# FIFTH
# FIVE-YEAR REVIEW REPORT FOR
# GREENWOOD CHEMICAL SUPERFUND SITE
# ALBEMARLE COUNTY, VIRGINIA

**Prepared by**

**U.S. Environmental Protection Agency**
**Region III**
**Philadelphia, Pennsylvania**

**September 2018**

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SEP 6 2018
Date

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# List of Acronyms

| | |
|---|---|
| ARAR | Applicable or Relevant and Appropriate Requirement |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| EPA | United States Environmental Protection Agency |
| ESD | Explanation of Significant Difference |
| GCC | Greenwood Chemical Company |
| GWI/FFS | Groundwater Investigation/Focused Feasibility Study |
| GMNC | Contaminated Groundwater Migration Not Under Control |
| GPRA | Government Performance and Results Act |
| HEUC | Current Human Exposure Controlled |
| HI | Hazard Index |
| IUR | Inhalation Unit Risk |
| MCL | Maximum Contaminant Level |
| MG | Million Gallons |
| NCP | National Contingency Plan (the "National Oil and Hazardous Substances Pollution Contingency Plan") |
| NPL | National Priorities List |
| O&M | Operation and Maintenance |
| OU | Operable Unit |
| PAH | Polycyclic Aromatic Hydrocarbon |
| PRP | Potentially Responsible Party |
| RA | Remedial Action |
| RAO | Remedial Action Objective |
| RD | Remedial Design |
| RfC | Reference Concentration |
| RfD | Reference Dose |
| RI/FS | Remedial Investigation/Feasibility Study |
| ROD | Record of Decision |
| RPM | Remedial Project Manager |
| RSE | Remedial System Evaluation |
| RCRA | Resource Conservation and Recovery Act |
| SFO | Slope Factor Oral |
| SWRAU | Site-Wide Ready for Anticipated Reuse |
| SSC | State Superfund Contract |
| TAL | Target Analyte List |
| TCDD | 2,3,7,8-tetrachlorodibenzo-p-dioxin |
| TCL | Target Compound List |
| TIC | Tentatively Identified Compound |
| USACE | United States Army Corps of Engineers |
| VDEQ | Virginia Department of Environmental Quality |
| VPDES | Virginia Pollution Discharge Elimination System |
| VOC | Volatile Organic Compound |

## Five-Year Review Summary Form

| SITE IDENTIFICATION | | |
|---|---|---|
| **Site Name:** Greenwood Chemical Superfund Site | | |
| **EPA ID:** VAD003125374 | | |
| **Region:** 3 | **State:** VA | **City/County:** Newtown/Albemarle |

| SITE STATUS | |
|---|---|
| **NPL Status:** Final | |
| **Multiple OUs?**<br>Yes | **Has the site achieved construction completion?**<br>Yes |

| REVIEW STATUS |
|---|
| **Lead agency:** State<br>**If "Other Federal Agency" was selected above, enter Agency name:** Click here to enter text. |
| **Author name (Federal or State Project Manager):** Eric Newman |
| **Author affiliation:** U.S. EPA Region 3 |
| **Review period:** 10/24/17 - signature date |
| **Date of site inspection:** 4/17/18 |
| **Type of review:** Statutory |
| **Review number:** 5 |
| **Triggering action date:** 9/9/2013 |
| **Due date *(five years after triggering action date)*:** 9/9/2018 |

# Five-Year Review Report

## 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 five-year review reports such as this one. In addition, FYR reports identify issues found during the review, if any, and document recommendations to address them.

The U.S. Environmental Protection Agency (EPA) is preparing this five-year review pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121, consistent with the National Contingency Plan (NCP)(40 CFR Section 300.430(f)(4)(ii)), and considering EPA policy.

This is the fifth FYR for the Greenwood Chemical Superfund Site. The triggering action for this statutory review is the date of the fourth five-year review: September 9, 2013. The five-year review 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 (UU/UE).

The Site has been addressed in four operable units (OUs):

- OU1 – Lagoons and disposal areas were excavated and transported to a permitted thermal destruction facility for treatment;
- OU2 – Ground water recovery wells were installed for "hot-spot" removal to prevent groundwater from migrating toward drinking water sources and treat recovered water in the on-Site treatment plant;
- OU3 – Former manufacturing buildings removed; and,
- OU4 – Ground water recovery wells used to contain contaminated groundwater within the waste management area (below OU1 excavations) to restore ground water quality within the area of attainment, and treat recovered water in the on-Site treatment plant.

The four OUs have been completed. All four OUs will be addressed in this FYR.

The Greenwood Chemical Superfund Site Five-Year Review was led by Eric Newman, EPA Remedial Project Manager (RPM), with EPA technical support staff Kathy Davies and Ayowale Ayodele (Hydrogeologists), Nancy JaFolla (Toxicologist), Kimberly Plank (Biologist) and Darriel Swatts and Megan Keegan (Community Involvement Coordinators). Michelle Payne, VDEQ Regulatory Analyst/ARAR Coordinator, assisted in the review as the project lead directing remedy implementation at the Greenwood Chemical Site. EPA received technical assistance from EA Engineering Science & Technology, Inc.

## II. Background

### Physical Characteristics

The Greenwood Chemical Site is located at 634 Newtown Road in the village of Newtown, Albemarle County, Virginia between the cities of Waynesboro and Charlottesville

(Site). See Figure 1. The Site is owned by the now-defunct Greenwood Chemical Company (GCC) and encompasses 33.59 acres, of which approximately 18 acres were used for chemical manufacturing and waste disposal activities.

EPA dismantled and removed the former chemical production buildings and other facility features. The Site is currently inactive except for the operation of an on-Site water treatment plant, operated as a long-term response action. See Figure 2. The entire Site is enclosed by a chain-link fence. The gate is opened during weekday business hours to accept deliveries at the treatment plant. The gate is locked in the evenings and on weekends.

The setting is rural and land use surrounding the Site is generally undeveloped woodlands or agricultural. There is a residential area along Summers Rest Road east of the northern property boundary. The Mt. Zion Baptist Church is located adjacent to the northwest corner of the Site. The Mt. Zion Baptist Church owns the undeveloped woodland along the western property boundary. The properties east and south of the Site are agricultural, currently used for cattle pastures. The farms in the area are generally 100+ acres and include a residence. Interstate 64 passes 100 yards north of the Site.

The topography slopes to the south-southeast and levels off at the southern end of the Site. Groundwater beneath the Site is not currently being used, however, surrounding properties do utilize groundwater for potable and agricultural purposes. Surface water features on the Site are limited to a small pond, referred to as "South Pond," and several intermittent streams which serve as tributaries to a perennial stream designated as "West Stream" located south of the Site. The groundwater treatment plant discharges clean water to one of the intermittent streams flowing to West Stream. West Stream meanders through cattle pastures and ultimately enters Stockton Creek several miles south of the Site.

## Land and Resource Use

The historic land use of the Site was agricultural until 1946. Starting in 1947 a chemical manufacturing plant specializing in pharmaceutical intermediates began operations. From 1947 until 1985, chemicals including pharmaceutical, dye and paint intermediates, plant growth regulators and photographic chemicals were manufactured on-Site. The two main areas of the property utilized by GCC for business operations are known as the "manufacturing area" and the "drum disposal area." A more detailed Site location map with features associated with historic land use is presented in Figure 3. Historic features within the manufacturing area included chemical processing buildings, offices and laboratory space, storage trailers and sheds, a pump house, a concrete bunker, five treatment lagoons and several abandoned structures.

Major manufacturing operations at the Site ceased in 1985; EPA and the Virginia Department of Environmental Quality (VDEQ) response teams began to clean the Site up shortly thereafter. From the late 1980's through the 1990's the GCC remained an active corporation and maintained an inventory of laboratory chemicals in storage units on Site. In 2004 EPA found that GCC abandoned scores of small containers of hazardous substances within trailers and

degraded laboratory facilities. The business component of the facility has been inactive since that time.

The projected land use for the former Greenwood Chemical Site is light industrial, recreational or conservancy/open space; however, local zoning restrictions on the property have reverted to agricultural use only. The other land uses surrounding the Site are expected to remain the same. Response actions completed by EPA anticipate safe and beneficial use of the Site for industrial or recreational purposes.

## Hydrogeology

The bedrock aquifer underlying the Site is used as a drinking water source in surrounding residential areas. The area surrounding the Site is not presently serviced with public water. The closest residential well is located approximately 400 feet from the Site, while the closest downgradient well is approximately 2,500 feet from the Site. The dominant groundwater flow direction is to the east-southeast in the direction of Stockton Creek and its tributaries.

The topography of the Site slopes predominantly to the southeast and levels off at the southern end. Total relief across the Site is approximately 196 feet with an average grade of 10 percent. The majority of the Site is covered with overburden ranging in thickness from 0 - 15 feet. Groundwater at the Site is present in both the overburden and underlying fractured bedrock. Aquifer testing indicates that overburden and bedrock units exhibit a high degree of hydraulic interconnection sufficient to consider the two units to be part of a single aquifer system. Significant movement within the bedrock is limited to its uppermost 50 feet. The water table at the Site is encountered at depths ranging from 5 feet to 35 feet below ground surface.

The water table generally follows surface topography. Groundwater in the overburden layer flows in a southeasterly direction toward West Stream, a tributary of Stockton Creek into which it discharges. The bedrock groundwater flow system is controlled by the nature and extent of bedrock fracturing. The direction of groundwater flow in the bedrock is also in a southeasterly direction. Groundwater located in the sloped areas of the Site generally has a downward vertical gradient (water moves downward from the overburden to the shallow bedrock). Topography at the southern end of the Site levels off and the vertical gradient of the groundwater is upward. The water table is generally located at or above the top of the bedrock.

In the southern portion of the Site, the groundwater elevations are at, or slightly above, ground surface elevations. Since the groundwater is found close to the surface in the southern portion of the Site, this indicates that the area serves as a groundwater discharge area. The West Stream and associated features at the southern periphery of the Site are probably groundwater discharge features.

## History of Contamination

The Greenwood Chemical Company operated a small volume batch chemical

manufacturing facility. Chemical manufacturing operations began in approximately 1947 under the name of Cockerille Chemical Company. The facility was sold to GCC in 1968 and continued to operate under that name until its closure. In April 1985, a toluene vapor fire destroyed the main processing building and resulted in the death of four workers. The plant ceased operations shortly thereafter. The facility produced chemicals for application in industrial, agricultural, pharmaceutical and photographic processes. The primary compounds manufactured at the Site during the 1980s included naphthalene acetic acid, 1-naphthaldehyde, and naphthoic acid. In addition, arsenic salts were used as catalysts in the production of chloromethylnaphthalene, an intermediary in the production of naphthalene acetic acid. Production processes used toluene, naphthalene derivatives, sodium cyanide and inorganic arsenic salts. In addition, naphthalene derivatives, sodium cyanide, sulfuric acid, hydrogen peroxide and paraformaldehyde were also used. Manufacturing activities involved the handling of large numbers of drums containing waste, feedstock, intermediate and final products.

In the course of these operations liquid wastes were discharged through floor drains in the process buildings to a series of unlined lagoons adjacent to the plant. The unlined lagoons were interconnected by unlined drainage ditches or above-ground piping. Liquid hazardous waste was routinely spilled onto process building floors and drained into the ground beneath and adjacent to the process buildings. In addition, drums were systematically buried on plant property. Trenches were used for the disposal of large quantities of 55-gallon drums containing hazardous substances. This activity resulted in the contamination of soil, groundwater, surface water and lagoon sludge. Contamination in groundwater consists primarily of volatile organic compounds (VOCs) including 1,2-dichloroethane, carbon tetrachloride and vinyl chloride, semi-volatile organic compounds including naphthalene and other organic compounds such as bis (2-chloroethyl) ether.

A complete chronology of milestones for this project can be reviewed in Attachment A

## Initial Response

In June 1985 the Virginia Department of Health completed a Preliminary Assessment that documented the presence of numerous unidentified drums of chemicals and chemicals in the waste lagoons. The report concluded by recommending that EPA conduct a detailed site investigation to further assess the potential for harm to the public health and environment at the Site.

In 1986, EPA evaluated the Site for a possible removal action. Between May 1986 and December 1987, the EPA Emergency Response Team and Technical Assistance Team planned and implemented a detailed sampling of the lagoons, lagoon sludge, and surface and subsurface soils. In addition, monitoring wells were installed to conduct a hydrogeological investigation and a magnetometer and soil gas survey was conducted. Analysis of the samples from the various media showed the presence of numerous hazardous substances at the Site.

EPA proposed the Greenwood Chemical Site for inclusion on the CERCLA National

Priorities List (NPL) in March 1987 and placed the Site on the NPL on July 22, 1987 (see 55 Fed Reg. 27263).

Between 1987 and 1990, EPA conducted two removal actions which included the removal of drums and smaller containers of chemicals (both buried and surface), the removal and treatment of lagoon water and sludges. In 1987, approximately 400 buried drums and 32 pressurized gas cylinders were excavated and removed from the Site. Waste water from lagoons 1, 2 and 3 was pumped into lagoon 4, treated with activated carbon, and released to lagoon 5. In addition, contaminated lagoon sludges were excavated and removed from the Site for disposal. In November 1989, EPA determined that further removal action was necessary after heavy rains in the region damaged the temporary soil/synthetic membrane cap covering the former drum disposal area. EPA repaired the temporary cover and several drainage swales were constructed around the waste lagoons to prevent further erosion.

## Basis for Taking Action

In October 1988 EPA initiated a site-wide Remedial Investigation. EPA conducted a baseline risk assessment using all available data collected during previous removal work and identified data gaps. Several data gaps were identified in the baseline risk assessment; however, it became clear that some initial steps could be taken to address obvious environmental problems at the Site. In order to simplify the management of the Site, EPA has divided the Site into components or Operable Units (OUs). The Operable Units for the Site (in summary form) are listed as follows:

- OU1: Source control remedy (soil)
- OU2: Interim groundwater and lagoon water remedy
- OU3: Removal of Process Buildings and waste chemicals
- 2004/2005 Removal Action (not assigned an OU #): Surface Soil, Lagoons 4 and 5, laboratory chemicals
- OU2/4: Final groundwater and deep soil source areas

EPA has issued three Records of Decision (RODs) and issued one Action Memorandum for the Site after placing it on the NPL. The first ROD addressed the OU1 source control remedy. The second ROD addressed the OU2 interim groundwater and lagoon water remedy. The third ROD reaffirmed the groundwater pump and treat remedy selected as an interim action and established performance standards for groundwater (OU2). The third ROD also addressed remaining deep soil contamination (OU4) located beneath areas excavated as part of OU1. See Section III (Remedial Action Summary) for a detailed discussion of respective remedy decisions.

A Remedial Investigation and Feasibility Study (RI/FS) for the entire Greenwood

Chemical Site was completed in August 1990. The report characterized the nature and extent of soil, surface water, sediment and groundwater contamination. The 1990 RI/FS process, including several preliminary reports, provided the basis for Records of Decision for OU1, OU2, the 1991 Explanation of Significant Differences (ESD) which defined OU3, and the 1994 ESD.

The baseline risk assessment determined that risk pathways driving the risk at the Site under current and future use scenarios were dermal contact and ingestion of contaminated soil and ingestion of contaminated groundwater. The baseline risk assessment completed for the OU1 (1989) and OU2 (1990) RODs assumed a future residential land use scenario. The baseline risk assessment completed for the final OU2/4 ROD (2005) assumed industrial and recreational future land use based on recommendations from state and local officials. The baseline risk assessment was completed prior to the development of the current ecological risk assessment guidance; however, a comparison of pre-remediation concentrations of contaminants in soil at the Site to ecological soil screening levels indicates that exposure to ecological receptors would have presented an unacceptable risk. Similarly, pre-remediation concentrations of contaminants in lagoon water were well above surface water quality standards currently known to be protective of aquatic life and ecological receptors.

**Soil**

The carcinogenic risks were highest for exposures to surface soil due to elevated concentrations of arsenic. Arsenic was the primary contributor to both the total excess cancer risk and the non-carcinogenic risk for exposure to soil[a]. The soil cleanup levels selected for organic compounds were based on the potential for migration to groundwater because the soil to groundwater performance standards were more conservative (i.e., lower) than cleanup concentrations developed for direct contact with soil assuming residential use. See Table 1 for soil cleanup standards for organics used during OU1 soil excavation[b]. The arsenic cleanup level in soil (27 mg/kg) was based on the direct exposure route because it was lower than the soil to groundwater target.

**Groundwater**

The 1990 interim OU2 ROD established that groundwater beneath the Site was grossly contaminated, primarily in the center of the Site (beneath the manufacturing area and the drum disposal area). The eleven contaminants identified as driving the risk assuming ground water consumption were:

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[a] The primary ecological risk driver was also arsenic in surface soil.

[b] In areas where arsenic was the only contaminant of concern present, excavation was deferred to the removal response taken in 2004/2005.

| Groundwater | |
|---|---|
| Arsenic | Non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) |
| Benzene | Semi-volatile Tentatively Identified Compounds (TICs) |
| Methylene Chloride | Toluene |
| Trichloroethene | Volatile TICs |
| Chlorobenzene | Cyanide |
| Tetrachloroethene | |

The interim ROD deferred establishment of groundwater cleanup levels to a subsequent ROD. See Operable Unit 2 (Final) and Operable Unit 4 Remedy Selection on Page 14 for final groundwater cleanup level discussion.

**Lagoons 4 and 5**

The response action for lagoon water was based on cyanide concentrations which exceeded the Virginia Surface Water Quality Standards for cyanide (5.2 ug/l). The cyanide levels presented an unacceptable risk to aquatic life. Once the lagoon was drained, the sludge/sediment was determined to exceed the soil cleanup level for arsenic.

## III. Response Action Summary

### Operable Unit 1 Remedy Selection

On December 29, 1989, EPA issued the OU1 ROD selecting a remedy to address contaminated soils remaining in the lagoons and other disposal areas after emergency removal actions had been completed to address the sludges from those areas. The remedial action objectives are to prevent direct exposure to contaminated soils and to eliminate the continued migration of contaminants to the underlying groundwater.

