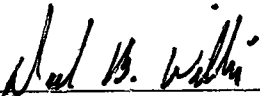


ARCADIS



Dave Willis
South Carolina P.G. #508

**Work Plan to Evaluate
Groundwater Quality at Area
#2, Brenntag Southeast
Charleston Facility**

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Brenntag Southeast

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Protection Division

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Introduction

Brenntag Southeast, Inc. (Brenntag) retained ARCADIS G&M (ARCADIS) to prepare a work plan to evaluate groundwater quality at Area #2 of the Brenntag Charleston, South Carolina facility. The location of the Brenntag facility is shown on Figure 1. Brenntag has entered into a consent agreement with the South Carolina Department of Health and Environmental Control (DHEC) to clean up impacted groundwater at the Brenntag facility in Charleston, South Carolina. Previous investigations identified two areas of impacted groundwater, Area #1 and Area #2. The DHEC has approved a groundwater remedial strategy for Area #1. This report recommends further investigation to determine an appropriate remedial strategy for Area #2.

Background

Burriss Chemical Co. Investigations

Burriss Chemical Company previously operated a chemical warehouse and distribution facility at this facility. Burriss Chemical initiated a groundwater investigation at this facility in 1990. Three phases of groundwater and soil investigations (GEL, 1991a; GEL, 1991b; GEL, 1992) included installation of Monitor Wells MW-1 through MW-9 and identified two primary areas of concern; 1) a former solvent storage area where small spills from solvent handling washed from a concrete pad to nearby soil (Area #1) and 2) a tank farm where there were documented spills (Area #2). The Area #1 solvent storage area and Area #2 tank farm are shown on Figure 2. Burriss Chemical submitted a fourth phase of investigation results with closely spaced temporary borings in Area #1 and Area #2 (Muthig, 1993). Groundwater quality analyses in 1993 showed more elevated VOCs at Area #1 (96.413 mg/L at Monitor Well MW-7 vs. 11.034 mg/L at MW-9), therefore Burriss Chemical initiated groundwater remediation activities at Area #1 first.

The 1993 investigation included a recommendation to install a combination air sparging and soil vapor extraction (AS/SVE) system downgradient of Area #1 to remediate groundwater in this area. Burriss Chemical Company installed the AS/SVE system in downgradient of Area #1 in 1994. Burriss Chemical Company sold part of the facility to Brenntag (formerly SouthChem Corporation) and the remainder of the property to the Bird Furniture Company in 1996. Brenntag continued to operate the AS/SVE system at Area #1 after they purchased a portion of the property. Burriss Chemical Company retained responsibility for environmental concerns on the Bird Furniture Company parcel.

Burris Chemical Company installed Monitor Wells MW-10 through MW-12 on the Bird Furniture Company property in 1997. The current monitor well network at the two facilities is shown as Figure 3. Brenntag included groundwater analyses from these off-site monitor wells on the adjacent downgradient property in the first semi-annual 2001 sampling report. The first semi-annual 2001 sampling event (March, 2001) detected free product or non-aqueous phase liquid (napl) from Monitor Well MW-12. Analysis of the napl reported mineral spirits (13,000 mg/L), dichlorobenzene (16,000 mg/L), ethylbenzene (53,000 mg/L), toluene (150,000 mg/L), trichloroethene (16,000 mg/L), and xylenes (310,000 mg/L) (ARCADIS, 2001). Burris Chemical pursued recovery of the napl without Brenntag involvement.

Brenntag Investigations

Brenntag submitted quarterly reports of groundwater quality to the DHEC after purchasing part of the Burris Chemical Co. property. Brenntag pursued further delineation of VOCs in soil and groundwater at Area #1 and Area #2 in 1998 with temporary borings in both areas (Groundwater Solutions Inc., 1999). The DHEC entered into a consent agreement with Brenntag in 2000 to remediate groundwater at the Brenntag Charleston facility (Ramos to Biehl, October 12, 2000).

Brenntag submitted a work plan to evaluate effectiveness of the AS/SVE system (Willis to Forrest, December 21, 2000). The DHEC approved a pilot test to evaluate anaerobic biodegradation of the VOCs at Area #1 (Forrest to Willis, January 18, 2001). Brenntag installed Monitor Well MW-13 downgradient of the AS/SVE system as part of the pilot test and temporarily shut down the AS/SVE system on September 20, 2001. The results of the pilot test suggested that the AS/SVE system was suppressing anaerobic biodegradation of the VOCs through forced aeration of the aquifer (ARCADIS, 2002). The DHEC approved continued cessation of AS/SVE system operation and continued monitoring of Area #1 (Forrest to Biehl, November 5, 2002). VOCs have significantly decreased downgradient of Area #1 since the AS/SVE system was turned off.

Local Hydrogeology of Area #2

Shallow Stratigraphy

The shallow stratigraphy in the Charleston area is composed of unconsolidated sands and clays overlying the Cooper Marl. The top of the Oligocene age Cooper Marl is approximately 15 to 18 feet deep at the Brenntag facility. The Copper Marl is a hard

silty clay unit approximately 180 feet thick in the Charleston area (Colquhoun et al, 1977). The Cooper Marl is homogeneous with very low transmissivity such that tunnels are commonly constructed through this unit without liners (Gibson, 1942). Only the shallow sediments above the Cooper Marl will be further investigated due to the excellent confining nature of this unit.

The stratigraphy of the shallow sediments at the Brenntag facility over the Cooper Marl is typical of late Pleistocene to Holocene age tidally influenced estuarine deposits (Hayes and Kana, 1977; Reineck and Singh, 1975). The sediments are dominated by partially preserved channel bar sequences composed of unconsolidated sand units with minor amounts of interstitial clay. Interbedded fine sand beds with thin clay beds represent the lower energy subtidal to intertidal flats. Tidal channel migration scoured previously deposited sand bars and resulted in limited lateral continuity of individual beds.

A previous investigation of Area #2 included closely spaced temporary borings through the shallow sediments to the top of the Cooper Marl (Groundwater Solutions Inc., 1999). The investigation included a series of temporary borings on Brenntag property (SCGP borings) and on Bird Furniture Company property (BESGP borings), shown on Figure 4.

Figure 5 is a cross section through Area #2. Note that a medium grain sand unit extends laterally throughout Area #2. The medium sand unit overlies a fine sand unit with interbedded clays and is beneath a fine sand unit. Based on the lithologic descriptions, the medium sand unit is considered the most transmissive unit in the shallow sediments.

Figure 6 is an isopach map of the medium sand thickness in the shallow sediments. Note that the medium sand unit extends under the former AREA #2 tank farm to Monitor Well MW-12. Limited medium grain sand downgradient of MW-12 (one foot at temporary boring BESGP-2) suggests that the massive medium grain sand unit may terminate downgradient of MW-12.

Contaminant Hydrogeology

Groundwater Flow Direction

Figure 7 shows the potentiometric surface of the shallow aquifer based on March, 2001 water level elevations, which is the most recent sampling event when water levels were

measured in all monitor wells on both properties. Groundwater flow in the shallow aquifer system mimics topography. Surface drainage and shallow groundwater flow to Brickyard Creek to the west of the two properties. Brickyard Creek probably is a groundwater discharge boundary for the shallow groundwater as there are no other nearby streams. The groundwater flow direction in the shallow aquifer suggests that Monitor Well MW-5 is downgradient of MW-12. The fate of impacted groundwater at MW-12 should be monitored by MW-5.

Distribution of VOCs in Groundwater at Area #2

There are no Brenntag monitor wells at Area #2. However, in 1998 Groundwater Solutions Inc. installed closely spaced temporary borings and collected soil vapor concentrations with an organic vapor analyzer from discrete soil samples (both unsaturated and saturated) of temporary borings. Figure 8 shows the most elevated soil vapors in each boring. Soil vapors closely match the lateral distribution of the medium sand unit (compare Figure 8 to Figure 6). These data suggest that the medium sand unit captured the majority of released organic compounds from the former Area #2 tank farm.

Selected temporary borings (BESGP-3, SCGP-9) show increasing soil vapors at the bottom of the temporary borings but most temporary borings show the maximum soil vapors within the medium sand unit close to the water table. These data suggest that the napl is less dense than water and remained at the water table. The soil vapor data suggest that the medium grain sand unit captured the bulk of released products from the former tank farm.

Groundwater Quality Trends at Area #2

The significantly impacted groundwater at Area #2 appears limited to the medium grain sand unit. Table 1 includes groundwater analyses from monitor wells downgradient of Area #2 including wells MW-4, MW-9, MW-10, and MW-12 (to year 2001 from Bird Furniture wells) and from MW-5 (to year 2003 from the Brenntag well). Figure 9 shows groundwater quality trends at Area #2 (MW-12 and MW-9). Groundwater analyses at MW-12 show elevated levels of dissolved VOCs (54.095 mg/L of total VOCs in 1998 analyses) prior to discovery of napl in March, 2001. However, groundwater is significantly less impacted laterally at MW-9 (all VOCs <0.010 mg/L in 2001 analyses) and MW-10 (0.195 mg/L of total VOCs in 2001 analyses). The distribution of dissolved VOCs in groundwater suggests that the bulk of the napl release was to the medium grain sand.

Groundwater Quality Trends Downgradient of Area #2

Groundwater quality trends downgradient of Area #2 show decreasing VOC impacts to water and suggest an older release that is getting smaller. Figure 10 shows the trends of total dissolved VOCs in groundwater in Bird Furniture monitor wells until March, 2001. Total VOCs have decreased in all monitor wells downgradient of MW-12 (MW-4, MW-5, and MW-10). Although napl was detected at MW-12 in 2001 analyses, total VOCs attenuate in MW-4 and MW-10 analyses (total VOCs of 0.124 mg/L and 0.195 mg/L respectively) downgradient of MW-12. Low chlorobenzenes and benzene were detected in MW-4 and MW-10 2001 analyses (total VOCs of 0.124 mg/L and 0.195 mg/L respectively) but all VOCs have been non-detect at MW-5 since 1999. The decreasing VOC concentrations in all monitor wells downgradient of MW-12 suggest that the area of impacted groundwater is decreasing.

Brenntag also collects surface water samples for VOC analysis on a semi-annual basis from sampling locations SW-1, SW-2 and SW-3. All VOC analyses at the three surface water sampling locations have always been below detection limits. Table 2 summarizes the non-detect analyses for specific VOCs of concern in surface water.

Scope of Work

The groundwater and soil quality data at Area #2 suggest an older release with limited free product at MW-12 and decreasing impacts to groundwater. ARCADIS recommends two investigation goals for AREA #2 at the Brenntag facility as follows:

- determine if there is napl (mobile free product) remaining on Brenntag property in Area #2.
- verify that impacts to Area #2 groundwater will continue to decrease.

There should be no unacceptable risks to human health from Brenntag property if there is no additional napl on Brenntag property and the impacted groundwater continues to decrease.

Investigation Tasks

New Monitor Well

Burriss Chemical Co. has detected napl on the Bird Furniture Co. at Monitor Well MW-12. The extent of napl is unknown but may be related to the distribution of the medium grain sand unit, which appears to be thickest (12 feet) at this well and may terminate downgradient of MW-12. The napl may be related to a low water table elevation caused by a recent drought. There may not be mobile napl at normally higher water table elevations.

ARCADIS does not recommend a temporary boring investigation here to further delineate the extent of napl. Temporary borings can estimate impacts to groundwater and soil and the data can be utilized with grain size estimates to speculate on mobile napl, but temporary borings are not able to actually measure mobile napl in aquifers.

