Fourth Five-Year Review Report
North Carolina State University
(Lot 86 Farm Unit #1) Site
Raleigh, Wake County, North Carolina
US EPA ID: NCD980557656

Prepared for
US Environmental Protection Agency
Region 4

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Prepared by
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LIST OF ACRONYMS

BGS	Below Ground Surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulation
COC	Contaminant of Concern
DHHS	Department of Health and Human Services
1,2-DCP	1,2-Dichloropropane
DRW	Deep Recovery Well
1,2-EDB	1,2-Dibromoethane
EPA	Environmental Protection Agency
ESD	Explanation of Significant Difference
FS	Feasibility Study
FY	Fiscal Year
FYR	Five-Year Review
GWE	Groundwater Extraction
IC	Institutional Control
IUP	Industrial Use Permit
LLRW	Low Level Radioactive Waste
MCL	Maximum Contaminant Level
MW	Monitoring Well
NC 2L	North Carolina Groundwater Standard
NC DEQ	North Carolina Department of Environmental Quality
NCP	National Contingency Plan
NCSU	North Carolina State University
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NS	Not Sampled
O&M	Operation and Maintenance
OU	Operable Unit
POTW	Publicly Owned Treatment Works
PPB	Parts per billion (or µg/L)
PRP	Potentially Responsible Party
QAP	Quality Assurance Plan
RAO	Remedial Action Objective
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
RW	Recovery Well
1,1,2-TCA	1,1,2-Trichloroethane
TCE	Trichloroethene
µg/L	Microgram per Liter (or ppb)
VOC	Volatile Organic Compound

I. INTRODUCTION

The purpose of a Five-Year Review (FYR) is to evaluate the implementation and performance of a remedy in order to determine if the remedy is and will continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in FYR reports such as this one. In addition, FYR reports identify issues found during the review, if any, and document recommendations to address them.

The North Carolina Department of Environmental Quality (NC DEQ) is preparing this FYR for the U.S. Environmental Protection Agency (EPA) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121, consistent with the National Contingency Plan (NCP) 40 Code of Federal Regulation (CFR) Section 300.430(f)(4)(ii), and considering EPA policy.

This is the fourth FYR for the North Carolina State University (NCSU), Lot 86 Farm Unit #1 Site (NCSU Site). The triggering action for this statutory review is the completion date of the previous FYR, September 20, 2013. The FYR has been prepared due to the fact that hazardous substances, pollutants, or contaminants remain at the Site above levels that allow for unlimited use and unrestricted exposure. The Site consists of one operable unit (OU), OU1, which encompasses both the soil and groundwater remedies.

The NCSU Site FYR was led by NC DEQ. Participants included David Mattison (NC DEQ), Stephanie Grubbs (NC DEQ), Michael Townsend (EPA, Remedial Project Manager [RPM]), and Angela Miller (EPA, Community Involvement Coordinator). The relevant entities such as the potentially responsible parties (PRPs) were notified of the initiation of the FYR. The review began on November 1, 2017.

Site Background

The NCSU Site is a 1.5-acre plot of grassy land located on the NCSU campus in western Raleigh, Wake County, North Carolina (See Appendix D, Figures D-1 and D-2). The Site is located on and surrounded by State-owned property; however, the Site remedial activities are maintained by NCSU. The impacted parcels are 0784366890 and 0785316741.

A six-foot gated chain-link fence topped with barbed-wire surrounds the entire Site. A metal building, housing the Site groundwater extraction system, is located inside the fenced enclosure. Since 2007, Carolina Solar Energy has leased this area from the State of North Carolina for a project in partnership with the Department of Energy who designated it a Solar "Brownfields to Brightfields" Technology Demonstration Project. The project consists of ground mounted photovoltaic panels arranged in 12 solar arrays located on top of the capped and stabilized mound for a renewable energy project. The electricity that is generated is sold back to Duke Energy. Carolina Solar Energy will own and operate the solar energy system until 2027 under a lease from the State of North Carolina.

NCSU selected Lot 86, Farm Unit No. 1 in 1969 as a burial site for hazardous chemical waste and low level radioactive waste (LLRW) generated in the University's education and research laboratories. Chemical wastes were placed in trenches located in the northwest portion of the Site. The trenches were approximately eight feet deep and varied from 50 feet to 150 feet in length. The University records show that 22 trenches, totaling approximately 2,000 linear feet, were used. The types of chemicals reported to have been buried at the Site include solvents, pesticides, inorganics, acids, and bases. Although some of

the liquid chemicals disposed during the initial Site operations were poured into the trenches, both liquid and solid chemicals were generally buried in metal, glass, or plastic containers.

Radiological wastes were buried in trenches in the eastern portion of the Site, similar to the other trenches in the northwest portion of the property, approximately six feet deep and 50 to 150 feet in length. Nine trenches were reportedly excavated and used for LLRW disposal. The NCSU Radiation Protection Office maintains records concerning waste disposal in this area. These records indicate that the wastes were properly disposed at the Site. Most of the LLRW is in solid form, primarily animal carcasses that were not containerized. Radionuclides present in the waste indicate tritium, carbon-14, iron-59, phosphorous-30, and phosphorous-32.

Land surrounding the Site is home to NCSU's football stadium, Carter-Finley Stadium, and NCSU's basketball and professional hockey facility, PNC Arena. A grass field used for parking during Carter Finley Stadium events is south of the Site, and to the east is the NCSU football training facility. Department of Health and Human Services facilities are located across the Wade Avenue Extension, a highway connecting to Interstate-40, which borders the Site to the north. The closest residents and water supply well is located approximately 2,000 feet southeast (and hydraulically upgradient) of the Site.

A Declaration of Perpetual Land Use Restrictions at the NCSU Site was recorded in June 2009 on parcel 0784366890 (Appendix H). It outlines land use restrictions for the Site, which prevent disturbance of the soil, use of the groundwater, and inappropriate use of the Site that could impact the remedy.

The groundwater plume, which extends under the adjacent highway (Wade Avenue Extension), does not require ICs as this land is within the State of NC highway right of way. At this time, the plume is contained and contaminated groundwater above the NC 2L groundwater standard does not extend beyond Wade Avenue to the adjacent parcel. Therefore, no ICs are required for parcel 0785316741.

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Site Name: North Carolina State University Lot 86 Site		
EPA ID: NCD980557656		
Region: 4	State: NC	City/County: Raleigh, Wake County

SITE STATUS	
NPL Status: Final	
Multiple OUs? No	Has the site achieved construction completion? Yes

REVIEW STATUS
Lead agency: US EPA
Author name: Michael Townsend (EPA RPM), David Mattison (NC DEQ), and Stephanie Grubbs (NC DEQ)
Author affiliation: US EPA and NCDEQ
Review period: 1/1/2018 – 9/20/2018
Date of site inspection: 3/6/2018
Type of review: Statutory
Review number: 4 (fourth)
Triggering action date: 9/20/2013
Due date *(five years after triggering action date)*: 9/20/2018

II. RESPONSE ACTION SUMMARY

Basis for Taking Action

Contaminants found on the Site that warranted remedial action included in the 1996 Record of Decision (ROD) include:

Groundwater: Acetone, Benzene, Bromodichloromethane, Carbon Tetrachloride, Chloroform, 1,2-Dichloropropane, Methylene Chloride, Tetrachloroethene, Trichloroethene (TCE), 1,1,2-Trichloroethane (1,1,2-TCA), Arsenic, and Manganese

Response Action

Summary of Pre-ROD Activities

The Site was proposed for listing on the National Priorities List (NPL) on October 15, 1984 and placed on the NPL on July 10, 1986. No removal or remediation occurred at the Site prior to the signing of the 1996 ROD, although environmental investigations had been ongoing at the Site since the early 1980s. After the initial phase of the work identified the presence of impacted groundwater beneath the Site, 33 monitoring wells were advanced near the Site for the purpose of evaluating potential groundwater impacts. A remedial investigation (RI) was completed in October 1994. A Baseline Risk Assessment (BRA) for the Site was completed in March 1995. The BRA considered the Site risks associated with the soils, groundwater, and the air pathways associated with soil and groundwater if no remediation were to occur. The current visitor, student, and recreational person at the Site were assumed to be potentially exposed to chemicals in the surface soil only. There were no current exposures to groundwater, therefore groundwater risks were not evaluated under a current use scenario. The future use scenario considered the possibility that future on-site or nearby residents were exposed to chemicals in the groundwater and surface soils. Consumption of the water from the contaminated plume would result in an unacceptable risk to human health and the environment.

After determining the nature and extent of contamination, a Feasibility Study (FS) and Revised FS were completed in February 1996. As part of the effort, a Limited Site Assessment, Source Characterization, additional soil samples, and soil vapor extraction test were conducted.

Remedial Action Objectives (RAOs)

Soil

Specific RAOs for soil were not developed at the time of the ROD.

Groundwater

The purpose of the remedial actions, as stated in the 1996 ROD, was to address contaminated media at the Site by eliminating, to the extent practicable, the volume and migration of contaminants present and to remediate all areas of contamination at the Site. As stated in the ROD, the RAOs for groundwater are:

- Prevent migrations of contaminants to surface water that would result in contamination to levels greater than the Ambient Water Quality Criteria.
- Control future releases of contaminants to ensure protection of human health and the environment.
- Permanently and significantly reduce mobility, toxicity, or volume of characteristic hazardous waste with treatment.

Remedy Components

1996 ROD

The remedies set forth in the September 30, 1996 ROD provide for remediation of contaminated soil and groundwater. The major components of the remedy include:

- In-situ mixing and encapsulation of the contaminated soils.
- Extraction of groundwater and treatment by air stripping and carbon adsorption.
- Discharge of treated groundwater to surface water or local publicly owned treatment works (POTW).

The ROD stated, "Groundwater remediation will consist of air stripping to remove volatile organics, and carbon adsorption to remove organics. The groundwater system will operate 24-hours per day. System controls will allow complete automated operation with minimal operator attention. Long-term monitoring for clean-up verification purposes and to track contaminant plume migration will be required. The system is expected to operate 30 years; samples will be collected from existing wells on a semi-annual basis for the first five years, and on an annual basis for the following 25 years. The groundwater treatment system will also require monitoring and maintenance. Monitoring of the influent and effluent from the treatment system and analysis in accordance with the permit requirements." Table 1 shows the Groundwater Remediation Goals as specified in the 1996 ROD.

Provisions for surface water sampling were not described in the ROD; however, groundwater monitoring continues to indicate that the groundwater plume is under hydraulic containment and is not projected to reach any surface water bodies.

Table 1: Groundwater Remediation Goals as Specified in the 1996 ROD

Contaminant	Groundwater Remediation Goal (ug/L)	Basis for Remediation Goal
Acetone	700	NC 2L [a]
Benzene	1	NC 2L
Bromodichloromethane	1	CRQL [b]
Carbon Tetrachloride	1	CRQL
Chloroform	1	CRQL
1,2-Dichloropropane	1	CRQL
Methylene Chloride	5	NC 2L
Tetrachloroethene	1	CRQL
1,1,2-Trichloroethane	1	CRQL
Trichloroethene	2.8	NC 2L
Arsenic	10	CRQL
Manganese	370	Background Concentration [c]

[a] NC 2L- North Carolina Groundwater Quality Standard (15NANC 02L)
[b] CRQL- Contract Required Quantitation Limit
[c] Value is based on the background concentration
ug/L – parts per billion or micrograms per liter

1999 Explanation of Significant Difference (ESD)

On July 21, 1999, an ESD was signed to modify the soil remedy at the Site. During implementation of the soil RA, competent bedrock and other obstructions (debris and compressed gas cylinders) were encountered at depths as shallow as three feet below ground surface (bgs). These obstructions caused damage to the crane mounted auger-mixing unit and could potentially compromise the integrity of the solidified grout/soil mixture. The ESD was issued to change the implementation of the technology. The shallow depths of the bedrock outcroppings caused the use of the crane-mounted auger-mixing unit to be ineffective; therefore, a trackhoe was selected to replace the crane for mixing and stabilizing the material. To address this change, the mixing and air monitoring procedures were revised. The primary changes documented in the ESD were:

- Use of a trackhoe in lieu of the crane for mixing operations. The trackhoe mixing process allowed for visual inspection of the nature and extent of contamination as well as verification of thorough homogeneous mixing.
- Mixing procedure revisions included the spraying of grout in the mixing area to suppress potential vapor emissions and/or covering the emissions with surrounding soils.
- The soils were mixed in individual cells of four feet wide by twelve feet long by ten feet deep.
- Air monitoring procedure revisions included the collection of whole air samples on a daily basis from no more than 50 feet downwind of the mixing area.
- Real-time fence line monitors were used to identify potential exposure to off-site receptors.
- Passive dosimeter badges were placed at five locations around the Site to monitor acute and cumulative exposures over the duration of the project.

Status of Implementation

Soil

In January 1999, contractors began in-situ mixing and encapsulation to address the waste material buried in trenches, as well as soils surrounding the trenches, at the Site. Based on the Limited Site Assessment, the northwest corner of the Site was suspected of having numerous drums. Disposal records and practices suggested that drums were isolated and scattered throughout the Site. During the operation, eight drum carcasses were unearthed and were placed in five 95-gallon overpack drums. The overpack drums were removed and disposed off Site.

Soil mixing began on January 19, 1999 using a crane-mounted, eight-foot diameter mixing auger. As stated previously (in Section titled *1999 Explanation of Significant Difference)*, the crane mounted mixing unit was abandoned and replaced by a trackhoe, which removed the top two feet of the soil from each trench and then the excavated space was filled with cement. The cement and the underlying soil in each trench was then mixed using a combination of digging and mixing motions to ensure that the soil and cement material were thoroughly mixed. During implementation of the trackhoe mixing and encapsulation process, releases of vapors to the atmosphere occurred in small vapor clouds, referred to as "puff" releases. From March to August 1999 results of air-dispersion modeling of the puff releases were submitted to and evaluated by the EPA. Based on the results of the modeling, which indicated no off-site impacts above health-based criteria, the EPA approved the continued use of the trackhoe mixing and encapsulation procedure. The change in the mixing methodology was addressed in the July 21, 1999 ESD. The operation recommenced on August 27, 1999 and continued until the final day of mixing, September 21, 1999.

During the remedial activities, a total of 113 samples of stabilized material were obtained to demonstrate conformance with the performance standards established for the Site. Approximately 2,240 tons of cement and approximately 743,000 gallons of water were used to stabilize almost 11,000 cubic yards of waste material and impacted soil. To prevent extensive erosion, the Site was re-graded with no slope exceeding a 4:1 ratio. The soil cover was crowned to deter infiltration and to direct runoff away from the monolith. The Site was covered with one foot of clean soil and all disturbed areas were reseeded. Since the source is immobilized and the encapsulation of the waste resulted in a relatively impervious concrete cap over the Site, no further action is required to address this media.

Groundwater

The groundwater system remedial design began January 25, 1999 and was completed January 3, 2006. Groundwater extraction (GWE) system wells and components installed near the right-of-way of Wade Avenue Extension also required an encroachment permit before installation occurred. GWE system installation occurred from April to September 2006. The GWE system installation is summarized as follows:

- April-June 2006: shallow GWE recovery wells (RWs) RW-1 through RW-13 and deep GWE wells (DRW) DWR-1 through DRW-4 were installed by air rotary drilling.
- July-August 2006: foundation and building construction completed.
- August-September 2006: groundwater treatment system equipment installed in building. Submersible pumps, electrical supply lines and groundwater effluent lines installed.

- Commercial operations of the GWE system began after the system inspection on September 30, 2006.

Appendix D, Figure D-3 is a Generalized Groundwater Extraction System Layout map.

From September 2006 through December 2006, the effluent was discharged to the City of Raleigh sanitary sewer system to ensure that the effluent met the National Pollutant Discharge Elimination System (NPDES) permit requirements. After December 2006, the treated water began discharging into the surface water under the NPDES permit.

Between 2009 and 2011, results of chronic toxicity testing failed to comply with the Site's NPDES discharge permit and resulted in the GWE system shutting down in 2012 from January 25 to May 31. Instead a 21,000-gallon tank received recovered groundwater from the treatment system through a temporary discharge line. The City of Raleigh issued a City of Raleigh Industrial User Pretreatment (IUP) permit in May 2012 allowing the discharge of treated groundwater from the temporary holding tank to the City's sanitary sewer system. On June 1, 2012, the GWE system resumed operation and treated groundwater was collected in a temporary holding tank for weekly discharge into the City of Raleigh's sanitary sewer via a nearby manhole, as directed by the IUP permit.

On May 28, 2013 NCSU received Permit NC0029033 from the City of Raleigh for the continuous discharge of treated groundwater into the City's sanitary sewer system. The permit, which expired May 28, 2018, was renewed through May 27, 2023.

Institutional Controls (ICs)
A Declaration of Perpetual Land Use Restrictions at the NCSU Site was recorded in June 2009 on parcel 0784366890 (Appendix H). It outlines land use restrictions for the Site, which prevent disturbance of the soil, use of the groundwater, and inappropriate use of the Site that could impact the remedy.

The groundwater plume, which extends under the adjacent highway (Wade Avenue Extension), does not require ICs as this land is within the State of NC highway right of way. At this time, the plume is contained and contaminated groundwater above the NC 2L groundwater standard does not extend beyond Wade Avenue to the adjacent parcel. Therefore, no ICs are required for the parcel 0785316741.

Table 2 summarizes the impacted parcels and instrument in place. Appendix D, Figure D-4 is the Site IC Overlay Map.

Table 2: IC Summary Table

OU	Media	ICs Needed	ICs Called for in the Decision Documents	Impacted Parcel(s)	IC Objective	Instrument in Place
OU1	Soil	Yes	Yes	0784366890	Restrict land use	Yes 06/01/2009
	Ground-water	Yes	Yes	0784366890	Restrict consumption of contaminated groundwater	Yes 06/01/2009 2009 Declaration of Perpetual Land Use Restrictions in place on fenced area (0784366890)

System Operation/Operation and Maintenance (O&M)

Information below was provided by NCSU. Their contractor, Piedmont Geologic, oversees all O&M activities at the Site. NCSU's annual O&M cost are, by fiscal year (FY):

FY14	$135,426.12
FY15	$102,762.23
FY16	$108,047.17
FY17	$131,878.58
FY18	$117,067.64

Piedmont Geologic has been tasked with the following responsibilities in accordance with the *Operation and Maintenance Plan: Groundwater Extraction System*, dated August 21, 2014, prepared by Piedmont Geologic. Routine O&M activities includes the following:

- Weekly system visits by the Operator in Responsible Charge or backup Operator in Responsible Charge, to meet City of Raleigh IUP permit requirements and maintain the Groundwater Treatment System Log.
- Monthly sampling and analysis of GWE system effluent water (i.e., treated water) in accordance with City of Raleigh Permit NC0029033.
- Monthly sampling and analysis of GWE system influent water (i.e., untreated water) for evaluation of recovery system efficacy.
- Remote monitoring of the system operation and on-site response to system upset conditions.
- Routine maintenance such as replacement of system bag filters.

- Quarterly collection and evaluation of groundwater potentiometric surface data from Site monitoring wells.
- Quarterly sampling and analysis of shallow GWE wells for gross beta activity and tritium.

III. Progress Since Last Five-Year Review

Table 3: Protectiveness Determination/Statements from the 2013 FYR

OU	Protectiveness Determination	Protectiveness Statement
OU1	Short-term Protective	*The remedy at the Site currently protects human health and the environment because contaminated soils were remediated through stabilization/solidification, groundwater contamination has been contained through extraction, treatment and discharge to the City sewer, and institutional controls are in place restricting access to contaminated groundwater and soils. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness: document the requirement for institutional controls and the change to the remediation goals in a decision document.*

The following table, Table 4, summarizes the issues and recommendations stated during the previous FYR report and the implementation status and/or completion of these recommendations.

Table 4: Explanation and Discussion of Recommendations and Issues from 2013 FYR

Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)
Institutional controls are in place on the fenced area of the Site, but were not called for in a decision document.	Document the requirement for institutional controls in a decision document.	Completed	2014 ESD	September 17, 2014

Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)
The State and Federal ARARs for acetone, and chloroform, are less stringent than the 1996 remediation goal.	Document the change to the remediation goals in a decision document.	Ongoing	NA	NA

The September 2014 ESD was implemented to document a final decision to include previously instituted ICs in the form of a Declaration of Perpetual Land Use Restrictions for a Federal Superfund Site as recorded on June 1, 2009 as part of the remedy for the Site. The land use restrictions for the Site prevent disturbance of the soil, use of the groundwater, and inappropriate use of the Site that could impact the remedy.

IV. FIVE-YEAR REVIEW PROCESS

Community, Notification and Interviews

The NC DEQ Superfund Section performed the FYR process for the NCSU Lot 86 Site. David Mattison (Environmental Engineer, NC Remedial Project Manager [RPM]) and Stephanie Grubbs (Hydrogeologist) from NC DEQ were responsible for gathering and reviewing data for this review and compiling all the information into the FYR Report for the EPA. Telephone and/or email discussions/interviews with Michael Townsend, EPA RPM, David Mattison, NC DEQ, Karen Trimberger, NCSU, and Pete Dressel, Piedmont Geologic, contractor, were conducted.

The EPA is responsible for contacting and interviewing the community surrounding the Site for concerns, comments, and/or questions regarding the remediation at the Site for the FYR. The community was notified via a press release to local media outlets on August 27, 2018 regarding the FYR process at the Site. In addition, a copy of the press release was posted on the EPA website (https://www.epa.gov/newsreleases/epa-conducting-fourth-five-year-review-superfund-site-raleigh-north-carolina). A copy of the press release is included in Appendix G. No community interviews were conducted for this review.

After this FYR has been approved and signed by the EPA, copies will be placed for the public to view at: the EPA Record Center, 11th Floor, 61 Forsyth Street, SW, Atlanta, GA 30303; the information repository for the Site located at the Cameron Village Regional Public Library located at 1930 Clark Avenue, Raleigh, NC 27605; and, on the EPA website https://www.epa.gov/superfund/search-superfund-five-year-reviews.

The following persons were interviewed by NC DEQ as part of this FYR regarding the activities and implementation of the remedial actions at the NCSU Site. Only a portion of the interviews are stated below. For the complete interview statements see Appendix G.

David Mattison, NC DEQ RPM:
What is your overall impression of the project? (general sentiment)
The groundwater extraction and treatment system is effective at containing the contaminant plume and treating the contaminated groundwater to meet City of Raleigh POTW discharge requirements. The groundwater extraction and treatment system is functioning as designed. Improvements in operation and maintenance made over the last 5 years have increased performance and efficiency of groundwater extraction, increasing the hydraulic containment of the contaminant plume.

Do you have any comments, suggestions, or recommendations regarding the project (i.e., design, construction documents, constructability, management, regulatory agencies, etc.)?
Additional investigative activities are anticipated to confirm the current Site Conceptual Model and hydraulic containment of contaminant plume.

Karen Trimberger, NCSU Project Manager
What is your overall impression of the project? (general sentiment)
Remedial activities are proceeding as designed.

What does the monitoring data show? Are there any trends that show contaminant levels are decreasing?
Groundwater concentrations of Contaminants of Concern (COC) are generally decreasing in the following wells: MW-2, MW-3, MW-6, MW-11, MW-11I, MW-12, MW-16, MW-16D, MW-17, MW-35D, MW-36S, and MW-36D. Groundwater concentrations of COCs have increased in the following wells: MW-37, MW12I, MW-17I, and MW-27. There has not been an obvious overall trend in the concentration of COCs in groundwater in the following wells: MW-18, MW-16I, MW-17D, MW-35S, MW-40, MW-41D, MW-21I, MW-43S, MW-43D, MW-45/45R, and MW-47.

Data Review

The GWE system, for remediation of dissolved-phase groundwater chemicals of concern (COCs), was started at the Site in September 2006. Since the startup of the system on September 26, 2006, the system has been operation for 70,987 hours (approximately 72%). The total volume of groundwater recovered since system startup is 17,792,929 gallons and the estimated mass of dissolved-phase volatile organic compounds (VOCs) extracted since system startup is approximately 2,500 pounds.

	Groundwater Volume Recovered	Estimated Mass of Dissolved Phase VOCs Extracted (pounds)
2013	1,048,607	126
2014	2,166,110	355
2015	2,126,735	248
2016	3,237,614	450
2017	2,769,302	291

Effluent/Influent
Monthly sampling and laboratory analysis of groundwater treatment system effluent groundwater was conducted in accordance with the requirements of the City of Raleigh IUP. The GWE system effluent groundwater analysis results were in compliance with requirements of the IUP as stated in the Remedial Action Progress Report. The predominant groundwater COCs at the Site in terms of frequency of detections and magnitude of concentrations are benzene, carbon tetrachloride, chloroform, 1,2-dibromoethane (EDB), 1,2-dichloropropane (1,2-DCP), 1,4-dioxane, and methylene chloride.

Groundwater Sampling
The annual Site groundwater sampling program includes the following 35 monitoring wells (MW) as specified in the August 2014 Site *Groundwater Sampling Quality Assurance Plan* (QAP):

MW-2, MW-3, MW-6, MW-8, MW-11S, MW-11I, MW-12S, MW-12I, MW-12D, MW-13D, MW-15, MW-16S, MW-16I, MW-16D, MW-17S, MW-17I, MW-17D, MW-27, MW-34DR, MW-35S, MW-35D, MW-36S, MW-36D, MW-37, MW-38, MW-41S, MW-41I, MW-41D, MW-42, MW-42I, MW-43S, MW-43D, MW-45R, MW-46, and MW-47.

As stated in the *2018 Remedial Action Progress Report* (Appendix J), based on the graphs of groundwater COC concentrations over time, a qualitative evaluation of overall trends in groundwater COC concentrations since 2002 is summarized in the following table, Table 5.

Table 5: Generalized Trends in Groundwater COC Concentrations: 2002 to 2017

Generally Decreasing	Flat or Slightly Increasing	Generally Increasing	Fluctuating (no dominant overall trend)
MW-2	MW-37	MW-12I	MW-8
MW-3		MW-17I	MW-16I (1)
MW-6		MW-27	MW-17D
MW-11			MW-35S (2)
MW-11I			MW-41D
MW-12			MW-42I
MW-16			MW-43S
MW-16D			MW-43D (2)
MW-17			MW-45/45R (2)
MW-35D			MW-47
MW-36S			
MW-36D			

(1) Decreasing trends have been observed for some groundwater COCs, and increasing trends for others.
(2) Groundwater COC concentrations have generally remained below, or slightly above, laboratory detection limits.

The above categorization of trends is highly generalized, and variations exist within the overall general trends that are opposite the trends, and, in some cases, transitions from generally increasing to generally decreasing COC concentrations occur over the history of well sampling/analysis.

Several ROD specified COCs currently have North Carolina Groundwater Quality Standard (15NANC 02L) (NC 2L) groundwater standards more stringent than the ROD specified remediation goal. These compounds are bromodichloromethane, carbon tetrachloride, 1,2-dischloropropane, tetrachloroethane, and manganese. See Table 6 ARAR Comparison of Remediation Goals and Current Standards. In addition to the ROD specified COCs, eight organic and three inorganic non-ROD specified compounds were detected in 2017 above the NC 2L groundwater standard. Table 6 lists the contaminants not designated as COCs in the ROD, the well and concentration in which the compound was detected at the highest concentration, and the NC 2L groundwater standard.

Table 6: Contaminants Not Designated in the ROD and the Highest Concentration Detected during August 2017 Sampling Event

Contaminants not designated as COCs in the ROD	NC 2L Groundwater Standard	MW in which the compound was detected at the highest concentration	Highest Concentration the compound was detected in 2017
VOCs (µg/L)			
Chlorobenzene	50	MW12S	87.1 µg/L
1,2-Dichlorobenzene	20	MW37	538 µg/L
1,2-Dibromo-3-chloropropane	0.04	MW12S	6,960 µg/L
1,2-Dibromoethane	0.02	MW12S	6,910 µg/L
1,2-Dichloroethane	0.4	MS37	494 µg/L
1,1,2,2-tetrachloroethane	0.2	MW3	53.1 µg/L
1,2,3-Trichloropropane	400	MW12S	1,130 µg/L
1,4-Dioxane	3	MW12I	11,700 µg/L
Inorganics (µg/L)			
Cadmium	2	MS12S	7.6 µg/L
Chromium	10	MW42S	57.4 µg/L
Mercury	1	MW16S	1.1 µg/L
µg/L - micrograms per liter			

Based on the recommendations in the *2018 Remedial Action Progress Report*, additional MWs are needed to address spatial coverage of the MWs for the intermediate and deep aquifers. Two additional intermediate monitoring wells will be installed at the Site; one intermediate monitoring well (MW-13I) will be coupled with existing shallow and deep monitoring wells MW-13S and MW-13D in the western portion of the Site, and the second intermediate monitoring well (MW-47I) will be coupled with existing deep monitoring well MW-47D in the southern portion of the Site. One deep monitoring well (MW-

45D) will be coupled with existing shallow monitoring well MW-45R in the northern portion of the Site. A Work Plan for the above well installation activities has been approved by the EPA and NCDEQ and will be implemented in 2018.

Appendix I contains the summary data tables for each of the ROD designated COC and the wells with detectable concentrations above the NC2L and/or the remediation goal for the previous five years. Monitoring-wells MW-2, MW-6, MW-11S, and MW-15 are occasionally dry during the August groundwater sampling events; this is noted in the tables as Not Sampled (NS).

Site Inspection

The Site inspection was conducted on March 6, 2018. In attendance were Michael Townsend (US EPA), David Mattison (NC DEQ), Karen Trimberger (NCSU), Ken Kretchman (NCSU), Bruce Stewart (NCSU), and Pete Dressel (Piedmont Geologic). Appendix C contains the Site Inspection Checklist and Site photographs.

The purpose of the inspection was to assess the protectiveness of the remedy. It was noted at the Site Inspection that all O&M documents, permits, and discharge compliance records were readily available and up to date. The Site fencing was inspected, undamaged, and in good condition. The landfill cover was inspected and no signs of settlement, cracking, erosion, holes, slope instability, or water damage were observed and the vegetative cover was properly established and showed no signs of stress.

Groundwater extraction pumps, and electrical were operating properly and in good condition. The treatment train (air stripper, bag filters, and additives [iron-reducing biocide]) were functioning and in good condition, functioning. Monitoring wells (MWs) were located, properly secured/locked, in relatively good condition and routinely sampled. Although most monitoring wells are functional and in good condition, several monitoring wells need new padlocks, new well caps, well pad repairs, etc. Piedmont Geologic will conduct an inventory of monitoring well repairs during the next monitoring event and schedule the appropriate maintenance and repairs. Monitoring data is routinely submitted on time and of acceptable quality. The groundwater plume is effectively contained and the concentrations are declining.

As stated in the Overall Observation section of the Site Inspection Checklist:

> *The groundwater extraction and treatment system is effective at containing the contaminant plume and treating the contaminated groundwater to meet City of Raleigh POTW discharge requirements. The groundwater extraction and treatment system is functioning as designed.*
>
> *Improvements in operation and maintenance made over the last 5 years have increased performance and efficiency of groundwater extraction, increasing the hydraulic containment of the contaminant plume and maintain current and long-term protectiveness offered by the groundwater extraction and treatment remedy.*
>
> *Additional investigative activities are anticipated to confirm the current Site Conceptual Model and hydraulic containment of contaminant plume.*

V. Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?
The EPA and NCDEQ have determined that all the remedial action construction activities were performed according to specifications and the remedial action continues to function as intended by the decision documents. Currently, no human exposure pathways exist to contaminated soil or groundwater. Contaminated soils were remediated through stabilization/solidification and groundwater contamination is actively being remediated through extraction, treatment, and discharge to the City sewer.

Based on the recommendations in the *2018 Remedial Action Progress Report,* additional MWs are needed to address spatial coverage of the MWs for the intermediate and deep aquifers. Additional monitoring wells will be installed at the Site in 2018: one intermediate monitoring well in the western portion of the Site; the second intermediate monitoring well in the southern portion of the Site; and one deep monitoring well in the northern portion of the Site.

A Declaration of Perpetual Land Use Restrictions at the NCSU Site was recorded in June 2009 on parcel 0784366890 (Appendix H). It outlines land use restrictions for the Site, which prevent disturbance of the soil, use of the groundwater, and inappropriate use of the Site that could impact the remedy.

The groundwater plume, which extends under the adjacent highway (Wade Avenue Extension), does not require ICs as this land is within the State of NC highway right of way. At this time, the plume is contained and contaminated groundwater above the NC 2L groundwater standard does not extend beyond Wade Avenue to the adjacent parcel. Therefore, no ICs are required for parcel 0785316741.

Question B: Are the exposure assumptions, toxicity data, clean-up levels and remedial action objectives (RAOs) used at the time of the remedy still valid?
The exposure assumptions, toxicity data, clean-up levels and remedial action objectives (RAOs) used at the time of the remedy are still valid for everything except arsenic and 1,1,2-trichloroethane. See Table 7 (further documentation in Appendix K). The analysis in Appendix K indicates that the groundwater remediation goal for arsenic results in a cancer risk greater than 1×10^{-4}. The groundwater remediation goals for arsenic and 1,1,2-trichloroethane both exceed an HQ of 1. None of the remaining remediation goals resulted in a cancer risk greater than 1×10^{-4} for carcinogens or a noncancer HQ of greater than 1, and therefore remain protective of human health.

Direct exposure to groundwater is not an issue due to ICs being implemented on the fenced portion of Parcel 0784366890, which prohibits the use of groundwater for potable and irrigational uses. Further, indirect exposure to groundwater as a result of vapor intrusion into occupiable buildings is also not a concern due to ICs in place to prevent the construction of buildings on the Site. The only building that is within the plume boundary is the groundwater treatment building, which is not occupied except during O&M operations. The current land use at the Site remains unchanged. There have been no changes in the physical conditions on the NCSU Lot 86 Site.

The NC Classifications and Water Quality Standards Applicable to the Groundwater of North Carolina, NCAC Title 15A Subchapter 2L, on which some of the remedial goals are based were last amended on April 1, 2013. CERCLA requires that the remedy comply with any standard, requirement, criteria, or limitation under any Federal environmental law (such as Federal maximum contaminant limits (MCLs) here), as well as any promulgated State standard that is more stringent than any federal standard (Appendix F).

Table 7: ARAR Comparison of Remediation Goals and Current Standards

COC	1996 ROD Remediation Levels & Rationale (µg/L)	Current NC 2L[a] (As of April 1, 2013) (µg/L)	Current Federal MCL*/CRQL (µg/L)	Change in ARAR Yes/No
Acetone	700 NC 2L	6,000	NA	Yes***
Benzene	1 NC 2L	1	5*/1	No
Bromodichloromethane	1 CRQL	0.6	80**/1	**Yes**
Carbon tetrachloride	1 CRQL	0.3	5*/1	**Yes**
Chloroform	1 CRQL	70	80**/1	No
Dichloropropane, 1,2-	1 CRQL	0.6	5*/1	**Yes**
Methylene chloride	5 NC 2L	5	5*	No
Tetrachloroethene	1 CRQL	0.7	5*/1	**Yes**
Trichloroethane, 1,1,2-	1 CRQL	NA	5*/1	No
Trichloroethene	2.8 NC 2L	3	5*	Yes***
Metals				
Arsenic	10 CRQL	10	10*/10	No
Manganese	370 Background	50	NA	**Yes**

Notes:

NA - Not Available

[a] NC 2L of North Carolina Administrative Code, Title 15A, Subchapter 2L, Classifications and Water Quality Standards Applicable to the Groundwater of North Carolina

* MCL for compound

** MCL for total trihalomethanes.

*** ARAR has changed but ROD remediation goal is more stringent than the current new standard.

BOLD and underlined indicates current NC 2L standard is more stringent than previous remediation goal.

µg/L - micrograms per liter

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information has come to light that could call into question the protectiveness of the remedy.

VI. Issues/Recommendations

Table 8: Issues and Recommendations Identified in the Five-Year Review:

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU1

Additional Findings:
These additional finding do not rise to the level of an issue; however, these findings need to be evaluated and /or addressed.

- The NC 2L groundwater standards, on which several of the remediation goals are based, were amended on June 1, 2013. Several ROD designated COCs currently have NC 2L standards more stringent than the ROD remediation goals. Direct exposure to groundwater is not an issue due to implemented ICs, which prohibits the use of groundwater for potable and irrigational uses. At this time, the plume is contained and contaminated groundwater above the NC 2L groundwater standards does not extend beyond Wade Avenue to the adjacent parcel. However, a review of these remediation goals will need to be undertaken before the Site can be closed out with the State of North Carolina's concurrence.
- In addition to the ROD specified COCs, eight organic and three inorganic non-ROD specified compounds were detected in 2017 above the NC 2L groundwater standards. These 11 compounds not designated in the ROD should continue to be analyzed and reported annually and if needed, add these compounds as COCs with a decision document.

VII. Protectiveness Statements

Protectiveness Statement		
Operable Unit:	***Protectiveness Determination:***	***Addendum Due Date***
OU1	Protective Short-Term	NA

Protectiveness Statement:
OU1 remains protective in the short-term. The completed OU1 remedy at the Site currently protects human health and the environment because contaminated soils were remediated through stabilization/solidification, groundwater contamination has been contained through extraction, treatment and discharge to the City sewer, and institutional controls are in place restricting access to contaminated groundwater and soils. Direct exposure to groundwater is not an issue due to these implemented institutional controls, which prohibits the use of groundwater for potable and irrigational uses. At this time, the plume is contained and contaminated groundwater above the NC 2L groundwater standards does not extend beyond Wade Avenue to the adjacent parcel. However, a review of the remediation goals and COCs will need to be undertaken before the Site can be closed out with the State of North Carolina's concurrence.

Sitewide Protectiveness Statement	
Protectiveness Determination: Protective Short-Term	***Addendum Due:***
Protectiveness Statement: The remedy at the Site currently protects human health and the environment because contaminated soils were remediated through stabilization/solidification, groundwater contamination has been contained through extraction, treatment and discharge to the City sewer, and institutional controls are in place restricting access to contaminated groundwater and soils. At this time, the plume is contained and contaminated groundwater above the NC 2L groundwater standards does not extend beyond Wade Avenue to the adjacent parcel. However, a review of the remediation goals and COCs will need to be undertaken before the Site can be closed out with the State of North Carolina's concurrence.	

VIII. Next Review

The next FYR for the Site is required five years from completion date of this review.

APPENDIX A
Reference List

U. S. Environmental Protection Agency, Region IV. September 30, 1996. Record of Decision, NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

North Carolina Department of Environment and Natural Resources. September 25, 2008. Second Five-Year Review Report. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Piedmont Geologic, P.C. September 24, 2007. Remedial Action Report. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Skeo Solutions. September 20, 2013. Third Five-Year Review Report. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

U. S. Environmental Protection Agency, Region IV. September 17, 2014. Explanation of Significant Difference, NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Piedmont Geologic, P.C. February 17, 2014. Remedial Action Progress Report January through December 2013. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Piedmont Geologic, P.C. February 17, 2014. Remedial Action Progress Report January through December 2013. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Piedmont Geologic, P.C. March 23, 2015. Remedial Action Progress Report January through December 2014. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Piedmont Geologic, P.C. March 2, 2016. Remedial Action Progress Report January through December 2015. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Piedmont Geologic, P.C. February 22, 2017. Remedial Action Progress Report January through December 2016. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

Piedmont Geologic, P.C. January 29, 2018. Remedial Action Progress Report January through December 2017. NCSU Lot 86 Superfund Site, Raleigh, North Carolina.

APPENDIX B
Site Chronology

Event	Date
NCSU uses Lot 86 as a burial site for hazardous chemical and low level radioactive waste generated by the University's laboratories.	1969 to November 1980
NCSU reports on the CERCLA Section 103© Hazardous Waste Notification form of waste disposal.	June 8, 1981
Final listing on National Priorities List (NPL)	June 10, 1986
Remedial Investigation (RI) Report completed	October 1994
Revised Feasibility Study (FS) completed	February 1996
ROD selecting the remedy is signed	September 30, 1996
Start of on-site mobilization for initiation of soil mixing activities	November 9, 1998
Consent Decree finalizing settlement for responsible party performance of remedy entered by Federal Court	November 13, 1998
Final Remedial Action Work Plan approved by EPA	December 30, 1998
Start of Remedial Action	January 19, 1999
Explanation of Significant Difference (ESD) issued by the US EPA to address the use of a trackhoe in lieu of a crane for mixing operations and air monitoring.	July 21, 1999
Remedial action for soil is completed	September 21, 1999
Evaluation of Monitored Natural Attenuation Report completed by GEI Consultants	March 2001
First Five-Year Review is completed.	September 25, 2003
Fractured Rock Assessment completed by East Coast Environmental	April 2004
Draft Remedial Action Work Plan for Groundwater completed	November 2005
Final Design Criteria Report for the Groundwater Remediation Phase is completed by Marshall Miller & Associates	March 2006
Shallow Groundwater Extraction (GWE) wells and deep GWE wells installed by air rotary drilling.	April through November 2006
Groundwater treatment system equipment installed in building and submersible pumps, electrical supply lines, and groundwater effluent lines installed.	August through September 2006
Groundwater Extraction system start-up.	September 26, 2006
Monthly NPDES monitoring begins on Site.	August 2007

PRP completed remedial action	September 20, 2007
Second Five Year Review Completed	September 26, 2008
Land Use Restriction filed with Wake County	June 1,2009
Discovery of Tritium and sampling results submitted	February 27, 2013
City of Raleigh Industrial User Pretreatment Permit issued	May 28, 2013
Installation of replacement well MW-45R	February 2014
Groundwater Sampling Quality Assurance Plan and Sampling and Analysis Plans submitted	June 3, 2014
Explanation of Significant Differences	September 2, 2014
2014 Annual Compliance Statement - Declaration of Perpetual Land Use Restrictions	September 17, 2014
US EPA Approval - Revised Work Plan for Monitoring Well Installations, Repairs, and Abandonments	January 24, 2018

APPENDIX C
Site Inspection Checklist/Photographs

SITE INSPECTION CHECKLIST

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

I. SITE INFORMATION

Site Name: NC State University (Lot 86, Farm Unit #1)	**Date of Inspection: March 6, 2018**
Location and Region: Raleigh NC, Region 4	**EPA ID: NCD980557656**
Agency, Office or Company Leading the Five-Year Review: NC DEQ on behalf of US EPA Region 4	**Weather/Temperature: Overcast, Periods of Rain, 45°F**

Remedy Includes: (Check all that apply)

- ☒ Landfill cover/containment
- ☒ Access controls
- ☒ Institutional controls
- ☒ Ground water pump and treatment
- ☐ Surface water collection and treatment
- ☐ Other:
- ☐ Monitored natural attenuation
- ☐ Ground water containment
- ☐ Vertical barrier walls

Attachments: ☐ Inspection team roster attached ☐ Site map attached

II. INTERVIEWS (check all that apply)

1. **O&M Site Manager** Karen Trimberger (Name) | Env Affairs Director, NCSU (Title) | March 6, 2018 (Date)
   Interviewed ☒ at site ☐ at office ☐ by phone : _____
   Problems, suggestions ☐ Report attached: _____

2. **O&M Staff** Pete Dressel (Name) | Piedmont Geologic (Title) | March 6, 2018 (Date)
   Interviewed ☒ at site ☐ at office ☐ by phone : _____
   Problems/suggestions ☐ Report attached: _____

3. **Local Regulatory Authorities and Response Agencies** (i.e., state and tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices). Fill in all that apply.

   Agency _____
   Contact _____ (Name) _____ (Title) _____ (Date) _____ (Phone No.)
   Problems/suggestions ☐ Report attached: _____

   Agency _____
   Contact _____ (Name) _____ (Title) _____ (Date) _____ (Phone No.)
   Problems/suggestions ☐ Report attached: _____

   Agency _____
   Contact _____ (Name) _____ (Title) _____ (Date) _____ (Phone No.)
   Problems/suggestions ☐ Report attached: _____

   Agency _____
   Contact _____ (Name) _____ (Title) _____ (Date) _____ (Phone No.)
   Problems/suggestions ☐ Report attached: _____

Agency _____
Contact _____ _____ _____ _____
Name Title Date Phone No.
Problems/suggestions ☐ Report attached: _____

4. **Other Interviews** (optional) ☐ Report attached: _____

Michael Townsend, Remedial Project Manager, US EPA

Ken Kretchman & Bruce Stewart, NCSU

III. ON-SITE DOCUMENTS AND RECORDS VERIFIED (check all that apply)

1. **O&M Documents**

☒ O&M manual	☒ Readily available	☒ Up to date	☐ N/A
☒ As-built drawings	☒ Readily available	☒ Up to date	☐ N/A
☒ Maintenance logs	☒ Readily available	☒ Up to date	☐ N/A

Remarks: NCSU retains O&M documents off-site at NCSU & Piedmont Geologic offices

2. **Site-Specific Health and Safety Plan** ☒ Readily available ☒ Up to date ☐ N/A

☐ Contingency plan/emergency response plan ☐ Readily available ☐ Up to date ☐ N/A

Remarks:

3. **O&M and OSHA Training Records** ☒ Readily available ☒ Up to date ☐ N/A

Remarks: NCSU retains O&M & OSHA training records off-site at NCSU & Piedmont Geologic offices

4. **Permits and Service Agreements**

☐ Air discharge permit	☐ Readily available	☐ Up to date	☒ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	☒ N/A
☒ Waste disposal, POTW	☒ Readily available	☒ Up to date	☐ N/A
☐ Other permits: _____	☐ Readily available	☐ Up to date	☒ N/A

Remarks: NCSU retains the POTW permit off-site at NCSU & Piedmont Geologic offices

5. **Gas Generation Records** ☐ Readily available ☐ Up to date ☒ N/A

Remarks: _____

6. **Settlement Monument Records** ☐ Readily available ☐ Up to date ☒ N/A

Remarks: _____

7. **Ground Water Monitoring Records** ☒ Readily available ☒ Up to date ☐ N/A

Remarks: NCSU retains groundwater monitoring records off-site at NCSU & Piedmont Geologic offices

8. **Leachate Extraction Records** ☐ Readily available ☐ Up to date ☒ N/A

Remarks: _____

9. **Discharge Compliance Records**

☐ Air	☐ Readily available	☐ Up to date	☒ N/A
☒ Water (effluent)	☒ Readily available	☒ Up to date	☐ N/A

Remarks: NCSU retains POTW discharge compliance records off-site at NCSU & Piedmont Geologic

offices

10. **Daily Access/Security Logs** ☐ Readily available ☐ Up to date ☒ N/A

Remarks: _____

IV. O&M COSTS

1. **O&M Organization**

☐ State in-house ☐ Contractor for state

☐ PRP in-house ☒ Contractor for PRP

☐ Federal facility in-house ☐ Contractor for Federal facility

☐ _____

2. **O&M Cost Records**

☒ Readily available ☒ Up to date

☒ Funding mechanism/agreement in place ☐ Unavailable

Original O&M cost estimate: _____ ☐ Breakdown attached

Total annual cost by year for review period if available

From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs during Review Period**

Describe costs and reasons: 2013 costs were unusually high due to cost of conducting third Five-Year Review

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. **Fencing Damaged** ☒ Location shown on site map ☒ Gates secured ☐ N/A

Remarks: Fencing is in good condition and undamaged.

B. Other Access Restrictions

1. **Signs and Other Security Measures** ☐ Location shown on site map ☐ N/A

Remarks: All signs are in place and in good condition.

C. Institutional Controls (ICs)

1. **Implementation and Enforcement***

Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A

Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A

Type of monitoring (e.g., self-reporting, drive by): Drive by in conjunction with groundwater extractions system O&M

Frequency: Weekly

Responsible party/agency: Piedmont Geologic

Contact	Pete Dressel	Geologist	March 6, 2018	919-854-9700
	Name	Title	Date	Phone no.

Reporting is up to date ☒ Yes ☐ No ☐ N/A

Reports are verified by the lead agency ☒ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A

Violations have been reported ☐ Yes ☒ No ☐ N/A

Other problems or suggestions: ☐ Report attached

2. **Adequacy** ☐ ICs are adequate ☒ ICs are inadequate ☐ N/A

Remarks: ICs are only implemented on the fenced portion of Parcel 0784366890, the second parcel of property (0785316741) does not have ICs implemented.

D. General

1. **Vandalism/Trespassing** ☐ Location shown on site map ☒ No vandalism evident

Remarks:

2. **Land Use Changes On Site** ☐ N/A

Remarks: No land use changes on site.

3. **Land Use Changes Off Site** ☐ N/A

Remarks: No land use changes off site.

VI. GENERAL SITE CONDITIONS

A. Roads ☐ Applicable ☒ N/A

1. **Roads Damaged** ☐ Location shown on site map ☐ Roads adequate ☐ N/A

Remarks: _____

B. Other Site Conditions

Remarks: _____

VII. LANDFILL COVERS ☒ Applicable ☐ N/A

A. Landfill Surface

1. **Settlement** (low spots) ☐ Location shown on site map ☒ Settlement not evident

Arial extent: _____ Depth: _____

Remarks: _____

2. **Cracks** ☐ Location shown on site map ☒ Cracking not evident

Lengths: _____ Widths: _____ Depths: _____

	Remarks: _____		
3.	**Erosion**	☐ Location shown on site map	☒ Erosion not evident
	Arial extent: _____		Depth: _____
	Remarks: _____		
4.	**Holes**	☐ Location shown on site map	☒ Holes not evident
	Arial extent: _____		Depth: _____
	Remarks: _____		
5.	**Vegetative Cover**	☒ Grass	☒ Cover properly established
	☒ No signs of stress	☐ Trees/shrubs (indicate size and locations on a diagram)	
	Remarks:		
6.	**Alternative Cover** (e.g., armored rock, concrete)		☒ N/A
	Remarks: _____		
7.	**Bulges**	☐ Location shown on site map	☒ Bulges not evident
	Arial extent: _____		Height: _____
	Remarks: _____		
8.	**Wet Areas/Water Damage**	☒ Wet areas/water damage not evident	
	☐ Wet areas	☐ Location shown on site map	Arial extent: _____
	☐ Ponding	☐ Location shown on site map	Arial extent: _____
	☐ Seeps	☐ Location shown on site map	Arial extent: _____
	☐ Soft subgrade	☐ Location shown on site map	Arial extent: _____
	Remarks: _____		
9.	**Slope Instability**	☐ Slides	☐ Location shown on site map
	☒ No evidence of slope instability		
	Arial extent: _____		
	Remarks: _____		
B. Benches		☐ Applicable	☒ N/A
	(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)		
1.	**Flows Bypass Bench**	☐ Location shown on site map	☐ N/A or okay
	Remarks: _____		
2.	**Bench Breached**	☐ Location shown on site map	☐ N/A or okay
	Remarks: _____		
3.	**Bench Overtopped**	☐ Location shown on site map	☐ N/A or okay
	Remarks: _____		
C. Letdown Channels		☐ Applicable	☒ N/A
	(Channel lined with erosion control mats, riprap, grout bags or gabions that descend down the steep side		

slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

1. **Settlement** (Low spots) ☐ Location shown on site map ☐ No evidence of settlement
   Arial extent: _____ Depth: _____
   Remarks: _____

2. **Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation
   Material type:_____ Arial extent: _____
   Remarks: _____

3. **Erosion** ☐ Location shown on site map ☐ No evidence of erosion
   Arial extent: _____ Depth: _____
   Remarks: _____

4. **Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting
   Arial extent: _____ Depth: _____
   Remarks: _____

5. **Obstructions** Type: _____ ☐ No obstructions
   ☐ Location shown on site map Arial extent: _____
   Size: _____
   Remarks: _____

6. **Excessive Vegetative Growth** Type: _____
   ☐ No evidence of excessive growth
   ☐ Vegetation in channels does not obstruct flow
   ☐ Location shown on site map Arial extent: _____
   Remarks: _____

D. Cover Penetrations ☐ Applicable ☒ N/A

1. **Gas Vents** ☐ Active ☐ Passive
   ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs maintenance ☐ N/A
   Remarks: _____

2. **Gas Monitoring Probes**
   ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs maintenance ☐ N/A
   Remarks: _____

3. **Monitoring Wells** (within surface area of landfill)
   ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs maintenance ☐ N/A
   Remarks: _____

4. **Extraction Wells Leachate**

☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition

☐ Evidence of leakage at penetration ☐ Needs maintenance ☐ N/A

Remarks: _____

5. **Settlement Monuments** ☐ Located ☐ Routinely surveyed ☐ N/A

Remarks: _____

E. Gas Collection and Treatment ☐ Applicable ☒ N/A

1. **Gas Treatment Facilities**

☐ Flaring ☐ Thermal destruction ☐ Collection for reuse

☐ Good condition ☐ Needs maintenance

Remarks: _____

2. **Gas Collection Wells, Manifolds and Piping**

☐ Good condition ☐ Needs maintenance

Remarks: _____

3. **Gas Monitoring Facilities** (e.g., gas monitoring of adjacent homes or buildings)

☐ Good condition ☐ Needs maintenance ☐ N/A

Remarks: _____

F. Cover Drainage Layer ☐ Applicable ☒ N/A

1. **Outlet Pipes Inspected** ☐ Functioning ☐ N/A

Remarks: _____

2. **Outlet Rock Inspected** ☐ Functioning ☐ N/A

Remarks: _____

G. Detention/Sedimentation Ponds ☐ Applicable ☒ N/A

1. **Siltation** Area extent: _____ Depth: _____ ☐ N/A

☐ Siltation not evident

Remarks: _____

2. **Erosion** Area extent: _____ Depth: _____

☐ Erosion not evident

Remarks: _____

3. **Outlet Works** ☐ Functioning ☐ N/A

Remarks: _____

4. **Dam** ☐ Functioning ☐ N/A

Remarks: _____

H. Retaining Walls ☐ Applicable ☒ N/A

1. **Deformations** ☐ Location shown on site map ☐ Deformation not evident

Horizontal displacement: _____ Vertical displacement: _____

Rotational displacement: _____

Remarks: _____

2. **Degradation** ☐ Location shown on site map ☐ Degradation not evident

Remarks: _____

I. Perimeter Ditches/Off-Site Discharge ☐ Applicable ☒ N/A

1. **Siltation** ☐ Location shown on site map ☐ Siltation not evident

Area extent: _____ Depth: _____

Remarks:

2. **Vegetative Growth** ☐ Location shown on site map ☐ N/A

☐ Vegetation does not impede flow

Area extent: _____ Type: _____

Remarks: _____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident

Area extent: _____ Depth: _____

Remarks: _____

4. **Discharge Structure** ☐ Functioning ☐ N/A

Remarks: _____

VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A

1. **Settlement** ☐ Location shown on site map ☐ Settlement not evident

Area extent: _____ Depth: _____

Remarks: _____

2. **Performance Monitoring** Type of monitoring:

☐ Performance not monitored

Frequency: _____ ☐ Evidence of breaching

Head differential: _____

Remarks: _____

IX. GROUND WATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A

A. Ground Water Extraction Wells, Pumps and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing and Electrical**

☒ Good condition ☒ All required wells properly operating ☐ Needs maintenance ☐ N/A

Remarks: _____

2. **Extraction System Pipelines, Valves, Valve Boxes and Other Appurtenances**

☒ Good condition ☐ Needs maintenance

Remarks: _____

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks: _____

B. Surface Water Collection Structures, Pumps and Pipelines ☐ Applicable ☒ N/A

1. **Collection Structures, Pumps and Electrical**

☐ Good condition ☐ Needs maintenance

Remarks: _____

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes and Other Appurtenances**

☐ Good condition ☐ Needs maintenance

Remarks: _____

3. **Spare Parts and Equipment**

☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks: _____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation*

☒ Air stripping ☐ Carbon adsorbers ☐ In-situ chemical oxidation*

☒ Filters: 2 bag filters ☐ Monitored natural attenuation*

☒ Additive (e.g., chelation agent, flocculent): Iron-reducing biocide

☐ Others: _____

☒ Good condition ☐ Needs maintenance

☒ Sampling ports properly marked and functional

☒ Sampling/maintenance log displayed and up to date

☒ Equipment properly identified

☒ Quantity of ground water treated annually: 7.5 gpm, 24 hours per day, 365 days/year

☐ Quantity of surface water treated annually: _____

Remarks:

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☐ Needs maintenance

Remarks: _____

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs maintenance

Remarks: _____

4. **Discharge Structure and Appurtenances**

☐ N/A ☒ Good condition ☐ Needs maintenance

Remarks: _____

5. **Treatment Building(s)**

☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair

☒ Chemicals and equipment properly stored

Remarks: _____

6. **Monitoring Wells** (pump and treatment remedy)

☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition

☒ All required wells located ☒ Needs maintenance ☐ N/A

Remarks: Although most monitoring wells are functional and in good condition, several monitoring wells need new padlocks, new well caps, well pad repairs, etc. Piedmont Geologic will conduct inventory of monitoring well repairs during next monitoring event and schedule the appropriate maintenance and repairs.

D. Monitoring Data

1. **Monitoring Data**

☒ Is routinely submitted on time ☒ Is of acceptable quality

2. **Monitoring Data Suggests:**

☒ Ground water plume is effectively contained ☒ Contaminant concentrations are declining

E. Monitored Natural Attenuation*

1. **Monitoring Wells** (natural attenuation remedy)

☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition

☐ All required wells located ☐ Needs maintenance ☒ N/A

Remarks: _____

X. OTHER REMEDIES

If there are remedies applied at the site and not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is designed to accomplish (e.g., to contain contaminant plume, minimize infiltration and gas emissions).

The groundwater extraction and treatment system is effective at containing the contaminant plume and treating the contaminated groundwater to meet City of Raleigh POTW discharge requirements. The groundwater extraction and treatment system is functioning as designed. Improvements in operation and maintenance made over the last 5 years have increased performance and efficiency of groundwater extraction, increasing the hydraulic containment of the contaminant plume.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

Improvements in operation and maintenance made over the last 5 years have increased performance and efficiency of groundwater extraction, increasing the hydraulic containment of the contaminant plume and maintain current and long-term protectiveness offered by the groundwater extraction and treatment remedy.

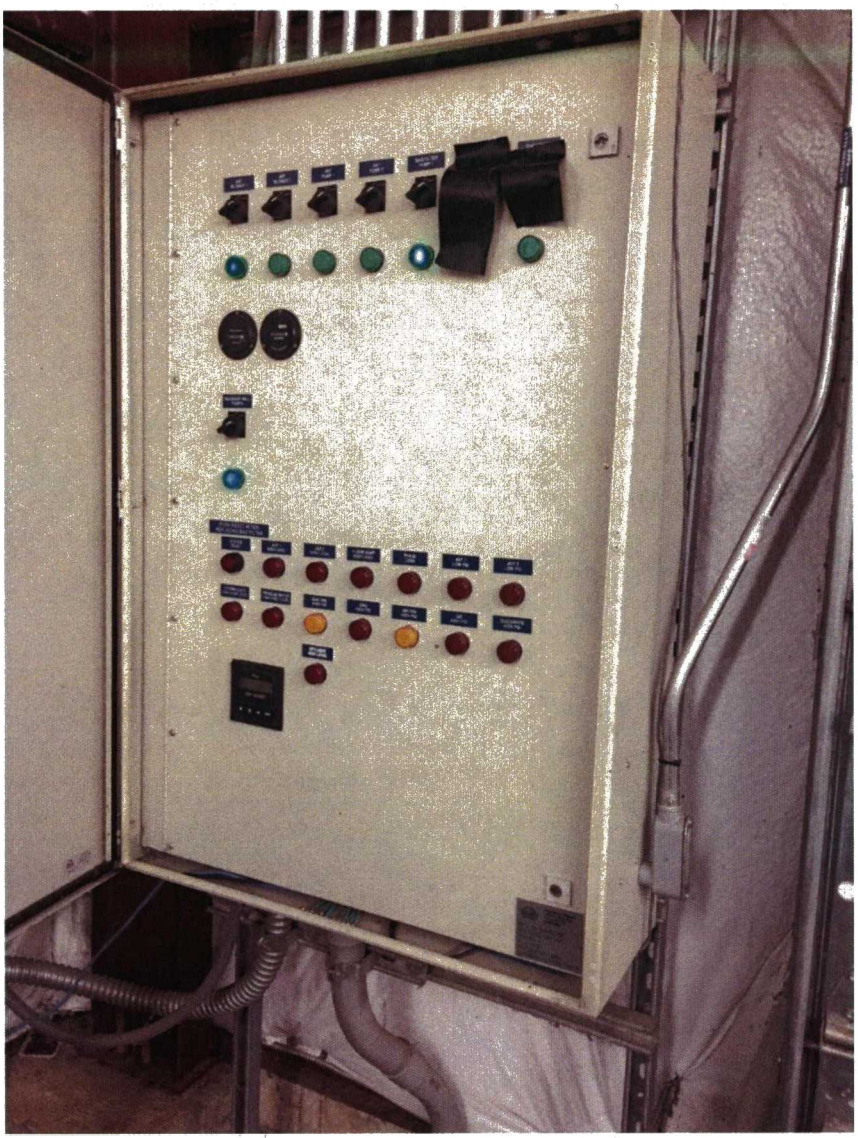
C. Early Indicators of Potential Remedy Problems

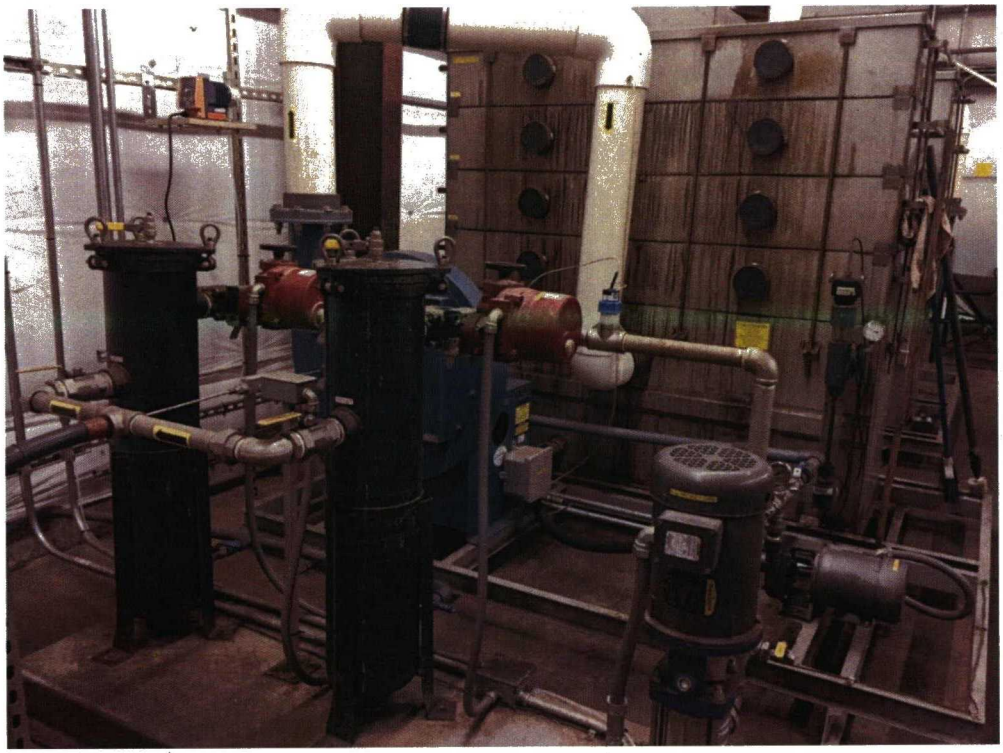
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. There have been no unanticipated issues.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Additional investigative activities are anticipated to confirm the current site conceptual model and hydraulic containment of contaminant plume.

