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FOURTH FIVE-YEAR REVIEW REPORT

For

U.S. TITANIUM SUPERFUND SITE

PINEY RIVER

NELSON COUNTY, VIRGINIA

MARCH 2015

PREPARED BY:

United States Environmental Protection Agency
Region III
Philadelphia, Pennsylvania

Approved by:

Cecil Rodrigues, Director
Hazardous Site Cleanup Division
U.S. EPA, Region III

Date:

MAR 24 2015

Table of Contents

EPA 2014

List of Acronyms

ARARs	Applicable or Relevant and Appropriate Requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COD	Chemical Oxygen Demand
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
GWC	Ground Water Collection
mg/L	milligrams per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
RAO	Remedial Action Objective
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SRI	Supplementary Remedial Investigation
SU	Standard Units
VDEQ	Virginia Department of Environmental Quality
VDWM	Virginia Department of Waste Management
VWCB	Virginia Water Control Board

Executive Summary

The remedy for the U.S. Titanium Superfund site in Piney River, Virginia consists of neutralization of the acidic soils in Areas 1, 2, 7, and 8; drainage controls; surface repair and re-vegetation in all areas; ground water collection and treatment; institutional controls; and long-term ground water monitoring. The site achieved construction completion with the signing of the Preliminary Closeout Report on August 25, 1997. The trigger for this Five-Year Review was the date of the previous Five-Year Review on March 24, 2010.

The remedy for the site is protective of human health and the environment in the short term and is expected to be protective in the long term after the issues identified in this five-year review have been adequately addressed. Exposure pathways that could result in unacceptable risks are being controlled. Acidic soils have been neutralized and capped, thus eliminating the direct contact exposure pathway. By eliminating most of the sources of acidic discharge into the river, the remedial action is preventing future fish kills. EPA will direct Cytec, the Potentially Responsible Party (PRP), to: perform an analysis to determine why low pH is still occurring in monitoring wells located beyond the ground water collection system; perform an optimization of the long-term ground water monitoring program; investigate the source of the low pH discovered in the surface drainage ways at the site and to propose a plan to address this situation; determine whether the low pH is impacting the Piney River and if the addition of lime into the drainage ways is preventing leaching of metals and degradation of the Piney River; and re-evaluate the monitoring program to ensure it addresses current site needs.

Although the depression in Area 5 was remediated by Cytec, this area should be specifically inspected at least yearly for the next three years to assure that the protective soil cover remains in good condition.

The institutional controls have been implemented. The Restrictive Covenants executed by the Piney River Recovery Corporation and Nelson County accomplish the following: ensure that drinking water supply wells are not installed or used on-site; that on-site activities do not adversely affect or interfere with the selected remedy; and, public use of the site is limited or restricted to areas that are considered safe and appropriate for general use.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: US Titanium		
EPA ID: VAD980705404		
Region: 3	**State:** VA	**City/County:** Piney River, Nelson County
SITE STATUS		
NPL Status: Final		
Multiple OUs? No	**Has the site achieved construction completion?** **Yes**	
REVIEW STATUS		
Lead agency: EPA **If "Other Federal Agency" was selected above, enter Agency name:**		
Author name (Federal or State Project Manager): Andrew Palestini		
Author affiliation: EPA Region 3		
Review period: May 2014 – March 2015		
Date of site inspection: September 29, 2014		
Type of review: Post-SARA		
Review number: 4		
Triggering action date: March 24, 2010		
Due date *(five years after triggering action date)*: March 24, 2015		

Five-Year Review Summary Form (continued)

The table below is for the purpose of the summary form and associated data entry and does not replace the two tables required in Section VIII and IX by the FYR guidance. Instead, data entry in this section should match information in Section VII and IX of the FYR report.

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
None

Issues and Recommendations Identified in the Five-Year Review:

OU(s): 00	**Issue Category:** Surface water			
	Issue: Low pH has been detected in the surface water in the drainage along the trail in Area 8 and the feeder drains.			
	Recommendation: Investigate the source of the low pH, propose a plan to remediate the problem if this continues, and determine whether the low pH is impacting the Piney River and ecological receptors in the drainage way. Also, re-evaluate the monitoring program to ensure that it addresses current site needs.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Cytec	EPA & VDEQ	12/30/16

Issues and Recommendations Identified in the Five-Year Review:

OU(s): 00	**Issue Category:** Ground water			
	Issue: Low pH continues to be detected in monitoring wells located beyond the ground water collection system.			
	Recommendation: Perform an analysis to determine why low pH is still occurring in monitoring wells located beyond the ground water collection system. An optimization of the ground water collection system may be necessary.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Cytec	EPA & VDEQ	12/30/16

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): 00	**Issue Category:** Cap maintenance			
	Issue: Two depressions occurred in the soil cover in Area 5.			
	Recommendation: Area 5 should be visually inspected yearly for the next three years to assure that no other depressions are formed.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Dates**
No	Yes	Cytec	EPA & VDEQ	12/1/15 12/1/16 12/1/17

Sitewide Protectiveness Statement (if applicable)	
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination: Protective in the short term.	*Addendum Due Date (if applicable):*

Protectiveness Statement:

The remedy for the site is protective of human health and the environment in the short term and is expected to be protective in the long term after the issues identified in this five-year review have been adequately addressed. Exposure pathways that could result in unacceptable risks are being controlled. Acidic soils have been neutralized and capped, thus eliminating the direct contact exposure pathway. By eliminating most of the sources of acidic discharge into the river, the remedial action is preventing future fish kills. EPA will direct Cytec, the Potentially Responsible Party (PRP), to: perform an analysis to determine why low pH is still occurring in monitoring wells located beyond the ground water collection system; investigate the source of the low pH discovered in the surface drainage ways at the site and to propose a plan to address this situation; determine whether the low pH is impacting the Piney River and if the addition of lime into the drainage ways is preventing leaching of metals and degradation of the Piney River; and re-evaluate the monitoring program to ensure it addresses current site needs. An optimization of the ground water collection system may be necessary.

Although the depression in Area 5 was remediated by Cytec, this area should be specifically inspected at least yearly for the next three years to assure that the protective soil cover remains in good condition.

The institutional controls have been implemented. The Restrictive Covenants executed by the Piney River Recovery Corporation and Nelson County accomplish the following: ensure that drinking water supply wells are not installed or used on-site; that on-site activities do not adversely affect or interfere with the selected remedy; and, public use of the site is limited or restricted to areas that are considered safe and appropriate for general use.

GPRA Measure Review:

As part of this Five-Year Review the GPRA Measures have also been reviewed. The GPRA Measures and their status are provided as follows:

Environmental Indicators:
Human Health: Current Human Exposure Controlled and Protective Remedy in Place (HEPR)
Groundwater Migration: Contaminated Ground Water Migration Under Control (GMUC)

Sitewide RAU:
The Site achieved Site-Wide Ready for Anticipated Use (SWRAU) status on February 23, 2007.

Other Comments:
N/A

Five-Year Review Report
For
U.S. Titanium Superfund Site
Piney River, Virginia

I. Introduction

The purpose of the Five-Year Review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues found during the review, if any, and recommendations to address them.

The United States Environmental Protection Agency (EPA) is preparing this Five-Year Review report pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) § 121 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA § 121states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The Agency interpreted this requirement further in the NCP; 40 Code of Federal Regulations (CFR) § 300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

The EPA Region III has conducted a Five-Year Review of the remedial actions implemented at the U.S. Titanium Superfund site (site) in Piney River, Virginia. This review was conducted by the Remedial Project Manager (RPM) from May 2014 to March 2015. This report documents the results of the review.

This is the fourth Five-Year Review for the site. The triggering action for this review is the date of the previous Five-Year Review report, March 24, 2010. EPA is performing this Five-Year Review because hazardous substances, pollutants, or contaminants are left on site above levels that allow for unlimited use and unrestricted exposure.

II. Site Chronology

The purpose of this section is to list all important site events and relevant dates.

Table 1: Chronology of Site Events

Event	Date
Six major fish kills	July 1977, August 1977, August 1979, July 1980, May 1981, and June 1981
Pre-NPL responses	Virginia Water Control Board orders U.S. Titanium to bury copperas by December 31, 1980.
Final NPL listing	September, 1983
American Cyanamid and Virginia enter into Stipulation and Order to provide temporary source control for the copperas burial pit and undertake Supplemental Remedial Investigation and Feasibility Study	April 30, 1986
Supplemental Remedial Investigation completed	November 1988
Feasibility Study completed	April 1989
ROD Issued	November 21, 1989
Consent Decree for RD/RA Work	February 18, 1991
ESDs	September 26, 1990, February 3, 1995, and September 25, 2002
Construction start date (Areas 1, 2, 3, 4, 5, 7, and ground water collection and treatment system)	August 1994
Construction completion date (Areas 1, 2, 3, 4, 5, 7, and ground water collection and treatment system)	September 1996
Preliminary Close-out Report (Areas 1, 2, 3, 4, 5, 7, and ground water collection and treatment system)	August 25, 1997
First Five-Year Review	March 17, 2000
Construction start date and completion date (Area 8)	June 16, 2003 – July 11, 2003
Second Five-Year Review	March 24, 2005
Declaration of Restrictive Covenants Recorded by Piney River Recovery Corporation and Nelson County	December 2006
Consent Decree Third Modification executed, incorporating the declaration of restrictive covenants	June 26, 2007
Third Five-Year Review	March 24, 2010

III. Background

The purpose of this section is to describe the characteristics of the site and to identify the threats that were posed to the public and the environment at the time of the initial Record of Decision (ROD) dated November 21, 1989.