The ROD developed cleanup standards for each compound considering: 1) the direct contact exposure route; and, 2) its potential to migrate from soil to groundwater. The cleanup standards developed for the protection of groundwater were more stringent than the standards developed for direct contact in each case except arsenic. See Table 1. The major components of the selected remedy include:

- Excavation of soil exceeding risk-based cleanup levels (soil associated with Lagoons 1, 2, 3 and Backfill North were estimated at 4,500 cubic yards[c]);
- Off-Site treatment of contaminated soil in a Resource Conservation and Recovery Act (RCRA)-permitted thermal destruction facility (i.e., incinerator);
- Treated soil was to be analyzed and stabilized/solidified in compliance with RCRA land ban restrictions, if necessary, prior to its disposal in a RCRA-permitted Subtitle C landfill;
- Excavated areas were to be backfilled with clean fill and re-vegetated; and,
- Abandoned chemicals located in on-Site buildings were to be treated via thermal destruction and disposed of off-Site.

## Operable Unit 3[d] Remedy Selection (Explanation of Significant Differences-1)

An Explanation of Significant Differences (ESD-1) augmenting the remedy selected in the OU1 ROD was issued on July 17, 1991. The OU1 ROD had been issued based on preliminary nature and extent of contamination data available at the time. The final RI Report completed in September 1990 identified additional contaminated soils exceeding risk-based soil cleanup levels (identified in the OU1 ROD) extending beneath on-Site Process Buildings A, B and C. ESD-1 required the removal of the process buildings to allow delineation of soils exceeding cleanup levels. The primary changes described in ESD-1 were:

- The Process Buildings A, B, and C were to be dismantled, decontaminated to the extent possible and appropriately disposed of in an off-Site landfill. Contaminated demolition debris was to be disposed of in a RCRA Subtitle C landfill; nonhazardous debris was to be disposed of in a RCRA Subtitle D landfill.

### ESD-2 (Modification to OU1 Remedy Selection)

A second ESD (ESD-2) modifying the remedy selected in the OU1 ROD was issued on March 24, 1994. ESD-2 refined the extent of contamination estimates based on soil sampling completed during pre-design activities in the footprint of the demolished process buildings and other disposal areas. ESD-2 asserted that contaminated soils in the source areas to be addressed by OU1 extended beyond 15 feet, which it established as the practical limit of cost-effective excavation. ESD-2 also stated that EPA would evaluate appropriate response actions for the deeper contaminated soils as Operable Unit 4. Further, ESD-2 modified the cleanup levels presented in the OU1 ROD based on an extensive fate and transport modeling program completed as part of pre-design activities. See Table 1.

ESD-2 determined that the remedy for OU1 would address contaminated soil in the following additional areas of the Site:

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[c] These soils were considered to be a principal threat to human health and the environment and are shown in Table 1

[d] Removal of process buildings and waste chemicals are referred to as Operable Unit 3 for administrative tracking purposes.

- The Backfill North area extending to and beneath former Process Building A;

- An area including the location of former process Buildings B and C; and

- The former Drum Disposal Area, the Waste Dump area, the Northeast Drum Area, and other areas if subsequent sampling revealed contaminant concentrations above risk-based levels.

The area of contaminated soil requiring remediation increased from the 1.5 acres estimated in the original OU1 ROD to approximately 7 acres. The estimated volume of soil to be transported off-Site for treatment and/or disposal increased from 4,500 cubic yards to approximately 11,000 cubic yards. ESD-2 also noted the following clarification to the original remedy:

- Certain areas on the Site were only contaminated with elevated levels of arsenic. These arsenic-contaminated soils do not pose an unacceptable risk through the groundwater pathway but only through direct contact. Noting that the incineration technology selected for OU1 is inappropriate for arsenic, EPA deferred the remediation of these arsenic-contaminated soils to a subsequent decision document.

## OU1 and OU3 Remedy Implementation

A total of 30 Potentially Responsible Parties (PRPs) were ultimately identified, including former owners and operators of the facility and various entities which did business with Greenwood Chemical. The major PRPs for the Site were issued a Unilateral Administrative Order in 1994 to conduct the OU1 remedial action (RA) but the PRPs declined to perform the RA. Therefore, all removal and remedial activities through the 2012 transfer of remedy operations to VDEQ have been accomplished with Superfund financing. However, EPA has recovered a portion of its response costs from 15 PRPs pursuant to several judicial settlements.

The work associated with OU3 was the first remedial action to be performed at the Site. In accordance with an interagency agreement, on November 27, 1991, the U.S. Army Corps of Engineers (USACE) awarded the contract to OHM Remediation Services Corp to remove the abandoned chemicals within the former process buildings A, B, and C and subsequently demolish the process buildings, thereby initiating RA. OHM mobilized to the Site in December 1991 to begin construction in the field. Major milestones included:

- Installation of a security fence;
- Removal of abandoned chemical containers in and around the buildings;
- Demolition, decontamination and off-Site disposal of 4 concrete block buildings (process buildings A, B and C and a laboratory/office building);
- Removal of a metal shed (storage shed/garage); and,
- Decontamination and proper disposal of six aboveground chemical storage tanks, one underground chemical storage tank and associated piping.

The OU3 work was completed in a manner consistent with the requirements of the July 1991 ESD and all project work plans. In March 1993 EPA, USACE and VDEQ conducted the final inspection and concluded that construction had been completed in accordance with the project work plans.

In accordance with an interagency agreement, on August 31, 1995 the USACE awarded a contract to Ogden Remediation Services to construct the OU 1 remedy in accordance with the approved remedial design (RD), thereby initiating the RA. Ogden mobilized to the Site in February 1996 to begin construction in the field. Major milestones included the following:

- Excavation of approximately 11,000 $yd^3$ of contaminated soil from the source areas addressed under OU1 and OU3;
- Shipment by rail of contaminated soils to a thermal destruction facility (incinerator) in Utah for treatment;
- Disposal of residue (ash) in an adjacent RCRA Subtitle C landfill;
- Implementation of stormwater drainage controls around excavation areas; and,
- Backfilling, regrading and revegetation of excavation areas.

On August 8, 1997 EPA, USACE and VDEQ conducted the final inspection and concluded that construction had been completed in accordance with the remedial design plans and specifications.

## Operable Unit 2 (Interim) Remedy Selection

On December 31, 1990, EPA issued an Interim ROD for OU2 selecting a pump and treat remedy to minimize migration of contaminated groundwater toward residential wells. The ROD was considered "interim" because the selection of groundwater cleanup goals was deferred to a subsequent ROD after further study. The remedial action objectives are to minimize migration of contaminants toward residential wells, eliminate unacceptable environmental risks in Lagoons 4 and 5, and to obtain additional information regarding aquifer characteristics to assist in designing a final groundwater remedy. The major components of the interim OU2 selected remedy include:

- Installation and operation of groundwater recovery wells to prevent migration of contaminated groundwater from the Site;
- Monitoring the effectiveness of the groundwater extraction network and systematic optimization to meet objectives over time; and
- Construction and operation of a water treatment plant to treat the recovered groundwater and surface water collected in Lagoons 4 and 5. The treatment plant discharge to surface water (tributary to West Stream) must meet Virginia Surface Water Quality Standards.

## Operable Unit 2 (Interim) Remedy Implementation

In accordance with an interagency agreement, on July 2, 1998 the U.S. Army Corps of Engineers awarded a contract to Norair Engineering to construct the remedy selected in interim OU2 ROD in accordance with the approved RD, thereby initiating the RA. Norair mobilized to the Site on September 18, 1998 to begin construction in the field.

Major milestones included the following:

- Installing and operating of five bedrock groundwater recovery wells (BR-2, BR-7, MW-23, BR-8 and BR-6);
- Installing of a floating pump assembly and pumping surface water from Lagoons 4 and 5 to the on-Site water treatment plant;
- Constructing a water treatment plant utilizing the following treatment train: precipitation, ultraviolet/chemical oxidation and carbon adsorption;
- Install plumbing necessary to convey recovered groundwater and lagoon surface water to the treatment plant;
- Beginning to operate the water treatment plant so that discharge consistently achieves VPDES criteria; and
- Installing an expanded monitoring well network.

The work was constructed in accordance with the remedial design plans and specifications. The final inspection and EPA/USACE, and VDEQ acceptance was completed May 9, 2000. The water treatment system began continuous operations on May 15, 2000, including initiation of routine groundwater monitoring. During the initial year the treatment plant operators were on-Site making equipment adjustments (as necessary) to ensure consistent and effective operation of the treatment system. Field testing and laboratory analyses confirmed that the plant was operating satisfactorily. On May 15, 2001, EPA and VDEQ determined the water treatment system to be operational and functional.

## 2004/2005 Removal Action Selection – Surface Soil, Lagoons 4 and 5 (No Operable Unit #)

On June 22, 2004 EPA issued an Action Memorandum to address additional laboratory chemicals abandoned by GCC, properly close out Lagoons 4 and 5, and to address the remaining arsenic-contaminated surface soil. The primary components of the removal response action include:

- Excavation and off-Site disposal of contaminated lagoon sludge (Lagoons 4 and 5) and surface soil with arsenic concentration greater than 27 mg/kg.
- Backfill with 2 feet clean soil.
- Removal and proper off-Site disposal of laboratory chemicals abandoned on-Site.

## 2004/2005 Removal Action Implementation

On June 28, 2004, EPA mobilized to the Site with Kemron Environmental, Inc. to begin removal activities. All chemicals were removed from buildings and trailers, and containers were laboratory packed for off-Site disposal. On October 4, 2004, the drums were picked up for disposal by Chemical Analytics, Inc.

Between August 2004 and November 2004, EPA drained the lagoons by pumping the water to the on-site treatment plant. Dewatered sludge/sediment was then excavated until confirmation samples demonstrated arsenic concentrations below 27 mg/kg. The former lagoons were then backfilled with clean soil and seeded.

Between June 2004 and June 2005, EPA delineated all areas containing greater than 27 mg/kg arsenic in soil. The soil sampling program determined that no excavated soils were RCRA-characteristic waste. Approximately 19,500 tons of arsenic-contaminated soil and sludge was excavated, sampled and appropriately disposed in a solid waste landfill. EPA implemented an extensive confirmation sampling program to document that all soils with elevated arsenic concentrations were removed. The excavations were backfilled with a minimum 2-feet clean soil and seeded for erosion control.

## Operable Unit 2 (Final) and Operable Unit 4 Remedy Selection

On September 22, 2005, EPA issued a final ROD for groundwater (OU2) and deep soil contamination (OU4). The ROD (OU2/4 ROD) established groundwater performance standards for the second operable unit interim action pump and treat system. In addition, the OU2/4 ROD defined the area including the deep soil contamination as a "waste management area." The OU2/4 ROD selected hydraulic containment of the waste management area utilizing an enhanced version of the pump and treat system selected for interim OU2. The remedial action objective was to contain the contaminant plume within the waste management area and to restore groundwater quality in the area of attainment. See Figure 4. A 2005 Groundwater Investigation and Focused Feasibility Study included a groundwater capture zone analyses that recommended additional wells be added to the existing five-well groundwater extraction network.

The risk-based remedial goals that were selected as groundwater cleanup standards for the area of attainment are specified in Table 2. The major components of the selected remedy include the following:

- Continued operation of an enhanced groundwater pump and treat system to prevent migration of contaminated groundwater to the area of attainment;
- Continued treatment of recovered groundwater to achieve VSWQS prior to discharge to on-Site stream;
- Soil cover over the former drum disposal and manufacturing areas[e];

[e] Installation of the clean soil cover was completed during the 2004/2005 removal response activities, combined with the placement of clean backfill (i.e., soil) in all source area excavation performed under OU1.

- Long-term groundwater monitoring; and,
- Institutional controls to be implemented and maintained by the property owner to ensure that prospective users of the Site are aware that deep soil contamination is present, and to prevent: the extraction of groundwater from the aquifer beneath the Site for use as a potable water source; any interference with the groundwater extractions wells, treatment system, and related equipment; and any removal of the soil cover without the written permission of VDEQ, and EPA as appropriate.

**ESD (Modification to Institutional Controls Selected in OU2/4 ROD)**

An ESD modifying the institutional controls that were selected in the OU2/4 ROD was issued on July 24, 2013. The ESD determined that there is potential for vapor intrusion into future buildings constructed near groundwater contaminated by VOCs. The ESD added a land use restriction requiring that any new habitable building constructed over or within 100 feet of the groundwater contaminated by VOCs above MCLs should include, at a minimum, a foundation vapor barrier and the subsurface piping for a sub-slab depressurization system.

Additionally, the ESD expanded the types of institutional controls that may be used. The Greenwood Chemical Company had abandoned the Site property, stopped paying property taxes and dissolved as a company. There is currently no party authorized to enter into an Environmental Covenant and Easement implementing the Institutional Controls for the Site property. The ESD expanded the types of institutional controls that may be used to implement the restrictions to include other forms of notice including listing on State or local Registries of Contaminated Sites and advisories.

## Final OU2 and OU4 Remedy Implementation

EPA determined that the groundwater related components of the remedy selected in the Final OU2/4 ROD were most efficiently implemented as optimization upgrades to the existing interim OU2 remedy. Accordingly, on June 30, 2005, EPA directed TetraTech, EPA's contractor, to install additional groundwater recovery wells to the existing five-well network. TetraTech mobilized to the Site to initiate well installation based on preliminary designs on August 15, 2005. The major components of the enhanced pump and treat remedy implemented at the Site include:

- Six additional recovery wells installed using the 1) drilling, 2) geophysical survey, 3) hydro-fracturing, 4) targeted zone screening sequence;
- Locking vaults were installed over each recovery well;
- Piping and wiring necessary to connect the new wells to the treatment plant were installed;
- Pumps were installed and the Programmable Logic Controller was modified; and
- Long term groundwater monitoring was refined to measure effectiveness of the recovery well network.

The work was completed in a manner consistent with the EPA-approved design and work plans, and the expanded 11-recovery well network began operation in December 2005. A final inspection conducted by EPA and the State on May 16, 2006 confirmed that all significant items on the punch list had been satisfactorily addressed. On March 15, 2012, EPA transferred responsibility for ongoing operations of the system to VDEQ.

The groundwater treatment plant effluent has consistently met its respective VPDES discharge limits. A groundwater monitoring program is in effect to evaluate the effectiveness of establishing the hydraulic containment necessary to achieve groundwater performance standards at the area of attainment. See Long Term Monitoring/Operation and Maintenance below.

The soil cover that was selected as a final remedy over the former drum disposal and manufacturing areas was acknowledged in the OU2/4 ROD to have been already completed during Removal Response actions conducted by EPA in 2004 and 2005.

The Preliminary Closeout Report was issued for the Site on September 30, 2005. The Report documents that the EPA completed construction activities at the Greenwood Chemical Superfund Site in accordance with *Closeout Procedures For National Priorities Sites* (OSWER Directive 9320.2-09A-P).

## Implementation of Institutional Controls

On September 18, 2013, EPA filed a Notice of Contamination with the Albemarle Recorder of Deeds Office (Book 4413, pages 601-618) to provide information concerning subsurface contamination affecting the property and to provide a list of activities and uses that may result in an increased threat of harm to public health or the environment. The Notice of Contamination has been placed on the Albemarle County Land Record Management System, the Albemarle County GIS-web and the EPA website for the Greenwood Chemical Site (https://semspub.epa.gov/src/document/03/2251195).

In recognition that the Site had been abandoned, pursuant to Virginia Code § 10.1-1406.1, the Circuit Court of Albemarle County granted access to VDEQ under Court Order (Case No.: CL12000268-00) for the purpose of performing remediation at the Site. VADEP representatives are on the Site operating the water treatment plant on a daily basis. No activities have been observed that would violate the institutional controls. The subject property is fenced and the gate is locked each night and weekend.

Table 3: Summary of Implemented ICs

| Media, engineered controls, and areas that do not support UU/UE based on current conditions | ICs Needed | ICs Called for in the Decision Documents | Impacted Parcel(s) | IC Objective | Title of IC Instrument Implemented and Date (or planned) |
|---|---|---|---|---|---|
| Site soil, groundwater | Yes | Yes | Parcel # 05400-00-00-01300 | No residential use; No potable use of groundwater; Future buildings constructed above contaminated groundwater must use vapor barrier | Notice of Contamination with the Albemarle Recorder of Deeds Office (Book 4413, pages 601-618) September 18, 2013 |

## Long-Term Monitoring/System Operation and Maintenance (O&M)

Response actions associated with OU1, OU3 and the 2004/2005 Removal Action did not require any operation and maintenance activities.

The long-term operations, maintenance and monitoring requirements for the OU2/4 remedies are set forth in the final OU2/4 ROD. EPA managed the long-term response action (LTRA) at the Greenwood Chemical Site until March 2012, when responsibility for ongoing operations were transferred to the Commonwealth of Virginia. VDEQ contracted Environmental Alliance, Inc., to conduct O&M at the Site through September 2017 and retained RETAW Engineering, LLC., to perform that work starting in October 2017. The work is being conducted in accordance with the Operation and Maintenance Manual dated July 2011 as amended March 10, 2017.

The primary activities associated with O&M include the following:

- Operation of the groundwater recovery well network and water treatment facility.
- Inspection and maintenance of each component of the treatment system.
- Monitoring treatment plant effluent quality and submission of monthly discharge monitoring reports to demonstrate compliance with the Virginia State Water Control Law, Code of Virginia §§ 62.1-44.2 et. seq., and the site-specific discharge limits established in accordance with VPDES Regulations (VR 680-14-01).
- Environmental monitoring appropriate to evaluate the effectiveness of the groundwater recovery well network in establishing and maintaining hydraulic containment of the waste management area. Monitoring includes generation of potentiometric maps and water quality sampling to measure progress toward meeting performance standards in the area of attainment.

- Inspection and maintenance of access to water treatment facility and all environmental monitoring points.

- Adjusting and upgrading the recovery well network as appropriate to maintain hydraulic containment and optimize water treatment system.

- Annual sampling of residential wells participating in a voluntary program.

- Preparation of Semi-Annual and Annual Operation, Maintenance and Monitoring Reports. Annual O&M Reports describe activities completed, present environmental data and include an engineering evaluation of system effectiveness and optimization analyses.

Since the Fourth Five-Year Review was issued in September 2013 there have been no significant changes to the treatment system. VDEQ has determined that off-site disposal of sludge generated at the treatment plant with vacuum-truck is more cost effective than use of the on-site filter press.

The treatment system increased treatment flow rates from approximately 6 million gallons/year to 16-19 million gallons/year in 2006 after the additional 6 extraction wells went online. Routine effluent monitoring has documented that the water quality discharged from the treatment facility meets numeric limits established by VDEQ.