ARCADIS recommends an additional monitor well in the thickest portion of the medium grain sand on Brenntag property upgradient of the known area of mobile napl. Figure 11 shows the location of the proposed monitor well. The monitor well will be installed in accordance with specifications included as Appendix A. After development, the new monitor well will be allowed to recover to static conditions, and sampled to determine the presence of mobile napl. If NAPL is present, ARCADIS will conduct a bail-down test in accordance with the technique utilized previously at MW-12 (Muthig to Forrest; June 20, 2001 letter). In the absence of napl, ARCADIS will sample the monitor well by EISOPQAM protocol and submit the water sample to a South Carolina certified laboratory for VOC analysis by SW 846 Method 8260.

Biogeochemical Analyses

Previous groundwater analyses demonstrated that anaerobic biodegradation is the dominant VOC removal mechanism at Area #1 groundwater. Table 3 summarizes the biogeochemical conditions at Area #1 and scores the biodegradation potential by accepted criteria (EPA, 1998). The EPA scoring suggests that Area #1 groundwater conditions are highly supportive of anaerobic biodegradation. The overall score by EPA criteria at Area #1 is 31; the EPA considers that a score of greater than 21 suggests a highly reductive environment.

The relatively elevated cis 1,2-DCE and vinyl chloride in MW-12 groundwater analyses suggest that anaerobic biodegradation is also a component of VOC removal in

the impacted shallow aquifer at Area #2. Also, the added dichlorobenzene isomers and non-chlorinated petroleum components in Area #2 groundwater may be added carbon sources for biodegradation.

Brenntag will collect a set of biogeochemical analyses from representative monitor wells to determine the anaerobic biodegradation mechanisms in shallow groundwater at Area #2. Table 4 recommends specific analytes for biogeochemical analyses. Monitor Well MW-2R will be sampled as the upgradient well, the new monitor well (to be identified as MW-14) will be sampled as the impacted well, and MW-5 will be sampled as the downgradient well. The biogeochemical analyses will be collected in accordance with "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water," (EPA, 1998).

Report

Brenntag will prepare a report with all results of the investigation including the monitor well installation as-built diagram and lithologic log, analytical results from the new monitor well (including free product analyses if present), and biogeochemical results from the three monitor wells. The report will include recommendations for remedial systems (or recommendations for additional investigation tasks if data are insufficient for remedial designs).

Schedule

A schedule to complete the tasks is included as Table 5. This schedule is based on minimal delays due to weather.

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TABLES

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Table 1. Summary of Area #2 Groundwater Analyses
Brenntag Southeast Charleston Facility

Well Number	Date Sampled	1,1-DCE mg/L	c-1,2-DCE mg/L	t-1,2-DCE mg/L	1,2-DCE mg/L	1,1-DCA mg/L	TCE mg/L	PCE mg/L	CB mg/L	CH mg/L	1,2-DB mg/L	1,3-DB mg/L	1,4-DB mg/L	VC mg/L	Total VOCs mg/L	Others mg/L
MW-4	2/6/1991	<0.050	<0.050	<0.050	<0.050	0.063	0.076	<0.050	0.221	<0.050	1.175	0.094	0.322	<0.050	2.620	EB(0.448), T(0.216), X(0.005)
	8/15/1991	<0.050	<0.050	<0.050	<0.050	0.053	0.068	0.060	0.240	<0.050	1.140	0.080	0.255	<0.050	2.195	EB(0.300)
	3/30/1993	0.004	0.011	<0.010	<0.010	0.013	0.016	<0.010	0.105	<0.020	0.649	0.040	0.148	<0.020	1.124	B(0.008), EB(0.133), T(0.012)
	5/18/1995	<0.005	0.004	<0.005	<0.005	0.011	0.010	<0.005	0.177	<0.010	1.070	<0.005	0.256	<0.010	1.604	EB(0.075), T(0.005)
	11/13/1995	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.141	<0.010	0.979	<0.005	0.130	<0.010	1.294	B(0.038)
	5/20/1996	<0.001	<0.001	<0.001	<0.001	0.005	0.007	<0.001	0.087	<0.001	0.475	0.028	0.091	<0.001	0.703	B(0.006), EB(0.005)
	11/14/1996	<0.001	0.003	<0.001	<0.001	0.005	0.002	<0.001	0.169	<0.001	0.401	0.026	0.104	<0.001	0.711	B(0.004)
	5/8/1997	<0.001	0.003	<0.001	<0.001	0.004	0.003	<0.001	0.128	<0.001	0.389	0.029	0.103	<0.001	0.656	B(0.002)
	11/26/1997	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	0.042	<0.010	0.067	0.007	0.024	<0.010	0.141	
	6/19/1998	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	0.119	<0.010	0.014	<0.005	0.025	<0.0079	0.260	B(0.103)
	11/30/1998	<0.005	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	0.066	<0.010	0.005	0.013	0.012	0.009	0.148	B(0.032), EB(0.010)
	5/15/1999	<0.005	0.061	<0.005	<0.005	<0.005	<0.005	<0.005	0.037	<0.005	<0.005	<0.005	0.006	0.050	0.116	B(0.008), X(0.016)
	12/27/1999	<0.002	0.065	<0.002	<0.002	0.003	<0.002	<0.002	0.041	<0.002	0.005	0.003	0.008	0.018	0.116	B(0.037)
	5/31/2000	<0.001	0.113	<0.001	<0.001	0.001	<0.001	<0.001	0.089	<0.001	<0.001	<0.001	<0.001	<0.001	0.105	B(0.015)
	11/10/2000	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	0.170	<0.005	<0.010	<0.010	0.030	<0.010	0.208	B(0.008)
	3/16/2001	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.100	<0.005	<0.010	<0.010	0.019	<0.010	0.122	B(0.003)
	9/20/2001	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.410	<0.005	<0.010	<0.010	0.023	0.002	0.525	B(0.072), X(0.018)

Table 1. Summary of Area #2 Groundwater Analyses
Brenntag Southeast Charleston Facility

Well Number	Date Sampled	1,1-DCE mg/L	o-1,2-DCE mg/L	p-1,2-DCE mg/L	1,1-DCA mg/L	TCE mg/L	PCE mg/L	CB mg/L	CH mg/L	1,2-DB mg/L	1,3-DB mg/L	1,4-DB mg/L	VC mg/L	Total VOCs mg/L	Others mg/L
MW-5	8/15/1991	<0.002		0.002	<0.002	<0.002	<0.002	0.051	<0.002	0.019	<0.002	0.004	0.089	0.171	B(0.004), T(0.003)
	3/30/1993	<0.005	0.096	0.002	<0.005	<0.005	<0.005	0.003	<0.010	0.004	<0.005	<0.005	0.079	0.090	B(0.002)
	5/18/1995	<0.005	0.003	<0.005	<0.005	<0.005	<0.005	0.007	<0.010	0.003	<0.005	<0.005	0.005	0.015	
	11/13/1995	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008	<0.010	<0.005	<0.005	<0.005	<0.010	0.008	
	5/20/1996	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021	<0.001	0.010	<0.001	0.002	0.039	0.073	B(0.001)
	11/14/1996	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.426	0.002	0.271	0.015	0.062	0.062	0.878	B(0.017), EB(0.004), T(0.004), X(0.014)
	5/8/1997	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	
	11/26/1997	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	0.016	<0.005	<0.010	0.016	
	6/19/1998	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013	<0.010	<0.005	<0.005	<0.005	<0.002	0.013	
	11/30/1998	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.011	<0.010	<0.005	<0.005	<0.005	<0.002	0.011	
	5/15/1999	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.002	0.000	
	12/27/1999	<0.002	0.011	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	
	5/31/2000	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.000	
	11/10/2000	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	0.000	
	3/16/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	0.000	
	9/20/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.002	0.000	
	2/25/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.002	0.000	
	9/30/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.002	0.000	
	3/17/2003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.002	0.000	

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Table 1. Summary of Area #2 Groundwater Analyses
Brenntag Southeast Charleston Facility

Well Number	Date Sampled	1,1-DCE	c-1,2-DCE	t-1,2-DCE	1,2-DCE	1,1-DCA	TCE	PCE	CB	CH	1,2-DB	1,3-DB	1,4-DB	VC	Total VOCs	Others
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MW-9	3/30/1993	<0.1	0.290	<0.1	<0.1	0.124	<0.1	0.326	<0.2	0.035	<0.1	<0.1	<0.1	<0.2	11.034	B(0.402), EB(0.867), T(3.83), X(5.16)
	5/18/1995	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	<0.005	<0.005	<0.005	<0.010	0.000	
	8/15/1995	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	<0.002	0.000	
	11/13/1995	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	<0.005	<0.005	<0.005	<0.010	0.000	
	5/20/1996	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.050	B(0.007), EB(0.008), X(0.031)
	11/14/1996	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.020	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.031	B(0.010)
	5/8/1997	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	B(0.001)
	11/26/1997	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	<0.005	<0.005	<0.005	<0.010	0.000	
	6/19/1998	<0.005	0.087	<0.005	0.023	0.015	<0.005	0.149	<0.010	0.007	<0.005	0.006	0.006	<0.002	1.260	B(0.248), EB(0.116), T(0.221), X(0.388)
	11/30/1998	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.122	<0.010	0.019	<0.005	0.010	0.010	<0.002	3.681	B(0.321), EB(0.386), T(0.937), X(1.88)
	5/15/1999	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.002	0.000	
	12/27/1999	<0.002	<0.002	<0.002	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	BB(0.003)
	5/31/2000	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.303	B(0.086), EB(0.018), T(0.0013), x(0.125)
	11/10/2000	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.027	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	0.043	B(0.016)
	3/16/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	0.000	
	9/20/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.002	0.000	
MW-10	8/26/1997	<0.002	0.034	<0.002	<0.002	<0.002	<0.002	0.052	<0.002	0.066	<0.010	0.017	0.017	0.107	0.302	
	3/16/2001	<0.002	0.030	<0.002	<0.002	<0.002	<0.002	0.040	<0.005	0.055	<0.010	0.021	0.021	0.018	0.174	
	9/20/2001	<0.002	0.038	<0.002	<0.002	<0.002	<0.002	0.031	<0.005	0.047	<0.010	0.020	0.020	0.024	0.169	
MW-12	8/26/1997	<0.2	8.550	<0.2	<0.2	0.829	0.353	0.374	<0.200	0.775	0.041	0.171	0.171	0.266	11.359	
	11/30/1998	0.039	2.280	0.008	<0.005	1.850	3.170	0.285	<0.010	1.840	0.079	0.103	0.103	0.144	54.126	B(0.490), EB(9.35), T(11), X(23.5)
	3/16/01*	<2000	<2000	<2000	<2000	16000.000	<2000	<10,000	<5000	16000.000	<10,000	<10,000	<10,000	<10,000		H-MIN.SP(13,000), EB(33,000) T(150,000), X(310,000)
	9/20/2001	<0.100	7.400	<0.100	<0.100	6.800	<0.100	<0.500	<0.250	1.600	<0.500	<0.500	<0.500	0.120	148.820	B(1.2), EB(8.7), T(75), X(49)

* analysis of free product at MW-12 on 03/16/01

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Table 2. Summary of Surface Water Analyses
Brentag Southeast, Charleston, South Carolina
(Revised 5/15/03)

Sample Number	Date Sampled	1,1-DCE mg/L	c-1,2-DCE mg/L	t-1,2-DCE mg/L	1,2-DCA, mg/L	1,1-DCA mg/L	TCE mg/L	PCE mg/L	CB mg/L	CH mg/L	VC mg/L
SW-1	11/19/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	12/20/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	1/30/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	2/25/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	9/30/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	3/17/2003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
SW-2	11/19/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	12/20/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	1/30/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	2/25/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	9/30/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	3/17/2003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
SW-3	11/19/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	12/20/2001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	1/30/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	2/25/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	9/30/2002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002
	3/17/2003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.005	<0.002