Physical Characteristics

The site is located at the southern border of Nelson County, about 40 miles south of the city of Charlottesville, in west central Virginia. The site lies along the north bank of the Piney River and east of Virginia Route 151, just east of the rural community of Piney River (see Figure 1).

Land and Resource Use

The site is located in the Piedmont physiographic province, about five miles east of the Virginia Blue Ridge. The elevation at the site ranges from 726 feet to 618 feet in the Piney River near the drainage area. The site is primarily wooded, except for three areas: 1. capped areas; 2. the area where the ground water collection passes underground; and 3. the approximately 2,000 foot long trail which cuts through the site.

The bedrock underlying the site consists of igneous and metamorphic rocks. Ground water is present primarily in the porous, unconsolidated granular material of the saprolite and, to a much lesser extent, in the fractures that run through the dense, hard bedrock. These two units are hydraulically interconnected over larger distances. The depth to the water table is about 44 feet at the highest elevation. Coming down the valley, the water table becomes more shallow, intersecting ground surface in the stream beds and springs along the base of the hill. Ground water flow within the site originates in the upland area, flows in a radiating pattern down hill toward the streams surrounding the base of the hill and to the Piney River.

The site lies within the Piney River drainage basin, a part of the larger James River drainage basin. Two of the waste areas lie within the floodplain of the Piney River. Surface water drainage runs off the site primarily via three drainage channels into the Piney River.

History of Contamination

In 1931, the Virginia Chemical Corporation began producing titanium dioxide from ilmenite ore using the sulfate process. The ore was obtained from mining operations directly south of the Piney River. In the sulfate process, the ilmenite ore is treated with sulfuric acid to dissolve the titanium dioxide product. Waste streams from this process include acid contaminated un-reacted ore, spent sulfuric acid, and solid ferrous sulfate, commonly called "copperas."

In July 1944, the American Cyanamid Corporation (Cyanamid) purchased the Virginia Chemical Company and operated the plant until it closed in June 1971. Following the plant closure, the site passed through several ownerships, including the U.S. Titanium Corporation from which the site received its name. The obligations associated with the site are being handled by Cytec Industries Inc. (Cytec) on behalf of Cyanamid. Responsibility for this site was transferred to Cytec on December 17, 1993, when Cyanamid spun-off its global chemicals business.

The site occupies approximately 50 acres of the approximately 175 acre titanium dioxide manufacturing facility. It originally contained seven separate and distinct areas that were identified as possible sources of contamination (Areas 1 through 7, as shown on Figure 2). EPA later determined that Area 6 did not require any remedial action. In 2001, an eighth area was identified and added as another source of contamination requiring remediation.

Contaminates of concern at the site are acidic soil and ground water conditions and elevated levels of iron in the soluble form (ground water and soils). The areas of concern are described below:

Area 1 is a clay-lined, clay-capped burial pit where copperas (ferrous sulfate) from Area 2 was landfilled in 1980. It encompasses approximately two acres and contained about 68,000 cubic yards of copperas.

Area 2 is the former copperas stockpile area located on the slope east of Area 3. It covers approximately eight acres. Copperas from manufacturing operations was deposited here from 1949 to 1971. The U.S. Titanium Corporation relocated the copperas to Area 1 in 1980 under an order from the Virginia Water Control Board (VWCB).

Area 3 contained the evaporation pond that operated between 1974 and 1980. It is located between Area 1 and Area 2. The evaporation pond covered about two acres. It was part of a system operated under a No-Discharge Certificate issued by the VWCB to prevent discharges to the Piney River. Surface water run-off and some ground water discharges were collected in a containment pond and pumped up to the evaporation pond.

Area 4 is an un-reacted ore waste pile located south of Area 2. It covers about one acre and consists of clean-outs from reactors used in the titanium dioxide process and dredged material from the sedimentation ponds in Area 5.

Area 5 contains two sedimentation ponds located along the Piney River used to remove settleable solids from plant wastewater prior to discharge to the river. The sedimentation ponds cover an area of approximately seven acres and contain extremely fine-grained sediment composed of un-reacted ore, filter cake, and gypsum. The area lies within the 100-year floodplain of the Piney River.

Area 6 contains a settling pond used to recover phosphate ore, a by-product from titanium dioxide production. It covers about one acre and is located north of Area 5.

Area 7 is the drainage area receiving most of the surface water run-off from the site and the flow from the on-site tributaries. The area is located in the southeast corner of the site and covers about one acre. The area lies within the 100-year floodplain of the Piney River.

Area 8 consists of a section in the drainage ditches that parallel the railroad right-of-way that bisects the site and an associated northern drainage swale that conveys surface run-off from Area 1 to the drainage ditches. The area is approximately 5,300 feet in length.

Basis for Taking Action

The following six major fish kills occurred in the Piney River between 1977 and 1981 that the VWCB attributed to contamination from the site:

Table 2 – Major Fish Kills at U.S. Titanium Site

DATE	Number of Fish Killed
July 1977	73,056
August 1977	8, 940
August 1979	26,136
July 1980	53,980
May 1981	20,482
June 1981	46,243
Total	228,837

The fish kill in August 1979 prompted the VWCB to request the Circuit Court of Nelson County to order the U.S. Titanium Corporation to bury the copperas from Area 2 by December 31, 1980. In response to the court order, the U.S. Titanium Corporation secured a contractor to remove the copperas waste from the storage pile (Area 2) and bury it in Area 1. This work was completed in December 1980. However, the ultimate failure of the cap placed over this material and the lack of source controls in other areas resulted in continued acidic discharge into surface water and ground water. Elevated concentrations of metals, including iron, aluminum, cadmium, chromium, nickel, and zinc were detected. In December 1982, the site was proposed for inclusion on the National Priorities List (NPL).

In August 1983, an EPA contractor submitted what was termed the Remedial Action Master Plan, similar to a Remedial Investigation/Feasibility Study (RI/FS) Work Plan. In addition, a Focused Feasibility Study, which evaluated possible remedial alternatives based on the documented nature and extent of contamination, was performed. This report was issued by EPA in October 1985.

A civil action was filed by the Commonwealth of Virginia against Cyanamid in State Court, based on a nuisance action for fish kills and environmental degradation resulting from site contamination. A liability judgment was rendered against Cyanamid in November 1985. In April 1986, Cyanamid and Virginia signed a stipulation and order establishing a schedule for completion of temporary source controls for the copperas burial pit, and a supplemental remedial investigation and feasibility study for the site. Results of these studies confirmed that the buried copperas and resulting contaminated ground water posed an unacceptable risk to human health and the environment, thus necessitating remedial action. It was also verified that cap failure and the lack of source controls resulted in the continued discharge of acidic runoff to ground water and the Piney River. The findings of this investigation are summarized below for each of the original seven suspected source areas.

In Area 1 (where the copperas from Area 2 was disposed of) the landfill cover failed, allowing surface water to infiltrate the pit. The infiltration resulted in ground water contamination (low pH and high iron). Acidic seepages from the burial pit have killed trees and other vegetation, resulting in denuded areas, and contamination in a stream feeding the Piney River. It is estimated that this area accounted for about 65 percent of the total acidic discharge at the site. Analyses of ground water samples downgradient of the burial pit showed a pH as low as 3.66, and concentrations of total dissolved iron of up to 2,190 milligrams per liter (mg/L), sulfate of up to 14,000 mg/L, and acidity of up to 10,050 mg/L as calcium carbonate.

Area 2 covers approximately 4 acres and is the location of the former stockpile for the copperas that was landfilled in Area 1 in 1980. The soil under the former copperas stockpile was acidified and ground water seepages killed the grass stand and formed iron sulfate deposits. The acidic ground water from the site seeped out at various locations along the lower edges of the Area and drained to an existing stream. The vegetation was distressed or non-existent near the seeps and in the streambed. It is estimated that this area accounted for about 11 percent of the total acidic discharge at the site. Analyses of samples from seeps at the base of Area 2 showed a pH as low as 2.66, and concentrations of total dissolved iron of up to 17,720 mg/L, sulfate of up to 45,000 mg/L, and acidity of up to 41,000 mg/L as calcium carbonate.

Area 3 consisted of a former evaporation pond. The pond was filled and re-vegetated. The soil under Area 3 is acidified up to the water table. It is estimated that the acidic contribution from this area was about 7 percent of the total acidic discharge at the site. Analyses of ground water samples from a well within Area 3 showed a pH as low as 3.32, and concentrations of total dissolved iron of 4,360 mg/L, sulfate of 54,000 mg/L, and acidity of 40,500 mg/L as calcium carbonate.

Area 4, the waste pile area of deposited spent ore and other by-products from the operation of the titanium dioxide manufacturing plant, contains residual acidity from processing. The slopes were eroded and unstable. The soil underneath this area is also acidified. An estimated four percent of the total acidity at the site was attributable to this area.

