April 15, 2019

Mr. Jeff Dewey
Land Recycling Program
Pennsylvania Department of Environmental Protection
400 Waterfront Drive
Pittsburgh, Pennsylvania 15222

Dear Mr. Dewey:

Subject: Transmittal of Act 2 Final Report
Shenango Coke Plant
200 Neville Rd, Pittsburgh, PA 15225
CEC Project 160-554

Enclosed are two copies of the Act 2 Final Report for the former Shenango Coke Plant located at 200 Neville Road, Pittsburgh, PA 15225. The report has been prepared in general accordance with Section II.B.3 of the Land Recycling Program Technical Guidance Manual (TGM) published on January 19, 2019, which provides guidance for Streamlined Reporting Requirements for the Site-Specific Standard When No Current and Future Complete Exposure Pathways Exist. This approach was discussed with, and approved by, Mr. Tom Buchan of the PADEP on October 4, 2018 and has been selected for the former Shenango Coke Plant.

Also enclosed with this submittal are a PADEP Transmittal Sheet for Report/Plan Submission, a check for $500 for the review fee, the Final Report Summary Form, and a copy of the newspaper and municipality notices. The certified mail receipt and proof of publication will be submitted under separate cover. Please call with any questions.

Very truly yours,

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

Robert A. Eaton
Project Manager

Martin C. Knuth
Vice President

Enclosures

160-554-L-RIR-RA-CP-FR-4.15.19/P

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF ENVIRONMENTAL CLEANUP AND BROWNFIELDS
LAND RECYCLING PROGRAM

Land Recycling Program
Transmittal Sheet for Plan/Report Submission

Instructions: Please provide all requested information in each of the four sections. This transmittal sheet shall accompany any plan/report submitted to the Department under the Land Recycling Program. Proper completion of the Transmittal Sheet will assist Department review and may avoid a finding of plan/report deficiency. The Facility ID number can be obtained from the Department's Environmental Cleanup Program in the region where the site is located.

Section 1 - Site Identification

eFACTS Facility ID eFACTS PF# 821728; eFACTS Activity 50989; LRP# 5-2-928-19590

Site Name Shenango Coke Plant

Site Address 200 Neville Rd. Pittsburgh, PA 15225

Municipality and County Neville Township; Allegheny County

Section 2 - Remediation Standard . . Plan/Report . . Fees

Identify the remediation standard being pursued and the type of plan/report being submitted. Please note required Department fees follow each type of plan/report.

Check the relevant standard and the type of plan/report being submitted.

☐ Background Standard
Final Report ($250 fee)

☒ Site-Specific Standard

- ☐ Remedial Investigation Report ($250 fee)
- ☐ Risk Assessment Report ($250 fee)
- ☐ Cleanup Plan ($250 fee)
- ☒ Final Report ($500 fee)

☐ Statewide Health Standard
Final Report ($250 fee)

☐ Special Industrial Area

- ☐ Work Plan (no fee)
- ☐ Baseline Environmental Report (no fee)

Ensure your check covers all required fees and is made payable to the **Commonwealth of Pennsylvania**.

Section 3 - Municipal/Public Notice Confirmation

There are two stages in the Land Recycling Program where municipal and public notices are required. Read the information associated with each stage. You will be asked to confirm that information establishing your compliance with these notification requirements has been included with this submission.

☐ Check here if you are planning to meet the Background or Statewide Health Standard and your Final Report has been submitted within 90 days of the release.

Indicate date of release here _____

No further completion of this section is required if your Final Report for these two standards conforms to the 90 day time frame.

Stage 1 - Notice of Intent to Remediate (NIR)

☒ Check here to confirm you have included proof that a copy of your NIR was provided to each municipality where your site is located. Proof will be a copy of your cover letter and a copy of a signed certified mail receipt slip from the municipality.

☒ Check here to confirm a copy of a proof of publication document from a newspaper serving the area of your site has been included with this submission.

☐ Check here to indicate that a Site-Specific Standard or a Special Industrial Area is involved and a municipal request was received for development of a public involvement plan. The plan/report submission shall include municipality and public comments, which were submitted, and your responses to those comments.

Stage 2 - Cleanup Plan/Report Submission

4/15/2019 Place date here that each municipality was notified of any plan or report submitted under any of the three remediation standards.

Pittsburgh Post Gazette scheduled for 4/18/2019 Place the newspaper name and date that your notice of your plan/report submission was published.

Section 4 - Project Contact

On the lines below, place the name, company, mailing addresses and business phone number of the individuals who can be contacted regarding this submission:

Consultant

Contact Person/Title: Martin Knuth/Vice President

Phone Number 412 429-2324

Email Address mknuth@cecinc.com

Company Name: Civil & Environmental Consultants, Inc

Mailing Address (street, city, state, zip)
333 Baldwin Rd. Pittsburgh, PA 15205

Remediator

Contact Person/Title: Ronald Burnette / Director of Operations

Phone Number 313 297-4258

Email Address ronald.burnette@dteenergy.com

Company Name: Shenango, LLC

Mailing Address (street, city, state, zip)
414 South Main St. Ann Arbor, MI 48104

Other

Contact Person/Title:

Relationship to Site
(e.g. owner, participant in cleanup, responsible party, etc.)

Phone Number

Email Address

Company Name:

Mailing Address (street, city, state, zip)

149494

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.
333 BALDWIN ROAD
PITTSBURGH, PA 15205
(412) 429-2324

PNC BANK, N.A.
Pittsburgh, PA

8-9/430

CHECK DATE 4/8/2019

PAY Five Hundred and 00/100 Dollars

AMOUNT 500.00

TO Commonwealth of Pennsylvania

AUTHORIZED SIGNATURE

Security features. Details on back

⑈149494⑈ ⑆043000096⑆ 0002272405⑈

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

149494

Check Date: 4/8/2019

Invoice Number	Date	Voucher	Amount	Discounts	Previous Pay	Net Amount
04082019	4/8/2019	000000333690	500.00			500.00
Commonwealth of Pennsylvania - Operating Account 7 00421		TOTAL	500.00			500.00

2610-FM-BECB0011 Rev. 12/2015

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF ENVIRONMENTAL CLEANUP AND BROWNFIELDS

For DEP Use Only
PF #_____
Rem ID #_____

FINAL REPORT SUMMARY

The Final Report Summary (FRS) is a brief report consisting of set of data required in addition to the Act 2 Final Report. The summary is used in part as a reference to the Final Report Approval Letter which conveys liability relief to the remediator and other applicable persons. It is of value long after the remediation to be used by the public and Department in understanding key information about the site and remediation.

