millsboro public water supply wells (PW-1 and PW-2) contained TCE at concentrations exceeding the maximum contaminant level (MCL) for TCE of 5 $\mu\text{g/L}$ and cancer-risk screening concentration for ground water of 0.21 $\mu\text{g/L}$. Millsboro's public supply wells PW-1 and PW-2 are approximately 1,000 feet northeast of Sources 1 and 2 (Ref. 2, pp. BI-13; Ref. 4; Ref. 10, p. 9).

Post-excavation soil samples collected from the walls of the tank excavation (Source 1) contained TCE up to 17,000,000 micrograms per kilogram ($\mu\text{g/kg}$) (See Table 1 of this documentation record). The presence of TCE in soil underlying the tanks indicates that all the hazardous waste quantity associated with the tanks has not been removed from Millsboro TCE. Source 2 soil samples contained TCE up to 54,000 $\mu\text{g/kg}$ (see Table 3 of this documentation record).

The TCE-contaminated ground water underlying Sources 1 and 2 is considered to be only present in the unconfined aquifer (Columbia aquifer). Ground water samples collected from the source areas indicate that the TCE concentration found at the source of the plume (100,000 $\mu\text{g/L}$) is higher than TCE concentrations downgradient or in the northeast section of the plume (1,000 to 10,000 $\mu\text{g/L}$). Ground water flows from the sources to the northeast and towards the Town of Millsboro public water supply wells PW-1 and PW-2. Because public water supply wells PW-1 and PW-2 are located within the northeastern portion of the area of ground water contamination, ground water pumped from those wells

increases the hydrogeologic gradient towards the northeast (Ref. 4; Ref. 8, p. 2-3; Ref. 7, p. 7-9, and Appendix J, Figures 1, 5, 6; Ref. 22; Ref. 23, p. 1-12). PW-1 and PW-2 are completed in the Columbia aquifer and are active wells. Ground water withdrawn from PW-1 and PW-2 is treated with GAC (Ref. 14; Ref. 17, p.2; Ref. 39). The two wells serve a population of 2,550 persons (Ref. 49, p. 1; Section 3.3.2 of this documentation record).

2.2 SOURCE CHARACTERIZATION

2.2.1 SOURCE IDENTIFICATION

Name of source: Underground Storage Tanks (USTs)

Number of source: 1

Source Type: Tanks and Other Containers

Description and Location of Source (with reference to a map of the site):

Two USTs, Tanks 2 and 3, were located on the property on which the sources of the Millsboro TCE ground water contamination are located. The tanks contained TCE-contaminated sludge (Ref. 21, p. 1-2). Reference 22 shows the former locations of the tanks on the southern portion of the property on which the sources of the Millsboro TCE ground water contamination are located (Ref. 22). A total of 209 tons of TCE-contaminated media (soil, concrete, and sludge) were removed during the excavation of Tanks 2 and 3 (Ref. 10, p. 5; Ref. 24, p. 1). During the removal of the contaminated soil and tanks, samples of the soil immediately surrounding the excavations (post-excavation samples), and sludge contained in the tanks and associated piping were collected and analyzed. Results indicated the presence of TCE at concentrations as high as 17,000 parts per million (ppm) in soil (Tank 3 South Wall) and as high as 2,900 ppm in sludge (Tank 3) (Ref. 23, p. 1-10; Ref. 32, p. 4). The USTs may have served as dry wells and/or septic systems (Ref. 10, p. 5; Ref. 34).

Although the USTs have been removed, post-excavation soil samples collected along the bottom and walls of the excavation area surrounding the former tank locations contain TCE, indicating that a release has occurred. The bottom and wall post-excavation soil samples collected from the excavation site contain up to 17,000 ppm of TCE (Ref. 10, pp. 5; Ref. 22; Ref. 39). Reference 22 shows the concentrations of TCE remaining in soil after the tank excavations. The dashed lines on Reference 22 identify the areas that were excavated. Reference 21, p. 1-3, indicates that TCE contamination in the soil underlying the tanks needs to be remediated. The shaded area on Figure 1-3, following page 1-3, in Reference 21 shows where TCE contamination remains on the property and in the tank excavation sites (Ref. 21, p. 1-3; Ref. 22). Therefore, although the tanks have been removed, all of the waste quantity or contamination associated with the release from the tanks has not been removed.

2.2.2 HAZARDOUS SUBSTANCES ASSOCIATED WITH THE SOURCE

DNREC and DNREC subcontractors collected the samples from Source 1. DNREC personnel oversaw Source 1 sampling and removal activities. DNREC and DNREC subcontractors followed procedures documented in Reference 44 to collect samples (Ref. 39). Sludge and soil samples were collected during the removal action (Ref. 23, p. 1-10). TCE concentrations detected in the sludge and soil samples are provided in Table 1 below. Reference 22 shows the sampling locations. The sludge and soil samples were analyzed as specified in the U.S. Environmental Protection Agency (EPA) publication, “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods” (SW-846, 3rd Edition) Method 8260B (Ref. 30, p. 12; Ref. 32, p. 15). Soil samples were collected from bottom and walls of the tank excavation site (Ref. 22; Ref. 39). The soil samples were analyzed for TCL volatile organic compounds (VOC) using EPA publication “Test Methods for Evaluating Solid Waste” (SW-846, 3rd Edition) Method 8260B (Ref. 32, p. 2). The DNREC-contracted analytical laboratories were required to follow procedures documented in Reference 44 (Ref. 39). The sludge and soil data packages were reviewed in accordance with EPA “Region III Modifications to National Functional Guidelines for Inorganic Data Review Multi-Media, Multi-Concentration,” April 1993 (Ref. 56), and EPA “Innovative Approaches for Validation of Organic Data Standard Operating Procedures,” June 1995 (Ref. 57), to level M3 for organic analysis (Ref. 47).

TABLE 1
SOURCE 1 SLUDGE AND SOIL SAMPLE ANALYTICAL RESULTS
2006 REMOVAL ACTION

Sample ID	Sample Type	Date Sampled	Hazardous Substances	Conc. (µg/kg)	SQL (µg/kg)	References
HDL_H2O_PIPE_SL1*	Soil	05/17/2006	Trichloroethene	13,000	150	30, pp. 2, 11; 35
HDL_TANK_2_SL1*	Soil	05/17/2006	Trichloroethene	1,500,000	26,000	30, pp. 4, 11; 35
HDL_TANK_2_SL2*	Soil	05/17/2006	Trichloroethene	780,000	9,500	30, pp. 6, 11; 35
Tank_2_East_Wall	Soil	07/11/2006	Trichloroethene	1,100	81	33, pp. 2, 14; 35
Tank_2_West_Wall	Soil	07/11/2006	Trichloroethene	3,400	100	33, pp. 4, 14; 35
Tank_2_North_Wall	Soil	07/11/2006	Trichloroethene	150	89	33, pp. 6, 14; 35
Tank_2_South_Wall	Soil	07/11/2006	Trichloroethene	20,000	130	33, pp. 8, 14; 35
Tank_2_Bottom	Soil	07/11/2006	Trichloroethene	6,400	98	33, pp. 12, 14; 35
Tank_3_Bottom	Soil	07/10/2006	Trichloroethene	930,000	14,000	32, pp. 2, 14; 35
Tank_3_South_Wall	Soil	07/10/2006	Trichloroethene	17,000,000	240,000	32, pp. 4, 14; 35
Tank_3_East_Wall	Soil	07/10/2006	Trichloroethene	1,300	130	32, pp. 6, 14; 35
Tank_3_North_Wall	Soil	07/10/2006	Trichloroethene	15,000	200	32, pp. 8, 14; 35
Tank_3_West_Wall	Soil	07/10/2006	Trichloroethene	26,000	230	32, pp. 10, 14; 35

Notes:

* Sludge samples are identified as “soil” matrix on analytical data sheets (Ref. 23, p. 1-10; Ref. 30, pp. 2, 4, 6, 11). The soil sample descriptions for the samples collected from the walls of the tank removals are not available. The soil samples were collected after contaminated material including tanks were excavated (Ref. 39).

µg/kg Micrograms per kilogram

Conc. Concentration

ID Identification

SQL Sample quantitation limit

The quantitation limits (QLs) or reporting limits (RLs) on the data sheets are equivalent to sample quantitation limits (SQLs). The QLs and RLs are analyte-specific calculations that correspond to the lowest quantitative point on the calibration curve and are adjusted for the amount of sample prepared, and any dilutions performed, as well as the percent of moisture in soil samples (Ref. 35).

List of Hazardous Substances Associated with Source 1:

Trichloroethylene

2.2.3 HAZARDOUS SUBSTANCES AVAILABLE TO A PATHWAY

Containment Description	Containment Factor Value	References
Gas release to air: Not scored	NS	NS
Particulate release to air: Not scored	NS	NS
Release to ground water: As documented in Section 3.0, there is evidence of hazardous substance migration from the source area. Additionally, there is no liner associated with Source 1. The sludge samples were collected from tanks and pipes. Reference 22 shows the location of the sludge samples.	10	1, Table 3-2; 22; 34
Release via overland migration and/or flood: Not scored	NS	NS

Notes:

NS Not scored

2.4.2 HAZARDOUS WASTE QUANTITY

2.4.2.1 SOURCE HAZARDOUS WASTE QUANTITY

2.4.2.1.1 Hazardous Constituent Quantity

The information available is not sufficient to adequately support evaluation of the hazardous constituent quantity for Source 1.

2.4.2.1.2 Hazardous Wastestream Quantity

The tanks have been removed; the wastestream quantity released from the tanks is unknown but greater than 0 (Ref. 10, p. 5; Ref. 24, p. 1).

Sum (pounds): >0

Sum of Wastestream Quantity/5,000 (Ref. 1, Table 2-5): >0

Hazardous Wastestream Quantity Assigned Value: >0

2.4.2.1.3 Volume

Tier C, volume, of Source 1 was not scored.