Area 5, which consists of the two sedimentation ponds containing un-reacted ore, gypsum, and other by-products from the plant operation, contains residual acidity from processing. The dike containment system had been breached by erosion and the pond sediments were being carried into the Piney River during rain events. Erosion of the sediments by storm run-off resulted in a significant lowering of the pH in the Piney River. In addition, ground water flowing through this area is acidified by contact with the waste prior to discharge to the Piney River. Area 5 accounts for about 12 percent of the total acidity at the site. Analyses of samples from wells located on the northeastern edge of this area showed a pH as low as 3.42, and concentrations of total dissolved iron of up to 1,840 mg/L, sulfate of up to 5,400 mg/L, and acidity of up to 3,220 mg/L as calcium carbonate.

Area 6, the settling pond used to recover phosphate ore, had no detectable copperas or acidity problem. There was also no ground water contamination.

Area 7 consists of an area of approximately 1 acre and is the discharge route for much of the site surface water drainage. Surface water and ground water flowing through the area have resulted in acidified soils. As such, the soil under Area 7 became acidified and contributed about one percent of the total acidity at the site. Analysis of samples from a well down-gradient of Area 7 has shown a pH as low as 3.09, and concentrations of total dissolved iron of up to 570 mg/L, sulfate of up to 2,400 mg/L, and acidity of up to 1,542 mg/L as calcium carbonate.

Subsequent to the remediation of Areas 1, 2, 3, 4, 5, and 7, a group of citizens in Amherst County and Nelson County, Virginia, in cooperation with the local governments, was successful in obtaining "Rails to Trails" grant funding to convert the former Blue Ridge Railroad right-of-way to public use. The right-of-way bisects the site and, as such, the condition of the site's soils, adjacent to the right-of-way, was of concern. An initial investigation by the citizens' group revealed residual acidity in the drainage ditches running parallel to the proposed pathway as it traverses the site. These ditches are in an area which is fed with surface runoff and subsurface drainage from several other site areas. The ditches are designated as Area 8.

In summary, as the copperas dissolves, it produces acidity as the result of two chemical reactions - oxidation and hydrolysis. The net effect of these reactions is that for every mole of copperas that is dissolved, two moles of excess hydrogen ion (H^+) are produced, resulting in the acidic leachate. All water entering the site eventually discharged to the Piney River. Ground water discharged into the Piney River either

directly or by way of the two site tributaries. Surface water run-off from the site eroded acidic sediments and discharged them into the river.

These discharges can contain high iron concentrations and have low pH values. The high iron concentrations resulted in the deposition of ferric hydroxide concentrations at the bottom of the river. These sediments disrupted the benthic community in the river. This in turn resulted in a decrease in the number and diversity of the fish population in the river adjacent to and downstream of the site because low pH discharges can be toxic to aquatic organisms.

The acidic nature of the site has also led to the leaching of other metals such as aluminum, copper, zinc, cadmium, and nickel from onsite soils. The concentrations of these metals and iron in surface water and ground water at the site in 1984 are shown below in Table 3 as well as how these concentrations compare to surface water criteria.

Table 3 – 1984 Mean Concentration in Surface Water Discharge & Ground Water at the U.S. Titanium Site

Contaminants	Units	Surface Water Discharge	Ground Water	Surface Water Criteria
Aluminum	mg/L	200.00	200.00	0.087
Arsenic	mg/L	<0.01	0.028	0.190
Cadmium	mg/L	0.013	0.047	0.0003
Chromium	mg/L	0.335	0.084	0.011
Copper	mg/L	1.355	0.45	0.0025
Nickel	mg/L	0.692	2.67	0.023
Zinc	mg/L	1.56	19.27	0.047
Iron	mg/L	267.00	698.00	1.0
pH	SU	2.4	3.1	6 – 9
Acidity		1446	2090	-

IV. Remedial Actions

The purpose of this section is to discuss initial plans, implementation history, and current status of the remedy.

Remedy Selection

The ROD for the site was signed on November 21, 1989. It was later amended on three separate occasions by an Explanation of Significant Differences (ESD).

The remedial action objective (RAO) in the ROD is to control risks at the site posed by acidic discharges into ground water and the Piney River. By eliminating most of the sources of acidic discharge into the river, the remedial action would prevent future

fish kills and stop further leaching of metals and continued degradation of the Piney River.

The remedy selected in the ROD consists of the following components:

Area 1:	In-situ dissolution of buried copperas waste and above ground treatment of leachate.
Area 2:	Surface repair of un-vegetated areas.
Area 3:	Improve surface drainage.
Area 4:	Drainage control and re-vegetation.
Area 5:	Drainage control and re-vegetation.
Area 6:	No action.
Area 7:	Above-grade dry neutralization, in combination with wetland construction.
Ground water:	Passive collection, with passive treatment in a constructed wetland.
Site wide:	Environmental monitoring to ensure the effectiveness of the remedial action.

The remedy addressed all six of the known sources of contamination at the site at the time of the ROD. The remedy consisted of dissolution and treatment of the buried copperas waste in Area 1. Drainage controls and re-vegetation would be implemented in Areas 2, 3, 4, and 5. The acidified soil in Area 7 would be mixed with lime to neutralize any leachate. Ground water would be collected by using subsurface drains and trenches. The ground water would flow to a constructed wetland for treatment. The wetland treatment would be supplemented with active treatment processes if necessary to meet discharge requirements.

After issuing the ROD, negotiations began with American Cyanamid for a consent decree to perform the remedial design and remedial action (RD/RA) of the selected remedy. During these negotiations, preliminary design studies prepared by American Cyanamid identified several issues associated with the remedial alternatives that had been selected. American Cyanamid began investigating other alternatives and subsequently presented additional information for a potential change in the method of treating the buried copperas in addition to changes in the requirements for discharge of treated water to the Piney River. The Virginia Department of Waste Management (VDWM) and EPA reviewed these new alternatives and determined that changes to the selected remedy were warranted. These changes are described in ESD Number 1, issued on September 20, 1990. Specifically, this ESD changed the selected remedy by:

- Providing the option of treating Area 1 soil and copperas by above ground dissolution rather than in-situ dissolution;

- Clarifying the objectives for design and operation of the ground water collection and treatment system. These changes included the design of auxiliary treatment units should the passive wetlands treatment system

prove incapable of treating the full capacity flow and concentration of iron in the ground water; and,

- Modifying the effluent limits and monitoring requirements for the discharge of treated ground water to the Piney River.

Under the Consent Decree dated February 18, 1991, executed with EPA and VDWM, American Cyanamid agreed to conduct the RD/RA for the site. The RD/RA was implemented in accordance with the ROD, as modified by ESD Number 1.

Following the issuance of ESD Number 1, major difficulties in the soil and ground water components of the remedy were identified. Specifically, additional sampling and pilot study work performed to determine the best treatment for Area 1 soils revealed that the soils were extremely difficult to handle in a soil washing process, rendering the selected remedy ineffective. American Cyanamid therefore began investigating other alternatives (soil neutralization) for treatment of Area 1 soils and copperas. In addition, it was determined that the ground water collection and treatment system may not be capable of effectively treating the contaminated ground water at the site and that more extensive monitoring would be required. This was supported by literature reviews which indicated that the site had a much higher level of contamination than other sites that had successfully utilized this remedy.

The two issues that formed the basis for issuing ESD Number 2 on February 3, 1995 are: Area 1 soils and copperas were to be treated using ex-situ neutralization rather than dissolution; and ground water was to be treated using neutralization in a tank followed by precipitation of iron-rich sludge in a surface impoundment prior to discharge to Piney River.

The components of the soils neutralization process consist of the following:

1) Excavation of Area 1 buried copperas and soils contaminated or mixed with the copperas. Excavation will be complete when the soils remaining contain less than 1% soluble iron.
2) Excavated material will be treated with dolomitic lime to neutralize and stabilize the soluble iron.
3) Successfully treated materials will be used as a sub-base for the cover systems to be installed over Areas 3 and 4 of the site.
4) Decontamination waters and collected rain waters will be neutralized, if necessary, and used on-site for dust control and irrigation water.

Changes to the ground water treatment system include the following:

1) Neutralization of acidified soils in Areas 2 and 7 that were previously designated as constructed wetlands. Lime will be added to the soils so that the soils will attain a pH from 7 to 9 standard units.

2) Collected ground water will be neutralized in tanks using an appropriate caustic agent. Once neutralized, the treated ground water will be discharged to a settling basin to allow for the precipitation of iron sludge from the liquid.
3) Iron sludges generated will be removed from the impoundments periodically and disposed off-site.
4) The effluent discharge limit for pH from the ground water treatment plant will be from 6 to 9 standard units and for total iron the effluent discharge limit will be 111,381 micrograms per liter. The limit for total iron is based on an estimated discharge of 40,000 gallons per day at a discharge rate of 104 gallons per minute.
5) Bioassay testing is limited to quarterly acute toxicity on the treatment plant effluent to the river.

The RD was divided into three distinct phases indicated as follows:

- Area 1 and 3 – On-site soil neutralization of the soil in Area 1 and disposal of the treated soil in a waste cell in Area 3, with both areas covered with soil and re-vegetated.
- Area 4 and 5 – re-grading, soil cover, and re-vegetating.
- Area 2 and 7 – soil neutralization – and Ground water collection and treatment (Areas 2 and 4, and Areas 1 and 3).