The water treatment plant has one full-time operator and one part time operator on staff. Operational uptime at the treatment plant was reported to be 93%, 95% and 95% in 2015, 2016 and 2017, respectively. The short downtimes that did occur were primarily due to power outages and system maintenance (e.g., carbon replacement).

O&M costs associated with the groundwater pump and treat system include the following categories:

- Labor
- Utilities (electricity)
- Consumables (treatment chemicals)
- Engineering Support/Technical Oversight
- Sampling and Monitoring (process, groundwater, discharge)
- Non-Routine Operations (sludge generation and disposal)
- Installation/abandonment of extraction and monitoring wells to optimize system

Operation costs for the last five years that VDEQ has complete cost information, extending through December 2017, are listed in Table 4. Annual costs of routine operation and maintenance activities associated with the recovery wells and treatment plant have been generally consistent with the final OU2/4 ROD estimated costs of approximately $463,000 per year.

| Table 4- Annual System Operations/O&M Costs | | |
|---|---|---|
| Dates | | Total Cost Rounded to the nearest $1,000 |
| From | To | |
| 1/1/2013 | 12/31/13 | $543,000 |
| 1/1/2014 | 12/31/14 | $432,000 |
| 1/1/2015 | 12/31/15 | $400,000 |
| 1/1/2016 | 12/31/16 | $400,000 |
| 1/1/2017 | 12/31/17 | $456,000 |

Groundwater and treatment plant effluent monitoring results are summarized in the Semi-Annual and Annual Operations, Maintenance and Monitoring Reports and are discussed in the data review section of this document.

## IV. Progress Since the Last Review

**Table 5**: Protectiveness Determinations/Statements from the 2013 FYR

| OU # | Protectiveness Determination | Protectiveness Statement |
|---|---|---|
| 1 | Protective | *The remedy at **OU1** is protective of human health and the environment. Contaminated soil and waste material was excavated and transported off-Site for treatment and/or disposal to minimize migration to groundwater and direct exposure. The excavated areas were backfilled with clean soil. The remedial action objectives have been met.* |
| 2/4 | Short-term Protective | *The remedy at **OU2/4** currently protects human health and the environment because hydraulic containment has been achieved and there is no current exposure to contaminated groundwater. However, in order for the remedy to be protective in the long term institutional controls must be placed on the Site to ensure protectiveness.* |
| 3 | Protective | *The remedy at **OU3** is protective of human health and the environment. The former manufacturing buildings and chemical wastes stored within those buildings were dismantled and properly disposed* |

| | | |
|---|---|---|
| | | *off-Site. The remedial action objectives have been met* |
| Sitewide | Short-term Protective | *The remedial actions at OUs 1 and 3 are protective and remedial actions at OUs 2 and 4 are protective in the short term. Because institutional controls are not in place remedial actions are not protective in the long term. There is no current exposure to contaminated groundwater; however, in order for the remedy to be protective in the long-term institutional controls must be placed on the Site to ensure protectiveness.* |

**Table 6**: Status of Recommendations from the 2013 FYR

| OU # | Issue | Recommendations | Current Status | Current Implementation Status Description | Completion Date (if applicable) |
|---|---|---|---|---|---|
| 2/4 | Implement institutional controls included in ESD | Implement Institutional Controls | Completed | Notice of Contamination filed with the Albemarle County Recorder of Deeds Office (Book 4413, pages 601-618) | 9/17/2013 |
| 2/4 | Long-term groundwater monitoring is required to assess and confirm that MCLs will be achieved throughout the Area of Attainment within a reasonable time period | Monitor groundwater quality trends outside the Waste Management Area to confirm that MCLs will be achieved throughout the Area of Attainment within a reasonable time period | Ongoing | Continuing to monitor groundwater and assess trends. Groundwater monitoring data collected in the last five years is summarized in the Data Review section below. | Click here to enter a date |
| | On February 17, 2012, EPA released the final non-cancer dioxin reassessment, publishing a non-cancer toxicity value, or reference dose (RfD), for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in EPA's Integrated Risk Information System (IRIS). Dioxin was never sampled for at the Site. | Limited sampling for TCDD in surface soil outside the perimeter of previously excavated areas should be completed to confirm that dioxin in not a concern at the Site. | Completed | Incremental sampling was conducted for dioxins at Greenwood Chemical Site on 27 and 28 May 2014. An analysis of the sampling data shows that dioxins are not a concern at the Greenwood Chemical site. The TCDD Toxicity Equivalence Quotient (TEQ) calculated for each sample collected not only met the Risk Screening Levels (RSLs) for industrial land use, but the results met the respective PRGs for residential land use. | 9/23/2014 |

## V. Five-Year Review Process

### Community Notification, Involvement and Site Interviews

The plan and schedule established for public outreach during the conduct of the five-year review process included public announcements and communications with local officials and residents. EPA contacted and provided a comprehensive update of Site progress to local emergency response and public health officials including:

- Jack McClelland, Virginia Department of Health – Thomas Jefferson Health District
- Amelia McCulley, Albemarle County Director of Zoning
- Mark Graham, Albemarle County Director of Community Development
- Andrew Walker, GIS Specialist, Albemarle County
- Shawn Maddox, Assistant Fire Marshall, Albemarle County Fire and Rescue

A notice announcing that EPA was conducting a five-year review for the Site was published in the Charlottesville, Virginia *Daily Progress* on May 11, 2018.

EPA RPM Newman conducted many interviews with VDEQ personnel and support contractors operating the treatment plant, local residents and local officials to inform them that EPA was completing the Five-Year Review process to confirm that the constructed remedy remains protective. In addition to continuing communications with local officials identified above, in May 2018, Mr. Newman called several area residents who participate in the voluntary residential well sampling program and other residents who have contacted EPA to inquire about the Site in recent years. During each interview Mr. Newman outlined the review process, including a detailed review of environmental monitoring and maintenance reports, a field inspection of the constructed remedy, and a literature review to confirm that the performance standards remain protective when considering the most up-to-date regulatory standards and toxicity data of site-related compounds. Mr. Newman conveyed the importance of communicating with local citizens and public officials to learn of any concerns related to the Site.

None of the citizens interviewed expressed any specific concerns related to the Site. The local citizens were aware of the cleanup work that EPA has completed and that responsibility for continuing operations at the Site had transitioned to VDEQ. Based on the interviews, the local citizens and officials continue to be comfortable with the work completed. The citizens expressed general satisfaction that EPA does maintain an interest in the Site and reviews the remedy for continued protectiveness after cleanups have occurred.

Shawn Maddox, Assistant Fire Marshall, Albemarle County Fire and Rescue expressed appreciation to VDEQ's site operations team for hosting and participating in a regional hazardous materials team training exercise conducted at the water treatment facility on November 8, 2016. More specifically, the regional hazardous materials team comprised of representatives from Charlottesville/Albemarle County/and University of Virginia conducted a

drill at the Site involving a leaking pipe and container to drill their response and performance capability. All parties agreed that the event served the dual purpose of providing a valuable forum for hands-on training to the local area first responders and familiarizing the local responders with routine treatment facility materials and operations.

## Document Review

Documents reviewed in the process of conducting this five-year review included the last five-year review, the 1989 ROD, the 1990 Interim ROD, the 1991 and 1994 ESDs, the June 2004 Action Memorandum, the 2005 On-Scene Coordinator Report, the 2005 final OU2/4 ROD, the 2013 ESD, 2013 Deed Notice, 2014 Technical Memorandum on Dioxin Sampling, 2017 Letter Health Consultation, and the Semi-Annual and Annual O&M Reports from 2013 through August 2017, including treatment plant operational data, treatment plant discharge and groundwater monitoring. A complete list of documents reviewed can be found in Attachment B.

An assessment of the Applicable or Relevant and Appropriate Requirements (ARARs) was conducted during the document review. The assessment determined that the ARARs are being met and/or are still appropriate for the remedies in place at the Site. The major ARARs include:

- MCLs and non-zero MCLGs are still promulgated under the Safe Drinking Water Act, 40 CFR § 141.11-16; 40 CFR §§ 141.50-51 and are still relevant and appropriate to the groundwater cleanup remedy in the area of attainment.

- MCLs and non-zero MCLGs are still promulgated under the Virginia Waterworks Regulation, 12 VAC 5-590-440, Tables 2.2 and 2.3 and are still relevant and appropriate to the groundwater cleanup remedy in the area of attainment.

- Discharge limitations into surface waters of the Commonwealth are still promulgated under the Virginia Pollutant Discharge Elimination System, 9 VAC 25-31-10 to 940 and are still applicable to the effluent discharge from the on-Site water treatment facility. A permit is not required for on-Site discharge; however, the substantive standards must be attained.

In January 2009 EPA and VDEQ completed a reassessment of the water treatment effluent quality. As part of the process the VDEQ VPDES program conducted a statistical analysis of the Greenwood Chemical Treatment Plant discharge reports between 2001 and 2008 and provided EPA with recommended Discharge Monitoring Report (DMR) modifications in October 2008 which were slightly revised again in 2013. VDEQ recommended that metals (aluminum, calcium, chromium (III), chromium (VI), copper, lead, mercury, and zinc) be removed from the monthly discharge monitoring requirements. VDEQ also recommended that the previously requested organics (benzene, bis-2-chloroethyl ether, bis-2-ethylhexyl phthalate, carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichlorobenzene, 1,2-dichloroethane, methylene chloride, naphthalene, tetrachloroethene, trichloroethene, toluene, and vinyl chloride) be removed from discharge monitoring requirements based on 8 years of effluent data

demonstrating consistent abatement of organic contaminants by the treatment plant. EPA confirmed that VDEQ reports only the limited parameters required by the VDEQ water program in its Quarterly and Annual VPDES Discharge Monitoring Reports but maintains a more robust data set in the Semi-Annual and Annual O&M Reports. The VPDES Discharge Monitoring Reports cannot be used alone to determine whether the water treatment plant is meeting its ARARs (Virginia Surface Water Quality Standards) because the DMRs do not report on all the known contaminants of concern.

In January 2009 EPA utilized the VDEQ Piedmont Region Water Quality Spreadsheet (Piedmont Spreadsheet) to generate water quality parameters for known Site contaminants that data collected from water treatment plant effluent can be compared against to confirm ARAR compliance for the receiving stream. See Table 7, column referred to as "informal performance goals." Table 7 includes effluent limits for nickel, benzene, bis-2-chloroethyl ether, carbon tetrachloride, 1,2-dichloroethane, tetrachloroethene, trichloroethene, and vinyl chloride. As part of this five-year review, EPA confirmed that the surface water quality standards used to generate the informal performance goals remain current. The informal performance goals allow EPA to monitor the effectiveness of the treatment system and confirm ARAR compliance.

## Data Review

Groundwater Monitoring

There are currently 59 groundwater/overburden monitoring wells and 11 extraction wells located across the Site and hydraulically down gradient of the Site. The groundwater monitoring plan includes approximately 20 wells for semi-annual monitoring (including extraction wells) and 41 wells for annual water quality monitoring. Water level measurements are collected from all 59 groundwater monitoring wells to generate potentiometric maps quarterly. The Annual Long-Term Monitoring reports completed by VDEQ between 2013 and 2017 present a general evaluation of the pump and treat system capture zone using a simple flow net analysis. Conducting a capture zone analysis is difficult in fractured rock lithologies due to the limited understanding of fracture orientation and connectivity. The actual capture zone is more complicated than predicted by the simple flow net analysis but it is considered as one line of evidence in assessing the effectiveness of the recovery well network along with evaluating groundwater elevation data (potentiometric maps), groundwater contaminant concentration trends and concentrations in perimeter wells. The groundwater contour maps generated using bedrock well elevation data (see Figure 5) suggest that the recovery wells are creating an inward gradient. The contours are more pronounced along the southern portion of the extraction well field where the topography begins to level off. Comparing TCE concentration contours from 2011 to 2017, the 1 µg/L contour line has indicated a measurable contraction in the southern and eastern portions of the Site. In addition, there is a reduction in size of the plume concentration contour >100 µg/L, currently centered between BR08, CW03, and CW04. This evidence indicates that the 11 recovery wells are preventing migration of contaminated groundwater.

In addition, residential well sampling has been conducted on an annual basis, generally in

February. The last sampling event reviewed was conducted in February 2017. Over the last five years 10 residential wells within an approximate one-half mile radius of the Site have participated in the voluntary sampling program. A review of the residential well data confirmed that no site-related contaminants have been detected above MCLs or above any other risk-based action level in a residential well.

Long term groundwater monitoring samples are analyzed for Target Compound List (TCL) volatile and semi-volatile organic compounds and Target Analyte List (TAL) metals. This five-year review focused on the semi-annual data reports presented from 2013 through 2016 and Annual O&M Reports including treatment plant operational data through August 2017.

Flow rates and water quality data from extraction wells were reviewed along with potentiometric maps to evaluate the effectiveness of the recovery well network in establishing hydraulic containment of the waste management area. The most concentrated portion of the "plume" within the waste management area appears to be located at the center of the Site between recovery wells MW-23, CW-5 and CW-2, north and east of the treatment plant (See Figure 6.). This is consistent with previous years, as MW-23 was originally placed in the center of the former manufacturing area as a hot-spot recovery well. The water level measurements and associated contour maps indicate that the recovery wells arrayed across the Site are containing groundwater moving down-slope toward the southern boundary. In July 2008 EPA installed additional monitoring wells (PMW-6 and PMW-7) downgradient of monitoring well PMW-5 to better understand groundwater flow along the eastern property boundary. The additional data points confirm that the new recovery wells CW-4, CW-5 and CW-6 have cut off the groundwater moving to the east in the vicinity of monitoring well PMW-5. Hydraulic containment of the waste management area has been achieved with the current extraction well alignment; however, further adjustments to the recovery well system (i.e., adding wells or changing extraction well alignment) may be useful to optimize the system.

The expanded 11-well extraction system has been in operation for twelve years. A review of monitoring data collected over the last 5 years confirmed that the risk-based remediation goals have been met in perimeter monitoring wells (PMW) but several other monitoring wells within the area of attainment closer to the WMA remain above remediation goals. See Table 8 for contaminant concentration trends. Data trends will need to be graphed over the next several years to confirm that the project is on track to meet risk-based remediation goals within a reasonable timeframe.

The review team looked at the water quality along the property boundary to determine if contaminants are migrating off the Site property. The four perimeter monitoring well locations (PMW-1, PMW-2, PMW-3 and PMW-4) that were placed along the southern property boundary all meet MCLs and additionally meet the more conservative site-specific risk-based groundwater performance standards[f], based upon the 2017 sampling results. The two off-Site wells west of the property boundary near the former drum disposal area (MW-19 and BR-04) meet both MCLs

[f] The site-specific performance standards are lower than MCLs to account for the potential cumulative risk of multiple contaminants.

and site-specific performance standards. The well placed along the eastern boundary of the property (PMW-5) has not been sampled since 2012 but at that time measured trichloroethene at concentrations more than a magnitude greater than the MCL. Three new extraction wells (CW-4, CW-5 and CW-6) were placed upgradient of PMW-5 in 2005. CW-4 and CW-5 are recovering relatively high concentrations of trichloroethene but a reduction in trichloroethene concentration at PMW-5 had not yet been evident at the time that the 2013 FYR was completed. For reasons not completely understood, VDEQ omitted PMW-5 from the list of monitoring wells to be sampled. EPA has requested that VDEQ add PMW-5 to the list of monitoring wells to be sampled to better evaluate the effectiveness of CW-4, CW-5 and CW-6 in the future. The off-Site well concentrations east of PMW-5 (PMW-6 and PMW-7) do not exceed MCLs, indicating that the contaminant plume has been confined to the Site.

Groundwater Pump and Treat System

Table 9 shows the average influent concentrations to the treatment plant from 2002 through August 2017. The average influent concentrations have been fairly constant since the extraction system was expanded.

The total volume of groundwater treated in 2016 was 18.3 million gallons (MG) and the cumulative quantity of groundwater treated from 2001 through August 2017 is approximately 244 MG. Table 10 presents the annual groundwater and lagoon water recovery and treatment rates from 2001 to 2017. Lagoons 4 and 5 were closed in November 2004; the six new recovery wells came on-line in December 2005.

**Table 10: Treatment Plant Flow Rates 2001-2017**

| Year | Lagoon Water (gal/yr) | Groundwater (gal/yr) | Total (gal/yr) |
|---|---|---|---|
| 2001 | 0 (Zero) | 5,928,652 | 5,928,652 |
| 2002 | 258,539 | 4,775,987 | 5,034,526 |
| 2003 | 430,847 | 5,961,277 | 6,392,124 |
| 2004 | 2,212,850 | 6,549,862 | 8,762,712 |
| 2005 | 0 (Zero) | 6,878,236 | 6,878,236 |
| 2006 | 0 (Zero) | 17,638,447 | 17,638,447 |
| 2007 | 0 (Zero) | 19,409,215 | 19,409,215 |
| 2008 | 0 (Zero) | 18,954,023 | 18,954,023 |
| 2009 | 0 (Zero) | 18,510,558 | 18,510,558 |
| 2010 | 0 (Zero) | 19,050,941 | 19,050,941 |
| 2011 | 0 (Zero) | 19,148,420 | 19,148,420 |
| 2012 | 0 (Zero) | 17,344,503 | 17,344,503 |
| 2013 | 0 (Zero) | 17,367,770 | 17,367,770 |
| 2014 | 0 (Zero) | 17,617,525 | 17,617,525 |
| 2015 | 0 (Zero) | 16,707,320 | 16,707,320 |
| 2016 | 0 (Zero) | 18337,119 | 18337,119 |
| 2017 (thru August) | 0 (Zero) | 11,506,421 | 11,506,421 |

Based on the plant flow rate and influent contaminant concentrations, the mass of organic contaminants removed from the groundwater has increased from 25.2 pounds in 2003 (the first full year of operational data) to a maximum of 75.8 pounds in 2006. The 2016 organic mass removed was 62.5 pounds (last full year of operational data). See Table 9.