This use is increased by the fact that it will ultimately be merged into the Department's eFACTS system, which allows the public to have the ease of computer access to environmental information at sites. For more information, see www.ahs.dep.pa.gov/eFACTSWeb/default.aspx. Finally, the summary will be used by the Department to help to better assess the status and the level of success of the program. In the past, numbers of sites remediated has been tracked. With the inclusion of this summary information, progress can be tracked in many specific ways, including identification of individual chemical constituents, and the mass treated, removed or managed safely in place.

Identification

Property Name Shenango Coke Plant

Property Descriptor eFACTS PF# 821728; eFACTS Activity 50989; LRP# 5-2-928-19590

Address / Location

Address 200 Neville Rd

City Pittsburgh Zip Code 15225

Municipality(s) Neville Twp. County(ies) Allegheny

Latitude 40 º (deg). 29 ' (min) 47 " (sec) Longitude 80 º (deg). 4 ' (min) 35 " (sec)

Horizontal Collection Method _____

Horizontal Reference Datum _____ Reference Point _____

Property Specifics

Size of Property 49.6 acres Number of Sites 1

Combined acreage of sites 49.6

Remediation

Standards attained or special industrial area attainment. (Check all that apply. Can use multiple.)

☐ Background ☐ Statewide Health ☒ Site-Specific ☐ Special Industrial Area

Proposed future property use - scenario for which the attainment of Statewide Health standard is demonstrated

☐ Residential ☒ Non-residential

List of contaminants

Soils

Chemical Name	CAS Number	Mass Contaminant Treated or Removed (lbs.)	Mass Contaminant Managed on Site (lbs.)
Benzene	71-43-2		5215
Benzo(a)anthracene	56-55-3		5,391
Benzo(a)pyrene	50-32-8		4,668
Benzo(b)fluoranthene	205-99-2		4,676
Benzo(k)fluoranthene	207-08-9		882
Dibenz(a,h)anthracene	53-70-3		389
Indeno(1,2,3-cd)pyrene	193-39-5		1,180
Naphthalene	91-20-3		41,275
Anthracene	120-12-7		7,325
Chrysene	218-01-9		4,426

Groundwater

Chemical Name	CAS Number	Mass Contaminant Treated or Removed (lbs.)	Mass Contaminant Managed on Site (lbs.)
Benzene	71-43-2		687
Styrene	100-42-5		21
Tetrachloroethene	127-18-4		0.4
Toluene	108-88-3		59
Anthracene	120-12-7		5
Benzo(a)anthracene	56-55-3		2
Benzo(a)pyrene	50-32-8		0.2
Benzo(b)fluoranthene	205-99-2		0.2
Chrysene	218-01-9		0.2
Naphthalene	91-20-3		280

Remediation

Number of sampling rounds for groundwater attainment: 8

Special Features

Non-use aquifer approval date: NA

Area-wide background approval date: NA

Amount of waste removed other than soil or groundwater (cubic yards): 24,020 tons solid waste; 38,848 gal liquid waste

☒ **Municipal ordinance prohibiting groundwater use:**

Township of Neville Ordinance No. 846

☒ **Post remediation care plan:**

Provided as Appendix O of combined Remedial Investigation Report (RIR)/Final Report

List of Soil contaminants continued

Chemical Name	CAS Number	Mass Contaminant Treated or Removed (lbs)	Mass Contaminant Managed on Site (lbs)
Arsenic	7440-38-2		1305
Ammonia	7664-41-7		493781
2-Hexanone	591-78-6		84
Styrene	100-42-5		527
Toluene	108-88-3		3237
Benzo(g,h,i)perylene	191-24-2		732
Fluoranthene	206-44-0		7619
Antimony	7440-36-0		90
Lead	7439-92-1		1514
Mercury	7439-97-6		120
Total Phenolics	NA		2792

List of Groundwater contaminants continued

Chemical Name	CAS Number	Mass Contaminant Treated or Removed (lbs)	Mass Contaminant Managed on Site (lbs)
Arsenic	7440-38-2		3
Cadmium	7440-43-9		0.4
Chromium	7440-47-3		0.6
Lead	7439-92-1		0.8
Nickel	7440-02-0		11
Selenium	7782-49-2		1
Zinc	7440-66-6		13
Ammonia	7664-41-7		43388
Total Phenolics	NA		81

Other Programs

☐ Key Site

☐ Multi-site Agreement; Date: _____

☐ Enterprise Zone

☐ Keystone Opportunity Zone

Administrative

☐ Municipality request for public involvement plan

Deed notification

☐ Deed acknowledgment:

☒ Environmental covenant:

A UEC for the Site will eliminate potential future exposure pathways to COCs in soil, air and groundwater. The UEC will require implementation of the following engineering and institutional controls at the Site:

1) Groundwater usage at the Site will be prohibited for any and all purposes
2) Land usage at the Site will be restricted to non-residential use
3) Construction of future buildings at the Site will require an evaluation of potential VI sources at the time future buildings are planned/constructed to determine if a complete VI pathway exists. If further evaluation indicates a complete VI pathway exists for planned future buildings, or in lieu of further evaluation, mitigation will be required as a means of eliminating or reducing vapor migration into future onsite buildings. Mitigation will involve the installation of an active sub-slab depressurization system or the installation of a vapor barrier to prevent VI into future buildings. In addition, construction of inhabited basements will be prohibited in the former byproducts area.
4) Prior to future construction activities at the Site, preparation of a HSP will be required to protect onsite workers during construction activities.
5) Prior to future excavation activities at the Site, preparation of a SMP will be required that describes the methods to field screen soils excavated from the Site and determine the applicability for site re-use or off-site disposal.
6) The soil cover areas, consisting of nominally six inches of cover material comprised of construction/demolition debris from the Site (e.g. uncontaminated concrete, brick, block, etc.) or commercially-purchased cover material, located over soil that is impacted with COCs shall remain in place and be properly maintained to prevent direct contact to the soil underneath.