As indicated previously, a group of citizens in Amherst County and Nelson County, Virginia was successful in obtaining "Rails to Trails" grant funding to convert the former Blue Ridge Railroad right-of-way to public use. Since the right-of-way bisects the site, the condition of the site's soils adjacent to the right-of-way was of concern. The citizens group conducted limited sampling of surface soils within the drainage ditches. These sampling results revealed residual acidity in the drainage ditches running parallel to the proposed pathway as it traverses the site, with pH values ranging from 2.57 to 5.88 standard units and most values being in the 3.0 to 4.5 standard units range. The contaminated soils in the ditches were then designated as Area 8.

The contaminated soils in Area 8 pose the same threat to human health and the environment as the contaminated soils in other areas at the site. As such, EPA issued ESD Number 3 on September 25, 2002 selecting soil neutralization by mixing the soil with lime. Area 8 includes the entire 4,000 foot length of the drainage ditch (2,000 feet for both the north and south ditches) and the 1,300 foot feeder swale to the north. The selected remedy in ESD Number 3 also included fencing and natural barriers between the public-use trail area and other areas of the site to ensure the general public remains in the public-use trail area and does not inadvertently wander into the remediated areas of the site.

In addition, ESD Number 3 clarified the need for additional institutional controls at the site in order to protect human health and the environment and to maintain the integrity of the selected remedy as described in the ROD, as amended by the ESDs. The

remedy selected in the ROD included "Local Deed Restrictions" to prohibit excavation at any of the contaminated areas of the site and the wetland, even after the remedial action was complete, unless all residual contamination was eliminated. Given that some residual contamination remained on-site after completing remediation, it was necessary to expand the restrictions. The institutional controls included in ESD Number 3 are: to insure that drinking water supply wells are not installed or used on-site; that on-site activities do not adversely affect or interfere with the selected remedy; and, that public use of the site is limited or restricted to areas that are considered safe and appropriate for general use. ESD Number 3 states that the institutional controls shall be implemented via easements, real covenants, title notices, a federal judicial consent decree, or a unilateral administrative order imposing such restrictions on use of the site.

Remedy Implementation

Area 1 and Area 3 Soils Neutralization, Cover, and Re-grade:

Area 1 consisted of a landfill for the containment of the copperas from Area 2, the result of a Consent Order from the VWCB. As stated previously, the landfill cover failed over time, allowing surface water infiltration. The infiltration resulted in ground water contamination (low pH and high iron). Seeps eventually developed downgradient from the landfill resulting in denuded areas and contamination in a stream feeding the Piney River.

Area 3 consisted of a former evaporation pond operated by the property owner at the direction of the State of Virginia. Site investigations prior to remedial action revealed low pH soil in the vadose zone beneath Area 3.

The remedial action for Area 1 consisted of excavating the landfilled material from Area 2, neutralizing the soil with lime and placing it in Area 3 as cover material for the evaporation pond. The excavation left in Area 1 was re-graded with a clay soil cap, covered with approximately 1 foot of topsoil and vegetated with grass.

Approximately 68,000 cubic yards of material was removed from Area 1, neutralized, and placed and compacted as a cap over Area 3.

The remedial action for Area 3 consisted of capping over the former evaporation pond, re-grading the area, and planting grass seed. Final cover for both Area 1 and Area 3 was obtained offsite and used as the vegetative soil layer. Remediation of Areas 1 & 3 was completed in October 1995.

Area 4 and Area 5 Re-grade and Cover:

Area 4 consisted of approximately 1.8 acres of deposited spent ore and other by-products from the operation of the titanium dioxide manufacturing plant. The slopes were eroded and unstable. The selected remedy consisted of slope stabilization, re-grading, placing a soil cover, and establishing vegetation. A key component of this

remedial action was the installation of a concrete crib retaining wall to provide long-term slope stabilization. The remedial action was completed in December 1996.

Area 5 consisted of approximately seven acres of former plant sedimentation basins containing un-reacted ore, gypsum, and other by-products from the plant operation. The dike containment system had been breached by erosion and the sediments were being carried into the Piney River during rain events. The selected remedy consisted of improving flood protection to meet the 100 year flood event by rebuilding the dikes, re-grading the sedimentation area to enhance storm water drainage, installing a clay cap over the sedimentation area, and establishing a vegetated cover. This remedial action was also completed in December 1996.

Area 2 Ground Water Collection (GWC) System

This portion of the GWC system was installed to intercept and transport acidic ground water from Area 2 to the ground water pumping station. The GWC system for Area 2 consists of approximately 1,600 feet of sub-surface collection trenches and associated collection and conveyance piping. The Area 2 GWC system was opened to collect water for transport to the treatment plant in April 1996. Final re-grading and re-seeding of the Area 2 slope was completed in July 1996.

Area 4 Ground Water Collection System

This portion of the GWC system was installed to intercept and transport acidic ground water flow from the area south of Area 1 and Area 3 to the ground water collection system. The Area 4 GWC system includes approximately 500 feet of sub-surface collection trenches and associated collection and conveyance piping. This section of the GWC system was placed in service in March 1996.

Area 1 + 3 Ground Water Collection System

This section was the last constructed component of the GWC system and was installed to complete the interception of acidic ground water flow to the south of Area 1 and Area 3. This section of the GWC system consists of approximately 1,100 feet of sub-surface collection trenches and associated collection and conveyance piping. It was placed into service in September 1996.

Area 2 and Area 7 Soil Remediation

Area 2 covers approximately 4 acres and is the location of the former stockpile for the copperas that was landfilled in Area 1 in 1980. The acidic ground water from the site seeped out at various locations along the lower edges of the Area and drained to an existing stream. The vegetation was distressed or non-existent near the seeps and in the streambed. The selected remedy for Area 2 consisted of liming the streambed and the bare areas along the base of the slope and re-vegetating the slopes. The total slope area

requiring re-vegetation was about 0.4 acres. A total area of 1,000 square yards of streambed was treated with limestone.

Area 7 is approximately 1 acre and is considered the discharge route for much of the site surface water drainage. Surface water and ground water flowing through this area have resulted in acidified soils. The selected remedy for Area 7 consisted of neutralizing the soil with lime and providing proper drainage and erosion controls.

Remedial action activities for these areas were completed in October 1996. Area specific remediation activities were as follows:

For the seeps adjacent to the streambed in Area 2, the top 12 inches of soil was removed and mixed with hydrated lime to a pH of 6 to 7 SU to support vegetation. The underlying soils were mixed in place with hydrated lime, to a pH of 7 to 9 SU. The mixed in-place soil was then compacted, covered with the excavated, neutralized soil, and seeded. A total of 639 cubic yards was removed and treated over an area of approximately 0.4 acres.

In the streambeds where insufficient sediments were available to mix with hydrated lime, limestone rock was placed in the bed. A total of 125 tons of limestone (2 to 3 inch size) was used for this treatment.

In Area 7, the impacted soils were removed, mixed with hydrated lime to a pH of 6 to 7 SU, placed back into the area, graded and seeded. A total of 1,630 cubic yards of soil was excavated and neutralized, placed back in the area and re-vegetated. Area 7 also required the installation of a new riprap lined drainage channel to control storm water runoff flow.

Ground Water Treatment Plant and Pumping Station

The ground water treatment plant and pumping station were constructed as designed, with no critical unknown conditions encountered. Construction of the treatment plant was completed in March 1996.

The official start date of the plant was March 12, 1996. The plant processed collected ground water for several days before being stopped to verify discharge limits for treatment and discharge to the Piney River. The limits for the plant discharge were formally issued by the Virginia Department of Environmental Quality (VDEQ) on March 22, 1996 and ground water treatment re-started on March 25, 1996.

Area 8 Soil Remediation

Area 8 consists of the drainage ditches that parallel the "railroad right-of-way" bisecting the site and the associated northern drainage swale that conveys surface run-off from Area 1 to the railroad right-of-way drainage ditch. The area of concern is approximately 5,300 feet in length. This area was identified in 2001 and remediation was completed July 11, 2003. The remedial action for Area 8 consisted of excavating the

acidic soil in the swale and the ditches, neutralizing it with lime, placing and compacting the neutralized soil back in the ditches and swale areas, and re-grading to promote proper drainage.

System Operation/Operation and Maintenance

The ground water collection and treatment system is operated and maintained by Cytec. The system was designed and constructed to intercept the acidic and high iron containing ground water emanating from Areas 1, 2, 3 & 4, convey the collected ground water to the treatment plant, treat it to meet the discharge limits set by VDEQ, and discharge it to the Piney River. The pumping station, located at the base of Area 4, consists of a wet well with excess flow storage capacity and two transfer pumps rated at 50 gallons per minute capacity. Collected ground water is pumped through a 2,500-foot force main to the treatment plant located on property adjacent to the Superfund site, near Highway 151.

The treatment plant is a batch operated system with the capacity to treat 120,000 gallons per day. The system was placed into service in March 1996 and consists of the following unit operations:

- Flow equalization and storage;
- Batch neutralization with lime;
- Lime storage and feed system;
- Sludge settling/drying ponds.

The flow to the treatment system varies seasonally and ranges from approximately 10,000 to 40,000 gallons per day. Treated water is intermittently discharged to the Piney River through a permitted outfall. The non-hazardous sludge generated from neutralizing the acidic and high iron containing ground water is gravity dewatered in the settling/drying ponds and disposed of off-site. During this five-year period, sludge was initially disposed at the Waste Management Amelia Landfill in Charles City, Virginia, and then at the First Piedmont Landfill in Ringgold, Virginia.