LIST OF ABBREVIATIONS

Benzene	B	1,1-Dichloroethane	1,1-DCE
Bromobenzene	BB	1,2-Dichloroethane	1,2-DCA
Chlorobenzene	CB	Ethylbenzene	EB
Chloroethane	CH	Hydrocarbons (Mineral Spirits)	H-MIN
Carbon Disulfide	CS ₂	Napthalene	N
Chloromethane	CM	P-Isopropyltoluene	P-IP
1,2-Dichlorobenzene	DB-1,2	Tetrachloroethene	PCE
1,3-Dichlorobenzene	DB-1,3	Trichloroethene	TCE
1,4-Dichlorobenzene	DB-1,4	Trans 1,2-Dichloroethene	trans 1,2-DCE
cis 1,2-Dichloroethene	cis 1,2-DCE	1,2,4-Trimethylbenzene	1,2,4-TMB
1,1-Dichloroethene	1,1-DCE	Toluene	T
1,2,4-Trichlorobenzene	1,2,4-B	Vinyl Chloride	VC
2-Chlorotoluene	2-CHT	Xylenes	X
4-Chlorotoluene	4-CHT		

* Analysis of free product

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Table 3. Summary of Area #1 Groundwater Biogeochemical Analyses.
Brenntag Southeast Charleston Facility

Analytical Parameter	MW-7		Concentration Limit	EPA Score
	September 20, 2001	February 25, 2002		
Carbon Dioxide	160	140	>2xBkgrd	0
Methane	3.5	3.6	>0.5 mg/L	3
Dissolved Oxygen	0.61	0.44	<0.5 mg/L	3
pH	7.5	7	5>pH>9	0
ORP	-195	-188	< -100 mV	2
Temperature	22.3	19.5	>20 C	1
Alkalinity	937	1440	>2xBkgrd	1
Chloride	211	177	>2xBkgrd	2
Sulfate	131	177	<20 mg/L	0
Sulfide	5	2	>1 mg/L	3
Nitrate Nitrogen	BDL	BDL	<1 mg/L	2
Ferrous Iron	3	1	> 1 mg/L	3
Ethane	0.33	0.054	>0.100 mg/L	2
Ethene	1.6	0.3	>0.010 mg/L	3
DCE	46	7.4	present	2
VC	6.3	1.5	present	2
TOC	70	NS	> 20 mg/L	2
			Total	31

G:\AProject\Brenntag Southeast\Presentation\[BiogeochemTable.xls]BioGeoChem Table

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Table 4. Recommended Biogeochemical Analyses for Groundwater
 Brenntag Southeast Charleston Facility
 revised (06/02/03)

Parameter	Analytical Method	Technical Protocol	Method Limit	Holding Time
Nitrite (NO ₂)	Hach Colorimeter	Hach DR/800	0.2 mg/L	immediate
Nitrate (NO ₃)	Hach Colorimeter	Hach DR/800	0.2 mg/L	immediate
Chlorides (Cl)	9250	SW846	0.2 mg/L	28 days
Ferric Iron (Fe ³⁺) and Ferrous Iron (Fe ²⁺)	Hach Colorimeter	Hach DR/800	0.025 mg/L	immediate
TOC (dissolved)	USEPA 9060	SW846	5 mg/L	14 days
Alkalinity	Hach Colorimeter	Hach DR/800	4 mg/L	immediate
Sulfate (SO ₄)	Hach Colorimeter	Hach DR/800	1 mg/L	immediate
Sulfide (S)	Hach Colorimeter	Hach DR/800	2 mg/L	immediate
Carbon Dioxide (CO ₂)	AM20G	N/A	0.6 mg/L	14 days
Methane (CH ₄)	AM20GAX	SW846	0.15 ug/L	14 days
Ethane & Ethene	AM20GAX	SW846	5 ng/L	14 days
Turbidity	NA	YSI 6820 water quality meter	Range: 0-1000 NTU	NA
Conductivity	NA	YSI 600XL or 6820 water quality meter	Range: 0 to 100 mS/cm	NA
Temperature	NA	YSI 600XL or 6820 water quality meter	Range: -5 to +45°C	NA
Dissolved Oxygen (DO)	NA	YSI 600XL or 6820 water quality meter	Range: 0 to 20 mg/L	NA
pH	NA	YSI 600XL or 6820 water quality meter	Range: 0 to 14 standard units	NA
Oxidation-Reduction Potential (ORP)	NA	YSI 600XL or 6820 water quality meter	Range: -999 to +999 mV	NA

Notes:

NA	Not applicable
mg/L	Milligrams per liter
ug/L	Micrograms per liter
ng/L	Nanograms per liter
mV	Millivolts;
mS/cm	Millisiemens per centimeter
°C	Degrees Celsius
NTU	Turbidity units

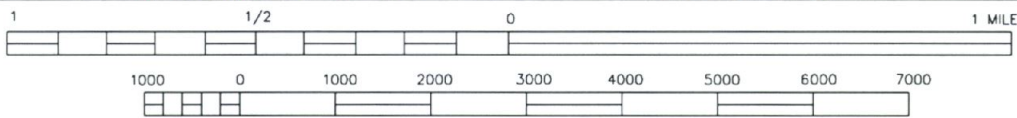
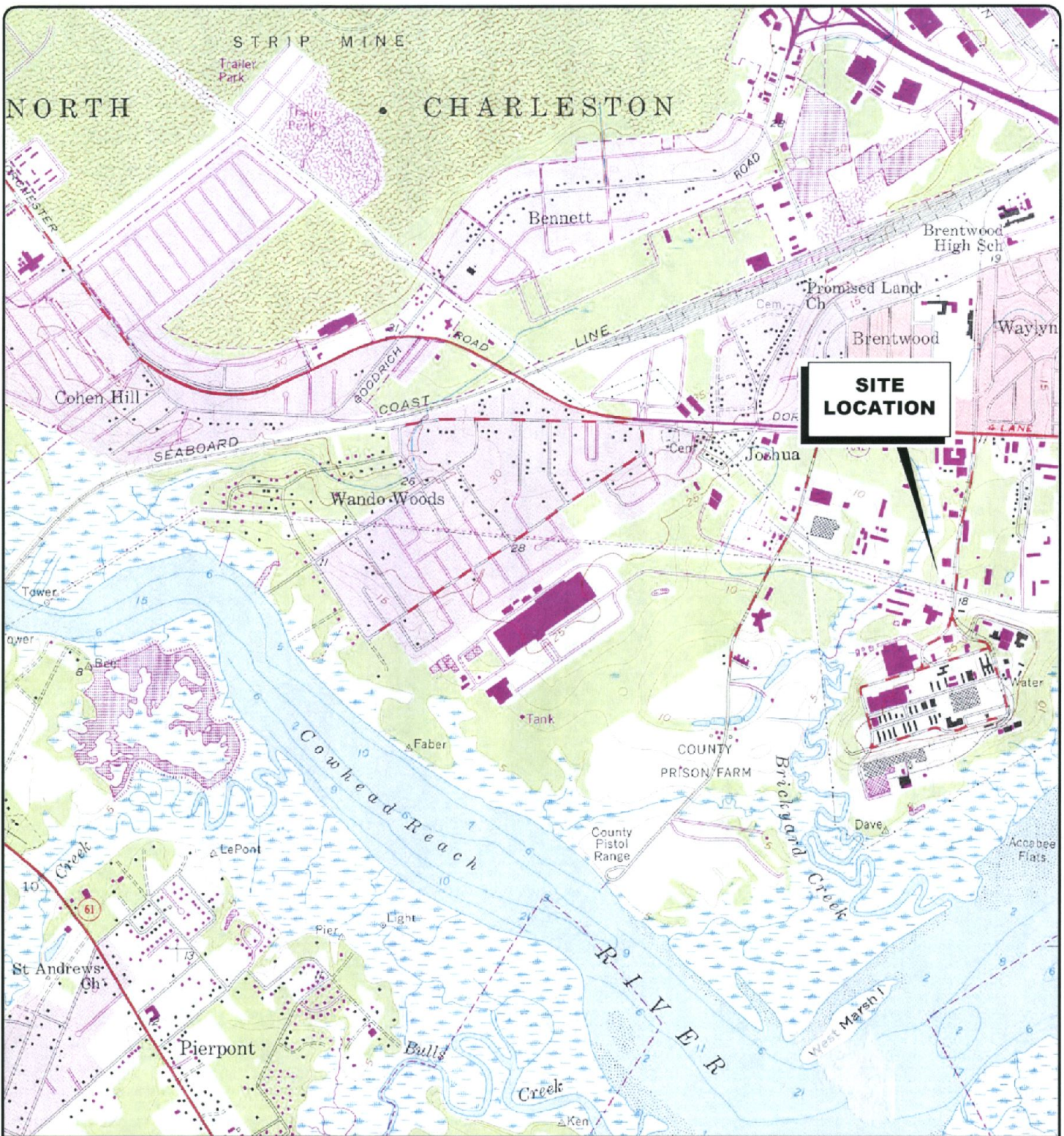
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Table 5. Implementation Schedule
 Brenntag Southeast Charleston facility
 revised (06/04/03)

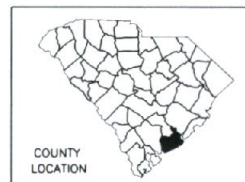
Task	Weeks After Approval to Proceed													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Contract monitor well installation	█	█	█											
Install monitor well				█	█									
Biogeochemical sampling					█	█								
Bail-down test (if free product is in the new well)					█	█								
Laboratory analyses and data validation						█	█	█	█	█				
Report preparation & submittal										█	█	█	█	█

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FIGURES



SCALE 1:24000
 Contour Interval 5 Feet Datum is Mean Sea Level
 Modified from USGS 7.5 Minute
 Johns Island, SC Topographic Quadrangle.



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PRJT MANAGER: T. MCKINSEY	CHECKED BY:
DRAWING: SCTPOD	
PRJT NO: SC000204.0003	
DWG DATE: 30SEPT02	DRAFTER: A. NORTON