Monitoring of the groundwater treatment system effluent for VPDES discharge requirements is conducted on a monthly basis and Discharge Monitoring Reports are submitted to VDEQ. VPDES discharge parameters include flow, pH, total cyanide. In addition, plant effluent is tested for whole effluent toxicity and chronic whole effluent toxicity on a quarterly basis and acute whole effluent toxicity annually. Review of the monthly effluent sampling results submitted from 2013 through August 2017 confirmed effluent discharge was within the VPDES required limits except for the following exceedance:

- Chronic toxicity to *C. dubia* reproduction 2/2016

The February 2016 *C. dubia* chronic toxicity testing failed the VDEQ permit equivalent limits [1.4 Tuc (Toxic unit chronic)] with a 1.45 Tuc result. The plant operations team also noted that dissolved copper measured at 70.8 µg/L in the February 2016 effluent. Copper concentrations in plant effluent had never exceeded the Virginia water quality standards (9.2 µg/L) before that sampling event. The team noted that the activated carbon had been recently replaced with regenerated media prior to the February 10, 2016 sampling event. It was decided to change-out carbon again but this time to use virgin carbon media. The carbon was changed

out and a retest was performed March 29, 2016. The March 2016 *C. dubia* chronic toxicity testing did not fail the VDEQ permit equivalent limits. Subsequent sampling events conducted in 2016 and 2017 did not demonstrate any failure of chronic toxicity to *C. dubia* nor have they demonstrated elevated copper concentrations.

In addition to monitoring for the parameters required by the VPDES DMR, the groundwater treatment system effluent was sampled for other known site contaminants to monitor the effectiveness of the treatment plant. Effluent data was screened against EPA's "informal performance goals" (See Table 7). All informal performance goals were met in plant effluent, meaning that effluent is meeting the Virginia Surface Water Quality Standards. Historically, carbon tetrachloride has been the first compound to break through the first of two 5,000 lb carbon filters in the treatment facility, indicating that replacing the carbon media in the lead filter tank needs to be scheduled.

## Site Inspection

On April 18, 2018, Eric Newman, EPA's RPM, and Michelle Payne, VDEQ's Regulatory Analyst/ARAR Coordinator and project lead responsible for ongoing operations, maintenance and monitoring at the Site conducted a systematic Site inspection specifically focused on evaluating the condition of engineered features and the protectiveness of the constructed remedy including the integrity of the soil cover and the operation of the wastewater treatment plant as part of the five-year review process. Also attending the Site Inspection were Ignatius Mutoti and Phillip Bgwanya, Retaw Engineering, the prime contractor performing operations, maintenance and monitoring services for VDEQ, and Mark Ryland, Apex Companies, LLC a subcontractor to Retaw providing support by maintaining the grounds and conducting the environmental monitoring. Virginia DEQ representatives maintain a routine presence on the Site to operate the government-financed water treatment plant. Weather at the time of inspection was sunny and in the low 70's F.

The water treatment plant was physically inspected with a walk through. Each monitoring and recovery well was inspected and determined to be in operable condition; proper access to wells has been maintained. The soil cover constructed over the former drum disposal and former manufacturing areas were inspected and found to be well vegetated. Conveyance details such as ditches and culverts, and treatment plant discharge points were observed to be free of debris. All components of the remedial action were confirmed to be operating as designed. No significant issues have been identified regarding the physical condition of the Site, the monitoring points or the operation of the water treatment plant.

Retaw representatives alerted the review team that several of the concrete vaults enclosing the recovery wells have become subject to periodic flooding in the event of heavy precipitation. The apparent cause is the weathering/degradation of a soft gasket/caulk seal between the course extending up to the ground surface and top course with an integral door providing access to the well. As natural storm water flows against the upgradient side of the recovery-well vault, water enters through the degraded seam and begins to fill the vault, in some

cases residual flotsam indicated that the surface water may over-top the well head, potentially introducing turbid water with high solids content to the recovered groundwater being conveyed to the treatment plant. Most of the recovery-well vaults had apparently been constructed with a drain pipe capable of passively draining excess standing water from the vault but a couple of the vaults had some source of blockage of the drain pipe. The increased dissolved solids in the recovered water does not impact the protectiveness of the remedy but may increase operation costs due to increased man-power needed to backwash the sand filters and increased solids generation that will require disposal.

During the Site inspection no activities were observed or reported that would violate the land use restrictions called for in the OU 2/4 ROD as augmented by the 2013 ESD. The subject property was fenced (not required by the ICs), the soil cover and surrounding areas were undisturbed, and no new uses of groundwater were observed. The gate to the facility is only opened during standard business hours.

## VI. Technical Assessment

*Question A: Is the Remedy functioning as intended by the decision documents?*

Yes. The remedy is functioning as intended by the decision documents but not all remedial action objectives have been met. The recovery well network is capturing groundwater and treating the groundwater successfully before discharge. Hydraulic containment has been demonstrated along the eastern, southern, and western edges of the waste management area (north is upgradient). Nevertheless, assessment and realignment of the recovery well network may be warranted to optimize the performance of the system. The extent of the plume has been reduced and the area of the plume exceeding MCLs is limited to the Site property (See Figure 6).

Concentrations of contaminants in groundwater beyond the waste management area (i.e., area of attainment) remain above MCLs. Natural attenuation processes expected to further reduce concentrations in groundwater within the area of attainment are very slow. Data trends will need to be graphed over the next several years to statistically confirm that the project is on track to meet performance standards within a reasonable timeframe. Stable concentrations of contaminants in the area of MW-21S suggest that improved capture in the area of containment well BR-06 may be warranted.

The groundwater treatment facility is functioning as designed. Effluent meets appropriate VPDES discharge standards for all organic and inorganic parameters and the effluent passes toxicity tests. No impact has been detected in any residential drinking water wells or agricultural wells around the Site.

Institutional controls are in place with the Albemarle Recorder of Deeds Office (see Table 3). The land use restrictions can be readily accessed online on the Albemarle County GIS-Web.

*Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?*

Changes in Standards and TBCs

*Have standards identified in the ROD been revised, and does this call into question the protectiveness of the remedy? Do newly promulgated standards call into question the protectiveness of the remedy? Have TBCs used in selecting cleanup levels at the site changed, and could this affect the protectiveness of the remedy?*

The groundwater Risk-Based Remedial Goals established in the 2005 ROD (see Table 2) remain at or below current MCLs. Bis (2-chloroethyl) ether [BCEE] does not have a promulgated federal or State MCL and the BCEE toxicity factors considered in the site-specific risk assessment remain unchanged.

The designated use of surface water on the Site is secondary use recreation/protection of aquatic life (ecological receptors). The discharge standards for the water treatment plant (see Table 7) have been established to meet ambient surface water standards for the protection of aquatic life assuming no dilution. The discharge standards being utilized were re-evaluated and determined to be consistent with current ARARs and protective of ecological receptors.

Changes in Toxicity and Other Contaminant Characteristics

*Have toxicity factors for contaminants of concern at the site changed in a way that could affect the protectiveness of the remedy? Have other contaminant characteristics changed in a way that could affect the protectiveness of the remedy?*

The toxicity data for contaminants remaining at the Greenwood Chemical Site were reassessed for the final OU2/4 ROD issued in 2005. The toxicity factors listed in Tables 2A and 2B of the 2005 ROD have changed since then; however the final OU2/4 ROD levels issued in 2005 are still protective based on the analysis described below. ROD contaminant toxicity profile changes established after the 2005 ROD are listed in Table 11.

Table 12 provides the 2018 hypothetically recalculated Risk-Based Remedial Goals derived from the new toxicity values in comparison to the existing 2005 Risk-Based Remedial Goals for groundwater. The 2018 Risk-Based Remedial Goals would be equal to or higher than the 2005 Risk-Based Remedial Goals. The 2005 Final Risk-Based Remedial Goals are still protective. The groundwater performance standards have not been met yet but the extent of the plume is well-defined.

The 27 mg/kg soil cleanup standard for arsenic contaminated surface soil was established in the 2004/2005 Removal Action. The exposure assumptions and toxicity factors for arsenic have not changed and this cleanup concentration remains protective.

Soil cleanup standards for organic compounds were developed in the OU1 ROD and modified by ESD-2. See Table 1. The baseline risk assessment and back-calculated cleanup standards completed for OU1 assumed the future land use to be residential. The soil cleanup levels selected for organic compounds were based on the potential for migration to groundwater because the soil to groundwater performance standards were more conservative (i.e., lower) than cleanup concentrations developed for direct contact and residential use. The soil cleanup standards set forth in ESD-2 were compared to the November 2017 Region III RBC Table for industrial land use[g]. The analysis determined that the OU1 cleanup levels for carcinogens represent a cancer risk within or less than EPA's acceptable risk range of $10^{-4}$ to$10^{-6}$ for all compounds.

The OU1 soil cleanup levels for site-related non-carcinogenic compounds represent a Hazard Index of approximately 1.0 if they all affected the same target organ, with the exceptions of chlorobenzene and tetrahydrofuran. The OU1 cleanup level for chlorobenzene would represent an HI of 5.5 if chlorobenzene remained in surface soil at 7,708 mg/kg. This would be above EPA's target of less than 1.0 HI. The OU1 cleanup level for tetrahydrofuran would represent an HI of 1.0 if tetrahydrofuran remained in surface soil at 97,269 mg/kg (i.e., 9.72% tetrahydrofuran). This is at EPA's target of 1.0 HI. It is very unlikely that chlorobenzene or tetrahydrofuran remains in surface soil at even a fraction of these high levels for the reasons stated below.

- Table 6 of the OU1 ROD reports that the pre-remediation maximum concentration of chlorobenzene measured at the site was 150 mg/kg. The presence of chlorobenzene was a potential contaminant of concern, but chlorobenzene was not driving the cleanup at the Site. The 150 mg/kg chlorobenzene measured before the cleanup began would only present 0.1 HI to an industrial worker. Again, it is possible that chlorobenzene was present at higher concentrations in areas of actual waste material, but it is unlikely that it was present at elevated concentrations in soil after the disposal areas were excavated.
- Table 6 of the OU1 ROD reports that the maximum concentration of tetrahydrofuran measured at the site was 2.5 mg/kg. Again, it is possible that tetrahydrofuran was present at higher concentrations in areas of actual waste material (e.g., in a drum), but it is unlikely that it was present in soil after the disposal areas were excavated. The lagoons and disposal areas remediated during OU1 remedial action were contaminated with multiple contaminants. Excavation proceeded until the lateral extent of the excavation was confirmed clean or the depth reached approximately 15 feet. Chlorobenzene and tetrahydrofuran were typically collocated with other contaminants and therefore would have been excavated to concentrations on average much lower than 7,708 mg/kg/97,269 mg/kg, respectively, due to the proximity of other contaminants with much lower cleanup targets. For example, cleanup levels for benzene, chloroform and 1,2-dichloroethane are more than 4 orders of magnitude lower that the chlorobenzene cleanup level.
- The excavation areas and former manufacturing area was covered with a minimum of 2 feet of clean soil and vegetated.

[g] EPA's 2005 Record of Decision established that the reasonably anticipated future land use at the Site is recreational or industrial.

Based on these considerations, EPA has a high degree of confidence that the OU1 cleanup levels remain protective of human health for the future industrial land use scenario.

Changes in Risk Assessment Methods

*Have standardized risk assessment methodologies changed in a way that could affect the protectiveness of the remedy?*

There have not been significant changes in EPA's risk assessment guidance since the final 2005 ROD.

There have been significant changes in EPA's human health risk assessment guidance since the original risk assessment was performed. These include changes in dermal guidance, inhalation methodologies and exposure factors. The original risk assessment assumed a conservative residential future land use and the ROD chose even lower performance standards because the soil to groundwater migration model generated lower concentrations than those for direct contact. Accordingly, these changes are not expected to affect the protectiveness of the remedy.

The remedial investigation and Record of Decision were completed prior to the development of the current ecological risk assessment guidance. The decision documents did not specifically establish ecologically protective remedial action objectives or cleanup values. While these ecologically protective objectives and values have not been specified, the available data indicates that the remedial action is protective of ecological receptors. Contaminated soil was excavated and treated / disposed of offsite. Groundwater is being captured and treated; the area of capture prevents contaminated groundwater from discharging to area surface water bodies. Monitoring data does not indicate the potential for unacceptable ecological risk.

Changes in Exposure Pathways

*Has land use or expected land use on or near the site changed?*

No, local zoning for the Site remains agricultural use only. Local land use remains mixed residential, woodlands and agricultural.

*Have human health or ecological routes of exposure or receptors been newly identified or changed in a way that could affect the protectiveness of the remedy? Are there newly identified contaminants or contaminant sources? Are there unanticipated toxic byproducts of the remedy not previously addressed by the decision documents? Have physical site conditions or the understanding of these conditions changed in a way that could affect the protectiveness of the remedy?*

Local land use zoning continues to limit the Site to agricultural use only. The Records of

Decision also considered potential future use of the Greenwood Chemical Site for recreational or industrial purposes; however, this would require a change in the local zoning to allow such use.

The Fourth FYR issued in 2013 noted that on February 17, 2012, EPA released the final non-cancer dioxin reassessment, publishing a non-cancer toxicity value, or reference dose, for 2,3,7,8- tetrachlorodibenzo-p-dioxin in EPA's Integrated Risk Information System. The new reference dose became the recommended value "to be considered" for use in developing site-specific dioxin preliminary remediation goals and cleanup levels under CERCLA and the NCP. The new preliminary remediation goals calculated using the new reference dose of 0.7 picograms per kilogram-day and EPA non-adjusted exposure factors is 0.6654 µg/kg *TEQ* for commercial/industrial soil (based on toxicity equivalence quotients, which add up the toxicity of all dioxin-like contaminants). A review of historical sampling data conducted as part of the 2013 FYR effort indicated that dioxins were not sampled for during previous field investigations completed at the Site. Although no specific source of dioxins had been identified at the Site, as discussed in the historical Background section previously, there had been a fire at the manufacturing facility in 1985 and chlorinated solvents are known to be present at the Site. Accordingly, the 2013 FYR recommended limited sampling for dioxin in surface soil outside the perimeter of previously excavated areas be considered to confirm that dioxin is not a concern at the Site.

In May 2014, EPA conducted incremental sampling for dioxins at the Site. As reported in a Technical Memorandum dated September 23, 2014, analysis of the sampling data demonstrated that dioxins are not a concern. The TCDD Toxicity Equivalence Quotient (TEQ) calculated for each sample collected not only met the Risk Screening Levels (RSLs) for industrial land use, but the results met the respective PRGs for residential land use.

There have been no changes that warranted additional follow-up since the 2013 FYR.

Expected Progress Towards Meeting RAOs

*Is the remedy progressing as expected?*

Yes. The remedy has met all remedial action objectives established by the EPA decision documents with the exception of meeting groundwater performance standards throughout the area of attainment. Hydraulic containment of the waste management area has generally been achieved with the current extraction well alignment.

Several wells located along the western edge of the site within the area of attainment demonstrated contaminant concentrations at or below the target groundwater performance standards, based upon sampling conducted in 2017; however, there are wells located in the eastern and central portions of the area of attainment which do not currently meet the groundwater performance standards. Continued monitoring and data/trend analysis of the wells within the area of attainment will be necessary to ensure that remedial action objectives will be achieved within a reasonable timeframe.

The extent of the plume has been reduced and the area of the plume exceeding MCLs is limited to the Site property. Nevertheless, continued assessment and realignment of the recovery well network may be warranted to optimize the performance of the system.

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

No other information has come to light that would call into question the protectiveness of the remedy.

## VII. Issues/Recommendations

| **Issues/Recommendations** |
|---|

| **OU(s) without Issues/Recommendations Identified in the Five-Year Review:** |
|---|
| **OU1, OU2, OU3 and OU4** |

## VIII. Protectiveness Statement

| **Protectiveness Statement(s)** |
|---|

| *Operable Unit:* | *Protectiveness Determination:* | *Addendum Due Date (if applicable):* |
|---|---|---|
| 1 | Protective | Click here to enter date. |

*Protectiveness Statement:*
The remedy at OU1 is protective of human health and the environment. Contaminated soil and waste material was excavated and transported off-Site for treatment and/or disposal to minimize migration to groundwater and direct exposure. The excavated areas were backfilled with clean soil. The remedial action objectives have been met.

| *Operable Unit:* 2/4 | *Protectiveness Determination:* Protective | *Addendum Due Date (if applicable):* Click here to enter date. |
|---|---|---|
| *Protectiveness Statement:* The remedy at OU2/4 is protective of human health and the environment. Hydraulic containment has been achieved, there is no current exposure to contaminated groundwater and institutional controls are in place. | | |

| *Operable Unit:* 3 | *Protectiveness Determination:* Protective | *Addendum Due Date (if applicable):* Click here to enter date. |
|---|---|---|
| *Protectiveness Statement:* The remedy at OU3 is protective of human health and the environment. The former manufacturing buildings and chemical wastes stored within those buildings were dismantled and properly disposed off-Site. The remedial action objectives have been met. | | |

| **Site wide Protectiveness Statement (if applicable)** | |
|---|---|
| *Protectiveness Determination:* Protective | *Addendum Due Date (if applicable):* Click here to enter date. |
| *Protectiveness Statement:* The site-wide remedy is protective of human health and the environment. | |

## IX. Next Review

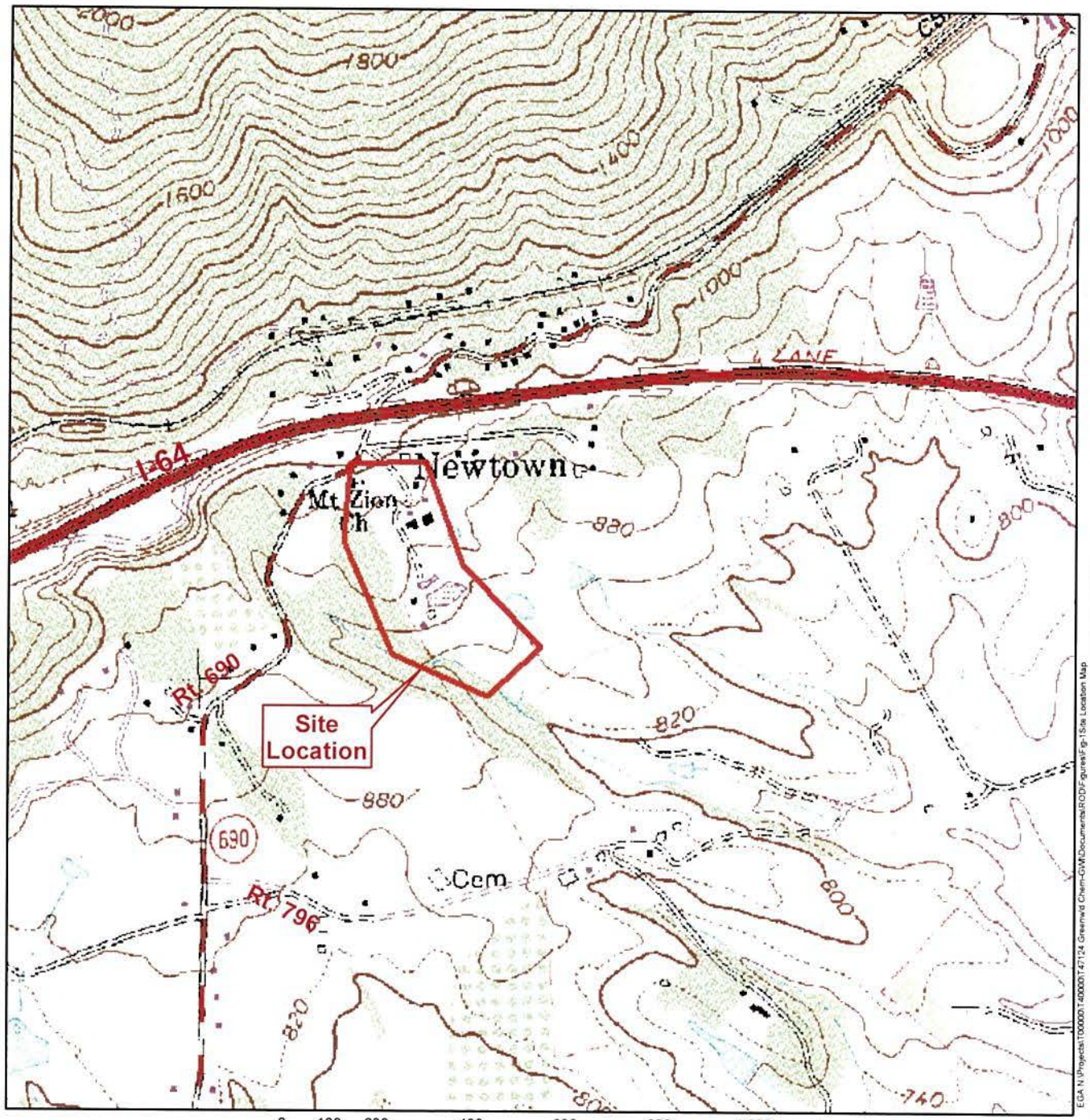
Since Site conditions do not allow for unlimited use and unrestricted exposure, EPA will need to conduct another five-year review of the Greenwood Chemical Site by September 6, 2023, five years from the date of this review.