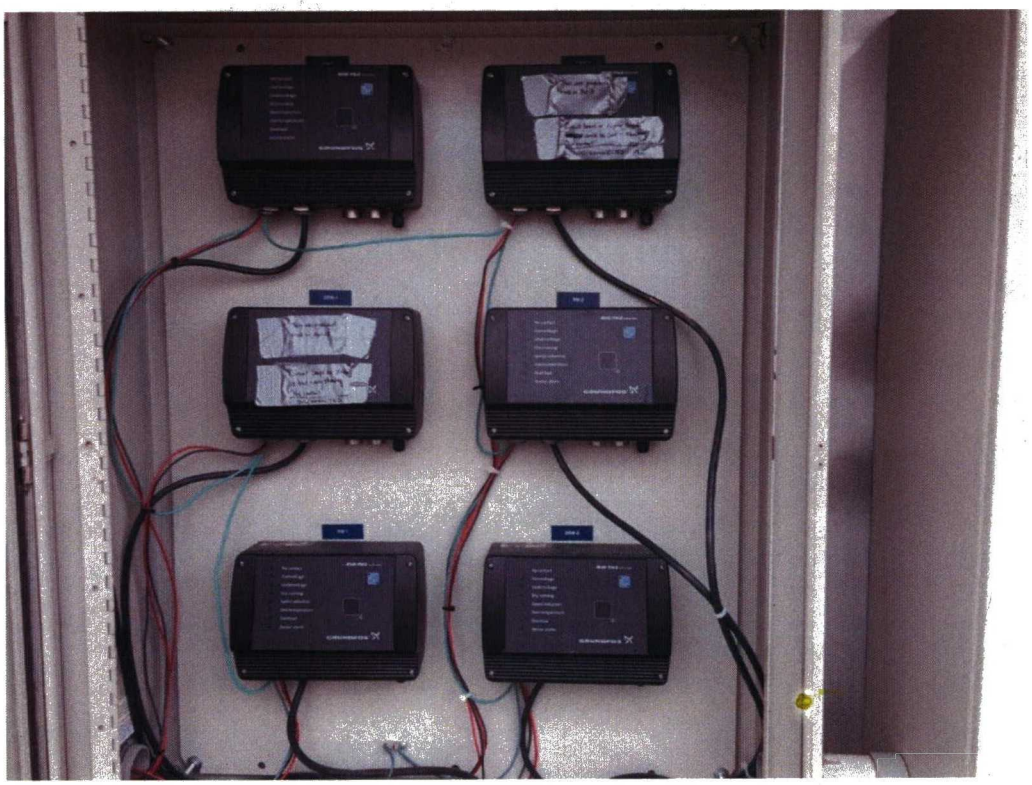
Site Inspection Participants

David Mattison, NC DEQ
Michael Townsend, US EPA
Karen Trimberger, NCSU
Ken Kretchman, NCSU
Bruce Stewart, NCSU
Pete, Dressel, Piedmont Geologic

Photographs
NCSU Lot 86







APPENDIX D
Figures

FIGURE 1: SITE LOCATION MAP

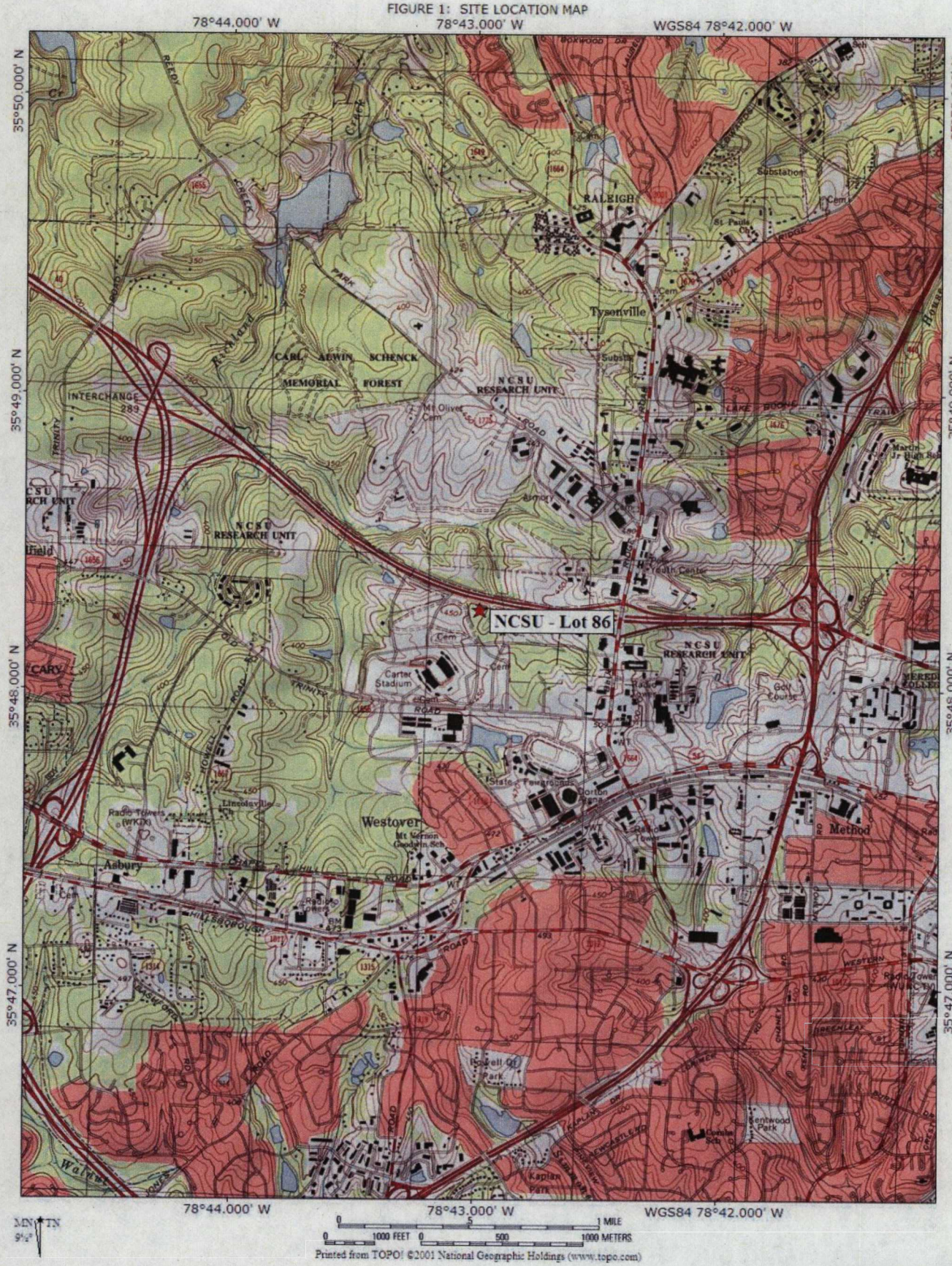


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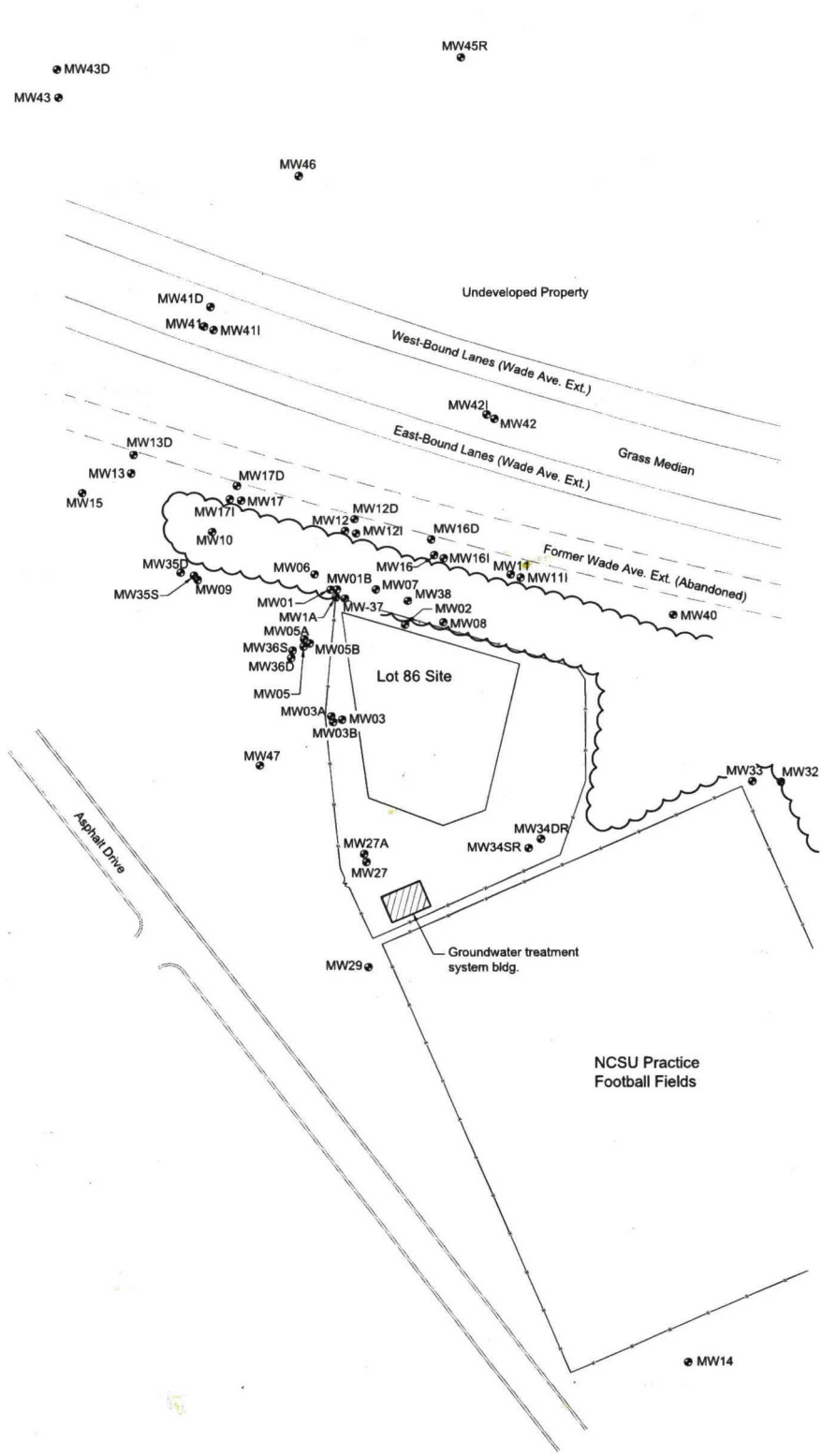
FIGURE D-1
SITE LOCATION MAP
NCSU – Lot 86
Raleigh, North Carolina



Scale (ft.)

0 120 240

LEGEND

MW33 Monitoring Well

Waste Burial Area (Source Area)

Fenced Area

Edge of Wooded Area

PIEDMONT GEOLOGIC
SMART EARTH SOLUTIONS

Gauging Date:	
Drawing Date:	8/13/14
ACAD File:	Fig 2.dwg
Designed: PD	Site Map
Detailed: PD	Client: North Carolina State University
Checked: PD	Location: Lot 86 Raleigh, North Carolina
Project No.:	1441
Figure:	D-2

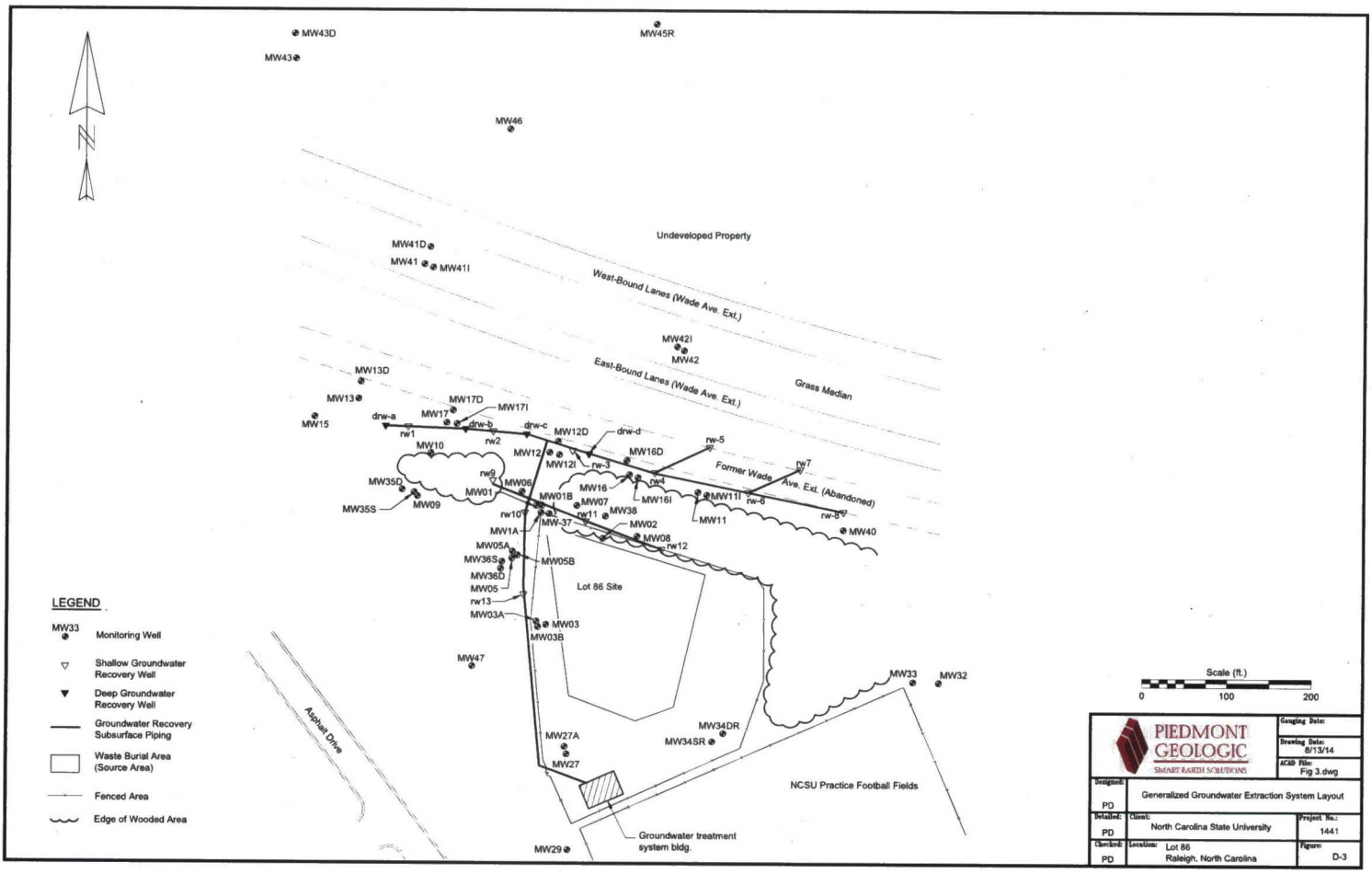

MW43D
MW45R
MW43
MW46
Undeveloped Property
MW41D
MW41
MW41I
West-Bound Lanes (Wade Ave. Ext.)
MW42I
MW42
East-Bound Lanes (Wade Ave. Ext.)
Grass Median
MW13D
MW13
MW17D
MW17I
MW17
MW15
drw-a
drw-b
drw-c
drw-d
rw1
rw2
MW12D
MW12
MW12I
rw-3
MW16D
rw-5
rw7
Former Wade Ave. Ext. (Abandoned)
MW10
rw9
MW06
MW16
rw4
MW35D
MW01
MW01B
MW07
MW16I
MW11I
rw-6
rw-8
MW35S
MW09
rw10
MW-37
rw11
MW38
MW11
MW40
MW1A
MW02
MW08
rw12
MW05A
MW36S
MW05B
MW36D
MW05
Lot 86 Site
rw13
MW03A
MW03
MW03B
MW47
MW33
MW32
Asphalt Drive
MW27A
MW34DR
MW34SR
MW27
NCSU Practice Football Fields
Groundwater treatment system bldg.
MW29
LEGEND
MW33
Monitoring Well
Shallow Groundwater Recovery Well
Deep Groundwater Recovery Well
Groundwater Recovery Subsurface Piping
Waste Burial Area (Source Area)
Fenced Area
Edge of Wooded Area
Scale (ft.)
0
100
200
PIEDMONT GEOLOGIC
SMART EARTH SOLUTIONS
Gauging Date:
Drawing Date: 8/13/14
ACAD File: Fig 3.dwg
Designed: PD
Generalized Groundwater Extraction System Layout
Detailed: PD
Client: North Carolina State University
Project No.: 1441
Checked: PD
Location: Lot 86 Raleigh, North Carolina
Figure: D-3

Figure D-4: Institutional Control Base Map

Disclaimer: This map and any boundary lines within the map are approximate and subject to change. The map is not a survey. The map is for informational purposes only regarding the EPA's response actions at the Site.

APPENDIX E
Current Site Status

Environmental Indicators
- Current human exposures at the Site are under control. *- Contaminated soils were remediated through stabilization/solidification and groundwater contamination is actively being remediated through extraction, treatment, and discharge to the City sewer.*

Are Necessary Institutional Controls in Place?
☐ All ☒ Some ☐ None *Direct exposure to groundwater is not an issue due to ICs being implemented on parcel (0784366890), which prohibits the use of groundwater for potable and irrigational uses. ICs are not in place for use of groundwater outside of the fenced area (parcel 0785316741); however, the majority of the off-site plume is under a highway.*

Has EPA Designated the Site as Sitewide Ready for Anticipated Use?
☒ Yes ☐ No

Has the Site Been Put into Reuse?
☒ Yes ☐ No

Appendix F
ARAR Review

Section 121 (d)(2)(A) of CERCLA specifies that Superfund remedial actions must meet any federal standards, requirements, criteria, or limitations that are determined to be legally ARARs. Applicable or Relevant and Appropriate Requirements are those standards, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, action, location, or other circumstance at a CERCLA site. To-Be-Considered criteria (TBCs) are non-promulgated advisories and guidance that are not legally binding, but should be considered in determining the necessary level of cleanup for protection of human health or the environment. While TBCs do not have the status of ARARs, EPA's approach to determining if a remedial action is protective of human health and the environment involves consideration of TBCs along with ARARs. Chemical-specific ARARs are specific numerical quantity restrictions on individually listed contaminants in specific media. Examples of chemical-specific ARARs include the MCLs specified under the Safe Drinking Water Act (SDWA) as well as the ambient water quality criteria that are enumerated under the Clean Water Act. Because there are usually numerous contaminants of potential concern for any site, various numerical quantity requirements can be ARARs.

In performing the Five-Year Review for compliance with ARARs, only those ARARs that address the protectiveness of the remedy are reviewed. Because the remedy at the Site currently addresses only groundwater contamination, this Five-Year Review will discuss compliance with chemical-specific groundwater ARARs only.

Soil ARARs
The OU1 ROD did not specify ARARs for soil.

Current Potentially-Applicable ARARs

It is the EPA's policy that ARARs are generally "frozen" at the time of the ROD signature unless a "new or modified requirement calls into question the protectiveness of the selected remedy", 55 Fed. Reg. 8757 (March 8, 1990). The NC Classifications and Water Quality Standards Applicable to the Groundwater of North Carolina, NCAC Title 15A Subchapter 2L, (NC 2L) on which several of the remedial goals are based were last amended on April 2013. Title 15A of the North Carolina Administrative Code, Subchapter 2L (NCAC 2L) is a Chemical-Specific State ARAR for this Site.

ARAR Comparison of Remediation Goals and Current Standards

COC	1996 ROD Remediation Levels & Rationale (µg/l)	Current NC 2L[a] (As of April 1, 2013) (µg/l)	Current Federal MCL*/CRQL (µg/l)	Change in ARAR Yes/No
Acetone	700 NC 2L	6,000	NA/5	Yes***
Benzene	1 NC 2L	1	5*/0.5	No
Bromodichloromethane	1 CRQL	0.6	80**/0.5	**Yes**
Carbon tetrachloride	1 CRQL	0.3	5*/0.5	**Yes**
Chloroform	1 CRQL	70	80**/0.5	No
Dichloropropane, 1,2-	1 CRQL	0.6	5*/0.5	**Yes**
Methylene chloride	5 NC 2L	5	5*	No
Tetrachloroethene	1 CRQL	0.7	5*/0.5	**Yes**
Trichloroethane, 1,1,2-	1 CRQL	NA	5*/0.5	No
Trichloroethene	2.8 NC 2L	3	5*	Yes***
Metals				
Arsenic	10 CRQL	10	10*/10	No
Manganese	370 Background	50	NA	**Yes**

Notes:

NA - Not Available

[a] NC 2L of North Carolina Administrative Code, Title 15A, Subchapter 2L, Classifications and Water Quality Standards Applicable to the Groundwater of North Carolina

* MCL for compound

** MCL for total trihalomethanes

BOLD and underlined indicates current NC 2L standard is more stringent than previous remediation goal.

µg/l = micrograms per liter

Appendix G
Press Release and Interviews

U.S. ENVIRONMENTAL PROTECTION AGENCY
NEWS RELEASE
WWW.EPA.GOV/NEWSROOM

EPA Conducting Fourth Five-Year Review for Superfund Site in Raleigh, North Carolina

Media Contact: Dawn Harris-Young, (404) 562-8421 (Direct), (404) 562-8400 (Main), harris-young.dawn@epa.gov

ATLANTA (August 27, 2018) – The U.S. Environmental Protection Agency (EPA) is currently conducting the Five-Year Review (FYR) of the selected cleanup action at the North Carolina State University (Lot 86, Farm Unit #1) Superfund site in Raleigh, North Carolina. The purpose of the FYR is to ensure the selected cleanup actions are working as intended and continue to protect public health and the environment.

The 1.5-acre site is located north of Carter-Finley Stadium on the University campus in Raleigh. Located on state-owned property, the site includes a metal building housing the site's ground water extraction system and an array of solar panels surrounded by secure fencing. Investigations in the early 1980s found that site activities resulted in the contamination of soil and ground water with heavy metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), pesticides, volatile organic compounds (VOCs) and radioactive wastes, including include tritium, carbon-14, iron-59 and phosphorus-32. The EPA placed the site on the National Priorities List in October 1984.

In the September 1996 Record of Decision, EPA selected a remedy to address soil and ground water contamination. The remedy included treatment and encapsulation of contaminated soil and the extraction and treatment of contaminated groundwater. Cleanup activities began in 1998 after the University, the site's potentially responsible party, signed a Consent Decree with the EPA to perform the cleanup. The cleanup was conducted with EPA oversight. The University completed soil remediation in October 1999 and construction of the groundwater remedy in September 2006. Groundwater treatment is ongoing. It includes air stripping and carbon adsorption to remove contaminants and treated water is discharged to the local sewer system. Long-term groundwater monitoring tracks contaminant plume migration and verifies the effectiveness of the ground water treatment system.

The FYR will be completed by September 2018. A final copy of the report will be placed in the site's local document repository, located at Cameron Village Regional Public Library, 1930 Clark Avenue in Raleigh and online at: http://www.epa.gov/region4/superfund/sites/npl/northcarolina/ncstatnc.html.

As part of the FYR process, EPA staff is available to answer any questions about the site. Community members who have questions about the site or the review process are asked to contact: **Michael Townsend, EPA Remedial Project Manager, at (404) 562-8813 or via email townsend.michael@epa.gov;** or **Angela Miller, EPA Community Involvement Coordinator, at (678) 575-8132 or via email miller.angela@epa.gov**

For more information about the North Carolina State University (Lot 86, Farm Unit #1) Superfund site, please visit: http://www.epa.gov/region4/superfund/sites/npl/northcarolina/ncstatnc.html.

###

Interview Questionnaire

Completed by David B. Mattison, Environmental Engineer, NC DEQ DWM Superfund Section

1. What is your overall impression of the project? (general sentiment)
   The groundwater extraction and treatment system is effective at containing the contaminant plume and treating the contaminated groundwater to meet City of Raleigh POTW discharge requirements. The groundwater extraction and treatment system is functioning as designed. Improvements in operation and maintenance made over the last 5 years have increased performance and efficiency of groundwater extraction, increasing the hydraulic containment of the contaminant plume.

2. What effects have site operations had on the surrounding community?
   None.

3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
   No.

4. Have there been any complaints, violations, or other incidents related to the site requiring a response by your office?
   No.

5. Do you feel well informed about the site's activities and progress?
   Yes.

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
   ICs are only implemented on the fenced portion of Parcel 0784366890, the second parcel of property (0785316741) does not have ICs implemented.

7. What is the current status of construction (*e.g.*, budget and schedule)?
   Remedial construction is complete. Site is in Operation & Maintenance (O&M).

8. Have any problems been encountered which required, or will require, changes to this remedial design or this ROD?
   No.

9. Have any problems or difficulties been encountered which have impacted construction progress or implementability?
   No.

10. Do you have any comments, suggestions, or recommendations regarding the project (i.e., design, construction documents, constructability, management, regulatory agencies, etc.)?.
Additional investigative activities are anticipated to confirm the current site conceptual model and hydraulic containment of contaminant plume.

11. Is the remedy functioning as expected? How well is the remedy performing?
Yes, the remedy is functioning as designed.

12. What does the monitoring data show? Are there any trends that show contaminant levels are decreasing?
Improvements in operation and maintenance made over the last 5 years have increased performance and efficiency of groundwater extraction, increasing the hydraulic containment of the contaminant plume and maintain current and long-term protectiveness offered by the groundwater extraction and treatment remedy. Additional investigative activities are anticipated to confirm the current site conceptual model and hydraulic containment of contaminant plume.

13. Is there a continuous on-site O&M presence? If so, please describe staff and activities. If there is not a continuous on-site presence, describe staff and frequency of site inspections and activities.
O&M presence is continuous in that system alarms are automatically routed to the Operator in Charge. Weekly site visits by the Operator in Charge are conducted for maintenance activities to ensure continued operation of the groundwater extraction and treatment system.

Interview Questionnaire
Completed by Karen A. Trimberger, Environmental Affairs Manager

1. What is your overall impression of the project?

   Remedial activities are proceeding as designed.

2. What effects have site operations had on the surrounding community?

   None that I am aware of. Site is surrounded by State owned land.

3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

   None that I am aware of.

4. Have there been any complaints, violations, or other incidents related to the site requiring a response by your office?

   None

5. Do you feel well informed about the site's activities and progress?

   Yes

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

   No, site O&M is occurring as required.

7. What is the current status of construction (*e.g.*, budget and schedule?

   We are in the Operation and Maintenance phase of the project.

   Summary of budget for the last 5 years

FY14	*$135,426.12*
FY15	*$102,762.23*
FY16	*$108,047.17*
FY17	*$131,878.58*
FY18	*$117,067.64*

8. Have any problems been encountered which required, or will require, changes to this remedial design or this ROD?

No

9. Have any problems or difficulties been encountered which have impacted construction progress or implementability?

No

10. Do you have any comments, suggestions, or recommendations regarding the project (i.e., design, construction documents, constructability, management, regulatory agencies, etc.)?

No

11. Is the remedy functioning as expected? How well is the remedy performing?

Yes. The remedy is functioning as designed

12. What does the monitoring data show? Are there any trends that show contaminant levels are decreasing?

Groundwater concentrations of Contaminants of Concern (COC) are generally decreasing in the following wells: MW-2, MW-3, MW-6, MW-11, MW-11I, MW-12, MW-16, MW-16D, MW-17, MW-35D, MW-36S, and MW-36D.
Groundwater concentrations of COCs have increased in the following wells: MW-37, MW12I, MW-17I, and MW-27.
There has not been an obvious overall trend in the concentration of COCs in groundwater in the following wells: MW-18, MW-16I, MW-17D, MW-35S, MW-40, MW-41D, MW-21I, MW-43S, MW-43D, MW-45/45R, and MW-47.

13. Is there a continuous on-site O&M presence? If so, please describe staff and activities. If there is not a continuous on-site presence, describe staff and frequency of site inspections and activities.

No. Site is visited once a week by O&M contractor along with remote monitoring of the site. If site goes into alarm Monday through Friday, O&M Contractor visits site to trouble shoot and determine cause for alarm. If fixable at the moment, system is reset. If fix requires additional/new equipment, equipment ordered and system reset upon installation. If system goes into alarm on Saturday/Sunday, system is checked Monday and reset.

APPENDIX H
Land Use Restrictions

BK013561PG00813

WAKE COUNTY, NC 500
LAURA M RIDDICK
REGISTER OF DEEDS
PRESENTED & RECORDED ON
06/01/2009 AT 15:09:48

BOOK:013561 PAGE:00813 - 00825

Return to: Teresa L. White, Associate General Counsel, NC State University, Campus Box 7008, Raleigh, NC 27695-7008

DECLARATION OF PERPETUAL LAND USE RESTRICTIONS FOR A FEDERAL SUPERFUND SITE

For Property Owned By: STATE OF NORTH CAROLINA

North Carolina State University Lot 86 Superfund Site, Wake County, North Carolina

The real property which is the subject of this Declaration of Perpetual Land Use Restrictions ("Declaration") is contaminated with hazardous substances, pollutants, or contaminants and is a Superfund Site (hereinafter referred to as the "Site") as defined under the Comprehensive Environmental Response, Compensation and Liability Act, as amended ("CERCLA/SARA"), 42 U.S.C. § 9601 *et seq.*, and as set forth in the Consent Decree filed in civil action no. 5:98-CV-893-1302 in the United States District Court for the Eastern District of North Carolina, entitled "United States of America, Plaintiff, v. North Carolina State University at Raleigh, Defendant." This Declaration is part of a Remedial Action Plan for the Site that is identified in the Federal Record of Decision and any amendments thereto ("ROD") for the Site and that has been approved by the Secretary of the North Carolina Department of Environment and Natural Resources (or its successor in function), or his/her delegate, as authorized by N.C.G.S. Section 143B-279.9. The North Carolina Department of Environment and Natural Resources shall hereinafter be referred to as "DENR."

The State of North Carolina, c/o State Property Office, Raleigh, NC, is the owner in fee simple of the Site, which is located in the County of Wake, City of Raleigh, State of North Carolina, and is described in Exhibit A. The Site is a portion of the real property legally described in Deed Book 833 Page 357 in the Office of the Register of Deeds for Wake County. The Site is also shown on a Notice of Contaminated Site, incorporated by reference into this Declaration, constituting a survey plat, which is concurrently being recorded with this Declaration in the Office of the Register of Deeds for Wake County at Map Book 2009 Page 620. An unrecorded copy of said survey plat is attached hereto as Exhibit B.

For the purpose of protecting public health and the environment, the State of North Carolina hereby declares that all of the Site shall be held, sold and conveyed subject to the following perpetual land use restrictions, which shall run with the land; shall be binding on all parties having any right,

title or interest in the Site or any part thereof, their heirs, successors and assigns; and shall, as provided in N.C.G.S. Section 143B-279.9 be enforceable without regard to lack of privity of estate or contract, lack of benefit to particular land, or lack of any property interest in particular land. These restrictions shall continue in perpetuity and cannot be amended or canceled unless and until the Wake County Register of Deeds receives and records the written concurrence of the Secretary of DENR (or its successor in function), or his/her delegate. If any provision of this Declaration is found to be unenforceable in any respect, the validity, legality, and enforceability of the remaining provisions shall not in any way be affected or impaired.

It is the intention of the State of North Carolina and DENR that, to the extent allowed by law, the United States Environmental Protection Agency, Region 4 (USEPA), is a third party beneficiary of the Declaration, and, as such, has the authority to enforce these restrictions, to the extent such enforcement is allowed by law. It is expressly agreed that USEPA is not the recipient of a real property interest under this Declaration.

PERPETUAL LAND USE RESTRICTIONS

1. The Site shall be maintained in a grassed condition. Site maintenance shall be such as to preclude the growth of woody plant species (i.e., trees or bushes).

2. Activities necessary to maintain the Site security and structural integrity of the landfill at the Site are permitted.

3. Except as approved in writing by DENR or its successor in function, all other uses of the Site are prohibited, specifically including, but not limited to, the following:

   a. The Site may NOT be used or developed for child care centers, schools, parks or recreational activities, including athletic activities, agricultural or grazing purposes or for timber production, kennels, animal pens, or for riding clubs.

   b. NO alteration, disturbance or removal of the existing soil, landscape and contours shall occur other than erosion control measures without written approval of DENR or its successor in function.

   c. NO surface or underground water shall be used for any purpose. The installation of groundwater wells or other devices for access to groundwater for any purpose other than monitoring groundwater quality is prohibited without prior approval by DENR, or its successor in function.

   d. NO groundwater beneath the Site shall be used as a source of potable or irrigation water. The installation of groundwater wells or other devices for access to groundwater for any purpose other than monitoring groundwater quality is prohibited without prior approval by DENR, or its successor in function.

e. The Site shall NOT be used for mining, extraction of coal, oil, gas or any other minerals or non-mineral substances.

f. NO surface or subsurface native or fill earthen materials may be removed from the Site without the written permission of DENR or its successor in function.

4. Site security shall be maintained to effectively protect the Site from public access. Site access shall be controlled by the owner or owner's representative. All routine and special access to the Site shall be through the owner or the owner's representative. Site access for other than Site maintenance activities, shall be approved in advance by DENR, or its successor in function.

5. The owner of any portion of the Site shall submit a letter report, containing the notarized signature of the owner, in January of each year on or before January 31st, to DENR and USEPA, or their successors in function, confirming that this Declaration is still recorded in the Office of the Wake County Register of Deeds and that activities and conditions at the Site remain in compliance with the land use restrictions herein.

6. No person conducting environmental assessment or remediation at the Site, or involved in determining compliance with applicable land use restrictions, at the direction of, or pursuant to a permit or order issued by, the USEPA, DENR or its successor in function may be denied access to the Site for the purpose of conducting such activities.

7. The owner of any portion of the Site shall cause any lease, grant, or other transfer of any interest in the property to include a provision expressly requiring the lessee, grantee, or transferee to comply with this Declaration. The failure to include such provision shall not affect the validity or applicability of any land use restriction in this Declaration.

REPRESENTATIONS AND WARRANTIES

The owner of the Site hereby represents and warrants to the other signatories hereto:

that the owner of the Site has the power and authority to enter into this Declaration, to grant the rights and interests herein provided and to carry out all obligations hereunder;

that the owner of the Site is the sole owner of the Site;

that the owner holds fee simple to the Site subject to the Successor Addendum, attached hereto as Exhibit C, and the interests or encumbrances identified in Exhibit D, attached hereto; has provided to DENR the names of all persons that own an interest in or hold an encumbrance on the Site; and has notified such persons of the owner's intention to enter into this Declaration; and

that this Declaration will not materially violate or contravene or constitute a material default under

any other agreement, document or instrument to which the owner is a party or by which the owner may be bound or affected.

ENFORCEMENT

The above land use restrictions are an integral part of the remedy for the contamination at the Site. Adherence to the restrictions is necessary to protect public health and the environment. These land use restrictions shall be enforced by any owner, operator, or other party legally responsible for any part of the Site. The above land use restrictions may also be enforced by DENR through the remedies provided by any provision of law that is implemented or enforced by DENR or by means of a civil action, and may also be enforced by any unit of local government having jurisdiction over any part of the Site, and by USEPA to the extent allowed by law. Any attempt to cancel this Declaration without the approval of DENR or its successor in function shall constitute noncompliance with the USEPA's Federal Record of Decision for the Site, which has been approved by DENR, and shall be subject to enforcement by DENR and/or, to the full extent allowed by law, by USEPA. Failure by any party required or authorized to enforce any of the above restrictions shall in no event be deemed a waiver of the right to do so thereafter as to the same violation or as to one occurring prior or subsequent thereto.

FUTURE SALES, LEASES, CONVEYANCES AND TRANSFERS

When any portion of the Site is sold, leased, conveyed or transferred, pursuant to N.C.G.S. Section 143B-279.10(e) the deed or other instrument of transfer shall contain in the description section, in no smaller type than that used in the body of the deed or instrument, a statement that the real property being sold, leased, conveyed, or transferred is a Contaminated Site and a reference by book and page to the recordation of the Notice of Contaminated Site referenced in the second paragraph of this Declaration.

SIGNATURES FOLLOW ON NEXT PAGE

OWNER SIGNATURE

IN WITNESS WHEREOF, The State of North Carolina has executed this Declaration on this 5th day of May, 2009.

Signature: June W Michaux

Signatory's name printed: June W. Michaux

Signatory's title typed or printed: Director State Property Office
for the State of North Carolina

STATE OF NORTH CAROLINA

COUNTY OF Wake

I, Angela M. Gordon, a Notary Public, do hereby certify that June W. Michaux personally appeared before me this day and Declared that he/she is the Director of the State Property Office for the State of North Carolina and that by authority duly given, and as the act of the State of North Carolina, he/she has signed this Declaration.

WITNESS my hand and official seal this 5th day of May, 2009.

Angela M. Gordon
Notary Public

My Commission expires: 10-14-2013

[SEAL]

ANGELA M. GORDON NOTARY PUBLIC JOHNSTON COUNTY, NC

APPROVAL AND CERTIFICATION OF THE NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

The foregoing Declaration of Perpetual Land Use Restrictions is hereby approved and certified.

By: Jack Butler

Jack Butler, Chief
Superfund Section
Division of Waste Management
North Carolina Department of Environment and Natural Resources

NORTH CAROLINA
WAKE COUNTY

I, Holly A. Murray, a Notary Public of said County and State, do hereby certify that Jack Butler did personally appear and sign before me this the 13th day of May, 2009.

Holly A Murray
Notary Public

SEAL

HOLLY A. MURRAY
Notary Public
Wake County, NC
My Commission Expires 1/19/14

My Commission expires: Jan 19 2014

REGISTER OF DEEDS CERTIFICATION

The foregoing Declaration of Perpetual Land Use Restrictions is certified to be duly recorded at the date and time, and the Book and Page, shown on the first page hereof.

Register of Deeds for Wake County

By: _____
(signature)

_____
(type or print name and title)

6/8/06

NORTH CAROLINA STATE UNIVERSITY
HAZARDOUS WASTE SITE "LOT 86", EPA# NCD 980557656
OWNER: STATE OF NORTH CAROLINA

EXHIBIT A

COMMENCING AT AN N.C.G.S MONUMENT "TENNIS" LOCATED IN RALEIGH, NORTH CAROLINA HAVING N.C. GRID COORDINATES (NAD 83) IN FEET OF N=745,199.792 AND E=2,090,535.077. THENCE NORTH 70 DEGREES 23 MINUTES 06 SECONDS WEST FOR A DISTANCE OF 7168.37 FEET TO A POINT; SAID POINT BEING THE SOUTHERN MOST CORNER OF THE ABOVE REFERENCED PROPERTY AND THE POINT AND PLACE OF BEGINNING. THENCE NORTH 25 DEGREES 33 MINUTES 08 SECONDS WEST FOR A DISTANCE OF 3.22 FEET TO A POINT. THENCE NORTH 38 DEGREES 01 MINUTES 16 SECONDS WEST FOR A DISTANCE OF 43.59 FEET TO A POINT. THENCE NORTH 15 DEGREES 43 MINUTES 09 SECONDS WEST FOR A DISTANCE OF 20.15 FEET TO A POINT. THENCE NORTH 14 DEGREES 07 MINUTES 06 SECONDS WEST FOR A DISTANCE OF 173.07 FEET TO A POINT. THENCE NORTH 01 DEGREES 40 MINUTES 03 SECONDS EAST FOR A DISTANCE OF 108.78 FEET TO A POINT. THENCE NORTH 50 DEGREES 02 MINUTES 08 SECONDS EAST FOR A DISTANCE OF 38.45 FEET TO A POINT. THENCE SOUTH 70 DEGREES 17 MINUTES 40 SECONDS EAST FOR A DISTANCE OF 176.13 FEET TO A POINT; SAID POINT BEING NORTH 16 DEGREES 31 MINUTES 10 SECONDS WEST A DISTANCE OF 16.38 FROM AN EXISTING RIGHT-OF-WAY MONUMENT. THENCE SOUTH 78 DEGREES 05 MINUTES 43 SECONDS EAST FOR A DISTANCE OF 60.05 FEET TO A POINT. THENCE SOUTH 20 DEGREES 15 MINUTES 18 SECONDS EAST FOR A DISTANCE OF 75.10 FEET TO A POINT. THENCE SOUTH 07 DEGREES 25 MINUTES 22 SECONDS WEST FOR A DISTANCE OF 76.73 FEET TO A POINT. THENCE SOUTH 19 DEGREES 34 MINUTES 37 SECONDS WEST FOR A DISTANCE OF 29.48 FEET TO A POINT. THENCE SOUTH 56 DEGREES 16 MINUTES 33 SECONDS WEST FOR A DISTANCE OF 151.05 FEET TO A POINT. THENCE SOUTH 65 DEGREES 41 MINUTES 25 SECONDS WEST FOR A DISTANCE OF 67.89 FEET TO THE POINT AND PLACE OF BEGINNING. THIS AREA CONTAINS 65,628 SQUARE FEET (1.507 ACRES).

BK013561PG00821

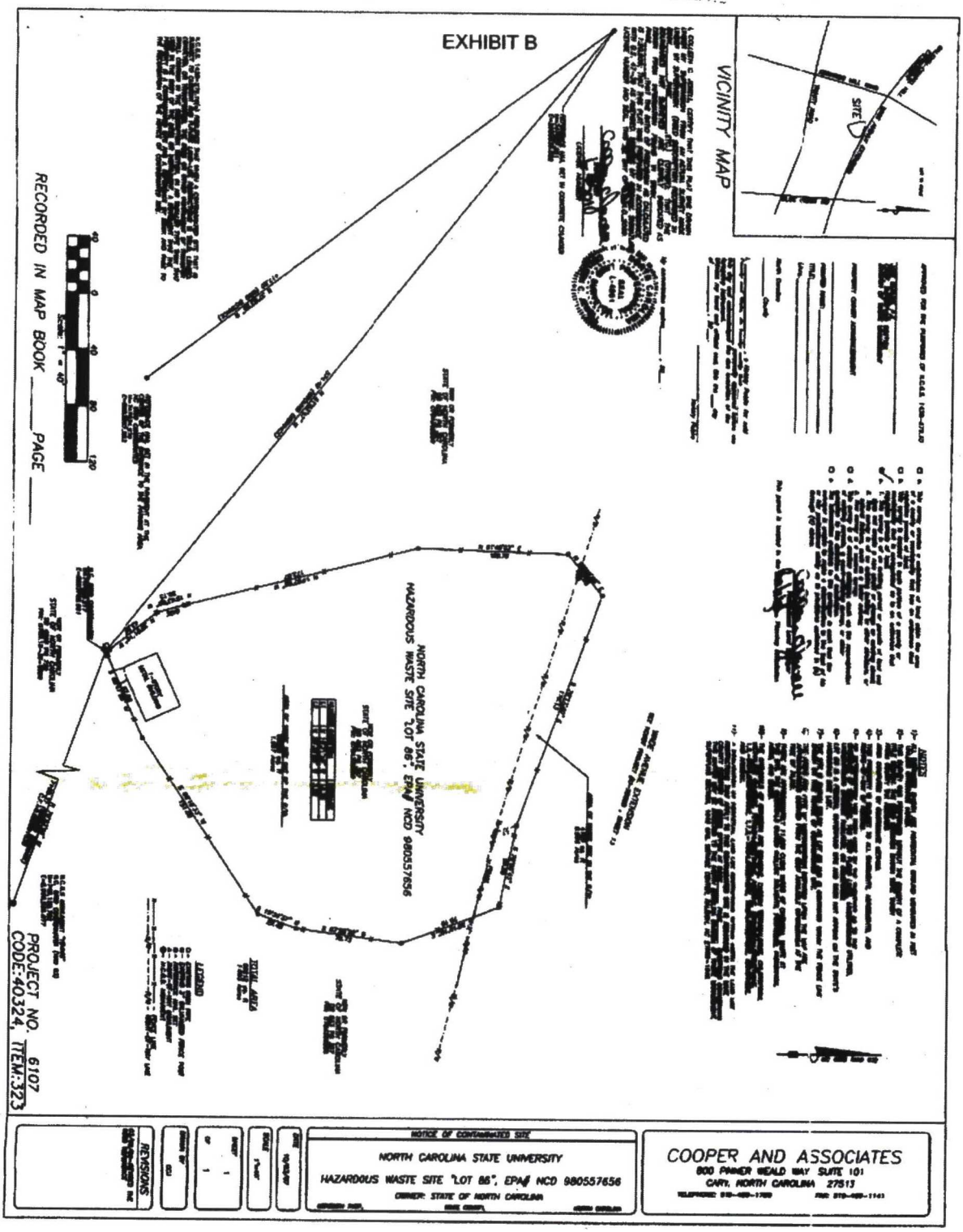


EXHIBIT C

STATE OF NORTH CAROLINA

SUCCESSOR ADDENDUM

COUNTY OF WAKE

The undersigned, Carolina Solar Carolina Solar Energy, LLC, hereinafter ("Grantee"), Grantee of the State of North Carolina, hereinafter ("State"), on behalf of North Carolina State University, hereinafter ("NC State") for all or a portion of property allocated to NC State, known as Lot 86, for good and valuable consideration, does hereby agree as follows:

1. Grantee agrees to provide the United States, including the United States Environmental Protection Agency, hereinafter ("EPA"), NC State, and the State, and their agencies, authorized officers, employees and representatives, and all other persons performing response actions under EPA oversight, an irrevocable right of access at all reasonable times, or at any time in the event of an emergency as determined by EPA, to Lot 86 for the purposes of performing and overseeing any response actions for the NC State Lot 86, hereinafter (the "Site"), including, but not limited to:
   a. Implementing, monitoring, overseeing response actions or operation and maintenance actions on the Site;
   b. Obtaining samples in connection with the Site;
   c. Verifying any data or information submitted to the United States or the State in connection with the Site;
   d. Conducting investigations relating to contamination or the release or threat of release of hazardous substances at or near the Site;
   e. Assessing the need for, planning, or implementing additional response actions at or near the Site;
   f. Determining NC State's compliance with the provisions of the Consent Decree between NC State and the United States concerning the Site; and,
   g. Determining whether Lot 86 is being used in accordance or inconsistent with the terms of this Successor Addendum.

2. Grantee recognizes that the implementation of response actions at the Site and at Lot 86 may interfere with Grantee's use of Lot 86. Grantee agrees to cooperate fully with EPA in the implementation of response actions at the Site and Lot 86, and to refrain from using Lot 86 in any manner that would interfere with or adversely affect the integrity or protectiveness of the response actions being and to be implemented on Lot 86 and the Site.

3. Grantee agrees that if it fails to comply with this Successor Addendum, the United States and NC State may take legal action to obtain access or to enforce, specifically and otherwise, the terms of this Successor Addendum and may recover costs incurred in taking such legal action from the Grantee.

4. Grantee agrees that this Successor Addendum shall be binding upon its heirs, executors, administrators, successors, legal representatives and assignees.

5. Definitions:

"CERCLA" means the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, 42 U.S.C. §9601, shall have the meaning set forth in that Section.

"EPA" means the United States Environmental Protection Agency and any successor departments, agencies or instrumentalities of the United States.

"Site" means NC State Lot 86 Superfund Site, located in Raleigh, North Carolina, and as further defined in the Record of Decision issued for the Site by EPA on September 30, 1986.

"United States" means the United States of America, including its departments, agencies and instrumentalities.

"NC State" means North Carolina State University at Raleigh.

This the 3 day of NOVEMBER, 2008.

CAROLINA SOLAR ENERGY, LLC,
a North Carolina limited liability company

By: _____
Richard Harkrader
Manager

EXHIBIT D

ENCUMBRANCES

1. North Carolina Department of Transportation ("NCDOT") right of way for Wade Avenue Extension. The right of way easement is recorded in Deed Book 6639, Page 0020 of the Wake County Registry.

2. Lease to Carolina Solar Energy, LLC. The lease is recorded in Deed Book 13010, Page 205 of the Wake County Registry.

BOOK:013561 PAGE:00813 - 00825

Yellow probate sheet is a vital part of your recorded document.
Please retain with original document and submit for rerecording.

Wake County Register of Deeds
Laura M. Riddick
Register of Deeds

This Customer Group
_____ # of Time Stamps Needed

This Document
_____ New Time Stamp
3 # of Pages

22.004-1/20/16

APPENDIX I
Summary Data Tables from 2013-2017

VOCs

Benzene Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW3	**63.4**	**58.4**	**14.1**	**30.5**	**35.2**	1 NC2L 1
MW8	-	-	-	**49.6**	-	
MW12S	**293**	**264**	**169**	**318**	-	
MW12I	**43.1**	-	**74.3**	**87.4**	**79.1**	
MW16S	-	-	2.38	-	-	
MW16I	**1.1**	**1.89**	**1.11**	**7.7**	(0.92)	
MW17I	**14,300**	**13,300**	**5,710**	**2,150**	**1,510**	
MW17D	**48.1**	-	-	**19.9**	-	
MW36S	-	-	-	**5.3**	**19.6**	
MW37	**4,060**	**4,020**	**8,200**	**9,470**	**18,100/ 11,400**	
MW42I	-	-	-	-	**3.1**	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

Bromodochloromethane Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW3	Did Not Analyze for this compound	-	**43.5**	**35.6**	**26.6**	1 CRQL NC2L 0.6
MW6		**1.53**	NS	NS	**18.0**	
MW8		-	**1.96**	-	-	
MW12S		-	**22.1**	-	-	
MW17I		-	**69.2**	**37.6**	**33.7**	
MW35S		-	-	-	**0.55**	
MW36S		**1.04**	-	-		
MW37		-	**242**	-	--	
MW41S		-	-	-	0.7	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

Carbon Tetrachloride Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW2	NS	**22**	NS	NS	-	1 CRQL 0.3
MW3	**184**	**162**	**275**	**264**	**132**	
MW6	NS	**1.61**	NS	NS	**94.9**	
MW8	**163**	**151**	**236**	**110**	**115**	
MW12S	**270**	**21**	**239**	**221**	**168**	
MW12I/ duplicate	**67.0/ 68.3**	-	**86.8/ 88.2**	**46.1/ 59.8**	**48.7/ 41.6**	
MW16S	**8.5**	**16**	**6.37**	-	-	
MW16I	0.94	-	-	**1.5**	-	
MS17S	-	-	0.548	-	0.52	
MW17I	**117**	-	**180**	**78.2**	**97.5**	
MW17D	**209**	**187**	**309**	**190**	**296**	
MW27	**13.8**	**5.79**	**16.2**	**9.4**	**8.9**	
MW35D	0.86	-	**1.95**	**2.1**	**4.9**	
MW36S	**14.4**	**15.7**	**35.0**	**31.0**	**44.1**	
MW36D	**4.0**	**4.22**	**5.62**	**5.5**	**7.9**	
MW37	-	-	**3.19**	-	-	
MW41D	**5.6**	**3.02**	**7.15**	**7.4**	**10.6**	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

Chloroform Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW2	NS	**4,730**	NS	NS	**5,740**	1 CRQL 70
MW3	**2,200**	**2,510**	**6,870**	**5,970**	**3,740**	
MW6	NS	**162**	NS	NS	**3,400**	
MW8	**7,520**	**7,930**	**10,800**	**5,800**	**2,960**	
MS11S	NS	477	NS	NS	NS	
MW12S	**12,800**	**10,300**	**12,000**	**12,500**	**7,700**	
MW12I/ duplicate	**4,350/ 4,430**	**4,290/ 4,190**	**7,060/ 6,980**	**4,850/ 5,370**	**5,340/ 5,130**	
MS13D	**4.9**	-	**4.01**	0.99	**1.7**	
MW16S	**328**	**901**	**111**	**1,930**	**5,690**	
MW16I	**27.5**	**40.5**	**18.6**	**106**	**23.6**	
MS17S	**3.7**	-	**13.7**	NS	**15.2**	
MW17I	**3,420**	**3,340**	**6,350**	**3,060**	**3,120**	
MW17D	**1,560**	**2,010**	**3,040**	**1,840**	**3,060**	
MW27	**35**	**32.4**	**33.8**	**22.4**	**21**	
MW35D	**6.7**	**8.93**	**17.0**	**18.3**	**41.0**	
MW36S	**272**	**356**	**706**	**928**	**1,510**	
MW36D	**148**	**242**	**315**	**337**	**516**	
MW37	**47,400**	**44,200**	**10,000**	**102,000**	**168,000**	
MW41S	**1.4**	NS	0.511	NS	**4.0**	
MW41I	**1.1**	NS	**1.52**	NS	**1.6**	
MW41D	**19.7**	**20.8**	**37.5**	**35.3**	**50.9**	
MW42S	**1.7**	-	**1.75**	-	**2.5**	
MW42I	0.56	-	**3.3**	**2.3**	**4.4**	
MW43S	**6.4**	-	**21.2**	**17.7**	**22.3**	
MW43D	**3.5**	-	**4.73**	**3.9**	**5.2**	
MW47	**9.6**	**11.0**	**22.0**	**20.0**	**24.5**	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

1,2-Dichloropropane Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW2	NS	**7,390**	NS	NS	**7,870**	1 CRQL 0.6
MW3	**5,350**	**5,380**	**5,700**	**6,610**	**2,420**	
MW6	NS	**86.4**	NS	NS	**565**	
MW8	**780**	**853**	**823**	**854**	**160**	
MS11S	-	**4.91**				
MW12S	**19,300**	**19,300**	**20,300**	**18,400**	**16,500**	
MW12I/ duplicate	**154/ 157**	**152/ 146**	**208/ 205**	**174/ 185**	**169/ 151**	
MS13D	**3.5**	**3.02**	**2.1**		0.86	
MW16S	**82.6**	**140**	**198**	**239**	**611**	
MW16I	**41.4**	**46.2**	**45.2**	**66.5**	**83**	
MS17S	-	NS	0.96	NS	**1.4**	
MW17I	**824**	**894**	**880**	**410**	**291**	
MW17D	**159**	**188**	**197**	**217**	**98.8**	
MW27	**12.6**	**28.5**	**19.4**	**17.1**	**15.5**	
MW35D					0.64	
MW36S	**86.0**	**129**	**204**	**392**	**539**	
MW36D	**5.5**	**106**	**11.1**	**13.7**	**16.8**	
MW37	**2,350**	**2,620**	**3,320**	**3,180**	**3,640**	
MW41S	-					
MW41I	-					
MW41D	**1.5**	**2.25**	**2.12**	**2.6**	**4.8**	
MW42S						
MW42I	**3.6**	**3.79**	**5.92**	**9.2**	**11.2**	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

Methylene Chloride Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW2	NS	-	NS	NS	**2,530**	5 NC2L 5
MW3	-	-	**310**	**414**	**489**	
MW6	NS	-	NS	NS	**68.9**	
MW8	**95.5**	-	**23.7**	**47.8**	-	
MW12S	**1,060**	-	**873**	**1050**	**1690**	
MW12I/ duplicate	-	-	**112/ 113**	**119/ 108**	**443/ 445**	
MW17I	-	-	**248**	**133**	**144**	
MW36S	-	-	**6.5**	**23**	-	
MW37	**6,210**	**5,760**	**11,500**	**14,800**	**32,400**	
MW42I	**2,190**	-	-	-	-	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

Tetrachloroethene Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW2	NS	**291**	NS	NS	-	1 CRQL 0.7
MW3	**30.8**	-	**84.6**	**52.7**	**35.2**	
MW6	NS	**4.21**	NS	NS	**64.2**	
MW8	**135**	-	**146**	**104**	**72.4**	
MS11S	-	**10.9**	-	-	-	
MW12S	**164**	-	**123**	**126**	-	
MW12I/ duplicate	**137/ 128**	**130/ 96.6**	**159/ 163**	**93.2/ 106**	**119/ 108**	
MW16S	**96.9**	**42.6**	**153**	**177**	**333**	
MW16I	**7.7**	**22**	**12.6**	**17.4**	**1.6**	
MW17I	-	-	**12.7**	-	-	
MW17D	**55.1**	**74.3**	**90.2**	**52.6**	**52.5**	
MW27	**2.9**	-	**2.09**	**1.3**	1.0	
MW36S	**4.7**	**7.98**	**10.1**	**8.7**	**14.9**	
MW36D	0.62	**1.06**	0.936	**1.5**	-	
MW37	**295**	**302**	**353**	-	-	
MW41D	0.65	-	0.775	0.9	**1.3**	
MW42I				**1.1**		

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

1,1,2-Tricloroethane Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW3	-	-	**12.2**	**20**	-	1 CRQL (NA)
MW8	-	-	0.503	**12**	-	
MW12S	**1170**	**1180**	**2250**	**1930**	**2070**	
MW12I/ duplicate	**66.6/ 68.1**	**-/ 65.9**	**89.1/ 90.6**	**72.6/ 73.5**	**70.7/ 63.7**	
MW16S	**7.8**	**20.7**	**49.1**	**199**	**471**	
MW16I	0.87	**1.48**	0.917	**3.3**	0.57	
MW17I	-	-	**30.6**	**17.4**	**16**	
MW17D	**32.8**	**35.4**	**40.4**	**51**	**30.4**	
MW37	-	-	**9.13**	-	-	
MW41D	-	-	-	0.51	0.58	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

Trichloroethene Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW2	NS	**239**	NS	NS	-	2.8 NC2L 2.8
MW3	**503**	**539**	**854**	**944**	**472**	
MW6	NS	**4.65**	-	-	**80.6**	
MW8	**90.6**	-	**90**	**63.5**	**32.9**	
MS11S	-	**6.28**	-	-	-	
MW12S	**320**	**275**	**375**	**310**	**299**	
MW12I/ duplicate	**111/ 118**	**-/ 86.3**	**137/ 138**	**94.4/ 106**	**93.4/ 87.6**	
MW16S	**42.4**	**40.3**	**126**	**161**	**412**	
MW16I	**6.3**	**14.7**	**8.82**	**15.6**	**1.3**	
MW17I	**260**	**245**	**243**	**134**	**127**	
MW17D	**107**	**134**	**162**	**107**	**101**	
MW27	**10.6**	**10.4**	**9.95**	**7.8**	**6.9**	
MW36S	**16.6**	**23**	**44.3**	**68.3**	**95.3**	
MW36D	1.5	2.3	**2.85**	**3.8**	**4.9**	
MW37	**744**	**600**	**942**	**1100**	**1580**	
- Indicates concentration Non-Detect or below the reporting limit **Bold** indicates above RG Shaded indicates a concentration above the NC2L NS- well not sampled						

Inorganic Compounds

Arsenic Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG/ Basis for RG/ Current NC2L**
MW16S				**68**		10 CRQL 10
MW36S	**28.8**	**51.5**	-	-	-	
MW36D	-	-	**31.2**	**35.9**	**36.3**	
- Indicates concentration Non-Detect or below the reporting limit **Bold** indicates above RG Shaded indicates a concentration above the NC2L NS- well not sampled (data) – parentheses indicates the concentration detected below the NC2L						

Manganese Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Basis for RG Current NC2L**
MW2	NS	**29,100**	NS	NS	**47000**	370 Background 50
MW3	**3,300**	**3,210**	**2,360**	**6,440**	**4,360**	
MW6	NS	**1,770**	NS	NS	**2,280**	
MW8	56.5	30.2	35.9	27.7	11.8	
MS11S	-	**1,620**	-	-	-	
MW11I	161	171	209	176	213	
MW12S	35,800	**27,000**	**31,000**	**37,800**	**22,500**	
MW12D	90	65.3	115	124	-	
MW12I/ duplicate	93.5/ 94.1	36/ 31.3	98.2/ 103	84.2/ 81.8	114/ 121	
MS13S	**1,060**	**966**	-	-	-	
MS13D	59.9	53.6	56.2	56.5	25.2	
MW16S	**13,400**	**7,730**	**9,630**	**23,600**	**15,800**	
MW16I	176	205	190	98.6	94.1	
MS17S	220	135	149	126	116	
MW17I	124	135	149	126	116	
MW27	48.9	54.2	54	239	120	
MW35D	-	180	-	-		
MW36S	**2,600**	**2,970**	**3,220**	**3,480**	**4,720**	
MW37	**32,500**	**37,800**	**47,300**	**48,300**	**49,200**	
MW38	66.2	55.4	64.6	-	91.8	
MW41S	147	321	115	214	72	
MW41I	6	77.2	-	-	13.1	
MW41D	365	156	224	50.8	62	
MW42S	146	289	61.7	78.8	149	
MW42I	352	321	352	329	277	
MW43S	102	**731**	36.4	9.1	34	
MW46	61.2	68.7	121	103	84	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

Compound Not Identified in the ROD but with exceedances above NC 2L in multiple wells

1,4-Dioxane Concentrations (µg/L)						
	2017	**2016**	**2015**	**2014**	**2013**	**RG Current NC2L**
MW2	NS	44.3	NS	NS	80	No RG established. NC2L is 3
MW3	126	42	486	620	610	
MW6	NS	18.8	NS	NS	410	
MW8	2.3	4.14	3.86	7.2	4.4	
MS11S	NS	858	1	NS	NS	
MW11I	119	82.9	110	84	440	
MW12S	111	102	58.8	150	30	
MW12D	-	-	-	7.3	4.6	
MW12I/ duplicate	11,700/ 11,200	22,100/ 11,700	18,300/ 15,400	10,000/ 13,000	19,000/ 16,000	
MS13S	-	5.12	-	-	-	
MS13D	-	-	-	7.5	-	
MW16S	23.4	14.4	32.6	100	180	
MW16I	2380	3620	3500	1400	550	
MS16D	120	155	387	550	130	
MW17I	232	449	468	250	260	
MS17D	13.7	20.1	14.4	19	32	
MW27	18.2	-	-	140	-	
MW36D	2.1	5.38	-	3.4	4.6	
MW36S	-	-	5.67	25	34	
MW37	4,310	8,820	10,300	10,000	18,000	
MW38	-	-	-	4.2	-	
MW42S	10.2	-	-	-	-	
MW42I	3,140	2,660	3,520	760	1,400	
MW47	-	-	19.6	-	-	

- Indicates concentration Non-Detect or below the reporting limit
Bold indicates above RG
Shaded indicates a concentration above the NC2L
NS- well not sampled

APPENDIX J
2018 Remedial Action Progress Report

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REMEDIAL ACTION PROGRESS REPORT: JANUARY THROUGH DECEMBER 2017

Lot 86 Farm Unit No. 1 Site
North Carolina State University
Raleigh, North Carolina

Prepared For:

North Carolina State University
Environmental Health and Safety Center
Raleigh, North Carolina 27695

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January 29, 2018

Piedmont Geologic is a professional corporation licensed to practice Geology (C-216) in North Carolina.