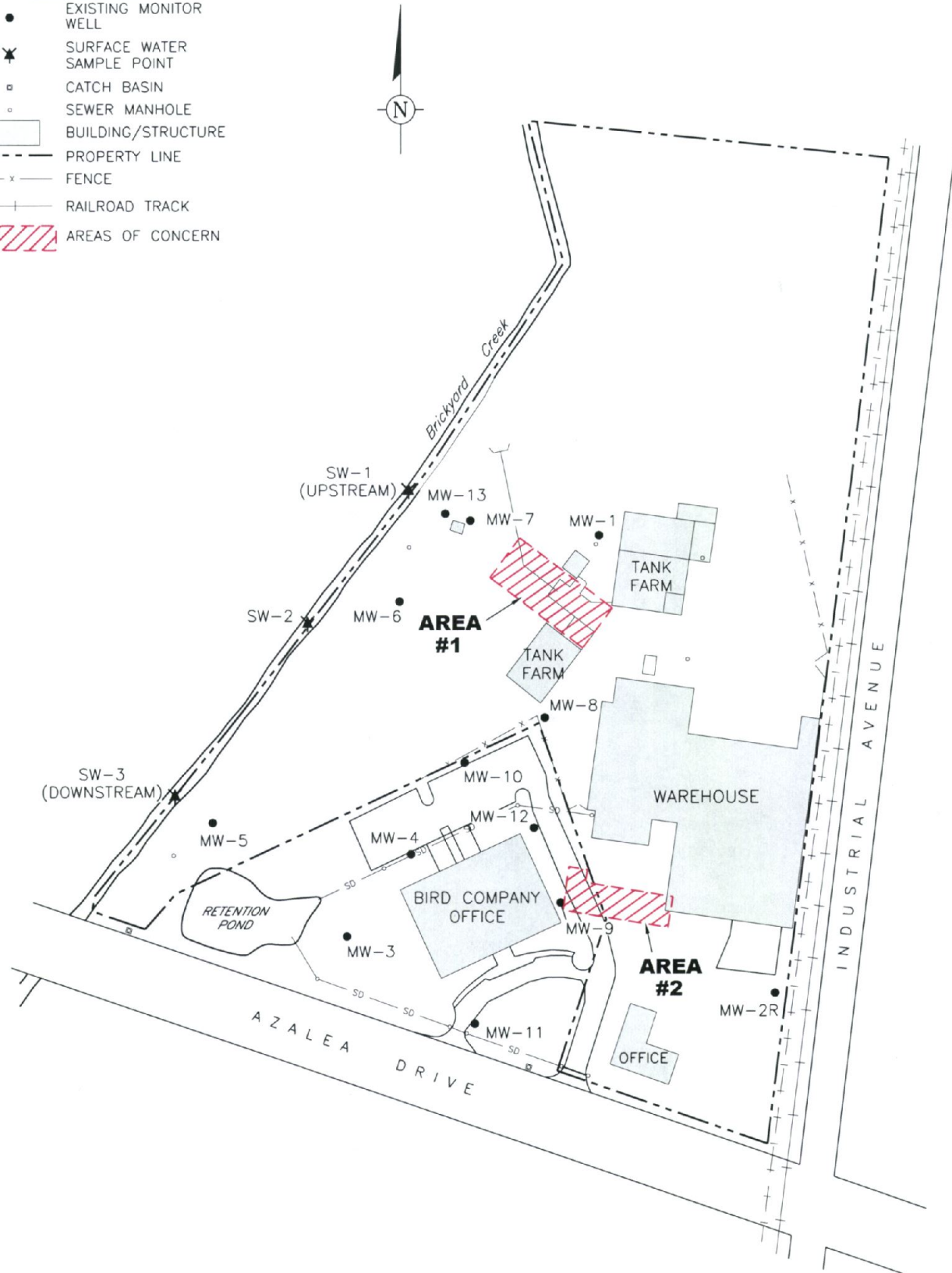
SITE LOCATION
 BRENNTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

FIGURE NO.

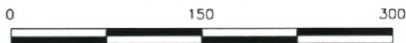
1

LEGEND

- EXISTING MONITOR WELL
- * SURFACE WATER SAMPLE POINT
- CATCH BASIN
- SEWER MANHOLE
- ▭ BUILDING/STRUCTURE
- - - PROPERTY LINE
- x - FENCE
- + RAILROAD TRACK
- ▨ AREAS OF CONCERN



SCALE IN FEET



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PRJT MANAGER: D. WILLIS	CHECKED BY:
DRAWING: ADC	
PRJT NO: SC000204.0005	
DWG DATE: 02JUN03	DRAFTER: A. NORTON

**AREA #1 & AREA #2
 AREAS OF CONCERN**

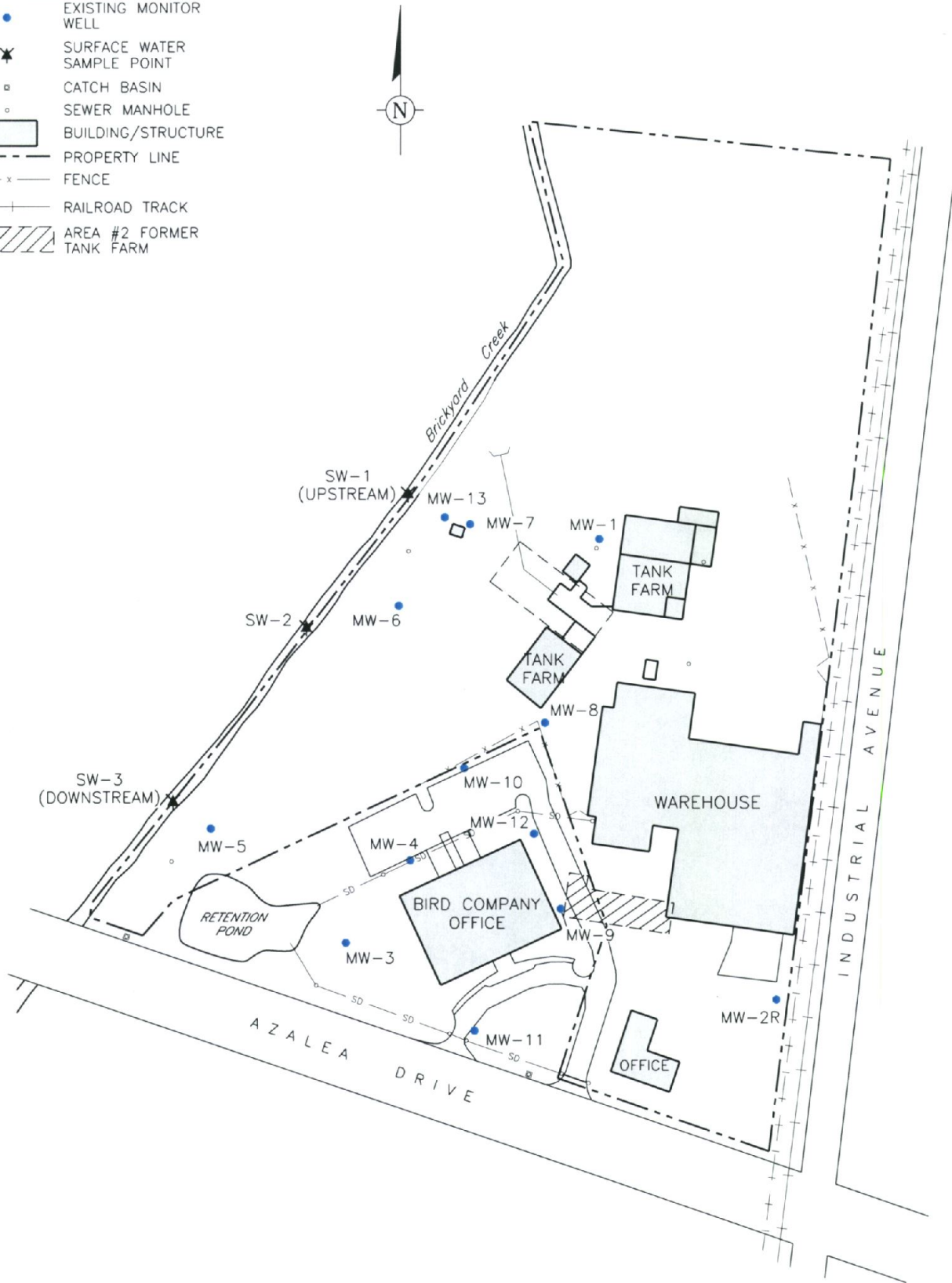
BRENNTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

FIGURE NO.

2

LEGEND

- EXISTING MONITOR WELL
- * SURFACE WATER SAMPLE POINT
- CATCH BASIN
- SEWER MANHOLE
- ▭ BUILDING/STRUCTURE
- - - PROPERTY LINE
- x - FENCE
- +— RAILROAD TRACK
- ▨ AREA #2 FORMER TANK FARM



SCALE IN FEET



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PRJT MANAGER: D. WILLIS	CHECKED BY:
DRAWING: SITE-LAYOUT	
PRJT NO: SC000204.0005	
DWG DATE: 02JUN03	DRAFTER: A. NORTON

**MONITOR WELL SYSTEM
 AT BRENNTAG AND
 BIRD FURNITUR CO.**
 BRENNTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

FIGURE NO.

3

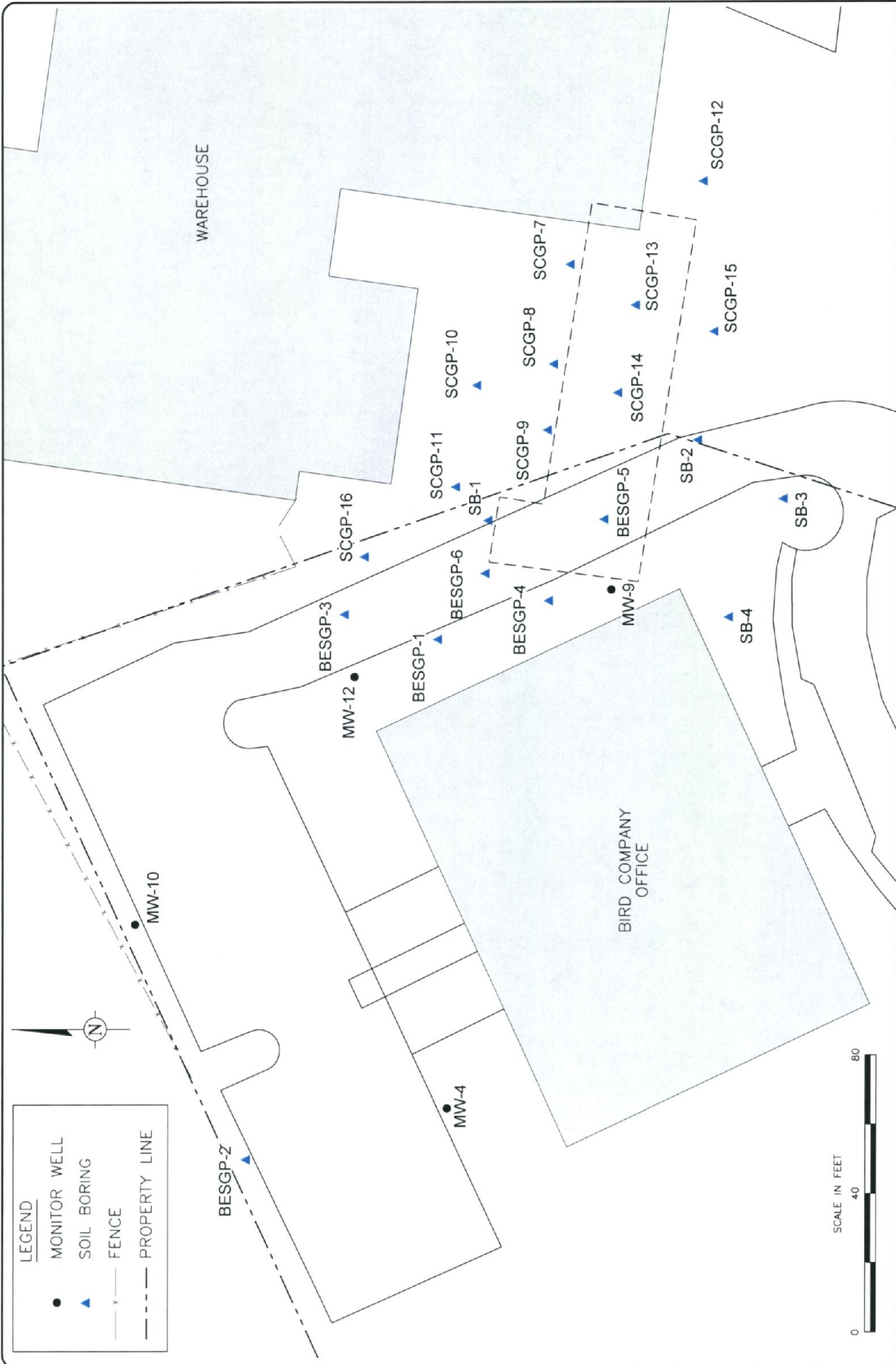


FIGURE: **4**

1998 TEMPORARY BORINGS AT AREA #2
 BRENNTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

PRJ.T MANAGER: D. WILLIS	CHECKED BY:
DRAWING: BSE - SITE -03	
PRJ.T NO: SC000204.0005	
DWG DATE: 02MAY03	DRAFTER: A. NORTON