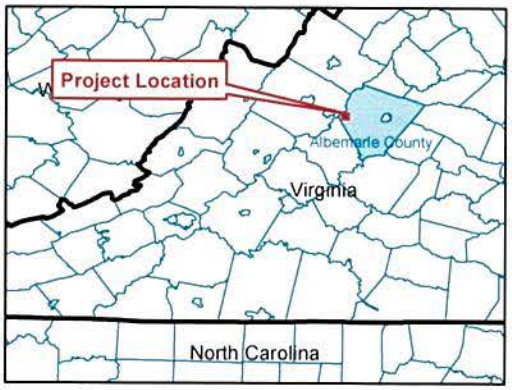
**Environmental Indicators**

Human Health: Current Human Exposure Controlled (HEUC)
Groundwater Migration: Contaminated Groundwater Migration Under Control (GMUC)

**Site-wide RAU**

The Site achieved Site-Wide Ready for Anticipated Use (SWRAU) on January 17, 2014.

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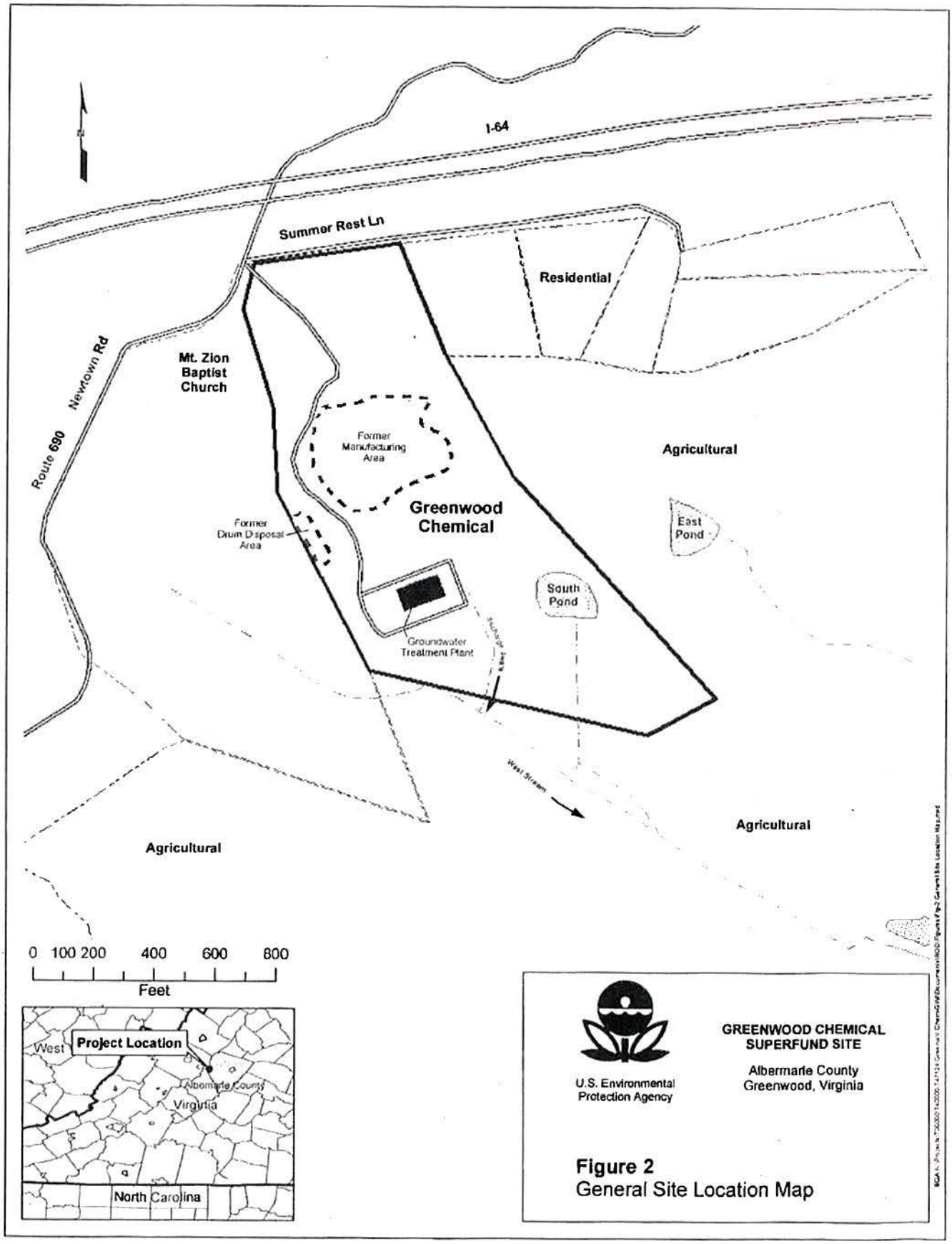
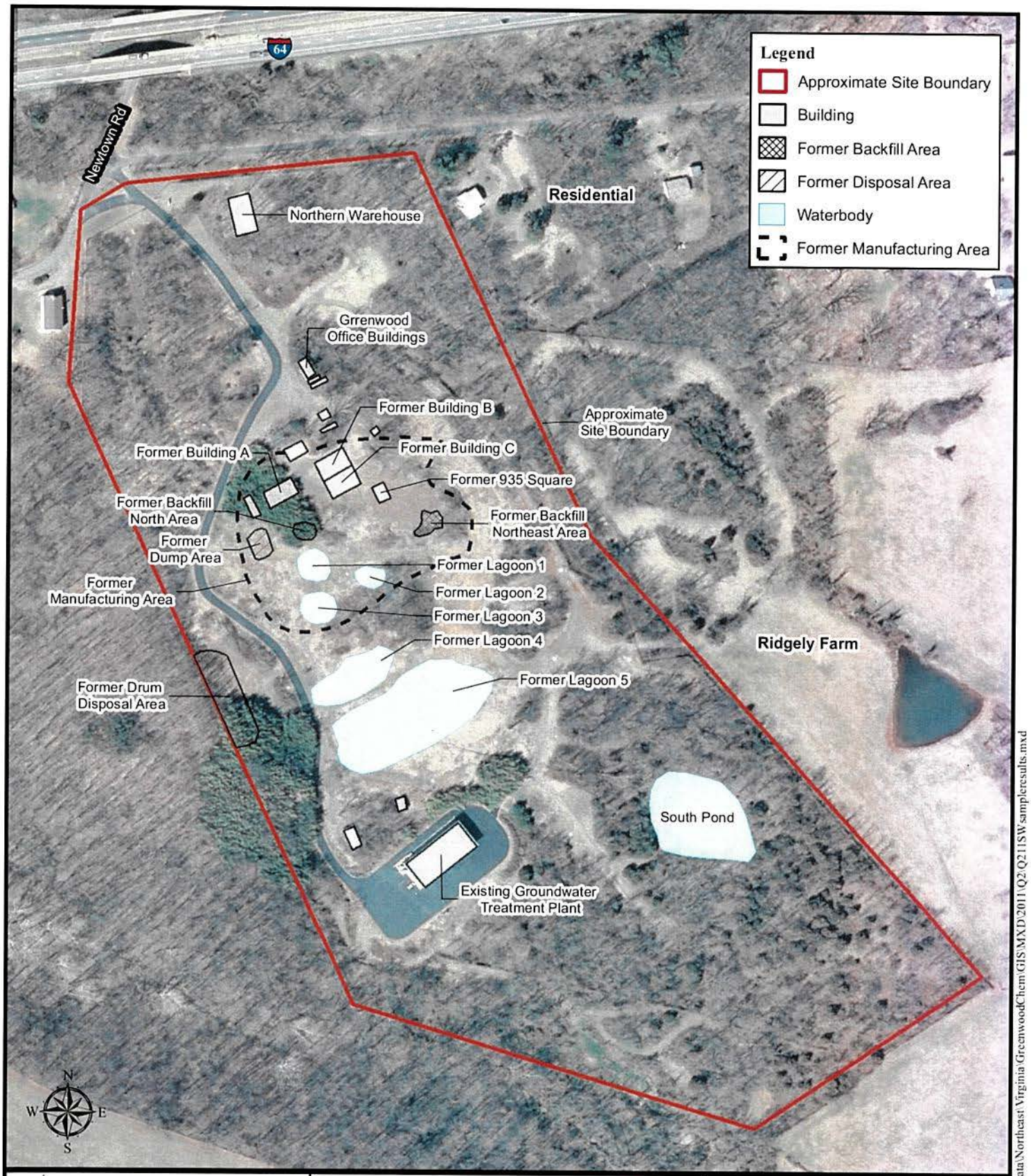
U.S. Environmental Protection Agency

**GREENWOOD CHEMICAL SUPERFUND SITE**

Albermarle County
Greenwood, Virginia

**Figure 1**
Site Location Map


I-64
Summer Rest Ln
Residential
Mt. Zion Baptist Church
Newtown Rd
Route 690
Former Manufacturing Area
Former Drum Disposal Area
Greenwood Chemical
Agricultural
East Pond
South Pond
Groundwater Treatment Plant
West Stream
Agricultural
Agricultural
0 100 200 400 600 800
Feet
West
Project Location
Albemarle County
Virginia
North Carolina
U.S. Environmental Protection Agency
GREENWOOD CHEMICAL SUPERFUND SITE
Albermarle County
Greenwood, Virginia
Figure 2
General Site Location Map




# Greenwood Chemical Site

Albemarle County
Greenwood, VA

0 150 300 Feet

Projection: NAD 83 State Plane Virginia South Feet
Aerial Image: USDA National Agriculture Imagery Program, 2003

**FIGURE 3**

**HISTORIC SITE FEATURES**

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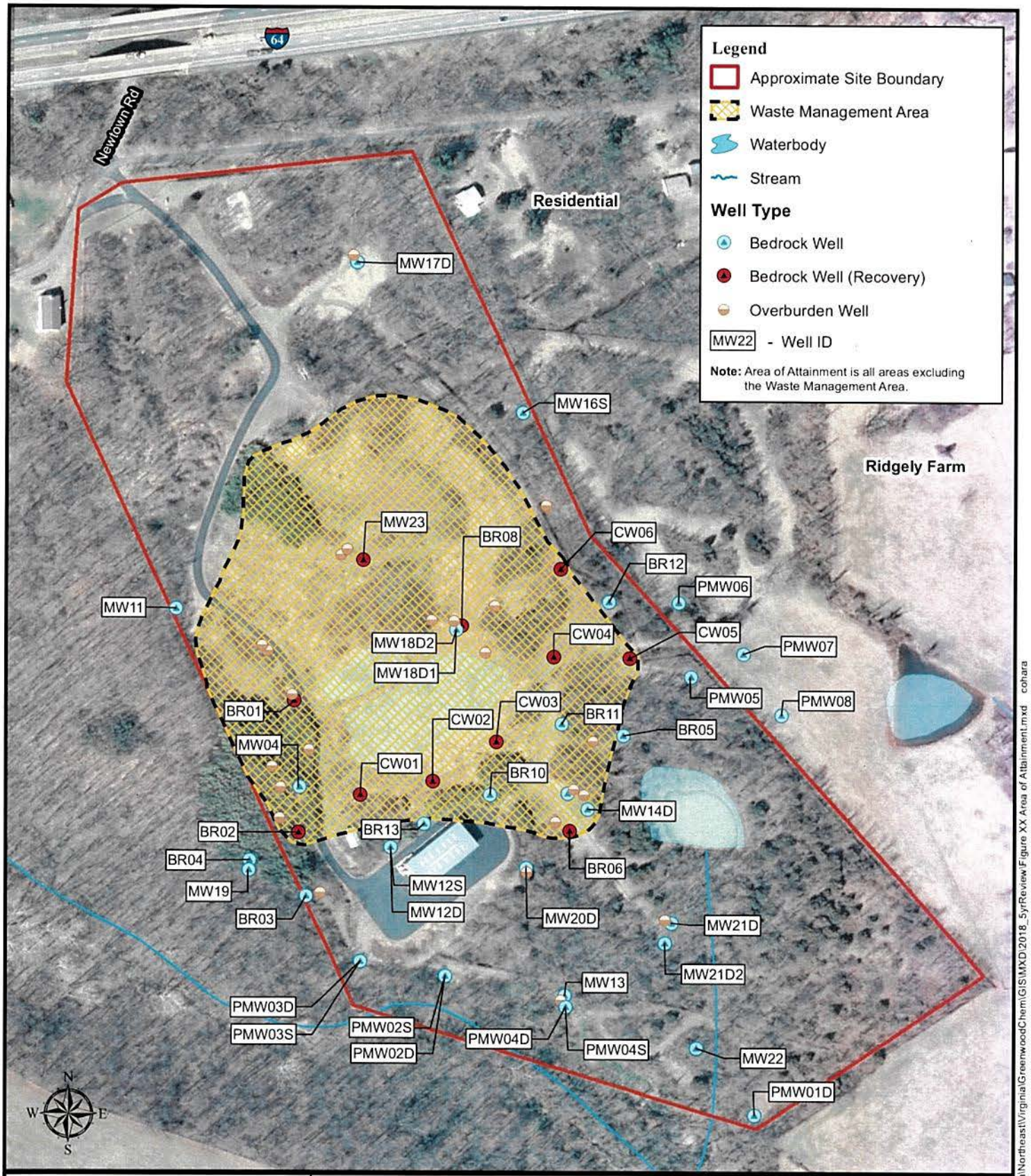


# Greenwood Chemical Site

Albemarle County
Greenwood, VA

0 150 300 Feet

Note: Groundwater elevations were collected 08/16/17
Projection: NAD 83 State Plane Virginia South Feet
Aerial Image: USDA National Agriculture Imagery Program, 2003

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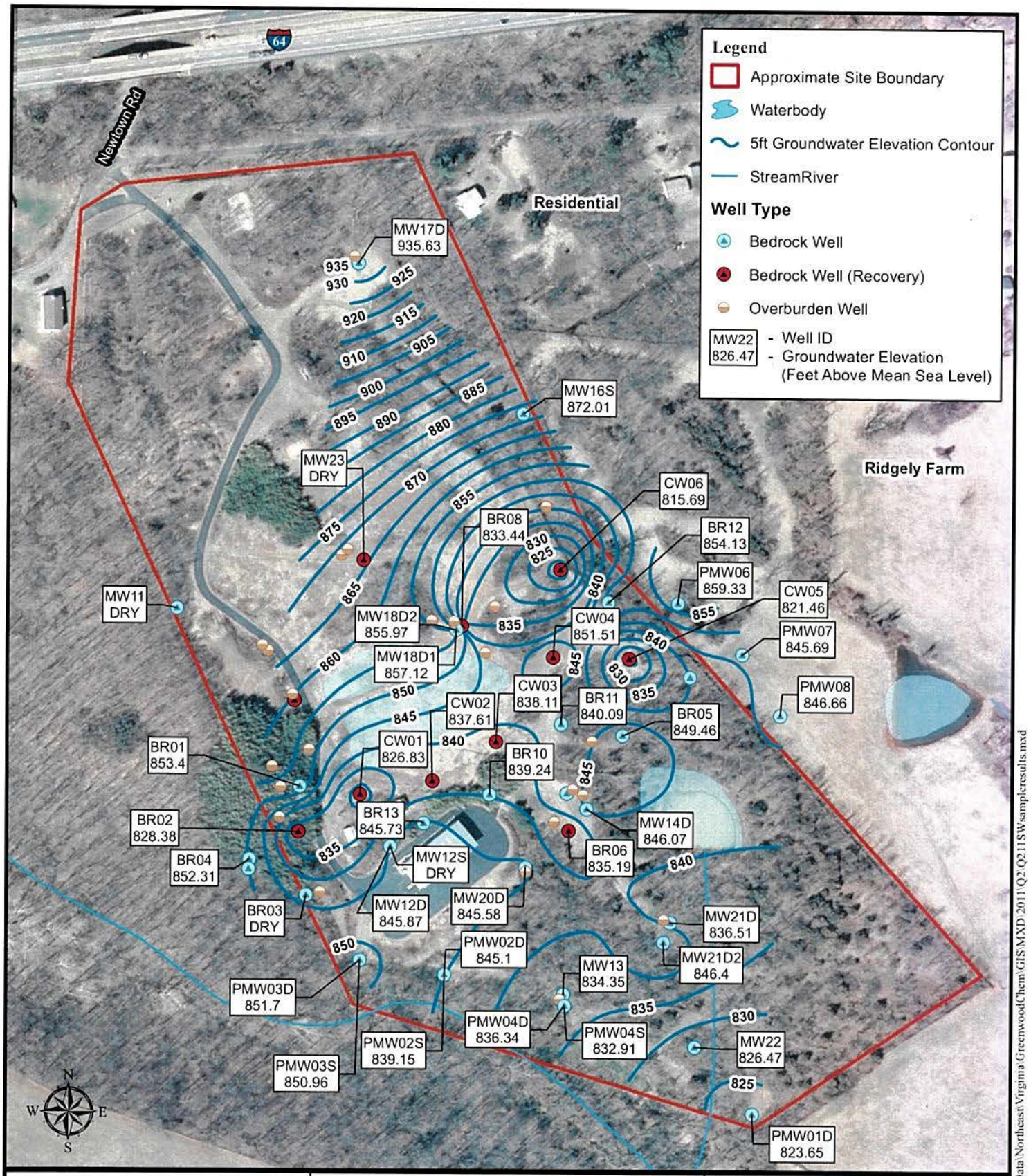
## FIGURE 4