Volume Assigned Value: 0

2.4.2.1.4 Area

Tier D, area, is not evaluated for the source type tank (Ref. 1, Table 2-5).

Area Assigned Value: 0

2.4.2.1.5 Calculation of a Source Hazardous Waste Quantity (HWQ) Value

The source area HWQ value for Source 1 is assigned a value of greater than 0 (Ref. 1, Table 2-5).

Source HWQ Value: >0

2.2 SOURCE CHARACTERIZATION

2.2.1 SOURCE IDENTIFICATION

Name of source: TCE-Contaminated Soil

Number of source: 2

Source Type: Contaminated Soil

Description and Location of Source (with reference to a map of the site):

Source 2 includes all areas of TCE-contaminated soil on the property on which the sources of the Millsboro TCE ground water contamination are located. A total of 209 tons of TCE-contaminated media (soil, concrete, and sludge) were removed during the excavations of the USTs from the property (Ref. 23, p. 1-10; Ref. 24, p. 1). Soil samples collected across the property after the removal action contained TCE concentrations as high as 54,000 µg/kg (Ref. 15, p. 52, 69). Therefore, all the TCE-contaminated soil has not been removed. DNREC is proposing to remediate the contaminated soil (Ref. 10, pp. 6, 7). Contaminated soil remains above the water table (Ref. 21, p. 1-1). The soil sampling locations with remaining TCE contamination are shown in Reference 22.

2.2.2 HAZARDOUS SUBSTANCES ASSOCIATED WITH THE SOURCE

As documented in Table 3, TCE was detected in soil samples collected on the property on which the sources of the Millsboro TCE ground water contamination are located. TCE is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers. TCE is not thought to occur naturally in the environment. However, it has been found in underground water sources and many surface water bodies as a result of the manufacture, use, and disposal of the chemical (Ref. 50, p. 1).

TCE was detected in the soil samples collected by DNREC and DNREC subcontractors from Source 2 during the removal action on the property on which the sources of the Millsboro TCE ground water contamination are located. DNREC personnel oversaw Source 2 soil sampling and removal activities. DNREC and DNREC subcontractors followed procedures documented in Reference 44 to collect soil samples (Ref. 39). Available logbook notes documenting the soil sampling activities are provided as Reference 31. The soil samples were analyzed as specified in EPA “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,” (SW-846, 3rd Edition) Method 8260B (Ref. 15, p. 70; Ref. 32, p. 15; Ref. 33, p. 15; Ref. 36; Ref. 37). The DNREC contracted analytical laboratories were required to follow procedures documented in Reference 44 (Ref. 39). The soil data packages were reviewed in accordance with EPA “Region III Modifications to National Functional Guidelines for Inorganic Data Review Multi-Media, Multi-Concentration,” April 1993 (Ref. 56), and EPA “Innovative Approaches for Validation of Organic Data Standard Operating Procedures,” June 1995 (Ref. 57), to level M3 for organic analysis (Ref. 47). The soil sampling locations and sample depths are shown on Reference 22. Descriptions of the soil samples are provided in Table 2 below. The soil samples in Table 2 summarize only those samples where TCE was detected above the SQLs, with consideration of data qualifiers. TCE concentrations detected in the soil samples are provided in Table 3.

As depicted on Reference 22, soil samples that appear to be unaffected by site activities (e.g., HDL Septa Pipe, HDL-SL2, HDL-SL3, HDL-SO2, and HDL-SO3) collected from the Millsboro TCE property did not contain TCE, indicating that TCE is not ubiquitous in the area (Ref. 22; Ref. 23, p. A-19).

- Source Samples:

TABLE 2
SOURCE 2 SOIL DEPTHS AND SAMPLE DESCRIPTIONS AND LOCATIONS

Sample Identification	Depth (ft bgs)	Sample Description	Location	References
HDLGP12-1	6-7	Tan to orange mottled clayey sand with fine sand	Southwest of Tank 2	22; 31, p. 11
HDLGP12-2	13-14	Light tan fine sand with black silt laminae	Southwest of Tank 2	22; 31, p. 12
HDLGP13-1	5-7	Fine-grained sand with black silt and some clay	West of Tank 2	22; 31, p. 12
HDLGP13-2	13-14	White to tan sand with some silt	West of Tank 2	22; 31, p. 13

TABLE 2 (Continued)
SOURCE 2 SOIL DEPTHS AND SAMPLE DESCRIPTIONS AND LOCATIONS

Sample Identification	Depth (ft bgs)	Sample Description	Location	References
HDLGP14-2	11-12	Sand with some silt	Northwest of Tank 2	22; 31, p. 14
HDLGP15-2	10-12	Sand with minor pebbles	Northwest of Tank 2	22; 31, p. 15
HDLGP16-1	6-8	Clay with fine-grained sand and silt	North of Tank 2	22; 31, p. 16
HDLGP16-2	10-12	Orange to tan interbedded fine-grained sand with sandy clay and silt	North of Tank 2	22; 31, p. 17
HDLGP17-1	7-8	Sand and silt with orange-stained water marks	Northeast of Tank 2	22; 31, p. 18
HDLGP17-2	11-12	Fine-grained sand and silt with orange-stained water marks	Northeast of Tank 2	22; 31, p. 18
HDLGP18-1	7-8	Light tan medium-grained sand with clay and silt, some pebbles	Northeast of Tank 2	22; 31, p. 19
HDLGP18-2	11-12	Medium-grained sand with orange staining and odor	Northeast of Tank 2	22; 31, p. 19
HDLGP19-1	6-7	Medium/coarse-grained sand	North of Tank 3	22; 31, p. 20
HDLGP19-2	11-12	Interbedded sand and clay with orange-stained lenses	North of Tank 3	22; 31, p. 20
HDLGP20-1	7-8	Medium-grained sand	Northeast of Tank 3	22; 31, p. 21
HDLGP20-2	11-12	Silty fine-grained sand, interlayered orange and tan sand	Northeast of Tank 3	22; 31, p. 21
HDLGP21-1	7-8	Tan medium-grained sand, some silt	Northeast of Tank 3	22; 31, p. 22
HDLGP21-2	11-12	Clayey silt	Northeast of Tank 3	22; 31, p. 22
HDLGP22-1	7-8	Fine to medium-grained sand with some silt	Northeast of Tank 3	22; 31, p. 23
HDLGP22-2	11-12	Silty very fine-grained sand	Northeast of Tank 3	22; 31, p. 23
HDLGP23-1	7-8	Dark orange sand and clay	Northeast of Tank 3	22; 31, p. 24
HDLGP23-2	11-12	Interlayered sand and clay, iron-stained lenses	Northeast of Tank 3	22; 31, p. 24
HDLGP24-1	7-8	Medium-grained sand, some silt	East of Tank 3	22; 31, p. 25
HDLGP24-2	11-12	Interlayered fine-grained sand and clay, some silt	East of Tank 3	22; 31, p. 25
HDLGP25-1	7-8	Dark tan to dark orange fine-grained sand, some pebbles	East of Tank 3	22; 31, p. 26

TABLE 2 (Continued)
SOURCE 2 SOIL DEPTHS AND SAMPLE DESCRIPTIONS AND LOCATIONS

Sample Identification	Depth (ft bgs)	Sample Description	Location	References
HDLGP25-2	11-12	Interlayered light tan to white fine-grained sand and silt, odor	East of Tank 3	22; 31, p. 26
HDLGP26-1	7-8	Light tan silty sand	Southeast of Tank 3	22; 31, p. 27
HDLGP26-2	11-12	Interlayered light tan to white fine-grained sand and silt, odor	Southeast of Tank 3	22; 31, p. 27
HDLGP27-1	3-4	Yellow fine-grained sand to orange silty sand	Southeast of Tank 3	22; 31, p. 28
HDLGP27-2	7-8	Orange to yellow fine-grained sand with silty clay lenses	Southeast of Tank 3	22; 31, p. 28
HDLGP27-3	11-12	Orange sand with yellow silty sand lenses	Southeast of Tank 3	22; 31, p. 28
HDLGP28-1	3-4	Brown silty sand with some clay and pebbles	Southeast of Tank 3	22; 31, p. 29
HDLGP28-2	7-8	Tan to orange and yellow fine-grained silty sand	Southeast of Tank 3	22; 31, p. 29
HDLGP28-3	11-12	Light yellow silty clay and fine-grained sand lenses	Southeast of Tank 3	22; 31, p. 29
HDLGP29-3	11-12	Orange and tan fine-grained sandy silt	East of HDLGP28	22; 31, p. 30
HDLGP30-1	3-4	Light yellow-tan silty fine-grained sand to orange clayey sand, pipe fragment	South of Tank 3	22; 31, p. 31
HDLGP30-2	7-8	Sandy-silty clay to orange-yellow silt	South of Tank 3	22; 31, p. 31
HDLGP30-3	11-12	Orange and tan fine-grained sandy silt	South of Tank 3	22; 31, p. 32
HDLGP31-1	3-4	Tan fine-grained sand to orange silty clay/clayey silt	Southwest of Tank 3	22; 31, p. 33
HDLGP31-2	7-8	Tan-yellow fine-grained silty sand	Southwest of Tank 3	22; 31, p. 33
HDLGP31-3	11-12	Silty fine-grained sand with silt lenses	Southwest of Tank 3	22; 31, p. 33