Quarterly ground water monitoring for the site was initiated in March 1997 to evaluate changes in ground water quality upon completion of all major remedial activities. The monitoring includes sampling the following thirteen site monitoring wells: MW-1, MW-2, MW-5, MW-6, MW-7, MW-8, EPA-2, EPA-4, EPA-5, 5-1, 5-5, 5-8, and 5-9 (MW-2 and MW-5-5 wells were installed on 9/24/97). The ground water is analyzed for field pH, field temperature, total iron, and dissolved iron. Ground water elevations are also recorded. In addition, Cytec voluntarily installed five additional wells (MW-9, MW-10, MW-11, MW-12, and MW-13) which were sampled in 2003 for an operations enhancement study they performed.

During calendar year 2013, the ground water treatment plant processed ground water for 247 days (actual treatment days). The total volume processed was 10,071,000 gallons, or 40,773 gallons per day average (yearly basis). This volume was approximately 118.7 percent of the 8,484,500 gallons treated in 2012. A total of 872 tons of sludge was removed from the system in 2013 and sent to the First Piedmont Landfill in Ringgold, Virginia. Since the start of operations in March 1996, a total of 20,804 tons of sludge have been removed and trucked to the Waste Management Amelia Landfill in Charles City, Virginia and the First Piedmont Landfill.

The largest maintenance problem at the site is the accumulation of iron in the collection lines, valves, pumps, and tanks. Even though removal of the accumulated iron is constantly performed by the plant crew and an outside pipe cleaning contractor, it still builds up to the point where pipes and sometimes valves or pumps need to be removed from the system because the iron has built up to the point where the piece of equipment can no longer function. For instance, Cytec previously changed the outfall pipe from the plant to discharge to the settling ponds at a higher elevation to allow the line to drain back to the plant rather than remaining in the line. This change has prevented the discharge line from building up with iron. At the time of the site inspection for this Five-Year Review, all equipment was in good operating condition.

O&M costs include the operation and maintenance of the ground water collection and treatment system, sampling and monitoring efforts, maintenance of the monitoring wells, and maintenance of the landfill covers (mowing and lime addition, as needed). O&M activities are performed by Cytec under the terms of the Consent Decree. They have not provided detailed information regarding actual expenditures for O&M.

In September 2012, Cytec proposed a work plan to EPA and VDEQ to investigate the soil cover in Area 5 because two depressions were detected. In February 2013, Cytec reported that the investigation showed one other potential erosional feature (a void beneath the western culvert) and, as such, proposed a scope of work which included enlarging the depressions, filling them with grout, repairing the soil cover to the elevation of the surrounding cap grades, and seeding the area to prevent further erosion of the cap. EPA approved the work plan in March 2013 and the work was completed by Cytec in July 2013.

On February 9, 2014, a person reported to the Nelson County Administrator the presence of orange sediment in the drainage ditch alongside the trail. This report was forwarded to VDEQ and Cytec. Cytec immediately directed the plant operators to take pH measurements in the field. These measurements indicated acidic surface water in the west branch of the stream that runs along the south side of the landfill area with pH that ranged from 4.02 to 5.82. Also, the pH where the stream runs under the walking trail was 3.80 and 3.26.

Based on these preliminary tests, Cytec directed their consultant to take additional pH readings. These measurements detected pH in the west branch of the stream that runs

along the south side of the landfill area ranging from 4.77 to 6.02; the stream on the east side of the landfill ranging from 2.78 to 3.89; and 4.84 where the two streams meet.

To address this situation in the short-term, Cytec proposed and EPA/VDEQ approved the addition of limestone (averaging in size from ½ inch to 1-1/2 inches in size) at five locations total (two each in the east and west branches of the stream and one down gradient from the stream confluence close to the river), to continue pH monitoring of the streams, and to investigate the collection trench that runs along the east edge of the landfill to determine whether the collection trench is compromised or fouled. Placement of the limestone occurred in May 2014. Follow-up action on the trench would be determined after the investigation is completed.

Prior to this, Cytec had been voluntarily evaluating in-situ enhanced treatment options at the site to determine a long term solution to improve remediation of the site. The ultimate goal of the evaluation was to identify options that may be considered to economically remediate the ground water at a faster rate than is now occurring at the site. This work was expedited and a pilot study proposed. After their consultant evaluated five different technologies, Cytec proposed in-situ neutralization via injection of a base. The pilot study consists of in-situ neutralization of the low pH ground water. For the pilot study, this will be accomplished by injecting approximately 350 gallons of sodium hydroxide in slurry form using gravity feed. Cytec will install a new well at which the injection will take place as well as four performance monitoring wells to collect performance data related to the pilot study objectives. EPA and VDEQ approved the pilot study on October 7, 2014.

V. Progress Since Last Five-Year Review

The purpose of this section is to discuss the progress taken on follow-up actions included in the previous Five-Year Review report.

The third Five-Year Review report was signed on March 24, 2010. The report contained the following protectiveness statement based on the findings of the second Five-Year Review:

> The remedy for the site is protective of human health and the environment in the short term. Exposure pathways that could result in unacceptable risks are being controlled. Risks at the site posed by acidic discharges into ground water and the Piney River are being controlled. By eliminating all or most of the sources of acidic discharge into the river, the remedial action is preventing future fish kills and has stopped further leaching of metals and continued degradation of the Piney River. Acidic soils have been neutralized and capped, thus eliminating the direct contact exposure pathway.

The institutional controls have been implemented. The Restrictive Covenants executed by the Piney River Recovery Corporation and Nelson County accomplish the following: ensure that drinking water supply wells are not installed or used on-site; that on-site activities do not adversely affect or interfere with the selected remedy; and, public use of the site is limited or restricted to areas that are considered safe and appropriate for general use.

Below is Table 5 from the previous Five-Year Review report listing the two issues brought up as a result of the review and the required recommendations/follow-up actions.

Table 5: Recommendations and Follow-Up Actions

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
The two gates where the access roadway intersects the trail are in disrepair.	Both gates need to be either repaired or replaced.	Cytec	VDEQ & EPA	6/1/2010	No	Yes
2008 every five years sampling did not occur as required.	Perform sampling in winter 2010 and again in 2013, as indicated by PRP.	Cytec	EPA	7/01/10 and 7/01/13	No	Yes

Cytec resolved both of the above issues to EPA's satisfaction. Both gates were replaced and the every five years sampling occurred in the winter of 2010 and again in 2013 to restore it back to the planned sampling schedule.

VI. Five-Year Review Process

The purpose of this section is to describe the activities performed during the Five-Year Review process and to provide a summary of findings.

Administrative Components

The site visit for this Five-Year Review occurred on September 29, 2014. Attending the five-year review site visit were: the EPA Remedial Project Manager (RPM), VDEQ project manager, U.S. Fish & Wildlife representative (as a member of the Biological Technical Assistance Group), Cytec, the operators of the ground water treatment system, and Cytec's consultants.

The Five-Year Review team was led by Andrew Palestini of EPA, the RPM for the U.S. Titanium site, and included Alexander Mandell, EPA's Community Involvement Coordinator, and members from the Regional Technical Advisory staff with expertise in the application of risk assessment, biology, and hydrology. Mr. Richard Criqui, VDEQ project manager, assisted in the review as the representative of the support agency. A site-specific approach was developed for this fourth Five-Year Review.

The approach established for the Five-Year Review included:

- Community Involvement –Notifying the community that EPA is conducting a Five-Year Review at the site and providing information on whom to contact and how to get more information about the process and notifying the community of how to obtain a copy of the third Five-Year Review report upon its completion;

- Document and Data Review – Reviewing significant site documents and environmental monitoring data. Researching the Applicable or Relevant and Appropriate Requirements (ARARs) cited in the ROD for revisions as well as potentially new ARARs which may be significant to the site circumstances. Checking published toxicity references for site-related contaminants to determine if there have been changes since the site-specific risk assessment, which may be relevant to the review team's evaluation of remedy protectiveness.

- Site Inspection – Visiting and inspecting the site to visually confirm and document the conditions of the remedy, the site, and the surrounding area.

- Five-Year Review Report - Developing and reviewing the Five-Year Review Report.

The Five-Year Review schedule extended from May 1014 to March 2015.

Community Involvement

There has been little community interest since the bulk of the construction completion in 1996, except for remediating the trail in Area 8. A notice was placed in the Charlottesville Daily Progress on November 17, 2014, to serve four functions:

1. Inform the public that EPA was conducting a Five-Year Review.
2. Provide information on whom to contact if they have any questions or comments on the operations at the site.
3. Inform the public on how to get more information about the Five-Year Review process.
4. Notifying the community on how they could obtain a copy of the Five-Year Review report upon its completion.