## WASTE MANAGEMENT AREA

\\lovetonfederal\GISData\Northeast\Virginia\GreenwoodChem\GISMXD\2018_5yrReview\Figure XX Area of Attainment.mxd cohara




# Greenwood Chemical Site

Albemarle County
Greenwood, VA

0 150 300 Feet

Note: Groundwater elevations were collected 08/16/17
Projection: NAD 83 State Plane Virginia South Feet
Aerial Image: USDA National Agriculture Imagery Program, 2003

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## FIGURE 5

### GROUNDWATER ELEVATION CONTOURS - AUGUST 2017

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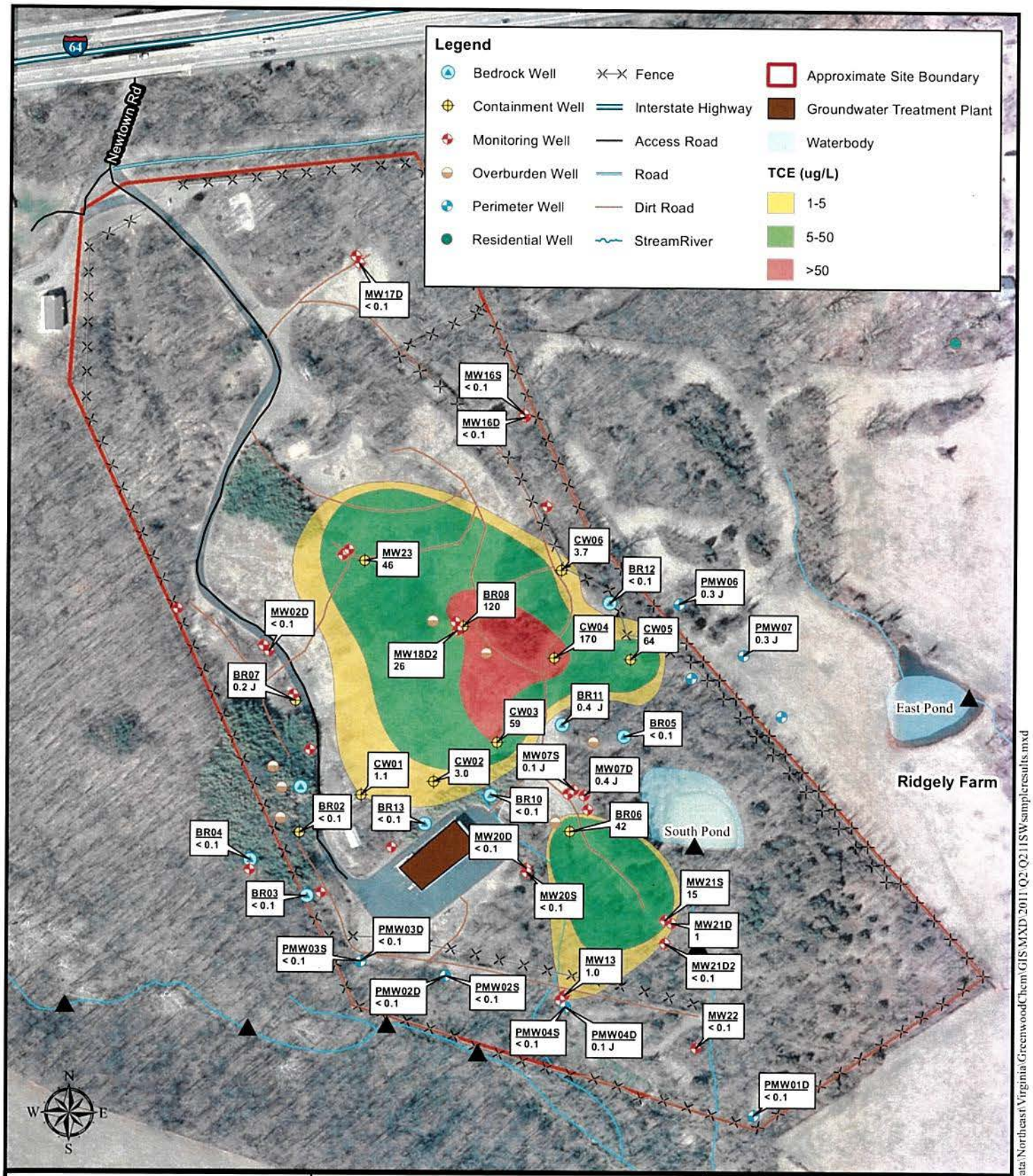


# Greenwood Chemical Site

Albemarle County
Greenwood, VA

0 150 300 Feet

Projection: NAD 83 State Plane Virginia South Feet
Aerial Image: USDA National Agriculture Imagery Program, 2003

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## FIGURE 6

## TRICHLOROETHANE RESULTS - AUGUST 2017

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**TABLES 3, 4, 5, 6 and 10**
**EMBEDDED IN TEXT**

Table 1

**SOIL CLEANUP LEVELS FOR CONTAMINANTS AT GREENWOOD CHEMICAL SUPERFUND SITE**

| | SOURCE AREA ACTION LIMITS (GROUNDWATER PROTECTION) | DRUM DISPOSAL ACTION LIMITS (GROUNDWATER PROTECTION) |
|---|---|---|
| **CLEANUP LEVELS** | | |
| **Volatile Organics** | **mg/kg** | **mg/kg** |
| Benzene | 0.225 | 0.0224 |
| Chlorobenzene | 7,708.7 | ¤ |
| Methylene Chloride | 2,665.1 | 10.83 |
| Tetrachloroethylene | ¤ | 0.2364 |
| Trichloroethylene | ¤ | 0.0974 |
| Toluene | 40,917.6 | 101.4 |
| 1,2-Dichloroethane | 0.124 | ¤ |
| Acetone | 1,462.1 | ¤ |
| Tetrahydrofuran | 97,269 | ¤ |
| Chloroform | 0.219 | 0.3262 |
| **Semi-Volatile Organics** | | |
| Semi-Volatile TICs | ¤ | 158.6 |
| 4-Chloroanaline | 565.7 | ¤ |

**Notes:**

¤ Soil excavation for the referenced hazardous substances is not required because their cleanup levels have not been exceeded in the referenced area. See "Final Fate & Transport Modeling For Determination of Soil Cleanup Goals Protective of Ground water (February, 1993), Table ES-1, p. ES-3.

1. EPA has determined that acetone present in the Northern Warehouse Area may also require remediation, and through the risk-based modeling has determined that the cleanup level for acetone in this area is 10.1 mg/kg. However, the acetone cleanup level is not presented in this table because, to date, EPA has documented only one exceedance of this cleanup level in this area. Whether remediation of this area is necessary will depend upon additional soil sampling.

## Table 2
## Groundwater Performance Standards
## (Excerpt from 2005 OU2/4 ROD)

In accordance with the NCP, cleanup options that include leaving the deep soils contamination in place require establishment of an area of attainment beyond the waste management area. Accordingly, EPA has developed chemical-specific cleanup goals for ground water which would not only meet the relevant and appropriate standards for drinking water but would also be sufficient to address the cumulative risk presented by multiple contaminants within the "area of attainment."

**Table 2**
**Risk-Based Remedial Goals ("RBRG") for Ground Water - Area of Attainment**

| Chemical of Potential Concern | PQL (ug/l)* | MCL (ug/l) | Final RBRG (ug/l) |
|---|---|---|---|
| 1,2-Dichloroethane | 0.5 | 5.0 | 5.0 |
| Bis(2-Chloroethyl)Ether | 0.01 | no MCL | 0.5 |
| Carbon Tetrachloride | 0.5 | 5.0 | 4.0 |
| Tetrachloroethene | 0.5 | 5.0 | 0.8 |
| Trichloroethene | 0.5 | 5.0 | 1.0 |
| Vinyl Chloride | 0.5 | 2.0 | 0.5 |

* The RBRG of 0.5 ug/L selected for vinyl chloride is the **practical quantitation limit ("PQL")** and represents an approximate risk level of $4 \times 10^{-5}$. The final RBRG for each of the other five contaminants was set at a level equivalent to a $1 \times 10^{-5}$ risk.

The ground water risk-based remediation goals ("RBRGs") set forth in Table 2 fall within the acceptable risk range of a cancer risk of $1 \times 10^{-4}$ to $1 \times 10^{-6}$ and a HI of 1, and assume that all six contaminants are present in a single well. In fact, the contamination at the Site varies by location, and no more than two contaminants above RBRGs were found in any one monitoring well. In summary, the contaminant-specific ground water cleanup goals were established at levels which: 1) comply with ARARs; 2) are detectable in a laboratory; and, 3) would achieve a cumulative risk within EPA's target risk range.

**Table 7 Site Discharge Limits Pre-2009 compared to current (2017).**

| PARAMETER | Pre-2009 DMR QUALITY or CONCENTRATION | | | EPA Calculated Limit | Calculated Limited Based Upon Aquatic Protection | Calculated Limited Based Upon Human Health | 2009 VADEQ Revised Limit | 2009 Informal Performance Goal | EPA Monitoring Frequency |
|---|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum Continuous | Units | | | | | | |
| **Inorganics** | | | | | | | | | |
| pH | 6 | 9 | SU | 6.0 to 9.0 | Y | | 6 to 9 | 6 to 9 | M |
| ALUMINUM, TOTAL RECOVERABLE | NA | 87 | µg/L | 87 [1] | | | NR | NA | NR [2] |
| CADMIUM, DISSOLVED | NA | 1 | µg/L | 1.1 | Y | | NR | NA | NR [2] |
| CHROMIUM, DISSOLVED TRIVALENT | NA | 171.6 | µg/L | 69 | Y | | NR | NA | NR [2] |
| CHROMIUM, DISSOLVED HEXAVALENT | NA | 16 | µg/L | 11 | Y | | NR | NA | NR [2] |
| COPPER, DISSOLVED | NA | 9.2 | µg/L | 8.3 | Y | | NR | NA | NR [2] |
| CYANIDE | NA | 7.6 | µg/L | 5.2 | Y | | 7.2 [5] | 7.2 | M |
| LEAD | NA | 1.9 | µg/L | 12 | Y | Y | NR | NA | NR [2] |
| MERCURY, DISSOLVED | NA | 0.018 | µg/L | 0.0051 | | Y | NR | NA | NR [2] |
| NICKEL, DISSOLVED | NA | 128.3 | µg/L | 19 | Y | | NR | 19 | M |
| ZINC, DISSOLVED | NA | 65 | µg/L | 110 | Y | | NR | NA | NR [2] |
| **Toxicity** | | | | | | | | | |
| ACUTE WHOLE EFFL TOXICITY (NOAEC%) | 100 | NA | NOAEC | 100 | Y | | 1 Tua | 1 Tua | Q [6] |
| CHRONIC WHOLE EFFL TOXICITY (TUc) | NA | 1 | Tuc | 1 | Y | | 1.4 TUc | 1.4 TUc | Q |
| **Organics** | | | | | | | | | |
| BENZENE | NA | 77.5 | µg/L | 71 | | Y | NR | 71 | M |
| BIS-2-CHLOROETHYL ETHER | NA | 1.4 | µg/L | 1.4 | | Y | NR | 1.4 | Q |
| BIS-2-ETHYLHEXL PHTHALATE | NA | R | µg/L | 59 | | Y | NR | NA | NR [3] |
| CARBON TETRACHLORIDE | NA | 90.8 | µg/L | 44 | | Y | NR | 44 | M |
| CHLOROBENZENE | NA | 21000 | µg/L | 21000 | | Y | NR | NA | NR [4] |
| CHLOROFORM | NA | R | µg/L | 2900 | | Y | NR | NA | NR [4] |
| 1,2-DICHLOROBENZENE | NA | R | µg/L | 1700 | | Y | NR | NA | NR [3] |
| 1,2-DICHLOROETHANE | NA | R | µg/L | 990 | | Y | NR | 990 | Q |
| METHYLENE CHLORIDE | NA | 1600 | µg/L | 1600 | | Y | NR | NA | NR [4] |
| NAPHTHALENE | NA | 90.7 | µg/L | 90.7 | | Y | NR | NA | NR [3] |
| TETRACHLORO-ETHYLENE | NA | R | µg/L | 89 | | Y | NR | 89 | M |
| TRICHLOROETHENE | NA | R | µg/L | 810 | | Y | NR | 810 | M |
| TOLUENE | NA | 256 | µg/L | 256 | | Y | NR | NA | NR [4] |
| VINYL CHLORIDE | NA | NA | µg/L | 5300 | | Y | NR | 5300 | M |

ABBREVIATIONS:
µg/L = Micrograms per liter
M = Monthly
NOAEC% = No observed adverse effect concentration
NA = Not applicable
NR = Not required
Q = Quarterly
R = Report only, no limit established
SU = Standard units
Tua = Toxicity Units, Acute
Tuc = Toxicity Units, Chronic
Y = Yes

NOTES:
1. Analyte not listed on the 2008 Piedmont Region Water Quality spreadsheet.
EA proposed retaining the previous value for continuity purposes
2. Sampling not required for DMR/Informal Performance Goals; however, this analyte is included in monthly TAL metals sampling used to evaluate Site treatment plant performance
3. Sampling not required for DMR/Informal Performance Goals; however, this analyte is included in quarterly SVOC sampling used to evaluate Site groundwater quality
4. Sampling not required for DMR/Informal Performance Goals; however, this analyte is included in monthly VOC sampling used to evaluate Site treatment plant performance
5. In 2013, the Cyanide value was changed to 7.9 µg/L.
6. In 2013, the Acute Whole Effl Toxicity monitoring frequency was changed to annually.