TABLE 2 (Continued)
SOURCE 2 SOIL DEPTHS AND SAMPLE DESCRIPTIONS AND LOCATIONS

Sample Identification	Depth (ft bgs)	Sample Description	Location	References
HDLGP32-1	3-4	Yellow-tan to orange-tan fine-grained sand	West of HDLGP31	22; 31, p. 34
HDLGP32-2	7-8	Orange silty sand to medium/coarse-grained sand	West of HDLGP31	22; 31, p. 34
HDLGP32-3	11-12	Light yellow-tan fine-grained sand	West of HDLGP31	22; 31, p. 34
HDLGP33-2	7-8	Bright orange medium/coarse-grained sand to tan silty sand	West of HDLGP32	22; 31, p. 35
HDLGP33-3	11-12	Orange fine-grained sand with silt to tan silty sand	West of HDLGP32	22; 31, p. 35
HDLGP34-1	3-4	Orange silty-clayey sand	West of HDLGP33	22; 31, p. 36
HDLGP34-2	7-8	Orange-tan fine-grained to coarse-grained sand at bottom	West of HDLGP33	22; 31, p. 36
HDLGP35-1	3-4	Tan silty sand to orange clayey sand	West of HDLGP34	22; 31, p. 40
HDLGP35-2	7-8	Orange medium clayey sand to tan medium sand	West of HDLGP34	22; 31, p. 40
HDLGP35-3	11-12	Tan medium/coarse-grained sand, with some pebbles	West of HDLGP34	22; 31, p. 40
HDLGP36-1	7-8	Orange medium clayey sand to tan medium sand with some pebbles at base	West of HDLGP35	22; 31, p. 41
HDLGP36-2	11-12	Tan medium/coarse-grained sand, with thin silt lenses	West of HDLGP35	22; 31, p. 41
HDLGP37-1	7-8	Orange-tan fine-grained to medium-grained sand	Northwest of HDLGP36	22; 31, p. 42
HDLGP37-2	11-12	Tan fine-grained sand to light orange sandy silt	Northwest of HDLGP36	22; 31, p. 42
HDLGP38-1	7-8	Orange-tan fine-grained to medium/coarse-grained sand	North of HDLGP37	22; 31, p. 43
HDLGP38-2	11-12	Silty fine-grained sand with medium-grained sand	North of HDLGP37	22; 31, p. 43

TABLE 2 (Continued)
SOURCE 2 SOIL DEPTHS AND SAMPLE DESCRIPTIONS AND LOCATIONS

Sample Identification	Depth (ft bgs)	Sample Description	Location	References
HDLGP39-1	7-8	Orange medium/coarse-grained sand with some pebbles to tan sandy clay	North of HDLGP38	22; 31, p. 44
HDLGP39-2	11-12	Tan fine-grained sand, trace silt with orange lenses	North of HDLGP38	22; 31, p. 44

Notes:

bgs Below ground surface

ft Feet

TABLE 3
SOURCE 2 SOIL SAMPLE ANALYTICAL RESULTS
2006 REMOVAL ACTION

Sample ID	Date Sampled	Hazardous Substances	Conc. (µg/kg)	SQL (µg/kg)	References
HDLGP12-1	08/28/2006	Trichloroethene	1,400	67	15, pp. 6, 67
HDLGP12-2	08/28/2006	Trichloroethene	6,600	76	15, pp. 8, 67
HDLGP13-1	08/28/2006	Trichloroethene	330	81	15, pp. 10, 67
HDLGP13-2	08/28/2006	Trichloroethene	21,000	120	15, pp. 12, 67
HDLGP14-2	08/28/2006	Trichloroethene	13,000	66	15, pp. 16, 67
HDLGP15-2	08/28/2006	Trichloroethene	7,400	56	15, pp. 20, 67
HDLGP16-1	08/28/2006	Trichloroethene	2,400	70	15, pp. 22, 67
HDLGP16-2	08/28/2006	Trichloroethene	21,000	110	15, pp. 24, 67
HDLGP17-1	08/28/2006	Trichloroethene	830	75	15, pp. 26, 68
HDLGP17-2	08/28/2006	Trichloroethene	15,000	75	15, pp. 28, 68
HDLGP18-1	08/28/2006	Trichloroethene	460	69	15, pp. 30, 68
HDLGP18-2	08/28/2006	Trichloroethene	20,000	300	15, pp. 32, 68
HDLGP19-1	08/28/2006	Trichloroethene	190	52	15, pp. 34, 68
HDLGP19-2	08/28/2006	Trichloroethene	8,000	60	15, pp. 36, 68
HDLGP20-1	08/28/2006	Trichloroethene	130	71	15, pp. 38, 68
HDLGP20-2	08/28/2006	Trichloroethene	9,200	62	15, pp. 40, 68
HDLGP21-1	08/28/2006	Trichloroethene	140	73	15, pp. 42, 68
HDLGP21-2	08/28/2006	Trichloroethene	510	66	15, pp. 44, 68
HDLGP22-1	08/28/2006	Trichloroethene	790	74	15, pp. 46, 69
HDLGP22-2	08/28/2006	Trichloroethene	10,000	140	15, pp. 48, 69
HDLGP23-1	08/28/2006	Trichloroethene	2,500	59	15, pp. 50, 69
HDLGP23-2	08/28/2006	Trichloroethene	54,000	620	15, pp. 52, 69
HDLGP24-1	08/28/2006	Trichloroethene	1,600	69	15, pp. 54, 69
HDLGP24-2	08/28/2006	Trichloroethene	52,000	540	15, pp. 56, 69
HDLGP25-1	08/28/2006	Trichloroethene	2,100	54	15, pp. 58, 69
HDLGP25-2	08/28/2006	Trichloroethene	46,000	580	15, pp. 60, 69
HDLGP26-1	08/28/2006	Trichloroethene	2,000	71	15, pp. 62, 69
HDLGP26-2	08/28/2006	Trichloroethene	36,000	510	15, pp. 64, 69
HDLGP27-1	08/30/2006	Trichloroethene	220	58	28, p. 8
HDLGP27-2	08/30/2006	Trichloroethene	1,600	75	28, p. 8
HDLGP27-3	08/30/2006	Trichloroethene	33,000	370	28, p. 9
HDLGP28-1	08/30/2006	Trichloroethene	1,300	48	28, p. 11

TABLE 3 (Continued)
SOURCE 2 SOIL SAMPLE ANALYTICAL RESULTS
2006 REMOVAL ACTION

Sample ID	Date Sampled	Hazardous Substances	Conc. (µg/kg)	SQL (µg/kg)	References
HDLGP28-2	08/30/2006	Trichloroethene	500	81	28, p. 11
HDLGP28-3	08/30/2006	Trichloroethene	14,000	150	28, p. 13
HDLGP29-3	08/30/2006	Trichloroethene	1,100	81	28, p. 15
HDLGP30-1	08/30/2006	Trichloroethene	12,000	83	28, p. 16
HDLGP30-2	08/30/2006	Trichloroethene	10,000	72	28, p. 17
HDLGP30-3	08/30/2006	Trichloroethene	28,000	300	28, p. 18
HDLGP31-1	08/30/2006	Trichloroethene	280	76	28, p. 19
HDLGP31-2	08/30/2006	Trichloroethene	3,800	74	28, p. 20
HDLGP31-3	08/30/2006	Trichloroethene	370	72	28, p. 21
HDLGP32-1	08/30/2006	Trichloroethene	380	74	28, p. 22
HDLGP32-2	08/30/2006	Trichloroethene	2,300	76	28, p. 23
HDLGP32-3	08/30/2006	Trichloroethene	5,300	77	28, p. 25
HDLGP33-2	08/30/2006	Trichloroethene	3,400	76	28, p. 26
HDLGP33-3	08/30/2006	Trichloroethene	5,300	78	28, p. 27
HDLGP34-1	08/30/2006	Trichloroethene	200	83	28, p. 28
HDLGP34-2	08/30/2006	Trichloroethene	7,000	66	28, p. 30
HDLGP35-1	08/30/2006	Trichloroethene	120	67	29, p. 1
HDLGP35-2	08/30/2006	Trichloroethene	2,900	69	29, p. 1
HDLGP35-3	08/30/2006	Trichloroethene	750	76	29, p. 2
HDLGP36-1	08/30/2006	Trichloroethene	680	65	29, p. 3
HDLGP36-2	08/30/2006	Trichloroethene	3,700	71	29, p. 4
HDLGP37-1	08/30/2006	Trichloroethene	1,000	64	29, p. 5
HDLGP37-2	08/30/2006	Trichloroethene	930	72	29, p. 6
HDLGP38-1	08/30/2006	Trichloroethene	260	67	29, p. 7
HDLGP38-2	08/30/2006	Trichloroethene	260	74	29, p. 8
HDLGP39-1	08/30/2006	Trichloroethene	680	68	29, p. 9
HDLGP39-2	08/30/2006	Trichloroethene	220	71	29, p. 10

µg/kg - Micrograms per kilogram

Conc. - Concentration

ID - Identification

SQL - Sample quantitation limit

The quantitation limits (QLs) or reporting limits (RLs) on the data sheets are equivalent to sample quantitation limits (SQLs). The QLs and RLs are analyte-specific calculations that correspond to the lowest quantitative point on the calibration curve and are adjusted for the amount of sample prepared, and any dilutions performed, as well as the percent of moisture in soil samples (Ref. 35).

List of Hazardous Substances Associated with Source 2:

TCE

2.2.3 HAZARDOUS SUBSTANCES AVAILABLE TO A PATHWAY

Containment Description	Containment Factor Value	References
Gas release to air: Not scored	NS	NS
Particulate release to air: Not scored	NS	NS
Release to ground water: As documented in Section 3.0, there is evidence of hazardous substance migration from the source area. Additionally, there is no liner associated with Source 2. Reference 31 documents that the samples were collected from soil. Reference 22 shows the soil sampling locations.	10	1, Table 3-2; 22; 34
Release via overland migration and/or flood: Not scored	NS	NS

Notes:

NS Not scored

2.4.2.1 SOURCE HAZARDOUS WASTE QUANTITY

2.4.2.1.1 Hazardous Constituent Quantity

The information available is not sufficient to adequately support evaluation of the hazardous constituent quantity for Source 2.

2.4.2.1.2 Hazardous Waste Stream Quantity

The information available is not sufficient to adequately support evaluation of the hazardous waste stream quantity for Source 2.

2.4.2.1.3 Volume

The information available is not sufficient to adequately support evaluation of the volume for Source 2.