PROFESSIONAL CERTIFICATION

The *Remedial Action Progress Report: January through December 2017* for the North Carolina State University – Lot 86 Farm Unit No. 1 site has been prepared under the responsible charge of the following Professional Geologist registered in the State of North Carolina.

Jonathan D. Murphrey
Printed Name

Signature

January 29, 2018
Date

Seal

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1.0 INTRODUCTION AND EXECUTIVE SUMMARY

This document presents a Remedial Action Progress Report (RAPR) for the North Carolina State University (NCSU) – Lot 86 Farm Unit No. 1 (Lot 86) site in Raleigh, North Carolina covering the period from January through December 2017. A groundwater extraction (GWE) system, for remediation of dissolved-phase groundwater chemicals of concern (COCs), was started at the site in September 2006 in accordance with the September 1996 Record of Decision (ROD) between NCSU and the U.S. Environmental Protection Agency (EPA).

This document presents site groundwater remediation objectives, GWE system specifications, GWE system monitoring and maintenance procedures, GWE operation statistics for the reporting period, groundwater monitoring procedures and results, and an evaluation of GWE system performance. Additional site background information is provided in the *Remedial Action Progress Report: September 2006 through December 2008*, prepared by Piedmont Geologic (January 2009). Summaries of GWE system operation and performance from startup in September 2006 through December 2017 are presented as follows.

Summary of GWE System Operation

GWE system startup date	September 26, 2006
Reporting period	Jan. 1 – Dec. 31, 2017
GWE system ON-time during reporting period	7,588 hours
GWE system OFF-time during reporting period	1,172 hours
GWE system ON-percentage during reporting period	87%
Total GWE system ON-time since startup	70,987 hours
Total GWE system ON-percentage since startup	72%
Volume of groundwater recovered/treated during reporting period	2,769,302 gallons
Mean groundwater recovery/treatment rate during reporting period	6.1 gpm
Total volume of groundwater recovered since GWE-system startup	17,792,929 gallons
Estimated mass of dissolved-phase VOCs extracted during reporting period	291.4 lbs
Estimated mass of dissolved-phase VOCs extracted since system startup	2,504.7 lbs

VOC = volatile organic compounds

Site groundwater potentiometric-surface contour maps generated for 2017 indicate substantial groundwater drawdown and capture zones for the shallow and intermediate aquifer zones. Comparison of 2005 and 2017 groundwater chloroform isoconcentration contour maps indicates substantial apparent shrinkage of the groundwater chloroform distribution in the shallow aquifer zone, particularly in the northern and southern site areas, over the duration of GWE-system operation thus far. Comparisons of 2005 and 2017 groundwater chloroform isoconcentration contour maps for the intermediate aquifer zone (and to some extent, the deep aquifer zone) indicate possible expansion of the groundwater chloroform distributions, although a precise determination of chloroform-distribution changes over time is limited by the lesser spatial coverage of monitoring wells for these aquifer zones relative to the shallow aquifer zone.

Graphs of groundwater COC concentrations versus time indicate generally decreasing or fluctuating trends in groundwater COC concentrations for most site monitoring wells with continued GWE system operation. Most site monitoring wells for which slightly increasing or generally increasing trends have been observed over time are screened within the shallow and intermediate aquifer zones.

In order to address concerns regarding spatial coverage of monitoring wells for the intermediate and deep aquifer zones, additional monitoring wells will be installed at the site during 2018. No other modifications to the site groundwater remediation/monitoring approaches are recommended.

2.0 SITE BACKGROUND INFORMATION

The site location and layout are presented in Figures 1 through 3. Site groundwater monitoring well construction details are listed in Table 1. A complete description of site background information, including site descriptions, historical waste disposal and management practices, regulatory history, site geological/hydrogeological characteristics, and findings of environmental site investigations are provided in the *Remedial Action Progress Report: September 2006 through December 2008*, prepared by Piedmont Geologic (January 2009).

3.0 SUMMARY OF GROUNDWATER REMEDIATION OBJECTIVES

Site groundwater remediation activities were implemented in 2006 in accordance with the 1996 Record of Decision (ROD) issued by the EPA. Groundwater remediation objectives established in the ROD are:

- Prevent COC migration to surface water to keep surface water COC levels from exceeding Ambient Water Quality Criteria (AWQC).
- Control future releases of COCs to ensure protection of human health and the environment (Superfund Amendments and Reauthorization Act (SARA) Section 121[d]).
- Permanently and significantly reduce mobility, toxicity, or volume of characteristic hazardous waste with treatment (SARA Section 121[d]).

Remedial Action Objectives for Groundwater

COC	Remediation Level (µg/L)	Basis
Benzene	1	NC groundwater standard (1)
Carbon tetrachloride	1	Contract Quantitation Limit (CRQL)
Chloroform	70	NC groundwater standard (1)
Methylene chloride (DCM)	5	NC groundwater standard (1)
Tetrachloroethene (PCE)	1	Contract Quantitation Limit (CRQL)
Acetone	700	NC groundwater standard (1)
Bromodichloromethane	1	Contract Quantitation Limit (CRQL)
1,2-Dichloropropane	1	Contract Quantitation Limit (CRQL)
1,1,2-Trichloroethane	1	Contract Quantitation Limit (CRQL)
Trichloroethene (TCE)	2.8	NC groundwater standard (1)
Manganese	370	Background concentration
Arsenic	10	Contract Quantitation Limit (CRQL)

(1) 15A NCAC 2L .0202 in 2006.

Cleanup goals for the site are the North Carolina groundwater quality standards defined in Title 15A NCAC 2L .0202 (2L Standards). For COCs with groundwater standards less than the laboratory practical quantitation limits (PQL), the PQL constitutes the groundwater cleanup goal. The site background groundwater concentration for manganese is the groundwater cleanup level for that compound.

4.0 GROUNDWATER EXTRACTION SYSTEM DESCRIPTION

The generalized layouts of the GWE wells and groundwater treatment system are shown in Figure 3 and Appendix A. A summary of the GWE system process and design is provided as follows.

- A conservative GWE system recovery and treatment design flow rate of 20 gallons per minute was selected based on the results of the pre-design pump test and groundwater flow modeling.
- The GWE system incorporates thirteen shallow GWE wells and four deep GWE wells. The shallow GWE wells are constructed of 4-inch inside diameter (I.D.), stainless-steel, well screen/casing and are installed to depths ranging from approximately 50 to 80 feet below grade (approximately 378 to 345 feet NGVD). The deep GWE wells are constructed of 4 inch I.D., stainless-steel, well screen/casing and are installed to depths ranging from approximately 118 to 152 feet below grade (approximately 310 to 265 feet NGVD), with outer 6-inch Schedule 40 PVC casings grouted into the top of bedrock. Each GWE wellhead is enclosed within a concrete vault that houses electrical and plumbing connections.
- Pumping depths of 380 feet NGVD for shallow GWE wells and 370 feet NGVD for deep GWE wells were selected to maximize groundwater flow from deeper to shallower aquifer zones.
- Contaminated groundwater is pumped from the GWE wells using dedicated, stainless-steel, variable-frequency drive, electric submersible pumps (Grundfos Redi-Flo3). Pump controls are located within a control panel located outside the groundwater treatment building. The pump speed (which controls groundwater recovery rate) is set manually for each well at the pump control panel. Each pump contains intrinsic protections that prevent the pump from running dry.
- Individual pump recovery lines manifold into a 2-inch I.D., high-density polyethylene (HDPE) header line that conveys recovered groundwater to the treatment building.
- Upon entering the treatment building, the GWE well header discharges to a 500-gallon stainless steel process water tank. The process water tank incorporates ultrasonic level controls to provide for shut down of the system during high-level and low-level conditions. The effluent tank is controlled by a variable speed drive so that transfer-pump rates may be programmed to match influent groundwater recovery rates.
- Recovered groundwater is pumped from the process water tank through two bag filters plumbed in series (skid #1) to remove particulate matter from the raw groundwater influent.
- After passing through the skid #1 bag filters, influent groundwater is discharged to two, 10 gpm, four-tray, low-profile air strippers plumbed in parallel for dissolved volatile organic compound (VOC) removal. The air stripper sumps incorporate high-level and low-level controls that turn-on and turn-off, respectively, the air stripper sump transfer pumps.

- Treated groundwater effluent from the air stripper sumps is pumped to the City of Raleigh sanitary sewer system through a 6-inch I.D. PVC pipe in accordance with a City Industrial User Pretreatment Permit (IUP).

The original GWE system design and operation from September 2006 through January 2012 included the following additional groundwater treatment processes after passing through the skid #2 bag filters. As explained below, these were taken off line permanently starting in June 2012.

- Treated groundwater effluent from the air stripper sumps was pumped to a 300-gallon intermediate tank. The intermediate tank incorporated high-level and low-level controls that turned on and turn off, respectively, the skid #2 transfer pump.
- Treated groundwater effluent was pumped from the intermediate tank through two bag filters plumbed in series (skid #2) to remove particulate matter generated from the air stripper treatment
- After passing through the skid #2 bag filters, treated groundwater effluent from the air strippers passed through two, 500-gallon, granular activated carbon (GAC) filter canisters plumbed in series for removal of organic compounds remaining following air stripping.
- After passing through the GAC filters, the treated groundwater effluent passed through two, 500-gallon, ion selective resin (i.e., ion exchange) (ISR) filter canisters plumbed in series for removal of mercury and other inorganics.
- After passing through the ISR filters, the final treated groundwater effluent discharged to a 350-gallon effluent tank. The effluent tank incorporates high-level and low-level controls that turn on and turn off, respectively, the effluent tank transfer pump.
- Final treated groundwater effluent was pumped from the effluent tank to the surface water discharge point through a 2-inch I.D. HDPE discharge pipe in accordance with a site National Pollution Discharge Elimination System (NPDES) permit.

The former 2,000-gallon capacity carbon-steel process water tank was replaced with a 500-gallon capacity stainless-steel tank in October-November 2016 (discussed further in Section 5.4).

As explained in the January-December 2012 RAPR (dated March 1, 2013), the site GWE system was shut down from January 25 through May 31, 2012 in response to recurring non-compliant results of chronic toxicity testing for GWE-system effluent groundwater samples collected as required under a former site NPDES discharge permit. A City of Raleigh IUP was issued in May 2012 to allow for the discharge of treated groundwater from the GWE system to the City sanitary sewer system. Following the restart of the GWE system on June 1, 2012, treated groundwater was stored in a 21,000-gallon capacity on-site holding tank, which was offloaded on a weekly basis and discharged to a City of Raleigh sanitary sewer manhole

located near the site, in accordance with the IUP. This process continued through April 2013, at which time the GWE system was shut down again. A second City of Raleigh IUP was issued in May 2013 to allow for continuous discharge of treated groundwater from the GWE system directly into the City sanitary sewer system via an underground discharge pipe. The GWE system was restarted on May 15, 2013 and has since been operating in accordance with the new discharge scenario.

From system startup in September 2006 to June 2008, all seventeen GWE wells were in service. Upon receipt of results of laboratory analysis of May 2008 groundwater samples in early June 2008, it was realized that increased dissolved COC concentrations had been detected in groundwater samples collected from intermediate and deep monitoring wells compared to the previous (May 2005) groundwater samples, collected prior to startup of the GWE system. As a result, concerns arose that groundwater pumping from the deep GWE wells could result in unwanted migration of dissolved COCs from the shallow saprolite aquifer to the deeper saprolite aquifer and the bedrock aquifer. In response, deep GWE wells DRW-A, B, C, and D were taken out of operation on June 10, 2008 and have remained off since that time.

5.0 GROUNDWATER EXTRACTION SYSTEM MONITORING AND MAINTENANCE

5.1 Overview

System operation and maintenance was conducted during the reporting period in accordance with the *Operation and Maintenance Plan: Groundwater Extraction System,* dated August 21, 2014, prepared by Piedmont Geologic. Routine O&M activities included the following.

- Weekly system visits by the Operator in Responsible Charge (ORC), or backup ORC, to meet City of Raleigh IUP permit requirements and maintain the Groundwater Treatment System Log.
- Monthly sampling and analysis of GWE system effluent water (i.e., treated water) in accordance with the system NPDES and City of Raleigh permits.
- Monthly sampling and analysis of GWE system influent water (i.e., untreated water) for evaluation of recovery system efficacy.
- Remote monitoring of the system operation and onsite response to system upset conditions.
- Routine maintenance such as replacement of system bag filters.
- Quarterly collection and evaluation of groundwater potentiometric surface data from site monitoring wells.
- Quarterly sampling and analysis of shallow GWE wells for gross beta activity and tritium.

5.2 Weekly System Visits by Operator in Responsible Charge

In accordance with the system NPDES permit, weekly system visits were conducted during the reporting period by the ORC, or backup ORC, to inspect the GWE system treatment components and discharge point. The site visits also included visual inspection of all system equipment; recording of gauge and meter readings for pumps; air strippers, bag filters, and other components; checks for air and water leaks from system components; and inspection of the GWE system effluent water for floating solids, foam, or sheens.

5.3 Remote Monitoring of System Operation and Response to System Upset Conditions

The system telemetry unit (EOS ProControl model B2) was retrofitted in May 2014 to allow for remote communication with the unit via the internet, rather than a telephone landline. Prior to the upgrade, the telemetry unit was programmed to transmit reports via facsimile, while the retrofitted unit is programmed to transmit email reports to Piedmont Geologic personnel, as follows, using a standardized transmittal form.

- Daily (routine) reports: the telemetry system is programmed to automatically send a report email each morning (7 days per week) that shows a "snapshot" of system operating conditions and the current system effluent totalizer reading (i.e., total gallons of groundwater effluent discharged by system).
- Alarm (system upset) reports: alarm report emails are sent in response to system alarms or upsets, such as high-level conditions in sumps/tanks, low pressure or high pressure conditions in the air stripper, high-pressure conditions in filter vessels, and/or other system shutdown conditions.

Email reports were reviewed on a daily basis during the reporting period to determine the general operating condition of the system. The 24-hour average groundwater recovery and discharge rate was calculated each day using the daily system effluent totalizer reading. Logged operational data in the telemetry system was downloaded and reviewed for issues. When system issues were observed, NCSU was promptly notified and response measures were conducted.

Emails were reviewed upon receipt to determine the nature of the alarm and to develop an appropriate response action. The NCSU project manager was informed of alarm conditions within one business day of the alarm, and appropriate system maintenance and/or repairs were conducted.

5.4 Operation and Maintenance Activities

Routine O&M activities were conducted during the reporting period to optimize system on-time and performance, including the following.

- Weekly, or as-needed, changing of 50-micron bag filters in each of the two bag filter canisters.
- As-needed cleaning of air-stripper sump sight tubes and skid #1 and #2 flow meters.
- Floor-sump pump cleaning and adjustments.
- Equipment lubricating.
- Bi-annual cleaning of the process water tank (PWT) interior.
- Annual replacement of effluent flow meter/totalizer (factory calibrated).
- Bio-dispersant injection system inspection/cleaning (see Section 5.8).

5.5 Monthly GWE System Effluent and Influent Water Sampling/Analysis

Monthly sampling and laboratory analysis of groundwater treatment system effluent groundwater was conducted in accordance with the requirements of the site City of Raleigh IUP during the reporting period. Sampling activities were documented using the system log described above, and samples were analyzed by North Carolina certified laboratories. GWE system effluent monitoring and performance requirements for the City of Raleigh IUP are listed as follows.

GWE System Effluent-Groundwater Analyses and Discharge Limitations
(City of Raleigh Industrial User Pretreatment Permit)

	Discharge Limits		Monitoring Requirements	
Parameter	Monthly Average	Daily Maximum	Frequency	Sample Type
Flow	--	12,000 gpd	continuous	recording
pH	--	--	each discharge event	grab
Mercury	--	--	1/month	grab
Arsenic	--	--	1/2months	grab
Copper	--	--	1/2months	grab
Iron	--	--	1/2months	grab
Lead	--	--	1/2months	grab
Zinc	--	--	1/2months	grab
Manganese	--	--	1/2months	grab
Molybdenum	--	--	1/6months	grab
Selenium	--	--	1/6months	grab
Silver	--	--	1/6months	grab
Cadmium	--	--	1/6months	grab
Chromium	--	--	1/6months	grab
Nickel	--	--	1/6months	grab
Benzene	--	--	1/month	grab
Carbon Tetrachloroethene	--	--	1/month	grab
Toluene	--	--	1/month	grab
1,1,2,2-Tetrachloroethane	--	--	1/month	grab
Trichloroethene	--	--	1/month	grab
Chloroform	--	--	1/month	grab
1,2-Dibromoethane	--	--	1/month	grab
1,2-Dichloropropane	--	--	1/month	grab
Tetrachloroethene	--	--	1/month	grab
1,4-Dioxane	--	--	1/month	grab
Tritium	--	--	1/3months*	grab
Gross beta activity	--	--	1/3months*	grab

*Tritium and gross beta activity sampling/analysis is being conducted on a monthly basis, rather than quarterly.

Effluent pH analysis was conducted by Piedmont Geologic (NC Certification #5560). Gross beta activity and tritium analyses were conducted by Test America Laboratories, Inc. (Test America) of Earth City, Missouri (NELAP Certification #E87689), ESC Lab Sciences (ESC) of Mt. Juliet, Tennessee (NC

Certification #375), or Pace Analytical Services, LLC (Pace) of Huntersville, North Carolina (NC Certification #5342). The remaining analyses were conducted by ESC or Pace.

GWE system influent-groundwater (i.e., untreated water) samples were collected on a monthly basis in conjunction with the effluent groundwater sampling discussed above. The influent-groundwater samples were collected from a sample port on the influent water pipe prior to discharge into the process water tank. The samples were submitted to Test America, ESC, or Pace and analyzed for VOCs by EPA Method 8260 (ESC/Pace), gross beta activity by EPA Method 900.0 (Test America/ESC/Pace), and tritium by EPA Method 906.0 (Test America/ESC/Pace).

Duplicate GWE system influent- and effluent-groundwater samples were also collected on a monthly basis and provided to NCSU for in-house laboratory analysis of gross beta activity and tritium.

5.6 Quarterly Groundwater Potentiometric Surface Data Evaluation

Quarterly monitoring-well gauging events for measurement of groundwater levels were conducted during the reporting period in February, May, August, and November 2017. Groundwater level data are provided in Tables 2 through 5, respectively. Groundwater potentiometric surface contour maps for the shallow, intermediate, and deep aquifer zones were developed from the groundwater-level data. The maps were reviewed to evaluate performance of the GWE system in terms of containment and capture of the site groundwater COC plume.

5.7 Quarterly GWE-System Recovery Well Sampling and Analysis

Groundwater samples were collected from GWE-system shallow recovery wells on a quarterly basis during the reporting period, concurrent with monitoring-well gauging events in February, May, August, and November 2017. The groundwater samples were collected from sample ports located along discharge piping at the GWE wellheads while the submersible GWE recovery pumps were in operation. No samples were collected from GWE recovery wells RW-12 and RW-13 during the August 2017 GWE-well sampling event due to the recovery pumps being offline, pending replacement. The groundwater samples were submitted under chain of custody to Test America (February 2017 samples) or Pace (May, August, and November 2017 samples) and analyzed for gross beta activity by EPA Method 900.0 and tritium by EPA Method 906.0. Duplicate samples were also provided to NCSU for in-house laboratory analysis of gross beta activity and tritium. Summarized results of laboratory analysis (analyzed by Test America or Pace) for

groundwater samples collected from GWE wells in February, May, August, and November 2017 are provided in Tables 6 through 9, respectively.

5.8 GWE System Issues and Corrective Actions

The GWE system was shut down for an approximately 1-month period from August to September 2017 due to a pinhole leak that was discovered in the sump component of air stripper #2. A relatively low pumping rate for the air stripper #1 transfer pump prevented the continued operation of the GWE system utilizing only air stripper #1 (while air stripper #2 was down for repairs). Air stripper #2 was disassembled in late September 2017, and the sump component was removed and taken offsite for repairs (i.e., re-welding). In conjunction with this action, the transfer pump for air stripper #2 was moved to air stripper #1, replacing the damaged/defunct pump. At that time, operation of the GWE system resumed. The repaired sump for air stripper #2, along with a new transfer pump were installed in early October 2017.

Short-term (i.e., generally three days or fewer) GWE-system down time occurred periodically during the reporting period due to miscellaneous typical operational and maintenance issues, such as high-pressure conditions in bag filter canisters, power failures, and other miscellaneous conditions, all of which were addressed within relatively short time periods.

Recurring high-pressure conditions at the skid #1 bag filter canisters, which was a result of excessive bio-fouling of the bag filters, were observed in early 2017. In response, pilot testing of a bio-dispersant injection system, which consists of a chemical dosing pump and bio-dispersant solution (Analytix AN-975E), was conducted in March 2017. Following a successful 2-week pilot testing period, the bio-dispersant injection system was implemented as part of routine system operations. The dosing pump is plumed to discharge piping between the PWT and the PWT transfer pump, and the bio-dispersant is injected at a relatively low dosage (i.e., less than 30 parts per million) whenever the PWT transfer pump turns on.

Periods of downtime for submersible pumps in GWE wells RW-12 and RW-13 occurred from August to October 2017 and August to November 2017, respectively. The pumps were offline due to damaged and seized impellors, and the issues were addressed by installing new pumps in those wells. These issues did not cause any downtime for the GWE system as a whole.

6.0 GROUNDWATER EXTRACTION SYSTEM OPERATION

6.1 Operation Summary

The GWE well pumps were on for a total of approximately 7,588 hours and were off for a total of approximately 1,172 hours during the January through December 2017 reporting period, for a total on-time percentage of approximately 87%. The largest portion of GWE system downtime during the reporting period occurred during late August through late September 2017, and was due to the air stripper issues described above in Section 5.8.

A total of approximately 2,769,302 gallons of groundwater was recovered, treated, and discharged from January through December 2017, at an average groundwater recovery rate of approximately 6.1 gallons per minute (gpm). A total of approximately 17,792,929 gallons of groundwater has been recovered, treated, and discharged by the GWE system from system start up in September 2006 through December 2017. The average groundwater recovery rate during 2017 (6.1 gpm) was slightly lower than the average recovery rate for 2016 (6.6 gpm), but higher than the average recovery rate for 2015 (4.7 gpm).

6.2 GWE System Influent Monitoring Results and Mass Removal Calculations

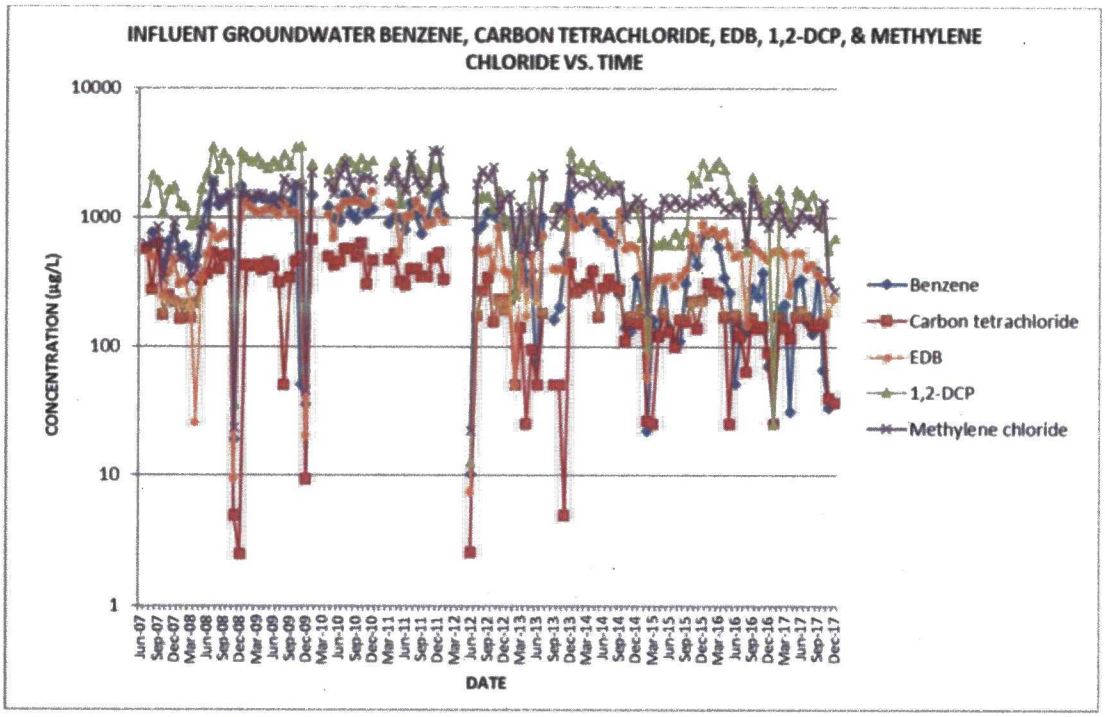
Results of laboratory analysis of monthly GWE system influent groundwater samples are tabulated in Table 10. The predominant groundwater COCs at the site in terms of frequency of detections and magnitude of concentrations are benzene, carbon tetrachloride, chloroform, 1,2-dibromoethane (EDB), 1,2-dichloropropane (1,2-DCP), 1,4-dioxane, and methylene chloride. A summary of laboratory analysis results for these COCs in monthly GWE system influent groundwater samples for 2017 is provided as follows.

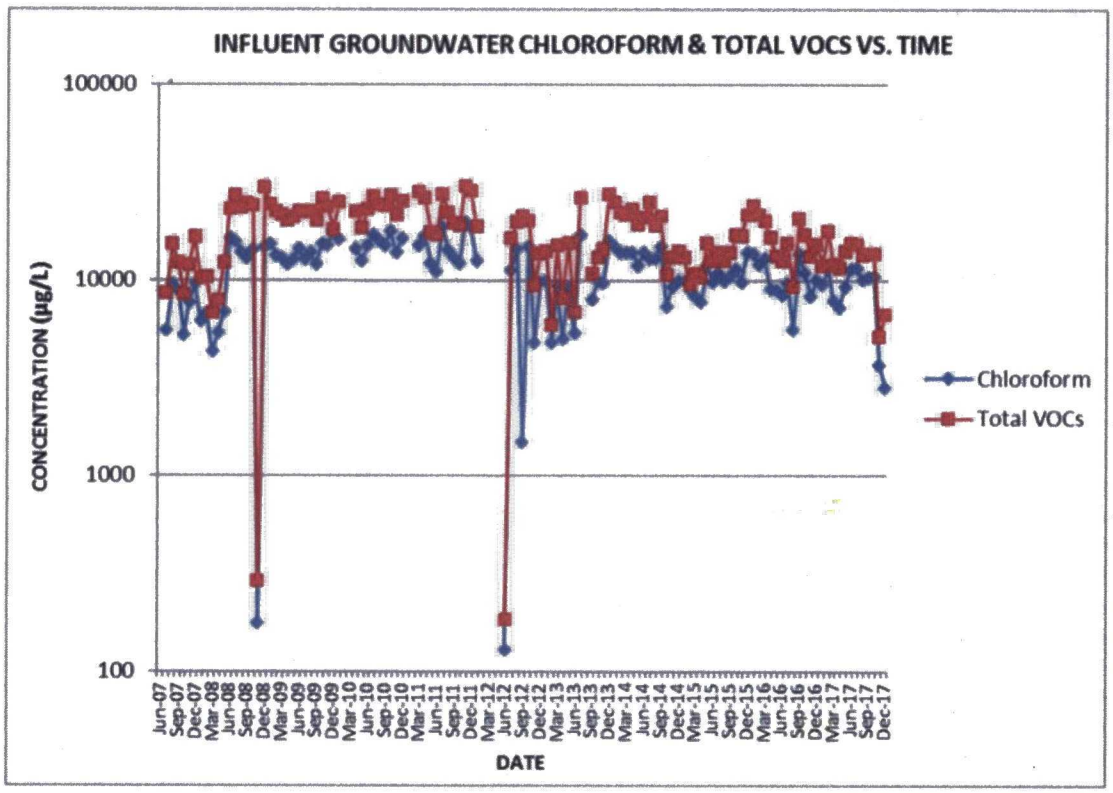
Summarized Results of Laboratory Analysis of GWE System Influent Samples

Sample Date	**1/17**	**2/17**	**3/17**	**4/17**	**5/17**	**6/17**
Analyte (µg/L)						
Benzene	98.3	187	212	30.8	307	330
Carbon tetrachloride	<50.0	168	137	115	170	186
Chloroform	9,550	11,700	7,900	7,280	9,360	11,500
EDB	531	559	511	246	523	529
1,2-DCP	<50.0	1,670	1,210	883	1,650	1,500
1,4-Dioxane	<5,000	1,300	<10,000	1,630	<2,500	<15,000
Methylene chloride	1,030	1,240 J	895	760	878	1,100
Total VOCs*	12,047	17,903	12,169	11,695	14,066	15,470
Sample Date	**7/17**	**8/17**	**9/17**	**10/17**	**11/17**	**12/17**
Analyte (µg/L)						
Benzene	154	125	381	65.6 J	33.5	35.9
Carbon tetrachloride	168	148	141	151	39.7	35.9
Chloroform	11,600	10,200	10,400	10,500	3,700	2,870
EDB	403	425	361	328	176	229
1,2-DCP	1,250	1,540	1,060	876	557	702
1,4-Dioxane	<15,000	<15,000	<15,000	<15,000	<3,750	2,260 J
Methylene chloride	983	973	846	1,290	320	268
Total VOCs*	15,278	13,613	13,797	13,731	5,151	6,737

* Total detected concentration of volatile organic compounds, including those analytes listed in Table 10 but not included in the above summary.
J Estimated concentration; above the method detection limit, but below the reporting limit.

Following are graphs of the GWE system effluent groundwater COCs listed above, plus total VOC concentrations, versus time. COCs not detected during any monthly analysis events are graphed at a value of one-half of the laboratory reporting limit. 1,4-dioxane is excluded from the graphs based on its inconsistent history of detections due to the relatively high laboratory detection limits for various samples.


INFLUENT GROUNDWATER BENZENE, CARBON TETRACHLORIDE, EDB, 1,2-DCP, & METHYLENE CHLORIDE VS. TIME
CONCENTRATION (µg/L)
10000
1000
100
10
1
DATE
Benzene
Carbon tetrachloride
EDB
1,2-DCP
Methylene chloride


INFLUENT GROUNDWATER CHLOROFORM & TOTAL VOCS VS. TIME
CONCENTRATION (µg/L)
100000
10000
1000
100
DATE
Chloroform
Total VOCs

The increase in influent groundwater VOC concentrations following June 2008 corresponds with the cessation of pumping of the deep GWE wells in June 2008. Influent groundwater VOC concentrations were, on average, generally lower in 2017 as compared to all previous reporting periods following June 2008.

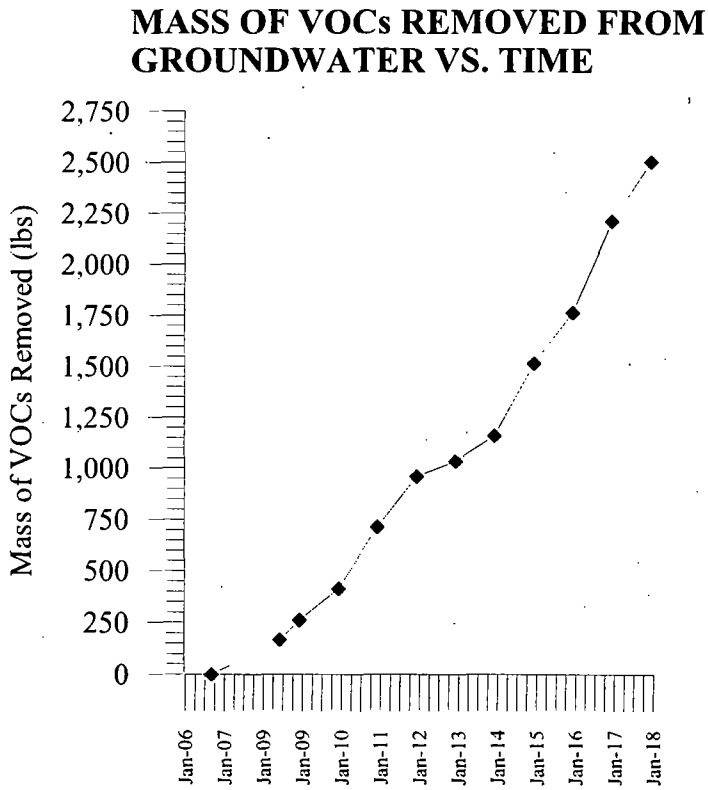
The estimated mass of total dissolved-phase VOCs removed from site groundwater through GWE during the reporting period is calculated as follows, along with VOC mass-removal calculations for previous reporting periods. The calculations incorporate the mean detected total VOC concentrations in GWE system influent samples collected during the reporting period.

Estimated Masses of VOCs Removed by the GWE System

	A	B	C	D	E	F
Period	**Mean Total Influent VOCs (mg/L)**	**Ground-water Volume (gal)**	**Conversion Factor (L/gal)**	**Conversion Factor (g/mg)**	**Conversion Factor (lbs/g)**	**Mass Removed (lbs)**
09/26/06 – 06/09/08	10.981	1,825,593	3.785	0.001	0.0022	166.9
06/10/08 – 12/31/08	25.529	446,717	3.785	0.001	0.0022	95.0
01/01/09 – 12/31/09	22.084	819,632	3.785	0.001	0.0022	150.7
01/01/10 – 12/31/10	23.964	1,511,460	3.785	0.001	0.0022	301.6
01/01/11 – 12/31/11	23.799	1,229,770	3.785	0.001	0.0022	243.7
01/01/12 – 12/31/12	15.027	611,262	3.785	0.001	0.0022	76.5
01/01/13 – 12/31/13	14.416	1,048,607	3.785	0.001	0.0022	125.9
01/01/14 – 12/31/14	19.664	2,166,110	3.785	0.001	0.0022	354.7
01/01/15 – 12/31/15	14.032	2,126,735	3.785	0.001	0.0022	248.5
01/01/16 – 12/31/16	16.685	3,237,614	3.785	0.001	0.0022	449.8
01/01/17 – 12/31/17	12.638	2,769,302	3.785	0.001	0.0022	291.4
					TOTAL	**2,504.7**

F = A x B x C x D x E

A graph of cumulative mass of dissolved-phase VOCs removed from groundwater since startup of the site GWE system in September 2006 is provided as follows.



Although the mean total groundwater VOC concentrations has decreased significantly since 2011, the total mass of groundwater VOCs recovered and the rate of groundwater VOC mass removed on an annual basis since 2014 has generally surpassed most prior annual periods due to substantial increases in the groundwater recovery rate since 2014.

6.3 GWE System Effluent Monitoring

Results of laboratory analysis of the monthly GWE system effluent (i.e., treated) groundwater samples during the reporting period were submitted to the City of Raleigh in monthly Discharge Monitoring Reports (DMRs), prepared in compliance with the site City of Raleigh IUP. GWE system effluent groundwater analysis results were in compliance with requirements of the IUP.

7.0 GROUNDWATER MONITORING

Performance of site remedial actions is based on results of site groundwater monitoring following startup of the GWE system in September 2006. Annual site groundwater sampling/analysis was initiated in 2008 in accordance with the following controlling documents.

- *Groundwater Sampling and Analysis Plan,* April 1, 2008, prepared by Piedmont Geologic;
- *Groundwater Sampling Quality Assurance Plan,* April 1, 2008, prepared by Piedmont Geologic.
- Letter from Piedmont Geologic to the North Carolina Department of Environment and Natural Resources (NCDENR), Superfund Branch, Waste Management Division, dated March 25, 2005, RE: *Request for Revisions to Laboratory QA/QC Requirements.*

The annual site groundwater sampling program includes the following 35 monitoring wells as specified in the August 2014 site *Groundwater Sampling Quality Assurance Plan* (QAP):

MW-2	MW-16I	MW-38
MW-3	MW-16D	MW-41S
MW-6	MW-17S	MW-41I
MW-8	MW-17I	MW-41D
MW-11S	MW-17D	MW-42
MW-11I	MW-27	MW-42I
MW-12S	MW-34DR	MW-43S
MW-12I	MW-35S	MW-43D
MW-12D	MW-35D	MW-45R
MW-13D	MW-36S	MW-46
MW-15	MW-36D	MW-47
MW-16S	MW-37	

Annual site groundwater sampling during the reporting period was conducted from August 7-15, 2017. Prior to groundwater sample collection, groundwater levels were measured in all site monitoring wells on August 7, 2017 using an optical interface probe, which distinguishes between non-aqueous phase liquid (NAPL) and water. August 2017 groundwater-level data are provided in Table 4. NAPL was not detected in any of the monitoring wells. Monitoring-wells MW-2, MW-6, MW-11S, and MW-15 were dry during the August 2017 groundwater sampling event. In accordance with the site QAP, monitoring-wells MW-8, RW-10, RW-6, and MW-13S, respectively, were substituted for those wells.

Groundwater samples were collected from the monitoring wells using either low-flow pumping or traditional purge-and-sample techniques in accordance with the site groundwater sampling and analysis plan. Groundwater quality indicators including pH, temperature, specific conductance, dissolved oxygen,

and turbidity were analyzed during monitoring-well purging using pre-calibrated, direct-read field meters equipped with a flow-through cell. All non-dedicated sampling equipment was cleaned prior to each use and in between well samplings in accordance with the procedures described in the site groundwater sampling/analysis work plan. Purge water and equipment cleaning wastewater was transferred to the site GWE system for treatment and discharge. The groundwater and QA/QC samples were submitted under chain of custody to Pace and analyzed for the following.

- VOCs by EPA Method 6200B;
- RCRA metals by EPA Method 6020 and 7470A;
- 1,4-Dioxane by EPA Method 8260B-SIM;
- Gross beta activity by EPA Method 900.0; and
- Tritium by EPA Method 906.0.

Duplicate groundwater samples were collected and provided to NCSU for in-house laboratory analysis of gross beta activity and tritium. Monitoring-well MW-16S contained an insufficient volume of groundwater for gross beta activity and tritium analyses by either Pace or NCSU.

Results of field and laboratory analysis of August 2017 groundwater samples are summarized in Tables 11 through 13. Trends in groundwater COC concentrations and distributions are discussed in Section 8.0.

8.0 PERFORMANCE AND EFFICACY OF SITE REMEDIAL ACTIONS

Performance and efficacy of site remedial actions are evaluated through examinations of the containment and capture of the site groundwater COC plume and reductions of site groundwater COC concentrations. Evaluation of plume containment and reduction is based on: 1) comparison of groundwater potentiometric-surface contour maps and COC isoconcentration contour maps prepared for data collected prior to startup of the GWE system to maps prepared for data collected following startup of the GWE system; and, 2) trend analysis of groundwater COC concentrations versus time for individual site monitoring wells.

8.1 Comparison of Groundwater Potentiometric-Surface Contour Maps and COC Isoconcentration Contour Maps

Groundwater drawdown/capture zones and COC concentration distributions are evaluated through site groundwater modeling completed using Surfer 8® contouring software (Golden Software, Inc.) The following data sets were incorporated into the groundwater models:

1. May 2005 groundwater potentiometric-surface data for the shallow, intermediate, and deep aquifer zones.
2. May 2005 groundwater chloroform-concentration data for the shallow, intermediate, and deep aquifer zones.
3. February 2017, May 2017, August 2017, and November 2017 groundwater potentiometric-surface data for the shallow, intermediate, and deep aquifer zones.
4. August 2017 groundwater chloroform-concentration data for the shallow, intermediate, and deep aquifer zones.

Data sets 1 and 2 represent conditions prior to startup of the site GWE system in September 2006. Data sets 3 and 4 represent conditions during the 2017 reporting period, with the monitoring-well potentiometric-surface data being collected with the GWE system in operation (i.e., under pumping conditions). Groundwater modeling output is provided in Appendix B.

May 2005 groundwater potentiometric-surface contour maps (Appendix B-1) indicate that groundwater flow under non-pumping conditions is towards the west-northwest over relatively shallow potentiometric-surface gradients of around 0.03 ft/ft. Comparison of the May 2005 potentiometric-surface contour maps with the corresponding 2017 maps (Appendix B-1) indicates groundwater drawdown in the shallow and intermediate aquifer zones in response to pumping, generally in the areas of GWE wells RW-1, RW-2,

RW-3, RW-4, RW-9, RW-10, RW-11, and RW-12 for the shallow and intermediate aquifer zones. Comparison of the May 2005 and 2017 potentiometric-surface contour maps for the deep aquifer indicate similar potentiometric-surface contour patterns. However, some apparent groundwater drawdown, possibly attributable to GWE system operation, was observed in the areas of monitoring-wells MW-13D (May 2017), MW-16D (May and August 2017), MW-17D (February, May, August, and November 2017), MW-35D (February 2017), MW-36D (February 2017), and MW-38 (May and November 2017). The drawdown and capture zones observed in 2017 are relatively similar to those observed in 2014-2016, and are much more pronounced as compared to years prior to 2014. This is attributed to the increased flow rates of the GWE system and an increase in GWE-system time-on percentages, both the result of a more continual operation following tie-in of the GWE-system effluent line to the City of Raleigh sanitary sewer system in May 2013.

Comparison of May 2005 and August 2017 groundwater chloroform isoconcentration contour maps (Appendix B-2) indicates substantial apparent lateral shrinkage of the groundwater chloroform distribution over time in the shallow aquifer zone, particularly in the northern and southern site areas. Comparison of May 2005 and August 2017 chloroform isoconcentration contour maps for the intermediate aquifer zone indicates possible lateral expansion of the groundwater chloroform distribution over time in the western site area, based on increased groundwater chloroform concentrations in monitoring-well MW-17I. Comparison of May 2005 and August 2017 maps for the deep aquifer zone indicates a similar groundwater chloroform distribution, with a possible slight lateral expansion towards the southeast.

Previous RAPRs have discussed possible lateral expansions of the groundwater chloroform distribution in the deep aquifer zone over time, towards the southeast and northeast or northwest directions. These observations have generally been based on increased groundwater chloroform concentrations observed in monitoring-wells MW-36D, MW-41D and MW-47. However, substantial decreases in groundwater chloroform concentrations have been observed in MW-36D following 2009, coinciding with taking deep GWE wells DRW-A, B, C, and D out of operation in June 2008. In addition, an apparent decreasing trend in groundwater chloroform concentrations has been observed for MW-41D and MW-47 following 2013, and groundwater chloroform concentrations in these wells have remained below the North Carolina groundwater standard. A more precise determination of groundwater chloroform distributions over time for the intermediate and deep aquifer zones is limited by the lesser spatial monitoring-well coverage for these aquifer zones relative to the shallow aquifer zone.

8.2 Trend Analysis of Site Groundwater COC Concentrations

Graphs of groundwater COC concentrations versus time for site monitoring wells are provided in Appendix C. The graphs include site monitoring wells that are part of the current groundwater monitoring program and from which groundwater samples since 2002 have had multiple detected COC concentrations on more than one occasion. Following are a summary of detected groundwater chloroform concentrations between May 2005 and August 2017. Chloroform has been the most prevalent groundwater COC generally detected at the highest concentrations in site groundwater samples. All monitoring wells that are part of the site groundwater monitoring program are included in the evaluation.

Groundwater Chloroform Concentrations: 2005-2017 (1)

Well I.D.	Aquifer Zone	May 2005	May 2008	May 2009	May 2010	Apr./ May 2011	Aug. 2012	Aug. 2013	Aug. 2014	Aug. 2015	Aug. 2016	Aug. 2017
MW-2	Shallow	25,000	12,600	13,200	8,600	NA	8,590	5,740	NA	NA	4,730	NA
MW-3	Shallow	41,000	7,650	7,720	6,400	3,170	5,130	3,740	5,970	6,870	2,510	2,220
MW-6	Shallow	9,500	10,100	8,710	4,600	NA	NA	3,400	NA	NA	162	NA
MW-8	Shallow	8,200	3,270	5,410	2,800	2,630	3,240	2,960	5,800	10,800	7,930	7,520
MW-11S	Shallow	1,500	2,960	NA	1,300	NA	NA	NA	NA	NA	477	NA
MW-11I	Interm.	ND	15.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-12S	Shallow	45,000	35,300	12,900	11,000	21,900	30,400	7,700	12,500	12,000	10,300	12,800
MW-12I	Interm.	4,200	7,590	8,360	5,400	6,270	5,910	5,340	5,370	7,060	4,290	4,430
MW-12D	Deep	180	NA	1.8	ND	ND	ND	ND	0.63	ND	ND	ND
MW-13S	Shallow	ND	ND	ND	NA	NA	NA	NA	NA	NA	ND	ND
MW-13D	Deep	ND	NA	ND	ND	0.65	0.53	1.7	0.99	4.01	ND	4.9
MW-14	Shallow	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA
MW-15	Shallow	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-16S	Shallow	22,000	13,600	15,000	5,700	9,440	5,090	5,690	1,930	111	901	328
MW-16I	Interm.	390	7,710	202	91	720	351	23.6	106	18.6	40.5	27.5
MW-16D	Deep	4.7	NA	ND	ND	ND	ND	ND	0.60	ND	ND	ND
MW-17S	Shallow	850	422	209	24	NA	22.5	15.2	NA	13.7	ND	3.7
MW-17I	Interm.	680	1,080	2,560	1,200	1,910	2,430	3,120	3,060	6,350	3,340	3,420
MW-17D	Deep	1,200	NA	3,710	2,500	1,780	2,440	3,060	1,840	3,040	2,010	1,560
MW-27	Shallow	17	14.5	9.7	13	10.0	12.1	21.0	22.4	33.8	32.4	35.0
MW-34DR	Deep	1.0	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-35S	Shallow	ND	ND	0.97	ND	ND	ND	6.8	ND	ND	ND	ND
MW-35D	Deep	4.0	41.1	51.1	43	27.9	31.6	41.0	18.3	17.0	8.93	6.7
MW-36S	Shallow	19,000	23,800	20,800	1,500	7,470	2,610	1,510	928	706	356	272
MW-36D	Deep	26	2,000	2,280	1,200	915	712	516	337	315	263	152
MW-37	Shallow	68,000	75,500	113,000	46,000	161,000	168,000	168,000	102,000	100,000	44,200	47,400
MW-38	Deep	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-40	Shallow	110	5.2	566	20	3.8	NA	NA	NA	NA	NA	NA
MW-41S	Shallow	ND	ND	ND	ND	ND	1.6	4.0	ND	0.511	ND	1.4
MW-41I	Interm.	ND	ND	1.5	ND	1.2	2.2	1.6	ND	1.52	ND	1.1
MW-41D	Deep	4.2	11.5	20.3	18	26.3	35.2	50.9	35.3	37.5	20.8	19.7
MW-42S	Shallow	ND	ND	ND	ND	0.66	1.1	2.5	ND	1.75	ND	1.7
MW-42I	Interm.	ND	67.9	ND	16	26.4	2.1	4.4	2.3	3.30	ND	0.56

(continued)

Groundwater Chloroform Concentrations: 2005-2017 (1)

Well I.D.	Aquifer Zone	May 2005	May 2008	May 2009	May 2010	Apr./ May 2011	Aug. 2012	Aug. 2013	Aug. 2014	Aug. 2015	Aug. 2016	Aug. 2017
MW-43S	Shallow	11	9.0	9.4	5.4	11.5	14.1	22.3	17.7	21.2	ND	6.4
MW-43D	Deep	2.1	ND	5.6	ND	5.3	5.0	5.2	3.9	4.73	ND	3.5
MW-45/45R	Shallow	ND	8.4	33.4	10	NA	NA	NA	ND	1.07	ND	ND
MW-46	Shallow	ND	ND	ND	ND	ND	ND	ND	ND	0.695	ND	ND
MW-47	Deep	1.1	NA	8.3	10	15.8	19.4	24.5	20.0	22.0	11.0	9.6

(1) Concentrations are listed in µg/L. For cases in which duplicate samples were collected, the higher of the two concentration are listed.
ND = Not detected.
NA = No data available – well dry or not sampled.

Detected groundwater chloroform concentrations increased in five site monitoring wells (MW-12I, MW-17I, MW-27, MW-37, and MW-43S) between August 2016 and August 2017. However, the observed increases in groundwater chloroform concentrations were less than 10% for all five monitoring wells. In addition, groundwater chloroform concentrations in MW-27 and MW-43S remain below the North Carolina groundwater standard (70 µg/L).

A qualitative evaluation of overall trends in groundwater COC concentrations since 2002, based on the graphs of groundwater COC concentrations over time in Appendix C, is summarized as follows.

Generalized Trends in Groundwater COC Concentrations: 2002 to 2017

Generally Decreasing	Flat or Slightly Increasing	Generally Increasing	Fluctuating (no dominant overall trend)
MW-2	MW-37	MW-12I	MW-8
MW-3		MW-17I	MW-16I (1)
MW-6		MW-27	MW-17D
MW-11			MW-35S (2)
MW-11I			MW-40 (3)
MW-12			MW-41D
MW-16			MW-42I
MW-16D			MW-43S
MW-17			MW-43D (2)
MW-35D			MW-45/45R (2)
MW-36S			MW-47
MW-36D			

(1) Decreasing trends have been observed for some groundwater COCs, and increasing trends for others.
(2) Groundwater COC concentrations have generally remained below, or slightly above, laboratory detection limits.
(3) Well was excluded from the annual groundwater sampling/analysis events following 2011.

Of the three wells listed above as showing generally increasing trends in groundwater COC concentrations, detected groundwater COC concentrations in MW-27 have generally been less than North Carolina groundwater standards.

The above categorization of trends is highly generalized, and variations exist within the overall general trends that are opposite the trends, and, in some cases, transitions from generally increasing to generally decreasing COC concentrations occur over the history of well sampling/analysis.

9.0 RECOMMENDATIONS

In order to address concerns regarding spatial coverage of monitoring wells for the intermediate and deep aquifer zones, additional monitoring wells will be installed at the site during 2018 as described in a Work Plan for Monitoring-Well Installations, Repairs, and Abandonments, dated December 6, 2017, which was submitted to the EPA and North Carolina Department of Environmental Quality (NCDEQ), Division of Waste Management (DWM), Superfund Section, Federal Remediation Branch. Two additional intermediate monitoring wells will be installed at the site; one intermediate monitoring well (MW-13I) will be coupled with existing shallow and deep monitoring wells MW-13S and MW-13D in the western portion of the site, and the second intermediate monitoring well (MW-47I) will be coupled with existing deep monitoring well MW-47D in the southern portion of the site. One deep monitoring well (MW-45D) will be coupled with existing shallow monitoring well MW-45R in the northern portion of the site. In conjunction with the additional monitoring well installations, various repairs and abandonment/replacement of existing site monitoring wells will be completed as follows.

- MW-13S: Due to the well cap being seized and unable to be removed during the August and November 2017 well gauging events, the well cap will be sawed off and replaced with an expansion plug.
- MW-13D: The well casing is bent at a depth of approximately 8-feet below grade (likely from landscaping equipment colliding with the well casing), preventing the insertion of standard well sampling equipment (i.e., a submersible sampling pump). In response, the well will be abandoned, through plugging and grouting, in accordance with North Carolina regulations (15A NCAC 2C), and a replacement well will be installed to a depth of approximately 100-feet below grade to match the existing well depth. The replacement well will be constructed utilizing 2-inch inside diameter (I.D.) Schedule 40 PVC screen/casing, with a screen interval from 90-100 feet below grade.
- MW-16S: An object, believed to be an approximately 3-feet long sampling bailer, is lodged in the bottom of the well. Multiple attempts have previously been made to remove the obstruction with no success. As a result, the well will be abandoned, through plugging and grouting, and replaced. Due to issues with the current monitoring well, which is installed to a depth of approximately 35-feet below grade, being periodically dry, the replacement well will be installed to a depth of approximately 40-feet below grade. The replacement well will be constructed of 2-inch I.D. Schedule PVC screen/casing with the well screen set from approximately 30-40 feet below grade.
- MW-43S: The well casing is bent at a depth of approximately 1-foot below grade. The wellhead will be removed and soil around the well casing will be excavated. The bent section of well

casing will be sawed off and removed, and a new length of casing will be installed to grade using a slip coupling. A new wellhead set within a concrete pad will be constructed.