Document Review

This Five-Year Review included a review of relevant documents including:

- U.S. Titanium Superfund Site Record of Decision, November 21, 1989.
- Explanation of Significant Differences, U.S. Titanium Superfund Site, September 26, 1990.
- Second Explanation of Significant Differences From the ROD, U.S. Titanium Site, February 3, 1995.
- Superfund Preliminary Site Close Out Report (Final Operable Unit Remedial Action), U.S. Titanium Superfund Site, August 25, 1997.
- VDEQ Permit Equivalent and Fact Sheet, U.S. Titanium Superfund Site, January 1, 1997.
- Benthic Macroinvertebrate Community Monitoring at the U.S. Titanium Site, December 1999.
- Third Explanation of Significant Differences, U.S. Titanium Superfund Site, September 25, 2002.
- U.S. Titanium Superfund Site One in Five Year Additional Effluent Monitoring Data Sheets, May 7, 2003.
- Second Five-Year Review Report, U.S. Titanium Superfund Site, March 24, 2005.
- Annual Report Numbers 19, 20, 21, 22, and 23 for the U.S. Titanium Superfund Site, for calendar years 2009, 2010, 2011, 2012, and 2013, respectively.
- December 4, 2014 Monthly Progress Report, which includes the semi-annual site inspection report.
- Third Five-Year Review Report, U.S. Titanium Superfund Site, March 25, 2010.
- Site Operations and Maintenance Monthly Reports and the Monthly Operations Data Sheets.

Data Review

Ground Water Monitoring

Ground water monitoring has been conducted on a quarterly basis since March 1997 from the system of thirteen wells strategically located throughout the site. Analytical parameters include field pH, field temperature, dissolved iron, and total iron. The wells are located both inside and outside the ground water collection system. The ground water monitoring program called for monitoring on a quarterly basis for a period of two years, after which a reduction in sampling frequency would be considered pending data review.

Contaminated ground water (pH < 4 and elevated iron concentrations) exists beyond the ground water collection system in Area 2. The ground water collection system was placed to create a containment system around the site perimeter to prevent acidic discharges from migrating off-site. By isolating the source, it was anticipated that regional ground water quality would improve over time. However, monitoring wells EPA 1, EPA 2, and EPA-5, which are outside the collection system, have continually exhibited low pH and/or elevated iron.

An evaluation of the analytical results from the quarterly sampling events for MW-1 has shown one brief period of significant pH increase since the last five-year review. This occurred in the summer of 2010 when the pH reached 6.0 and 6.8 in two consecutive sampling events. The only period of significant increase in pH since the collection system was installed was the period from June 2000 to March 2003 when the pH reached 6.0 or greater four times and 5.86 once. Other than these isolated instances, the pH at MW-1 has consistently ranged from 3.0 to 3.9. At MW-7, the pH exceeded 3.5 on two occurrences, March 2002 when it reached 5.9 and September 2002 when it reached 4.4. During the period from 2010 to 2012, the well was dry one-third of the sampling events and the pH levels ranged from a low of 2.8 to the high of 3.5. At EPA-2, which is the farthest downgradient point, since 1997 the pH has consistently ranged from 3.0 to 3.9 except for one period from late 2001 to early 2003 when the pH reached 5.0 or greater four times and 7.5 once.

However, at many of the points there has been dramatic improvement in the iron concentrations in ground water. For MW-2, MW-7, and EPA-2, in the first four quarters of monitoring from the 1991/1998 total iron averaged 1,511 mg/l, 1,330 mg/l, and 121 mg/l respectively, while in the most recent four quarters (2014), those same wells averaged 5.7 mg/l, 287 mg/l, and 14 mg/l, respectively. The highest total iron concentration of 11,600 mg/l was recorded in 1997 from MW-5. The maximum concentration from the most recent event in 2014 was 2,490 mg/l from MW-1.

As indicated in the previous five-year review report, this evaluation indicates that the ground water quality outside the collection system still fluctuates with significant improvement in iron concentrations but no long-term sustainable improvement in pH. The sampling results indicate that the remedial treatment and ground water collection

system are effectively improving iron conditions in ground water but the pH is substantially unchanged from March 1997, when the system was put in place.

Surface Water Discharge Monitoring

VDEQ Water Programs issued a discharge permit for outfall 001 from the ground water treatment system with an effective date of January 1, 1997. The permit specified a maximum discharge of 80,000 gallons per day and required monthly measurements of flow, pH, and Chemical Oxygen Demand (COD). The pH must be in the range of 6.0 to 9.0 Standard Units and no limitation on COD. Data from the monthly operation reports indicate that the discharge has been in compliance with the permit criteria. In addition, monitoring for hexavalent chromium (dissolved), mercury (dissolved), selenium (dissolved), and hardness is required every five years. One of the two issues noted during the third five-year review was that this additional sampling occurred in 2003 but did not occur in 2008, as required. Cytec was notified of the missed sampling and they corrected this oversight by sampling in the winter of 2010 as well as sampling in 2013 to put it back onto the correct timetable. All of the analyses show results below detection levels.

The discharge permit includes a provision for a Toxics Management Program (that was modified on April 7, 1999), which includes bioassay testing, toxicity reduction evaluation, and a benthic macroinvertebrate survey. Bioassay testing of the surface water discharge is supposed to be performed quarterly during times of non-intermittent discharge. Specifically, the acute toxicity tests should be performed in March, June, September, and December using the organism *ceriodaphnia dubia* but the tests are not always performed because of the intermittent discharge from the treatment plant. Chronic toxicity testing is performed once per year, in September, also using *ceriodaphnia dubia.*

In the past, the bioassay tests have experienced acute toxicity test failures with the 100% final effluent sample from the ground water treatment system. VDEQ requested a plan from Cytec to address these results and to evaluate the condition of the river with respect to the river's resident biological communities. Cytec does not believe the standard bioassay test accurately reflects the actual, current, natural conditions in the river. As such, Cytec proposed a different approach to evaluate the effects of the discharge from the ground water treatment system on the stream habitat and water quality of the Piney River. Cytec's proposal and follow-up work plan, dated December 12, 2003 and February 13, 2004, respectively, were approved by VDEQ on February 24, 2005 with two changes: 300 organisms were to be sorted from each benthos sample rather than 200 included in the work plan and relocating the most downstream sampling location. VDEQ approved relocating the downstream sampling location on April 11, 2005. Sampling was conducted on April 28 and September 8, 2005, and the final monitoring report indicated that: "the results of both the April and September 2005 sampling events demonstrated that the benthic macroinvertebrate community is healthy and thriving in the Piney River upstream, adjacent to, and downstream of the final effluent discharge from the ground water treatment." VDEQ reviewed both reports and, since they had concerns about the

biotic indices used to evaluate the benthos in the Piney River, they indicated they would perform their own review of the data.

VDEQ requested a sampling plan for continued benthos monitoring. Cytec submitted the requested sampling plan on January 28, 2008. A conference call was held with VDEQ and Cytec on June 9, 2008 to discuss the proposed reduction in sampling effort to water quality and benthos collection adjacent to the site only. VDEQ agreed to the reduced sample collection; however, if the results showed degradation in the benthic community, sampling would resume at Stations 1 and 3 during subsequent events. Sampling was scheduled for Spring 2009, and Cytec agreed to submit a revised work plan that included agreements made during the June 9 conference call, as well as a re-evaluation of historic benthos data using the Virginia Stream Condition Index (VSCI) to facilitate comparisons of the benthos over time. This work plan was submitted to VDEQ on July 27, 2009. Reports for spring and fall sampling were submitted to VDEQ on August 4 and December 22, 2009, respectively. VDEQ has approved the reports.

Piney River Monitoring

The monitoring program for the river consisted of semiannual water quality sampling and benthic macroinvertebrate surveys at three sample stations along the Piney River, until 2009. In 1991/1992, 1997, 1998, and 1999, the monitoring was conducted in April and September located upstream (approximately 1,800 feet upstream of the site), adjacent to (approximately 3,500 feet downstream of the site), and downstream (approximately four miles downstream of the site). In 2005, monitoring was conducted in April and September at the same upstream and adjacent locations as in previous years; however, the downstream location was relocated to approximately two miles downstream of the site. In 2009, monitoring was conducted in April and September at the adjacent location only. Water quality sampling included field measurements for temperature, dissolved oxygen, pH, and specific conductance and samples for laboratory analysis of alkalinity and total hardness.

In the spring and fall of 2014, Cytec performed sampling at Station 2 in the Piney River and the results, interpretations, and conclusions are contained in the 2014 Sampling Summary Report for the Benthic Macroinvertebrate Population Monitoring Report dated December 29, 2014 and submitted in January 2015. Although EPA and VDEQ are still reviewing the document, the conclusion in the report indicates that the results for the physical and chemical water quality analyses were normal and within acceptable ranges for Virginia streams and rivers. The habitat assessment and biological evaluations indicated continued acceptable habitats and healthy benthic macroinvertebrate communities living in those habitats at Station 2. Since the habitat assessments were consistent with previous assessments at Station 2, Stations 1 and 3 would not need to be sampled, as agreed with VDEQ.

Site Inspection

The site inspection was conducted on September 29, 2014. The purpose of the inspection was to observe the site conditions by making a visual inspection of the various components of the long-term response and to observe whether any development had occurred on or near the site. Attending the site inspection were Mr. Ken Milo, Manager of Site Remediation in the Environmental Services Department of Cytec Industries Inc., Mr. Bernly Bressler and Mr. Richard Dulcey, ERM, the environmental engineering and consulting firm representing Cytec, Codey Hoehna, ESS, consulting firm utilized by Cytec for environmental sampling, the operators of the ground water treatment system, Mr. Richard Criqui, VDEQ project manager, Mr. John McCloskey, U.S. Fish & Wildlife Service, and Mr. Andrew Palestini, RPM for EPA.