2.4.2.1.4 Area

As documented in Table 3 of this documentation record, soil samples collected from Source 2 revealed the presence of TCE in soil at various locations on the property on which the sources of the Millsboro TCE ground water contamination are located. It is not known whether remaining contamination in Source 2 is continuous throughout the source area on the property. Therefore, the area of observed soil contamination associated with Source 2 is undetermined but greater than 0, and is assigned a HWQ value of > 0 (Ref. 1, Table 2-5).

Area Assigned Value: >0

2.4.2.1.5 Calculation of a Source Hazardous Waste Quantity (HWQ) Value

The source area HWQ value for Source 2 is assigned a value of >0 (Ref. 1, Table 2-5).

Source HWQ Value: >0

SUMMARY OF SOURCE DESCRIPTIONS

Source No.	Source Hazardous Waste Quantity Value	Source Hazardous Constituent Quantity Complete? (Yes/No)	Containment Factor Value by Pathway				
			Ground Water (GW) (Ref. 1, Table 3-2)	Surface Water (SW)		Air	
				Overland/flood (Ref. 1, Table 4-2)	GW to SW (Ref. 1, Table 3-2)	Gas (Ref. 1, Table 6-3)	Particulate (Ref. 1, Table 6-9)
1	>0	No	10	NS	NS	NS	NS
2	>0	No	10	NS	NS	NS	NS

Notes:
NS = Not scored

3.0 GROUND WATER MIGRATION PATHWAY

3.0.1 GENERAL CONSIDERATIONS

Aquifer/Stratum Name: Columbia Aquifer/Beaverdam Formation

TCE ground water contamination has been documented in the Columbia aquifer underlying Sources 1 and 2 (Ref. 7, pp. 2-1, 2-1a, 6-3c, and 7-9). The Beaverdam Formation is the primary geologic unit formation comprising the Columbia aquifer (Ref. 5, p. 1).

Ground Water Migration Pathway Description:

Regional Geology:

Sources 1 and 2 are located within the Mid-Atlantic Coastal Plain Physiographic Province (Ref. 11, pp. 2, 3). The topography is generally flat with a gradual slope towards the northeast and the low-lying areas adjacent to the regional river systems. Elevations within a 4-mile radius of the source areas range from about 45 feet above mean sea level (AMSL) west of Millsboro to sea level northeast of Millsboro (Ref. 4).

Sources 1 and 2 are underlain by a gently southeast-dipping, heterogeneous wedge of unconsolidated beds of late Quaternary to early Tertiary sands, silts, and clays of the following formations in descending order: the Lynch Heights Formation, the Beaverdam Formation, the Bethany Formation, and the Cat Hill Formation. The Lynch Heights Formation lies unconformably above the Beaverdam Formation. The sandy to clayey sediments of the Lynch Heights Formation function as either part of the unconfined aquifer system or as confining beds. The Beaverdam Formation contains the Columbia Aquifer, which is an unconfined aquifer, and is primarily fine to medium-grained sands. The Bethany Formation underlies the Beaverdam Formation. The Bethany Formation contains the confined Pocomoke Aquifer, and is predominately clays and silts with discontinuous lenses of fine to coarse-grained sand. Below the Bethany Formation lies the Cat Hill Formation. This formation contains the confined Manokin aquifer, which is predominately sand with minor beds of silts and clays (Ref. 5, pp. 7 to 11).

Rather than being distinct stratigraphic units, the four formations are lithostratigraphic units. However, in any section, the main bodies of these four formations are found with the Cat Hill at the base and either the Lynch Heights or the Beaverdam at the top. In Sussex County, the units have the following approximate thicknesses, for a total thickness of approximately 250 feet or more (Ref. 5, pp. 6 to 11, 16, Plate 1):

- | | |
|--|-------------|
| ➤ Lynch Heights Formation | 0-15 feet |
| ➤ Beaverdam Formation (Columbia Aquifer) | 50-100 feet |
| ➤ Bethany Formation (Pocomoke Aquifer) | 50-100 feet |
| ➤ Cat Hill Formation | 50 feet |

According to Delaware Geological Survey maps, the Lynch Heights Formation crops out in a 5 to 7-mile-wide belt in Eastern Sussex County. The formation is noted to outcrop at land surface elevations between about 15 and 40 feet in the Millsboro area (Ref. 5, Figure 9, pp. 10, 11). The Lynch Heights Formation consists of several distinct lithologies: (1) sand, fine to coarse, trace silt, granules, and pebbles; (2) sand, fine to medium, silty, trace granules; (3) clay, silty, trace sand, fine; and (4) silty, clayey, sandy, fine. Coarse-grained beds function as part of the unconfined aquifer. Thicker, areally extensive fine-grained beds of the Lynch Heights Formation function as confining units. These confining units do not form a regionally continuous confining unit. However, the thickness and lateral continuity of confining beds in

Ground Water – General Considerations

the Beaverdam, Lynch Heights, and Scott Corners Formations are significant for local-scale hydrology (Ref. 5, pp. 11, 16). The lithologies of the geologic units forming the confining beds are typically dominated by clay and silt, but in some locations, contain thin beds and mixtures of sand and even gravel. Inter- and intra-formational unconformities truncate the fine-grained beds. Because of the lithologies and the spatial discontinuities of individual beds and geologic units, the confining unit is expected to be leaky (Ref. 5, p. 17).

Colors of the Lynch Heights Formation are typically described as yellow, orange, and brown, reflecting generally oxidizing geochemical conditions. In locations where geochemical conditions in the formation sediments are more reduced, colors are described as white, light to dark gray, and light blue. The Lynch Heights Formation rests unconformably on the Beaverdam Formation. The thickness of the Lynch Heights Formation in the area varies from 0 to about 15 feet (Ref. 5, p. 11).

The Beaverdam Formation is the main lithostratigraphic unit comprising of the unconfined Columbia Aquifer in the Millsboro area. This formation out crops at the land surface approximately 5 miles west of Millsboro. Lithologically, the Beaverdam is heterogeneous and consists of multiple facies. The following three distinct facies are present in this formation in eastern Sussex County (Ref. 5, pp. 10, 11):

1. Sand, medium to coarse, trace silt, and granules; sand, medium to coarse, gravelly fine to medium, with fine gravel-sized mud rip-up clasts. Individual gravel beds are typically 1 foot thick, although gravel intervals can be as much as 35 feet thick. Coarse to medium sand-size multi-colored quartz grains, and white, soft grains are very common. This assemblage functions as an aquifer (Ref. 5, p. 11).
2. Sand, fine to coarse, trace silt and granules; sand, fine to medium, silty; sand, fine, and silt. A clayey matrix occurs in some sand beds. In most of these occurrences, beds are grain-supported not matrix-supported. The finer-grained lithologies tend to occur in thin (less than 1-foot-thick) beds and are not areally extensive. As in lithologic assemblage 1, multicolored quartz and white, soft sand-size mud clasts are very common. The coarser-grained lithologies in this assemblage function as an aquifer. The finer-grained beds influence local ground water flow, but because they are areally discontinuous, they do not function as confining beds. (Ref. 5, p. 11).
3. Laminated to thinly bedded silt, clayey, sandy, fine to medium; clay and silt, trace sand, fine; sand, fine to coarse, silty. A clayey matrix commonly occurs in some sand beds. Typically, there are equal occurrences of matrix- and grain-supported beds. Beds of fine-grained materials are commonly stacked sequences that are 2 to 10 feet thick. The thicker sequences can be correlated between boreholes over hundreds to thousands of feet. Sand-size quartz that occurs in multiple colors and white, soft sand-size mud clasts are very common. The assemblage of finer-grained beds influence local ground water flow and function as confining beds where they have sufficient areal extent (Ref. 5, p. 11).

The Beaverdam Formation generally fines upward with the occurrences of lithologic assemblage 3 being more common in the upper half, and assemblage 1 being more common in the lower half of the unit. Colors typically are described as yellow, orange, and brown reflecting generally oxidizing geochemical conditions. In locations and at depths where geochemical conditions are more reduced, colors are observed as white, light to dark gray, and light blue (Ref. 5, p. 11).

Within the Millsboro area, data indicate that the Bethany Formation is overlain by the Beaverdam Formation. Limited data indicate that the upper contact between the Bethany Formation and Beaverdam Formation is a complex surface that generally dips to the southeast (Ref. 5, p. 9).

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The Bethany Formation does not crop out within 4 miles of Millsboro. Available data indicate that the Bethany Formation occurs only in the subsurface. The more sandy intervals in the Bethany Formation function as the Pocomoke Aquifer. The finer-grained (silts and clays) intervals represent the confining beds and in many locations in eastern Sussex County form the base of the unconfined aquifer. Because individual fine-grained beds are laterally discontinuous, there are locations where aquifer sands of the Bethany Formation are in direct contact with aquifer sands of the overlying Beaverdam Formation and likely function as part of the unconfined aquifer (Ref. 5, p. 9).

The Cat Hill Formation does not crop out within 4 miles of Millsboro. All available data show that the Cat Hill Formation occurs only in the subsurface. The more sandy intervals of the Cat Hill Formation function as the Manokin aquifer. There are some locations where aquifer sands of the Cat Hill Formations are in direct contact with aquifer sands of the overlying Beaverdam Formation, and as a result, are likely to function as part of the unconfined aquifer. The Cat Hill Formation is predominately sand with minor beds of mud (silt and clay) informally subdivided into two subunits. The lower subunit (a) is a coarsening upward fine to medium silty quartzose sand and clayey fine sand; the upper subunit (b) is a medium to coarse gray quartzose sand with beds of gravelly coarse sand. Where unoxidized, colors are typically described as white to shades of gray and blue; colors are described as yellow to brown where oxidized (Ref. 5, pp. 7, 8).

The stratigraphic relationships between the Cat Hill Formation and overlying units vary with location. Because the contact between the Cat Hill Formation and the overlying Bethany Formation occurs only in the subsurface and is typically observed on geophysical readings and drillers' logs, it is difficult to characterize. In many locations the point of contact is marked by an abrupt change from sand to mud indicating either an unconformable erosional surface or a change in depositional environment. Where the Bethany Formation is absent, the Cat Hill Formation is unconformably overlain by the Beaverdam Formation or younger units. The upper point of contact between the Cat Hill Formation and the younger units is a complex surface that generally dips to the southeast (Ref. 5, p. 8, Figure 7).