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A

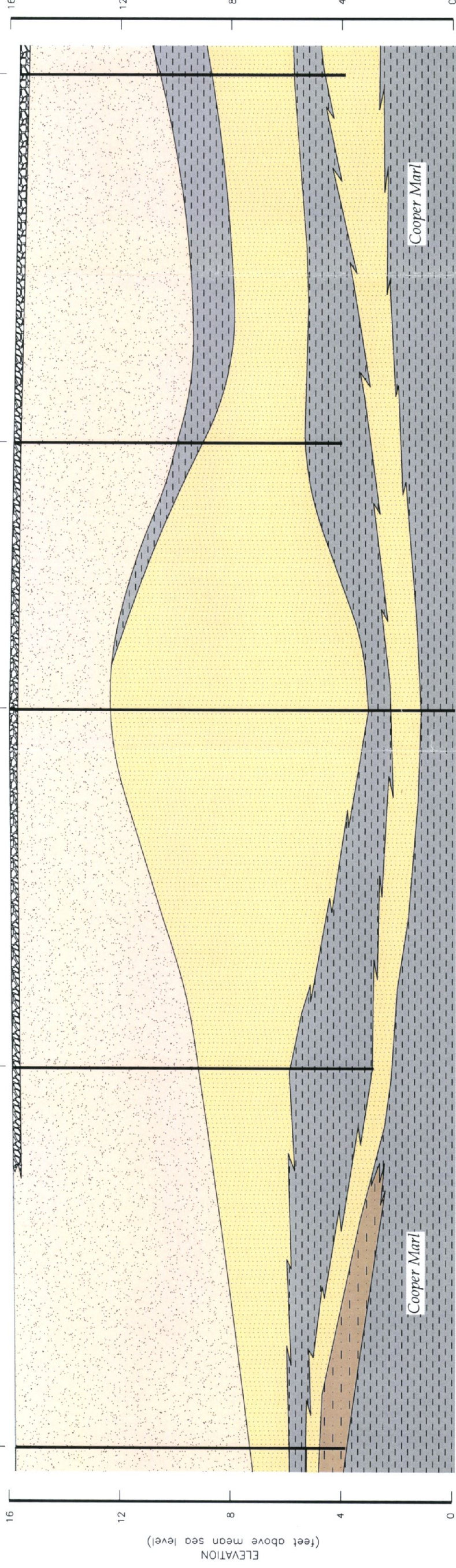
SCGP-16

SCGP-11

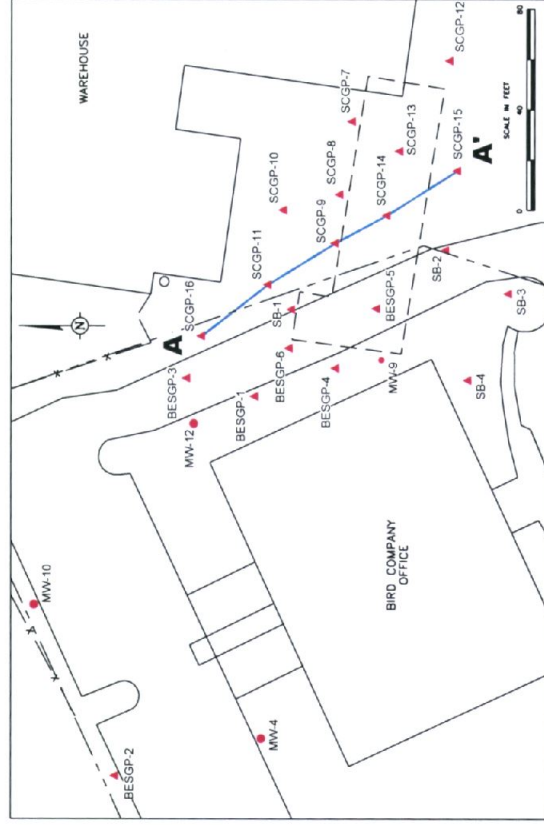
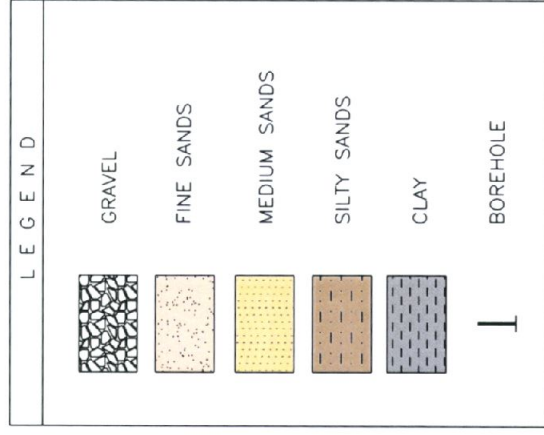
SCGP-9

SCGP-14

SCGP-15



A'



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PRJT MANAGER:
D. WILLIS

CHECKED BY:

DRAFTER:
A. NORTON

PROJECT NUMBER: SC000204.0005

NOTES:

DRAWING:
A-A

BRENNTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

FIGURE:

5

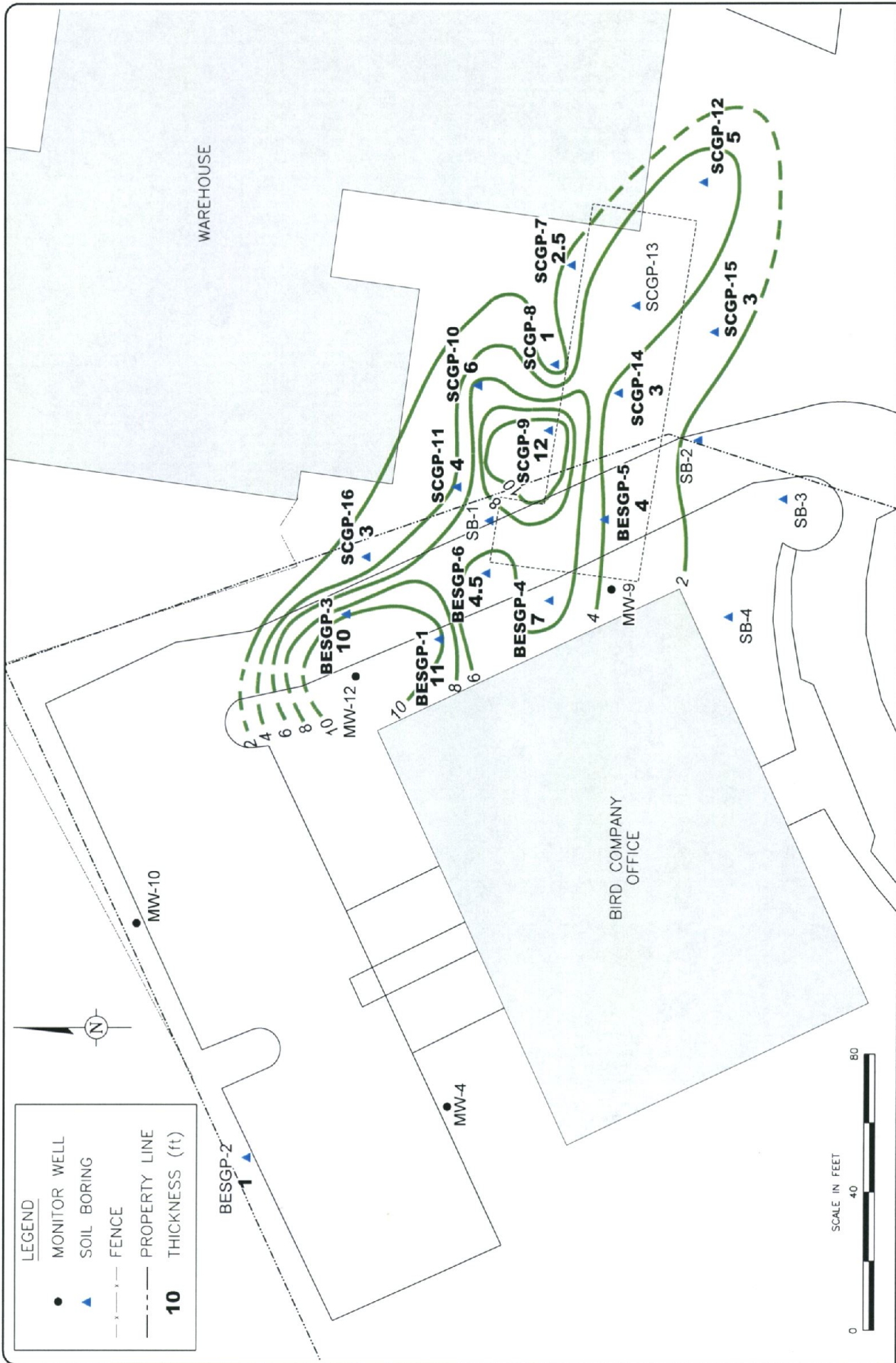


FIGURE: **6**

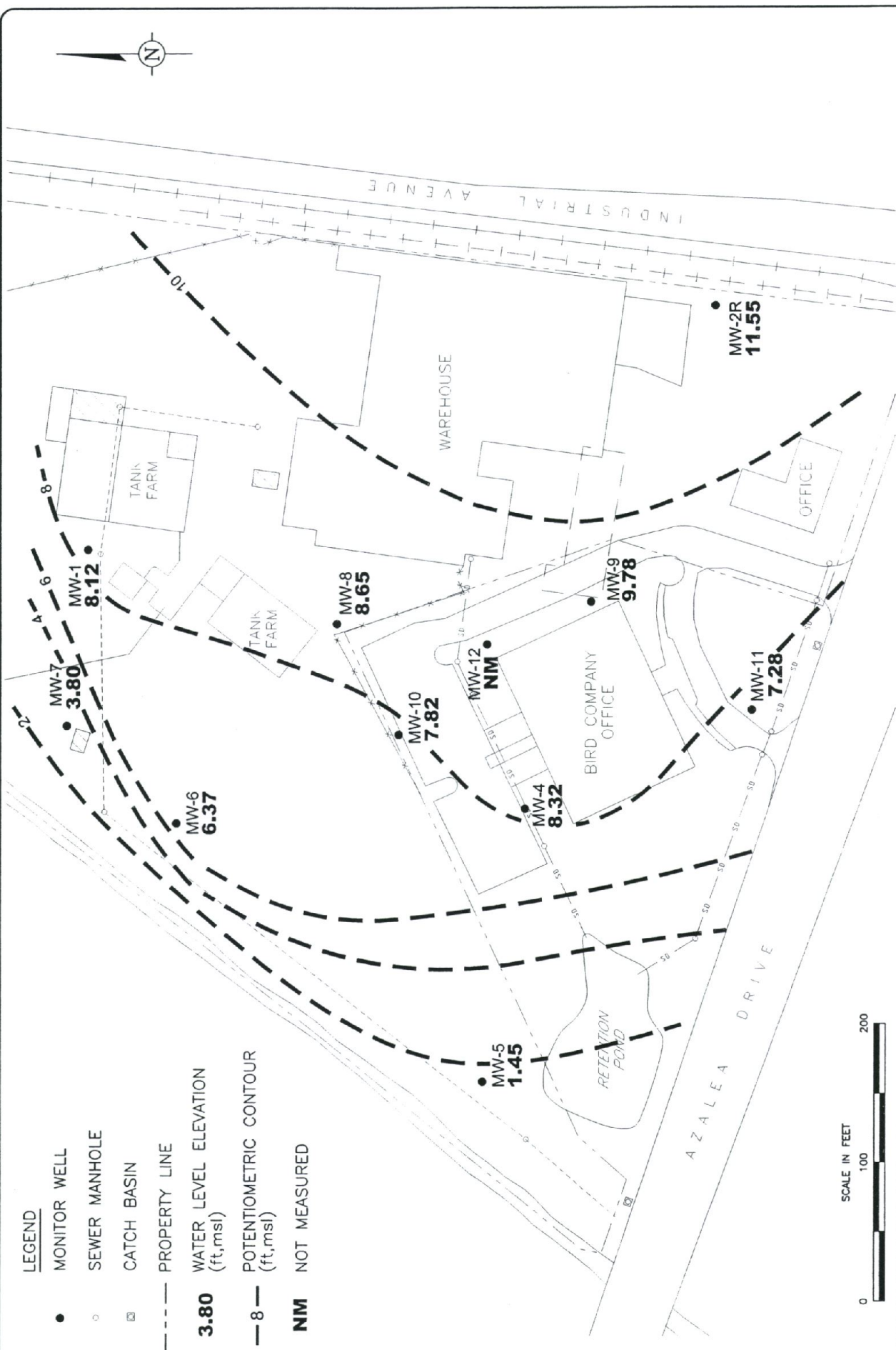
ISOPACH THICKNESS OF MEDIUM GRAIN SAND
 BRENNTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