Cleanup cost ($): 8,000,000

Jobs created/saved: Undetermined

Narrative: Provide property history and description, site characterization findings, site description, summary of remediation, summary of attainment demonstration, description of pathway elimination, engineering and institutional controls, and benefits of land reuse, when applicable.

Review of the history of the Site indicates that the Site was originally utilized for agriculture prior to 1900. In 1900, the Site was purchased and operated as a steel-making operation until the 1920's. From the 1920's to 2016, the site was used for coking operations, iron and coke production, miscellaneous chemicals production, and cement and activated carbon production. In 2016, operations ceased at the Site, residual raw materials and waste products were removed, and process tanks and vessels were cleaned in anticipation of Site demolition. Site structures and equipment were demolished in 2018.

The site is underlain by fill and alluvium. Groundwater flow across the Site is generally from the Ohio River into Neville Island prior to flowing in a northwestward direction down the axis of the island.

The Remedial Investigation shows that releases of contaminants from historic Site operations, and potentially from offsite operations, have impacted Site soil and groundwater. The primary areas of impacted soil and groundwater occur in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, and a former above-ground storage tank area in the westernmost portion of the Site. The main contaminants in both soil and groundwater are volatile and semi-volatile organic compounds, metals, and ammonia.

Fate and transport analysis indicates that contaminated groundwater is migrating offsite in a northwesterly direction downgradient of the former byproducts area; however, groundwater is not being used in the impacted area.

The results of a screening-level ecological risk assessment indicate that no species or habitats of concern have been identified at the Site, and no substantial ecological risk exists at the Site.

A human health risk assessment completed for the Site indicates that all current and future exposure pathways to human receptors have been eliminated through pathway elimination measures, including both engineering and institutional controls. Engineering controls to be implemented at the Site include the placement of a soil cap over areas of surface soil contamination and the use of vapor mitigation measures for future buildings constructed onsite. Institutional controls include requirements for land usage at the Site to remain non-residential, requirements for a Health and Safety Plan and Soil Management Plan during future construction activities, and restrictions on groundwater usage, all of which will be required through implementation of a Uniform Environmental Covenant (UEC).

Remediator / Property Owner / Consultant. Complete the form below for *each* recipient obtaining a release of liability upon approval of the final report. Attach additional sheets as necessary.

Remediator

Contact Person/Title Ronald Burnette / Director of Operations eFACTS Client ID* _____

Relationship to Site owner's representative Client Type* _____
(e.g. owner, remediator, participant in cleanup, consultant, etc.)

Phone Number 313 297-4258 Email Address ronald.burnette@dteenergy.com

Company Name Shenango, LLC EIN or Federal ID # _____

Street Address 414 South Main St.

City Ann Arbor State MI Zip Code 48104

Property Owner

Contact Person/Title Ronald Burnette / Director of Operations eFACTS Client ID* _____

Relationship to Site owner's representative Client Type* _____
(e.g. owner, remediator, participant in cleanup, consultant, etc.)

Phone Number 313 297-4258 Email Address ronald.burnette@dteenergy.com

Company Name Shenango, LLC EIN or Federal ID # _____

Street Address 414 South Main St.

City Ann Arbor State MI Zip Code 48104

Consultant

Contact Person/Title Martin Knuth eFACTS Client ID* _____

Relationship to Site consultant Client Type* _____
(e.g. owner, remediator, participant in cleanup, consultant, etc.)

Phone Number 412 429-2324 Email Address mknuth@cecinc.com

Company Name Civil & Envir Consultants, Inc EIN or Federal ID # _____

Street Address 333 Baldwin Rd

City Pittsburgh State PA Zip Code 15205

*Include eFACTS Client ID (if known) – "Client Types" below:

Association/Organization	Limited Liability Company	Partnership-General
Authority	Limited Liability Partnership	Partnership-Limited
County	Municipality	School District
Estate/Trust	Non-Pennsylvania Government	Sole Proprietorship
Federal Agency	Other (Non-Government)	State Agency
Individual	Pennsylvania Corporation	

Attachments: In addition to the data entered in this FRS, the Department requests scanned image(s) of a map view of the site indicating, at a minimum, the boundaries of the "site" relative to the locations of the adjacent property boundaries. The location of the site (as defined by Act 2) is that which will receive the liability relief conveyed by Act 2, Chapter 5. The maps may portray other features but should clearly show the Act 2 site boundaries. You may also attach other applicable image files or attachments. These files should be in Adobe Acrobat (*.pdf), GIF (*.gif) or JPEG file interchange format (*.jpg).

April 15, 2019

CERTIFIED MAIL

Ms. Jeanne Creese, Township Manager
Neville Township
5050 Grand Ave
Pittsburgh, Pennsylvania 15225

Dear Ms. Creese:

Subject: Transmittal of Act 2 Final Report
Shenango Coke Plant
200 Neville Rd, Pittsburgh, PA 15225
CEC Project 160-554

Notice is hereby given that Shenango LLC has submitted an Act 2 Final Report to the Pennsylvania Department of Environmental Protection (DEP) for the former Shenango Coke Plant located at 200 Neville Road, Pittsburgh, PA 15225. The document indicates that the remediation attained compliance with the site-specific cleanup standard. This notice is made under the provisions of the Land Recycling and Environmental Remediation Standards Act.