All eight of the contaminated areas described previously were visually inspected, as well as the surface areas above the ground water collection lines and the ground water treatment plant. The vegetation at all eight areas was in very good condition, with lush growth evident. The fencing, especially along the trail making up Area 8, appeared to be in satisfactory condition.

The two depressions in Area 5 were specifically inspected and we found the repaired area in such good condition that we were only able to locate them by looking for the markers left to identify the work area.

The ground water treatment plant was in good condition and appeared to be well maintained. This is attributed to the routine plant maintenance and process pipe cleaning. Performing preventive maintenance is very important, especially at this plant, because of the excessive amount of iron build-up in the system.

No development has occurred on or near the site. The only active facility observed on the site was the ground water treatment plant.

VII. Technical Assessment

The purpose of this section of the Five-Year Review is to answer the following three questions:

- Is the remedy functioning as intended by the decision documents?
- Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?
- Has any other information come to light that could call into question the protectiveness of the remedy?

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

Yes.

Portions of the remedy (erosion controls, soil neutralization, ground water treatment, and vegetation) are functioning as intended by the ROD and the three ESDs. In addition, institutional controls have been implemented. It is not known at this time whether the ground water collection system is effectively capturing all of the low pH ground water.

The remedy for Area 5 (improving flood protection to meet the 100-year flood event by rebuilding the dikes, re-grading the sedimentation area to enhance storm water drainage, installing a clay cap over the sedimentation area, and establishing a vegetated cover) is successfully preventing direct erosion of acidified soil and sediment into Piney River.

The vegetation at all seven of the contaminated areas as well as the surface areas above the ground water collection lines and the ground water treatment plant is in very good condition, with lush growth evident. All fencing appeared to be in satisfactory condition.

The ground water collection and treatment system was designed and constructed to intercept the acidic and high iron containing ground water, convey the collected ground water to the treatment plant, treat it to meet the discharge limits set by VDEQ, and discharge it to the Piney River. Low pH is still consistently detected in several monitoring wells located beyond the ground water collection system. In addition, low pH has recently been detected in the surface water in the drainage way along the trail in Area 8 and in the feeder streams. At this time, the source of the low pH is not known. To temporarily alleviate this situation in the surface drainage ways until the source is identified and a permanent remedy selected, EPA approved Cytec's proposal to place limestone dams in these surface drainage ways to increase the pH. This temporary action has addressed the low pH. However, a permanent solution is being considered.

While the cause for the bioassay test failures in the plant effluent discharge to Piney River has not been determined, Cytec has conducted benthic macroinvertebrate studies that indicate the plant effluent to the river is not causing toxicity to organisms in the river.

The institutional controls have been implemented. The Restrictive Covenants executed by the Piney River Recovery Corporation and Nelson County accomplish the following:

- ensure that drinking water supply wells are not installed or used on-site;
- that on-site activities do not adversely affect or interfere with the selected remedy; and,
- public use of the site is limited or restricted to areas that are considered safe and appropriate for general use.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?

No.

There have been changes in risk assessment methods, exposure assumptions, and toxicity data since the ROD was issued. However, the protectiveness of the soil neutralization, capping, and surface water remedies would still be valid regardless, provided the on-site remediated pH is maintained.

Have the 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 changed so as to affect the protectiveness of the remedy?

The remediation action objective (RAO) set in the ROD (1989) for the U.S. Titanium site is:

1. Source control for all areas of the site currently impacting ground water and surface water discharging from the site into the Piney River.

The remedial action appears to be preventing future fish kills in the Piney River by eliminating most of the sources of acidic discharge and treating the ground water prior to release into the river. Additional sampling of the Piney River will be undertaken to determine if low pH water is discharging to the river.

The ground water treatment plant routinely meets the discharge limits set by VDEQ.

To resolve effluent toxicity questions, Cytec conducted benthic macro invertebrate monitoring in 2005 and 2009 in accordance with VDEQ-approved work plans. Results of the monitoring indicated the benthic community is thriving in Piney River and has improved in diversity and condition over time. The effluent discharge is not impacting the benthic community in the river.

The evaluation of the remedy for ground water is difficult, as the 1989 ROD did not appear to consider human health a primary concern or establish ARARs for ground water. Due to the low pH and iron observed in ground water (both in monitoring wells and ground water treatment facility influent), it can be concluded that the ground water has not been restored to potable quality. However, the ground water is not currently a source of potable water and institutional controls have been established to prevent use as potable source. Of important note, the ground water collection system may not be operating as planned, as evidenced by the occurrence of low pH and iron in ground water monitoring well 1 and along the drainage ditches parallel to the trail, both of which are down gradient from the ground water collection system.

Changes in Exposure Pathways

Have land uses or expected land uses on or near the site changed? Have 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 byproducts of the remedy not previously addressed?

There are no new land uses, routes of exposure or receptors, newly identified contaminants, or unanticipated toxic byproducts.

The source of the acidic surface water in the drainage ditches along the trail is unknown and will be investigated.

Changes in Toxicity and Other Contaminant Characteristics

Have toxicity factors 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?

Toxicity factors have changed since the 1989 ROD. This is not expected to affect the protectiveness of the soil neutralization, capping, ground water collection and treatment, erosion controls, re-vegetation, and institutional controls.

Changes in Risk Assessment Methods

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

There have been changes in methods since the 1989 ROD; however, the updated guidance would not affect the protectiveness of the remedy.

Expected Progress Towards Meeting RAOs

Is the remedy progressing as expected? Have physical site conditions or the understanding of these conditions changed in a way that could affect the protectiveness of the remedy?

The capping, re-vegetation, ground water treatment, and institutional controls appear to be functioning as designed. The functionality of the ground water collection system is unknown, as acidic surface water with orange sediment and ground water with iron concentrations that may pose health risks have been observed down gradient of the collection system.

It is recommended that the source of the acidic surface and ground water observed beyond the ground water collection system be investigated.

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 other than that which has been previously identified.

Technical Assessment Summary

The remedial action objective in the ROD is to control risks posed by acidic discharges into ground water and the Piney River. Portions of the remedy, including erosion controls, soil neutralization, ground water treatment, and re-vegetation, are controlling the acidic discharges which occurred in the past, as intended by the ROD and the three ESDs. By eliminating most of the sources of acidic discharge into the river, the remedial action is preventing future fish kills. However, low pH is still detected in monitoring wells located beyond the ground water collection system. In addition, failures have occurred in the bioassay tests on the treatment plant discharge to the river. To resolve effluent toxicity questions, Cytec conducted benthic macroinvertebrate monitoring in 2005 and 2009 in accordance with VDEQ-approved work plans. Results of the monitoring indicated the benthic community in Piney River has improved in diversity and condition over time. The effluent discharge is not impacting the benthic community in Piney River.

At present, the source of the low pH surface water in the drainage along the trail in Area 8 is unknown but, for the interim, EPA approved the placement of limestone dams in the drainage way and the feeder streams to increase the pH. This work has been completed by Cytec. This temporary action has addressed the low pH. However, a more permanent solution is being considered.

The institutional controls included in ESD Number 3 are: to insure that drinking water supply wells are not installed or used on-site; that on-site activities do not adversely affect or interfere with the selected remedy; and, that public use of the site is limited or restricted to areas that are considered safe and appropriate for general use. These institutional controls have been implemented through restrictive covenants by both the Piney River Recovery Corporation and Nelson County.

VIII. Issues

The purpose of this section is to provide details on any issues related to the current site operations, conditions, or activities which would prevent the remedy from being protective.

Table 4: Issues

Issues	Affects Current Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
Low pH water has been detected in the surface drainage along the trail in Area 8 and the feeder drains.	No	Yes
Low pH continues to be detected in monitoring wells located beyond the ground water collection system.	No	Yes
Two depressions were detected in Area 5.	No	Yes

IX. Recommendations and Follow-Up Actions

The purpose of this section is to specify the required and suggested improvements to current site operations, activities, remedy, or conditions.

Table 5: Recommendations and Follow-Up Actions

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Low pH has been detected in the surface water in the drainage along the trail in Area 8 and the feeder drains.	Investigate the source of the low pH, propose a plan to remediate the problem if this continues, and determine whether the low pH is impacting the Piney River and ecological receptors in the drainage way. Also, re-evaluate the monitoring program to ensure that it addresses current site needs.	Cytec	EPA & VDEQ	12/30/16	No	Yes
Low pH continues to be detected in monitoring wells located beyond the ground water collection system.	Perform an analysis to determine why low pH is still occurring in monitoring wells located beyond the ground water collection system. An optimization of the ground water collection system may be necessary.	Cytec	EPA & VDEQ	12/30/16	No	Yes
Two depressions occurred in the soil cover in Area 5.	Area 5 should be visually inspected yearly for the next three years to assure that no other depressions are formed.	Cytec	EPA & VDEQ	12/1/15 12/1/16 12/1/17	No	Yes