PRJ.T MANAGER: D. WILLIS	CHECKED BY:
DRAWING: BSE-SITE-03a	
PRJ.T NO: SC000204.0005	DRAFTER: A. NORTON
DWG DATE: 06MAY03	

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LEGEND

- MONITOR WELL
- SEWER MANHOLE
- ☒ CATCH BASIN
- - - PROPERTY LINE
- 3.80** WATER LEVEL ELEVATION (ft,msl)
- - - POTENTIOMETRIC CONTOUR (ft,msl)
- NM** NOT MEASURED



PRJT. MANAGER: D. WILLIS	CHECKED BY: C. LAWSON
DRAWING: PS3-01	
PRJT. NO: SC000204.0005	DRAFTER: A. NORTON
DWG. DATE: 02JUN03	

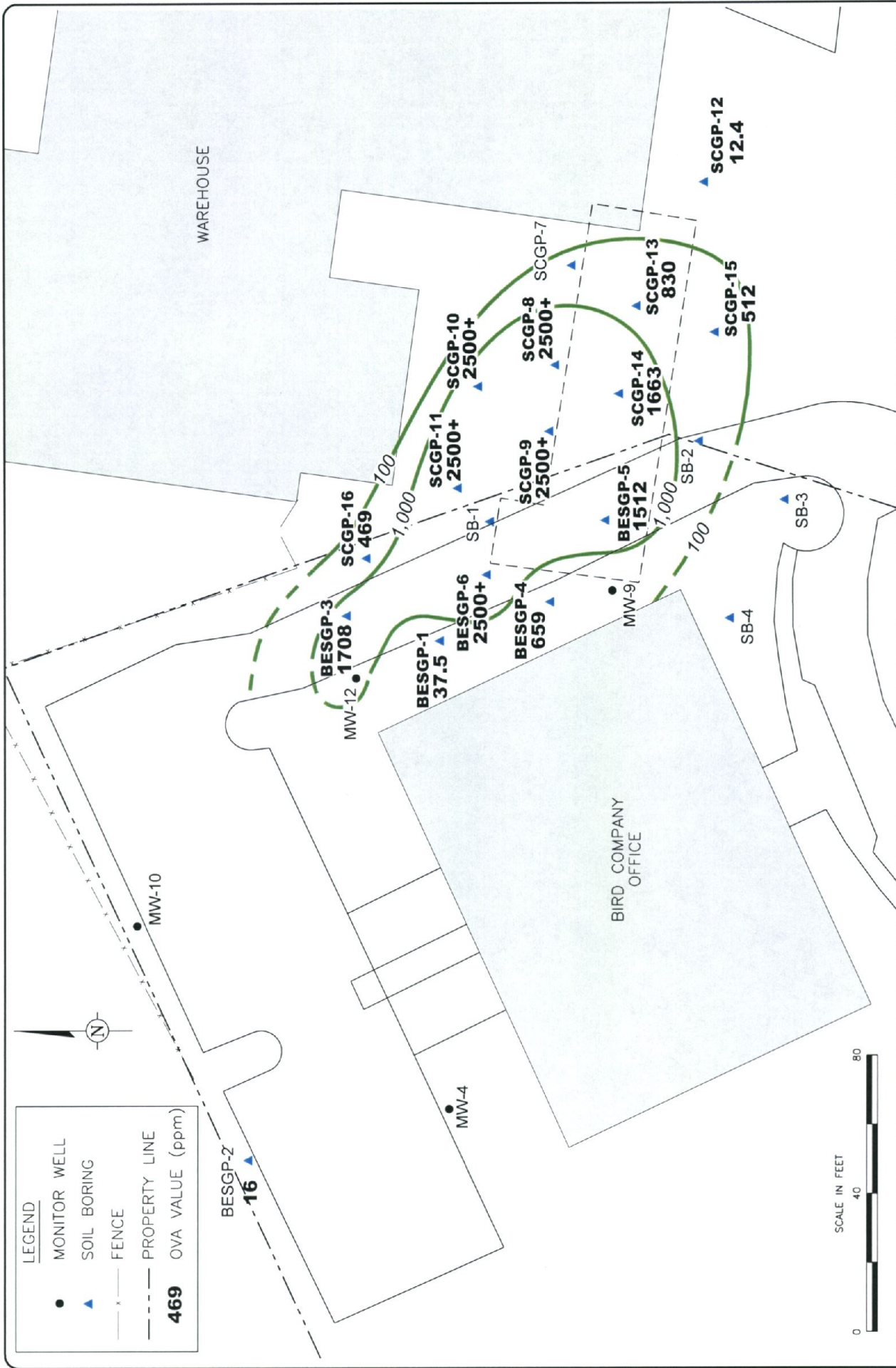


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**POTENTIOMETRIC SURFACE OF THE SHALLOW AQUIFER
 MEASURED MARCH 16, 2001**

BRENTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

FIGURE:



<p>830 Colony Parkway AIKEN, SC 29803 Tel: 803/649-3981 Fax: 803/649-3120</p>	<p>PRJT MANAGER: D. WILLIS</p>	<p>CHECKED BY: D. WILLIS</p>	<p>FIGURE: 8</p>
	<p>DRAWING: BSE-DVA</p>	<p>PRJCT NO: SC000204.0005</p>	
	<p>DWG DATE: 27/MAY/03</p>	<p>DRAFTER: A. NORTON</p>	
	<p>MAXIMUM OVA READINGS AREA #2 TEMPORARY BORINGS</p> <p>BRENTAG SOUTHEAST CHARLESTON, SOUTH CAROLINA</p>		

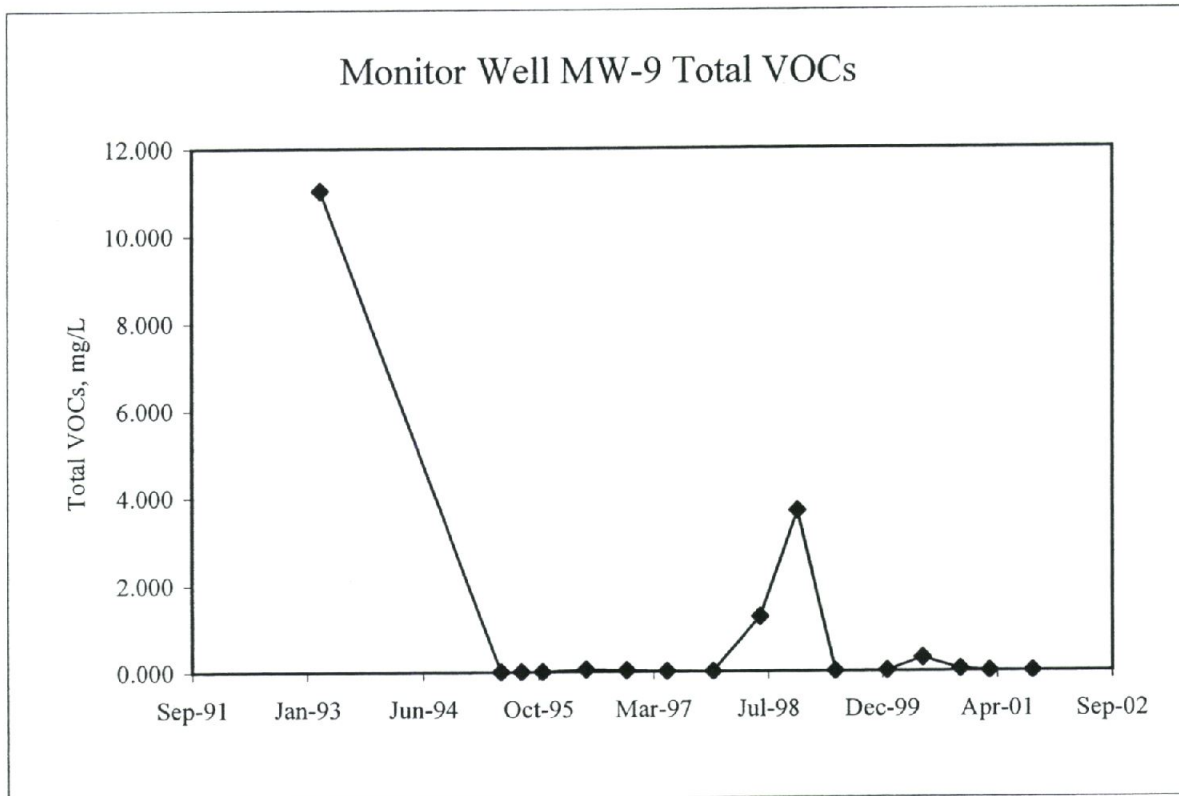
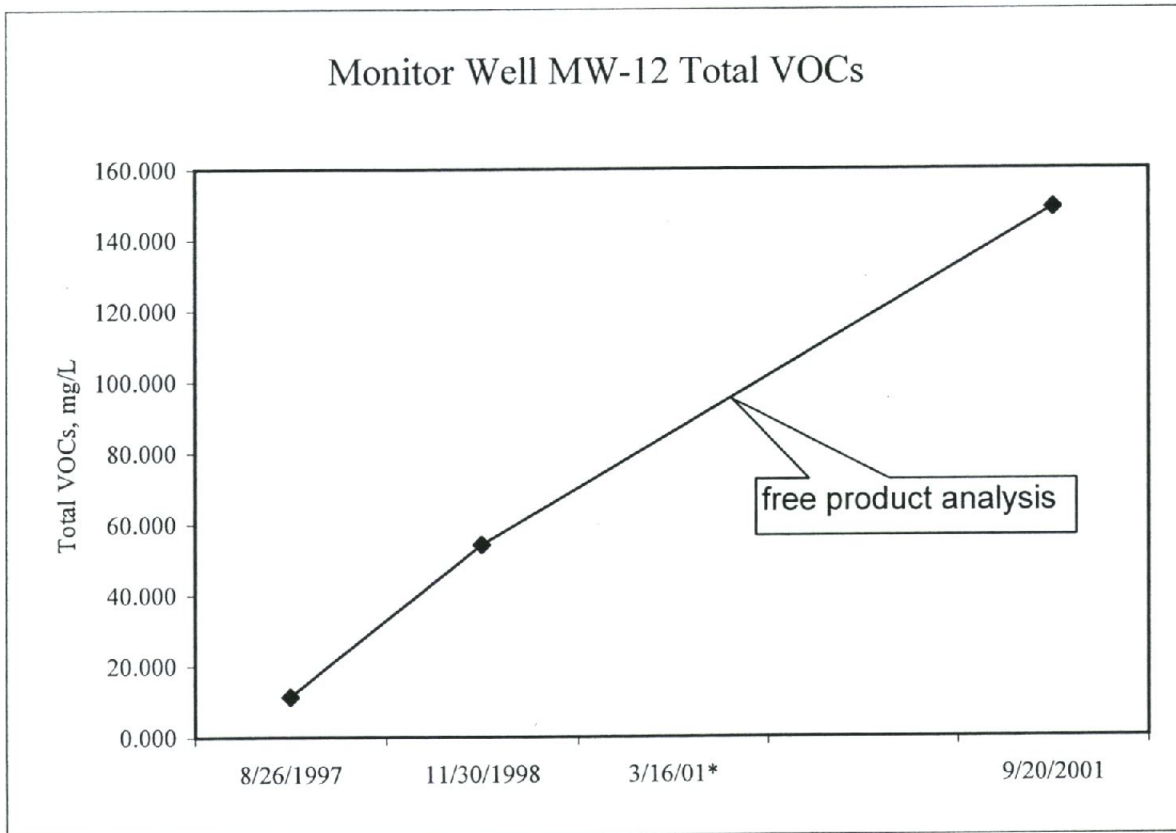


Figure 9. Total VOC Trends at Area #2.