FIGURES

FIGURE 1: SITE LOCATION MAP

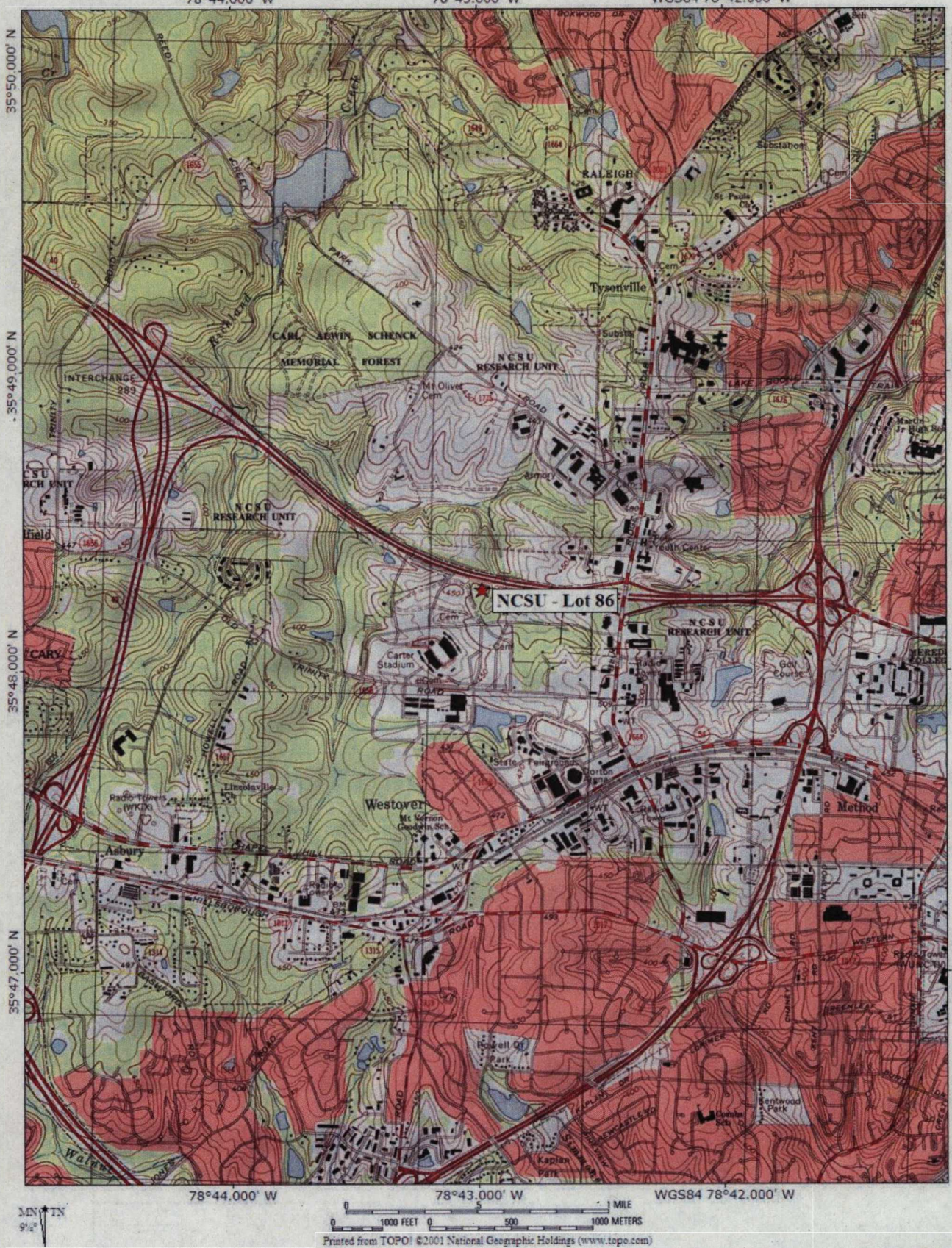
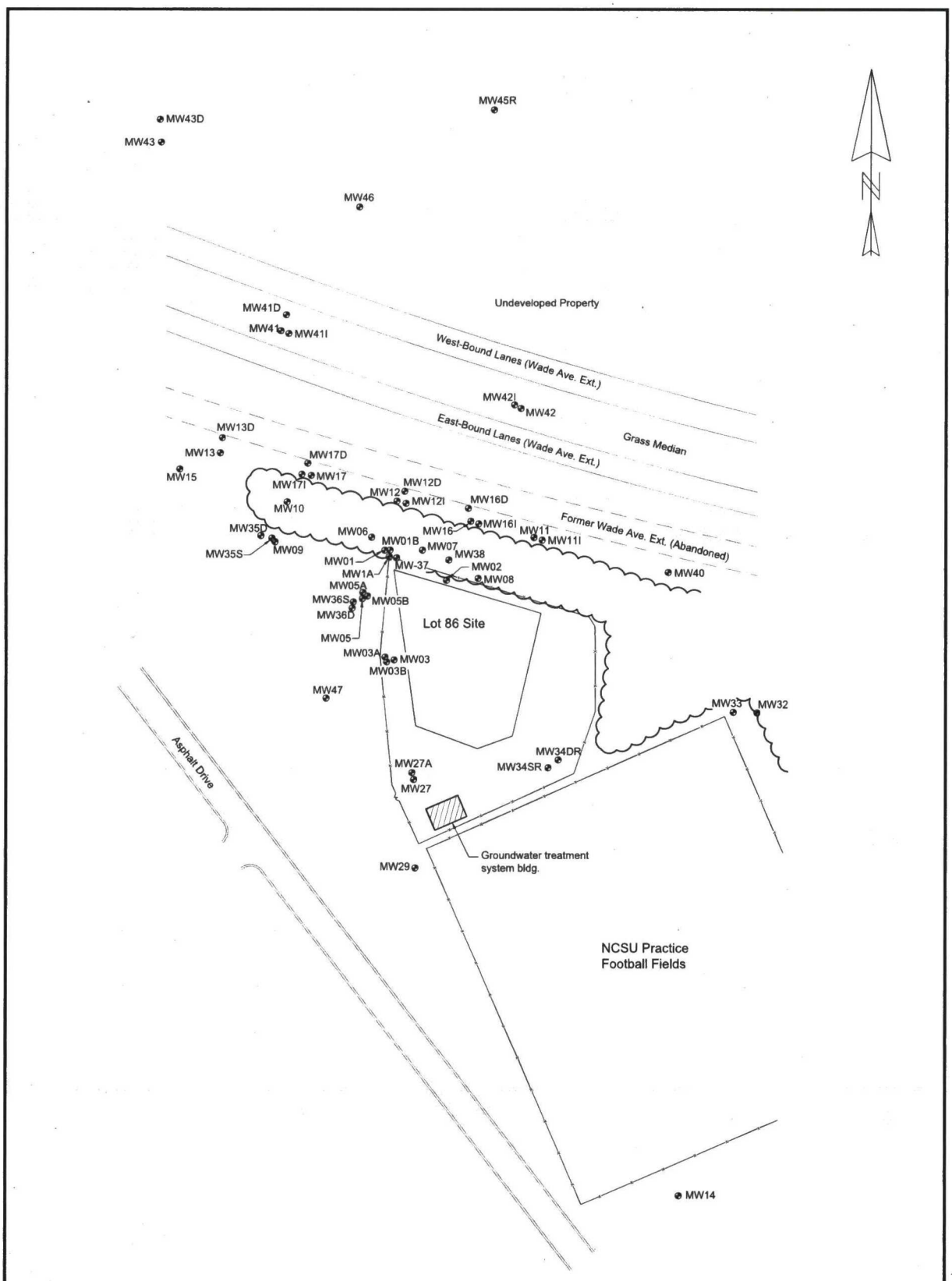


FIGURE 1
SITE LOCATION MAP
NCSU – Lot 86
Raleigh, North Carolina



LEGEND

MW33 Monitoring Well

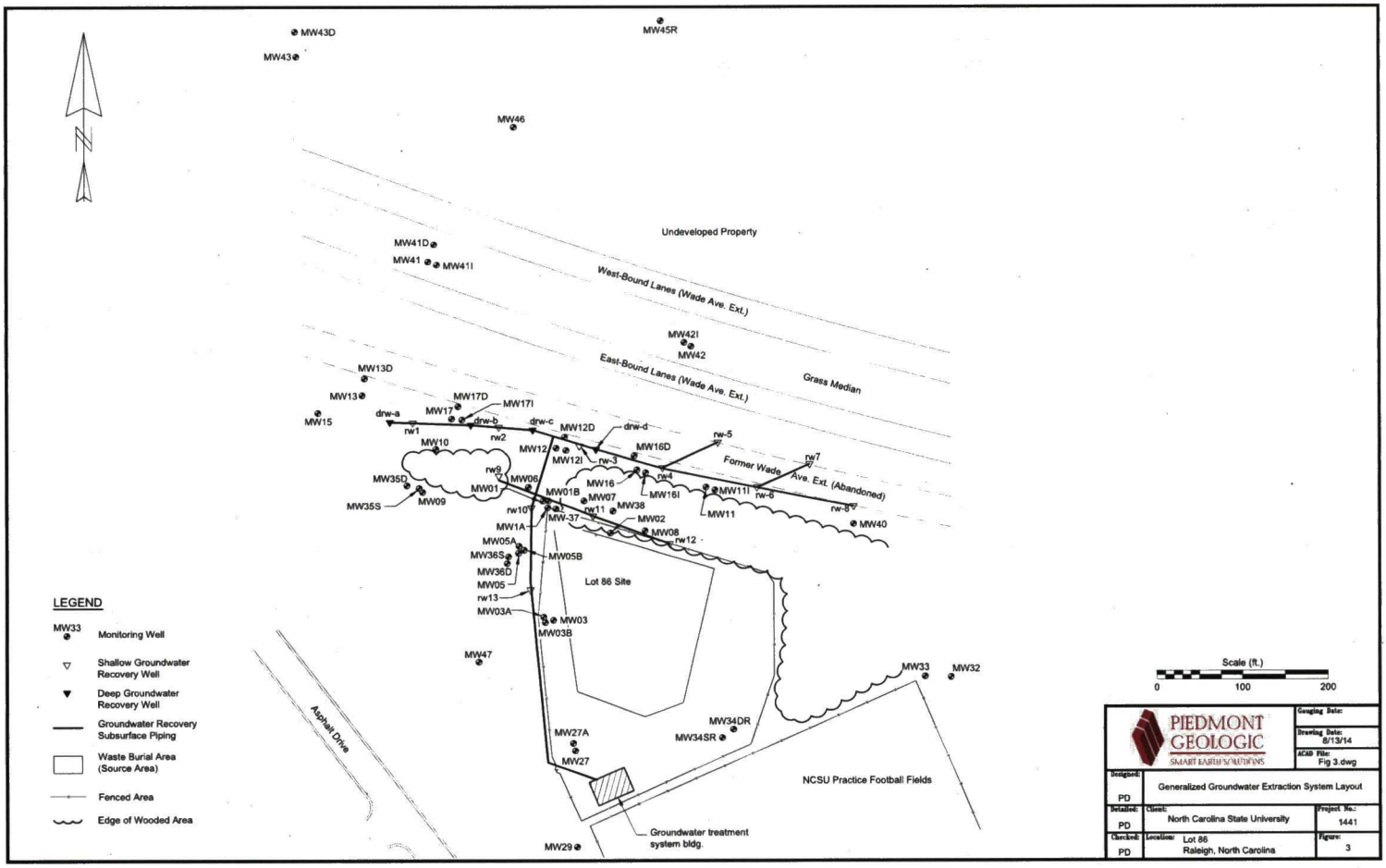
Waste Burial Area (Source Area)

Fenced Area

Edge of Wooded Area

PIEDMONT GEOLOGIC
SMART EARTH SOLUTIONS

Designed: PD	Site Map	Gauging Date:
		Drawing Date: 8/13/14
		ACAD File: Fig 2.dwg
Detailed: PD	Client: North Carolina State University	Project No.: 1441
Checked: PD	Location: Lot 86 Raleigh, North Carolina	Figure: 2


MW43D
MW45R
MW43
MW46
Undeveloped Property
MW41D
MW41
MW41I
West-Bound Lanes (Wade Ave. Ext.)
MW42I
MW42
East-Bound Lanes (Wade Ave. Ext.)
Grass Median
MW13D
MW13
MW17D
MW17I
MW17
MW15
drw-a
drw-b
drw-c
drw-d
MW12D
rw1
rw2
MW10
MW12
MW12I
rw-3
MW16D
rw-5
rw7
Former Wade Ave. Ext. (Abandoned)
rw-6
rw-8
MW40
rw9
MW06
MW16
rw4
MW35D
MW01
MW01B
MW07
MW16I
MW11I
MW35S
MW09
rw10
MW38
rw11
MW11
MW37
MW02
MW1A
MW08
rw12
MW05A
MW36S
MW05B
MW36D
MW05
Lot 86 Site
rw13
MW03A
MW03
MW03B
MW47
MW33
MW32
MW34DR
MW34SR
MW27A
MW27
NCSU Practice Football Fields
Asphalt Drive
Groundwater treatment system bldg.
MW29
LEGEND
MW33
Monitoring Well
Shallow Groundwater Recovery Well
Deep Groundwater Recovery Well
Groundwater Recovery Subsurface Piping
Waste Burial Area (Source Area)
Fenced Area
Edge of Wooded Area
Scale (ft.)
0
100
200
PIEDMONT GEOLOGIC
SMART EARTH SOLUTIONS
Gauging Date:
Drawing Date: 8/13/14
ACAD File: Fig 3.dwg
Designed: PD
Generalized Groundwater Extraction System Layout
Detailed: PD
Client: North Carolina State University
Project No.: 1441
Checked: PD
Location: Lot 86 Raleigh, North Carolina
Figure: 3

TABLES

TABLE 1
GROUNDWATER MONITORING WELL CONSTRUCTION DETAILS

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class (1)	Top of Casing Elevation (2)	Ground Elev. (2)	Screen Elevation (2)		Screen Depth (3)	
						Top	Bottom	Top	Bottom
MW-1	747,972.81	2,083,713.47	S	439.30	437.73	400.5	395.5	37.2	42.2
MW-1A	747,968.37	2,083,717.18	S	438.92	438.05	397.4	392.4	40.7	45.7
MW-1B	747,972.08	2,083,718.51	S	438.25	437.93	387.4	382.4	50.5	55.5
MW-2	747,934.50	2,083,791.44	S	448.74	446.00	401.2	396.2	44.8	49.8
MW-3	747,831.30	2,083,724.81	S	445.39	443.58	411.2	406.2	32.4	37.4
MW-3A	747,833.58	2,083,714.96	S-I	443.15	441.89	381.9	379.9	60.0	62.0
MW-3B	747,829.10	2,083,716.16	S-I	443.66	442.02	371.0	369.0	71.0	73.0
MW-4	747,738.38	2,083,847.26	S	454.32	452.54	405.5	400.5	47.0	52.0
MW-5	747,911.73	2,083,684.29	S	441.26	439.53	400.5	395.5	39.0	44.0
MW-5A	747,917.11	2,083,685.48	S	439.81	439.38	393.4	388.4	46.0	51.0
MW-5B	747,913.31	2,083,688.75	S-I	440.13	439.72	383.7	378.7	56.0	61.0
MW-6	747,987.81	2,083,695.81	S	438.61	436.36	402.9	397.9	33.5	38.5
MW-7	747,972.40	2,083,759.49	S	441.94	440.09	401.3	396.3	38.8	43.8
MW-8	747,936.68	2,083,831.30	S	447.85	445.91	397.9	392.9	48.0	53.0
MW-9	747,984.18	2,083,569.82	S	442.52	ND	ND	ND	ND	ND
MW-10	748,035.32	2,083,584.16	S	438.09	ND	ND	ND	ND	ND
MW-11	747,987.24	2,083,904.54	S	430.01	429.56	405.6	400.6	24.0	29.0
MW-11I	747,982.67	2,083,914.92	I	434.29	431.20	373.6	363.6	57.6	67.6
MW-12	748,035.37	2,083,726.83	S	427.24	426.18	397.2	392.2	29.0	34.0
MW-12I	748,031.08	2,083,738.92	I	430.70	427.45	359.8	354.8	67.7	72.7
MW-12D	748,048.21	2,083,735.45	D	427.45	427.95	331.0	321.0	97.0	107.0
MW-13	748,099.25	2,083,498.80	S	423.82	423.73	394.7	389.7	29.0	34.0
MW-13D	748,122.47	2,083,503.49	D	423.43	423.93	333.9	323.9	90.0	100.0
MW-14	747,148.54	2,084,091.12	S	451.87	450.38	413.4	408.4	37.0	42.0
MW-15	748,078.43	2,083,447.10	S	432.38	431.67	397.7	392.7	34.0	39.0
MW-16	748,009.06	2,083,822.21	S	427.94	427.61	399.6	394.6	28.0	33.0
MW-16I	748,004.62	2,083,832.41	I	432.14	429.23	374.7	364.7	54.5	64.5
MW-16D	748,024.15	2,083,819.82	D	428.98	429.48	349.5	339.5	80.0	90.0
MW-17	748,068.64	2,083,615.41	S	425.09	424.02	398.0	393.0	26.0	31.0
MW-17I	748,062.71	2,083,626.56	I	427.74	424.96	371.8	361.8	53.2	63.2
MW-17D	748,087.86	2,083,612.19	D	425.44	425.94	330.9	320.9	95.0	105.0
MW-27	747,678.44	2,083,751.29	S	448.26	447.22	407.2	402.2	40.0	45.0
MW-27A	747,687.36	2,083,749.28	S	448.55	447.40	392.9	388.9	54.5	58.5
MW-29	747,565.34	2,083,753.75	S	447.67	446.01	395.5	390.5	50.5	55.5
MW-30	747,579.80	2,084,072.68	S	440.86	438.17	399.2	389.2	39.0	49.0
MW-31	747,564.14	2,084,073.85	S	440.72	438.15	396.2	386.2	42.0	52.0
MW-32	747,760.44	2,084,186.72	S	438.15	436.21	411.4	401.4	24.8	34.8
MW-33	747,760.99	2,084,157.91	I	441.38	438.42	378.4	368.4	60.0	70.0
MW-34SR	747,694.98	2,083,926.43	S	454.82	452.32	424.3	404.3	28.0	48.0
MW-34DR	747,702.24	2,083,936.61	D	454.71	452.21	361.2	351.2	91.0	101.0
MW-35S	747,989.14	2,083,565.01	S	443.12	441.57	401.6	391.6	40.0	50.0
MW-35D	747,991.91	2,083,552.20	D	444.69	441.99	305.0	295.0	137.0	147.0

TABLE 1 (continued)
GROUNDWATER MONITORING WELL CONSTRUCTION DETAILS

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class (1)	Top of Casing Elevation (2)	Ground Elev. (2)	Screen Elevation (2)		Screen Depth (3)	
						Top	Bottom	Top	Bottom
MW-36S	747,905.86	2,083,672.19	S	442.71	439.64	399.6	389.6	40.0	50.0
MW-36D	747,898.07	2,083,671.54	D	442.87	439.75	335.5	325.5	104.3	114.3
MW-37	747,964.33	2,083,718.54	S	440.88	438.70	398.7	388.7	40.0	50.0
MW-38	747,959.35	2,083,794.05	D	445.38	442.47	345.4	335.4	97.1	107.1
MW-40	747,908.53	2,084,062.93	S	435.47	432.87	405.1	395.1	27.8	37.8
MW-41	748,239.12	2,083,608.18	S	421.17	421.30	396.9	386.9	24.4	34.4
MW-41I	748,235.91	2,083,619.56	I	421.57	421.47	371.0	361.0	50.5	60.5
MW-41D	748,278.60	2,083,583.47	D	420.67	421.17	341.2	331.2	80.0	90.0
MW-42	748,149.51	2,083,907.73	S	427.25	427.18	402.0	392.0	25.2	35.2
MW-42I	748,155.61	2,083,896.58	I	426.68	426.76	376.8	366.8	50.0	60.0
MW-43	748,526.66	2,083,396.75	S	437.03	438.74	385.4	375.4	53.3	63.3
MW-43D	748,532.52	2,083,416.56	D	438.01	435.50	339.5	329.5	96.0	106.0
MW-45R	748,539.15	2,083,844.73	S	426.15	426.45	396.5	381.5	30.0	45.0
MW-46	748,444.92	2,083,683.30	S	451.35	449.42	396.2	386.2	53.2	63.2
MW-47	747,787.80	2,083,636.72	D	441.11	441.61	336.6	321.6	105.0	120.0

(1) S = shallow wells with screen intervals in the elevation range from 382-413 ft;
I = intermediate-depth wells with screen intervals in the elevation range from 355-377 ft;
D = deep wells with screen intervals in the elevation range from 295-360 ft in bedrock.
(2) Measured in feet relative to National Vertical Datum (NGVD) of 1929.
(3) Measured in feet below ground surface.
ND = No data currently available.

TABLE 2
MONITORING-WELL GAUGING DATA: FEBRUARY 1, 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class	Top of Casing Elevation (ft)(1)	Depth to Ground-water (ft)(2)	Groundwater Elevation (ft)(1)
MW-1	747,972.81	2,083,713.47	shallow	439.30	43.74	395.56
MW-1A	747,968.37	2,083,717.18	shallow	438.92	42.90	396.02
MW-1B	747,972.08	2,083,718.51	shallow	438.25	42.44	395.81
MW-2	747,934.50	2,083,791.44	shallow	448.74	50.71	398.03
MW-3	747,831.30	2,083,724.81	shallow	445.39	46.58	398.81
MW-3A	747,833.58	2,083,714.96	shallow	443.15	44.69	398.46
MW-3B	747,829.10	2,083,716.16	intermediate	443.66	42.86	400.80
MW-5	747,911.73	2,083,684.29	shallow	441.26	44.70	396.56
MW-5A	747,917.11	2,083,685.48	shallow	439.81	43.37	396.44
MW-5B	747,913.31	2,083,688.75	intermediate	440.13	43.77	396.36
MW-6	747,987.81	2,083,695.81	shallow	438.61	DRY	NA
MW-7	747,972.40	2,083,759.49	shallow	441.94	45.11	396.83
MW-8	747,936.68	2,083,831.30	shallow	447.85	49.13	398.72
MW-9	747,984.18	2,083,569.82	shallow	442.52	DRY	NA
MW-10	748,035.32	2,083,584.16	shallow	438.09	42.73	395.36
MW-11	747,987.24	2,083,904.54	shallow	430.01	DRY	NA
MW-11I	747,982.67	2,083,914.92	intermediate	434.29	34.38	399.91
MW-12	748,035.37	2,083,726.83	shallow	427.24	32.06	395.18
MW-12I	748,031.08	2,083,738.92	intermediate	430.70	34.49	396.21
MW-12D	748,048.21	2,083,735.45	deep	427.45	28.60	398.85
MW-13	748,099.25	2,083,498.80	shallow	423.82	29.16	394.66
MW-13D	748,122.47	2,083,503.49	deep	423.43	29.03	394.40
MW-14	747,148.54	2,084,091.12	shallow	451.87	34.70	417.17
MW-15	748,078.43	2,083,447.10	shallow	432.38	DRY	NA
MW-16	748,009.06	2,083,822.21	shallow	427.94	30.20	397.74
MW-16I	748,004.62	2,083,832.41	intermediate	432.14	35.96	396.18
MW-16D	748,024.15	2,083,819.82	deep	428.98	30.26	398.72
MW-17	748,068.64	2,083,615.41	shallow	425.09	29.80	395.29
MW-17I	748,062.71	2,083,626.56	intermediate	427.74	32.55	395.19
MW-17D	748,087.86	2,083,612.19	deep	425.44	30.46	394.98
MW-27	747,678.44	2,083,751.29	shallow	448.26	42.93	405.33
MW-27A	747,687.36	2,083,749.28	shallow	448.55	43.32	405.23
MW-29	747,565.34	2,083,753.75	shallow	447.67	43.15	404.52
MW-32	747,760.44	2,084,186.72	shallow	438.15	31.62	406.53
MW-33	747,760.99	2,084,157.91	intermediate	441.38	34.40	406.98
MW-34SR	747,694.98	2,083,926.43	shallow	454.82	43.26	411.56
MW-34DR	747,702.24	2,083,936.61	deep	454.71	42.34	412.37
MW-35S	747,989.14	2,083,565.01	shallow	443.12	47.49	395.63
MW-35D	747,991.91	2,083,552.20	deep	444.69	48.87	395.82

(continued)

TABLE 2 (CONTINUED)
MONITORING-WELL GAUGING DATA: FEBRUARY 1, 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class	Top of Casing Elevation (ft)(1)	Depth to Ground-water (ft)(2)	Groundwater Elevation (ft)(1)
MW-36S	747,905.86	2,083,672.19	shallow	442.71	45.96	396.75
MW-36D	747,898.07	2,083,671.54	deep	442.87	46.39	396.48
MW-37	747,964.33	2,083,718.54	shallow	440.88	44.93	395.95
MW-38	747,959.35	2,083,794.05	deep	445.38	46.89	398.49
MW-40	747,908.53	2,084,062.93	shallow	435.47	29.08	406.39
MW-41	748,239.12	2,083,608.18	shallow	421.17	26.23	394.94
MW-41I	748,235.91	2,083,619.56	intermediate	421.57	26.45	395.12
MW-41D	748,278.60	2,083,583.47	deep	420.67	25.79	394.88
MW-42	748,149.51	2,083,907.73	shallow	427.25	28.42	398.83
MW-42I	748,155.61	2,083,896.58	intermediate	426.68	27.58	399.10
MW-43	748,526.66	2,083,396.75	shallow	437.03	46.68	390.35
MW-43D	748,532.52	2,083,416.56	deep	438.01	47.75	390.26
MW-45R	748,539.15	2,083,844.73	shallow	426.15	32.66	393.49
MW-46	748,444.92	2,083,683.30	shallow	451.35	56.17	395.18
MW-47	747,787.80	2,083,636.72	deep	441.11	43.25	397.86

(1) Measured in feet relative to site datum.

(2) Measured relative to top-of-casing reference point.

NA = Not Applicable

TABLE 3
MONITORING-WELL GAUGING DATA: MAY 22, 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class	Top of Casing Elevation (ft)(1)	Depth to Ground-water (ft)(2)	Groundwater Elevation (ft)(1)
MW-1	747,972.81	2,083,713.47	shallow	439.30	DRY	NA
MW-1A	747,968.37	2,083,717.18	shallow	438.92	43.19	395.73
MW-1B	747,972.08	2,083,718.51	shallow	438.25	42.60	395.65
MW-2	747,934.50	2,083,791.44	shallow	448.74	DRY	NA
MW-3	747,831.30	2,083,724.81	shallow	445.39	45.99	399.40
MW-3A	747,833.58	2,083,714.96	shallow	443.15	43.95	399.20
MW-3B	747,829.10	2,083,716.16	intermediate	443.66	43.12	400.54
MW-5	747,911.73	2,083,684.29	shallow	441.26	44.19	397.07
MW-5A	747,917.11	2,083,685.48	shallow	439.81	42.87	396.94
MW-5B	747,913.31	2,083,688.75	intermediate	440.13	43.11	397.02
MW-6	747,987.81	2,083,695.81	shallow	438.61	DRY	NA
MW-7	747,972.40	2,083,759.49	shallow	441.94	DRY	NA
MW-8	747,936.68	2,083,831.30	shallow	447.85	49.63	398.22
MW-9	747,984.18	2,083,569.82	shallow	442.52	DRY	NA
MW-10	748,035.32	2,083,584.16	shallow	438.09	DRY	NA
MW-11	747,987.24	2,083,904.54	shallow	430.01	29.52	400.49
MW-11I	747,982.67	2,083,914.92	intermediate	434.29	35.42	398.87
MW-12	748,035.37	2,083,726.83	shallow	427.24	32.81	394.43
MW-12I	748,031.08	2,083,738.92	intermediate	430.70	34.75	395.95
MW-12D	748,048.21	2,083,735.45	deep	427.45	29.69	397.76
MW-13	748,099.25	2,083,498.80	shallow	423.82	29.31	394.51
MW-13D	748,122.47	2,083,503.49	deep	423.43	29.48	393.95
MW-14	747,148.54	2,084,091.12	shallow	451.87	35.12	416.75
MW-15	748,078.43	2,083,447.10	shallow	432.38	DRY	NA
MW-16	748,009.06	2,083,822.21	shallow	427.94	DRY	NA
MW-16I	748,004.62	2,083,832.41	intermediate	432.14	36.41	395.73
MW-16D	748,024.15	2,083,819.82	deep	428.98	31.10	397.88
MW-17	748,068.64	2,083,615.41	shallow	425.09	30.02	395.07
MW-17I	748,062.71	2,083,626.56	intermediate	427.74	32.81	394.93
MW-17D	748,087.86	2,083,612.19	deep	425.44	30.92	394.52
MW-27	747,678.44	2,083,751.29	shallow	448.26	43.70	404.56
MW-27A	747,687.36	2,083,749.28	shallow	448.55	44.11	404.44
MW-29	747,565.34	2,083,753.75	shallow	447.67	43.91	403.76
MW-32	747,760.44	2,084,186.72	shallow	438.15	31.85	406.30
MW-33	747,760.99	2,084,157.91	intermediate	441.38	34.74	406.64
MW-34SR	747,694.98	2,083,926.43	shallow	454.82	44.51	410.31
MW-34DR	747,702.24	2,083,936.61	deep	454.71	43.60	411.11
MW-35S	747,989.14	2,083,565.01	shallow	443.12	47.81	395.31
MW-35D	747,991.91	2,083,552.20	deep	444.69	49.43	395.26

(continued)

TABLE 3 (CONTINUED)
MONITORING-WELL GAUGING DATA: MAY 22, 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class	Top of Casing Elevation (ft)(1)	Depth to Ground-water (ft)(2)	Groundwater Elevation (ft)(1)
MW-36S	747,905.86	2,083,672.19	shallow	442.71	45.52	397.19
MW-36D	747,898.07	2,083,671.54	deep	442.87	45.88	396.99
MW-37	747,964.33	2,083,718.54	shallow	440.88	45.11	395.77
MW-38	747,959.35	2,083,794.05	deep	445.38	47.29	398.09
MW-40	747,908.53	2,084,062.93	shallow	435.47	29.85	405.62
MW-41	748,239.12	2,083,608.18	shallow	421.17	26.30	394.87
MW-41I	748,235.91	2,083,619.56	intermediate	421.57	26.62	394.95
MW-41D	748,278.60	2,083,583.47	deep	420.67	26.09	394.58
MW-42	748,149.51	2,083,907.73	shallow	427.25	28.63	398.62
MW-42I	748,155.61	2,083,896.58	intermediate	426.68	28.08	398.60
MW-43	748,526.66	2,083,396.75	shallow	437.03	46.98	390.05
MW-43D	748,532.52	2,083,416.56	deep	438.01	48.14	389.87
MW-45R	748,539.15	2,083,844.73	shallow	426.15	33.03	393.12
MW-46	748,444.92	2,083,683.30	shallow	451.35	56.56	394.79
MW-47	747,787.80	2,083,636.72	deep	441.11	43.10	398.01

(1) Measured in feet relative to site datum.

(2) Measured relative to top-of-casing reference point.

NA = Not Applicable

TABLE 4
MONITORING-WELL GAUGING DATA: AUGUST 7, 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class	Top of Casing Elevation (ft)(1)	Depth to Ground-water (ft)(2)	Groundwater Elevation (ft)(1)
MW-1	747,972.81	2,083,713.47	shallow	439.30	43.47	395.83
MW-1A	747,968.37	2,083,717.18	shallow	438.92	42.79	396.13
MW-1B	747,972.08	2,083,718.51	shallow	438.25	42.18	396.07
MW-2	747,934.50	2,083,791.44	shallow	448.74	50.80	397.94
MW-3	747,831.30	2,083,724.81	shallow	445.39	45.67	399.72
MW-3A	747,833.58	2,083,714.96	shallow	443.15	43.63	399.52
MW-3B	747,829.10	2,083,716.16	intermediate	443.66	42.71	400.95
MW-5	747,911.73	2,083,684.29	shallow	441.26	43.85	397.41
MW-5A	747,917.11	2,083,685.48	shallow	439.81	42.54	397.27
MW-5B	747,913.31	2,083,688.75	intermediate	440.13	42.81	397.32
MW-6	747,987.81	2,083,695.81	shallow	438.61	DRY	NA
MW-7	747,972.40	2,083,759.49	shallow	441.94	45.02	396.92
MW-8	747,936.68	2,083,831.30	shallow	447.85	49.26	398.59
MW-9	747,984.18	2,083,569.82	shallow	442.52	DRY	NA
MW-10	748,035.32	2,083,584.16	shallow	438.09	42.82	395.27
MW-11	747,987.24	2,083,904.54	shallow	430.01	29.36	400.65
MW-11I	747,982.67	2,083,914.92	intermediate	434.29	34.78	399.51
MW-12	748,035.37	2,083,726.83	shallow	427.24	32.10	395.14
MW-12I	748,031.08	2,083,738.92	intermediate	430.70	34.53	396.17
MW-12D	748,048.21	2,083,735.45	deep	427.45	29.62	397.83
MW-13	748,099.25	2,083,498.80	shallow	423.82	NG	NA
MW-13D	748,122.47	2,083,503.49	deep	423.43	29.60	393.83
MW-14	747,148.54	2,084,091.12	shallow	451.87	34.62	417.25
MW-15	748,078.43	2,083,447.10	shallow	432.38	DRY	NA
MW-16	748,009.06	2,083,822.21	shallow	427.94	31.00	396.94
MW-16I	748,004.62	2,083,832.41	intermediate	432.14	36.08	396.06
MW-16D	748,024.15	2,083,819.82	deep	428.98	31.14	397.84
MW-17	748,068.64	2,083,615.41	shallow	425.09	29.85	395.24
MW-17I	748,062.71	2,083,626.56	intermediate	427.74	32.51	395.23
MW-17D	748,087.86	2,083,612.19	deep	425.44	30.51	394.93
MW-27	747,678.44	2,083,751.29	shallow	448.26	43.07	405.19
MW-27A	747,687.36	2,083,749.28	shallow	448.55	43.49	405.06
MW-29	747,565.34	2,083,753.75	shallow	447.67	43.38	404.29
MW-32	747,760.44	2,084,186.72	shallow	438.15	32.38	405.77
MW-33	747,760.99	2,084,157.91	intermediate	441.38	34.95	406.43
MW-34SR	747,694.98	2,083,926.43	shallow	454.82	43.59	411.23
MW-34DR	747,702.24	2,083,936.61	deep	454.71	42.81	411.90
MW-35S	747,989.14	2,083,565.01	shallow	443.12	47.74	395.38
MW-35D	747,991.91	2,083,552.20	deep	444.69	49.18	395.51

(continued)

TABLE 4 (CONTINUED)
MONITORING-WELL GAUGING DATA: AUGUST 7, 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class	Top of Casing Elevation (ft)(1)	Depth to Ground-water (ft)(2)	Groundwater Elevation (ft)(1)
MW-36S	747,905.86	2,083,672.19	shallow	442.71	45.20	397.51
MW-36D	747,898.07	2,083,671.54	deep	442.87	45.56	397.31
MW-37	747,964.33	2,083,718.54	shallow	440.88	44.70	396.18
MW-38	747,959.35	2,083,794.05	deep	445.38	47.13	398.25
MW-40	747,908.53	2,084,062.93	shallow	435.47	29.57	405.90
MW-41	748,239.12	2,083,608.18	shallow	421.17	26.66	394.51
MW-41I	748,235.91	2,083,619.56	intermediate	421.57	26.85	394.72
MW-41D	748,278.60	2,083,583.47	deep	420.67	26.17	394.50
MW-42	748,149.51	2,083,907.73	shallow	427.25	28.78	398.47
MW-42I	748,155.61	2,083,896.58	intermediate	426.68	28.05	398.63
MW-43	748,526.66	2,083,396.75	shallow	437.03	47.17	389.86
MW-43D	748,532.52	2,083,416.56	deep	438.01	48.30	389.71
MW-45R	748,539.15	2,083,844.73	shallow	426.15	33.18	392.97
MW-46	748,444.92	2,083,683.30	shallow	451.35	56.67	394.68
MW-47	747,787.80	2,083,636.72	deep	441.11	42.79	398.32

(1) Measured in feet relative to site datum.

(2) Measured relative to top-of-casing reference point.

NA = Not Applicable

NG = Not Gauged (due to seized well cap)

TABLE 5
MONITORING-WELL GAUGING DATA: NOVEMBER 20, 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Well I.D.	Northing	Easting	Well Class	Top of Casing Elevation (ft)(1)	Depth to Ground-water (ft)(2)	Groundwater Elevation (ft)(1)
MW-1	747,972.81	2,083,713.47	shallow	439.30	43.20	396.10
MW-1A	747,968.37	2,083,717.18	shallow	438.92	42.49	396.43
MW-1B	747,972.08	2,083,718.51	shallow	438.25	41.99	396.26
MW-2	747,934.50	2,083,791.44	shallow	448.74	51.80	396.94
MW-3	747,831.30	2,083,724.81	shallow	445.39	46.05	399.34
MW-3A	747,833.58	2,083,714.96	shallow	443.15	43.99	399.16
MW-3B	747,829.10	2,083,716.16	intermediate	443.66	43.30	400.36
MW-5	747,911.73	2,083,684.29	shallow	441.26	43.70	397.56
MW-5A	747,917.11	2,083,685.48	shallow	439.81	42.42	397.39
MW-5B	747,913.31	2,083,688.75	intermediate	440.13	42.74	397.39
MW-6	747,987.81	2,083,695.81	shallow	438.61	42.66	395.95
MW-7	747,972.40	2,083,759.49	shallow	441.94	DRY	NA
MW-8	747,936.68	2,083,831.30	shallow	447.85	50.61	397.24
MW-9	747,984.18	2,083,569.82	shallow	442.52	DRY	NA
MW-10	748,035.32	2,083,584.16	shallow	438.09	43.42	394.67
MW-11	747,987.24	2,083,904.54	shallow	430.01	29.31	400.70
MW-11I	747,982.67	2,083,914.92	intermediate	434.29	36.51	397.78
MW-12	748,035.37	2,083,726.83	shallow	427.24	32.01	395.23
MW-12I	748,031.08	2,083,738.92	intermediate	430.70	34.96	395.74
MW-12D	748,048.21	2,083,735.45	deep	427.45	30.25	397.20
MW-13	748,099.25	2,083,498.80	shallow	423.82	NG	NA
MW-13D	748,122.47	2,083,503.49	deep	423.43	29.63	393.80
MW-14	747,148.54	2,084,091.12	shallow	451.87	35.22	416.65
MW-15	748,078.43	2,083,447.10	shallow	432.38	DRY	NA
MW-16	748,009.06	2,083,822.21	shallow	427.94	32.05	395.89
MW-16I	748,004.62	2,083,832.41	intermediate	432.14	37.16	394.98
MW-16D	748,024.15	2,083,819.82	deep	428.98	30.99	397.99
MW-17	748,068.64	2,083,615.41	shallow	425.09	32.68	392.41
MW-17I	748,062.71	2,083,626.56	intermediate	427.74	30.10	397.64
MW-17D	748,087.86	2,083,612.19	deep	425.44	30.52	394.92
MW-27	747,678.44	2,083,751.29	shallow	448.26	44.02	404.24
MW-27A	747,687.36	2,083,749.28	shallow	448.55	44.36	404.19
MW-29	747,565.34	2,083,753.75	shallow	447.67	35.73	411.94
MW-32	747,760.44	2,084,186.72	shallow	438.15	32.88	405.27
MW-33	747,760.99	2,084,157.91	intermediate	441.38	35.66	405.72
MW-34SR	747,694.98	2,083,926.43	shallow	454.82	44.46	410.36
MW-34DR	747,702.24	2,083,936.61	deep	454.71	45.83	408.88
MW-35S	747,989.14	2,083,565.01	shallow	443.12	48.02	395.10
MW-35D	747,991.91	2,083,552.20	deep	444.69	49.09	395.60

(continued)

TABLE 6
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GROUNDWATER SAMPLES COLLECTED FROM GWE SYSTEM RECOVERY WELLS
FEBRUARY 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.: / **Sample Date:**	**RW-1** 2/1/17	**RW-2** 2/1/17	**RW-3** 2/1/17	**RW-4** 2/1/17	**RW-5** 2/1/17	**RW-6** 2/1/17	**RW-7** 2/1/17
Method 900.0 (pCi/L)							
Gross Beta	**0.767**	**1.77**	**3.13**	**1.54**	**2.01**	**1.94**	**1.69**
Count uncertainty (2σ+/-)	0.324	0.398	0.518	0.368	0.397	0.414	0.387
Total uncertainty (2σ+/-)	0.333	0.435	0.605	0.399	0.445	0.457	0.422
Method 906.0 (pCi/L)							
Tritium	**31.5 U**	**81.1 U**	**1,440**	**8,460**	**2,590**	**-36.0 U**	**90.1 U**
Count uncertainty (2σ+/-)	214	228	328	628	378	211	231
Total uncertainty (2σ+/-)	214	228	352	974	442	211	231
Sample I.D.: / **Sample Date:**	**RW-8** 2/1/17	**RW-9** 2/1/17	**RW-10** 2/1/17	**RW-11** 2/1/17	**RW-12** 2/1/17	**RW-13** 2/1/17	
Method 900.0 (pCi/L)							
Gross Beta	**1.77**	**1.19**	**6.27**	**1.57**	**2.70**	**1.81**	
Count uncertainty (2σ+/-)	0.401	0.386	0.666	0.422	0.461	0.414	
Total uncertainty (2σ+/-)	0.438	0.404	0.915	0.450	0.534	0.452	
Method 906.0 (pCi/L)							
Tritium	**-273 U**	**-144 U**	**-144 U**	**1,990**	**2,410**	**-54.1 U**	
Count uncertainty (2σ+/-)	188	204	198	342	371	204	
Total uncertainty (2σ+/-)	189	204	199	384	427	204	

U = Analyte was not detected.

TABLE 7
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GROUNDWATER SAMPLES COLLECTED FROM GWE SYSTEM RECOVERY WELLS
MAY 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.: / **Sample Date:**	**RW-1** 5/22/17	**RW-2** 5/22/17	**RW-3** 5/22/17	**RW-4** 5/22/17	**RW-5** 5/22/17	**RW-6** 5/22/17	**RW-7** 5/22/17
Method 900.0 (pCi/L)							
Gross Beta	**0.999**	**8.68**	**3.00**	**1.90**	**1.30**	**2.48**	**2.32**
Uncertainty	0.476	2.15	0.681	0.510	0.439	0.630	0.590
Method 906.0 (pCi/L)							
Tritium	**-98.3 U**	**120 U**	**2,229**	**7,380**	**2,752**	**207 U**	**242 U**
Uncertainty	135	151	379	1,032	443	156	156
Sample I.D.: / **Sample Date:**	**RW-8** 5/22/17	**RW-9** 5/22/17	**RW-10** 5/22/17	**RW-11** 5/22/17	**RW-12** 5/22/17	**RW-13** 5/22/17	
Method 900.0 (pCi/L)							
Gross Beta	**1.39**	**0.811**	**4.70**	**1.26**	**3.21**	**1.45**	
Uncertainty	0.462	0.895	1.01	0.527	0.810	0.976	
Method 906.0 (pCi/L)							
Tritium	**-50.3 U**	**23.4 U**	**38.3 U**	**1,965**	**4,018**	**1,792**	
Uncertainty	137	140	142	347	603	324	

(1) Laboratory analysis conducted by Pace Analytical Services.
U = Analyte was not detected.

TABLE 7
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GROUNDWATER SAMPLES COLLECTED FROM GWE SYSTEM RECOVERY WELLS
MAY 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.:	**RW-1**	**RW-2**	**RW-3**	**RW-4**	**RW-5**	**RW-6**	**RW-7**
Sample Date:	**5/22/17**	**5/22/17**	**5/22/17**	**5/22/17**	**5/22/17**	**5/22/17**	**5/22/17**
Method 900.0 (pCi/L)							
Gross Beta	**0.999**	**8.68**	**3.00**	**1.90**	**1.30**	**2.48**	**2.32**
Uncertainty	0.476	2.15	0.681	0.510	0.439	0.630	0.590
Method 906.0 (pCi/L)							
Tritium	**-98.3 U**	**120 U**	**2,229**	**7,380**	**2,752**	**207 U**	**242 U**
Uncertainty	135	151	379	1,032	443	156	156
Sample I.D.:	**RW-8**	**RW-9**	**RW-10**	**RW-11**	**RW-12**	**RW-13**	
Sample Date:	**5/22/17**	**5/22/17**	**5/22/17**	**5/22/17**	**5/22/17**	**5/22/17**	
Method 900.0 (pCi/L)							
Gross Beta	**1.39**	**0.811**	**4.70**	**1.26**	**3.21**	**1.45**	
Uncertainty	0.462	0.895	1.01	0.527	0.810	0.976	
Method 906.0 (pCi/L)							
Tritium	**-50.3 U**	**23.4 U**	**38.3 U**	**1,965**	**4,018**	**1,792**	
Uncertainty	137	140	142	347	603	324	

(1) Laboratory analysis conducted by Pace Analytical Services.
U = Analyte was not detected.

TABLE 8
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GROUNDWATER SAMPLES COLLECTED FROM GWE SYSTEM RECOVERY WELLS
AUGUST 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.: / **Sample Date:**	**RW-1** **8/7/17**	**RW-2** **8/7/17**	**RW-3** **8/7/17**	**RW-4** **8/7/17**	**RW-5** **8/7/17**	**RW-6** **8/7/17**	**RW-7** **8/7/17**
Method 900.0 (pCi/L)							
Gross Beta	**2.70 U**	**2.31**	**4.28**	**1.54 U**	**1.75 U**	**1.35 U**	**0.818 U**
Uncertainty	2.41	1.14	1.44	0.970	1.00	0.896	0.839
Method 906.0 (pCi/L)							
Tritium	**-81.6 U**	**-88.2 U**	**2,037**	**6,957**	**2,967**	**-2.94 U**	**0.000 U**
Uncertainty	144	145	360	978	474	150	141
Sample I.D.: / **Sample Date:**	**RW-8** **8/7/17**	**RW-9** **8/7/17**	**RW-10** **8/7/17**	**RW-11** **8/7/17**	**RW-12** **NS**	**RW-13** **NS**	
Method 900.0 (pCi/L)							
Gross Beta	**2.14 U**	**2.50**	**5.25**	**1.18 U**	--	--	
Uncertainty	1.23	1.17	2.09	0.916	--	--	
Method 906.0 (pCi/L)							
Tritium	**8.71 U**	**-82.4 U**	**-207 U**	**1,403**	--	--	
Uncertainty	140	145	138	284	--	--	

(1) Laboratory analysis conducted by Pace Analytical Services.
U = Analyte was not detected.
NS = No sample collected due to well pump not operating.

TABLE 9
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GROUNDWATER SAMPLES COLLECTED FROM GWE SYSTEM RECOVERY WELLS
NOVEMBER 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.: / **Sample Date:**	**RW-1** 11/20/17	**RW-2** 11/20/17	**RW-3** 11/20/17	**RW-4** 11/20/17	**RW-5** 11/20/17	**RW-6** 11/20/17	**RW-7** 11/20/17
Method 900.0 (pCi/L)							
Gross Beta	**1.26 U**	**1.95**	**2.64**	**1.76**	**2.55**	**1.54 U**	**3.53**
Uncertainty	0.934	1.00	1.16	0.997	1.16	1.01	1.36
Method 906.0 (pCi/L)							
Tritium	**-38.1 U**	**5.85 U**	**1,762**	**7,260**	**2.321**	**85.0 U**	**88.2 U**
Uncertainty	143	146	324	1,018	392	151	152
Sample I.D.: / **Sample Date:**	**RW-8** 11/20/17	**RW-9** 11/20/17	**RW-10** 11/20/17	**RW-11** 11/20/17	**RW-12** 11/20/17	**RW-13** 11/21/17	
Method 900.0 (pCi/L)							
Gross Beta	**1.37 U**	**1.62**	**4.31**	**3.12**	**3.14**	**11.1**	
Uncertainty	0.835	0.912	1.39	1.17	1.17	2.35	
Method 906.0 (pCi/L)							
Tritium	**-17.7 U**	**-43.9**	**-106 U**	**1,245**	**5,106**	**-100.0 U**	
Uncertainty	145	143	140	265	742	270	

(1) Laboratory analysis conducted by Pace Analytical Services.
U = Analyte was not detected.

TABLE 10
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GWE SYSTEM INFLUENT GROUNDWATER SAMPLES

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample Date:	1/3/17	2/1/17	3/1/17	4/6/17	5/5/17	6/1/17	7/6/17	8/7/17	9/26/17	10/5/17	11/1/17	12/1/17
EPA Method 8260 (µg/L)(1)												
Acetone	<2,500	76.2	<5,000	<50.0	<50.0	<2,500	<2,500	<2,500	<2,500	<2,500	<625	<625
Acetonitrile	<2,500	<50.0	<5,000	<50.0	20.2 J	NA	NA	NA	NA	NA	NA	NA
Benzene	98.3	187	212	30.8	307	330	154	125	381	65.6 J	33.5	35.9
Bromodichloromethane	61.3	70.7	67.5 J	45.4	72.1	<100	<100	<100	55.7 J	53.3 J	<25.0	7.6 J
Bromoform	<50.0	2.07	<100	0.668 J	0.778 J	<100	<100	<100	<100	<100	<25.0	<25.0
Carbon disulfide	<50.0	2.92	<100	0.726 J	1.20	NA	NA	NA	NA	NA	NA	NA
Carbon tetrachloride	<50.0	168	137	115	170	186	168	148	141	151	39.7	35.9
Chlorobenzene	18.7 J	23.1	<100	9.90	24.2	<100	<100	<100	25.6 J	<100	<25.0	<25.0
Chlorodibromomethane	<50.0	0.410 J	<100	<1.00	<1.00	<100	<100	<100	<100	<100	<25.0	<25.0
Chloroform	9,550	11,700	7,900	7,280	9,360	11,500	11,600	10,200	10,400	10,500	3,700	2,870
1,2-Dibromoethane (EDB)	531	559	511	246	523	529	403	425	361	328	176	229
1,2-Dibromo-3-chloropropane	178 J	<1,250	184 J	178	188	<200	454	<200	<200	<200	92.6	108
Dibromomethane	<50.0	0.437 J	<100	<1.00	0.435 J	<100	<100	<100	<100	<100	<25.0	<25.0
1,2-Dichlorobenzene	<50.0	18.9	<100	11.0	15.7	<100	<100	<100	<100	<100	<25.0	<25.0
1,3-Dichlorobenzene	<50.0	1.20	<100	0.861 J	0.910 J	<100	<100	<100	<100	<100	<25.0	<25.0
1,4-Dichlorobenzene	<50.0	2.70	<100	1.96	2.38	<100	<100	<100	<100	<100	<25.0	<25.0
Dichlorodifluoromethane	<250	1.68 J	<500	1.18 J	1.65 J	<100	<100	<100	<100	<100	<25.0	<25.0
1,1-Dichloroethane	<50.0	3.98	<100	2.21	4.60	<100	<100	<100	<100	<100	<25.0	<25.0
1,2-Dichloroethane	69.0	78.3	84.8 J	57.3	87.8	<100	<100	<100	86.5 J	85.3 J	22.9 J	21.6 J
1,1-Dichloroethene	<50.0	6.29	<100	3.58	6.33	<100	<100	<100	<100	<100	<25.0	<25.0
cis-1,2-Dichloroethene	<50.0	1.04	<100	0.585 J	0.935 J	<100	<100	<100	<100	<100	<25.0	<25.0
1,2-Dichloropropane	<50.0	1,670	1,210	883	1,650	1,500	1,250	1,540	1,060	876	557	702
Ethylbenzene	<50.0	14.6	41.0 J	3.37	14.7	<100	<100	<100	<100	<100	<25.0	<25.0
Iodomethane	<500	<10.0	<1,000	3.25 J	<10.0	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	1,030	1,240 J	895	760	878	1,100	983	973	846	1,290	320	268
4-Methyl-2-pentanone (MIBK)	<500	34.3	<1,000	5.74 J	70.3	<500	<500	<500	<500	<500	<125	<125
Naphthalene	NA	NA	NA	NA	NA	<100	<100	<100	<100	<100	24.7 J	<25.0
1,1,2,2-Tetrachloroethane	8.84 J	11.2	<100	6.01	11.8	<100	<100	<100	<100	<100	<25.0	<25.0
Tetrachloroethene	85.9	94.0	74.8 J	88.7	70.2	<100	<100	<100	61.0 J	69.2 J	47.0	43.4
Toluene	41.3 J	71.9	295	17.8	98.0	104	<100	<100	92.9 J	49.1 J	9.6 J	15.0 J
1,1,1-Trichloroethane	<50.0	0.777 J	<100	<1.00	0.456 J	<100	<100	<100	<100	<100	<25.0	<25.0
1,1,2-Trichloroethane	74.0	111	56.2 J	64.0	121	<100	<100	<100	91.2 J	55.3 J	30.4	28.9
Trichloroethene	252	315	243	196	224	221	266	202	195	208	70.5	81.9
Trichlorofluoromethane	<250	2.18 J	<500	2.13 J	2.50 J	<100	<100	<100	<100	<100	<25.0	<25.0
1,2,3-Trichloropropane	49.1 J	64.6	<250	31.1	66.2	<100	<100	<100	<100	<100	27.5	30.2
Vinyl chloride	<50.0	0.634 J	<100	0.429 J	0.867 J	<100	<100	<100	<100	<100	<25.0	<25.0
Xylenes	<150	68.6	258 J	18.8	71.0	<100	<100	<100	<100	<100	<25.0	<25.0
1,4-Dioxane	<5,000	1,300	<10,000	1,630	<2,500	<15,000	<15,000	<15,000	<15,000	<15,000	<3,750	2,260 J

(1) Method analytes detected in one or more samples are listed.
J = Estimated concentration; above the method detection limit, but below the reporting limit.
NA = Not Analyzed

TABLE 11
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
VOLATILE ORGANIC COMPOUNDS
GROUNDWATER SAMPLES COLLECTED AUGUST 2017
North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.:	MW-3	MW-8	MW-11I	MW-12S	MW-12I	MW-12I (2)	MW-12D
Sample Date:	**8/15/17**	**8/15/17**	**8/10/17**	**8/15/17**	**8/14/17**	**8/14/17**	**8/9/17**
EPA Method 6200B (µg/L)(1)							
Benzene	**63.4**	<20.0	<0.50	**293**	**43.1**	**46.9**	<0.50
Carbon tetrachloride	**184**	**163**	<0.50	**270**	**67.0**	**68.3**	<0.50
Chlorobenzene	<25.0	<20.0	<0.50	**87.1**	<12.5	<20.0	<0.50
Chloroform	**2,220**	**7,520**	<0.50	**12,800**	**4,350**	**4,430**	<0.50
1,2-Dibromo-3-chloropropane	<50.0	<40.0	<1.0	**6,960**	<25.0	<40.0	<1.0
1,2-Dibromoethane (EDB)	**6,740**	**840**	<0.50	**6,910**	**14.4**	<20.0	<0.50
1,2-Dichlorobenzene	<25.0	<20.0	<0.50	<62.5	<12.5	<20.0	<0.50
1,2-Dichloroethane	**49.3**	**21.7**	<0.50	**130**	<12.5	<20.0	<0.50
1,2-Dichloropropane	**5,350**	**780**	<0.50	**19,300**	**154**	**157**	<0.50
1,3-Dichloropropane	**33.6**	<20.0	<0.50	**171**	<12.5	<20.0	<0.50
Di-isopropyl ether	<25.0	<20.0	<0.50	<62.5	<12.5	<20.0	<0.50
Ethylbenzene	<25.0	<20.0	<0.50	<62.5	<12.5	<20.0	<0.50
Methylene chloride	<100	**95.5**	<2.0	**1,060**	<50.0	<80.0	<2.0
1,1,2,2-Tetrachloroethane	**53.1**	<20.0	<0.50	<62.5	<12.5	<20.0	<0.50
Tetrachloroethene	**30.8**	**135**	<0.50	**164**	**137**	**128**	<0.50
Toluene	<25.0	<20.0	<0.50	**225**	<12.5	<20.0	<0.50
1,1,2-Trichloroethane	<25.0	<20.0	<0.50	**1,170**	**66.6**	**68.1**	<0.50
Trichloroethene	**503**	**90.6**	<0.50	**320**	**111**	**118**	<0.50
1,2,3-Trichloropropane	**266**	<20.0	<0.50	**1,130**	<12.5	<20.0	<0.50
o-Xylenes	<25.0	<20.0	<0.50	**67.0**	<12.5	<20.0	<0.50
EPA Method 8260B SIM (µg/L)							
1,4-Dioxane	**126**	**2.3**	**119**	**111**	**11,700**	**11,200**	<2.0
Sample I.D.:	**MW-13S**	**MW-13D**	**MW-16S**	**MW-16I**	**MW-16D**	**MW-17S**	**MW-17I**
Sample Date:	**8/15/17**	**8/9/17**	**8/14/17**	**8/14/17**	**8/11/17**	**8/10/17**	**8/14/17**
EPA Method 6200B (µg/L)(1)							
Benzene	<0.50	<0.50	<1.0	**1.1**	<0.50	<0.50	**14,300**
Carbon tetrachloride	<0.50	<0.50	**8.5**	**0.94**	<0.50	<0.50	**117**
Chlorobenzene	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<50.0
Chloroform	<0.50	**4.9**	**328**	**27.5**	<0.50	**3.7**	**3,420**
1,2-Dibromo-3-chloropropane	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<100
1,2-Dibromoethane (EDB)	<0.50	<0.50	<1.0	**0.89**	<0.50	<0.50	<50.0
1,2-Dichlorobenzene	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<50.0
1,2-Dichloroethane	<0.50	<0.50	<1.0	**0.71**	<0.50	<0.50	<50.0
1,2-Dichloropropane	<0.50	**3.5**	**82.6**	**41.4**	<0.50	<0.50	**824**
1,3-Dichloropropane	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<50.0
Di-isopropyl ether	<0.50	<0.50	<1.0	**0.62**	<0.50	<0.50	<50.0
Ethylbenzene	<0.50	<0.50	**1.0**	<0.50	<0.50	<0.50	<50.0
Methylene chloride	<2.0	<2.0	<4.0	<2.0	<2.0	<2.0	<200
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<50.0
Tetrachloroethene	<0.50	<0.50	**96.9**	**7.7**	<0.50	<0.50	<50.0
Toluene	<0.50	<0.50	**1.1**	<0.50	<0.50	<0.50	<50.0
1,1,2-Trichloroethane	<0.50	<0.50	**7.8**	**0.87**	<0.50	<0.50	<50.0
Trichloroethene	<0.50	<0.50	**42.4**	**6.3**	<0.50	<0.50	**260**
1,2,3-Trichloropropane	<0.50	<0.50	<1.0	**0.50**	<0.50	<0.50	<50.0
o-Xylenes	<0.50	<0.50	**1.9**	<0.50	<0.50	<0.50	<50.0
EPA Method 8260B SIM (µg/L)							
1,4-Dioxane	<2.0	<2.0	**23.4**	**2,380**	**120**	<2.0	**232**

TABLE 11 (continued)
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
VOLATILE ORGANIC COMPOUNDS
GROUNDWATER SAMPLES COLLECTED AUGUST 2017
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Sample I.D.:	MW-17D	MW-27	MW-34DR	MW-35S	MW-35D	MW-36S	MW-36D
Sample Date:	**8/11/17**	**8/11/17**	**8/8/17**	**8/10/17**	**8/10/17**	**8/11/17**	**8/11/17**
EPA Method 6200B (µg/L)(1)							
Benzene	**48.4**	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
Carbon tetrachloride	**209**	**13.8**	<0.50	<0.50	**0.86**	**14.4**	**4.0**
Chlorobenzene	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
Chloroform	**1,560**	**35.0**	<0.50	<0.50	**6.7**	**272**	**148**
1,2-Dibromo-3-chloropropane	<12.5	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0
1,2-Dibromoethane (EDB)	<6.2	<0.50	<0.50	<0.50	<0.50	**1.8**	<0.50
1,2-Dichlorobenzene	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
1,2-Dichloroethane	<6.2	<0.50	<0.50	<0.50	<0.50	**3.3**	**0.63**
1,2-Dichloropropane	**159**	**12.6**	<0.50	<0.50	<0.50	**86.0**	**5.5**
1,3-Dichloropropane	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
Di-isopropyl ether	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
Ethylbenzene	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
Methylene chloride	<25.0	<2.0	<2.0	<2.0	<2.0	<4.0	<2.0
1,1,2,2-Tetrachloroethane	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
Tetrachloroethene	**55.1**	**2.9**	<0.50	<0.50	<0.50	**4.7**	**0.62**
Toluene	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
1,1,2-Trichloroethane	**32.8**	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
Trichloroethene	**107**	**10.6**	<0.50	<0.50	<0.50	**16.6**	**1.5**
1,2,3-Trichloropropane	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
o-Xylenes	<6.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50
EPA Method 8260B SIM (µg/L)							
1,4-Dioxane	**13.7**	**18.2**	<2.0	<2.0	<2.0	<2.0	**2.1**
Sample I.D.:	**MW-36D (3)**	**MW-37**	**MW-38**	**MW-41S**	**MW-41I**	**MW-41D**	**MW-42S**
Sample Date:	**8/11/17**	**8/15/17**	**8/10/17**	**8/9/17**	**8/9/17**	**8/11/17**	**8/10/17**
EPA Method 6200B (µg/L)(1)							
Benzene	<0.50	**4,060**	<0.50	<0.50	<0.50	<0.50	<0.50
Carbon tetrachloride	**4.0**	<125	<0.50	<0.50	<0.50	**5.6**	<0.50
Chlorobenzene	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
Chloroform	**152**	**47,400**	<0.50	**1.4**	**1.1**	**19.7**	**1.7**
1,2-Dibromo-3-chloropropane	<1.0	<250	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromoethane (EDB)	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichlorobenzene	<0.50	**538**	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloroethane	**0.70**	**494**	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloropropane	**5.5**	**2,350**	<0.50	<0.50	<0.50	**1.5**	<0.50
1,3-Dichloropropane	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
Di-isopropyl ether	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
Ethylbenzene	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
Methylene chloride	<2.0	**6,210**	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2,2-Tetrachloroethane	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
Tetrachloroethene	**0.64**	**295**	<0.50	<0.50	<0.50	**0.65**	<0.50
Toluene	<0.50	**283**	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,2-Trichloroethane	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
Trichloroethene	**1.6**	**744**	<0.50	<0.50	<0.50	**1.3**	<0.50
1,2,3-Trichloropropane	<0.50	<125	<0.50	<0.50	<0.50	<0.50	<0.50
o-Xylenes	<0.50	**210**	<0.50	<0.50	<0.50	<0.50	<0.50
EPA Method 8260B SIM (µg/L)							
1,4-Dioxane	**2.3**	**4,310**	<2.0	<2.0	<2.0	<2.0	**10.2**

TABLE 11 (continued)
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
VOLATILE ORGANIC COMPOUNDS
GROUNDWATER SAMPLES COLLECTED AUGUST 2017
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Sample I.D.:	MW-42I	MW-43S	MW-43D	MW-45R	MW-46	MW-47	RW-6
Sample Date:	8/11/17	8/9/17	8/8/17	8/9/17	8/9/17	8/9/17	8/15/17
EPA Method 6200B (µg/L)(1)							
Benzene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Carbon tetrachloride	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chlorobenzene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chloroform	**0.56**	**6.4**	**3.5**	<0.50	<0.50	**9.6**	**12.5**
1,2-Dibromo-3-chloropropane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromoethane (EDB)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichlorobenzene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloroethane	**0.74**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloropropane	**3.6**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,3-Dichloropropane	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Di-isopropyl ether	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Ethylbenzene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Methylene chloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tetrachloroethene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Toluene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,2-Trichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Trichloroethene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,2,3-Trichloropropane	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
o-Xylenes	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
EPA Method 8260B SIM (µg/L)							
1,4-Dioxane	**3,140**	<2.0	<2.0	<2.0	<2.0	<2.0	**154**

Sample I.D.:	RW-10	FB-1 (4)	FB-2 (5)	Trip Blank	NC 2L Std. (µg/L)
Sample Date:	8/15/17	8/11/17	8/15/17	8/10/17	---
EPA Method 6200B (µg/L)(1)					
Benzene	**1,020**	<0.50	<0.50	<0.50	1
Carbon tetrachloride	<62.5	<0.50	<0.50	<0.50	0.3
Chlorobenzene	**73.0**	<0.50	<0.50	<0.50	50
Chloroform	**20,300**	<0.50	<0.50	<0.50	70
1,2-Dibromo-3-chloropropane	**136**	<1.0	<1.0	<1.0	0.04
1,2-Dibromoethane (EDB)	<62.5	<0.50	<0.50	<0.50	0.02
1,2-Dichlorobenzene	**189**	<0.50	<0.50	<0.50	20
1,2-Dichloroethane	**309**	<0.50	<0.50	<0.50	0.4
1,2-Dichloropropane	**1,100**	<0.50	<0.50	<0.50	0.6
1,3-Dichloropropane	<62.5	<0.50	<0.50	<0.50	NS
Di-isopropyl ether	<62.5	<0.50	<0.50	<0.50	70
Ethylbenzene	<62.5	<0.50	<0.50	<0.50	600
Methylene chloride	**2,190**	<2.0	<2.0	<2.0	5
1,1,2,2-Tetrachloroethane	<62.5	<0.50	<0.50	<0.50	0.2
Tetrachloroethene	**105**	<0.50	<0.50	<0.50	0.7
Toluene	<62.5	<0.50	<0.50	<0.50	600
1,1,2-Trichloroethane	<62.5	<0.50	<0.50	<0.50	NS
Trichloroethene	**417**	<0.50	<0.50	<0.50	3
1,2,3-Trichloropropane	<62.5	<0.50	<0.50	<0.50	0.005
o-Xylenes	**83.8**	<0.50	<0.50	<0.50	500
EPA Method 8260B SIM (µg/L)					
1,4-Dioxane	**2,200**	<2.0	<2.0	<2.0	3

TABLE 11 (continued)
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
VOLATILE ORGANIC COMPOUNDS
GROUNDWATER SAMPLES COLLECTED AUGUST 2017
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(1) Method compounds detected in one or more samples are listed.
(2) Duplicate sample; labeled "MW-62" in chain of custody and laboratory report.
(3) Duplicate sample; labeled "MW-61" in chain of custody and laboratory report.
(4) Field rinseate blank; labeled "MW-63" in chain of custody and laboratory report.
(5) Field rinseate blank; labeled "MW-64" in chain of custody and laboratory report.
Bold type denotes detected compound.
Shaded type denotes concentration above North Carolina 2L standard.