X. Protectiveness Statement

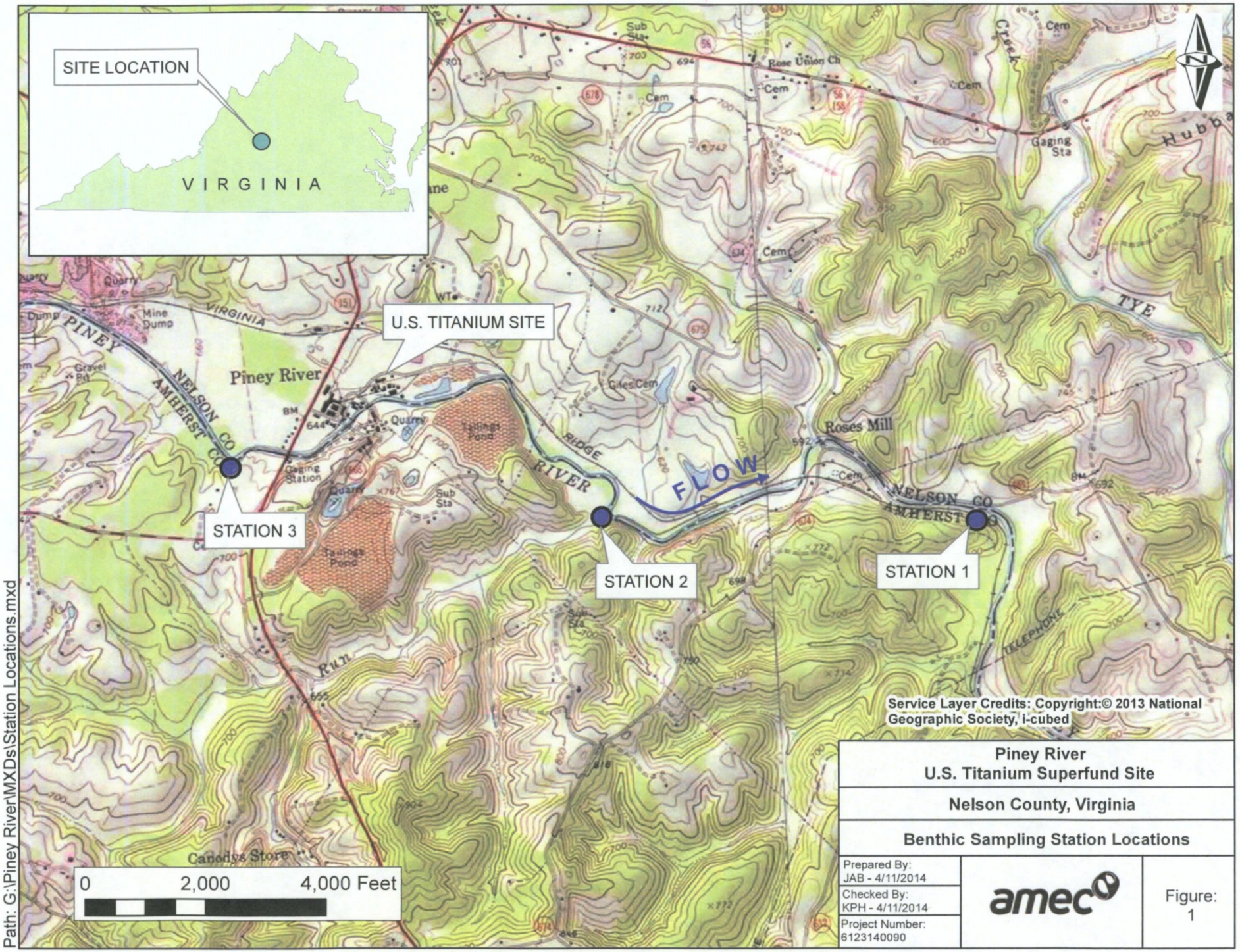
The remedy for the site is protective of human health and the environment in the short term and is expected to be protective in the long term after the issues identified in this five-year review have been adequately addressed. Exposure pathways that could result in unacceptable risks are being controlled. Acidic soils have been neutralized and capped, thus eliminating the direct contact exposure pathway. By eliminating most of the sources of acidic discharge into the river, the remedial action is preventing future fish kills. EPA will direct Cytec, the Potentially Responsible Party (PRP), to: perform an analysis to determine why low pH is still occurring in monitoring wells located beyond the ground water collection system; investigate the source of the low pH discovered in the surface drainage ways at the site and to propose a plan to address this situation; determine whether the low pH is impacting the Piney River and if the addition of lime into the drainage ways is preventing leaching of metals and degradation of the Piney River; and re-evaluate the monitoring program to ensure it addresses current site needs. An optimization of the ground water collection system may be necessary.

Although the depression in Area 5 was remediated by Cytec, this area should be specifically inspected at least yearly for the next three years to assure that the protective soil cover remains in good condition.

The institutional controls have been implemented. The Restrictive Covenants executed by the Piney River Recovery Corporation and Nelson County accomplish the following: ensure that drinking water supply wells are not installed or used on-site; that on-site activities do not adversely affect or interfere with the selected remedy; and, public use of the site is limited or restricted to areas that are considered safe and appropriate for general use.

XI. Next Review

Since site conditions do not allow for unlimited use and unrestricted exposure, EPA will conduct another Five-Year Review of the U.S. Titanium site by March 2020, five years from the date of this review.



Path: G:\Piney River\MXDs\Station Locations.mxd

Piney River
U.S. Titanium Superfund Site

Nelson County, Virginia

Benthic Sampling Station Locations

Prepared By: JAB - 4/11/2014 Checked By: KPH - 4/11/2014 Project Number: 6123140090	amec	Figure: 1

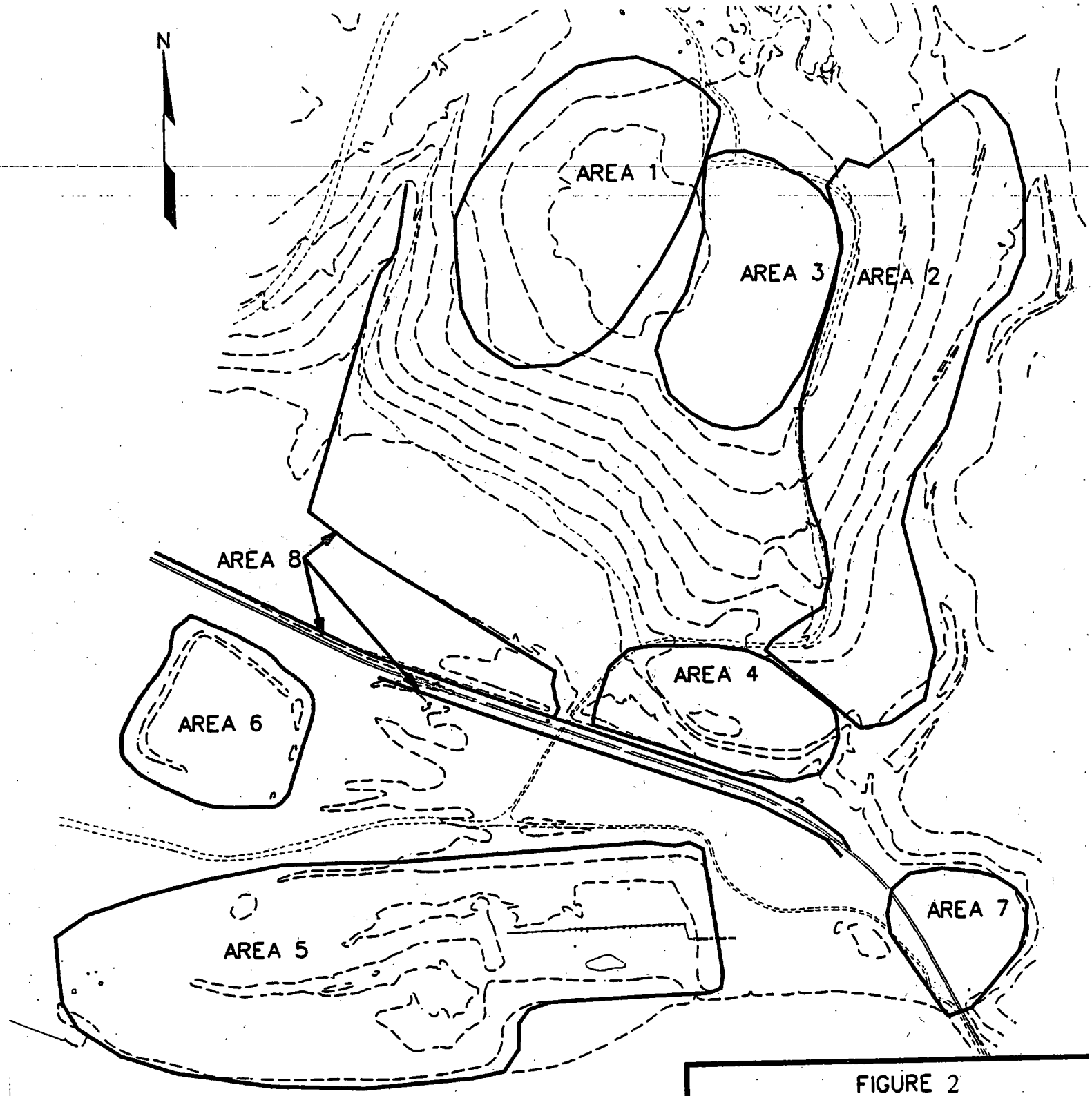


FIGURE 2

REMEDIATION AREAS
US TITANIUM SUPERFUND SITE
PINEY RIVER , VIRGINIA

RD/RA AREAS

Wiley & Wilson
ARCHITECTS ENGINEERS PLANNERS
LYNCHBURG, VIRGINIA

300' 0 300'

File Name: SiteArea.dgn

BY FTA APPROVED SWL