Very truly yours,

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

Robert Eaton
Project Manager

To be run in Pittsburgh Post-Gazette on April 18, 2019.

NOTICE OF SUBMITTAL OF FINAL REPORT

In accordance with the provisions of the Land Recycling and Environmental Remediation Standards Act (Act 2), notice is hereby given that Shenango LLC and Civil & Environmental Consultants, Inc. have submitted a Final Report for the former Shenango Coke Plant located at 200 Neville Rd, Pittsburgh, PA 15225. The report demonstrates that remedial efforts at the site have met the site-specific requirements of Act 2.

REMEDIAL INVESTIGATION REPORT/FINAL REPORT
FORMER SHENANGO COKE PLANT
200 NEVILLE ROAD
NEVILLE TOWNSHIP, ALLEGHENY COUNTY, PENNSYLVANIA

EFACTS PF# 821728
LRP # 5-2-928-19590

Prepared for:

SHENANGO, LLC
PITTSBURGH, PENNSYLVANIA

APRIL 2019

CEC PROJECT 160-554

Civil & Environmental Consultants, Inc.

Pittsburgh

333 Baldwin Road | Pittsburgh, PA 15205 | p: 412-429-2324 f: 412-429-2114 | www.cecinc.com

TABLE OF CONTENTS

Page

1.0 Introduction 1
- 1.1 Site Description 1
  - 1.1.1 Physical Setting 1
  - 1.1.2 Site Layout 3
  - 1.1.3 Description of Coke Making and By-Products Recovery Processes 3
- 1.2 Site History 10
- 1.3 Site Closure and Commencement of Act 2 14

2.0 Initial Site Conceptual Model 15

3.0 Site Characterization 17
- 3.1 Site Characterization Methodology 17
  - 3.1.1 Site Assessment Phase I 17
  - 3.1.2 Site Assessment Phase II 20
  - 3.1.3 Site Assessment Phase III 21
  - 3.1.4 Site Assessment Phase IV 23
  - 3.1.5 Site Assessment Phase V 25
  - 3.1.6 Quarterly Groundwater Monitoring 26
  - 3.1.7 Groundwater and Surface Water Elevation Monitoring 27
  - 3.1.8 Single-Well Permeability Tests 28
- 3.2 Site Characterization Findings 28
  - 3.2.1 Site Geology 28
  - 3.2.2 Site Hydrogeology 29
  - 3.2.3 Site Analytical Data 33
    - 3.2.3.1 Surface Soil 33
    - 3.2.3.2 Subsurface Soil 35
    - 3.2.3.3 Groundwater 37
    - 3.2.3.4 LNAPL 39

4.0 Identification of Chemicals of Concern 40
- 4.1 Surface Soil 40
- 4.2 Subsurface Soil 41
- 4.3 Groundwater 42

5.0 Nature and Extent of Contamination 43
- 5.1 Soils 43
  - 5.1.1 Surface Soil 43
  - 5.1.2 Subsurface Soil 45
  - 5.1.3 Summary of Extent of Soil Contamination 46
- 5.2 Groundwater 48
  - 5.2.1 COCs in Groundwater 49
  - 5.2.2 Summary of Extent of Groundwater Contamination 52

5.2.3 Groundwater Fate and Transport 54
5.2.3.1 Overview 54
5.2.3.2 Model Calibration 58
5.2.3.3 Predictive Modelling 66
5.2.3.4 Diffuse Groundwater Flow to the Ohio River 78
5.3 Vapor Intrusion 87
5.3.1 Introduction 87
5.3.2 Identification of Constituents of VI Concern 88
5.3.3 Identification of Potential VI Sources 93
5.3.4 Onsite VI Evaluation 94
5.3.5 Offsite VI Evaluation 95

6.0 Screening-Level Ecological Risk Assessment 101
6.1 Step 1 – Fundamental Concepts 102
6.1.1 Environmental Setting and Site History 103
6.1.2 Constituents of Potential Ecological Concern 104
6.1.3 Receptors and Chemical Migration Pathways 104
6.1.4 Habitats and Species of Concern 105
6.1.5 Wetlands Evaluation 106
6.1.6 Site Visit 106
6.1.7 Preliminary Exposure Pathway Analysis 108
6.2 Step 2 – Preliminary Exposure Estimate and Risk Assessment 108

7.0 Human-Health Risk Assessment 109
7.1 Site Characterization 109
7.1.1 COCs 109
7.1.2 Nature and Extent of Contamination 109
7.1.3 Conceptual Site Model 111
7.2 Exposure Assessment 111
7.2.1 Exposure Scenario 112
7.2.2 Potential Receptors 112
7.2.3 Summary of Complete Exposure Pathways 113
7.2.3.1 Surface Soil 113
7.2.3.2 Subsurface Soil 115
7.2.3.3 Groundwater 116
7.2.3.4 LNAPL 118
7.2.3.5 Surface Water 119
7.2.3.6 Summary and Final CSM 120

8.0 Cleanup Plan 121
8.1 Site Demolition and Cleanup 121
8.2 Placement of Cover Material 122
8.3 Uniform Environmental Covenant 123

8.4 Post-Remedial Care Plan 124

9.0 Limitations 125

10.0 References 126

11.0 Signatures and Certifications 127

FIGURES

Figure 1 – USGS Site Location Map
Figure 2 – Site Setting and Parcel Information
Figure 3 – Historic Site Layout
Figure 4 – Initial CSM
Figure 5 – Sample Location Map
Figures 6A/6B – Geologic Cross-Sections
Figure 7 – Groundwater and Surface Water Elevation Data
Figure 8 – Conceptual Groundwater Contour Map
Figure 9 – Site-Specific Groundwater Contour Map
Figure 10 – Act 2 MSC Exceedances – Surface Soil
Figure 11 – Tar Area Overview
Figure 12 – Act 2 MSC Exceedances – Subsurface Soil
Figure 13 – Act 2 MSC Exceedances – Groundwater
Figure 14 – Modelled Ammonia Plume at MW-8
Figure 15 – Modelled Benzene Plume at MW-9
Figure 16 – Modelled Ammonia Plume at MW-13
Figure 17 – Modelled Benzene Plume at MW-18
Figure 18 – Modelled Tetrachloroethene Plume at MW-12
Figure 19 – Modelled Thallium Plume at MW-7
Figure 20 – SV_{Soil} Exceedances
Figure 21 – SV_{GW} Exceedances
Figure 22 – Ecological Habitat Map
Figure 23 – Revised CSM
Figure 24 – Final CSM
Figure 25 – Soil Cover Areas