TABLE 12
SUMMARIZED RESULTS OF LABORATORY AND FIELD ANALYSES
METALS AND FIELD PARAMETERS
GROUNDWATER SAMPLES COLLECTED AUGUST 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.:	MW-3	MW-8	MW-11I	MW-12S	MW-12I	MW-12I (1)	MW-12D	MW-13S
Sample Date:	8/15/17	8/15/17	8/10/17	8/15/17	8/14/17	8/14/17	8/9/17	8/15/17
LABORATORY ANALYSES								
EPA Method 6020 (µg/L)								
Arsenic	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Barium	**206**	**20.5**	**26.9**	**658**	**25.4**	**25.8**	**15.6**	**359**
Cadmium	<1.0	<1.0	<1.0	**7.6**	<1.0	<1.0	<1.0	<1.0
Chromium	<5.0	<5.0	<5.0	<5.0	**7.9**	**8.1**	<5.0	<5.0
Lead	<5.0	**5.3**	<5.0	**8.4**	<5.0	<5.0	<5.0	<5.0
Manganese	**3,300**	**56.5**	**161**	**35,800**	**93.5**	**94.1**	**90.0**	**1,060**
Selenium	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
EPA Method 7470A (µg/L)								
Mercury	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
FIELD ANALYSES								
pH	5.8	6.0	9.6	5.0	6.0	6.0	6.9	6.7
Temperature (°C)	21.2	20.4	19.6	19.6	19.9	19.9	20.4	19.9
Specific Cond. (umhos/cm)	93	42	96	193	62	62	137	85
Turbidity (NTU)	11.0	28.1	10.9	5.62	46.6	46.6	0.00	19.3

Sample I.D.:	MW-13D	MW-16S	MW-16I	MW-16D	MW-17S	MW-17I	MW-17D	MW-27
Sample Date:	8/9/17	8/14/17	8/14/17	8/11/17	8/10/17	8/14/17	8/11/17	8/11/17
LABORATORY ANALYSES								
EPA Method 6020 (µg/L)								
Arsenic	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Barium	**11.9**	**170**	**20.9**	**21.5**	**57.5**	**12.6**	<5.0	**16.9**
Cadmium	<1.0	**1.8**	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	**5.4**	**6.7**	**15.9**	<5.0	<5.0	<5.0	<5.0	<5.0
Lead	<5.0	**12.3**	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Manganese	**59.9**	**13,400**	**176**	<5.0	**220**	**124**	<5.0	**48.9**
Selenium	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
EPA Method 7470A (µg/L)								
Mercury	<0.20	**1.1**	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
FIELD ANALYSES								
pH	6.5	6.6	6.6	8.5	5.4	5.8	6.2	6.5
Temperature (°C)	19.7	22.0	20.7	19.5	18.9	21.7	19.3	19.6
Specific Cond. (umhos/cm)	72	212	108	130	56	47	60	41
Turbidity (NTU)	2.37	9.32	36.2	4.95	47	6.18	1.23	6.30

TABLE 12 (continued)
SUMMARIZED RESULTS OF LABORATORY AND FIELD ANALYSES
METALS AND FIELD PARAMETERS
GROUNDWATER SAMPLES COLLECTED AUGUST 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.:	MW-34DR	MW-35S	MW-35D	MW-36S	MW-36D	MW-36D (2)	MW-37	MW-38
Sample Date:	**8/8/17**	**8/10/17**	**8/10/17**	**8/11/17**	**8/11/17**	**8/11/17**	**8/15/17**	**8/10/17**
LABORATORY ANALYSES								
EPA Method 6020 (µg/L)								
Arsenic	<10.0	<10.0	<10.0	<10.0	**28.8**	**25.7**	<10.0	<10.0
Barium	**33.9**	**31.9**	<5.0	**89.5**	<5.0	<5.0	**927**	**26.2**
Cadmium	<1.0	<1.0	<1.0	<1.0	**1.2**	<1.0	<1.0	<1.0
Chromium	**6.7**	**11.5**	**9.6**	**20.8**	**33.0**	**34.8**	<5.0	<5.0
Lead	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**11.5**	<5.0
Manganese	**24.9**	**34.1**	**8.5**	**2,600**	**13.3**	**14.9**	**32,500**	**66.2**
Selenium	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
EPA Method 7470A (µg/L)								
Mercury	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**0.38**	<0.20
FIELD ANALYSES								
pH	6.0	6.0	6.7	5.4	7.1	7.1	6.1	7.4
Temperature (°C)	20.7	18.0	19.4	22.5	20.7	20.7	18.8	21.2
Specific Cond. (umhos/cm)	64	38	83	58	99	99	184	132
Turbidity (NTU)	23.64	24.1	2.57	25.8	7.00	7.00	41.7	30.2

Sample I.D.:	MW-41S	MW-41I	MW-41D	MW-42S	MW-42I	MW-43S	MW-43D	MW-45R
Sample Date:	**8/9/17**	**8/9/17**	**8/11/17**	**8/10/17**	**8/11/17**	**8/9/17**	**8/8/17**	**8/9/17**
LABORATORY ANALYSES								
EPA Method 6020 (µg/L)								
Arsenic	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Barium	**77.4**	**36.4**	**50.8**	**18.4**	**23.5**	**34.6**	**11.8**	**16.0**
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	**50.7**	**10.3**	**24.4**	**57.4**	<5.0	**16.2**	<5.0	<5.0
Lead	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Manganese	**147**	**6.0**	**365**	**146**	**352**	**102**	**11.7**	**77.2**
Selenium	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
EPA Method 7470A (µg/L)								
Mercury	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
FIELD ANALYSES								
pH	6.0	6.3	7.0	8.5	6.7	6.0	7.9	5.2
Temperature (°C)	25.1	21.8	21.6	20.6	19.9	18.4	19.1	19.4
Specific Cond. (umhos/cm)	154	85	58	84	115	72	89	41
Turbidity (NTU)	13.12	0.00	42.1	23.2	5.57	18.50	2.13	0.00

TABLE 12 (continued)
SUMMARIZED RESULTS OF LABORATORY AND FIELD ANALYSES
METALS AND FIELD PARAMETERS
GROUNDWATER SAMPLES COLLECTED AUGUST 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.:	MW-46	MW-47	RW-6	RW-10	FB-1 (3)	FB-2 (4)	NC 2L Std. (µg/L)
Sample Date:	8/9/17	8/9/17	8/15/17	8/15/17	8/11/17	8/15/17	
LABORATORY ANALYSES							
EPA Method 6020 (µg/L)							
Arsenic	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	10
Barium	**19.6**	**13.6**	**25.9**	**834**	<5.0	<5.0	700
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2
Chromium	<5.0	**7.0**	<5.0	<5.0	<5.0	<5.0	10
Lead	<5.0	<5.0	<5.0	**8.4**	<5.0	<5.0	15
Manganese	**61.2**	<5.0	**1,120**	**19,100**	<5.0	<5.0	50
Selenium	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	20
EPA Method 7470A (µg/L)							
Mercury	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	1
FIELD ANALYSES							
pH	5.3	6.0	6.5	6.2	NA	NA	NS
Temperature (°C)	18.1	19.1	24.1	29.8	NA	NA	NS
Specific Cond. (umhos/cm)	42	61	111	168	NA	NA	NS
Turbidity (NTU)	0.00	0.00	6.82	2.32	NA	NA	NS

(1) Duplicate sample; labeled "MW-62" in chain of custody and laboratory report.
(2) Duplicate sample; labeled "MW-61" in chain of custody and laboratory report.
(3) Field rinseate blank; labeled "MW-63" in chain of custody and laboratory report.
(4) Field rinseate blank; labeled "MW-64" in chain of custody and laboratory report.
NA = Not analyzed. NS = No North Carolina 2L standard exists.
Bold type denotes detected compound.
Shaded type denotes concentration above North Carolina 2L standard.

TABLE 13
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GROSS BETA AND TRITIUM
GROUNDWATER SAMPLES COLLECTED AUGUST 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.:	**MW-3**	**MW-8**	**MW-11I**	**MW-12S**	**MW-12I**	**MW-12I (1)**	**MW-12D**	**MW-13S**
Sample Date:	**8/15/17**	**8/15/17**	**8/10/17**	**8/15/17**	**8/14/17**	**8/14/17**	**8/9/17**	**8/15/17**
EPA Method 900.0 (pCi/L) Gross Beta	**10.0**	**16.9**	**2.12**	**67.9**	**10.8**	**4.62**	**1.76 U**	**107**
Total uncertainty (2σ+/-)	1.92	3.18	0.860	14.0	2.09	0.977	1.41	25.5
EPA Method 906.0 (pCi/L) Tritium	**-136 U**	**-108 U**	**769**	**-79.3 U**	**4,317**	**3,819**	**5.86 U**	**-14.4 U**
Total uncertainty (2σ+/-)	131	134	216	136	641	577	141	137
Sample I.D.:	**MW-13D**	**MW-16I**	**MW-16D**	**MW-17S**	**MW-17I**	**MW-17D**	**MW-27**	**MW-34DR**
Sample Date:	**8/9/17**	**8/14/17**	**8/11/17**	**8/10/17**	**8/14/17**	**8/11/17**	**8/11/17**	**8/8/17**
EPA Method 900.0 (pCi/L) Gross Beta	**1.93**	**7.11**	**3.28**	**101**	**0.837 U**	**1.17**	**33.5**	**4.67**
Total uncertainty (2σ+/-)	1.02	1.41	0.778	27.2	0.589	0.452	6.25	2.33
EPA Method 906.0 (pCi/L) Tritium	**-14.8 U**	**9,217**	**200 U**	**-91.6 U**	**23.4 U**	**14.6 U**	**-23.6 U**	**-64.3 U**
Total uncertainty (2σ+/-)	141	1,267	156	145	142	142	140	136
Sample I.D.:	**MW-35S**	**MW-35D**	**MW-36S**	**MW-36D**	**MW-36D (2)**	**MW-37**	**MW-38**	**MW-41S**
Sample Date:	**8/10/17**	**8/10/17**	**8/11/17**	**8/11/17**	**8/11/17**	**8/15/17**	**8/10/17**	**8/9/17**
EPA Method 900.0 (pCi/L) Gross Beta	**33.7**	**1.36**	**1.99**	**5.70**	**5.38**	**26.3**	**3.77**	**3.67**
Total uncertainty (2σ+/-)	8.30	0.548	0.579	1.17	1.11	4.96	0.859	1.24
EPA Method 906.0 (pCi/L) Tritium	**-156 U**	**-111 U**	**206 U**	**-37.9 U**	**-35.4 U**	**108 U**	**-76.6 U**	**38.1 U**
Total uncertainty (2σ+/-)	141	142	157	137	139	148	146	143
Sample I.D.:	**MW-41I**	**MW-41D**	**MW-42S**	**MW-42I**	**MW-43S**	**MW-43D**	**MW-45R**	**MW-46**
Sample Date:	**8/9/17**	**8/11/17**	**8/10/17**	**8/11/17**	**8/9/17**	**8/8/17**	**8/9/17**	**8/9/17**
EPA Method 900.0 (pCi/L) Gross Beta	**0.802 U**	**17.5**	**13.4**	**3.63**	**5.91**	**2.87 U**	**2.70**	**0.591 U**
Total uncertainty (2σ+/-)	0.824	3.57	2.56	0.815	2.37	1.97	1.60	1.16
EPA Method 906.0 (pCi/L) Tritium	**5.87 U**	**-118 U**	**-96.3 U**	**234 U**	**38.0 U**	**-93.7 U**	**-66.5 U**	**155 U**
Total uncertainty (2σ+/-)	141	135	134	158	143	135	135	152

TABLE 13 (continued)
SUMMARIZED RESULTS OF LABORATORY ANALYSIS
GROSS BETA AND TRITIUM
GROUNDWATER SAMPLES COLLECTED AUGUST 2017

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

Sample I.D.:	MW-47	RW-1	RW-2	RW-3	RW-4	RW-5	RW-6	RW-7
Sample Date:	**8/9/17**	**8/7/17**	**8/7/17**	**8/7/17**	**8/7/17**	**8/7/17**	**8/7/17**	**8/7/17**
EPA Method 900.0 (pCi/L)								
Gross Beta	**1.97 U**	**2.70 U**	**2.31**	**4.28**	**1.54 U**	**1.75 U**	**1.35 U**	**0.818 U**
Total uncertainty (2σ+/-)	1.60	2.41	1.14	1.44	0.970	1.00	0.896	0.839
EPA Method 906.0 (pCi/L)								
Tritium	**151 U**	**-81.6 U**	**-88.2 U**	**2,037**	**6,957**	**2,967**	**-2.94 U**	**0.000 U**
Total uncertainty (2σ+/-)	151	144	145	360	978	474	150	141

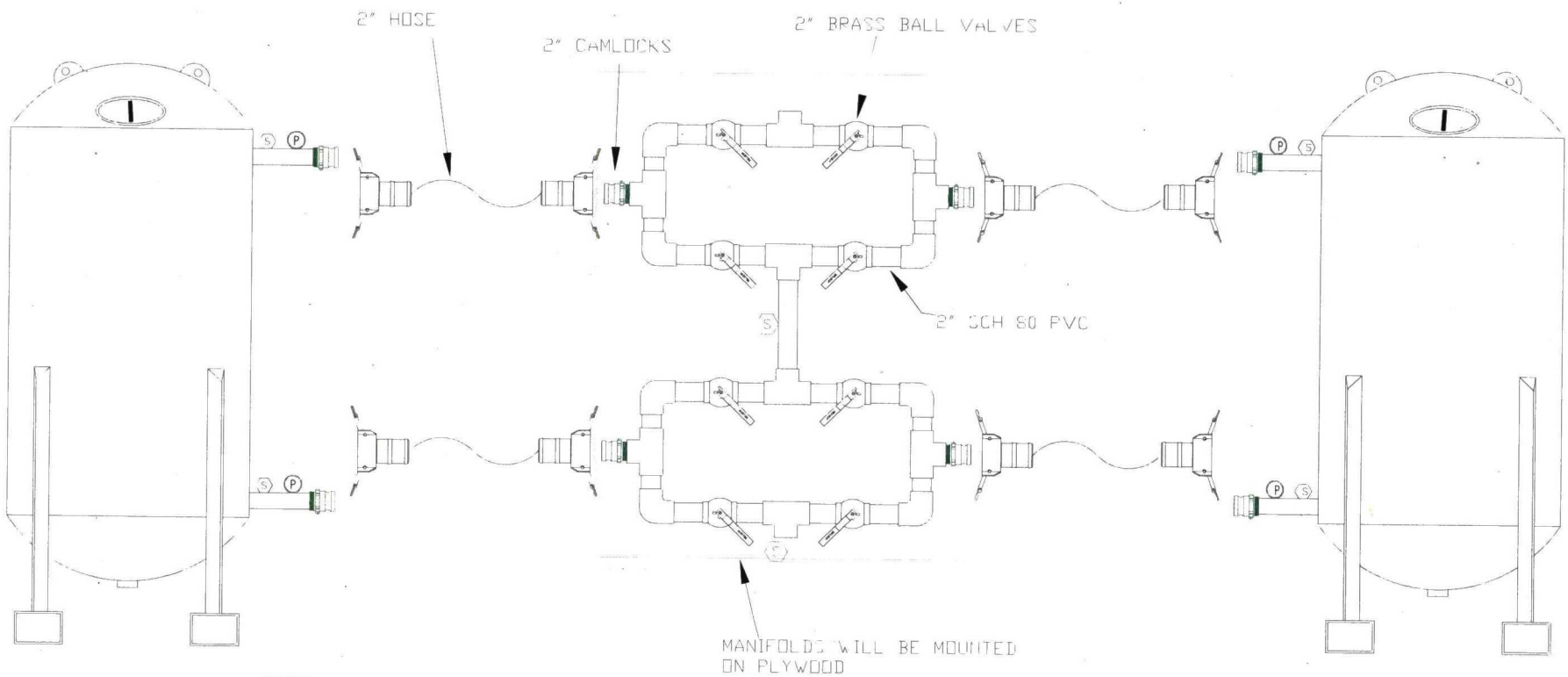
Sample I.D.:	RW-8	RW-9	RW-10	RW-11
Sample Date:	**8/7/17**	**8/7/17**	**8/7/17**	**8/7/17**
EPA Method 900.0 (pCi/L)				
Gross Beta	**2.14 U**	**2.50**	**5.25**	**1.18 U**
Total uncertainty (2σ+/-)	1.23	1.17	2.09	0.916
EPA Method 906.0 (pCi/L)				
Tritium	**8.71 U**	**-82.4 U**	**-207 U**	**1,403**
Total uncertainty (2σ+/-)	140	145	138	284

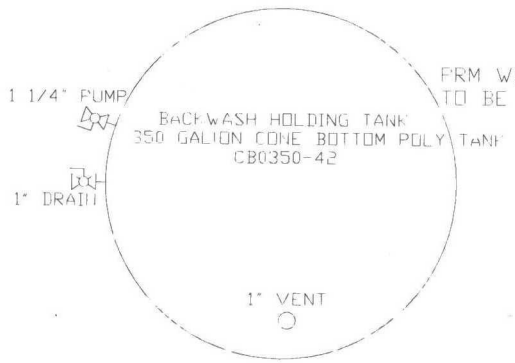
(1) Duplicate sample; labeled "MW-62" in chain of custody and laboratory report.
(2) Duplicate sample; labeled "MW-61" in chain of custody and laboratory report.
U = The analyte was analyzed for but not detected.

APPENDIX A

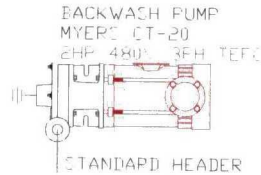
GWE SYSTEM EQUIPMENT SCHEMATICS

TWO MANIFOLDS ONE FOR CARBON ONE FOR ION





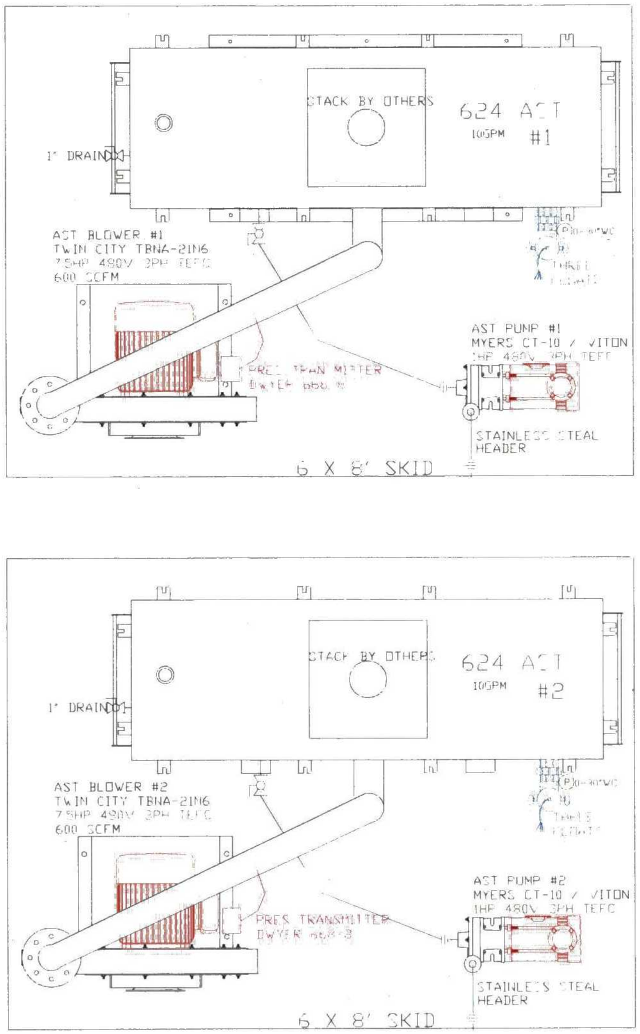
PRM WILL PROVIDE BULKHEAD FITTINGS TO BE INSTALLED AT SITE

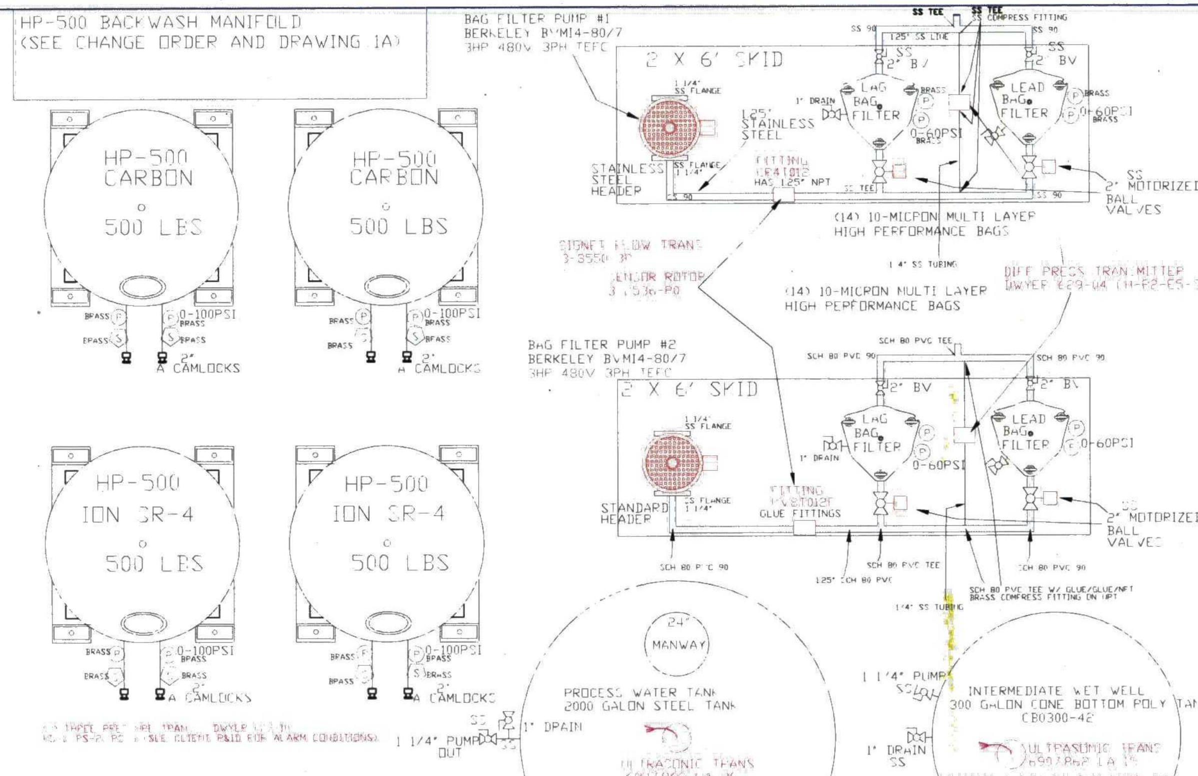


HEPACO
NC STATE LOT 86 SITE
BACKWASH MANIFOLD LAYOUT

PRM
PRODUCT RECOVERY MANAGEMENT
a division of Philips Electric Company of Durham, Inc

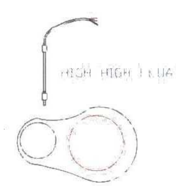
FIGURE	1B	JOB #:	WO-001292
DRAWN	G.A.C.	DATE:	7/06
CHECKED	N/A	REV #:	1a





GROUNDWATER PUMPS

(17) MODEL # 10 REDI-FLO3-100 GROUNDWATER PUMPS
(17) 50' TEFZEL CABLE KITS
(17) CU300 STATUS BOXES
(2) R100 INFARED REMTES
STATUS BOXES WILL BE INSTALLED INTO (3) PANEL BOXES
PANEL BOXES WILL BE MOUNTED TO A EQUIPMENT RACK SIZED TO ACCOMMODATE POWER
RACK WILL BE FITTED WITH WET LOCATION FLOURESCENT LIGHT FIXTURE AND BULBS
GFCI ALL WEATHER OUTLET LOCATED ON OUTSIDE OF TRAILER
500' OF ADDITIONAL TEFZEL CABLE W/ SPLICE KITS (CO #1)



FLOOR SUMP PUMP
DAYTON (3BB78)
1/3HP 120V 3PH TEFC

CONTROL PANEL

1 MET LISTED	YES (OPTION 5)	11 PLC OP	YES
2 DEADFRONT	YES	12 7/24 TIMER	NO
3 VOLTAGE	480	13 SURGE PROTECTOR	YES
4 PHASE	3	14 PHASE MONITOR	YES (OPTION 3)
5 AUTO RESTART	YES	15 PANEL TRANSFORMER	NO
6 BREAKERS IN PANEL	YES	16 FAN IN PANEL	NO
7 HOUR METERS	AST MOTORS (OPTION 2)	17 TELEMETRY	ED 82
8 AMP METERS	NO	18 AUTODIALER	NO
9 HOA AND RESET BUTTON	AST BLOWER 1 & 2 AST PUMP 1 & 2 FILTER SKID 1 & 2	19 VFD'S	FILTER SKID PUMP 1 FILTER SKID PUMP 2 CONTROLLED BY SIGNET UNIT
10 OXIDIZER INTERLOCK	NO		

LIGHTNING PROTECTION
BATTERY BACKUP
GFCI INSIDE PANEL
PC WITH MONITOR AND SMALL DESK FOR PLC SYSTEM (MEL TO GET)
PANEL WILL HAVE A 100 AMP 2 POLE CONTACTOR TO KILL POWER TO THE RECOVERY PUMPS
MAIN PANEL INCLUDES 100 AMP 2 POLE BREAKER TO FEED RECOVERY PUMP PANELS
RECOVERY PUMP PANELS WILL HAVE INDIVIDUAL CIRCUIT BREAKERS FOR INDIVIDUAL PUMPS

BAG FILTER CONTROLS
THE MOTOR OPERATED VALVES SHALL AUTOMATICALLY ISOLATE THE LEAD FILTER AND START FLOW TO THE LAG FILTER WHEN THE DIFF TRANS REACHES SETPOINT. (SET AT 10 PSI TO START)

CONTACT:
JAMES KESSLER - 704-564-8850
cary OFFICE - 719-1603
CHUCK (DOING SITE INSTALL)
CELL 704-564-8854

NC STATE LOT 86
RALEIGH, NC
RBC CENTER

THIRD PARTY LISTED SYSTEM

HEPACO
NC STATE LOT 86 SITE
PUMP AND TREAT SYSTEM
PLAN VIEW

PRODUCT RECOVERY MANAGEMENT

PRM
PRODUCT RECOVERY MANAGEMENT
a division of Philips Electric Company of Durham, Inc.

FIGURE	1	JOB #:	WO-001292
DRAWN	G.A.C.	DATE:	5/06
CHECKED	N/A	REV #:	2

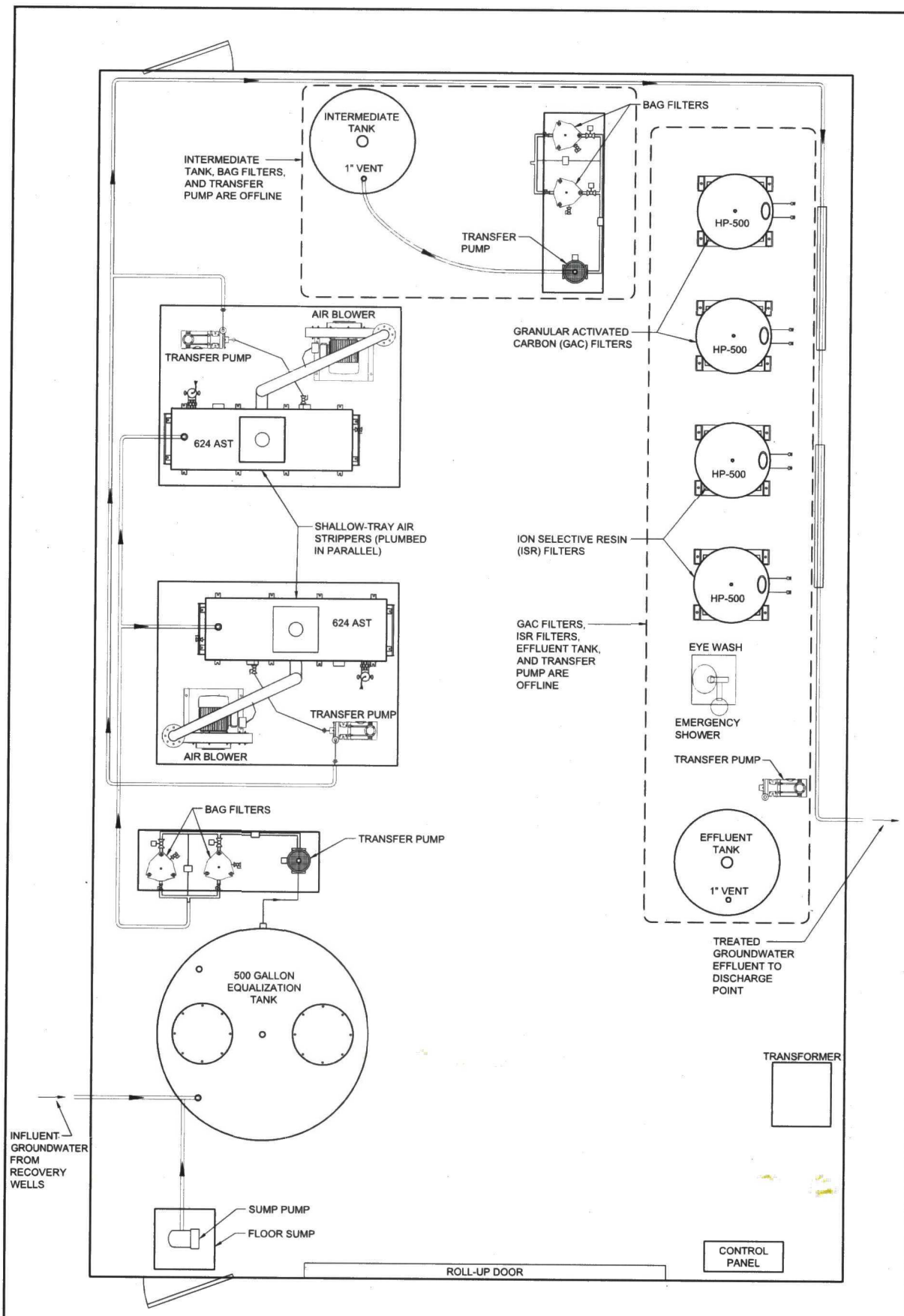


FIGURE 1A	JOB #: WO-001292
DRAWN P.J.D.	DATE: September 2017
CHECKED N/A	REV #: 3

PRM
PRODUCT RECOVERY MANAGEMENT
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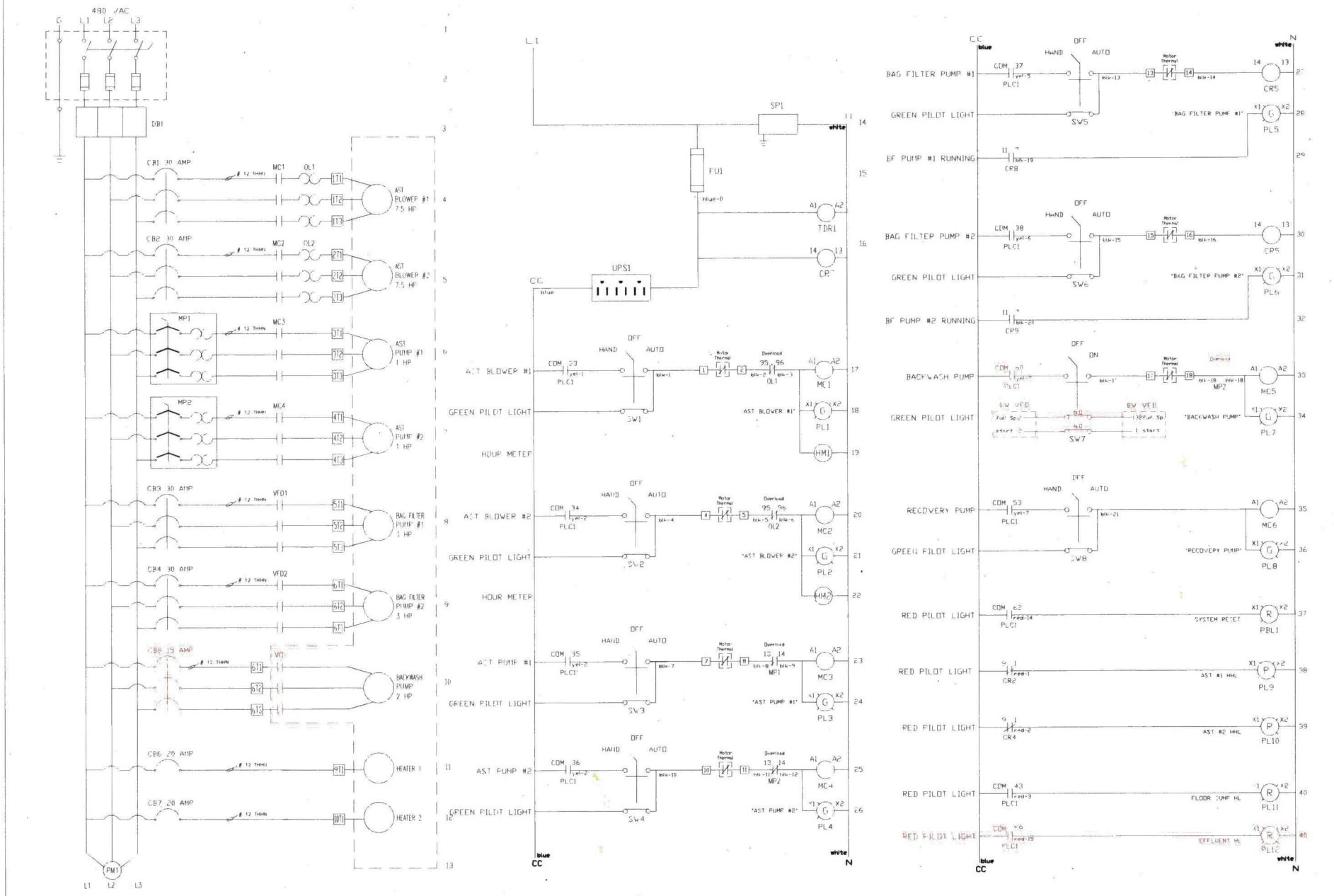
PRODUCT RECOVERY MANAGEMENT

NC STATE LOT 86 SITE
PUMP AND TREAT SYSTEM
PLAN VIEW



Broken lines show components outside of control panel

HEPACO
NC STATE LOT 86 SITE
CONTROL PANEL SCHEMATIC

PRM
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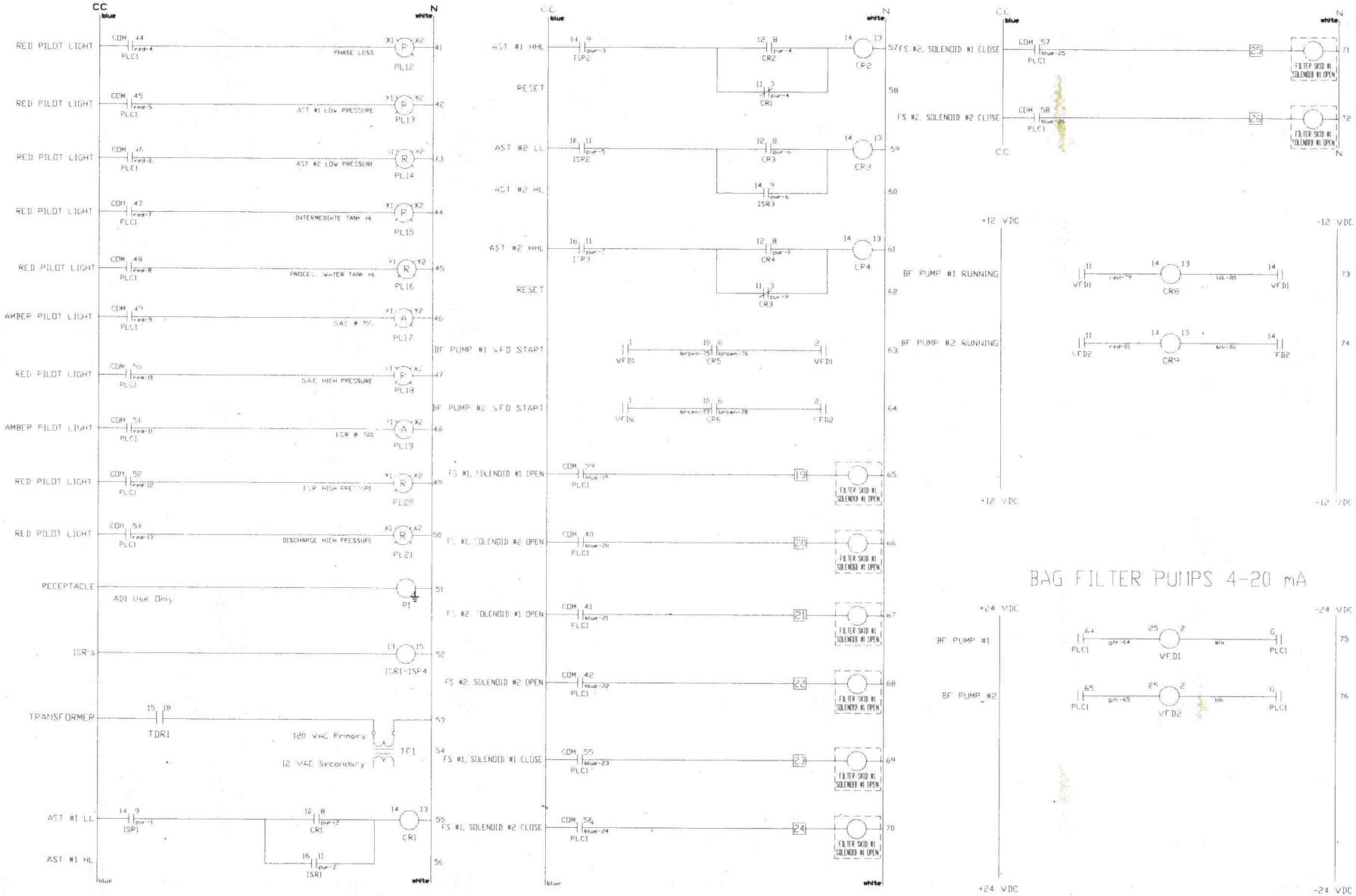
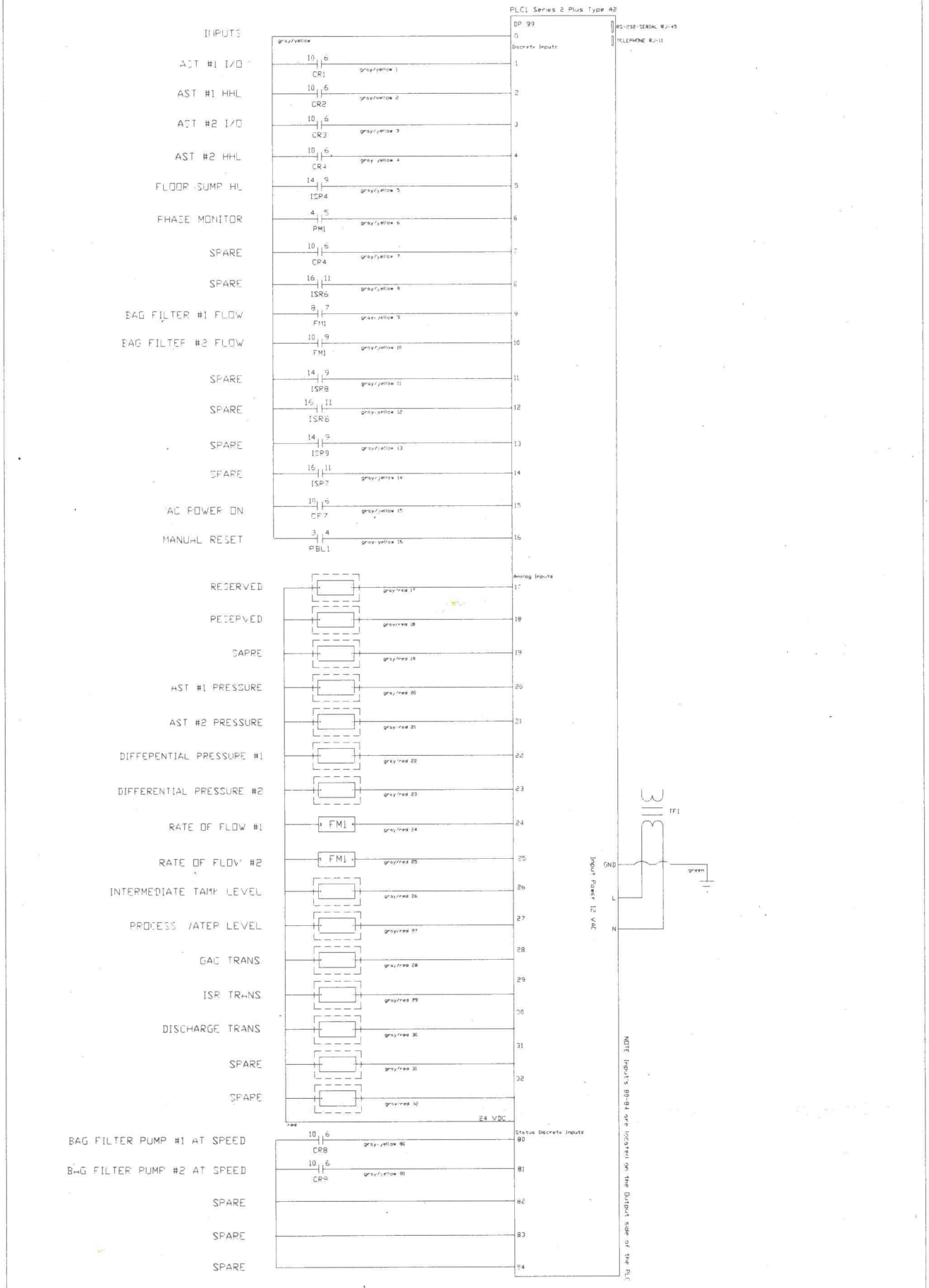
MET	JOB #	WO-001292	
DRAWN	DJM	DATE:	09/06/06
FIGURE 2	PAGE 1 OF 3	CHECKED	N/A



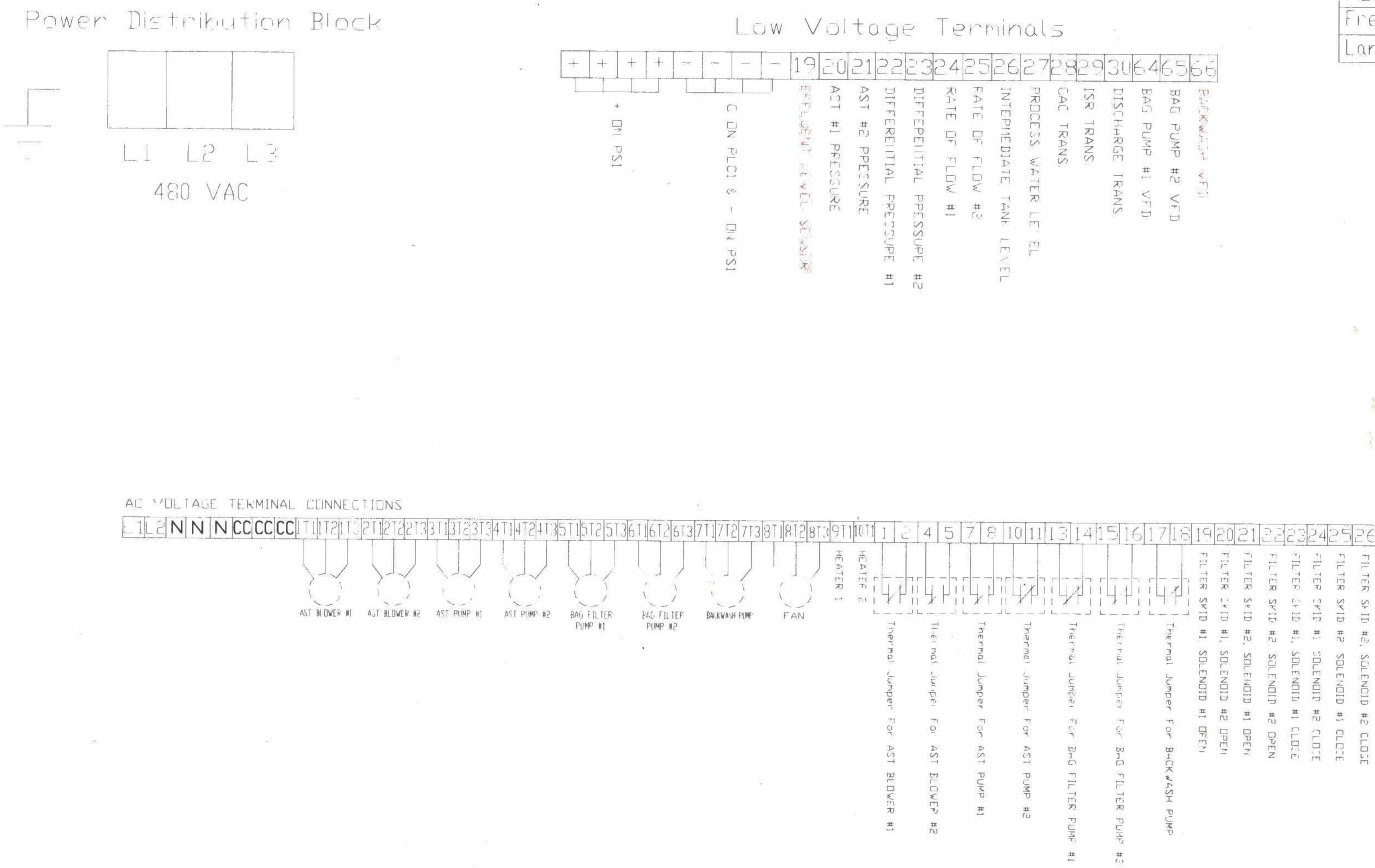
HEPACO
NC STATE LOT 86 SITE
CONTROL PANEL SCHEMATIC

PRM
PRODUCT RECOVERY MANAGEMENT
a division of Philips Electric Company of Durham, Inc.

MET	JOB #	SN0118	WO-001292
DRAWN	DATE	DJM	09/06/06
FIGURE 2	FACE 2 OF 3	CHECKED	N/A



MET SN0118	JOB #: WO-001292	PRM PRODUCT RECOVERY MANAGEMENT a division of Phillips Electric Company of Durham, Inc.	HEPACO
DRAWN DJM	DATE: 09/06/06	This information is proprietary and confidential. No copies or reproductions allowed without the express written consent of PRM.	NC STATE LOT 86 SITE
FIGURE 2 PAGE 3 OF 3	CHECKED N/A		CONTROL PANEL SCHEMATIC



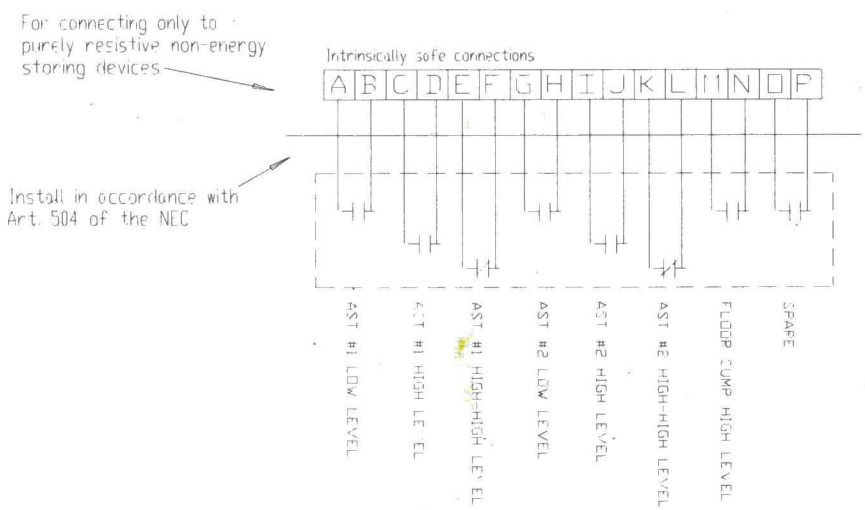
I.D.	hep001292
Voltage	480 VAC
Phase	3
F.L.A.	56.8
Frequency	60
Largest Motor: 7.5 HP	

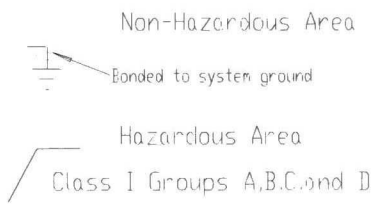
NOTES: Some connections may have already been made by PRM
Broken lines indicate components outside of control panel

HEFACO
NC STATE LOT 86 SITE
NON-INTRINSIC WIRING DIAGRAM

PRM
PRODUCT RECOVERY MANAGEMENT
a division of Phillips Electric Company of Durham, Inc.

MET	SN0118	JOB # WO-001292
DRAWN	DJM	DATE 09/06/06
FIGURE 3	PAGE 1 OF 2	CHECKED N/A





I.S. NOTES

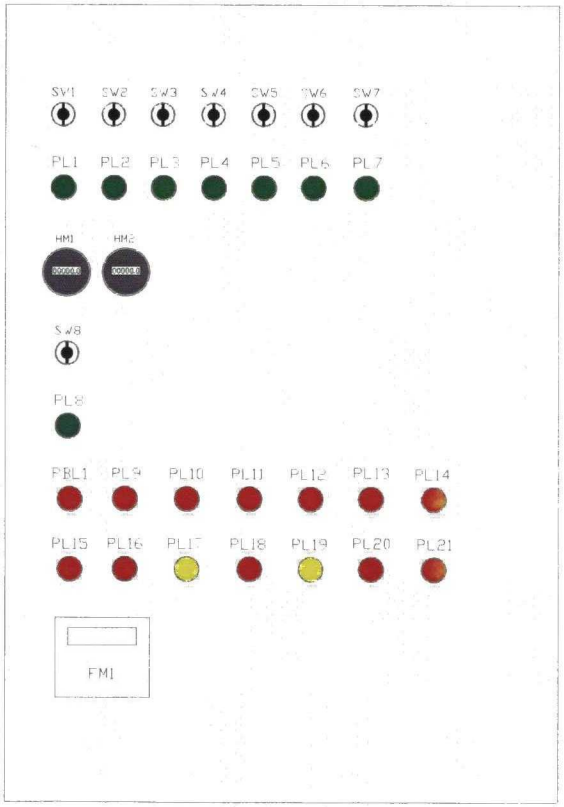
1. Maximum cable length-21,217 ft.

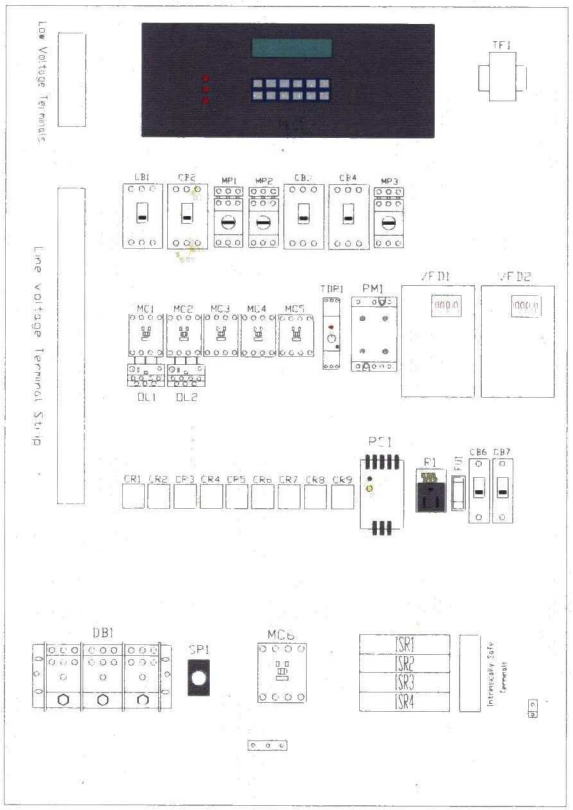
NOTES: Some connections may have already been made by PRM
Broken lines indicate components outside of control panel

HEPACO
IIC STATE LOT 86 SITE
INTRINSIC WIRING DIAGRAM

PRM
PRODUCT RECOVERY MANAGEMENT
a division of Phillips Electric Company of Durham, Inc.

MET	SN0118	JOB #	WO-001292
DRAWN	DJM	DATE:	09/06/06
FIGURE 3	PAGE 2 OF 2	CHECKED	N/A





Qty.	Drawing I.D.	Part No.	Description
		Enclosures	
1		28260	Rittal Enclosure
1		28845	Backplate
1		25311	Deadfront
		Components	
2	CB1-CB2	C0D330	Siemens Circuit Breaker
2	CB3-CB4	C0D315	Siemens Circuit Breaker
9	CR1-CR9	700-HC24A1	Allen-Bradley Control Relay
9		DPS-02-14P	Magnics Relay Base
1	DB1	16021-2	Buss Distribution Block
1	FM1	LTI-P-2	Signet Flow Meter
1	FU1	KTK-R-2	Class CC Fuse
1		BM6031PD	Buss Fuse Holder
2	HM1-HM2	T50B2	ENM Hour Meter
4	ISR1-ISR4	GHG122 3121 R1003	Crouse Hinds 120 VAC ISR
2	MC1-MC2	100-C12-D10	Allen-Bradley Motor Controller
3	MC3-MC5	100-C09-D10	Allen-Bradley Motor Controller
1	MC6	KB5	Benedikt & Jager Motor Controller
2	MP1-MP2	140M-C2E-B25-KY	Allen-Bradley Manual Motor Protector
1	MP3	140M-C2E-B40-KY	Allen-Bradley Manual Motor Protector
2	OL1-OL2	193-EA2FB	Allen-Bradley Overload
1	PBL1	800EP-LE4	Allen-Bradley Reset Button
1		800E-3X10	Allen-Bradley N.O. Contact Block
8	PL1-PL8	800EP-P3	Allen-Bradley Green Lens
8		800-3NL5G	Allen-Bradley 120VAC Green LED Module
12	PL9-PL16,PL18,PL20-PL21	800EP-P4	Allen-Bradley Red Lens
13		800E-3NL5R	Allen-Bradley 120VAC Red LED Module
2	PL17, PL19	800EP-P5	Allen-Bradley Amber Lens
2		800-3NL5A	Allen-Bradley 120VAC Amber LED Module
1	PLC1	m2	EOS Procontrol PLC
1	PM1	460-14	SymCom Phase Monitor
1	PS1	1606-XLP	Allen-Bradley 24VDC Power Supply
1	R1	991548	Weidmuller Receptacle 125V 15A
1	SP1	DTK-120HW	Ditek Surge Protector
7	SW1-SW7	800EP-SL32	Allen-Bradley Spring from Left Switch
1	SW8	800EP-3M32	Allen-Bradley Spring All-Maintained Switch
8		800E-3LX20	Allen-Bradley N.O. Contact Block
8		800E-11BE128	Allen-Bradley HOA Legend Plates
1	TDR1	TEA3T	Allen-Bradley Time Delay Relay
1	TF1	CL2-40-12	EOS Transformer
1		SB718	4 Conductor Grounding Bar Kit
1		1DE375	9 Conductor Grounding Bar Kit
1		3LN44	1 Conductor Grounding Lug
47		1492-CAM1	Allen-Bradley Terminal Blocks
39		1492-HM1	Allen-Bradley Terminal Blocks
1		CONT35MDINMT	35 mm Din Rail
1		SB371	22 mm Din Rail
1		CONTWDSG6080	60 x 80 Technomatic Wire Duct

Broken lines show components outside of control panel

HEPACO
FIC STATE LOT 86 SITE
CONTROL PANEL LAYOUT

PRM
PRODUCT RECOVERY MANAGEMENT
a division of Phillips Electric Company of Durham, Inc.