Regional Hydrogeology

Ground water in the Millsboro area is present as primary porosity in the unconfined sand intervals of the Columbia aquifer of the Beaverdam Formation. The Columbia aquifer also is referred to as the unconfined aquifer in reference documentation. The Beaverdam Formation is the primary geologic unit forming the unconfined Columbia aquifer in the Millsboro area. The top of the water table portion of the aquifer occurs at depths of less than 10 feet below ground surface (bgs) (Ref. 5, p. 1). The definition of a water-table aquifer is one in which the pressure of water in the aquifer is equal to atmospheric pressure. In the Millsboro area, this condition is recognized when the static water level observed in a shallow well is equal to the top elevation of the aquifer. In other words, the top of the aquifer is the water table (Ref. 5, p. 3). The Columbia aquifer within the Beaverdam Formation has a transmissivity in excess of 1,000 square feet per day (ft²/day) (Ref. 5, p. 17). The hydraulic conductivity of the Columbia aquifer ranges from 84.24 to 236.90 feet per day (ft/day) or from 2.97×10^{-2} to 8.36×10^{-2} centimeters per second (cm/sec) (Ref. 7, pp. 5-1, 5-2, and Table 5-1). The Columbia aquifer is recharged by precipitation infiltration (Ref. 5, p. 17).

Ground water is also present as primary porosity in the unconfined to confined (in parts) sand intervals of the Pocomoke aquifer of the Bethany Formation and the sands of the Manokin aquifer of the Cat Hill Formation (Ref. 5, p. 1).

Site Geology and Hydrogeology

In the immediate vicinity of Sources 1 and 2, sands outcropping at the surface are primarily those of the Lynch Heights Formation, with the subsurface sands of the Beaverdam Formation (Ref. 5, pp. 10, 11). The nearest outcrop of the Beaverdam Formation is approximately 5 miles west of Sources 1 and 2 (Ref. 5, p. 10; Ref. 22). The contact between the Beaverdam lithofacies and the overlying Lynch Heights facies is gradational, and the formation contact is defined as a break in slope at land surface elevations between 40 and 45 feet AMSL (Ref. 5, p. 11).

Within a 4-mile radius of Sources 1 and 2, the unconsolidated sedimentary beds strike from north to south and dip to the east as a result of a deltaic depositional system with the fluvial and estuarine deposits in channel, beach, and shallow near-shore environments (Ref. 5, p. 11; Ref. 9). The resulting stratigraphy would consist of Lynch Heights Formation near the surface, with the Beaverdam unconformably below the Lynch Heights Formation. Because of the eastern dip of the beds, the Beaverdam Formation crops out west of the sources and passes underneath the sources (Ref. 5, p. 10; Ref. 9).

Using well logs, the presence of the Beaverdam Formation can be confirmed or implied based on the lithology descriptions (Ref. 7, Appendix A). The Beaverdam Formation contains the unconfined Columbia Aquifer, which occurs at about 10 feet below land surface and upwards to approximately 250 feet in some locations. This aquifer has a median thickness of 64 feet (Ref. 5, p. 1). The well log for monitoring well MW-1D, installed as part of an investigation of the Millsboro TCE, indicates a well-sorted and poorly-sorted, reddish-yellow, medium sand between the depths of 86 and 100 feet below grade (Ref. 7, pp. 3-2, and Appendix A, p. A-5). The Town of Millsboro public supply wells PW-1 and PW-2 are completed in the Columbia Aquifer (Ref. 7, p. 2-1; Ref. 8, p. 2-1). The Columbia Aquifer is an unconfined aquifer of moderate to high water-bearing capacity comprised predominately of yellow and reddish-brown quartz sand with some gravel (Ref. 7, p. 2-1, 2-2). Plate 1 of Reference 5 shows an interpretation of a gamma well log for the well identified as “Pg53-14”, also known as the Test Well-1 (TW-1), installed in the Town of Millsboro (Ref. 12, pp. 33, 34). The well log indicates that the Beaverdam Formation underlies the Lynch Heights Formation, the Bethany Formation underlies the Beaverdam Formation, and the Cat Hill Formation underlies the Bethany Formation in Millsboro (Ref. 5, Plate 1; Ref. 12, pp. 33, 34)

The uppermost aquifer in the Millsboro TCE ground water plume is the unconsolidated sandy sediments known as the Columbia Aquifer (unconfined aquifer) of the Beaverdam Formation (Ref. 5, pp. 10, 11; Ref. 13, p. 2). Investigations in the vicinity of the source areas have found that ground water generally flows northeast, towards the Town of Millsboro public supply wells PW-1, PW-2, and PW-3 (Ref. 7, Figure 3-2, p. 3-5a; Ref. 23, p. 1-12).

Millsboro public supply well PW-3 is screened in the Cat Hill (Manokin) Formation. In the area of PW-3, the Manokin Formation is a confined aquifer that is separated from the Columbia aquifer by a low-permeability clay layer, the Bethany Formation (Ref. 5, pp. 6; Ref. 7, p. 2-2; Ref. 43, pp. 1, 4, 5, 6).

Aquifer/Stratum 1 (Shallowest)

Stratum Name: Beaverdam Formation (Columbia Aquifer)

Description:

The Beaverdam Formation contains the Columbia Aquifer, which primarily consists of yellow, orange and brown quartz, with some gravel (Ref. 5, pp. 1, 10, 11; Ref. 7, pp. 2-1, 2-2). The sandy deposits of the Beaverdam Formation form the largest portion of the volume of the aquifer, and most wells that pump water from the unconfined aquifer are finished in the Beaverdam Formation (Ref. 5, pp. 13, 14). However, according to a map of the area (Ref. 5, p. 10), younger units (i.e. Lynch Heights Formation) that overlay the Beaverdam Formation form the top of the aquifer over most of the area surrounding Millsboro. In cross-sections (Ref. 5, Plate 1), the younger units appear to be relatively thin and sandy beds of the Beaverdam Formation and seem to form the bulk of the unconfined aquifer. The coarser-grained, most permeable beds of the Beaverdam Formation (facies 1 – see description above under Regional Geology) are thought to have been deposited in high-energy conditions such as river channel, beach, and shallow near-shore environments. The thickest and therefore more transmissive sections of the aquifer occur where the beds are vertically stacked. The coarse-grained beds of facies 2, deposited in moderate energy environments such as smaller tributary tidal channels, levee, tidal delta, and sub-tidal flats also are likely to form a highly transmissive aquifer in locations where the coarse-grained beds are vertically stacked (Ref. 5, p. 14). The hydraulic conductivity of the Columbia Aquifer ranges from 84.24 to 236.90 ft/day or from 2.97×10^{-2} to 8.36×10^{-2} cm/sec (Ref. 7, pp. 5-1, 5-2, and Table 5-1). In the Beaverdam Formation, the unconfined aquifer is recharged by precipitation infiltration (Ref. 5, p. 17).

The depth from Sources 1 and 2 to the water-bearing zones of the Columbia aquifer is estimated to be 15 feet bgs based on screening intervals of the shallow wells installed on the property on which the sources of the Millsboro TCE ground water contamination are located (Ref. 7, Appendix B, p. B-1). No aquifers or formation capable of producing significant quantities of water have been identified above the Columbia aquifer in the area of Millsboro (Ref. 5, p. 1).

Columbia Aquifer – Barriers to Ground Water Flow

Reference 5, plate 1, provides a geologic cross-section including the area underlying Sources 1 and 2. Sources 1 and 2 are located within the vicinity of the well identified as Pg53-14, also known as the Test Well-1 (TW-1), installed in the Town of Millsboro (Ref. 5, Plate 1; Ref. 12, pp. 33, 34). No barriers to vertical ground water flow are shown on the cross section (Ref. 5, Plate 1). The well logs on the property on which the sources of the Millsboro TCE ground water contamination are located do not show any barriers to vertical ground water flow, such as continuous clay layers (Ref. 7, Appendix A). The geologic map for Millsboro including the locations of Sources 1 and 2 and Millsboro public water supply wells, does not show any horizontal barriers to ground water flow in the Columbia aquifer (Ref. 9). The topographic map for Millsboro, Delaware, including the locations of Sources 1 and 2 and Millsboro public water supply wells, does not shown any physical barriers to horizontal ground water flow, such as mountains or large rivers, (Ref. 3; Ref. 4).

SUMMARY OF AQUIFER(S) BEING EVALUATED

The Columbia Aquifer is the only aquifer being evaluated.

Aquifer No.	Aquifer Name	Is Aquifer Interconnected with Upper Aquifer within 2 miles? (Yes/No/NA)	Is Aquifer Continuous within 4-mile TDL? (Yes/No)	Is Aquifer Karst? (Yes/No)
1	Columbia Aquifer	NA	NA	No

Notes:

NA Not applicable, no upper aquifer

TDL Target distance limit

3.1 LIKELIHOOD OF RELEASE

3.1.1 OBSERVED RELEASE – Beaverdam Formation – Columbia Aquifer

Aquifer Being Evaluated: Beaverdam Formation - Columbia Aquifer

As documented in this section, the aquifer in which drinking water wells are completed and in which the observed release has been documented is the Columbia aquifer of the Beaverdam Formation (Ref. 7, p. 2-1). As documented in Section 3.0, a fine-grained (clay) confining unit (the Bethany Formation) acts as a barrier to ground water flow between the Beaverdam and underlying Bethany Formation (Ref. 7, p. 2-2). The finer-grained (silts and clays) intervals that represent the confining beds in many locations in eastern Sussex County form the base of the unconfined (Columbia) aquifer (Ref. 5, pp. 16, 17).