TABLES

Table 1 – Well Construction Details
Table 2 – Summary of Groundwater Sample Collection
Table 3 – Summary of Slug Test Results
Table 4 – Surface Soil Compared to MSCs
Table 5 – Subsurface Soil Compared to MSCs

Table 6 – Groundwater Compared to MSCs
Table 7 – Summary of LNAPL Thickness
Table 8 – Soil Bulk Density Data
Table 9 – Surface Soil Compared to SV_{Soil}
Table 10 – Subsurface Soil Compared to SV_{Soil}
Table 11 – Groundwater Compared to SV_{GW}

APPENDICES

Appendix A Offsite Groundwater Use Documentation
Appendix B Historic Aerial Photos
Appendix C Historic Sanborn Maps
Appendix D NIR and Public Notifications
Appendix E Aqtesolv Data Files
Appendix F Analytical Data Packages – Site Characterization
Appendix G Quick Domenico Model Files – Model Calibration
Appendix H Quick Domenico Model Files – Predictive Models
Appendix I Diffuse Groundwater Flux into Ohio River
Appendix J SWLOAD5B Model Files
Appendix K PNDI Receipt
Appendix L NWI Map
Appendix M Ecological Risk-Screen Site Photographs
Appendix N Analytical Data Packages – Site Demolition
Appendix O Post-Remedial Care Plan

EXECUTIVE SUMMARY

Shenango, LLC (Shenango) and Civil & Environmental Consultants, Inc. (CEC) have completed a Remedial Investigation of the former Shenango Coke Plant (Site) in Neville Township, Allegheny County, Pennsylvania in accordance with Pennsylvania's Land Recycling and Environmental Remediation Standards Act (Act 2).

Review of the history of the Site indicates that the Site was originally utilized for agriculture prior to 1900. In 1900, the Site was purchased and operated as a steel-making operation until the 1920's. From the 1920's to 2016, the site was used for coking operations, iron and coke production, miscellaneous chemicals production, and cement and activated carbon production. In 2016, operations ceased at the Site, residual raw materials and waste products were removed, and process tanks and vessels were cleaned in anticipation of Site demolition. Site structures and equipment were demolished in 2018. Following completion of remedial activities in accordance with Act 2, Shenango anticipates marketing the Site for sale and reuse for non-residential purposes.

The site is underlain by fill and alluvium. Groundwater flow across the Site is generally from the Ohio River into Neville Island prior to flowing in a northwestward direction down the axis of the island.

The Remedial Investigation shows that releases of contaminants from historic Site operations, and potentially from offsite operations, have impacted Site soil and groundwater. The primary areas of impacted soil and groundwater occur in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, and a former above-ground storage tank area in the westernmost portion of the Site. The main contaminants in both soil and groundwater are volatile and semi-volatile organic compounds, metals, and ammonia.

Fate and transport analysis indicates that contaminated groundwater is migrating offsite in a northwesterly direction downgradient of the former byproducts area; however, groundwater is not being used in the impacted area.

The results of a screening-level ecological risk assessment indicate that no species or habitats of concern have been identified at the Site, and no substantial ecological risk exists at the Site.

A human health risk assessment completed for the Site indicates that all current and future exposure pathways to human receptors have been eliminated through pathway elimination measures, including both engineering and institutional controls. Engineering controls to be implemented at the Site include the placement of a soil cap over areas of surface soil contamination and the use of vapor mitigation measures for future buildings constructed onsite. Institutional controls include requirements for land usage at the Site to remain non-residential, requirements for a Health and Safety Plan and Soil Management Plan during future construction activities, and restrictions on groundwater usage, all of which will be required through implementation of a Uniform Environmental Covenant (UEC).

The following report has been prepared in general accordance with the Land Recycling Program Technical Guidance Manual (TGM) published on January 19, 2019. Section II.B.3 of the TGM provides guidance for Streamlined Reporting Requirements for the Site-Specific Standard When No Current and Future Complete Exposure Pathways Exist. This section describes a preferred outline for providing a document that combines the site characterization and final report into a single document for review and approval by the Pennsylvania Department of Environmental Protection (PADEP). A preferred outline combining the site characterization and final report into a single document for review and approval by the PADEP is included in Table II-7 of the TGM. This approach was discussed with, and approved by, Mr. Tom Buchan of the PADEP on October 4, 2018 and has been selected for the former Shenango Coke Plant. This report contains the following main sections:

1.0 Introduction
2.0 Initial Conceptual Site Model
3.0 Site Characterization
4.0 Identification of Chemicals of Concern
5.0 Nature and Extent of Contamination
6.0 Screening-Level Ecological Risk Assessment

7.0 Human Health Risk Assessment

8.0 Cleanup Plan

9.0 Limitations

10.0 References

11.0 Signatures and Certification

1.0 INTRODUCTION

1.1 SITE DESCRIPTION

1.1.1 Physical Setting

The Shenango Coke Plant (Site) is located at 200-D Neville Road in Neville Township, Allegheny County, Pennsylvania. The Site is located in Lot 2A of the Shenango Plan No. 4, Plan Book Vol. 209, Page 11, and has an Allegheny County tax parcel ID of 0159-N-00135-0000-00. The Site is currently owned by Shenango, LLC. The general location of the Site and physiographic features of the surrounding area are shown on Figure 1, developed from the United States Geological Survey (USGS) topographic map for Pittsburgh West, Pennsylvania.