MET	JOB #	WO-001292	
DRAWN	DATE	09/06/06	
FIGURE 4	PAGE 1 OF 1	CHECKED	N/A

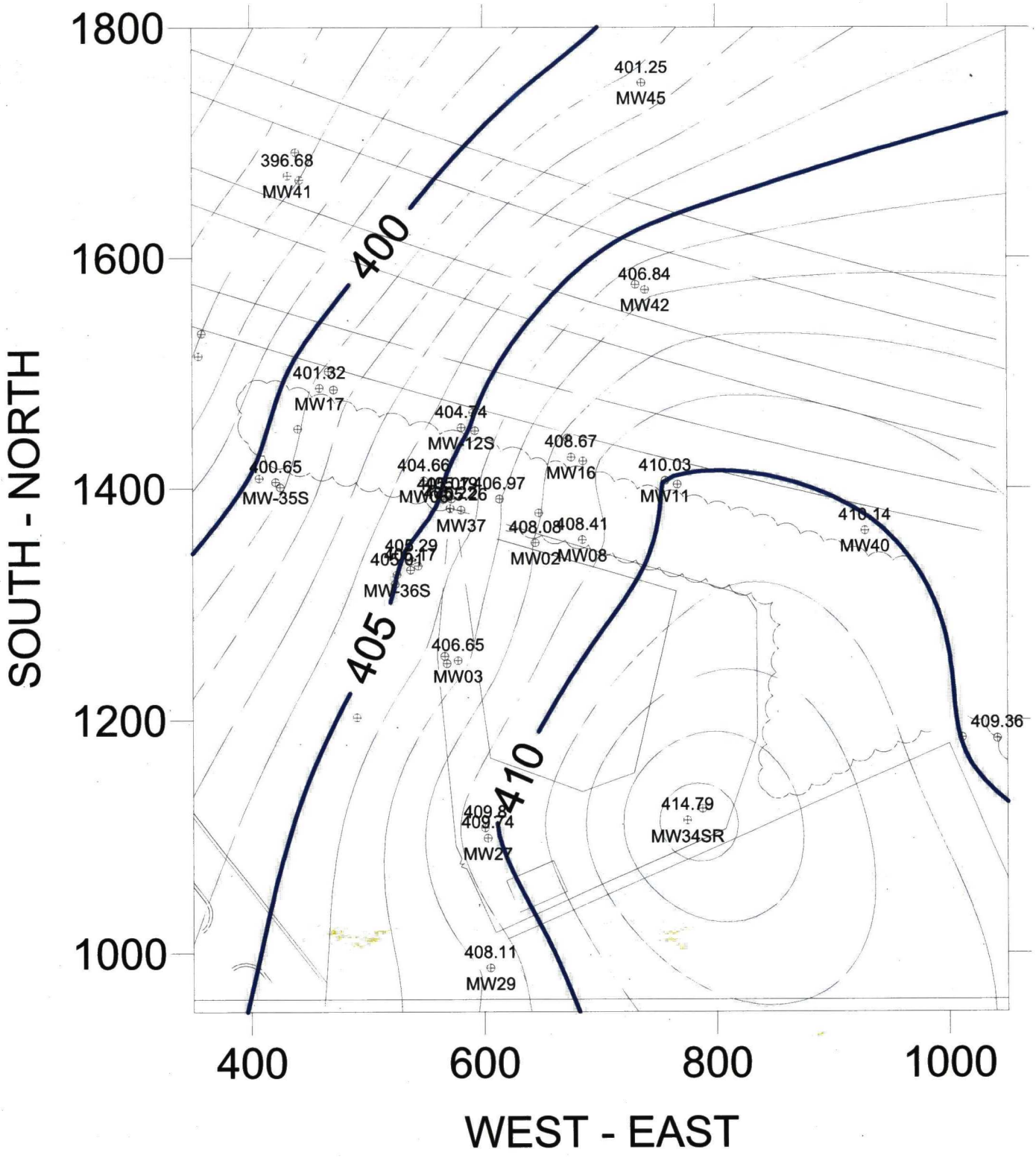
APPENDIX B

GROUNDWATER MODELING OUTPUT

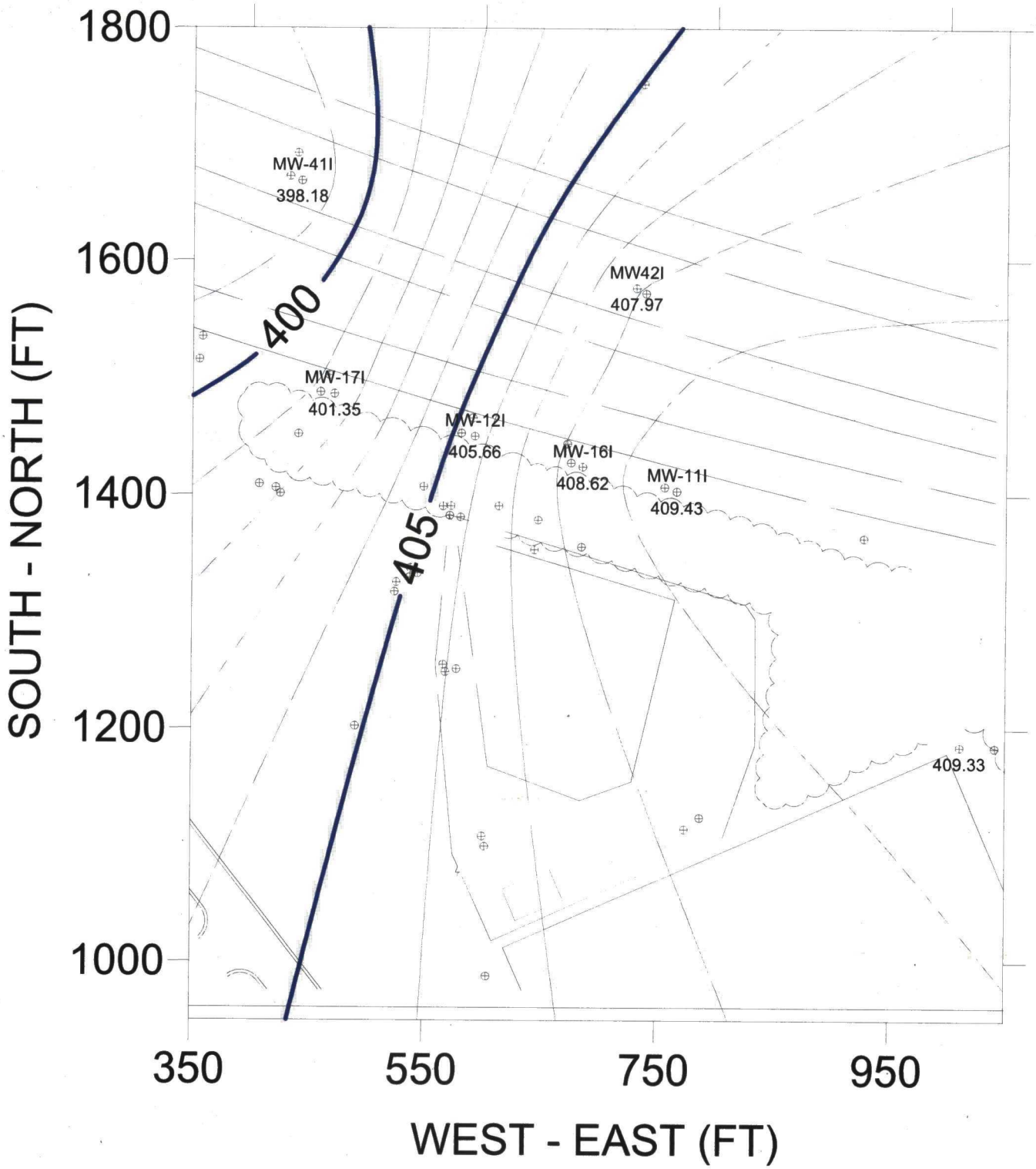
APPENDIX B-1

GROUNDWATER POTENTIOMETRIC-SURFACE AND FLOW MODELS

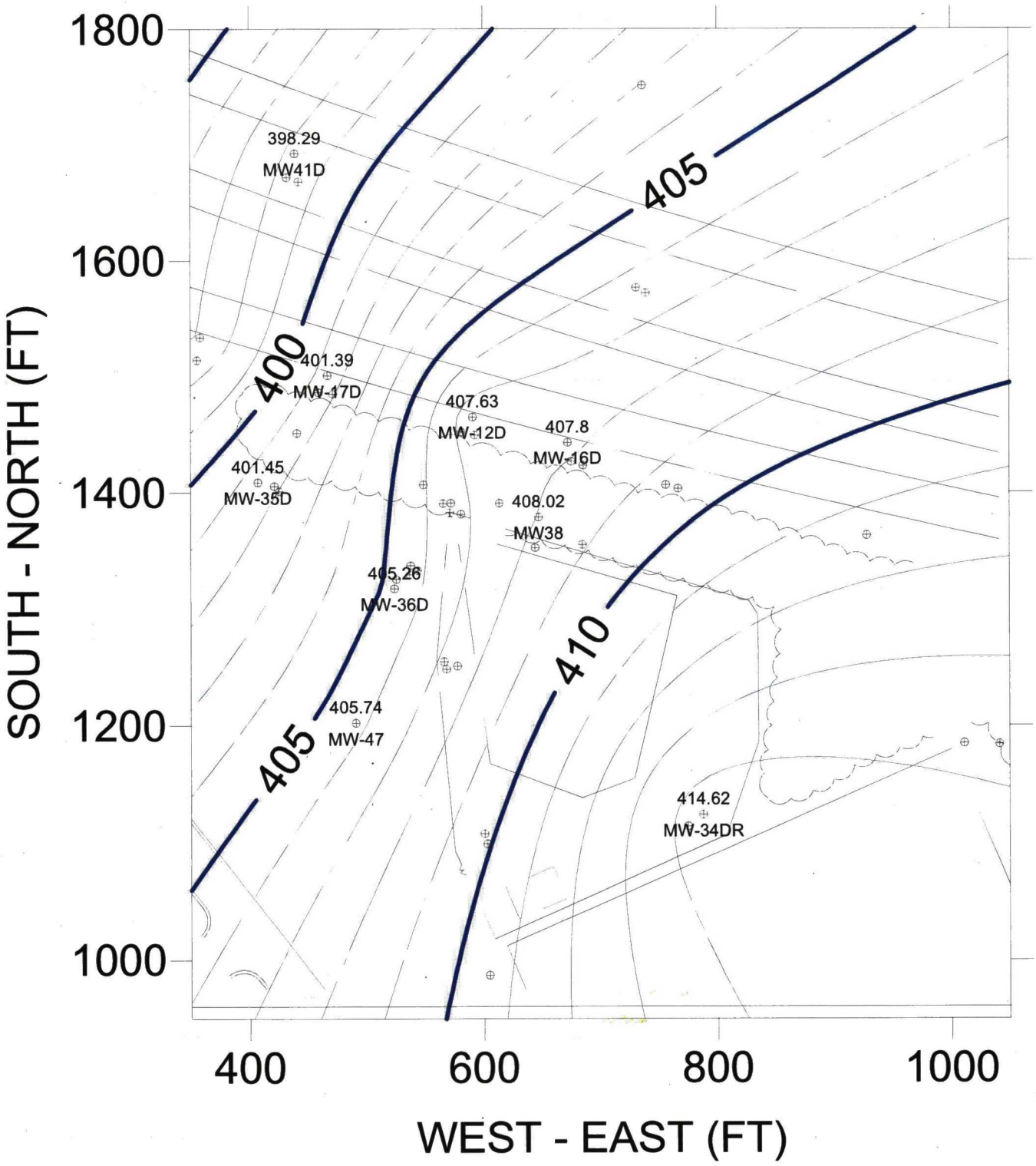
SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR MAP: MAY 2005 - NON-PUMPING CONDITIONS NCSU - LOT 86 SITE



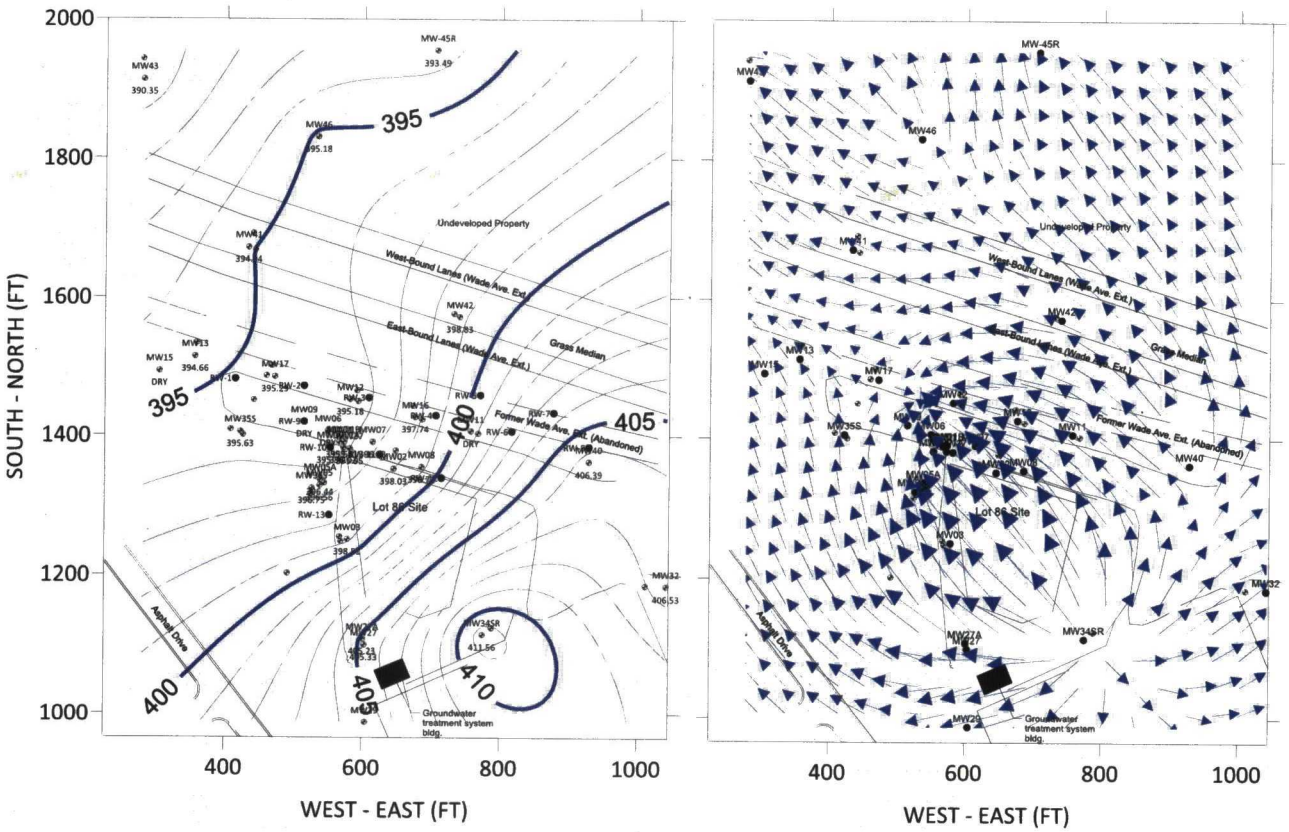
INTERMEDIATE GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR MAP: MAY 2005 - NON-PUMPING CONDITIONS NCSU - LOT 86 SITE



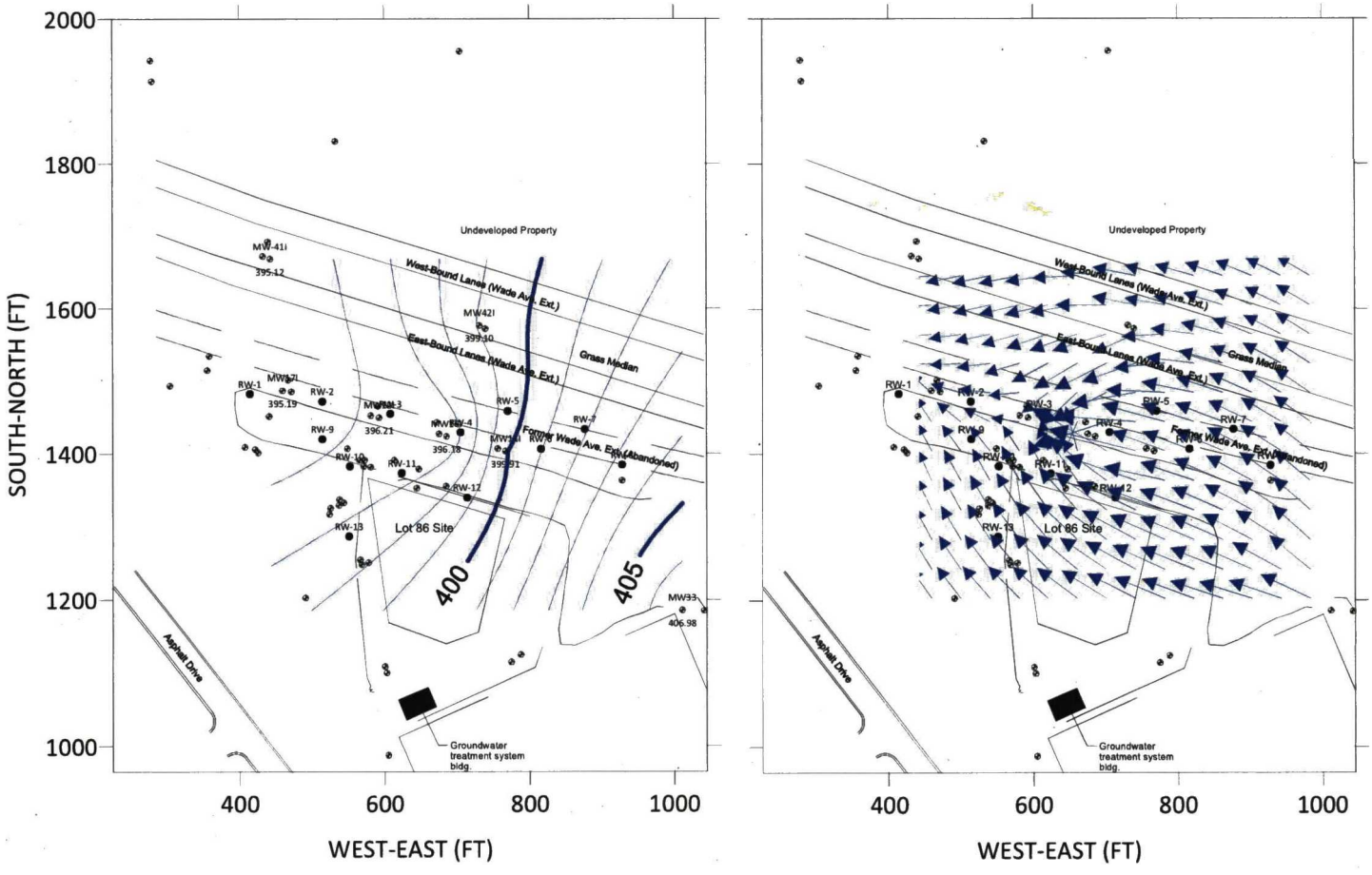
DEEP GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR MAP: MAY 2005 - NON-PUMPING CONDITIONS NCSU - LOT 86 SITE



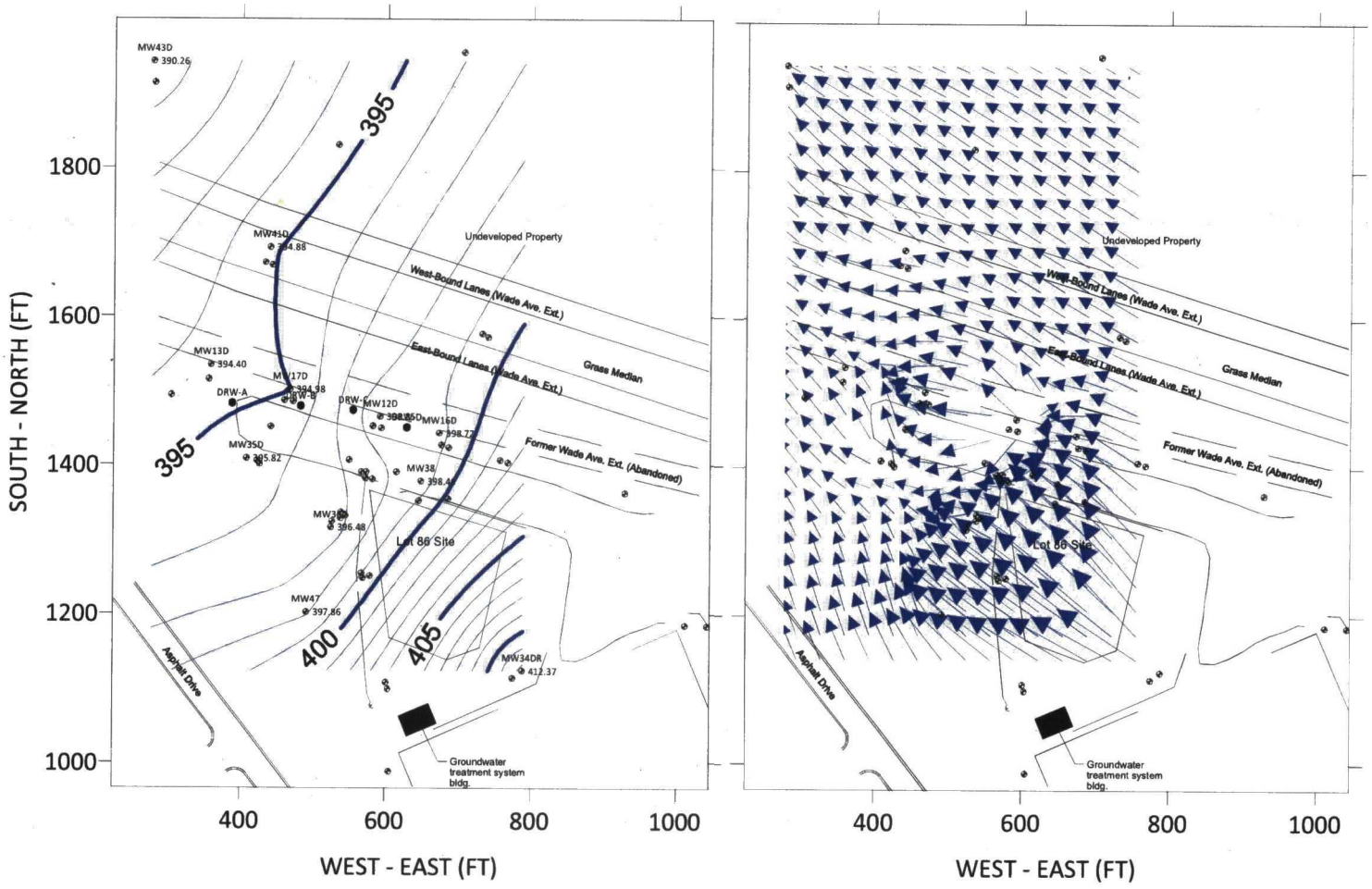
SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: FEBRUARY 1, 2017
NCSU - LOT 86 SITE



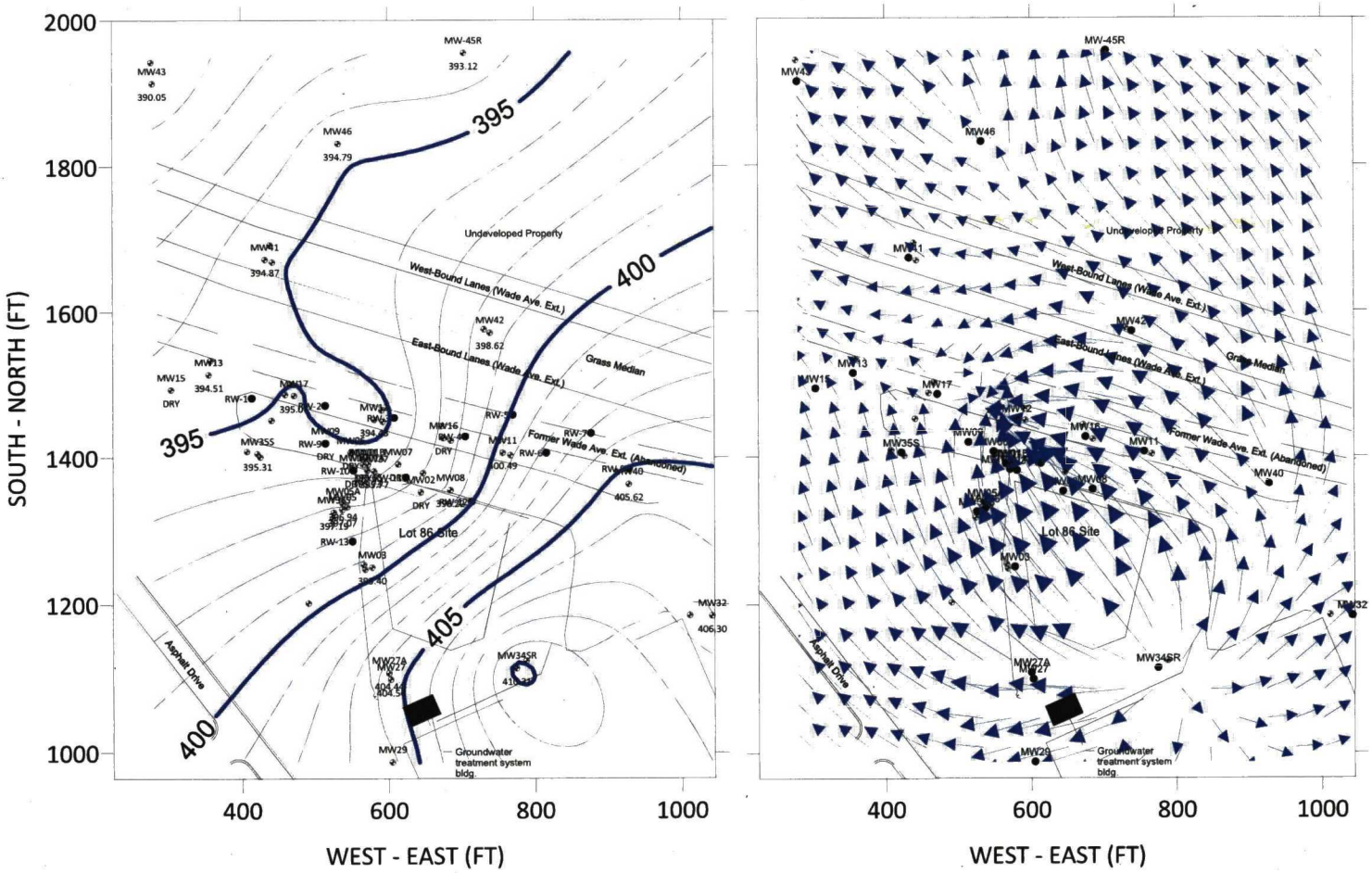
INTERMEDIATE GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: FEBRUARY 1, 2017
NCSU - LOT 86 SITE



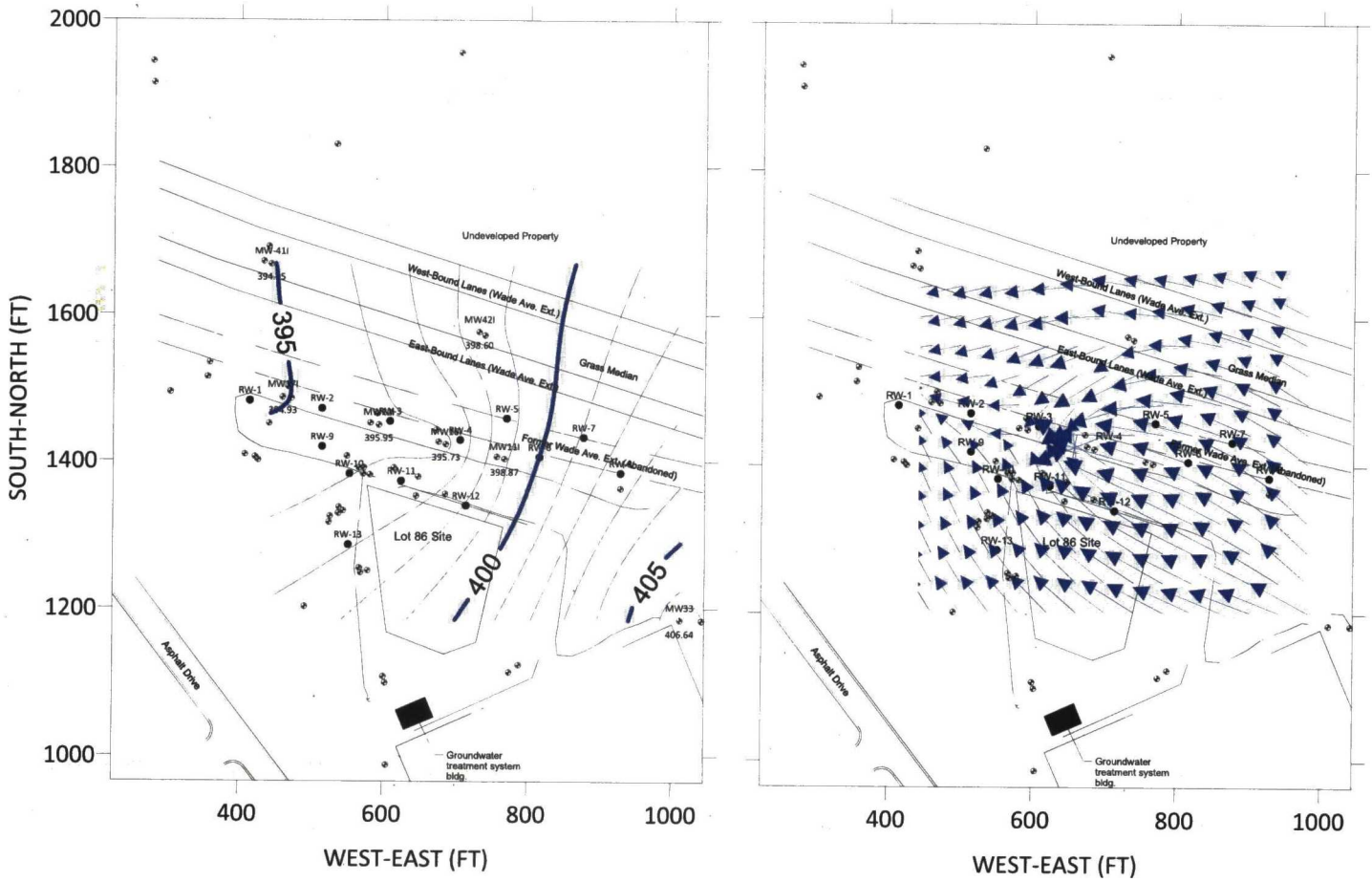
DEEP (BEDROCK) GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: FEBRUARY 1, 2017
NCSU - LOT 86 SITE



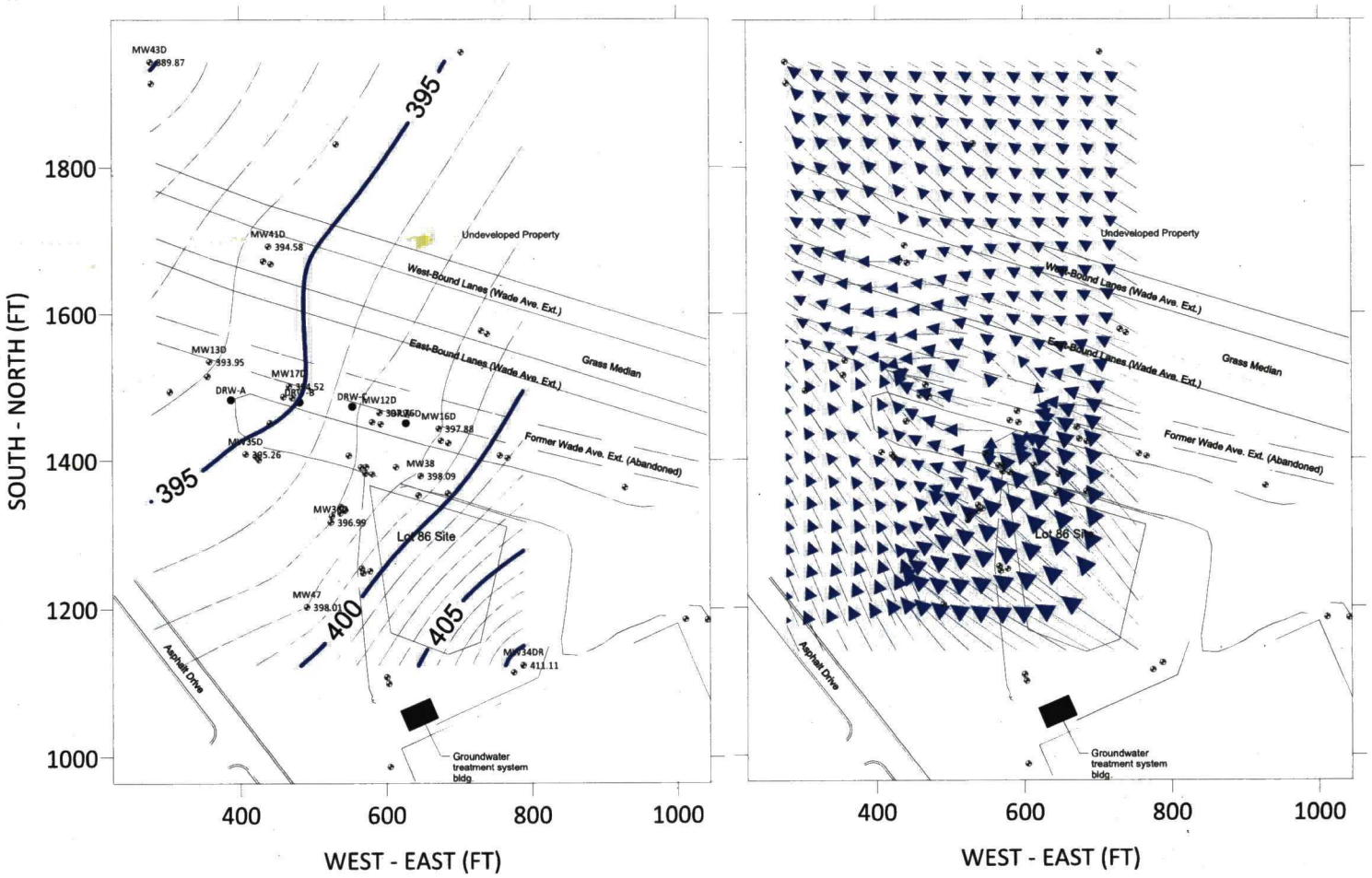
SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: MAY 22, 2017
NCSU - LOT 86 SITE



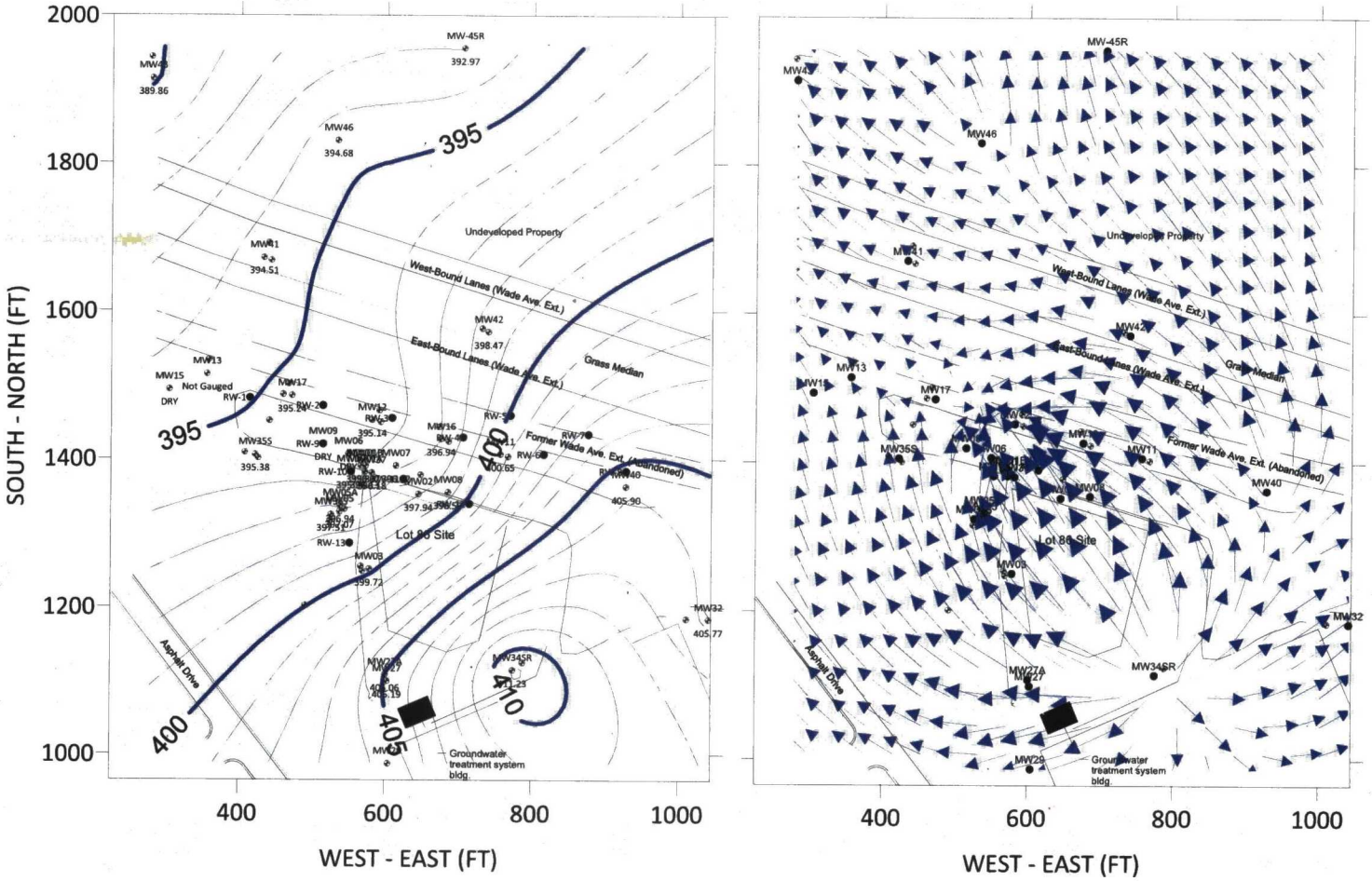
INTERMEDIATE GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: MAY 22, 2017
NCSU - LOT 86 SITE



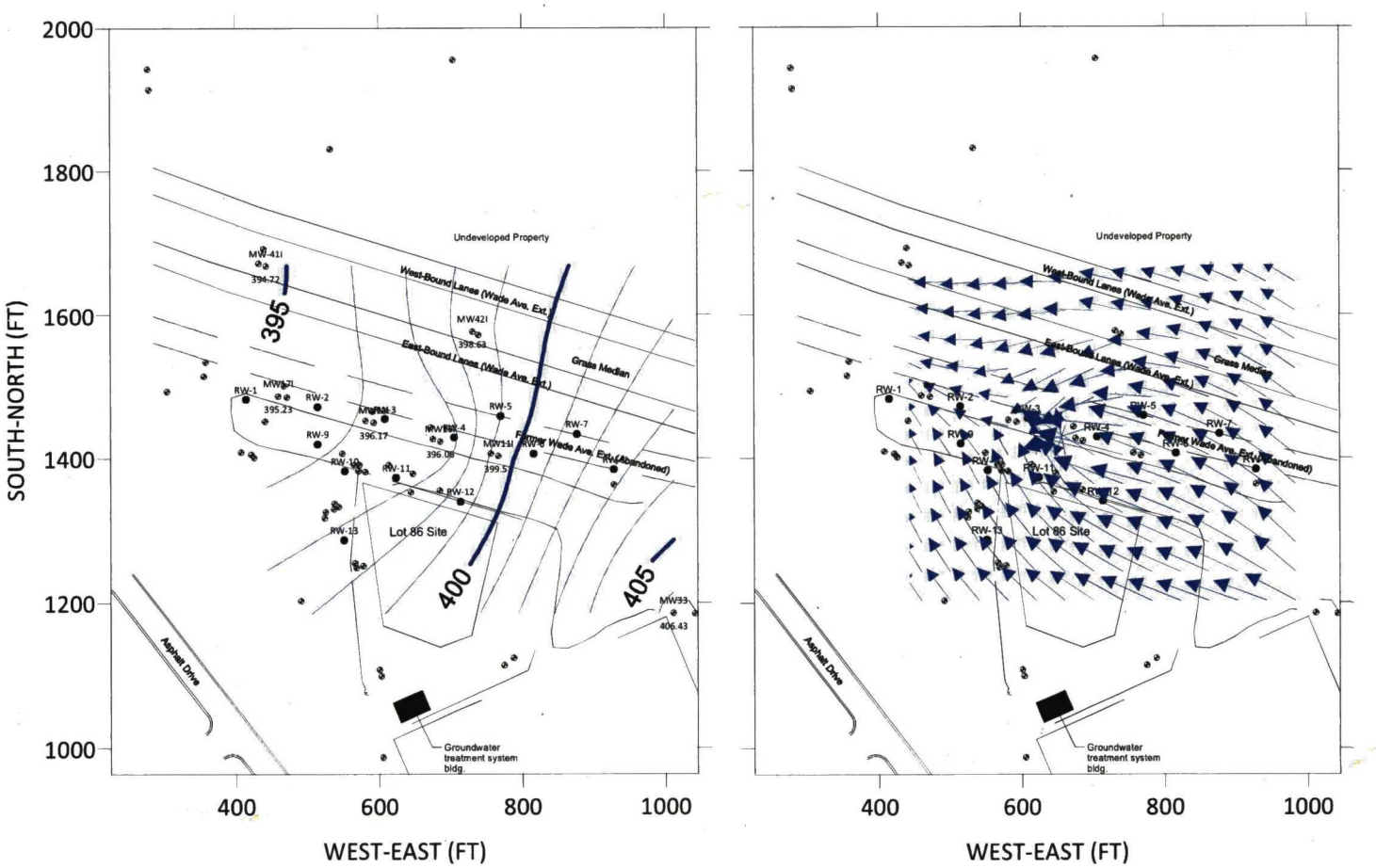
DEEP (BEDROCK) GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: MAY 22, 2017
NCSU - LOT 86 SITE



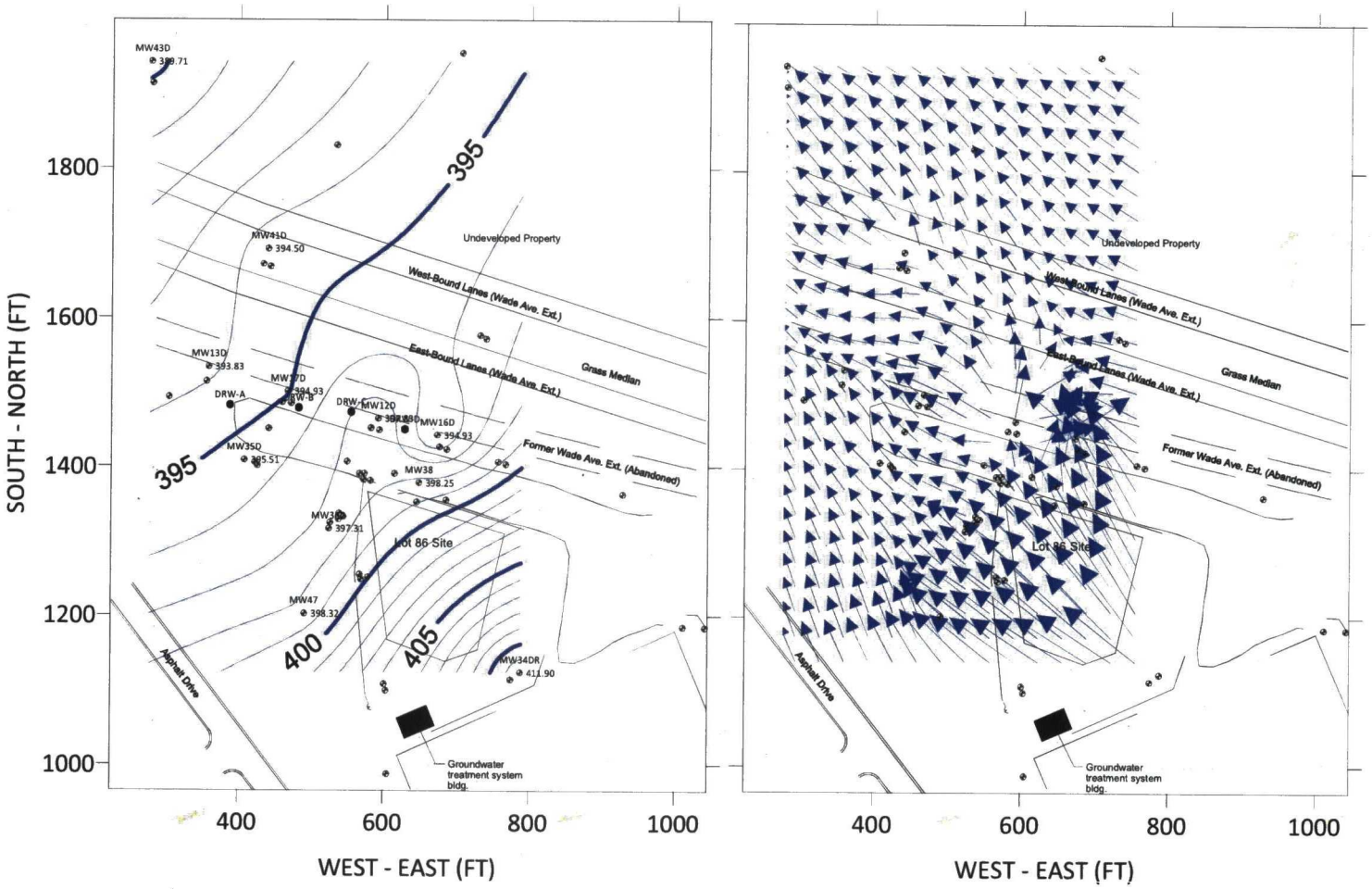
SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: AUGUST 7, 2017
NCSU - LOT 86 SITE



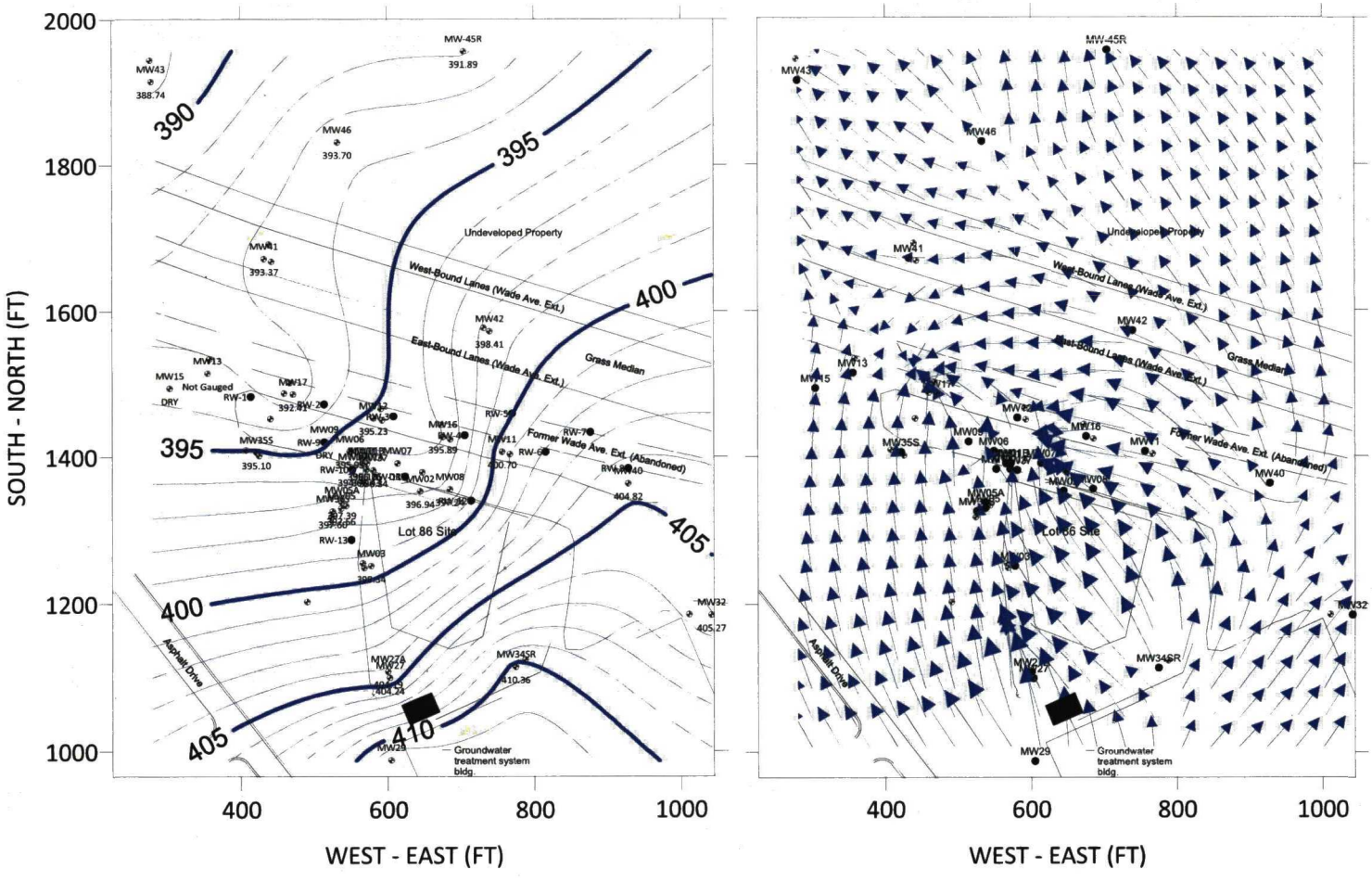
INTERMEDIATE GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: AUGUST 7, 2017
NCSU - LOT 86 SITE



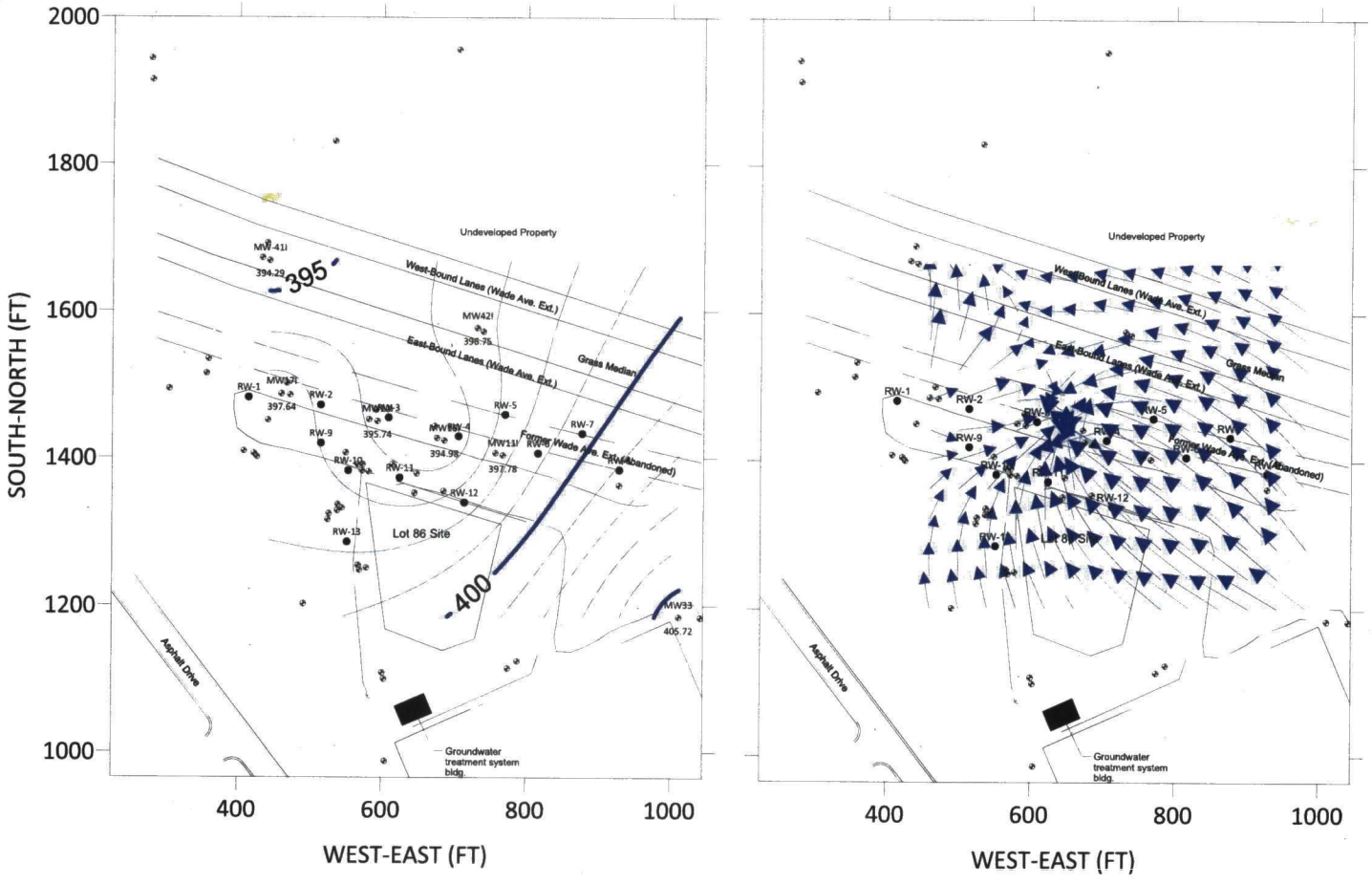
DEEP (BEDROCK) GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: AUGUST 7, 2017
NCSU - LOT 86 SITE



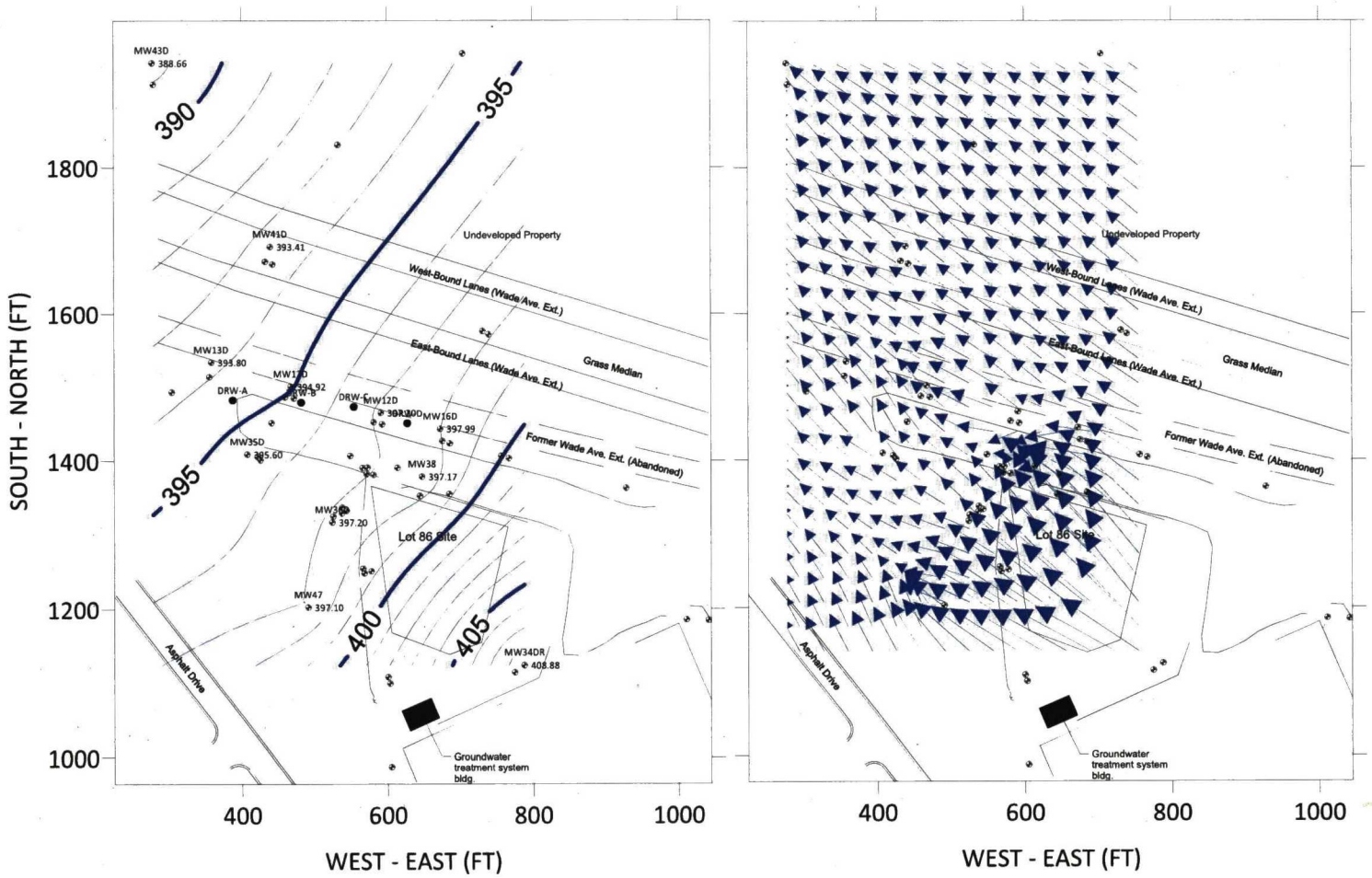
SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: NOVEMBER 20, 2017
NCSU - LOT 86 SITE



INTERMEDIATE GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: NOVEMBER 20, 2017
NCSU - LOT 86 SITE



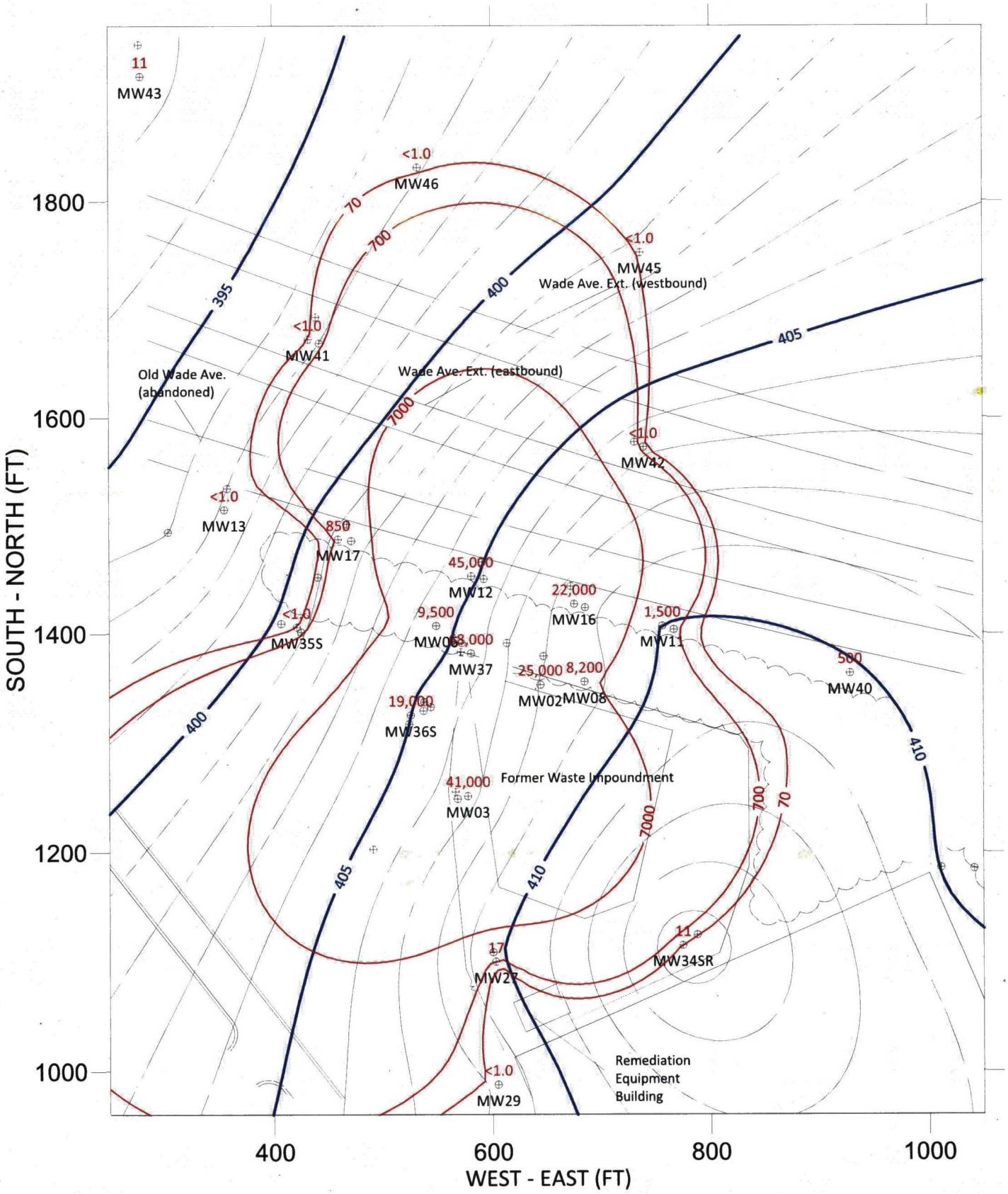
DEEP (BEDROCK) GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR
AND FLOW VECTOR MAPS: NOVEMBER 20, 2017
NCSU - LOT 86 SITE



APPENDIX B-2

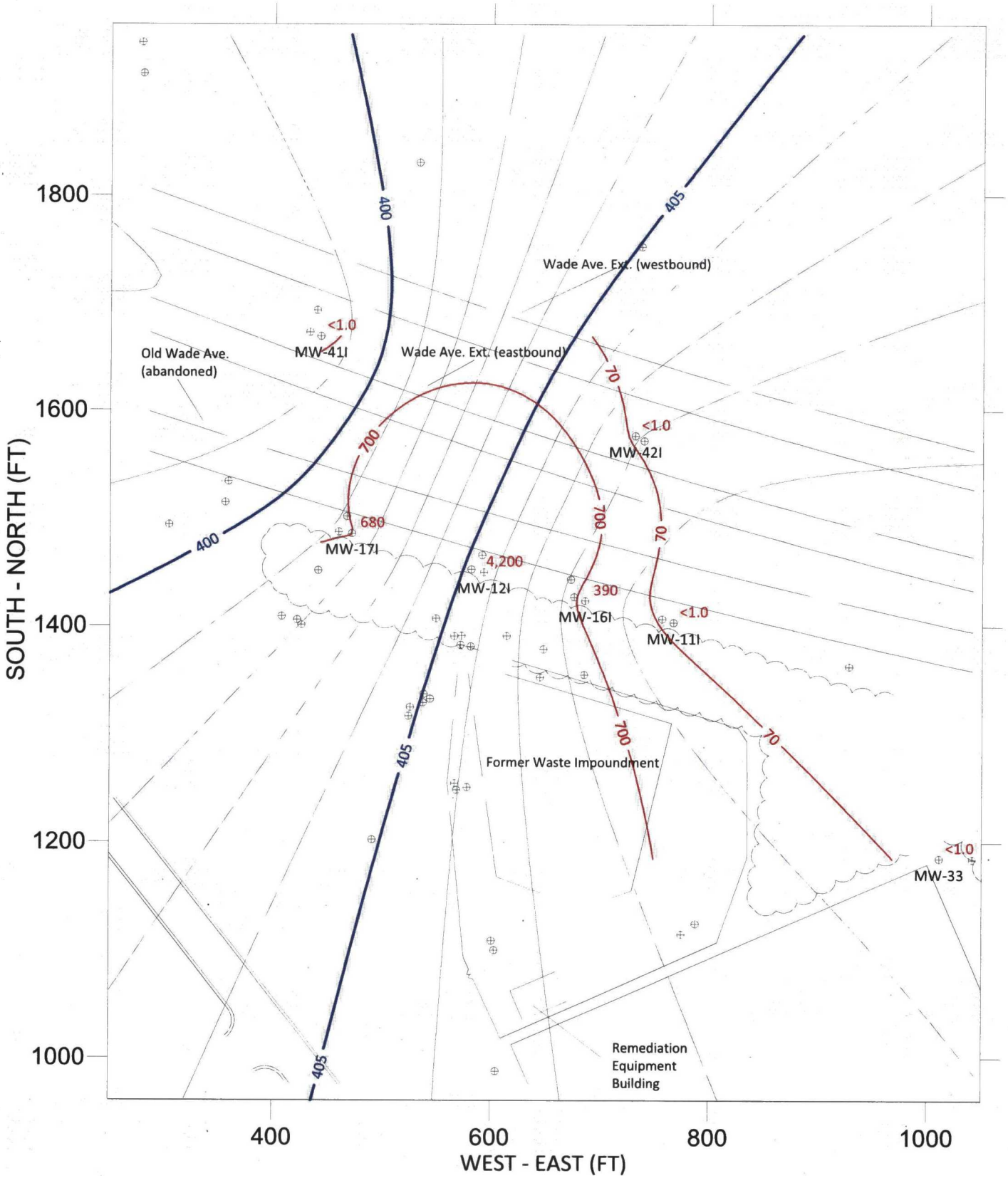
GROUNDWATER COC DISTRIBUTION MODELS

SHALLOW AQUIFER ZONE: GROUNDWATER POTENTIOMETRIC SURFACE AND CHLOROFORM ISOCONCENTRATION CONTOURS: MAY 2005 NCSU - LOT 86 SITE



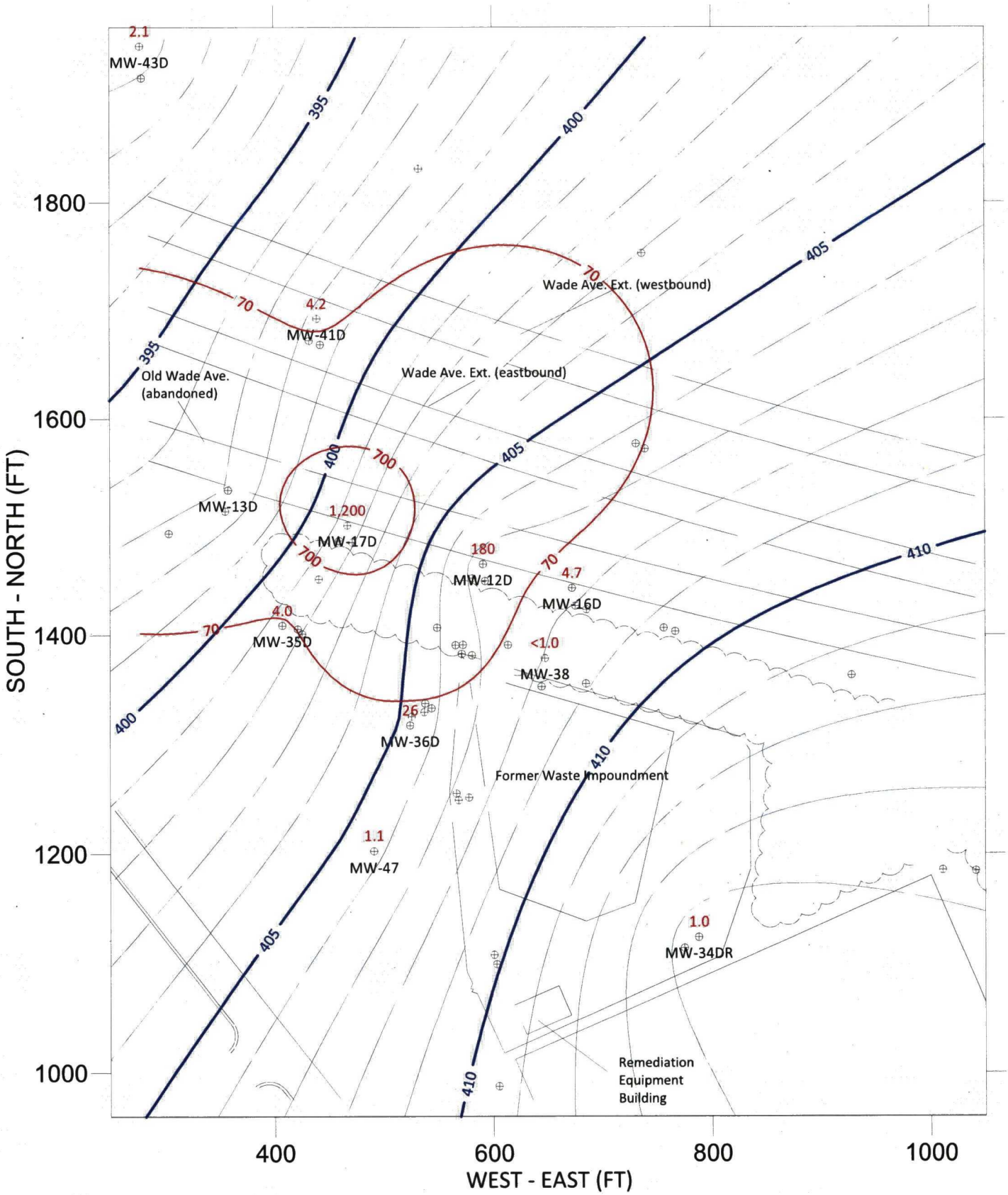
Groundwater potentiometric surface elevations (blue) in feet relative to site datum. Data collected May 3, 2005.
Groundwater chloroform concentrations (red) in ug/L. Groundwater samples collected May 5-13, 2005.