Table 8
Well Trend Results

| Well ID | Year of 1st datapoint in EQuIS | ROD Contaminant Concentration Detected in 1st Sampling Event | | | | | | Date Last sampled | ROD Contaminants Detected in Most Recent Sampling Event | | | | | | ROD Contaminants Trend from 1st to Most Recent Sampling Event | | | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROD Limit | 5 | 0.5 | 4 | 0.8 | 1 | 0.5 | | 5 | 0.5 | 4 | 0.8 | 1 | 0.5 | | | | | | | |
| Bedrock Wells | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | |
| BR01 | 2004 | | | 2.4 | <0.5 B | | | 8/19/2015 | | | **10** | 0.4 J | **2.3** | | | | S | S | U | | |
| BR03 | 2004 | | | 0.11 J | <0.5B | 0.40 J | | 8/16/2017 | | | | | | | | | D | D | D | | Clean since 2014 |
| BR04 | 2004 | | | 2.1 | <0.5B | | | 8/16/2017 | | | | | | | | | D | D | | | Clean since 2014 |
| BR05 | 2004 | 1.2 | | <0.5B | <0.5B | **2.3** | | 8/16/2017 | | | | | | | D | | D | D | D | | Clean since 2008 |
| BR10 | 2005 | **100** | | **140** | **11** | **56** | **2.4** | 8/16/2017 | | | | | | | D | | D | D | D | D | Clean since 2016 |
| BR11 | 2005 | **7.3** | | **27** | **2.4** | **13** | | 8/16/2017 | | | 0.3 J | | 0.4 J | | D | | D | D | D | | |
| BR12 | 2005 | 3.9 J | | | **4.15 B** | **93** | | 8/17/2017 | | | | | | | D | | | D | D | | Clean since 2012 |
| BR13 | 2005 | | | 0.81 | <0.5 B | <0.5 B | **1.6** | 8/16/2017 | | | | 0.1 J | | | | | D | D | D | | |
| Containment and Recovery Wells | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | |
| CW01 | 2006 | | 0.17 | **54** | **2.3** | **7.3** | | 8/17/2017 | | 0.013 J | **22** | **2.8** | **1.1** | | | S | S | S | S | | |
| CW02 | 2006 | **11** | **5.2 J** | **240** | **9.1** | **12** | **1.2** | 8/17/2017 | 0.2 J | 0.24 | **190** | **22** | **3** | 0.4 J | D | D | S | U | D | D | |
| CW03 | 2006 | **140** | **55 J** | **290** | **19** | **170** | **4.1** | 8/17/2017 | **25** | **7.7** | **670** | **8.5** | **59** | **2.1 J** | D | D | S | D | D | S | |
| CW04 | 2006 | **140** | **13 J** | **580** | **53** | **290** | | 8/17/2017 | **45** | **0.74** | **250** | **24** | **170** | **1.8** | D | D | S | S | S | U | |
| CW05 | 2006 | **44** | 0.35 J | **11 J** | **32** | **580** | | 8/17/2017 | **5.3** | 0.054 | 0.1 J | **3.7** | **64** | **0.6** | D | D | D | D | D | U | |
| CW06 | 2006 | 1.7 J | 0.01 UJ | 0.70 J | 0.67 J | **67** | | 8/17/2017 | 0.2 J | | | 0.2 J | **3.7** | | D | | | S | D | | |
| BR02 | 2004 | | | **20** | **2.7** | **6.0** | | 8/17/2017 | | | | | | | | | D | D | D | | |
| BR06 | 2004 | **52** | | **84** | **21** | **89** | **4.5** | 8/16/2017 | 2.8 | | 2.9 | **3.2** | **42** | | D | | D | D | S | D | |
| BR07 | 2004 | **53** | | **100** | **23** | **99** | **5.3** | 8/16/2017 | | | **410** | **0.8** | 0.2 J | | | | S | D | D | | |
| BR08 | 2004 | **110** | | **24** | **18** | **91** | **1.0** | 8/17/2017 | **130** | | | **1.1 J** | **120** | **33** | S | | D | U | D | S | |
| MW23 | 2004 | | **43** | **750** | **26** | **37** | | 8/17/2017 | **12** | **11** | **5900** | **48** | **46** | | U | S | U | S | S | | |
| Monitoring Wells | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | |
| MW02D | 2004 | | <0.01 B | **13** | | | | 8/15/2017 | | | 3.8 | 0.2 J | | | | | D | U | | | |
| MW02S | 2004 | | <0.01 B | 0.27 J | **8.8** | 0.21 J | | 6/22/2004 | | | | | | | | | S | S | S | | |
| MW03 | 2004 | | <0.01 B | | | | | 9/18/2004 | | | | | | | | | | | | | Clean in 2004 |
| MW04 | 2004 | | | 0.12 J | 0.25 J | | | 9/15/2004 | | | | | | | | | | | | | Clean in 2004 |
| MW06 | 2004 | | 0.48 | 0.42 J | <0.5 B | **2.1** | | 9/15/2004 | | 0.25 J | 0.12 J | <0.5 B | <0.5 B | | | S | S | S | D | | |
| MW07D | 2004 | **91 J** | **76** | **13** | **11** | **60** | **<1 B** | 8/15/2017 | 0.5 J | 0.30 | | 0.4 J | | | D | D | D | D | D | D | |
| MW07S | 2004 | **31** | **44** | **40** | **3.9** | **16** | | 8/18/2017 | | | | | | | D | D | D | D | D | | Clean since 2016 |
| MW09 | 2004 | | | | | | | 1/11/2006 | | | | | | | | | | | | | Clean since 2004 |
| MW10D | 2004 | | <0.01 B | | **8.6** | **3.6** | | 9/11/2004 | | | | | | | | D | | D | D | | Clean in 2004 |
| MW11 | 2004 | | <0.01 B | | | | | 9/13/2004 | | | | | | | | D | | | | | Clean in 2004 |
| MW12D | 2004 | | <0.01 B | | | | | 8/16/2016 | | | | | | | | D | | | | | BCEE detect in 2008 |
| MW12D2 | 2007 | | | | | | | 11/27/2007 | | | | | | | | | | | | | Clean in 2007 |
| MW12S | 2006 | | | **10** | **0.84** | 0.52 | | 5/19/2009 | | | | | | | | | D | D | D | | Clean since 2007 |
| MW13 | 2004 | | 0.27 | | **2.7** | **7.4** | **1.6** | 8/17/2017 | 0.1 J | 0.048 J | | 0.1 J | **1.0** | 0.1 J | U | D | | D | S | D | |
| MW14D | 2004 | <0.5 B | **9.6** | 0.13 J | <0.5 B | **1.3** | | 5/21/2008 | 0.43 J | 0.11 J | | | 0.27 J | | U | D | D | | D | | |
| MW16D | 2004 | | <0.01 B | | <0.5 B | <0.5 B | | 8/17/2017 | | | | | | | | | | | | | Clean since 2004 |
| MW16S | 2004 | | <0.01 B | | | | | 8/15/2017 | | | | | | | | | | | | | Clean since 2004 |
| MW17D | 2004 | | | | | | | 8/15/2017 | | | | | | | | | | | | | Clean since 2004 |
| MW17S | 2004 | | <0.01 B | | <0.5 B | | | 9/16/2004 | | | | | | | | | | | | | Clean in 2004 |
| MW18D1 | 2004 | **580** | **0.51 J** | 2.9 | **69** | **920** | | 9/14/2004 | **480** | **0.67 J** | **6.9** | **56** | **720** | **24** | S | S | S | S | S | U | |
| MW18D2 | 2004 | **370** | 0.18 | **8.8** | **87** | **760** | **23** | 8/16/2017 | **100** | 0.11 | 0.2 J | 0.7 | **26** | **8.3** | S | S | D | D | D | D | |
| MW18S | 2004 | **310** | 0.091 | 2.1 | **11** | **150** | **6.1** | 9/14/2004 | **860** | | **4.8 J** | **27** | **390** | **17** | S | S | S | S | S | S | |
| MW19 | 2004 | | <0.01 B | 1.8 | <0.5 B | | | 2/24/2009 | | | 0.51 | | | | | | D | | | | |
| MW20D | 2004 | 0.53 | 0.44 | **19** | **7.8** | **2.4** | | 8/17/2017 | | | | 0.5 J | | | D | D | D | D | D | | |
| MW20S | 2004 | | 0.054 | 0.31 J | **2.2** | 0.50 | | 8/17/2017 | | | | | | | | D | D | D | D | | Clean in 2017 |
| MW21D | 2004 | 2.9 | **1.4** | 0.38 J | **2.5** | **13** | **<0.5 B** | 8/18/2017 | | 0.077 | | 0.3 J | 1 | | D | D | D | D | D | | |
| MW21D2 | 2004 | | <0.01 B | | | | | 8/17/2017 | | | | | | | | | | | | | BCEE detect 2010 - 2012 |
| MW21S | 2004 | **20** | **9.6** | 0.42 J | **25** | **20** | **4.8** | 8/17/2017 | **5.3** | **5.1** | 0.1 J | **17** | **15** | **1.3** | D | U | S | S | S | S | |
| MW22 | 2004 | 3.5 | 1.2 J | | **1.7** | **7.2** | **0.53** | 8/17/2017 | 0.2 J | 0.12 | | | | | U | S | | D | D | | |
| MW24 | 2007 | **9.1 J** | **0.5** | **4600** | **36** | **33** | | 11/26/2007 | **22** | **15** | **780** | **27 J** | **41** | **0.67** | U | U | D | S | S | U | |
| Overburden Wells | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | |
| OB1 | 2004 | | < 0.01 B | | **6.9** | **40** | | | | | | | | | | | | | | | Not resampled |
| OB2 | 2004 | | 0.23 | 1.1 | **8.6** | **6.4** | | 1/12/2006 | | | | **7.9** | **11** | | | D | D | S | U | | |
| OB5 | 2004 | **430** | | | **42** | **1500** | **83** | 9/14/2004 | **470** | | | **38** | **1500** | **57 K** | S | | | S | S | S | |
| OB6 | 2004 | **170** | **7.4** | **34** | **7.1** | **46** | | 9/14/2004 | **120** | 1.3 J | **23** | **9.6** | **61** | | S | S | S | S | S | | |
| OB7 | 2004 | **81** | **17** | **43** | **15** | **190** | | 1/12/2006 | **110** | **18** | **72** | **21** | **330** | **3.3 J** | U | S | S | U | S | U | |
| OB8 | 2004 | | 0.097 | **9.7** | **20** | **4.3** | | 9/17/2004 | | | **6.6** | **15** | **2.9 J** | | | D | S | S | S | | |
| Perimeter Monitoring Wells | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | 1-2DCA | BCEE | CCl4 | PCE | TCE | VC | |
| PMW01 | 2012 | 2.0 | 0.96 | | | 0.5 J | | 8/17/2017 | | | | | | | D | D | | | D | | |
| PMW01D | 2004 | 1.9 | 0.99 | | < 0.5 B | **2.1** | | 8/17/2017 | | | | | | | D | D | | D | D | | Clean in 2017 |
| PMW02D | 2004 | | 0.094 | | **0.88** | 0.70 | | 8/17/2017 | | | | | | | | D | | D | D | | Clean since 2012 |
| PWM02S | 2004 | | < 0.01 B | | < 0.5 B | 0.23 J | | 8/17/2017 | | | | | | | | D | | D | D | | Clean since 2015 |
| PMW03D | 2004 | | < 0.01 B | | < 0.5 B | 0.081 J | | 8/15/2017 | | | | | | | | D | | D | D | | Clean since 2013 |
| PMW03S | 2004 | | < 0.01 B | | < 0.5 B | 0.23 J | | 8/15/2017 | | | | | | | | D | | D | D | | Clean since 2007 |
| PMW04D | 2004 | | 0.060 | | **1.4** | 0.90 | | 8/15/2017 | 0.2 J | 0.038 J | | | 0.1 J | | U | S | | D | S | | |
| PMW04S | 2004 | | 0.30 | | **6.2** | **3.1** | **0.76** | 8/17/2017 | | | | | | | | D | | D | D | D | Clean in 2017 |
| PMW05S | 2004 | 17 | < 0.01 B | 1.9 | **6.4** | **120** | 0.33 J | 2/14/2012 | | | | 0.78 B | **33** | | D | D | D | D | D | D | |
| PMW06 | 2008 | | **3.2** | | | **1.5** | | 8/16/2017 | | | | | 0.3 J | | | D | | | D | | |
| PMW07 | 2008 | 0.54 | 0.093 B | | | **6.6** | | 8/16/2017 | 0.6 | | | | 0.3 J | | S | D | | | D | | |
| PMW08 | 2008 | | | | | 0.49 J | | 8/23/2011 | | | | | 0.54 | | | | | | S | | |

Notes

| | |
|---|---|
| 1-2DCA | 1,2-dichloroethane |
| BCEE | Bis(2-ethylhexyl) phthalate |
| CCl4 | Carbon tetrachloride |
| PCE | Perchloroethene |
| TCE | Trichloroethene |
| VC | Vinyl Chloride |
| D | Trend Down (order of magnitude) |
| S | Trend Stable (order of magnitude) |
| U | Trend Up (order of magnitude) |
| **Bold** | ROD Exceedence |

Table 9 Treatment Plant Influent Concentrations and Pounds of Contaminants Removed Annually

| Time Period | $CCl_4$ (µg/L) | BCEE (µg/L) | Others (µg/L) | Total Organics (µg/L) | Influent Flow (gallons) | Mass Removed (pounds) [1] | Annual Total Mass (pounds) |
|---|---|---|---|---|---|---|---|
| Mar-02 | 207 | 23.5 | 106.1 | 336.6 | 327,184 | 0.9 | 18.5 |
| Apr-02 | 197 | 29 | 116 | 342 | 322,741 | 0.9 | |
| May-02 | 210 | 27 | 176 | 413 | 327,458 | 1.1 | |
| Jun-02 | 270 | 27 | 240 | 537 | 397,374 | 1.8 | |
| Jul-02 | 400 | 46 | 222 | 668 | 541,603 | 3.0 | |
| Aug-02 | 190 | 35 | 221 | 446 | 563,167 | 2.1 | |
| Sep-02 | 250 | 47 | 276 | 573 | 453,346 | 2.2 | |
| Oct-02 | 410 | 48 | 423 | 881 | 434,044 | 3.2 | |
| Nov-02 | 250 | 46 | 246 | 542 | 490,304 | 2.2 | |
| Dec-02 | 130 | 22 | 85.4 | 237.4 | 530,810 | 1.1 | |
| Jan-03 | 72 | 45 | 126.7 | 243.7 | 519,089 | 1.1 | 25.2 |
| Feb-03 | 470 | 21 | 303.7 | 794.7 | 459,077 | 3.0 | |
| Mar-03 | 0 | 20 | 138 | 158 | 504,799 | 0.7 | |
| Apr-03 | 83 | 12 | 53.5 | 148.5 | 412,636 | 0.5 | |
| May-03 | 190 | 13 | 90.4 | 293.4 | 509,022 | 1.2 | |
| Jun-03 | 210 | 22 | 240 | 472 | 541,938 | 2.1 | |
| Jul-03 | 320 | 24 | 197.2 | 541.2 | 538,729 | 2.4 | |
| Aug-03 | 330 | 24 | 173.8 | 527.8 | 614,305 | 2.7 | |
| Sep-03 | 400 | 25 | 287 | 712 | 501,655 | 3.0 | |
| Oct-03 | 220 | 13 | 114.2 | 347.2 | 635,084 | 1.8 | |
| Nov-03 | 510 | 24 | 314.6 | 848.6 | 688,806 | 4.9 | |
| Dec-03 | 250 | 22 | 164.4 | 436.4 | 466,984 | 1.7 | |
| Jan-04 | 360 | 24 | 219.1 | 603.1 | 911,079 | 4.6 | 39.7 |
| Feb-04 | 100 | 27 | 101.91 | 228.91 | 775,940 | 1.5 | |
| Mar-04 | 250 | 15 | 572.8 | 837.8 | 734,302 | 5.1 | |
| Apr-04 | 440 | 17 | 218.1 | 675.1 | 672,508 | 3.8 | |
| May-04 | 140 | 17 | 154.7 | 311.7 | 661,850 | 1.7 | |
| Jun-04 | 460 | 22 | 266.4 | 748.4 | 624,352 | 3.9 | |
| Jul-04 | 220 | 21 | 189.9 | 430.9 | 534,085 | 1.9 | |
| Aug-04 | 350 | 16 | 239 | 605 | 538,252 | 2.7 | |
| Sep-04 | 180 | 11 | 115.3 | 306.3 | 606,336 | 1.5 | |
| Oct-04 | 210 | 7.4 | 159.7 | 377.1 | 807,601 | 2.5 | |
| Nov-04 | 490 | 23 | 225.9 | 738.9 | 1,406,220 | 8.7 | |
| Dec-04 | 260 | 15 | 154.56 | 429.56 | 490,187 | 1.8 | |
| Jan-05 | 140 | 18 | 93.2 | 254.4 | 463,888 | 1.0 | 27.9 |
| Feb-05 | 310 | 18 | 219 | 554.2 | 480,857 | 2.2 | |
| Mar-05 | 460 | 20 | 213.9 | 703 | 627,217 | 3.7 | |
| Apr-05 | 460 | 15 | 269.15 | 744.15 | 417,367 | 2.6 | |
| May-05 | 410 | 6.8 J | 257.5 | 667.5 | 556,098 | 3.1 | |
| Jun-05 | 260 | 23 | 186.2 | 469.2 | 475,376 | 1.9 | |
| Jul-05 | 280 | 15.5 | 126.7 | 422.2 | 503,597 | 1.8 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Aug-05 | 245 | 21.25 | 107.8375 | 374.0875 | 506,351 | 1.6 | |
| Sep-05 | 190.2 | 9.24 | 113.864 | 313.304 | 452,948 | 1.2 | |
| Oct-05 | 98 | 17 | 127.9 | 242.9 | 489,829 | 1.0 | |
| Nov-05 | 740 | 19 | 489.6 | 1248.6 | 192,608 | 2.0 | |
| Dec-05 | 130 | 11 | 309.2 | 450.2 | 1,583,054 | 5.9 | |
| Jan-06 | 140 | 11 | 216 | 367 | 1,407,803 | 4.3 | 75.8 |
| Feb-06 | 130 | 8.3 | 259.6 | 397.9 | 1,350,960 | 4.5 | |
| Mar-06 | 140 | 15 | 271.8 | 426.8 | 1,433,760 | 5.1 | |
| Apr-06 | 280 | 12 | 380.1 | 672.1 | 1,225,250 | 6.9 | |
| May-06 | 240 | 12 | 284.2 | 536.2 | 1,187,577 | 5.3 | |
| Jun-06 | 210 | 14 | 264 | 488 | 1,352,785 | 5.5 | |
| Jul-06 | 300 | 13 | 325.6 | 638.6 | 1,639,485 | 8.7 | |
| Aug-06 | 280 | 11 | 373.1 | 664.1 | 1,612,527 | 8.9 | |
| Sep-06 | 290 | 13 | 382.9 | 685.9 | 1,384,525 | 7.9 | |
| Oct-06 | 200 | 7.7 | 267.5 | 475.2 | 1,411,204 | 5.6 | |
| Nov-06 | 210 | 13 | 281.9 | 504.9 | 1,491,593 | 6.3 | |
| Dec-06 | 200 | 3.2 | 261.9 | 465.1 | 1,747,054 | 6.8 | |
| Jan-07 | 120 | 7.4 | 168.2 | 295.6 | 1,734,053 | 4.3 | 56.0 |
| Feb-07 | 110 | 12 | 177.1 | 299.1 | 1,497,348 | 3.7 | |
| Mar-07 | 130 | 5.8 | 187.8 | 323.6 | 1,357,745 | 3.7 | |
| Apr-07 | 220 | 5 | 191.4 | 416.4 | 1,558,601 | 5.4 | |
| May-07 | 230 | 9.6 | 201.9 | 441.5 | 1,601,221 | 5.9 | |
| Jun-07 | 320 | 11 | 248 | 579 | 1,265,251 | 6.1 | |
| Jul-07 | 160 | 10 | 150.8 | 320.8 | 1,636,007 | 4.4 | |
| Aug-07 | 190 | 5.4 | 117.7 | 313.1 | 1,597,163 | 4.2 | |
| Sep-07 | 380 | 7.5 | 217.4 | 604.9 | 1,791,013 | 9.0 | |
| Oct-07 | 120 | 8.5 | 217.5 | 346 | 1,485,646 | 4.3 | |
| Nov-07 | 20 | 1.8 | 38.9 | 60.7 | 1,660,671 | 0.8 | |
| Dec-07 | 130 | 9.2 | 188.4 | 327.6 | 1,545,735 | 4.2 | |
| Jan-08 | 240 | 5.9 | 286.1 | 532 | 2,010,607 | 8.9 | 74.3 |
| Feb-08 | 245 | 5.8 | 197.9 | 448.7 | 1,839,200 | 6.9 | |
| Mar-08 | 250 | 5.7 | 109.7 | 365.4 | 1,562,871 | 4.8 | |
| Apr-08 | 130 | 8 | 156.2 | 294.2 | 1,640,741 | 4.0 | |
| May-08 | 190 | 8.7 | 243.7 | 442.4 | 1,686,810 | 6.2 | |
| Jun-08 | 280 | 6.1 | 157.8 | 443.9 | 1,393,427 | 5.2 | |
| Jul-08 | 300 | 9.7 | 194.7 | 504.4 | 1,648,660 | 6.9 | |
| Aug-08 | 290 | 10 | 209.3 | 509.3 | 1,518,133 | 6.4 | |
| Sep-08 | 340 | 6.7 | 212.8 | 559.5 | 1,258,913 | 5.9 | |
| Oct-08 | 360 | 5.4 | 231.3 | 596.7 | 1,677,727 | 8.3 | |
| Nov-08 | 280 | 5.7 | 207.2 | 492.9 | 1,224,931 | 5.0 | |
| Dec-08 | 230 | 6 | 168.2 | 404.2 | 1,683,776 | 5.7 | |
| Jan-09 | 260 | 7.6 | 203.46 | 471.06 | 1,612,580 | 6.3 | |
| Feb-09 | 99 | 9.1 | 157.4 | 265.5 | 1,438,436 | 3.2 | |
| Mar-09 | 180 | ns | 218.81 | 398.81 | 1,671,821 | 5.6 | |
| Apr-09 | 160 | 6.4 | 273.71 | 440.11 | 1,672,789 | 6.1 | |
| May-09 | 370 | ns | 245.72 | 615.72 | 1,490,294 | 7.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Jun-09 | 240 | | ns | | 154.45 | 394.45 | 1,459,671 | 4.8 | 65.8 |
| Jul-09 | 240 | | 5.1 | | 158.27 | 403.37 | 1,713,926 | 5.8 | |
| Aug-09 | 350 | | ns | | 210.45 | 560.45 | 1,668,457 | 7.8 | |
| Sep-09 | 270 | | ns | | 134.52 | 404.52 | 1,532,196 | 5.2 | |
| Oct-09 | 330 | | 6.3 | | 274.89 | 611.19 | 1,580,667 | 8.1 | |
| Nov-09 | 79 | | 7.7 | | 72.5 | 159.2 | 1,726,326 | 2.3 | |
| Dec-09 | 130 | | ns | | 132.37 | 262.37 | 1,407,162 | 3.1 | |
| Jan-10 | 260 | | ns | | 145.1 | 405.1 | 1,565,549 | 5.3 | 72.4 |
| Feb-10 | 210 | | 2.5 | J | 132.9 | 345.4 | 1,598,412 | 4.6 | |
| Mar-10 | 140 | | ns | | 90 | 230 | 1,737,301 | 3.3 | |
| Apr-10 | 180 | | ns | | 129.4 | 309.4 | 1,569,676 | 4.1 | |
| May-10 | 270 | E | 6.3 | E | 160.9 | 437.2 | 1,574,334 | 5.7 | |
| Jun-10 | 390 | | ns | | 194.5 | 584.5 | 1,443,807 | 7.0 | |
| Jul-10 [2] | 0.23 | J | ns | | UL[2] | 0.23 | 1,659,556 | 0.0 | |
| Aug-10 | 410 | | 7.4 | E | 234.6 | 652 | 1,780,193 | 9.7 | |
| Sep-10 | 220 | | ns | | 145.9 | 365.9 | 1,582,260 | 4.8 | |
| Oct-10 | 380 | | ns | | 937.7 | 1317.7 | 1,536,527 | 16.9 | |
| Nov-10 | 220 | | nd | | 177.7 | 397.7 | 1,639,390 | 5.4 | |
| Dec-10 | 250 | | ns | | 146.9 | 396.9 | 1,652,934 | 5.5 | |
| Jan-11 | 180 | + | ns | | 168.9 | 348.9 | 1,428,788 | 4.2 | 55.6 |
| Feb-11 | 300 | + | 7.5 | | 188.4 | 495.9 | 1,300,455 | 5.4 | |
| Mar-11 | 88 | + | ns | | 99.5 | 187.5 | 1,753,447 | 2.7 | |
| Apr-11 | 150 | + | 3.6 | J | 133.2 | 286.8 | 1,780,020 | 4.3 | |
| May-11 | 190 | + | ns | | 186.3 | 376.3 | 1,920,276 | 6.0 | |
| Jun-11 | 180 | L | ns | | 167.9 | 347.9 | 1,395,817 | 4.1 | |
| Jul-11 | 130 | + | nd | | 117.8 | 247.8 | 1,852,948 | 3.8 | |
| Aug-11 | 220 | + | ns | | 187.5 | 407.5 | 1,835,454 | 6.2 | |
| Sep-11 | 330 | + | ns | | 207.0 | 537.0 | 1,507,956 | 6.8 | |
| Oct-11 | 210 | + | 5.9 | | 128.2 | 344.1 | 975,035 | 2.8 | |
| Nov-11 | 100 | +L | ns | | 62.2 | 162.2 | 1,535,090 | 2.1 | |
| Dec-11 | 290 | +J | ns | | 153.3 | 443.3 | 1,959,229 | 7.2 | |
| 1Q 2012 | 220 | | 3 | | 170.0 | 445.2 | 4,335,125 | 16.1 | 69.8 |
| 2Q 2012 | 195 | | 2.1 | | 175.0 | 583.0 | 4,365,123 | 21.2 | |
| 3Q 2012 | 191 | | 2.2 | | 165.0 | 543.0 | 4,315,435 | 19.6 | |
| 4Q 2012 | 192 | +J | 2.1 | | 153.3 | 355.0 | 4,345,327 | 12.9 | |
| Jan-Jun 2013[3] | 305 | J | 6.6 | | 174.7 | 486.2 | 9,257,468 | 37.5 | 61.9 |
| Jul-Dec 2013[3] | 206 | J | 6.5 | | 148.3 | 360.4 | 8,110,311 | 24.4 | |
| Jan-Jun 2014[3] | 371 | +J | 4.3 | | 180.6 | 556.3 | 8,575,285 | 39.8 | 72.9 |
| Jul-Dec 2014[3] | 255 | J | 1.2 | | 182.4 | 438.7 | 9,042,240 | 33.1 | |
| Jan-Jun 2015[3] | 224 | | 4.2 | | 163.8 | 391.8 | 8,795,564 | 28.7 | 56.8 |
| Jul-Dec 2015[3] | 254 | | 3.7 | | 167.4 | 425.2 | 7,911,756 | 28.1 | |
| Jan-Jun 2016[3] | 251 | J | 2.7 | | 146.0 | 399.6 | 8,961,985 | 29.9 | 62.5 |
| Jul-Dec 2016[3] | 252 | | 2.5 | J | 163.2 | 417.8 | 9,375,134 | 32.7 | |
| Jan-Jun 2017[3] | 220 | | 2.7 | | 154.1 | 376.4 | 8,673,325 | 27.2 | 37.8 |
| Jul-Aug 2017[3,4] | 289 | J | 2.1 | | 155.3 | 446.8 | 2,833,096 | 10.6 | |