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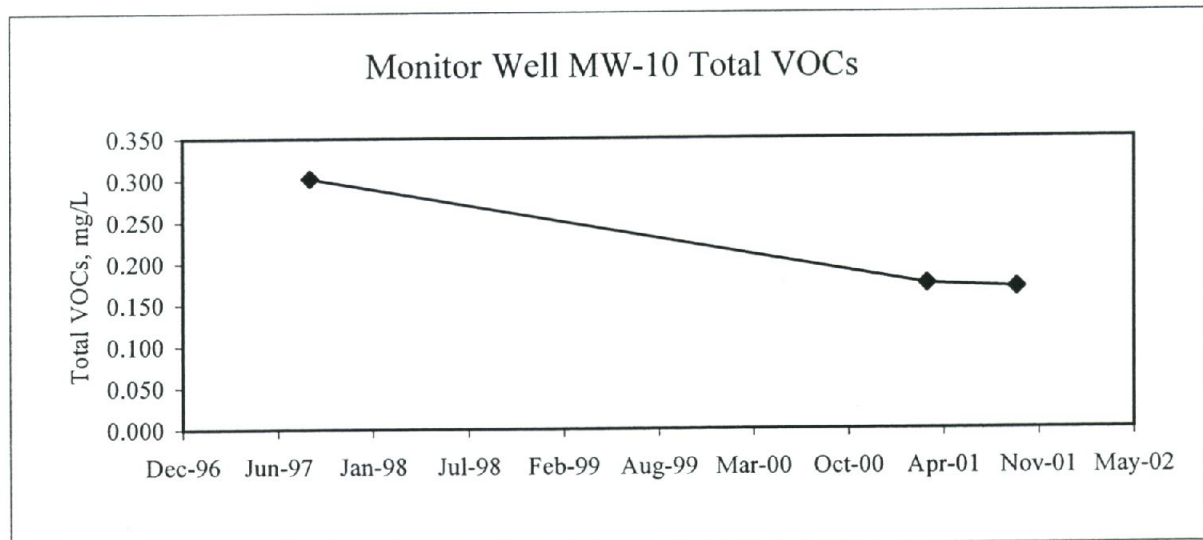
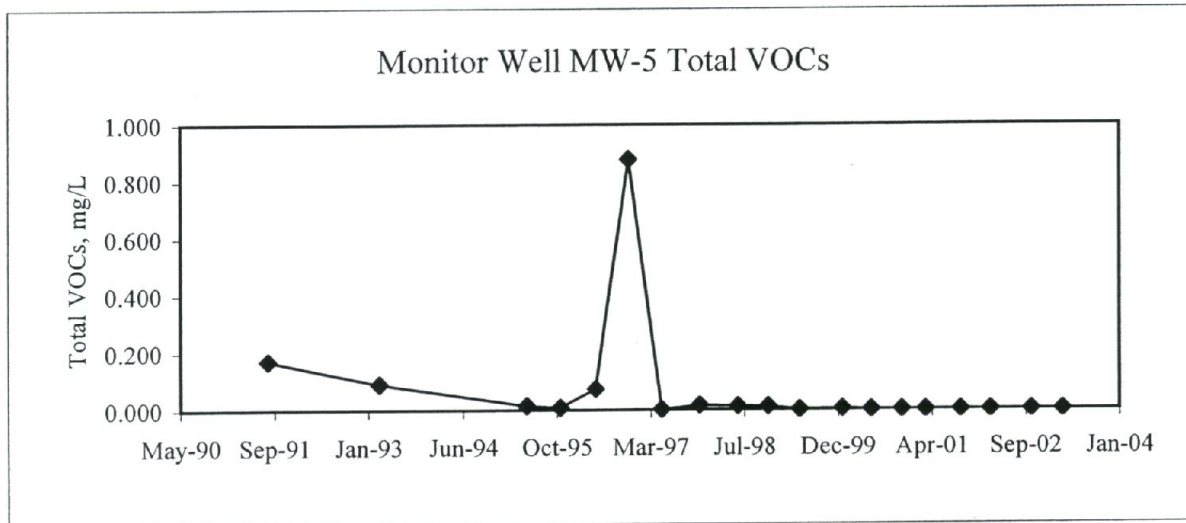
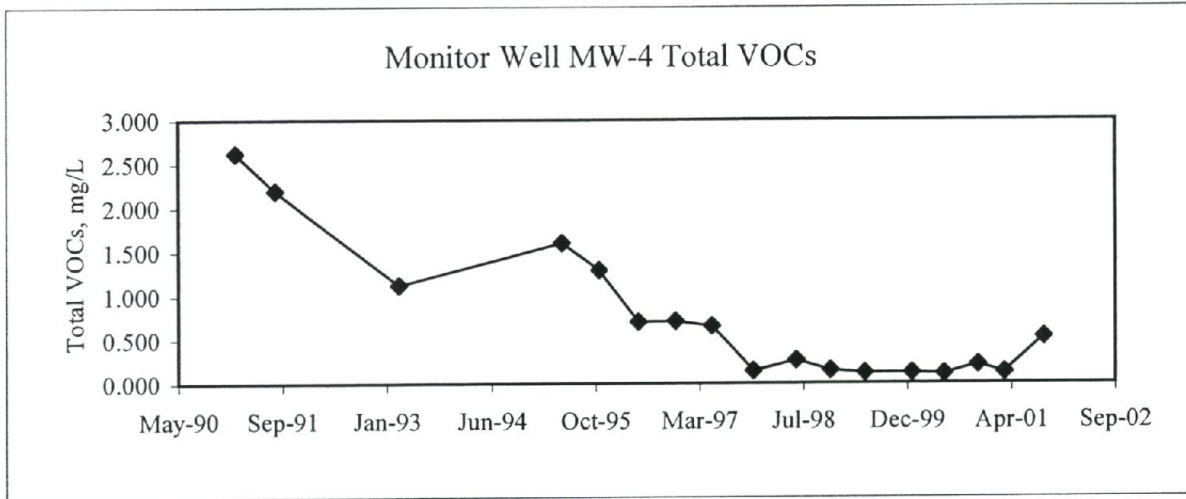


Figure 10. Total VOC Trends Downgradient of Area #2.

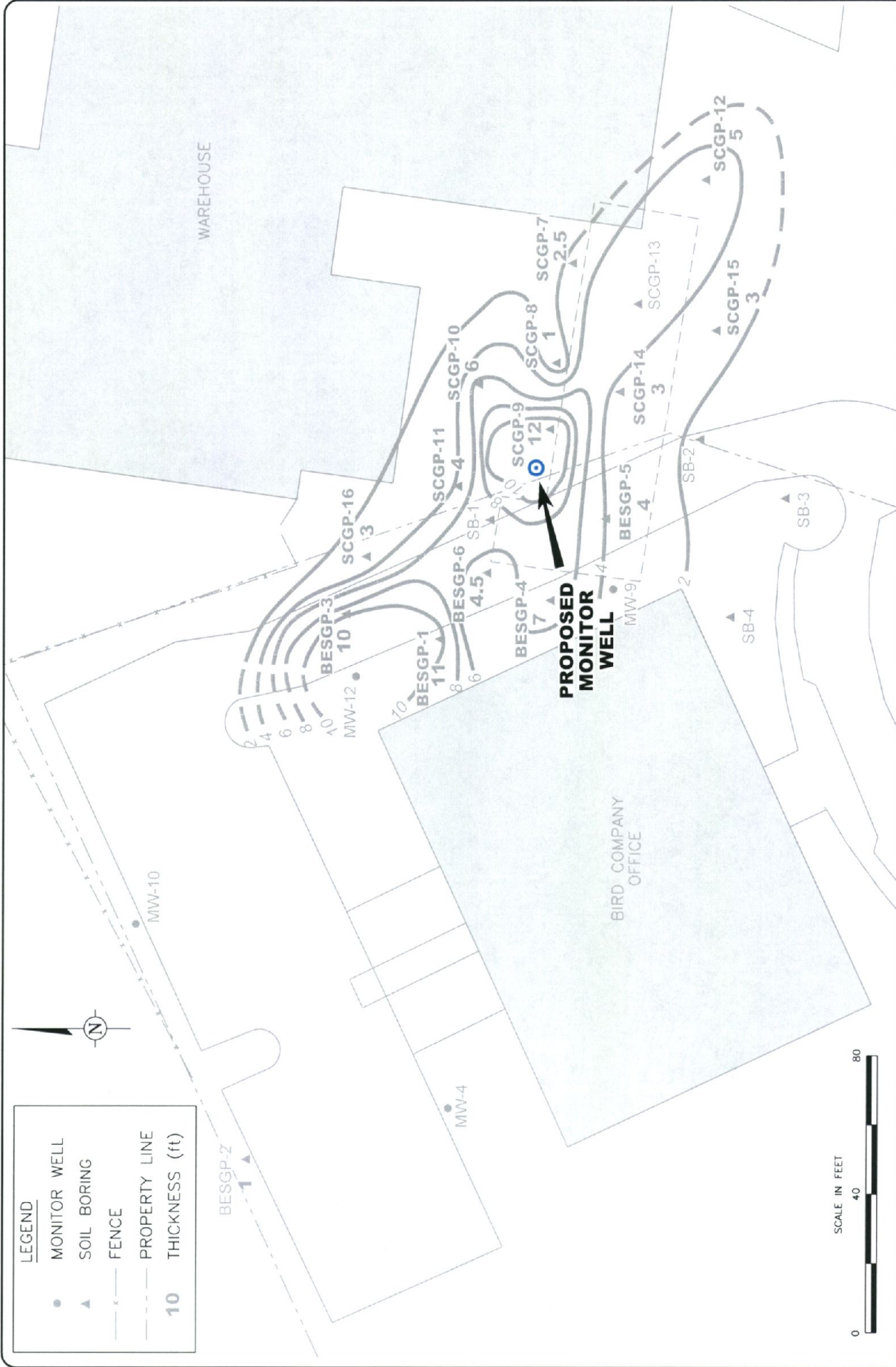


FIGURE: **11**

PROPOSED MONITOR WELL LOCATION

BRENNTAG SOUTHEAST
CHARLESTON, SOUTH CAROLINA

PRJT MANAGER: D. WILLIS	CHECKED BY:
DRAWING: BSE-PMW	
PRJT NO: SC000204.0005	
DWG DATE: 02JUN03	DRAFTER: A. NORTON

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Appendix A
Monitor Well Installation Specifications