INTERMEDIATE AQUIFER ZONE: GROUNDWATER POTENTIOMETRIC SURFACE AND CHLOROFORM ISOCONCENTRATION CONTOURS: MAY 2005 NCSU - LOT 86 SITE



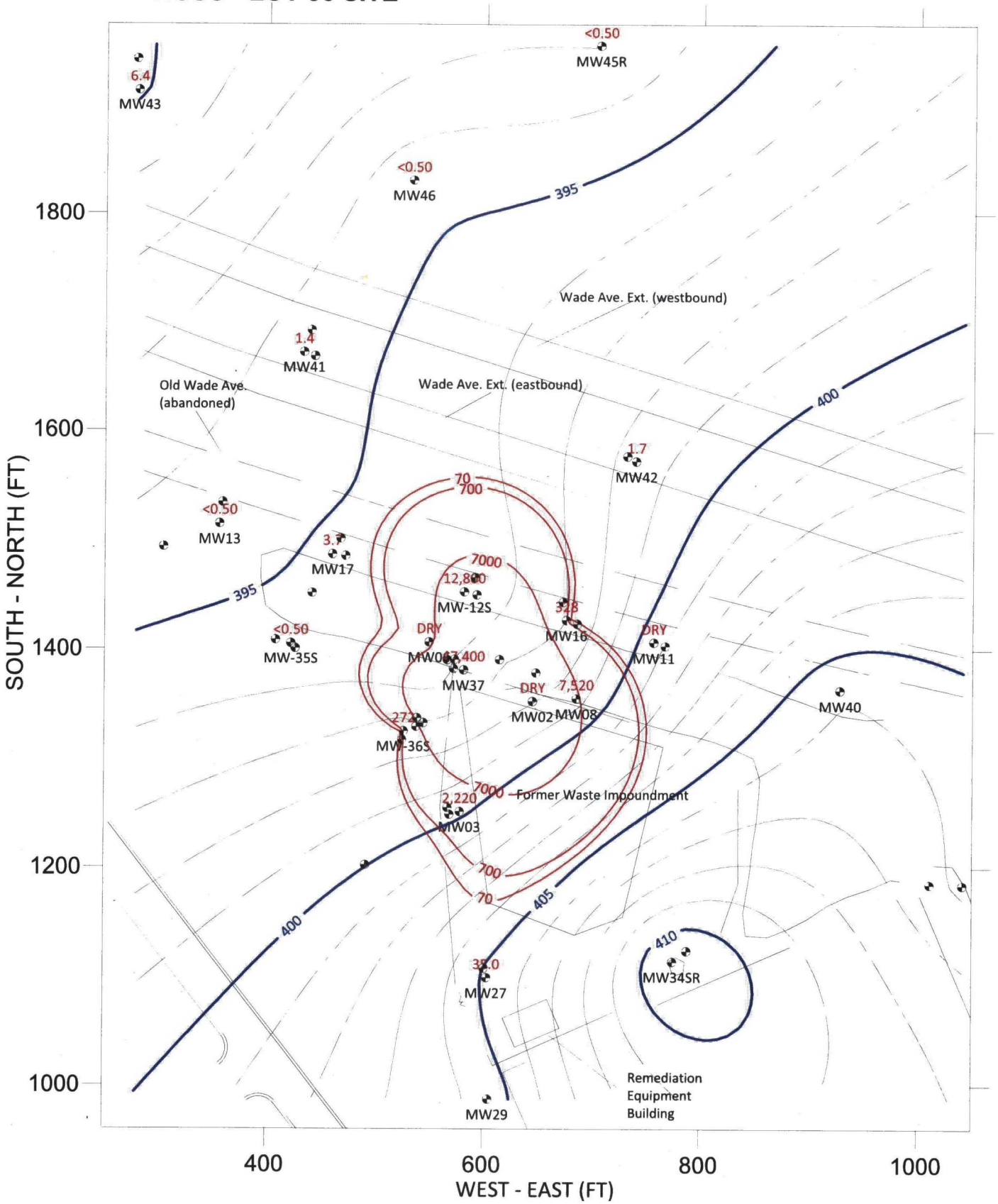
Groundwater potentiometric surface elevations (blue) in feet relative to site datum. Data collected May 5, 2005.
Groundwater chloroform concentrations (red) in ug/L. Groundwater samples collected May 5-13, 2005.

DEEP AQUIFER ZONE:
GROUNDWATER POTENTIOMETRIC SURFACE AND CHLOROFORM ISOCONCENTRATION CONTOURS: MAY 2005
NCSU - LOT 86 SITE



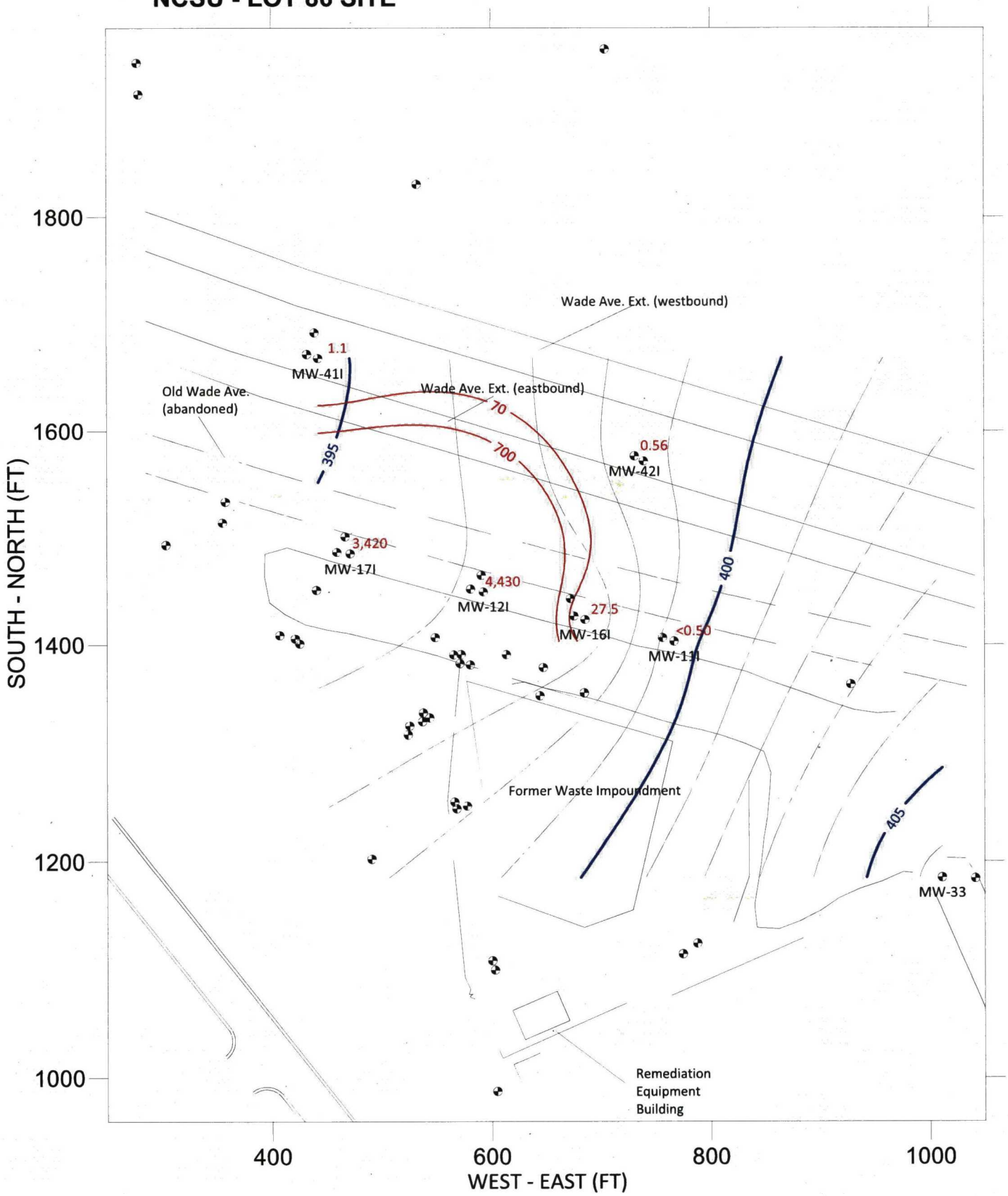
Groundwater potentiometric surface elevations (blue) in feet relative to site datum. Data collected May 3, 2005.
Groundwater chloroform concentrations (red) in ug/L. Groundwater samples collected May 5-13, 2005.

SHALLOW AQUIFER ZONE: GROUNDWATER POTENTIOMETRIC SURFACE AND CHLOROFORM ISOCONCENTRATION CONTOURS: AUGUST 2017 NCSU - LOT 86 SITE



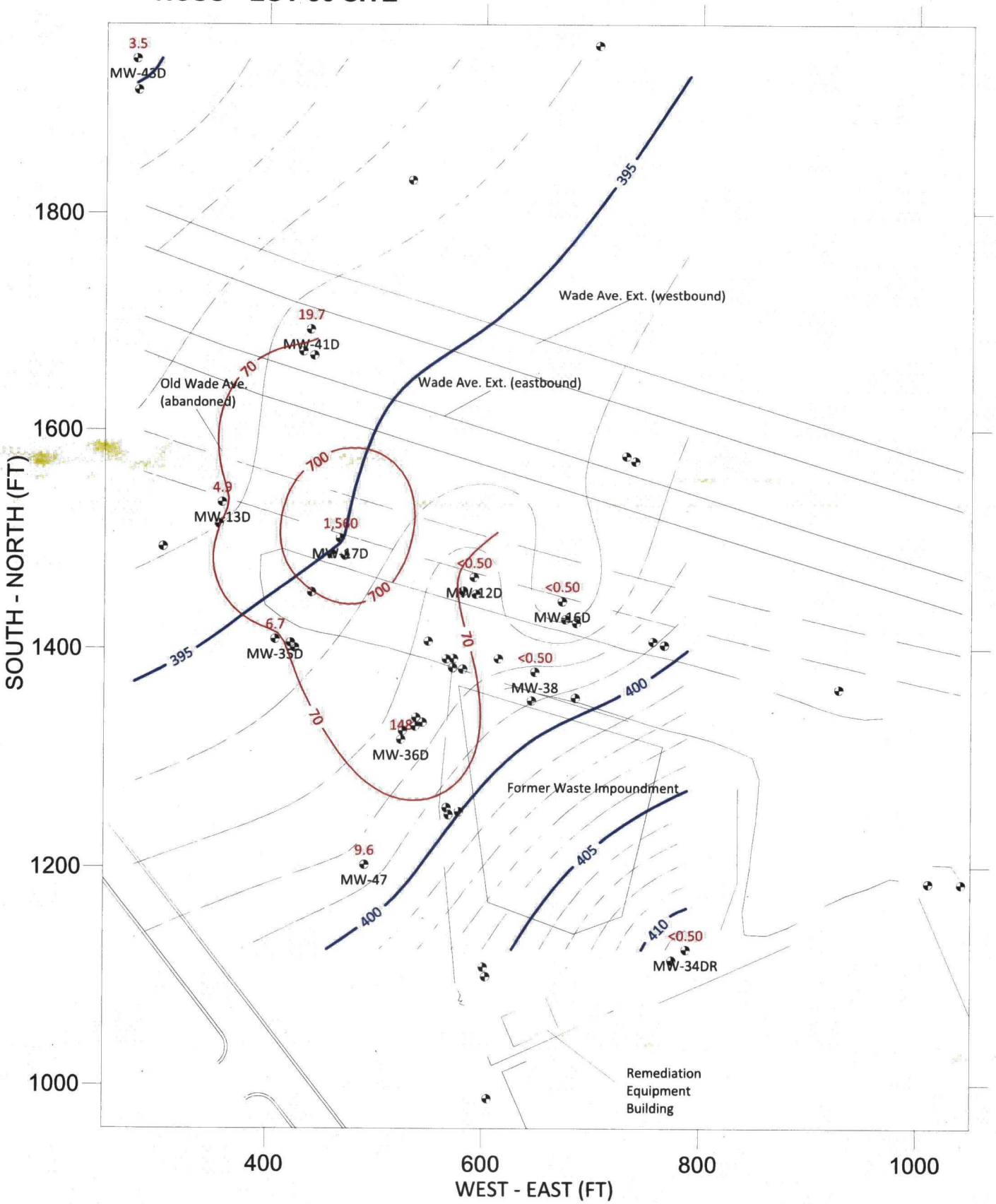
Groundwater potentiometric surface elevations (blue) in feet relative to site datum. Data collected Aug 7, 2017.
Groundwater chloroform concentrations (red) in ug/L. Groundwater samples collected Aug 8-15, 2017.

INTERMEDIATE AQUIFER ZONE: GROUNDWATER POTENTIOMETRIC SURFACE AND CHLOROFORM ISOCONCENTRATION CONTOURS: AUGUST 2017 NCSU - LOT 86 SITE



Groundwater potentiometric surface elevations (blue) in feet relative to site datum. Data collected Aug 7, 2017.
Groundwater chloroform concentrations (red) in ug/L. Groundwater samples collected Aug 8-15, 2017.

DEEP AQUIFER ZONE:
GROUNDWATER POTENTIOMETRIC SURFACE AND CHLOROFORM ISOCONCENTRATION CONTOURS: AUGUST 2017
NCSU - LOT 86 SITE



Groundwater potentiometric surface elevations (blue) in feet relative to site datum. Data collected Aug 7, 2017.
Groundwater chloroform concentrations (red) in ug/L. Groundwater samples collected Aug 8-15, 2017.

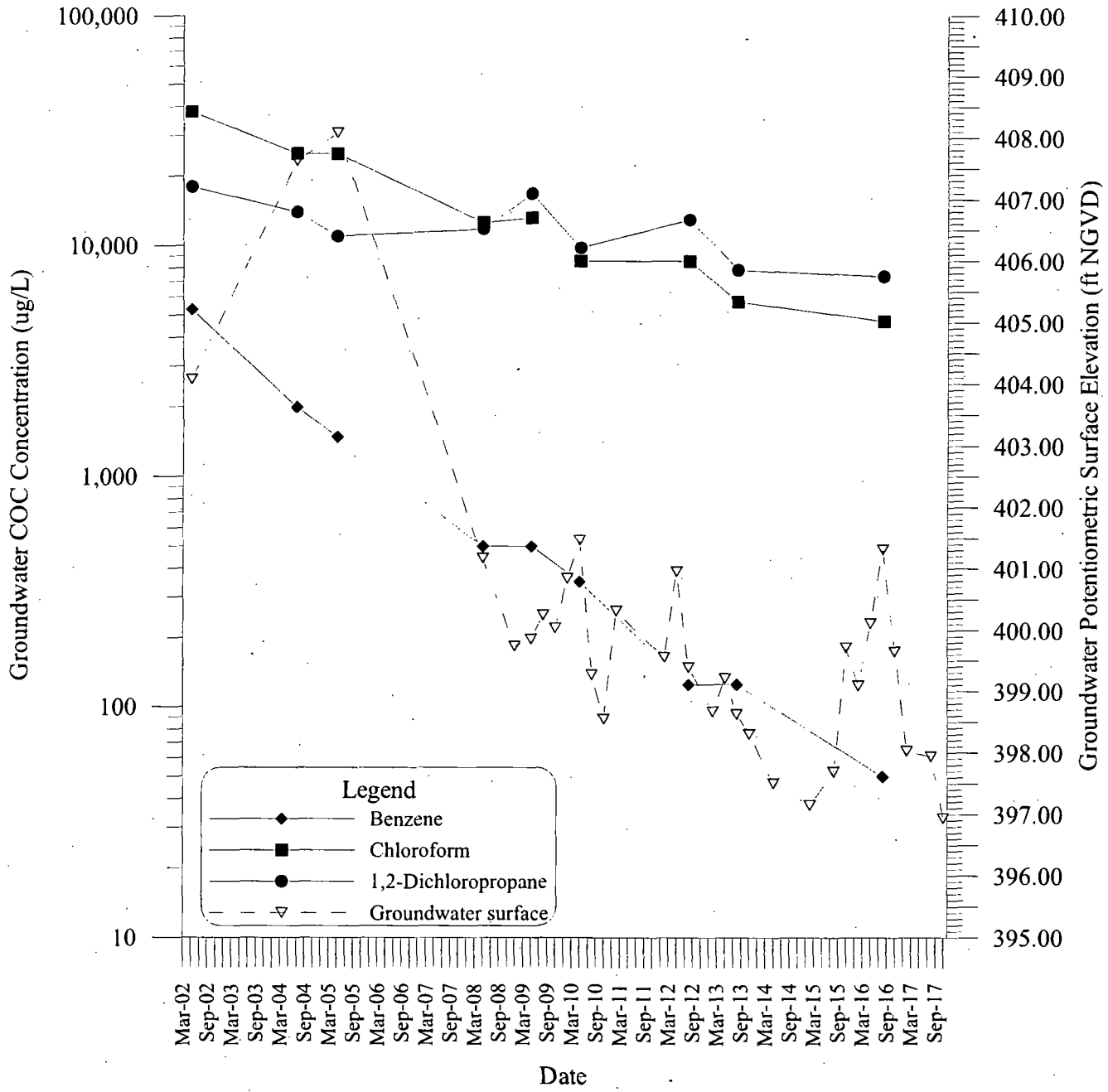
APPENDIX C

GRAPHS

SHALLOW MONITORING WELL

MW-2: Groundwater Chemical of Concern Concentrations vs. Time

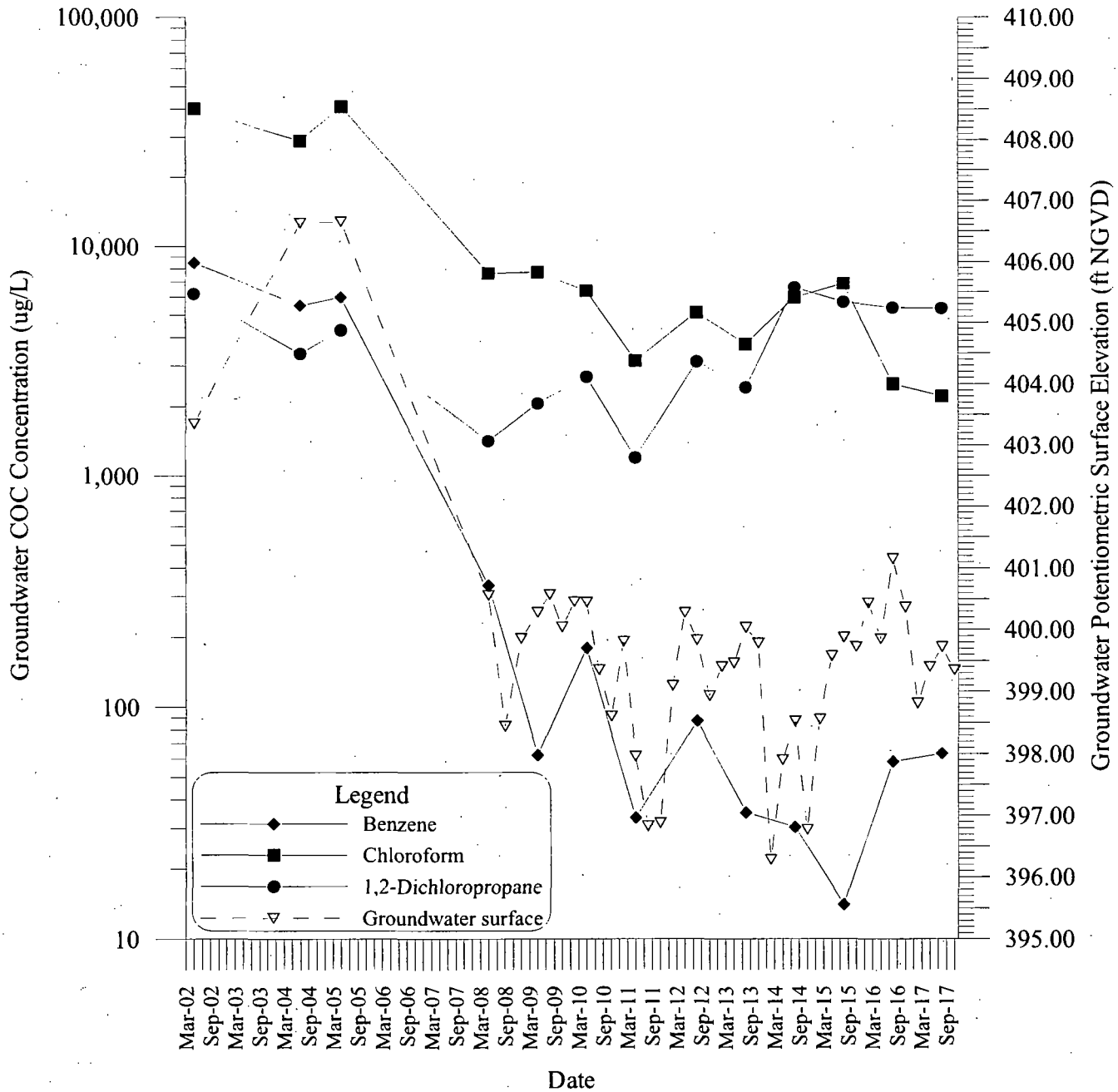
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-3: Groundwater Chemical of Concern Concentrations vs. Time

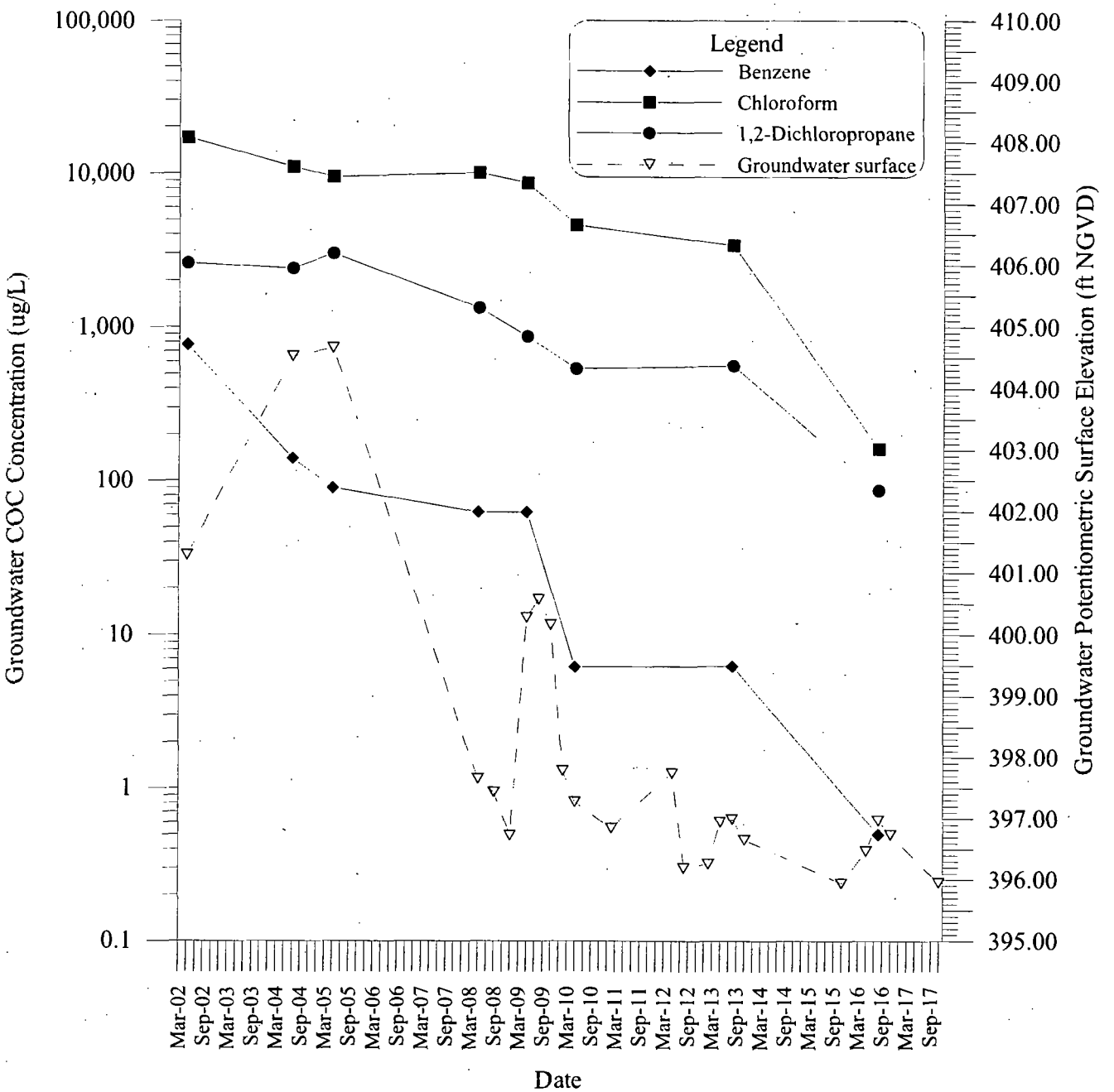
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-6: Groundwater Chemical of Concern Concentrations vs. Time

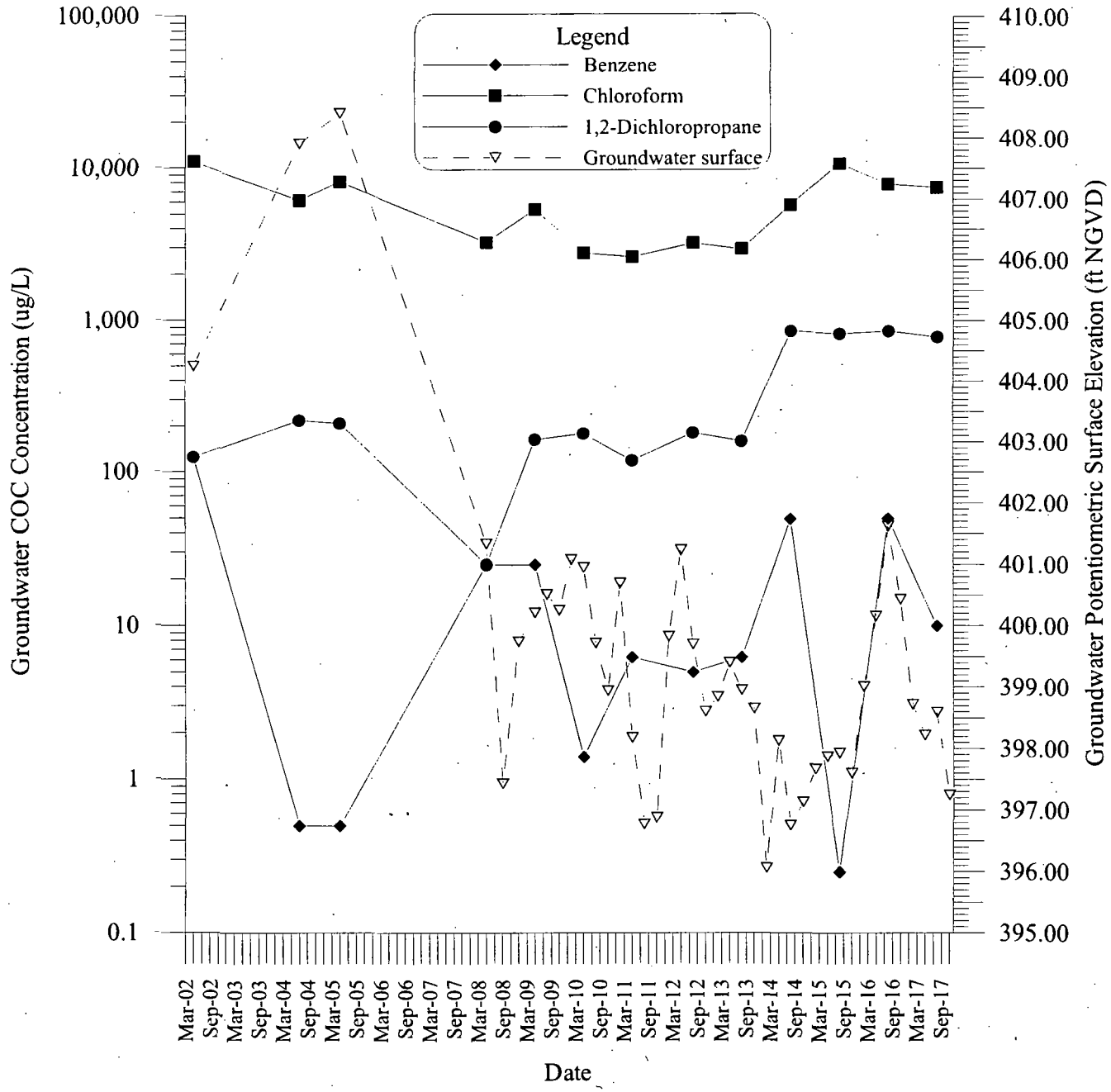
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-8: Groundwater Chemical of Concern Concentrations vs. Time

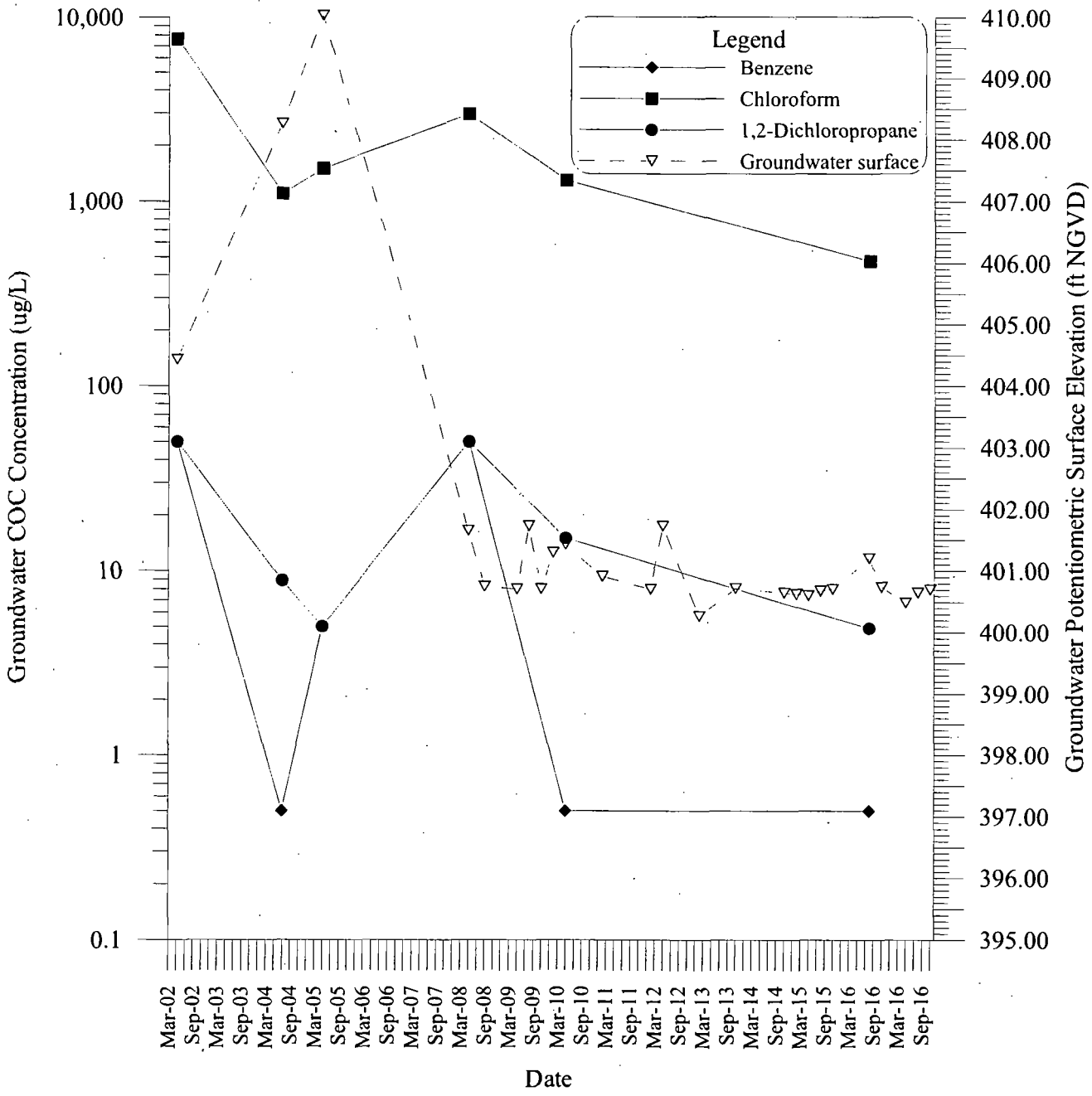
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-11: Groundwater Chemical of Concern Concentrations vs. Time

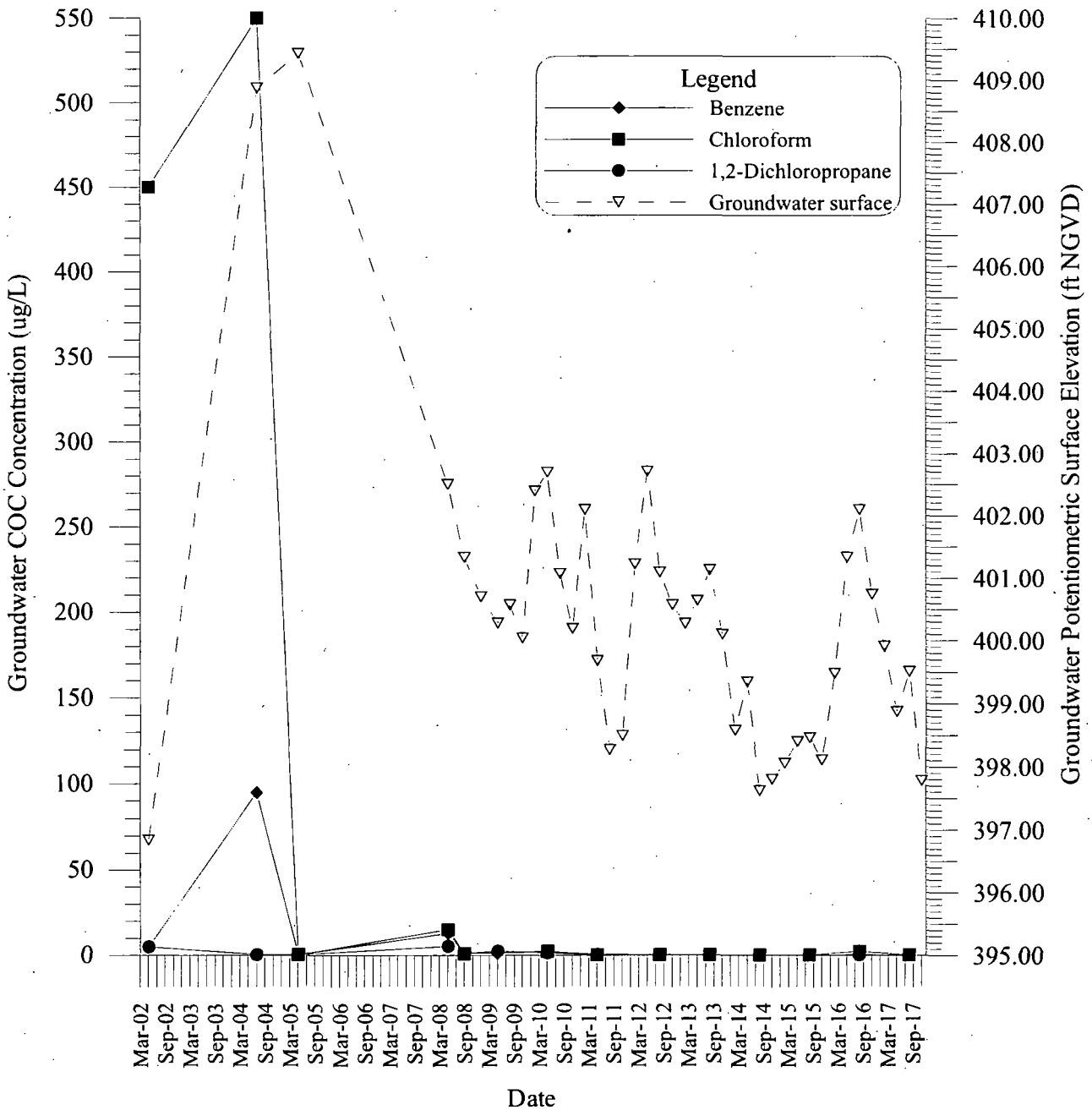
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



INTERMEDIATE MONITORING WELL

MW-11I: Groundwater Chemical of Concern Concentrations vs. Time

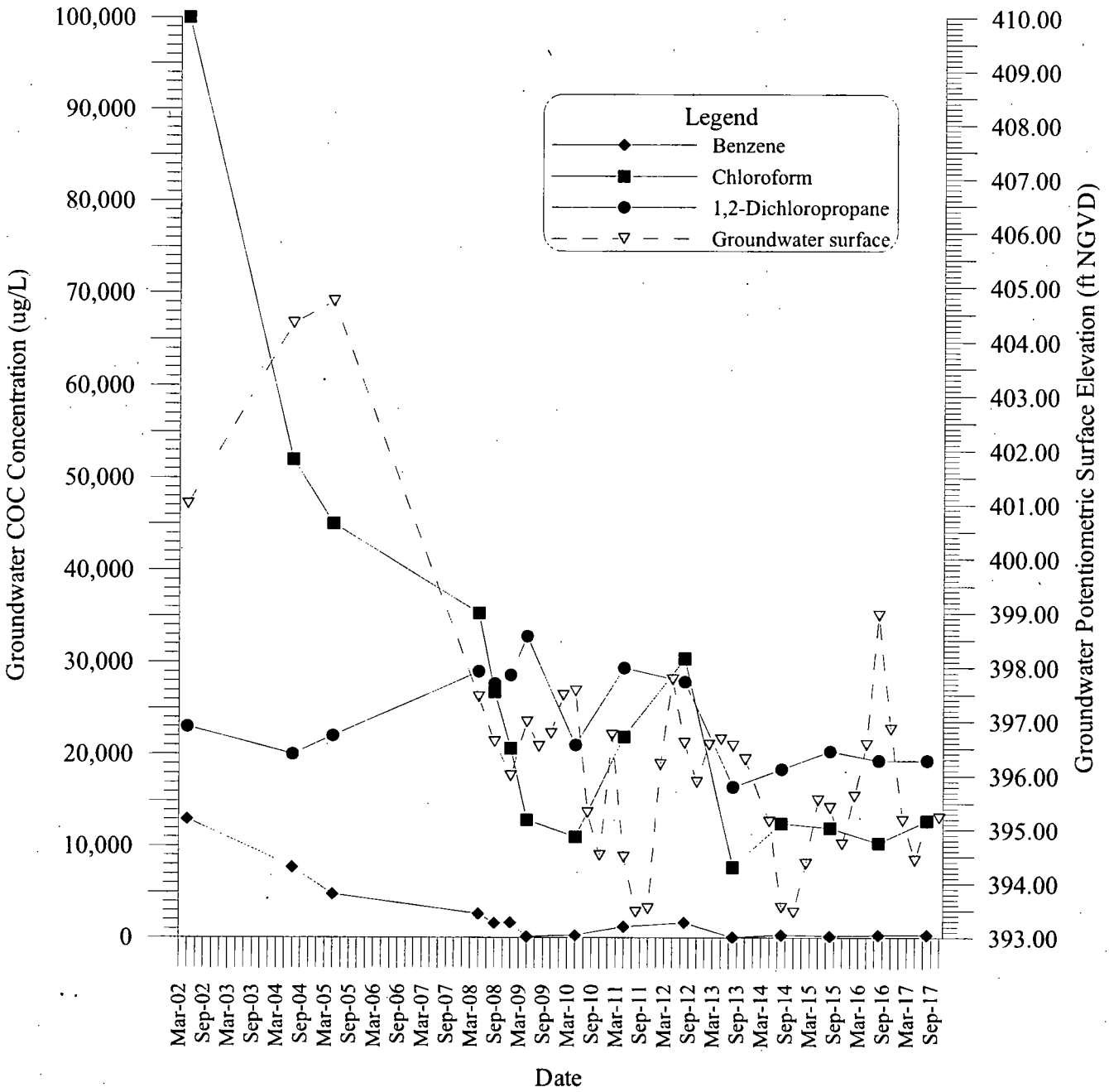
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-12: Groundwater Chemical of Concern Concentrations vs. Time

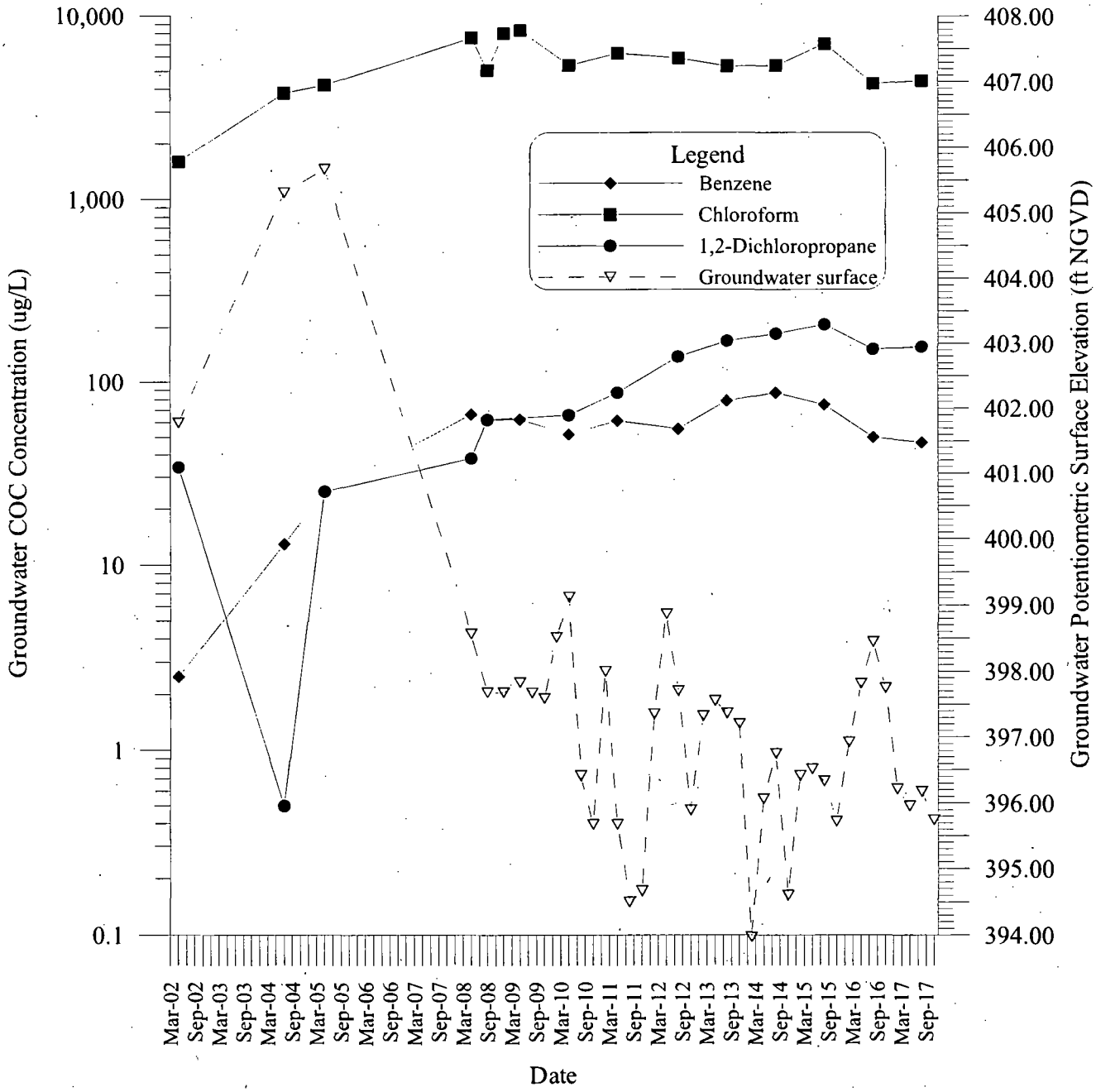
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



INTERMEDIATE MONITORING WELL

MW-12I: Groundwater Chemical of Concern Concentrations vs. Time

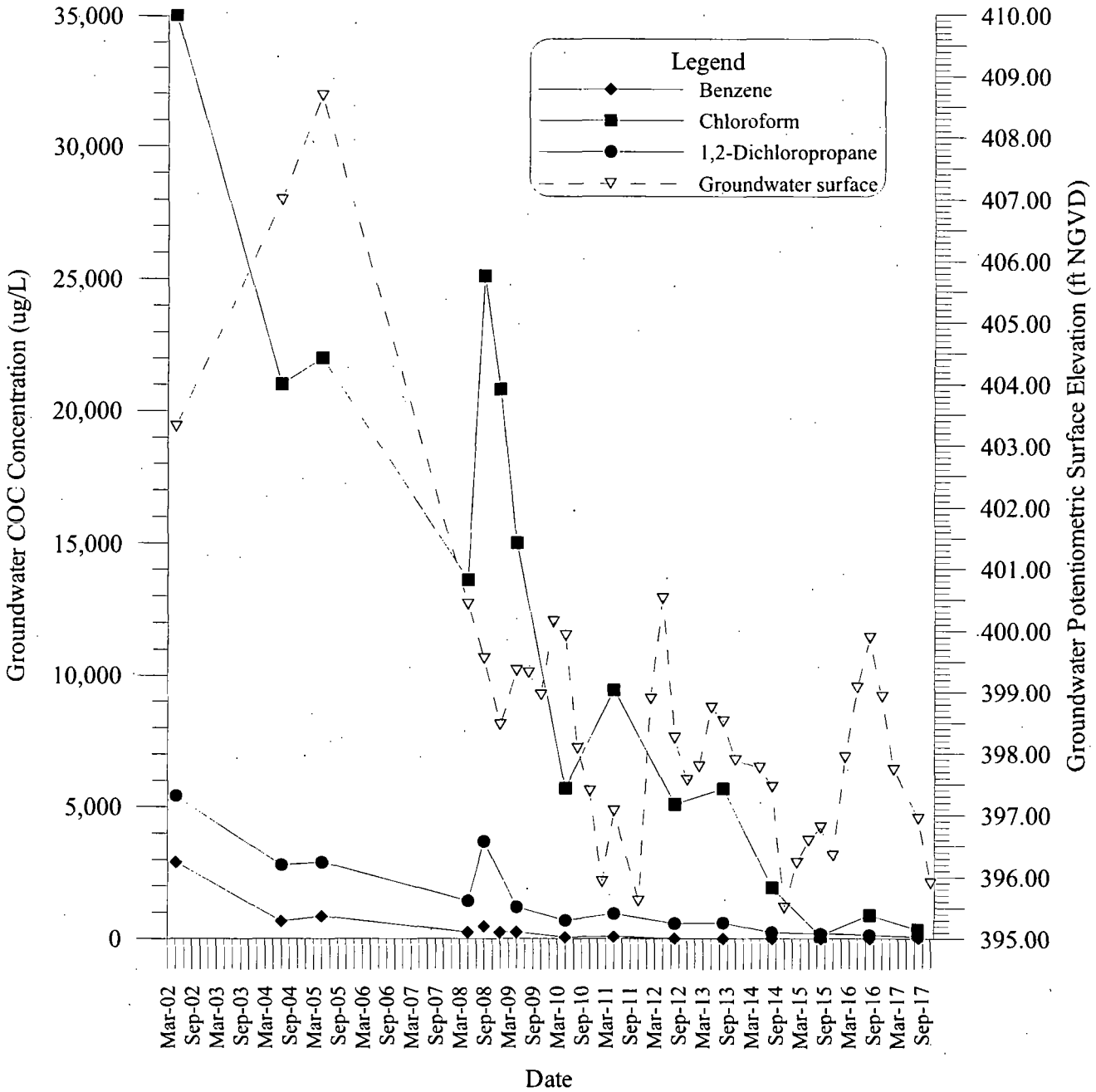
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-16: Groundwater Chemical of Concern Concentrations vs. Time

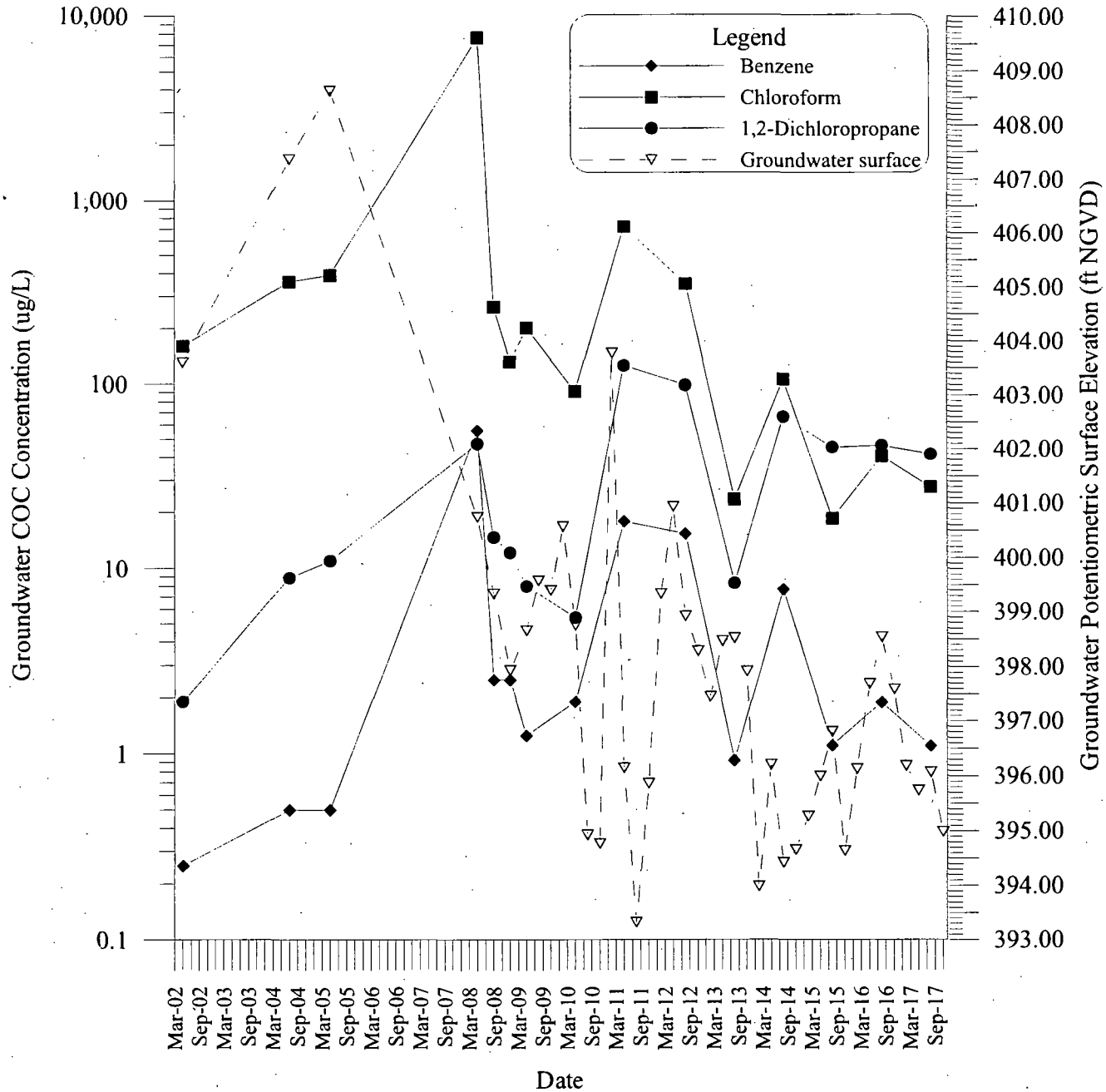
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



INTERMEDIATE MONITORING WELL

MW-16I: Groundwater Chemical of Concern Concentrations vs. Time

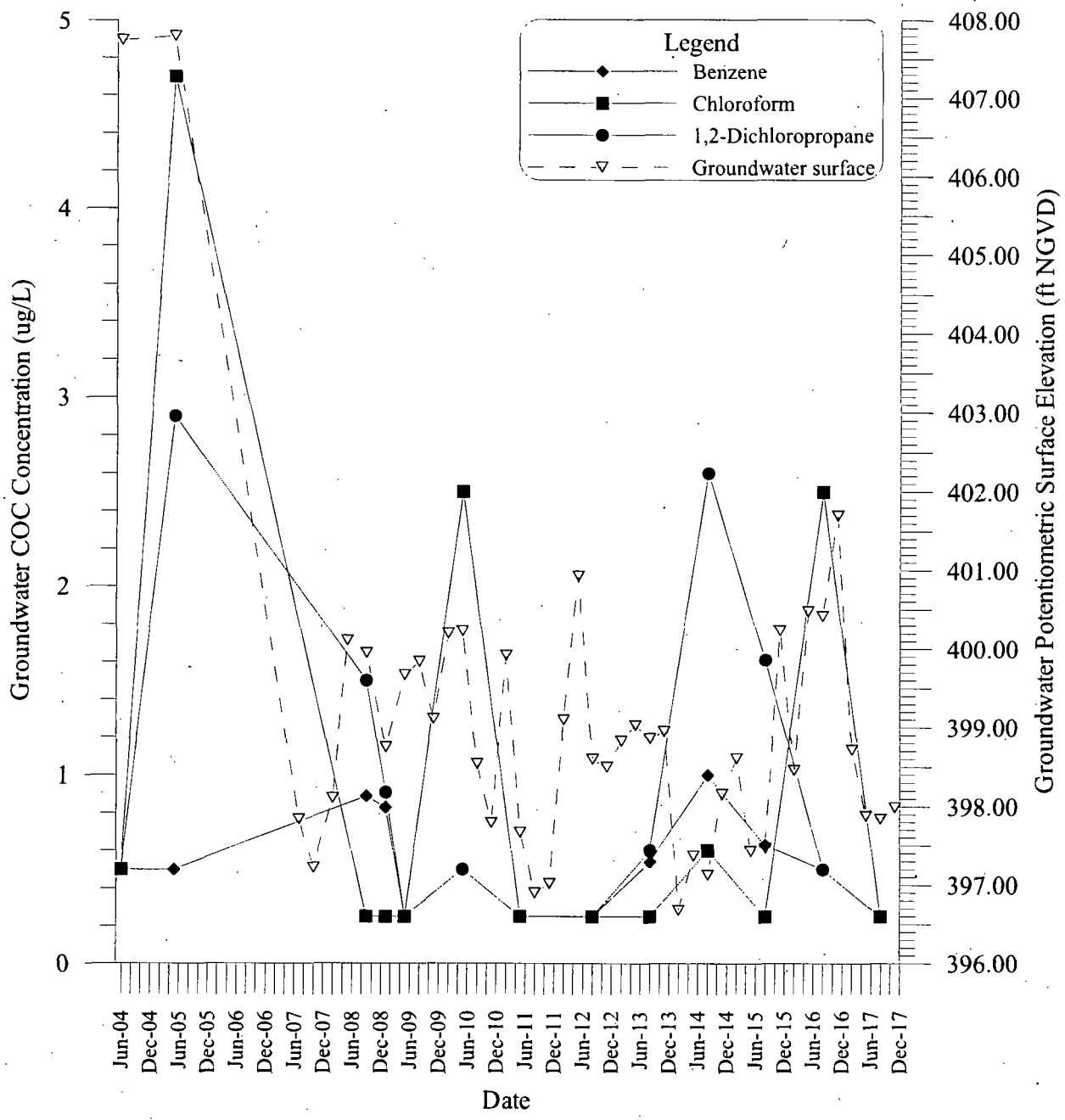
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



DEEP MONITORING WELL

MW-16D: Groundwater Chemical of Concern Concentrations vs. Time

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

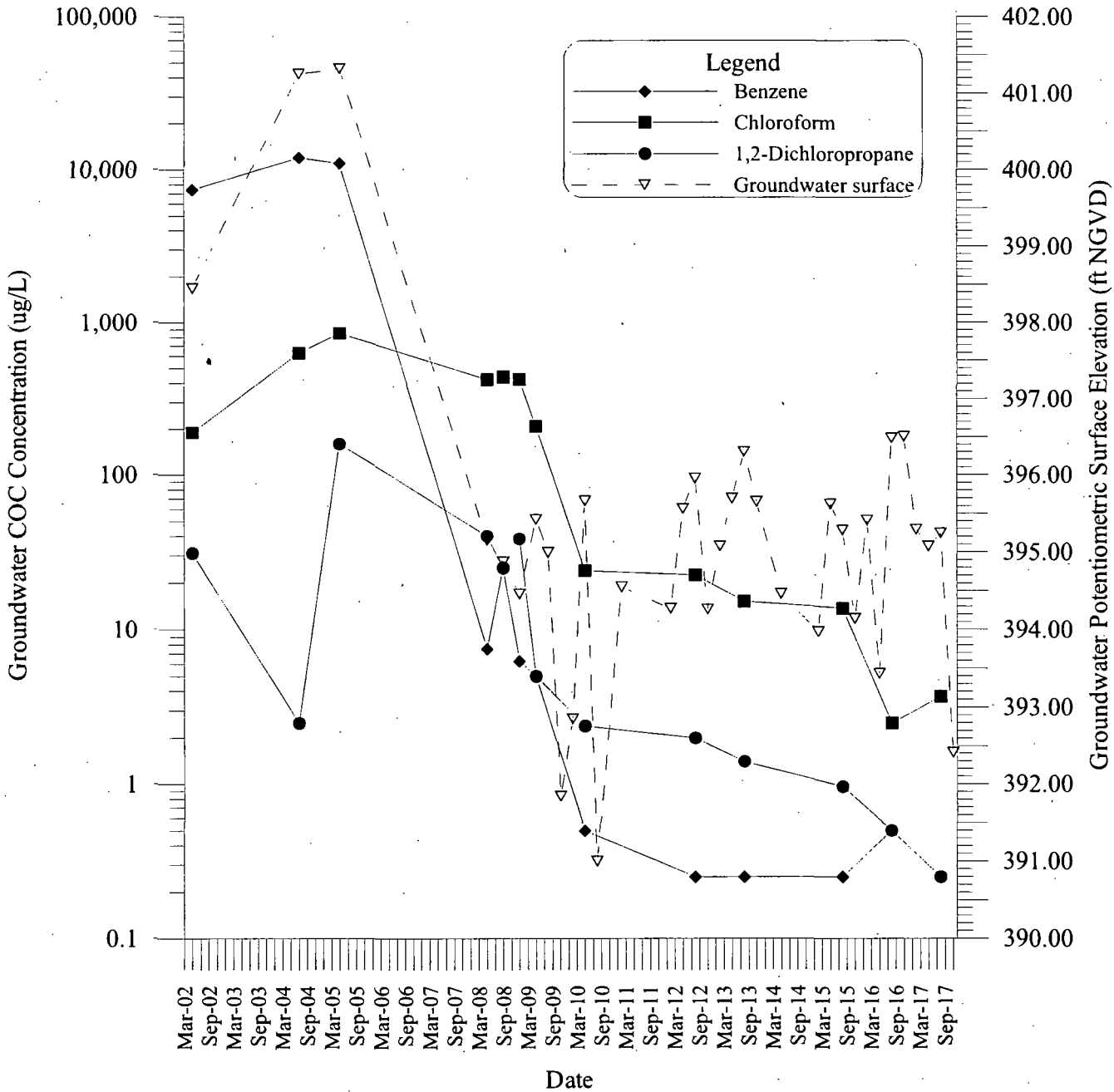


Non-detected concentrations are plotted at one-half the detection limit.