The Site is located in an industrial setting near the eastern (upstream) tip of Neville Island, an island within the Ohio River approximately five miles west of downtown Pittsburgh, Pennsylvania. The Site is comprised of an approximate 49.6-acre, irregularly-shaped parcel of land that generally spans the entire width of the island in the north-south direction. The main channel of the Ohio River is located along the northern boundary of the Site; the "back channel" is located to the south. The Site is generally flat except near the river where it is steeply sloped to the river. Improvements on the Site included buildings, tanks, coke ovens, and other associated facilities from the now-demolished former coke plant. Several mooring cells are located within the main channel of the Ohio River. As shown on Figure 2, the area surrounding the Site is developed with heavy and light industry, including the following:

- Lindy Paving owns the adjacent parcel northeast of the Site and operates an asphalt plant and river terminal for aggregate materials and bulk commodities.
- West View Water Authority owns the parcel of property east of the Site and operates a potable surface water withdrawal from the Ohio River.
- Calgon Carbon Corporation owns the parcel southeast of the Site and uses it for activated carbon regeneration.

- Kosmos Cement Company owns the property just south of Calgon. Their operations include packaging and distribution of cement products.
- Pittsburgh Activated Carbon owns the property southwest of Kosmos Cement.
- Ashland Inc. owns the adjacent property to the west and uses it to process various solvents.
- CSX Railroad operates the railroad along the southern boundary of the Ashland site.

According to a 2007 Arcadis Phase I Environmental Site Assessment (ESA) Report, the closest residence on the island is approximately 2.7 miles west of the Site on First Street.

Public utilities are available at the Site, and include the following:

- Water: Public water is supplied by Neville Township, which sources the water from West View Water Authority.
- Sanitary and Storm Sewerage: Sanitary waste is discharged to the public sewerage system operated by Neville Township, and ultimately to the Allegheny County Sanitary Authority (ALCOSAN). Storm water drains to National Pollution Discharge Elimination System (NPDES; Permit PA0002437)) outfall 001 and the Ohio River.
- Electric: Electricity on Neville Island is provided by Penn Power. Transmission is provided by Duquesne Light Company.
- Natural Gas: Natural gas is provided by Columbia Gas.

Groundwater in the vicinity of the Site is not currently used as a drinking water source, as the Township of Neville Ordinance No. 846 (Appendix A) requires that "Pursuant to the First Class Township code, § 2707, owners of property abutting the Neville Township water supply system shall connect with and use the same except for those industries or farms who have their own supply of water for uses other than human consumption". In addition, groundwater use on the immediately downgradient, adjacent Parcel # 159-E-50 (Ashland Inc.) is prohibited "for any purpose, including, but not limited to, drinking water supplies, agricultural operations, irrigation of crops or vegetation, cooling water, and industrial or manufacturing operations" in accordance with a Declaration of Restrictive Covenant dated December 24, 2007 (Appendix A), and in accordance with the Special Warranty Deed for the immediately downgradient, adjacent Parcel #

159-E-100 dated December 6, 2010 (Appendix A) "the installation of any water wells for drinking or irrigation purposes, or the use of any groundwater beneath the Property for any other purpose" is prohibited. The closest known downstream water users on the Ohio River are the surface-water intake for Sewickley, four miles downstream of the site (Earth Science Consultants, 1998b), and Robinson Township, 2.2 miles downstream of the site on the back channel.

1.1.2 Site Layout

Since circa the 1920's, the Site has been used for coke making and by-products recovery operations. A generalized site layout that depicts plant operations prior to demolition in 2018 is provided as Figure 3. Section 1.1.3 provides a generalized overview of the coke making and by-products recovery processes.

During recent plant operation, approximately 25 acres of the Site contained process equipment and the remaining 25 acres were used for storage of various types of equipment and miscellaneous materials such as coke breeze, coal and ore which were primarily stored in the northern portions of the Site. Process equipment at the Site included a coke battery, by-products plant, desulfurization plant, boiler house, office building, wastewater treatment plant, coal pulverizers/conveyors and coke conveyors/loading structure. Additionally, there were miscellaneous buildings located throughout the Site that housed maintenance activities or stored materials such as spare parts or building materials. As discussed in more detail in Section 1.2, there were additional historic operations and structures at the Site, such as a blast furnace, a powerhouse, and other miscellaneous structures that have been decommissioned over the years. As noted above, Site operations ceased in 2016, and Site structures and equipment were demolished in 2018.

1.1.3 Description of Coke Making and By-Products Recovery Processes

The following information was obtained from the www.ispatguru.com website and has been included here to provide a generalized overview of the coke making and by-products recovery process. Not all processes described below were necessarily utilized at the Site during its operation.

Overview

Coke is one of the basic materials used in blast furnaces for the conversion of iron ore into hot metal (liquid iron), most of which is subsequently processed into steel. Coke is a solid carbonaceous material produced by destructive distillation (also known as carbonization) of low ash and preferably low-sulphur bituminous coal. Coal is distilled in ovens at controlled temperature of about 1100 -1200 deg C, and coke is produced as a combustible residue consisting of residual ash and fixed carbon. During the process, the impurities present in coal, such as volatile matters (tars, oil, grease, etc), are driven off as a gas, which is then processed to remove tar, ammonia (usually recovered as ammonium sulphate), phenol, naphthalene, light oil, and sulphur before the gas is used as fuel for heating the ovens.

The coke oven by-product plant is an integral part of the by-product coke making process. During the production of coke in a coke oven battery, a large amount of gas is generated due to the vaporization of volatile matter in the coal. The gas is generated over most of the coking period. The composition and the rate of evolution changes during this period and is normally complete by the time coal charge temperature reaches 700 deg C. This gas is known as "raw coke oven gas" and is processed in the by-product plant. The functions of the by-product plant are to process the raw gas to recover valuable coal chemicals and to condition the gas so that it can be used as a clean, environmentally friendly fuel gas.