Chemical Analysis

Millsboro TCE Ground Water Contamination Site - 2008 Ground Water Sampling

In 2008, an environmental consultant to DNREC completed a site characterization investigation at Millsboro TCE (Ref. 7, p. 1-1). As part of the investigation, 17 monitoring wells were installed. Eight of the wells were installed as shallow (S) wells (MW-1S, -2S, -3S, -4S, -6S, -7S, -9S, and -10S), one of the wells was installed in the middle (M) of the aquifer (MW-1M) and eight of the wells were installed as deep (D) wells (MW-1D, -2D, -3D, -4D, -6D, -7D, -9D, and -10D). No well 5 or 8 was installed (Ref. 7, Figure 3-1). All well locations are provided in Figure 3-1 of Reference 7. Data from MW-1M was not included in the observed release section because a background well is not available for the screened interval of MW-1M. All of the monitoring wells form Columbia (unconfined) aquifer well cluster pairs (Ref. 7, p. 3-2, Figure 3-1). Shallow wells were identified with the letter “S,” deep wells were identified with the letter “D,” and mid-range wells were identified with the letter “M.” Cluster 1 was the only location where three instead of two wells were installed (Ref. 7, p. 3-4).

Each monitoring well boring was drilled with a 6-inch mud rotary. Split-spoon sampling methods were in effect, except for the first drilled location (MW-10D), which was drilled initially using a 4.25-inch hollow-stem auger at the request of the potentially responsible parties (PRP) and at the approval of DNREC. However, because running sands were encountered at approximately 18 feet bgs at MW-10D, a mud rotary was used to complete drilling for the well installation (Ref. 7, p. 3-2).

The monitoring wells were constructed with 2-inch, schedule-40 polyvinyl chloride (PVC) well casings and a maximum of 10 feet of 2-inch, schedule-40 PVC, 0.010-inch machine-slotted well screen. Only location MW-1D was cased off at 49 feet bgs within sand because of the absence of clay in an attempt to possibly prevent downgradient migration of TCE contamination, as directed by DNREC. Contractors lowered 4-inch PVC casing to 49 feet bgs, and pressure-filled the annular space between the PVC casing and the borehole via tremie pipe with a cement/bentonite slurry. After allowing a maximum of 8 hours for the grout to cure, the drilling fluids were flushed and replaced with new drilling fluids before mud-rotary drilling continued through the 4-inch PVC casing to approximately 100 feet bgs at MW-1D (Ref. 7, p. 3-3).

The monitoring wells were completed flush with the ground surface at the majority of the locations with a concrete pad and flush-mounted well covers. The surface around the well was completed by continuously pouring concrete from below the frost line to the ground surface. However, six well locations (MW-2S, -2D, -3S, -3D, -10S, and -10D) were completed to approximately 2 feet above ground surface, with a 4-inch-diameter concrete-filled steel pipe extending to a minimum of 3 feet above ground surface (Ref. 7, pp. 3-3, 3-4).

Ground Water – Observed Release

Based on the well locations in Reference 7, Figure 3-1, and the well construction details in Reference 7, Appendix B, Table 3-1, the wells were positioned and screened to capture the horizontal and downward migration of TCE, which is a dense, nonaqueous-phase liquid (DNAPL) (Ref. 7, p. 3-1, Figure 3-1, and Appendix B, Table 3-1; Ref. 16, pp. 1, 2; Ref. 23, p. 1-12). This means TCE will flow downward because the density of TCE is greater than water. As a result, TCE will flow downward within the aquifer until it reaches an impermeable layer (i.e. clay) (Ref. 16, pp. 4, 6).

Ground water samples were collected from the monitoring wells approximately 2 weeks after well development. Well purging and sampling methods were performed in accordance with low-flow sampling procedures defined by EPA Region II. The monitoring wells were sampled once as part of the site characterization. The ground water samples were analyzed for VOCs by EPA Method 8260B, total organic carbon, dissolved gases (methane, ethane, and ethene), sulfate, nitrate, total and dissolved iron and manganese, total alkalinity, and chemical oxygen demand (COD) (Ref. 7, p. 6-1). The samples were analyzed by a DNREC-certified laboratory (Ref. 7, p. 6-3). DNREC laboratory standard operating procedures (SOP) including sample management, quality assurance and quality control (QA/QC), and laboratory data review, are documented in Reference 44. Reference 45, *Hazardous Substance Cleanup Act Guidance Manual*, outlines procedures followed by DNREC and DNREC subcontractors when conducting environmental investigations or cleanup (Ref. 39). Available logbook notes for the samples are provided as Reference 53.

Background Wells and Concentrations – Millsboro TCE Ground Water Contamination Site

Monitoring wells MW-10S and MW-10D are considered the background wells for the shallow and deep monitoring wells at the site, respectively, because of their upgradient location and ground water elevations (Ref. 7, Appendix B, Table 3-1). The background well locations are shown in Reference 3, Figure 2-1. Both MW-10S and MW-10D are located southwest of the site outside of the source area boundaries (Ref. 7, Figure 2-1). Both MW-10S and MW-10D are completed in the Beaverdam Formation/Columbia Aquifer (Ref. 7, Appendix B, Table 3-1). The well construction details for the background wells are summarized in Table 4. The concentrations of TCE detected in background wells MW-10S and MW-10D are summarized in Table 5. As documented in Table 5, TCE is non-detect in the background samples.

The background and release monitoring wells were screened within the same relative depth and aquifer (see Tables 4 and 6). The monitoring well samples also were collected using the same procedures within the same time span, and were analyzed using the same analytical method, EPA Method 8260 B (Ref. 7, pp. 6-1, 6-2, 6-3).

No public drinking water well was identified in the 4-mile radius that could be used as a background well. Therefore, the background monitoring well is used to establish background concentrations of TCE for the public water wells. The monitoring and public water wells are completed within the same relative depth of the aquifer, as documented in Tables 4 and 5. The public water supply wells are screened between minus 50 to minus 70 feet AMSL (Ref. 14, p. 1). The deep background well was screened between minus 68.88 to minus 77.88 feet AMSL (Ref. 7, Appendix B, p. B-17). The monitoring wells have a 2-inch diameter and the public water supply well has an 8-inch diameter (Ref. 7, Appendix B, p. B-17). Because the public water supply well has a larger diameter, the well would draw more water. This is not expected to significantly affect the TCE concentrations found in the public water supply. TCE concentrations in the public water supply wells potentially could be somewhat lower than the TCE concentrations in the monitoring wells because the public water supply wells draw more water due to the greater diameter of the well, the larger screening interval, and greater probability of vitalization of TCE (Ref. 7, Appendix B;

Ground Water – Observed Release

Ref. 12, p. 77; Ref. 43, p. 4). TCE was not detected in water from supply wells PW-1 and PW-2 prior to 2005 (Ref. 55). Since TCE was not detected in the supply wells prior to 2005, the background concentration for TCE in ground water at PW-1 and PW-2 was below the detection limit, prior to releases from Sources 1 and 2.

Reference 4 shows the locations of the monitoring wells and the public water supply wells PW-1 and PW-2. Reference 7, Figure 3-2, following page 3-5, provides the ground water contour elevations. A review of these contour elevation illustrations shows that ground water flows from the southwest, from background monitoring well location MW-10, towards the northeast, the location of Sources 1 and 2, and public water supply wells PW-1 and PW-2 (Ref. 4; Ref. 7, Figure 3-2, p. 3-5). Therefore, the best location for a background well is located southwest of Sources 1 and 2 and PW-1 and PW-2, the location of background well MW-10 (Ref. 4).

As documented in Table 7, the monitoring well and public water supply wells were sampled within the same relative timeframe. The ground water samples were analyzed using EPA-approved Superfund analytical methods. The ground water samples collected from the monitoring wells were analyzed using EPA Method 8260 B, and public water supply wells were analyzed using EPA Method 524.2 (Ref. 7, p. 6-1; Ref. 27, p. 4, 6, 8, 10, 12, 14, 16, 18, 20). The analytical methods are publically available at: <http://www.epa.gov/waste/hazard/testmethods/sw846/pdfs/8260b.pdf> and http://www.epa.gov/waterscience/methods/method/files/524_2.pdf. The two analytical methods are similar. Method 524.2 was developed to meet drinking water standards (Ref. 48, p. 2). The data package was reviewed in accordance with EPA “Region III Modifications to National Functional Guidelines for Inorganic Data Review Multi-Media, Multi-Concentration,” April 1993 (Ref. 56), and EPA “Innovative Approaches for Validation of Organic Data Standard Operating Procedures,” June 1995 (Ref. 57), to level M3 for organic analysis (Ref. 46).

**TABLE 4
MILLSBORO TCE - BACKGROUND WELLS
CONSTRUCTION DETAILS**

Well ID	Well Location	Well Depth (feet AMSL)*	Screened Interval (feet AMSL)*	Water Elevation (feet AMSL)* June 2008	References
MW-10S	Southwest of Sources (Upgradient)	-27.34	(-17.34) – (-27.34)	12.06	4; 7, p. 2-1a, Figure 2-1, Appendix B, p. B-16, Table 3-1; 22; 51
MW-10D	Southwest of Sources (Upgradient)	-77.88	(-67.88) – (-77.88)	11.91	4; 7, p. 2-1 a, Figure 2-1, Appendix B, p. B-17, Table 3-1; 22; 51

Notes:

- * Vertical datum = NAVD 88; “-“ negative sign indicates below mean sea level
- AMSL Above mean sea level
- D Deep
- ID Identification
- MW Monitoring well
- S Shallow

**TABLE 5
MILLSBORO TCE
BACKGROUND WELL CONCENTRATIONS**

Sample ID	Date Sampled	Hazardous Substances	Conc. (µg/L)	SQL (µg/L)	References
MW-10S	06/23/08	Trichloroethene	ND	1.0	19, pp. 2, 13; 7, Appendix I, p. I-1; 53, p. 44
MW-10D	06/23/08	Trichloroethene	ND	1.0	19, pp. 4, 13; 7, Appendix I, p. I-1; 53, p. 44

Notes:

- µg/L Micrograms per liter
 - Conc. Concentration
 - D Deep
 - ID Identification
 - ND Not detected
 - MW Monitoring well
 - S Shallow
 - SQL Sample quantitation limit
- The quantitation limits (QLs) or reporting limits (RLs) on the data sheets are equivalent to sample quantitation limits (SQLs). The QLs and RLs are analyte-specific calculations that correspond to the lowest quantitative point on the calibration curve and are adjusted for the amount of sample prepared, and any dilutions performed, as well as the percent of moisture in soil samples (Ref. 35).