SHALLOW MONITORING WELL

MW-17: Groundwater Chemical of Concern Concentrations vs. Time

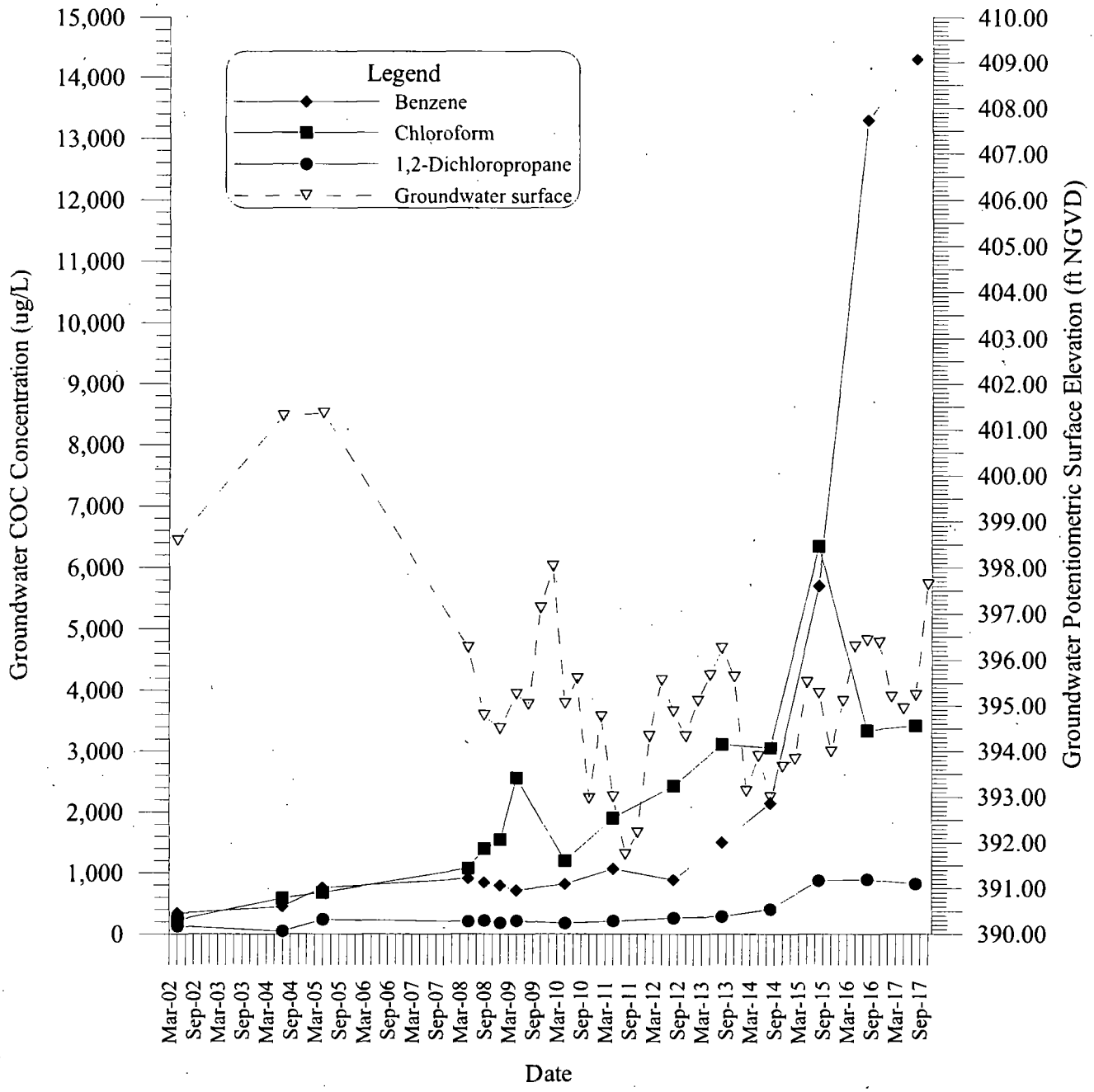
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



INTERMEDIATE MONITORING WELL

MW-17I: Groundwater Chemical of Concern Concentrations vs. Time

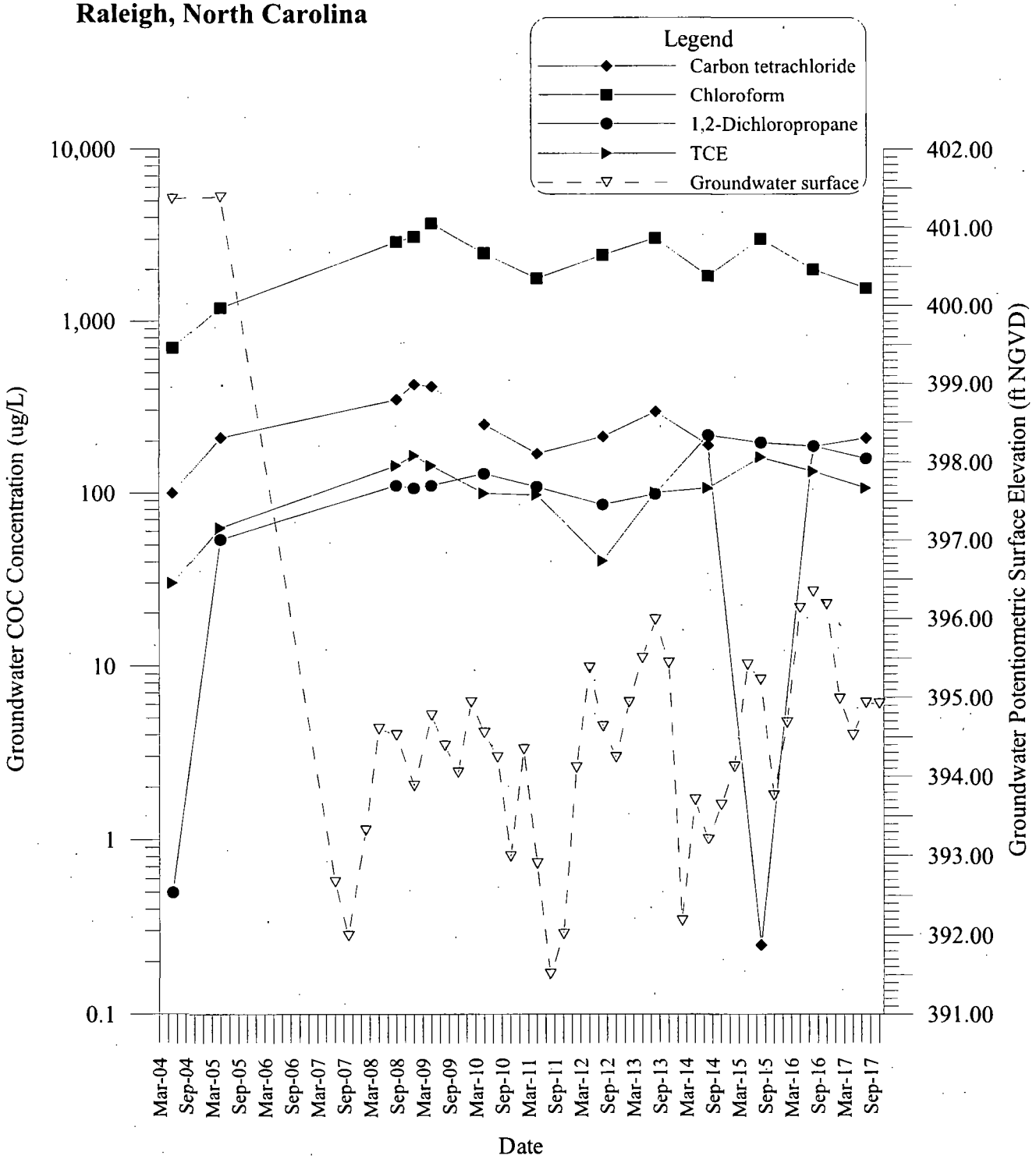
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



DEEP MONITORING WELL

MW-17D: Groundwater Chemical of Concern Concentrations vs. Time

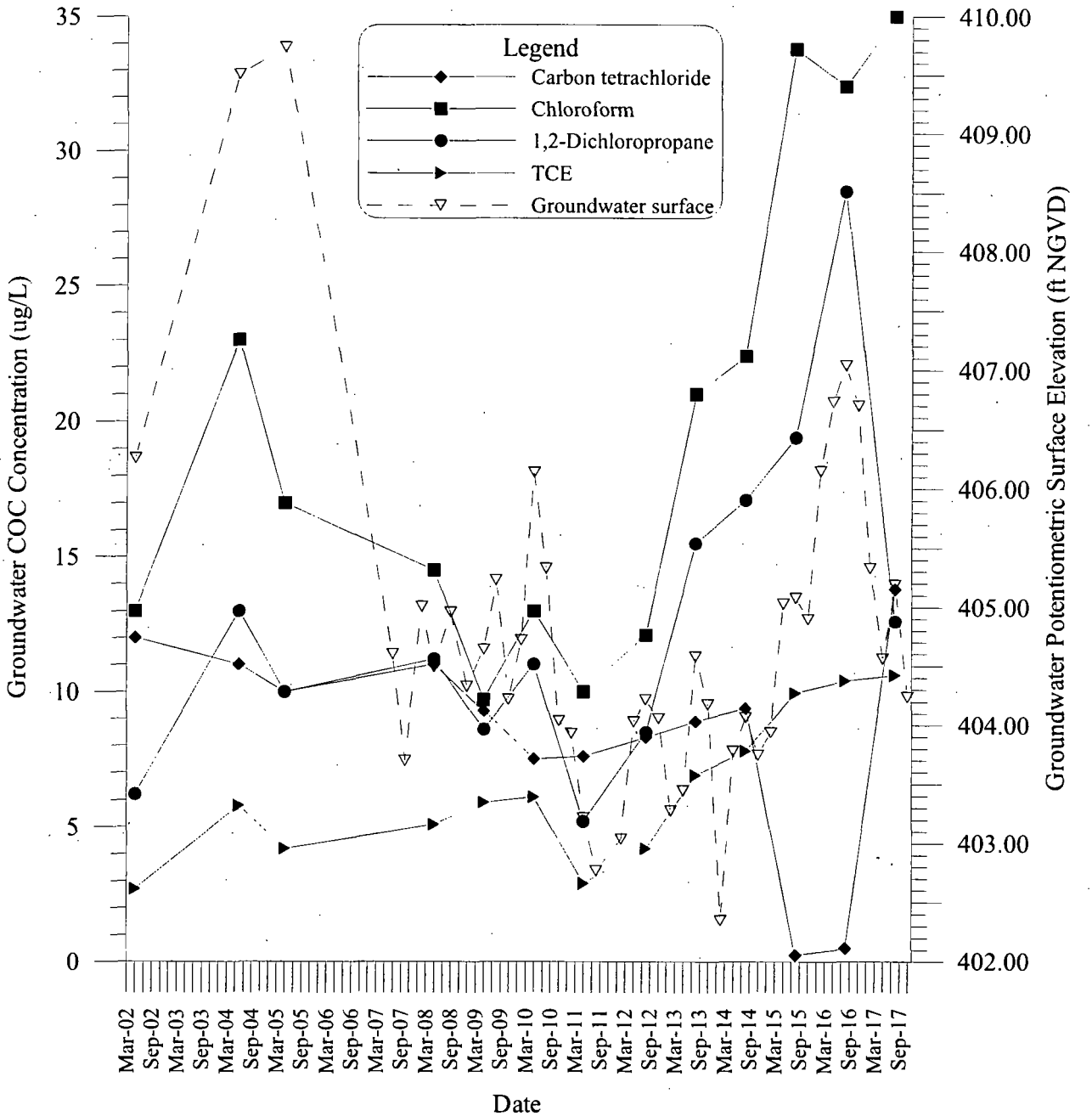
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-27: Groundwater Chemical of Concern Concentrations vs. Time

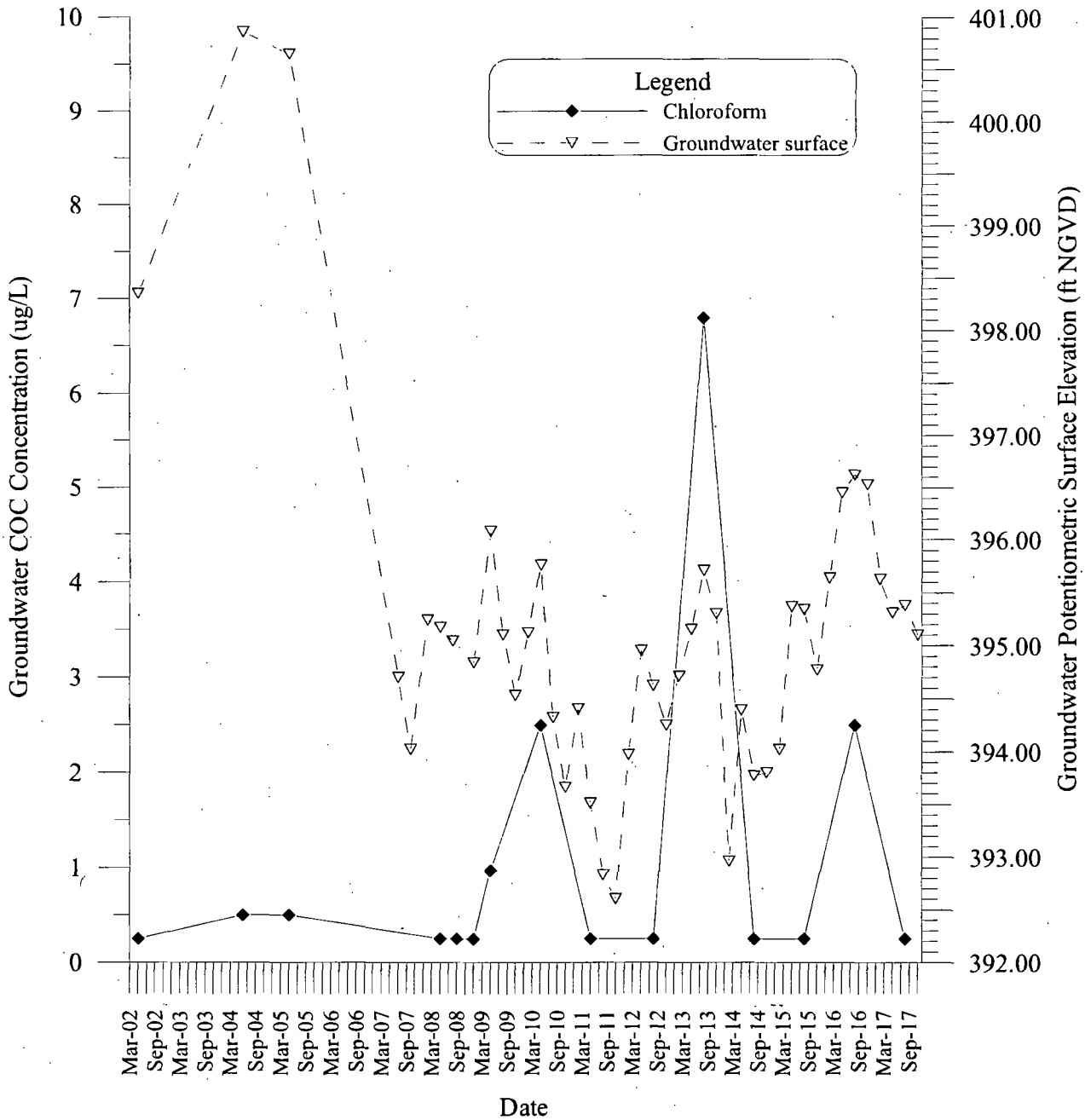
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-35S: Groundwater Chemical of Concern Concentrations vs. Time

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

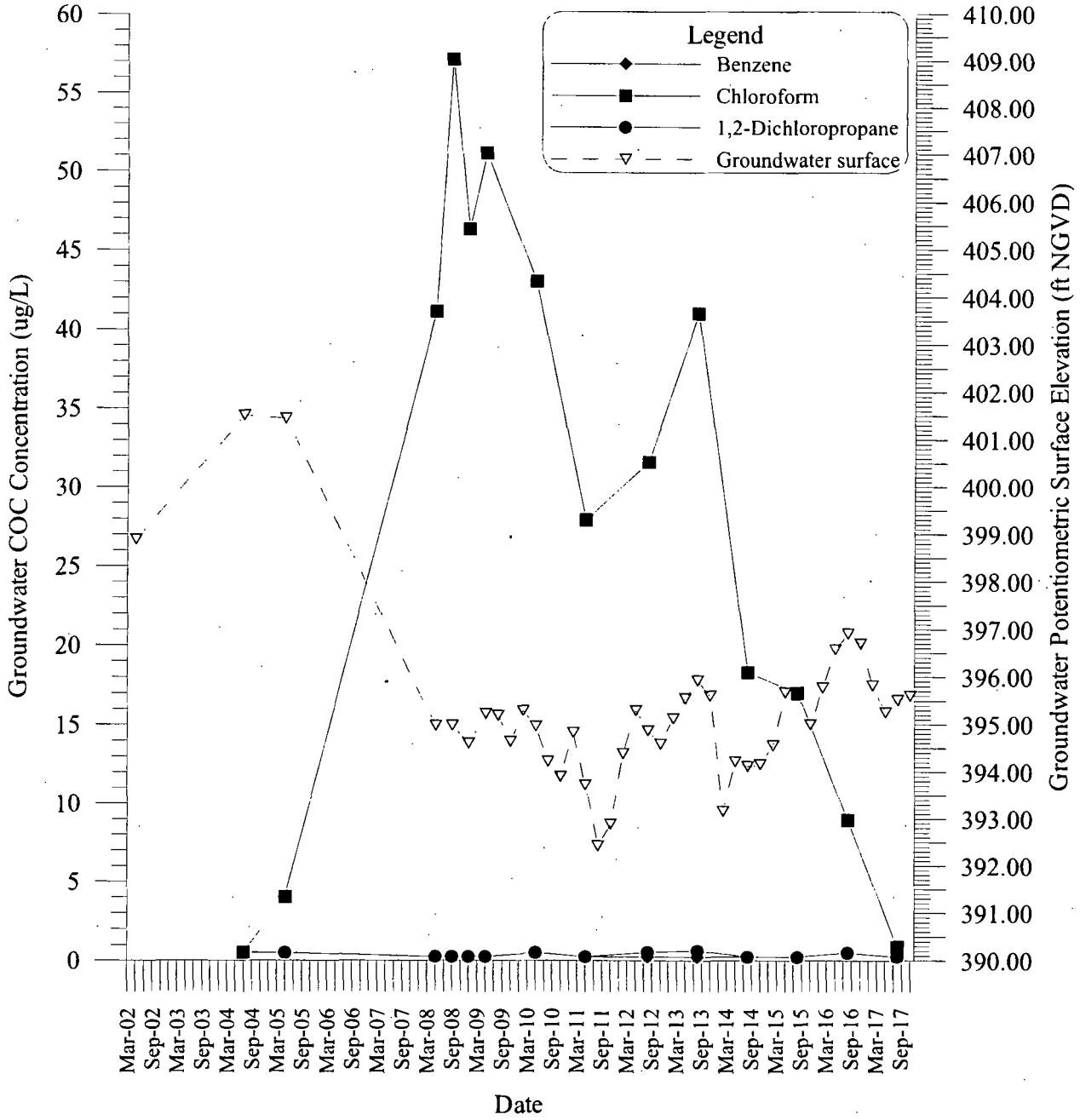


Note: Non-detected concentrations are plotted at one-half of the detection limit.

DEEP MONITORING WELL

MW-35D: Groundwater Chemical of Concern Concentrations vs. Time

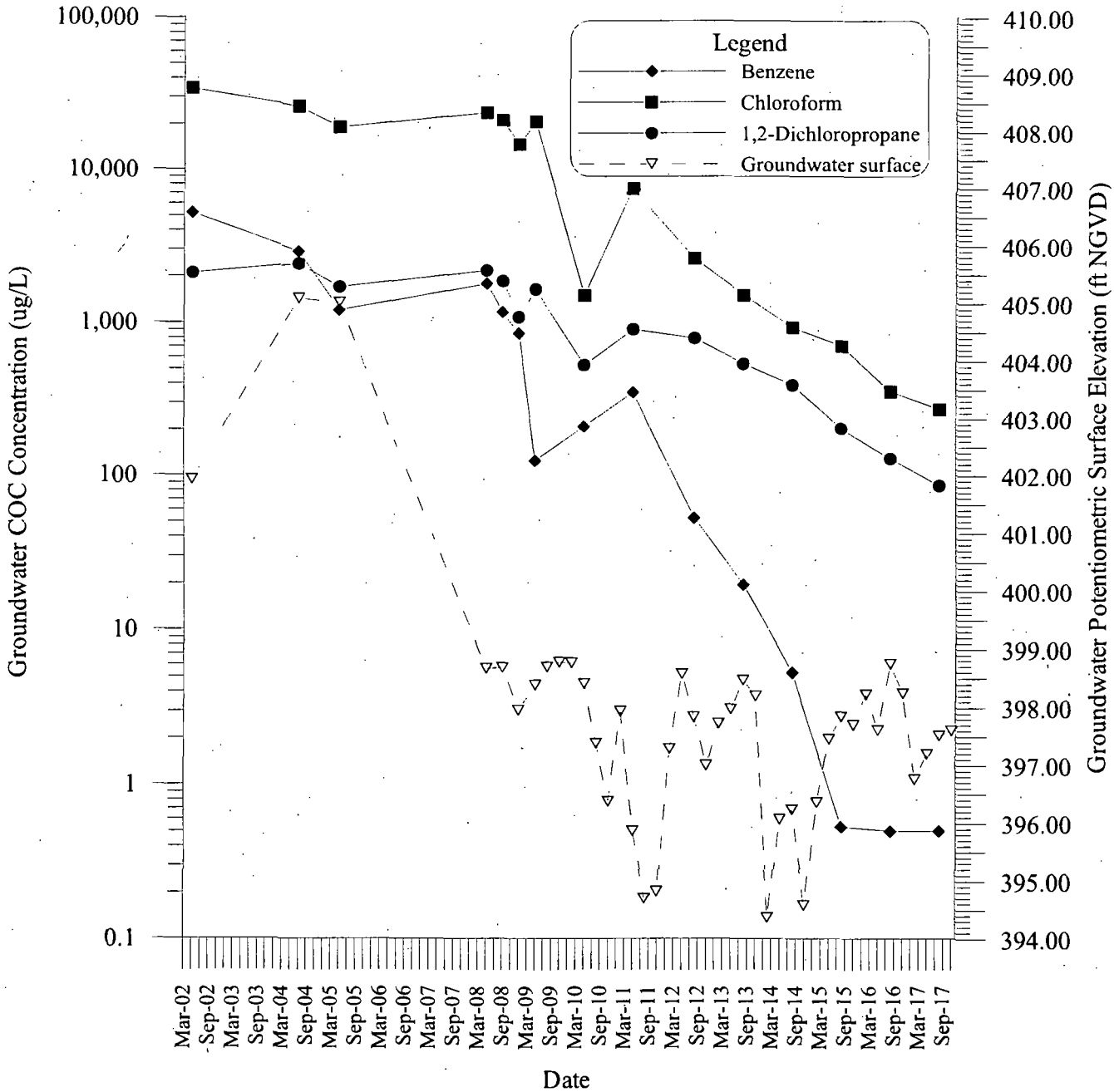
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-36S: *Groundwater Chemical of Concern Concentrations vs. Time*

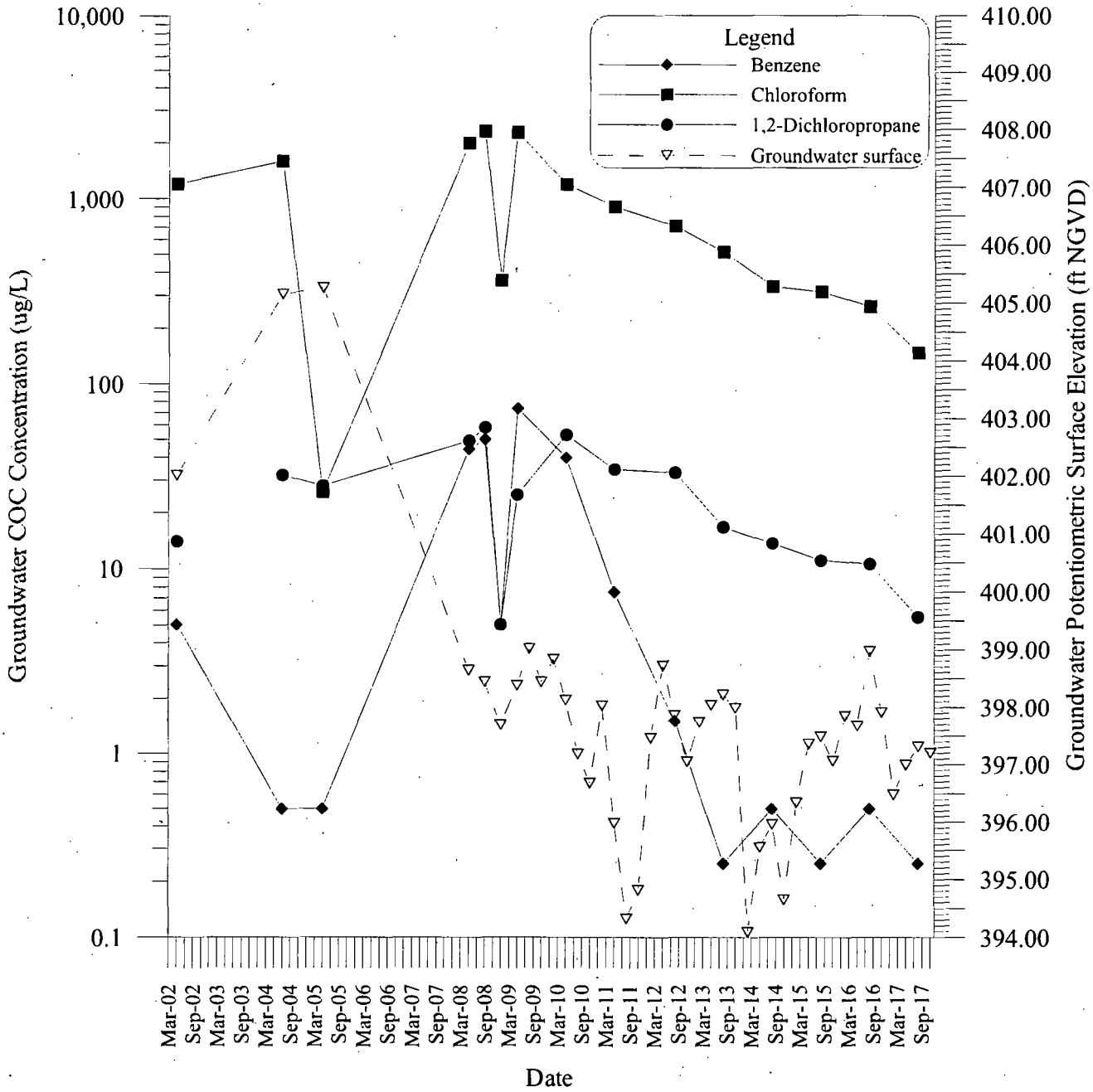
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



DEEP MONITORING WELL

MW-36D: Groundwater Chemical of Concern Concentrations vs. Time

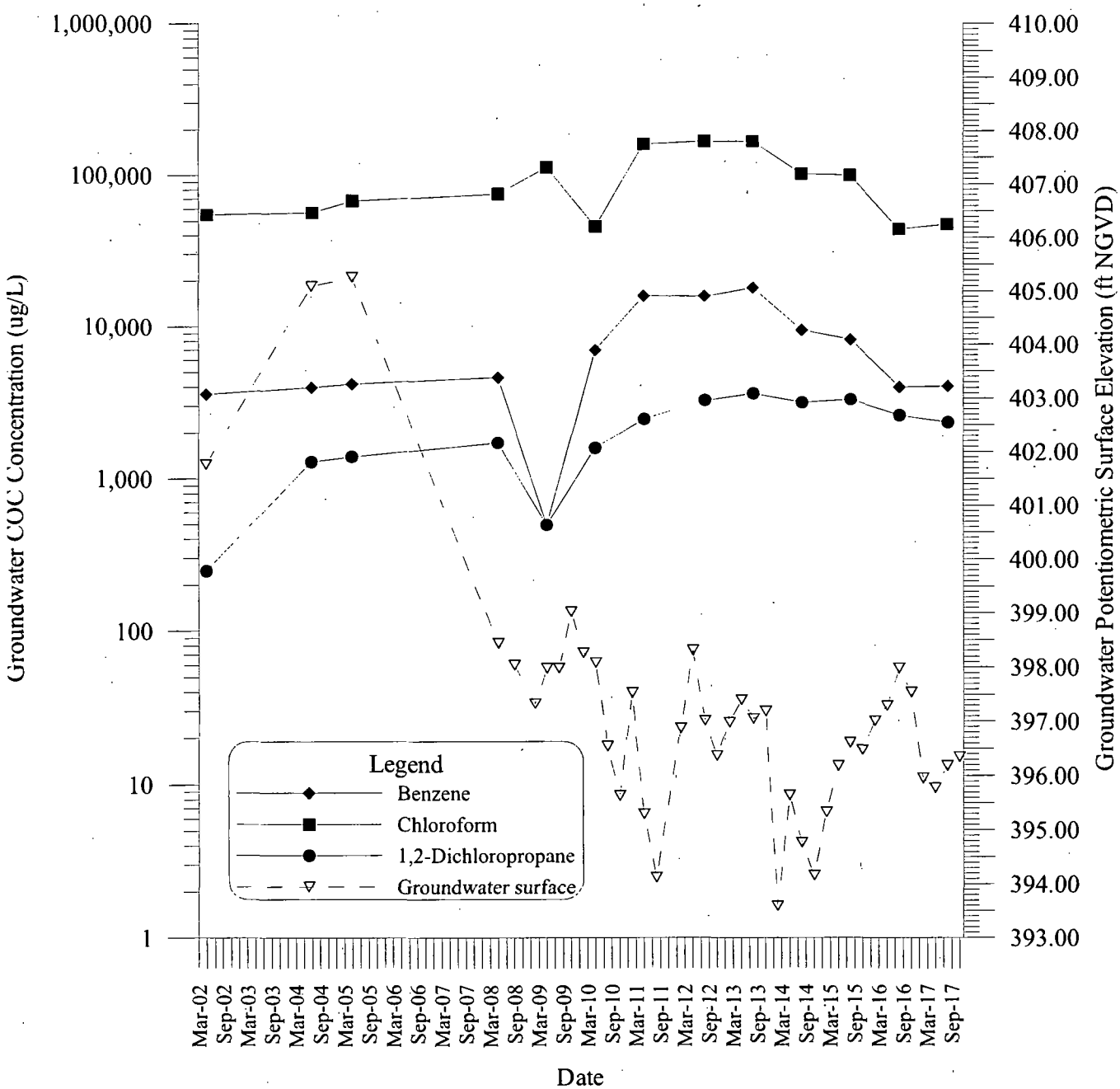
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-37: Groundwater Chemical of Concern Concentrations vs. Time

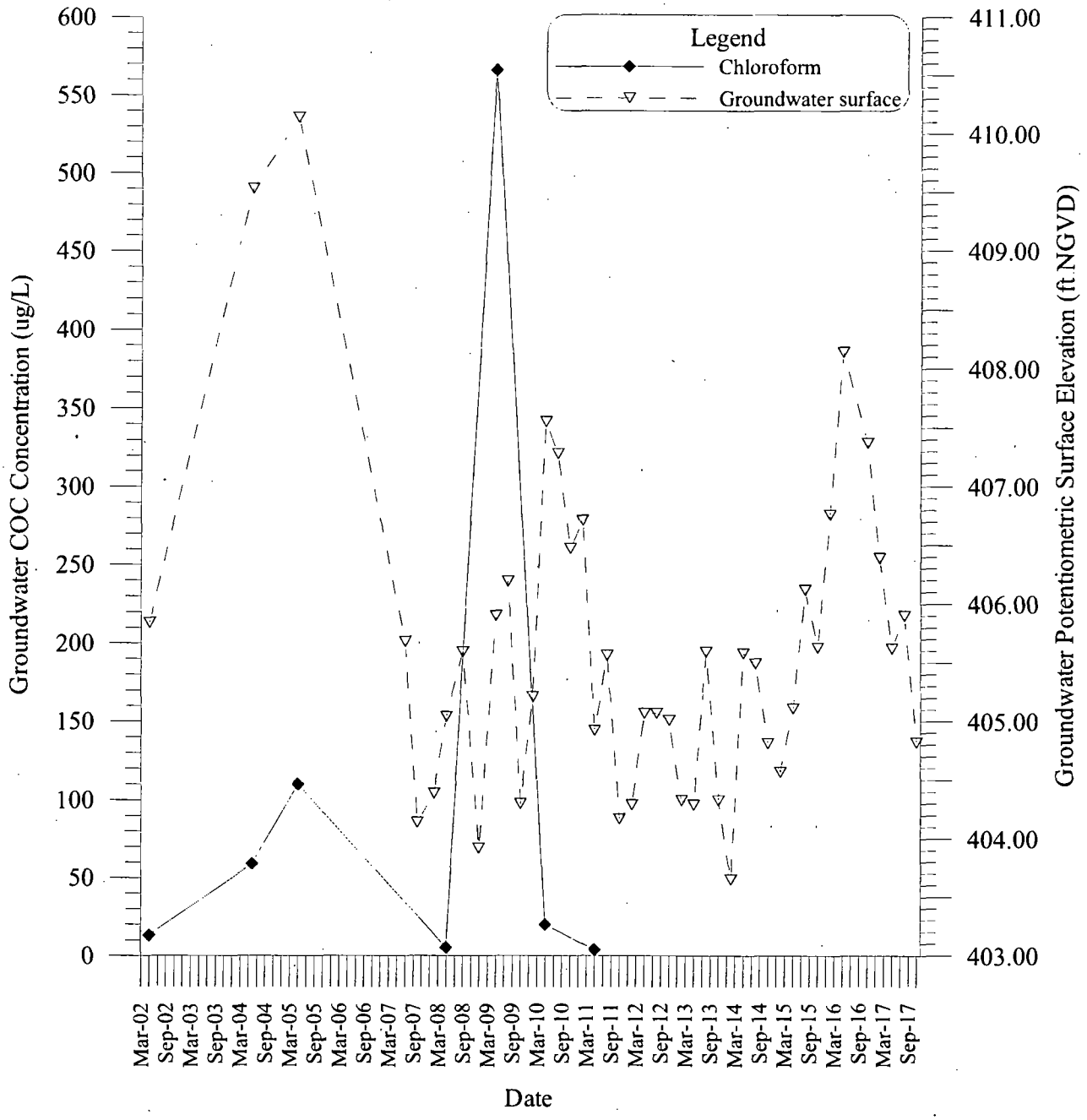
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-40: Groundwater Chemical of Concern Concentrations vs. Time

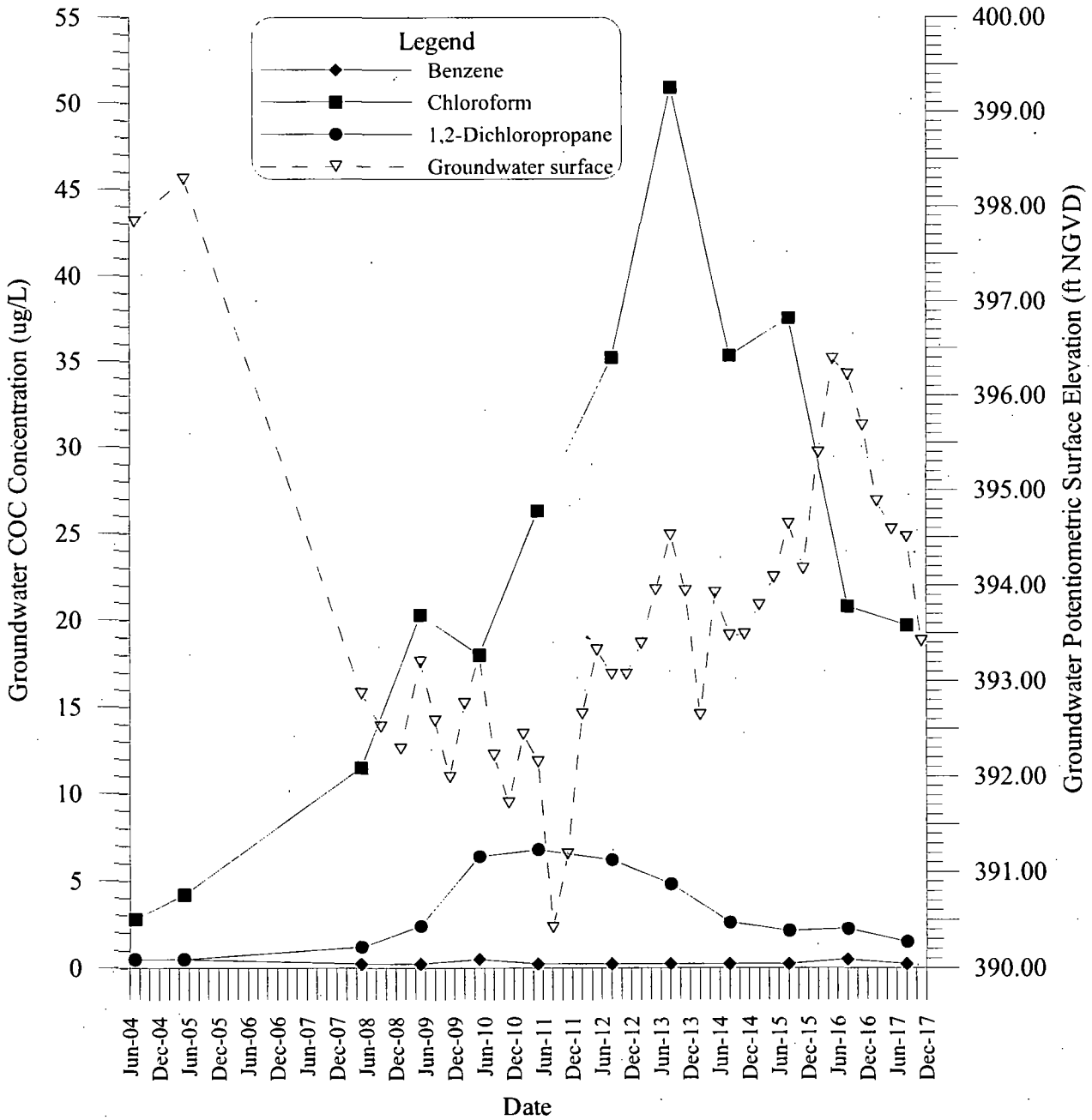
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



DEEP MONITORING WELL

MW-41D: Groundwater Chemical of Concern Concentrations vs. Time

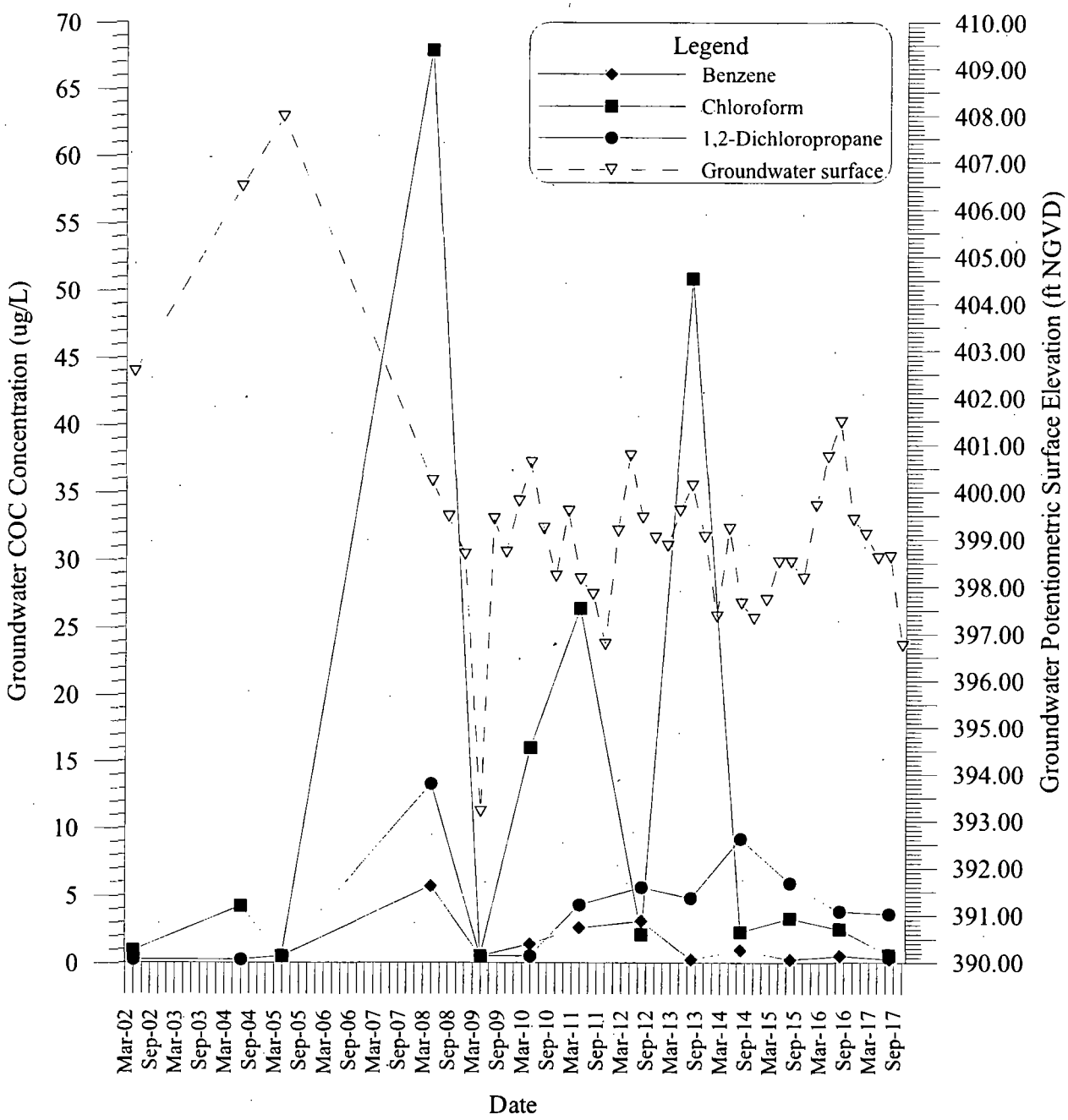
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



INTERMEDIATE MONITORING WELL

MW-42I: Groundwater Chemical of Concern Concentrations vs. Time

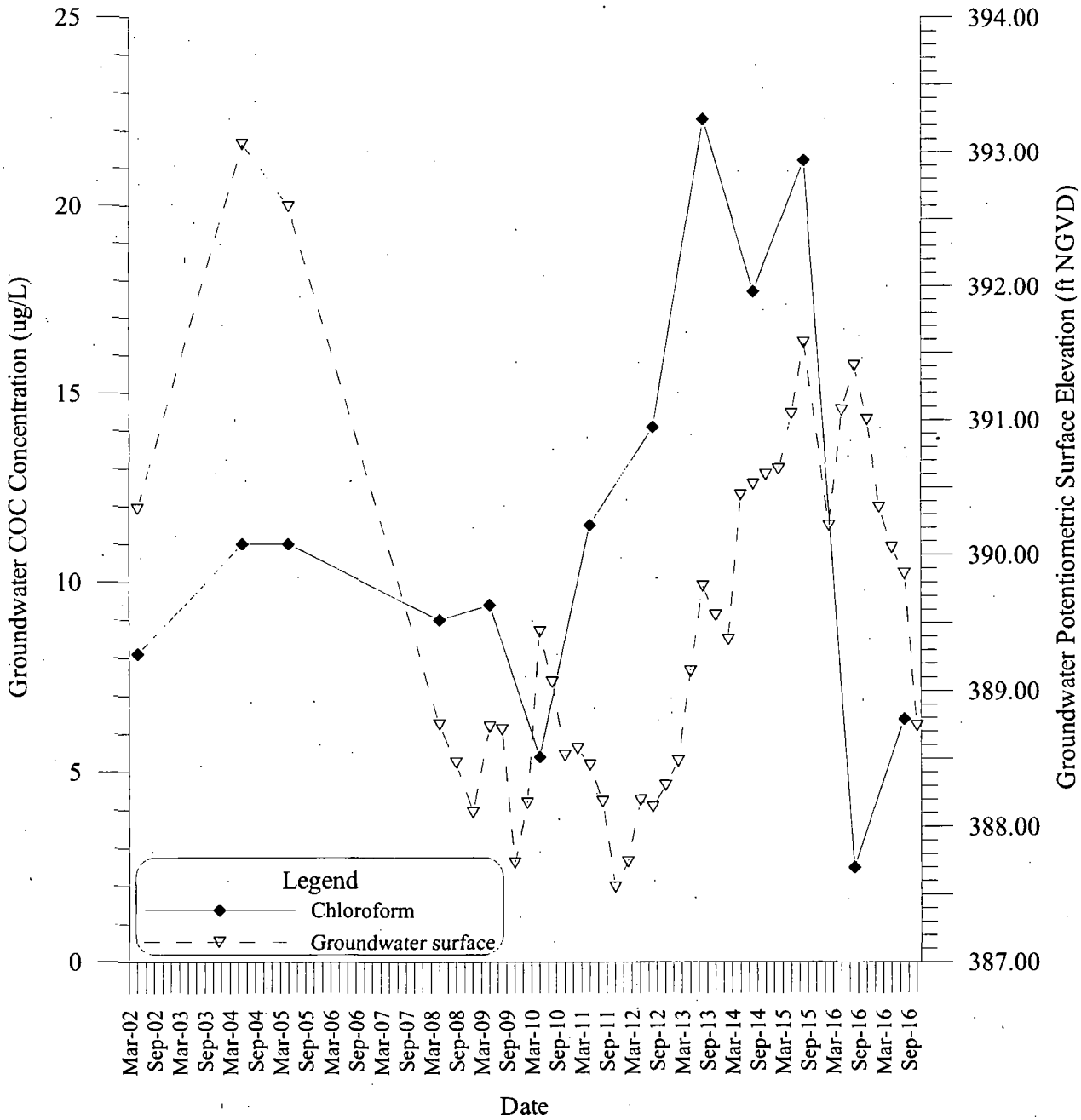
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



SHALLOW MONITORING WELL

MW-43S: Groundwater Chemical of Concern Concentrations vs. Time

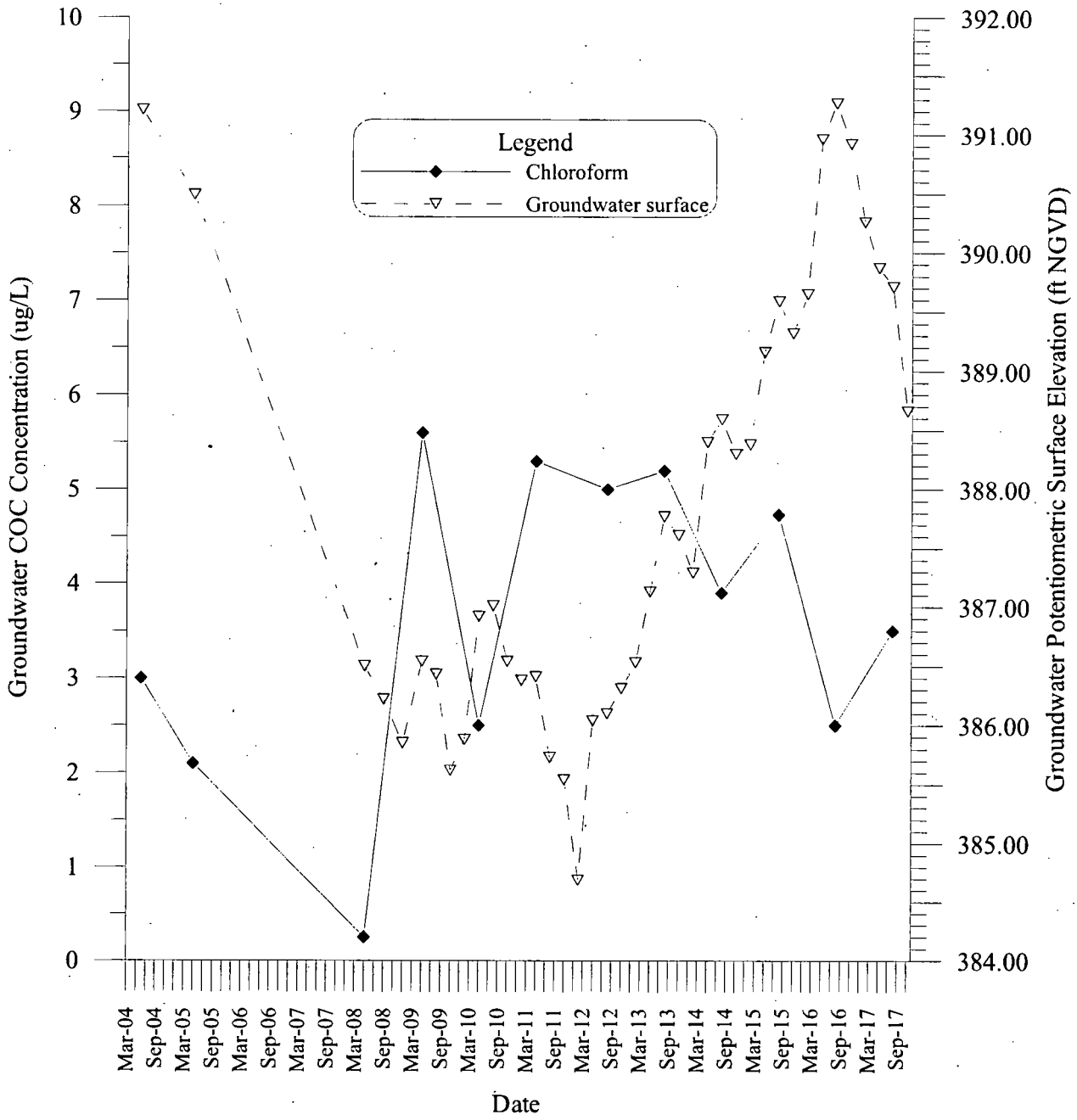
North Carolina State University
Lot 86 Site
Raleigh, North Carolina



DEEP MONITORING WELL

MW-43D: Groundwater Chemical of Concern Concentrations vs. Time

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

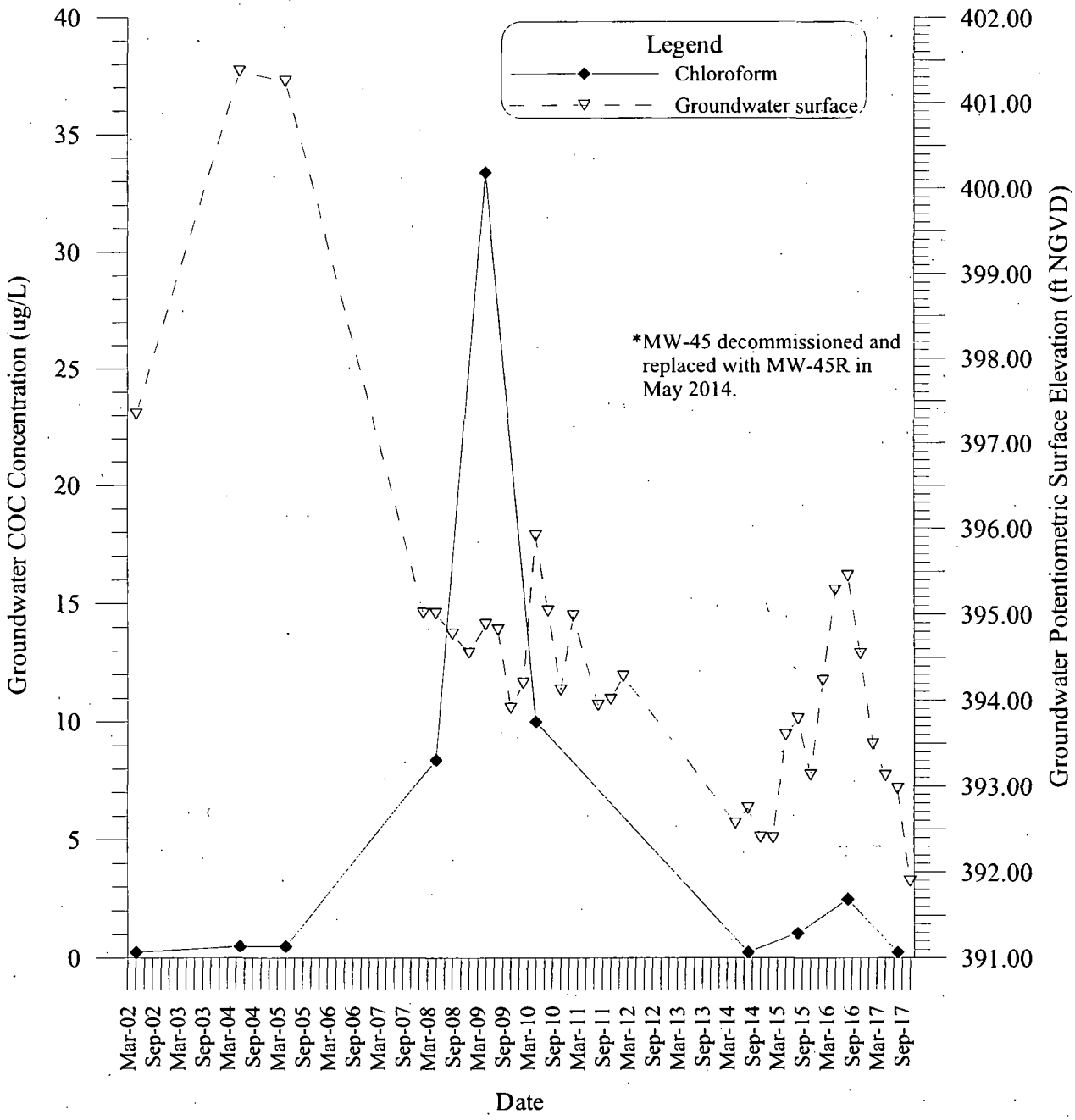


Note: Non-detected concentrations are plotted at one-half of the detection limit.

SHALLOW MONITORING WELL

MW-45/MW-45R: Groundwater Chemical of Concern Concentrations vs. Time

North Carolina State University
Lot 86 Site
Raleigh, North Carolina

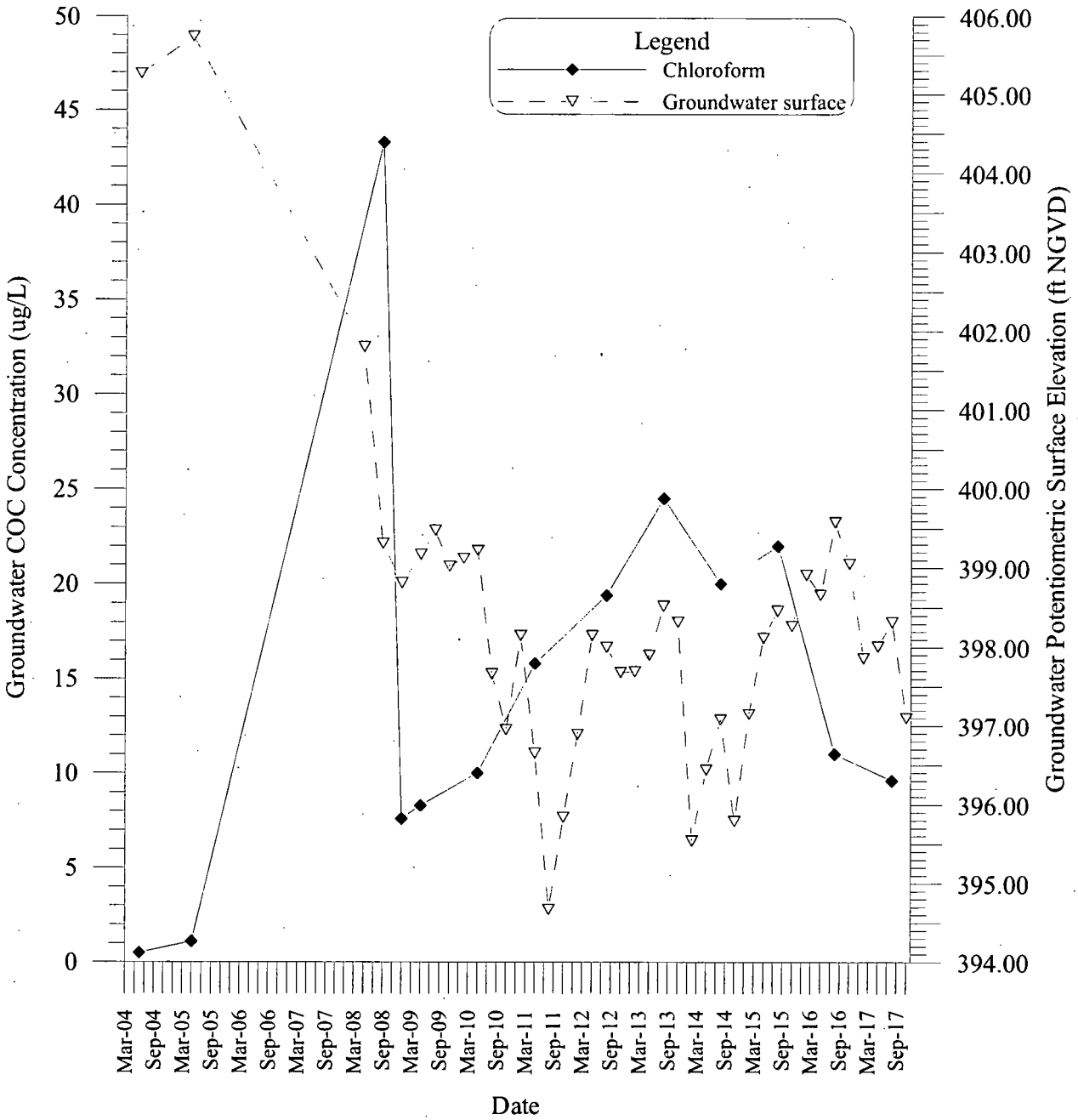


Note: non-detected concentrations are plotted at one-half of the detection limit.

DEEP MONITORING WELL

MW-47: Groundwater Chemical of Concern Concentrations vs. Time

North Carolina State University
Lot 86 Site
Raleigh, North Carolina



Note: Non-detected concentrations are plotted at one-half of the detection limit.

APPENDIX K
Detailed Risk Assessment and Vapor Intrusion Screening

Table K-1: Review of Groundwater Remediation Goals

COC	Groundwater Remedial Goal (µg/l)	Tapwater RSL[a] 10^{-6} Risk (µg/l)	Tapwater RSL[a] HQ = 1 (µg/l)	Risk[b]	HQ[c]
Acetone	700	NA	1.4E+04	NA	5.0E-02
Benzene	1	4.6E-01	3.3E+01	2.2E-06	3.0E-02
Bromodichloromethane	1	1.3E-01	3.8E+02	7.7E-06	2.6E-03
Carbon tetrachloride	1	4.6E-01	4.9E+01	2.2E-06	2.0E-02
Chloroform	1	NA	9.7E+01	NA	1.0E-02
Dichloropropane, 1,2-	1	8.5E-01	8.2E+00	1.2E-06	1.2E-01
Methylene chloride	5	1.1E+01	1.1E+02	4.5E-07	4.5E-02
Tetrachloroethene	1	1.1E+01	4.1E+01	9.1E-08	2.4E-02
Trichloroethane, 1,1,2-	1	2.8E-01	4.1E-01	3.6E-06	**2.4E+00**
Trichloroethene	2.8	4.9E-01	2.8E+00	5.7E-06	1.0E+00
Metals					
Arsenic	10	5.2E-02	6.0E+00	**1.9E-04**	**1.7E+00**
Manganese	370	NA	4.3E+02	NA	8.6E-01

Notes:

NA = Not Available

a) Current EPA RSLs, dated November 2017, are available at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-november-2017

b) Cancer risk = (cleanup goal / cancer-based RSL) x 10^{-6}.

c) HQ = (cleanup goal / noncancer RSL).

Bold = risk exceeds EPA's risk management range of 10^{-6} to 10^{-4} or HQ exceeds 1.

µg/l = micrograms per liter

The analysis in Appendix K indicates that the groundwater remediation goal for arsenic results in a cancer risk greater than 1 x 10-4. The groundwater remediation goals for arsenic and 1,1,2-trichloroethane both exceed an HQ of 1.

None of the remaining cleanup goals resulted in a cancer risk greater than 1 x 10-4 for carcinogens or a noncancer HQ of greater than 1, and therefore, remain protective of human health.

Indoor air concentrations were calculated from groundwater remediation levels for the ten volatile chemicals of concern. The cancer risk posed by these air concentrations are all less than 1 x 10-4, and the noncancer HQ for each is less than 1.

Table K-2: Groundwater ARAR Review				
COC	1996 ROD Cleanup Levels & Rationale (µg/l)	Current NC 2L[a] (As of April 1, 2013) (µg/l)	Current Federal MCL*/CRQL (µg/l)	Change in ARAR Yes/No
Acetone	700 NC 2L	6,000	NA/5	Yes***
Benzene	1 NC 2L	1	5*/0.5	No
Bromodichloromethane	1 CRQL	0.6	80**/0.5	**Yes**
Carbon tetrachloride	1 CRQL	0.3	5*/0.5	**Yes**
Chloroform	1 CRQL	70	80**/0.5	No
Dichloropropane, 1,2-	1 CRQL	0.6	5*/0.5	**Yes**
Methylene chloride	5 NC 2L	5	5*/0.5	No
Tetrachloroethene	1 CRQL	0.7	5*/0.5	**Yes**
Trichloroethane, 1,1,2-	1 CRQL	NA	5*/0.5	No
Trichloroethene	2.8 NC 2L	3	5*/0.5	Yes***
Metals				
Arsenic	10 CRQL	10	10*/10	No
Manganese	370 Background	50	NA	**Yes**

Notes:
NA - Not Available
[a] NC 2L of North Carolina Administrative Code, Title 15A, Subchapter 2L, Classifications and Water Quality Standards Applicable to the Groundwater of North Carolina
* MCL for compound
** MCL for total trihalomethanes.
*** ARAR has changed but ROD remediation goal is more stringent than the current new standard.
BOLD and underlined indicates current NC 2L standard is more stringent than previous remediation goal.
µg/l = micrograms per liter

Are the exposure assumptions, toxicity data, clean-up levels and remedial actions (RAOs) used at the time of the remedy still valid?

Yes, for or everything except arsenic and 1,1,2-trichloroethane. See write-up below Table K-1.

VISL Version 3.5
Updated October 2017
Current Toxicity Values from June 2017 RSL Update

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5, June 2017 RSLs

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m³)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m³)⁻¹	IUR Source*	Reference Concentration RfC (mg/m³)	RFC Source*	Mutagenic Indicator
67-64-1	Acetone	7.0E+02	1.00E+00	No IUR	3.1E-05			3.10E+01	A	
71-43-2	Benzene	1.0E+00	2.27E-01	6.3E-07	7.3E-03	7.80E-06	I	3.00E-02	I	
74-97-5	Bromochloromethane	1.0E+00	5.97E-02	No IUR	1.4E-03			4.00E-02	X	
56-23-5	Carbon Tetrachloride	1.0E+00	1.13E+00	2.4E-06	1.1E-02	6.00E-06	I	1.00E-01	I	
67-66-3	Chloroform	1.0E+00	1.50E-01	1.2E-06	1.5E-03	2.30E-05	I	9.80E-02	A	
78-87-5	Dichloropropane, 1,2-	1.0E+00	1.15E-01	1.5E-07	2.8E-02	3.70E-06	P	4.00E-03	I	
75-09-2	Methylene Chloride	5.0E+00	6.64E-01	6.6E-09	1.1E-03	1.00E-08	I	6.00E-01	I	Mut
127-18-4	Tetrachloroethylene	1.0E+00	7.24E-01	6.7E-08	1.7E-02	2.60E-07	I	4.00E-02	I	
79-00-5	Trichloroethane, 1,1,2-	1.0E+00	3.37E-02	1.9E-07	1.6E-01	1.60E-05	I	2.00E-04	X	
79-01-6	Trichloroethylene	2.8E+00	1.13E+00	2.4E-06	5.4E-01	see note	I	2.00E-03	I	TCE

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	26
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	26
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	350
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater (-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas (-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	IURTCE_C_GW	0.00E+00	mIURTCE_GW	1.00E-06
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	3.10E-06

Mutagenic Chemicals

The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride

See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5, June 2017 RSLs

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m³)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m³)⁻¹	IUR Source*	Reference Concentration RfC (mg/m³)	RFC Source*	Mutagenic Indicator

P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).