After leaving the coke oven chambers, the raw coke oven gas is sprayed with flushing liquor so as to reduce its temperature and condense the most easily condensable (high boiling point) components. The raw gas is cooled by adiabatic evaporation of some of the spray liquor to around 80 deg C and is water saturated. The temperature of the gas becomes sufficiently low so that it can be handled in the gas collecting mains. From the gas collecting main the raw coke oven gas flows into the suction main. The amount of flushing liquor sprayed into the hot gas leaving the oven chambers is far more than is required for cooling, and the remaining flushing liquor which is not evaporated provides a liquid stream in the gas collecting main. At this stage there are two streams, namely a liquid condensate stream and a gas stream. The two streams pass through a control valve

before leaving the coke oven battery area. This control valve is set to maintain a slightly positive pressure in the collecting main to provide safe working conditions in the coke oven chambers.

The liquid stream in the gas collecting main flushes away condensed tar and other compounds. The stream of flushing liquor flows under gravity into the suction main along with the raw coke oven gas. The raw coke oven gas and the flushing liquor are separated using a drain pot in the suction main. The flushing liquor and the raw coke oven gas then flow separately to the by-product plant for treatment prior to reuse in the coke oven battery.

Saturated raw gas coming from the coke oven battery contains around 46 % to 48 % water vapor. Other components of raw gas include hydrogen, methane, nitrogen, carbon monoxide, carbon dioxide, high paraffins, unsaturated hydrocarbons (ethane, propane, etc.), and oxygen, as well as various contaminants that give coke oven gas its unique characteristics, including the following:

- *Tar components*
- *Tar acid gases (phenolic gases)*
- *Tar base gases (pyridine bases)*
- *Benzene, toluene and xylene (BTX)*
- *Light oil and other aromatics*
- *Naphthalene*
- *Ammonia gas*
- *Hydrogen sulfide gas*
- *Hydrogen cyanide gas*
- *Ammonium chloride*
- *Carbon disulfide*

<u>Functions of a by-product plant</u>

In order to make raw coke oven gas suitable for use as a clean, environmentally friendly fuel gas, the by-product plant must carry out the following functions:

- *Cool the coke oven gas for condensing of water vapor and contaminants*
- *Remove tar aerosols to prevent gas line/equipment fouling*
- *Remove ammonia to prevent gas line corrosion*
- *Remove naphthalene to prevent gas line fouling by condensation*
- *Remove light oil for recovery and sale of benzene, toluene and xylene (BTX)*
- *Remove hydrogen sulfide to meet local emissions regulations governing the combustion of coke oven gas.*

In addition to treating the coke oven gas, the by-product plant must also condition the flushing liquor that is returned to the coke oven battery and treat the waste water that is generated by the coke making process.

Gas treatment processes

The gas treatment processes in the by-product plant typically consist of the following plant equipment.

Primary gas cooler – The primary gas cooler cools the raw coke oven gas to remove water vapor so as to reduce its volume. Primary coolers are of two basic types, the spray type cooler and the horizontal tube type. In a spray type cooler the coke oven gas is cooled by direct contact with a recirculated water spray, with the contact cooling water being itself cooled externally in heat exchangers. In the tubular type, the coke oven gas is cooled indirectly by flowing across horizontally mounted tubes through which cooling water is pumped. In this case, the cooling water does not come into contact with the coke oven gas and can be cooled in a cooling tower. As the coke oven gas is cooled, water, tar and naphthalene condense out. The condensate collects in the primary cooler system and is discharged to the tar and liquor processing plant described below.

Tar precipitators – As the raw coke oven gas is cooled, tar vapor condenses and forms aerosols which are carried along with the gas flow. These tar particles contaminate and foul downstream processes, gas lines and burner nozzles if allowed to continue in the gas stream. The tar precipitators typically use high voltage electrodes to charge the tar particles and collect them from

the gas by means of electrostatic attraction. The tar precipitators can be installed before, or after the exhauster.

Exhauster – The exhauster provides the motive force to induce the coke oven gas to flow from the coke oven battery and through the by-product plant. The exhauster is of prime importance to the operation of the coke oven battery. It allows the close control of the gas pressure in the collecting main, which in turn affects the degree of emissions in the coke oven battery, such as door emissions. A failure of the exhauster will immediately result in venting to the atmosphere all the generated raw coke oven gas through the battery flares.

Ammonia removal – Due to the corrosive nature of ammonia, its removal is necessary in by-product plants. The removal of ammonia from coke oven gas produces ammonium sulfate, a saleable product. The ammonium sulfate process basically involves contacting the coke oven gas with a solution of sulfuric acid. The different variations include the use of an absorber, in which the sulfuric acid solution is sprayed into the gas, or the use of a saturator in which the gas is bubbled through a bath of sulfuric acid solution. The sulfuric acid reacts readily with the ammonia in the coke oven gas to form ammonium sulfate, which is then crystallized, removed from the solution, dried and sold as a fertilizer.

More modern processes for ammonia removal include the water wash process in which the coke oven gas is scrubbed by water, which dissolves the ammonia, along with some hydrogen sulfide and hydrogen cyanide. The resulting scrubbing solution is pumped to an ammonia still where steam is used to strip out the ammonia. The ammonia vapors from the still can be processed to form ammonium sulfate similar to the processes described above, condensed to form a strong ammonia solution, incinerated or catalytically converted to nitrogen and hydrogen which are then recycled back into the coke oven gas.

Another process for ammonia removal from coke oven gas is the PHOSAM process developed by US Steel. This process absorbs the ammonia from the coke oven gas using a solution of mono ammonium phosphate. The process produces saleable anhydrous ammonia.