Contaminated Wells and Concentrations – Millsboro TCE

Monitoring well construction details for the release wells are provided in Table 6, and TCE concentrations detected in the wells are summarized in Table 7.

**TABLE 6
MILLSBORO TCE - RELEASE SAMPLES
WELL CONSTRUCTION DETAILS**

Well ID	Well Location	Well Depth (feet AMSL)*	Screened Interval (feet AMSL)*	Water Elevation (feet AMSL)* June 2008	References
MW-1S	North of Sources	-1.95	8.05 – (-1.95)	9.88	4; 7, p. 2-1a, Figure 2-1, Appendix B, p. B-1, Table 3-1; 51
MW-2S	North of Sources	-12.03	(-2.03) – (-12.03)	9.59	4; 7, p. 2-1a, Figure 2-1, Appendix B, p. B-4, Table 3-1; 51
MW-3S	North of Sources	-14.51	(-4.51) – (-14.51)	8.64	4; 7, p. 2-1a, Figure 2-1, Appendix B, p. B-6, Table 3-1; 51
MW-4S	Northeast of Sources	-25.46	(-15.46) – (-25.46)	7.43	4; 7, p. 2-1a, Figure 2-1, Appendix B, p. B-8, Table 3-1; 51
MW-6S	Northeast of Sources	-36.29	(-26.29) – (-36.29)	3.93	4; 7, p. 2-1a, Figure 2-1, Appendix B, B-10, Table 3-1; 51
MW-6D	Northeast of Sources	-66.8	(-56.8) – (-66.8)	3.71	4; 7, p. 2-1a, Figure 2-1, Appendix B, B-11, Table 3-1; 51
PW-1	Northeast of Sources	-60	(-50) – (-60)	20.0**	4; 8, p. 2-1; 14, p. 1; 12, pp. 10, 77; 17, p. 1; 51
PW-2	Northeast of Sources	-70	(-50) – (-70)	NA	4; 8, p. 2-1; 14, p. 1; 12, pp. 29, 77; ;17, p. 1; 51

Notes:

* Vertical datum = NAVD 88; “-“ negative sign indicates below mean sea level

** Measured March 9, 2009 (Ref. 17).

D Deep

ID Identification

MW Monitoring well

NA Not available

PW Public water

S Shallow

**TABLE 7
MILLSBORO TCE - RELEASE WELL CONCENTRATIONS**

Sample ID	Date Sampled	Hazardous Substances	Conc. (µg/L)	DL (µg/L)	References
MW-1S	06/25/08	Trichloroethene	17,000	100	41, pp. 11, 14; 7, Appendix I, pp. I-3, I-24; 53, p. 48
MW-2S	06/25/08	Trichloroethene	11	1.0	41, pp. 9, 14; 7, Appendix I, pp. I-3, I-21; 53, p. 47
MW-3S	06/25/08	Trichloroethene	12,000	100	41, pp. 7, 14; 7, Appendix I, pp. I-3, I-21; 53, p. 47
MW-4S	06/24/08	Trichloroethene	2,800	25	40, pp. 6, 14; 7, Appendix I, pp. I-2, I-11; 53, p. 46
MW-6S	06/23/08	Trichloroethene	32	1.0	42, pp. 8, 10; 7, Appendix I, pp. I-1, I-4; 53, p. 44
MW-6D	06/23/08	Trichloroethene	15	1.0	42, pp. 6, 10; 7, Appendix I, pp. I-1, I-4; 53, p. 44
Well # 1 BF (PW-1)	06/24/08	Trichloroethene	46	0.1	27, pp. 4, 23, 24
Well # 2 BF (PW-2)	06/24/08	Trichloroethene	260	0.1	27, pp. 10, 23, 24

Notes:

- µg/L Micrograms per liter
- BF Before (Carbon) Filters
- D Deep
- DL Detection limit (SQLs or method detection limits [MDLs]). See note below.
- ID Identification
- MW Monitoring well
- PW Public water
- S Shallow
- SQL Sample quantitation limit

The quantitation limits (QLs) or reporting limits (RLs) on the data sheets in References 40 through 42 are equivalent to sample quantitation limits (SQLs). The QLs and RLs are analyte-specific limits that correspond to the lowest point on the calibration curve and are adjusted for the amount of sample prepared, and any dilutions performed, as well as the percent moisture in soil samples (Ref. 35). The method detection limits are listed for samples in Reference 27.

Attribution:

The origin of the TCE detected in Millsboro supply wells PW-1 and PW-2 has been investigated by DNREC. DNREC conducted direct-push and ground water screening surveys. The direct-push survey screening results confirmed the presence of TCE in the shallow sand aquifer (Columbia Aquifer). The direct-push survey identified a potential source of the TCE contamination on the property on which the sources of the Millsboro TCE ground water contamination are located (225 West Dupont Highway) and provided spatial ground water screening data used to prepare a TCE plume map (Ref. 23, p. 1-9). The dimensions of the plume are shown in Figure 1-3 of Reference 23. The plume was estimated to be more than 1,500 feet long and up to 300 feet wide (Ref. 23, p. 1-9). Figure 1-4 in Reference 23 illustrates a cross-sectional view and interpretation of the vertical profile of measured TCE concentrations in ground water along plume centerline A-A. The data indicate that TCE is present in ground water at depths ranging from less than 15 ft bgs to depths in excess of 85 feet bgs. Figures 1-3 and 1-4 in Reference 23 illustrate that the dissolved-phase TCE plume has migrated laterally to the northeast and to greater depths as consequence of the influence that public water supply wells (PW-1 and PW-2) have on local ground water flow. These two wells pump at an aggregate average daily rate of approximately 480 gallons per minute (Ref. 23, p. 1-9).

Millsboro TCE includes the location of a former poultry vaccine manufacturing facility located at 225 West Dupont Highway, Millsboro, Sussex County, Delaware (Ref. 10, p. 4; Ref. 21, pp. 1-1, 1-3; Ref. 23, p. ES-1). TCE was used for an unknown period of time as a heat transfer medium within a closed refrigeration system (Ref. 23, p. 1-7). TCE contamination was found in the USTs beneath the property (Source 1) and soils across the property (Source 2) (Ref. 10, p. 5). TCE-contaminated soil was detected at various locations on the property on which the sources of the Millsboro TCE ground water contamination are located (Ref. 22 and Table 3 of this documentation record). Reference 22 shows the locations of the tanks (Source 1) and areas of soil contamination (Source 2).

The shape and configuration of the ground water plume clearly indicates that TCE is being drawn from Sources 1 and 2 into the Columbia Formation by the Millsboro public water supply wells. Since the original detection of TCE in supply wells, TCE levels have slightly increased and subsequently stabilized. Concentrations of TCE have increased by more than one-half order of magnitude in less than 1 year in one of the supply wells (PW-2), with maximum TCE concentrations (measured by laboratory analysis) of 790 ppb (Ref. 23, pp. 1-9, 1-9a, 1-9b).

The ground water plume associated with Sources 1 and 2 emanates from a zone directly below Sources 1 and 2. Maximum TCE concentrations ranging from 10,000 to greater than 100,000 µg/L were identified in the ground water at the depth of the water table in this area. Ground water TCE concentrations decrease across the 2,000-foot length of the plume from the source areas in the southeast to the public supply wells in the northeast. TCE plume depth also increases to the northeast. The concentration trend and the directionality of the diving plume are consistent with both the natural ground water gradient and the hydraulic gradient induced by the Millsboro public water supply wells. In conjunction with concentrations and elevation trends, the correspondence between the location of the former building and the location of maximum TCE concentration level supports the deduction that the region directly beneath the former building is the source of TCE infiltration into the aquifer (Ref. 7, p. 7-9, Figure 2-1, p. 2-1a, Figure 6-1, p. 6-3c and Appendix J, Figures 1, 5, 6; Ref. 4; Ref. 22).

As documented in Table 6, TCE has been detected in monitoring wells between Sources 1 and 2 and the public water supply wells (Ref. 22; Table 6 of this documentation record).

The ground water flow direction from Sources 1 and 2 also provides evidence that the TCE-contamination in the public water supply wells (PW-1 and PW-2) is from Sources 1 and 2. Ground water

Ground Water – Attribution

flows from the southwest of Sources 1 and 2 to the northeast towards Sources 1 and 2 and continues northeast towards PW-1 and PW-2. Reference 4 (in the upper right hand corner) shows the locations of PW-1 and PW-2 relative to the monitoring well locations where water level measurements were obtained. Reference 7, Figure 3-2, page 3-5a, shows the ground water contour elevations. The ground water contour elevations show that ground water continues to flow towards the northeast (Ref. 4; Ref. 7, Figure 3-2, p. 3-5a).

Soil data are consistent with saturated zone data indicating that the soil beneath the former building on the Millsboro TCE property is the source of TCE contamination of the ground water. A TCE soil impact model was extended from 3 to 12 feet bgs in the vadose zone underlying Sources 1 and 2. Within this region, the maximum concentration of soil TCE was 110,000 µg/kg. Regions of elevated TCE concentrations corresponded with the soil directly below the former building as opposed to those beyond its southwestern walls. Regions of maximum soil TCE concentrations corresponded to regions of maximum ground water TCE concentrations (Ref. 7, p. 7-10, and Appendix J, Figures 7, 8, and 9).