| | | | Total mass removed since 2002 (pounds) | 873.0 |
|---|---|---|---|---|

Notes:

1 Mass removed is based on calculations using monthly concentrations from the SL-1 sampling port (equalization tank) from 2001-2012.□

2 The samples arrived at the lab > 4°F and many data were UL qualified.

3 Mass reported in the 2013-2017 Annual O&M Reports is in kilograms.

4 The 2017 Annual O&M Report inluded data from January through August 2017.

Acronyms:

µg/L - micrograms per liter

BCEE-Bis(2-chloroethyl) Ether

$CCl_4$ - carbon tetrachloride

kg - kilograms

nd - not detected above quantitation limit

ns - not sampled for analyte

Data Qualifiers:

E - Estimated

J - Analyte present. Value may not be accurate or precise.

L-Analyte present.Actual value is expected to be higher.

UL - Not detected. Quantitation limit is probably higher.

+ - sample was diluted

TABLE 11
COMPARISON OF TOXICITY VALUES
GREENWOOD CHEMICAL SITE

| Chemical of Concern | 2005 RBRGs[1] | | | | 2018 RBRGs[2] | | | |
|---|---|---|---|---|---|---|---|---|
| | Carcinogenic Toxicity Value | | Non-Carcinogenic Toxicity Value | | Carcinogenic Toxicity Value | | Non-Carcinogenic Toxicity Value | |
| | Slope Factor $(mg/kg\text{-}day)^{-1}$ | Inhalation Unit Risk $(\mu g/m^3)^{-1}$ | Reference Dose (mg/kg-day) | Reference Concentration $(mg/m^3)$ | Slope Factor $(mg/kg\text{-}day)^{-1}$ | Inhalation Unit Risk $(\mu g/m^3)^{-1}$ | Reference Dose (mg/kg-day) | Reference Concentration $(mg/m^3)$ |
| Bis(2-Chloroethyl)Ether | 1.1E+00 | 3.3E-04 | -- | -- | 1.1E+00 | 3.3E-04 | -- | -- |
| Carbon Tetrachloride | 1.3E-01 | 1.5E-05 | 7.0E-04 | 2.0E-03 | 7.0E-02 | 6.0E-06 | 4.0E-03 | 1.0E-01 |
| 1,2-Dichloroethane | 9.1E-02 | 2.6E-05 | 2.0E-02 | 4.9E-03 | 9.1E-02 | 2.6E-05 | 6.0E-03 | 7.0E-03 |
| Tetrachloroethene | 5.4E-01 | --[3] | 1.0E-02 | 4.9E-01 | 2.1E-03 | 2.6E-07 | 6.0E-03 | 4.0E-02 |
| Trichloroethene | 4.0E-01 | --[3] | 3.0E-04 | 4.0E-02 | 4.6E-02 | 4.1E-06 | 5.0E-04 | 2.0E-03 |
| Vinyl Chloride | 7.2E-01 | 4.4E-06 | 3.0E-03 | 1.0E-01 | 7.2E-01 | 4.4E-06 | 3.0E-03 | 1.0E-01 |

RBRGs = Risk-Based Remedial Goals
-- = No toxicity values available

1) 2005 RBRGs toxicity values taken from TetraTech/Black & Veatch, 2005, *Final Ground-Water Investigation and Focused Feasibility Study Report, Green Chemical Site, Greenwood, Albemarle County, Virginia*. June 2005
2) 2018 RBRGs toxicity values taken from USEPA Regional Screening Level Summary Table, May 2018, for resident adult and child exposure to tap water, available at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm.
3) Inhalation unit risks were extrapolated based upon the oral slope factor.

**Table 12. Comparison of Risk-Based Remedial Goals (RBRGs) Greenwood Chemcial Site**

| Chemical of Concern | MCL (mg/L) | 2005 RBRGs [1] | | | 2018 Revised RBRGs [5] | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | without adult dermal | | with adult dermal | |
| | | Carcinogenic [3] (mg/L) | Non-Carcinogenic [4] (mg/L) | Final RBRG (mg/L) | Carcinogenic [3] (mg/L) | Non-Carcinogenic [4,6] (mg/L) | Carcinogenic [3] (mg/L) | Non-Carcinogenic [4,6] (mg/L) |
| Bis(2-Chloroethyl)Ether | NA | 0.0005 | -- | 0.0005 | 0.0007 | -- | 0.0007 | -- |
| Carbon Tetrachloride | 0.005 | 0.004 | 0.008 | 0.004 | 0.011 | 0.133 | 0.0089 | 0.11 |
| 1,2-Dichloroethane | 0.005 | 0.006 | 0.1 | 0.005 (MCL) | 0.0086 | 0.2 | 0.0082 | 0.19 |
| Tetrachloroethene | 0.005 | 0.0008 | 0.1 | 0.0008 | 0.37 | 0.2 | 0.237 | 0.13 |
| Trichloroethene | 0.005 | 0.001 | 0.004 | 0.001 | 0.012 | 0.017 | 0.01 | 0.014 |
| Vinyl Chloride | 0.002 | 0.0001 | 0.04 | 0.0005 (CRQL) | 0.0002 | 0.1 | 0.0002 | 0.092 |

ABBREVIATIONS:
-- = No toxicity values available
CRQL = Contract-Required Quantification Limit
MCL = Maximum Contaminant Level
mg/L = milligram per liter
NA = Not Available
RBRGs = Risk-Based Remedial Goals

NOTES:
1) 2005 RBRGs taken from TetraTech/Black & Veatch, 2005, Final Ground-Water Investigation and Focused Feasibility StudyReport
2) 2013 RBRGs calculated using USEPA Screening Level calculator, available at: http://epa-prgs .ornl.gov/cgi-bin/chemicals/csl_search, assuming resident adult and child exposure to tap water.
3) Carcinogenic RBRGs are based upon a carcinogenic risk level of 10-5.
4) Non-carcinogenic RBRGs are based upon a hazard quotient of 1
5) 2018 RBRGs calculated using USEPA Screening Level calculator, available at https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search. Inhalation risk has not been included.
6) RBRGs for adult non-carcinogenic hazards have been shown; however, current EPA guidance considers child non-carcinogenic hazards. Consideration of child non-carcinogenic hazards would result in lower RBRGs.

# Attachment A - Site Chronology

| Event | Date |
|---|---|
| Chemical Manufacturing Operations | 1947-1985 |
| Finalized on National Priorities List (NPL) | July 22, 1987 |
| EPA begins Emergency Removal Actions | October 15, 1987 |
| Operable Unit 1 (OU1) Record of Decision (ROD) issued requiring excavation, treatment and disposal of surface soil and sludge and off-Site disposal of abandoned chemicals. | December 29, 1989 |
| Operable Unit 2 (OU2) Interim ROD issued requiring groundwater pump and treat to be implemented as a preliminary action. | December 31, 1990 |
| Explanation of Significant Differences (ESD) No. 1 clarified that former manufacturing buildings needed to be demolished to access contaminated soil. Referred to as OU3. | July 17, 1991 |
| OU1 State Superfund Contract (SSC) signed | October 17, 1991 |
| EPA accepted the OU3 Remedial Action Report documenting demolition and disposal of buildings | October 15, 1993 |
| ESD-2 clarified that excavation required by OU1 ROD would extend to practical limits of excavation; deeper contamination would be addressed by an OU4 Record of Decision. | March 24, 1994 |
| EPA completed Remedial Design for OU1; excavation, treatment, off-Site disposal of contaminated soil and sludge | June 30, 1994 |
| EPA accepted the OU1 Remedial Action Report documenting completion | September 3,1996 |
| EPA completed Remedial Design for Interim Remedy OU2, including water treatment plant | September 29, 1997 |
| First Five-Year Review issued | January 23, 1998 |
| Final inspection and acceptance of constructed water treatment plant (Interim OU2) | May 9, 2000 |
| Interim OU2 remedy determined to Operational and Functional | May 15, 2002 |
| EPA accepted the Interim OU2 Remedial Action Report documenting completion | September 19, 2003 |
| Second Five-Year Review issued | September 29, 2003 |
| Issue Action Memo, Remove Lagoons 4&5 and arsenic-contaminated surface soil | June 22, 2004 – May 2005 |
| OU2 (final) and OU4 ROD issued requiring containment of deep soils and achieving groundwater performance standards with upgraded pump and treat system | September 22, 2005 |
| Preliminary Closeout Report issued | September 30, 2005 |
| EPA accepts Interim OU2 Remedial Action Report | July 10, 2006 |
| Third Five-Year Review issued | September 29, 2008 |
| Operations transferred from EPA to VDEQ | March 15, 2012 |
| ESD for OU 2/4 ROD issued requiring new buildings on Site to be constructed in a manner that protects occupants from vapor intrusion from underlying contaminated ground water. | July 24, 2013 |
| Fourth Five-Year Review Issued | September 9, 2013 |
| Institutional Controls placed by filing of Notice of Contamination with Albemarle Recorder of Deeds Office | September 18, 2013 |
| Site-Wide Ready for Anticipated Use determination signed | January 16, 2014 |

## ATTACHMENT B: List of Documents Reviewed

Record of Decision [OU1], Greenwood Chemical, Albemarle County, Newtown, VA, dated December 29, 1989

Record of Decision [Interim OU2], Greenwood Chemical, Albemarle County, Newtown, VA, dated December 31, 1990

Explanation of Significant Differences, Greenwood Chemical, Albemarle County, Newtown, VA, dated July 17, 1991

Explanation of Significant Differences, Greenwood Chemical, Albemarle County, Newtown, VA, dated March 24, 1994

Record of Decision [Final OU2 and OU4], Greenwood Chemical, Albemarle County, Newtown, VA, dated September 22, 2005

Fourth Five-Year Review Report, Greenwood Chemical, Newtown, VA, September 2013

Technical Memorandum, VDEQ/EA Discharge Limits Comparison Discussion, Greenwood Chemical Site, Operable Unit (OU) -2 and OU-4, Greenwood, Albemarle County, Virginia, December 2008

Semi-Annual Operation, Maintenance and Monitoring Report, Jan-Jun 2013, dated July 30, 2013

Annual Operations & Maintenance (O&M) and Monitoring Report for 2013, dated April 30, 2014

Semi-Annual Operation, Maintenance and Monitoring Report, Jan-Jun 2014, dated July 31, 2014

Annual Operations & Maintenance (O&M) and Monitoring Report for 2014, dated February 27, 2015

Semi-Annual Operation, Maintenance and Monitoring Report, Jan-Jun 2015, dated July 31, 2015

Annual Operations & Maintenance (O&M) and Monitoring Report for 2015, dated March 14, 2016

Semi-Annual Operation, Maintenance and Monitoring Report, Jan-Jun 2016, dated August 24, 2016

Annual Operations & Maintenance (O&M) and Monitoring Report for 2016 Rev. 1, dated May 4, 2017

Annual Operations & Maintenance (O&M) and Monitoring Report Jan-August 2017, dated Sept 15, 2017

Operations and Maintenance Manual Addendum, dated March 10. 2017

Residential Well Water Samples Reviewed for Public Health Implications – Greenwood Chemical Company, Letter Health Consultation, Virginia Department of Health – Division of Epidemiology dated October 31, 2017

EPA Risk Based Screening Tables, November 2017

Explanation of Significant Differences, Record of Decision [final OU2 and OU4], Greenwood Chemical,

Albemarle County, Newtown, VA, dated July 24, 2013

Deed Notice – Notice of Contamination filed with Albemarle County Recorder of Deeds September 17, 2013 (Doc ID 032729990018)

Technical Memorandum - Results of Incremental Sampling for Dioxin Greenwood Chemical Site dated September 23, 2014