**TECHNICAL SPECIFICATIONS
FOR A MONITOR WELL
AT THE
BRENNTAG SOUTHEAST CHARLESTON FACILITY**

1. **SCOPE:** The work consists of the installation of one 2-inch-diameter monitor well in Charleston, South Carolina. The well will be installed using hollow stem augers in a driveway of an industrial facility.
2. **PERSONNEL:** The Driller, in addition to furnishing the services of skilled, experienced, and licensed drillers, shall also furnish an adequate number of experienced, competent helpers. The Drillers shall be capable of keeping good well logs and reports of the drilling, developing, and test-pumping operations as instructed by the Consultant.
3. **HOURS:** Work will be performed not less than 10 hours per day, 5 days per week, nor more than 12 hours per day, 6 days per week. During well completion (casing installation, gravel packing, grouting), work will be performed on an around-the clock basis until the hole is completed unless otherwise instructed by the Consultant.
4. **PERMITS:** South Carolina Department of Health and Environmental Control approval to drill the required wells will be the responsibility of ARCADIS G&M.
5. **CEMENT SPECIFICATIONS:** Cement mixtures will consist of Class A, type 1 Portland cement with 3 percent beneficiated sodium bentonite by volume. The specific mixture to be used will be directed by the Consultant's on-site representative but will generally be as follows: approximately 2 cups of bentonite, 8.5 gallons water per 1 ft³ cement (94 lb sack) producing a slurry volume of about 1.65 ft³/sack and weighing about 13.7 pounds per gallon. The water and required volume of bentonite will be mixed prior to the addition of cement. The cement slurry will be installed by the pressure tremie method from the top of the sand cap to land surface. The tremie pipe will be lowered to about 3 ft above the sand cap for the installation of the cement slurry.
6. **STANDBY TIME:** Payment of standby time will be granted only for delays caused by the Consultant. No standby time will be paid for time incurred during the cementing, gravel packing or well-installation procedures, while the cement is setting up, unusual geologic conditions, delays caused by Driller's error, repairs to equipment, tools stuck in hole nor delays due to inclement weather.
7. **SUPPORT ACTIVITIES:** Electricity will be supplied by the driller. The facility will have nearby sanitary facilities and a source of potable water.
8. **ABANDONMENT OF THE WELL:** Any hole in which the Driller voluntarily stops work, and/or fails to complete in a satisfactory manner, and in accordance with the specifications

and approved changes, shall be considered as abandoned by the Driller. If the Consultant then declares the hole abandoned by the Driller, no payment will be made for the abandoned hole. All abandoned holes shall be properly plugged and sealed by the Driller at his own expense in accordance with state and local regulations. All salvageable material furnished by the Driller may be removed and remain his property. The Driller shall submit a plan of action for abandonment and plugging. Casings may be removed only with the permission and approval of the Consultant. After the hole has been properly abandoned, the Driller shall drill a new hole at a location approved by the Consultant.

9. **PLUMBNESS AND ALIGNMENT:** The casings shall be installed in the well as near to plumb and true as possible in order that a proper cement seal can be placed in the annulus. Deviation from plumb shall not exceed 1 degree. If, in the opinion of the Consultant, it is necessary to straighten the hole, the Driller shall perform the necessary straightening procedure at his own expense.

10. **GUARANTEE:** The Driller guarantees that the work and service to be performed under the Contract and all workmanship, material, and equipment, performed, furnished, used, or installed in the work shall be free from defects and flaws, and shall be performed and furnished in strict accordance with these specifications and contract documents; that the strength of all parts of all manufactured equipment shall be adequate and as specified; and that performance test requirements of the Contract shall be fulfilled. The Driller shall repair, correct, or replace all damage to the work resulting from failures covered by the guarantee.

11. **SAFETY:** The Driller shall be responsible for the safety of the rig and crew on the site at all times. The Driller is responsible for assuring that his personnel are adequately protected against contact hazards and/or hazardous vapors. The Driller will be responsible for all safety regulations promulgated by the State of South Carolina, and the United States Government. The Driller's representative at the site shall be familiar with these regulations and shall take all necessary measures to assure that Driller's personnel comply with same.

The level of protection required at each drilling location should be Level D. This determination is based upon a hazard evaluation of the site and previously documented information. In the event that the personnel protection level is upgraded from Level D to Level C, all subcontractors will provide full-face respirators equipped with an appropriate canister for their own employees from those approved by the National Institute for Occupational Safety and Health under provisions of 30 CFR Part II. All canisters used at Level C personnel protection sites will be disposed of after 4 hours of use and fresh canisters installed prior to work start.

12. **HOUSEKEEPING:** The Driller shall maintain good housekeeping at all times. Facilities and equipment should be kept neat, clean, and orderly. All trash should be contained at each well site and disposed of periodically. At the conclusion of work at each site, the drill cuttings will be cleaned up and the site returned to original grade. Any trash, scrap debris, concrete, etc., shall be removed and disposed of at the appropriate disposal facilities.

13. **SITE CLEANUP:** At the conclusion of work at each site, any trash, scrap, debris, concrete, etc., shall be removed and disposed of at the appropriate disposal site by the Driller before proceeding to other sites.

14. **DEVIATIONS:** All work shall be performed based on these specifications and the scope of work. All items, tasks, and requirements of these specifications and scope of work must be accomplished and/or executed and are subject to the approval of the Consultant. Deviations to these specifications must be approved in writing by the Driller and the Consultant.

15. **DETAILED DESCRIPTION OF WORK:**

A. **Well Construction Design for Monitor Well.**

(1) **Equipment:** All drilling equipment and well material will be thoroughly steam cleaned at the facility before installation of the monitor wells. No lubricants will be allowed on drill rods. Any compressor used during drilling or development must be equipped with oil removal filters to prevent oil from being introduced into the wells

(2) **Borehole:** The borehole will be drilled to a depth of 18 ft with a nominal 6 1/4-inch bit. The total depth should be sufficient to straddle the water table with about nine foot of the screen submerged.

(3) **Formation Samples:** The Driller shall collect formation samples during all drilling. Samples will be collected every 5 ft, change of formation, or as directed by the Consultant. The sampling procedures will not interfere with the Driller's operations or cause him any delay. Samples are to be stored in clear plastic bags supplied by the Driller and labeled as to well designation and sample interval.

(4) **Casing and Screen for Monitor Well:** A casing with screen shall be installed using Schedule 40 PVC casing, 10 feet of #10 slot (0.010 inch) stainless steel wire-wrapped screen, and a threaded plug.

(5) **Filter Pack:** After the casing has been set, the screened interval will be filter packed inside the auger stems with clean sand acceptable for a #10 slot screen. Until used, the filter pack material will be bagged and stored away from potential contaminants. The filter pack material will be added until it extends to 2 ft above the top of the screen.

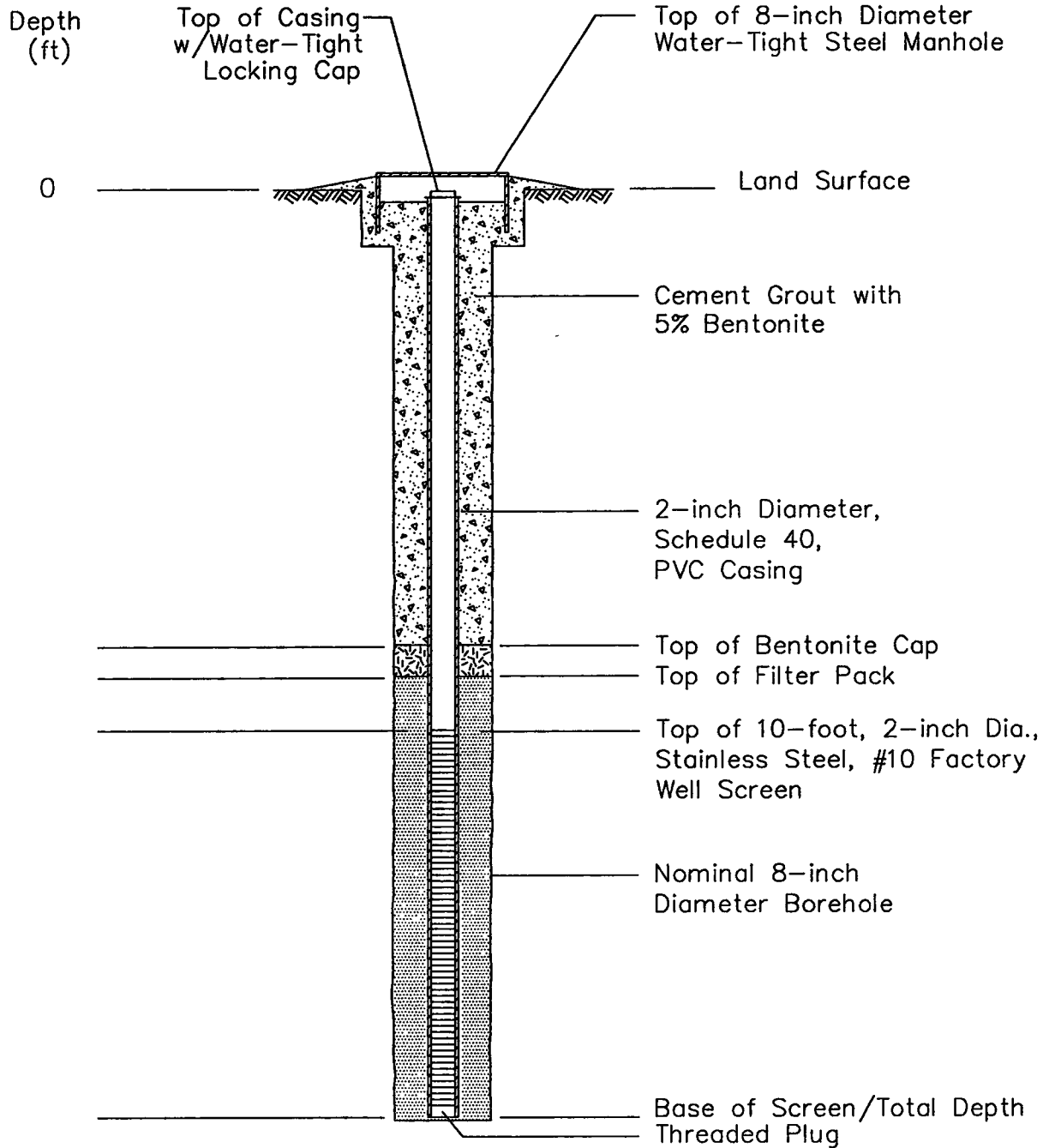
(6) **Sand Cap:** After the filter pack has been tagged for fill, 1 ft of fine sand and 1 foot of bentonite pellets will be installed above the gravel pack and tagged for fill. The bentonite will be hydrated with distilled water.

(7) **Cementing for Monitor Well:** A cement grout will be installed by the pressure tremie method, from the top of the sand cap to land surface. Cement shall be Class A, containing 3 percent bentonite as specified above.

(8) Development: After the cement has set for a minimum of 24 hours (this time will not be billed as standby time), the well shall be developed by swabbing the screen and alternately pumping the well for a period of about 4 hours and/or until clear, sand-free water is produced. Air-lifting or bailing may be used in conjunction with swabbing but will not be the primary method of development. Any compressor used during development must be equipped with oil removal filters to prevent oil from being introduced into the wells. The Driller will be compensated only for time accrued during actual well development. Well development tools must be approved by the Consultant prior to use.

(9) Protective Casing for Monitor Well: Monitor wells will be completed at ground surface with a heavy duty meter box cemented in place with concrete.

Well Number	Location Charleston, SC	Ground Elevation	Relative Top-of-Casing Elevation
Geologist	Drilling Contractor	Drilling Method	Rig Type
Development Method	Volume Evacuated	Well Completed	Formation Monitored



Not To Scale

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PRJT MANAGER: D. WILLIS	CHECKED BY:
DRAWING: WCD-001	
PRJT NO: SC000204.0005	
DWG DATE: 11JUN03	DRAFTER: A. NORTON

**WELL CONSTRUCTION
 DIAGRAM**

BRENNTAG SOUTHEAST
 CHARLESTON, SOUTH CAROLINA

FIGURE NO.