The ground water screening data collected from the area of Sources 1 and 2 indicate that the TCE plume is from Sources 1 and 2 (described as 225 West Dupont Highway in reference documentation). Screening results from ground water samples collected to the immediate southwest, northwest, and southeast of Sources 1 and 2 (described as the property in reference documentation) were reported as non-detect, further verifying that Sources 1 and 2 (described as the subject property in reference documentation) are the primary sources of TCE found in the ground water sampled from the Town of Millsboro supply wells (Ref. 23, p. 1-12, Figures 1-3, p. 1-9a and 1-4, p. 1-9b).

Dissolved-phase TCE levels in ground water present beneath Sources 1 and 2 (described as the property in reference documentation) in excess of 100 ppm indicate the likely presence of DNAPL. Pure TCE has a density greater than water and, if released, will sink below the water table as a mobile mass until (1) it is either retarded by a low permeability layer (clay layer) or (2) the mobile DNAPL mass is immobilized as it migrates vertically and resides in pore spaces of the aquifer material where it slowly dissolves into ground water (referred to as the residual phase). Small volumes of TCE DNAPL can contaminate large volumes of ground water and last many years because of its relatively low solubility in ground water (Ref. 23, p. 1-12; Ref. 16, pp. 3 to 7; Ref. 52, p. 2).

The dissolved-phase plume from Sources 1 and 2 has migrated north-northeast towards the Millsboro public water supply wells, which based on the local topography and natural ground water flow patterns, would also be to the north-northeast if the supply wells were not pumping. The pumping of the supply wells draws the dissolved-phase plume towards the supply wells (Ref. 23, p. 1-12).

Millsboro public water supply well PW-3 is completed in the Manokin aquifer. At this location, the aquifer is confined because a significant clay layer exists between the ground surface and the well screen (Ref. 43, pp. 1, 4, 6, 8, 9). This confining layer would prevent any ground water contamination from the Manokin aquifer from entering the Columbia aquifer; however, it has not been determined whether the confining layer is continuous within 2 miles of Sources 1 and 2.

A preponderance of ground water data collected along the plume flanks and toe confirms that potential sources external to the TCE envelope have not contributed to the observed TCE impacts. The TCE concentrations in the envelope of the plume ranged from 100 to greater than 100,000 µg/L. Sampling locations outside the body of the plume showed TCE concentrations less than 5 µg/L, with the exception of the HAGP-11 direct-push sample screen, which had an observed concentration of 20 parts per billion (ppb) near the surface of the water tables (12 ft bgs) (Ref. 7, p. 7-9, and Appendix J, Figures 1, 3, 4; Ref. 22).

Ground Water – Attribution

The environmental setting surrounding Sources 1 and 2 in Millsboro is generally mixed residential with light commercial businesses surrounded by agricultural and rural properties (Ref. 3; Ref. 4; Ref. 20; Ref. 43, pp. 11, 21). The Source Water Assessment completed for the Town of Millsboro supply wells did not identify any viable sources of TCE in the area of the wells (Ref. 43, p. 10). Based on this fact and the analytical results discussed above, Sources 1 and 2 are likely the sole source contributors to TCE ground water contamination at Millsboro TCE.

A database search was conducted to identify possible sources of ground water contamination to Millsboro public water supply wells (Ref. 18). The NCR Corporation (NCR) was identified as a possible source (Ref. 18, p. 5). NCR (Millsboro Plant) is located approximately 1 mile to the southeast of Millsboro, Delaware. NCR is a National Priorities List (NPL) site and a source of TCE-contaminated ground water (Ref. 18, pp. 5, 8, and 12). However, the TCE concentrations at Millsboro TCE in ground water indicate that Sources 1 and 2 are the source of TCE contamination at Millsboro TCE (Ref. 7, pp. 2-1, 7-9, 7-11; Ref. 23, p. 1-9). Additionally, the ground water plume at NCR discharges to Iron Branch Creek and therefore, would not contaminate the ground water at Millsboro TCE. The TCE ground water contamination at NCR is reportedly characterized by hexavalent chromium and TCE, which are not characteristic of the ground water contamination at Millsboro TCE (Ref. 39).

The NCR NPL site is located 0.25 mile southeast of the intersections of Routes 113 and 24 in the town of Millsboro (Ref. 38, pp. 12, 24). According to the Five-Year Review, ground water leaving NRC meets drinking water standards for TCE (Ref. 38, p. 9). No drinking water wells have been found to have been affected by Site-related contaminants (Ref. 38, p. 13). No Site related contaminants have been detected in residential wells across Iron Branch at concentrations exceeding MCLs, suggesting that Iron Branch Creek acts as a hydraulic divide between the Site and the residences (Ref. 38, p. 16). Since a remediation system has been installed on the NCR site, the amount remaining in the subsurface at NCR has continued to decline with operations of the systems. The results from ground water sampling at NCR indicate that contamination is not migrating off site and that no contamination has reached residential wells (Ref. 38, p. 18).

Other possible sources of contamination within 1 mile of Sources 1 and 2 are provided in Reference 18, page 6. None of these possible sources are associated with TCE contamination (Ref. 18, pp. 13 to 17).

Hazardous Substances Released

TCE

Ground Water Observed Release Factor Value: 550

3.2 WASTE CHARACTERISTICS

3.2.1 TOXICITY/MOBILITY

Table 8 below summarizes the toxicity and mobility factor values for TCE-associated sources and in the observed releases to ground water. The values are assigned in accordance with Section 3.2.1 of Reference 1. The mobility and toxicity values were obtained from Reference 2. If a hazardous substance was detected in the observed release to ground water, a mobility value of 1 is assigned.

**TABLE 8
TOXICITY/MOBILITY FACTOR VALUES**

Hazardous Substance	Source No. (and/or Observed Release)	Toxicity Factor Value	Mobility Factor Value*	Does Hazardous Substance Meet Observed Release by Chemical Analysis? (Yes/No)	Toxicity/Mobility (Ref. 1, Table 3-9)	References
Trichloroethylene (TCE) (also known as trichloroethene)	1, 2, OR	10,000	1	Yes	10,000	2, p. BI-13

Note:

* = Documented in the observed release to ground water. A mobility factor value of 1 is assigned (Ref. 1, Section 3.2.1.2).

OR = Observed release (TCE was detected in the ground water observed release samples.)

Toxicity/Mobility Factor Value: 10,000

3.2.2 HAZARDOUS WASTE QUANTITY

The hazardous waste quantity (HWQ) values for Sources 1 and 2 are summarized in the table below.

**TABLE 9
HAZARDOUS WASTE QUANTITY VALUES**

Source No.	Source Type	Source Hazardous Waste Quantity
1	Tank/Container	>0
2	Contaminated soil	>0

Sum of Values: > 0

The HWQ value of 100 is assigned to the ground water migration pathway because observed releases to ground water and actual contamination at Level I concentrations in drinking water wells are documented. If any target for a migration pathway is subject to actual contamination, a value of 100 is assigned if the value obtained from Table 2-6 of Reference 1 is less than 100 (Ref. 1, Section 2.4.2.2).

HWQ Factor Value (Ref. 1, Table 2-6): 100

3.2.3 WASTE CHARACTERISTICS FACTOR CATEGORY VALUE

The waste characteristics factor value is assigned based on the product of the HWQ factor value (100) and the highest toxicity/mobility factor value (10,000). Based on the total waste characteristics product of 1,000,000, a HWQ factor value is assigned from Table 2-7 of Reference 1. The waste characteristics factor value is 32.

Toxicity/Mobility Factor Value: 10,000
Hazardous Waste Quantity Factor Value: 100

Toxicity/Mobility Factor Value X
Hazardous Waste Quantity Factor Value: 1,000,000

Waste Characteristics Factor Category Value: 32
(Ref. 1, Table 2-7)

3.3 TARGETS

The ground water targets evaluated for the ground water migration pathway are summarized below.

Level I Concentrations

Level I concentrations have been documented in two of the Town of Millsboro public water supply wells that draw from the Columbia Aquifer and are summarized in Table 10 below.

**TABLE 10
LEVEL I CONCENTRATIONS**

Sample ID	Hazardous Substance	Hazardous Substance Concentration (µg/L)	Benchmark Concentration (µg/L)	Benchmark	References for Benchmark
PW-1	Trichloroethylene	46	0.21	Cancer Screening Concentration	2, p. BI-13
PW-2	Trichloroethylene	260	0.21	Cancer Screening Concentration	2, p. BI-13

Notes:

The benchmark used is the cancer screening concentration (0.21 µg/L) (Ref. 2, p. BI-13). See Table 7 for the concentrations of TCE detected in the drinking water well samples.

µg/L Micrograms per liter

ID Identification

MCL Maximum contaminant level

3.3.1 NEAREST WELL

Because actual contamination at Level I concentrations has been documented, a nearest well factor value of 50 is assigned (Ref. 1, Section 3.3.1, Table 3-11).

Well ID: PW-1; PW-2

Level of Contamination (I, II, or potential): I

Nearest Well Factor Value: 50
(Ref. 1, Table 3-11)

3.3.2 POPULATION

3.3.2.1 Level of Contamination

3.3.2.2 Level I Concentrations

Level I Population Targets

The total population served by the Millsboro Water Department is approximately 3,825 persons. Of the three public wells, no one well supplies greater than 40 percent of the total water supply after the water is blended. Therefore, the population served by each well is 1,275 persons (Ref. 34; Ref. 49; Ref. 1, Section 3.3.2). The Level I wells are documented in Tables 7 and 10. Table 11 summarizes the Level I population affected by each public supply well completed in the Columbia aquifer.

**TABLE 11
LEVEL I POPULATION**

Level I Well	Aquifer No. 1	Population	References
PW-1	Unconfined or Columbia	1,275	34; 49
PW-2	Unconfined or Columbia	1,275	34; 49

Sum of Population Served by Level I Wells: 2,550

Sum of Population Served by Level I Wells x 10: 25,500 (Ref. 1, Section 3.3.2.2).

Level I Concentrations Factor Value: 25,500

3.3.2.3 Level II Concentrations

Not scored.

3.3.2.4 Potential Contamination

Not scored.