Final gas cooler – The final gas cooler removes the heat of compression from the coke oven gas which it gains while flowing through the exhauster. This is necessary since the efficiencies of many of the by-product plant processes greatly improve at lower temperature. The final gas cooler is therefore placed upstream of water wash ammonia scrubbers. Final gas coolers typically cool the coke oven gas by direct contact with a cooling medium, either water or wash oil. An important aspect of final gas cooler operation is that when the coke oven gas is cooled below the outlet temperature of the primary gas cooler, naphthalene will condense from the gas, will readily crystallize from the cooling medium and will foul equipment if not removed. In wash oil final gas coolers, the naphthalene dissolves in the wash oil and a side stream of oil is steam-stripped to remove the naphthalene. In water-based final gas coolers, the condensed naphthalene is absorbed using tar. The tar is either entrained in the cooling water, with a portion of the flow being continuously blown down for treatment, or it takes the form of a tar layer through which the cooling water flows. The tar is continuously exchanged with fresh tar from the tar and liquor processing plant to dispose of the absorbed naphthalene.

Naphthalene removal – Naphthalene is removed from coke oven gas in a gas scrubbing vessel using wash oil. The vessel can be a packed type or it can be of the 'void' type in which the wash oil is sprayed into the gas in several stages. The wash oil is regenerated by stripping out the naphthalene from the wash oil using steam in a still. In some plants, naphthalene removal is integrated with the similar process of light oil removal. The naphthalene is often recovered as a heavier oil stream which is then mixed with the tar produced in the by-product plant.

Light oil removal – This is a general term for a mixture of similar chemicals consisting mainly of benzene, toluene and xylene (BTX). It is also known as Benzol oil. The removal of light oil from coke oven gas uses wash oil in a similar process to that described for naphthalene removal. The light oil is stripped from the wash oil in a still and is then condensed to form crude light oil. This oil can either be sold for further refining offsite or it can be refined in the by-product plant using several distillation steps in the light oil plant. The light oil can actually be left in the coke oven gas, where it increases the calorific value.

Coke oven gas desulphurization – There are several different processes for removal of hydrogen sulfide from coke oven gas. The specific process determines where in the gas train it is installed. The main desulfurization processes in use are the vacuum process, ammonia process, wash process, sulfiban process, and claus process.

<u>Tar and liquor treatment processes</u>

The tar and liquor plant process the flushing liquor that circulates between the by-product plant and the coke oven battery. It also processes the waste water that is generated by the coke making process and which results from coal moisture and chemically bound water in the coal. The main functions of this plant are as follows.

- *Continuous rapid separation of a suitable flushing liquor stream. This is a very important function since this flow is needed to cool the hot oven gases to a temperature which can be handled in the gas collecting system. Since the flushing liquor supply is very important, stand by equipment are normally provided for flushing liquor decanting and recirculation.*
- *Separation of a clean and tar-free excess ammonia liquor for further processing.*
- *Separation of a clean tar essentially free from water and solids.*

The flushing liquor flows into tar decanters where the tar separates from the water and is pumped to tar storage units for processing in a tar distillation plant or for sale. Heavier solid particles separate out from the tar layer and are removed as tar decanter sludge. The aqueous liquor is then pumped back to the battery, with a portion, known as the coke plant 'excess liquor' or waste water, bled off from the circuit. The excess liquor contains ammonia and, after further removal of tar particles, is steam stripped in a still. An alkali such as sodium hydroxide is added in the still to decompose ammonia compounds dissolved in the liquor. The ammonia vapor from the still is then either fed into the coke oven gas upstream of the ammonia removal system, or the still itself is often integrated into the ammonia removal system. Either way, the ultimate fate of the ammonia removed from both the coke oven gas and the waste water is the same. The stripped still effluent is either discharged or is treated in an on-site biological effluent treatment plant to remove residual ammonia, phenol and cyanides.

1.2 SITE HISTORY

According to a 2007 Arcadis Phase I ESA Report, the Site was originally utilized for agriculture (specifically an asparagus farm) prior to 1900. On February 8, 1900, 182 acres of land on the eastern portion of Neville Island, including the current ±49.6-acre Shenango Site and the adjacent properties currently occupied by Lindy Paving, West View Water Authority, Kosmos Cement, Calgon Corporation, Pittsburgh Activated Carbon, Ashland Inc., and the railroad tracks south of the Site currently owned by CSX Railroad, was purchased by American Steel and Wire and was operated as a steel-making operation (primarily steel wire and rod products) from 1900 to circa the 1920's.

During the late 1920's, the Davison Family purchased the 182-acre parcel of which the Site was a part and began coking operations (Davison Coke and Iron). In 1935, the Hillman Family purchased the 182-acre parcel and operated the site as Pittsburgh Coke and Chemical, which expanded operations at the Site to include iron and coke production, miscellaneous chemicals production, and cement and activated carbon production. In 1962, Pittsburgh Coke and Chemical transferred approximately 70 acres of the original 182-acre parcel, including its blast furnace and coke operations, to a newly-formed company (Shenango Incorporated) in exchange for a 50% equity interest in the new company. At the same time, Shenango Furnace Company (owned by the Snyder Family) contributed its ingot mold foundries in Mercer County, Pennsylvania and on Neville Island to Shenango Incorporated in exchange for the remaining 50% equity interest in the company. Over the next five years, the Snyder Family acquired the Hillman Family's interest in Shenango Incorporated and became the sole owners in 1967. In 1986, the Aloe family acquired 100% of the stock of Shenango Incorporated. By the end of 1990, the blast furnace and iron production at the Site permanently ceased operations, while coking operations continued. Following bankruptcy proceedings in 1994, Shenango Incorporated sold two parcels from the original 70-acre tract, leaving it with the approximately ±49.6 acres that currently comprises the Site. In 2008, the current owner, Shenango, LLC, purchased the ±49.6-acre Site from the Aloe family and continued to operate the Site as a coke-making and by-products recovery operation until 2016.

To further develop an understanding of historic site operations, aerial photographs of the Site from 1939, 1949, 1957, 1967, 1973, 1982, 1990, 1993, 2005, 2006, 2008 and 2010 and Sanborn Fire Insurance Company maps (Sanborn maps) from 1950 and 1965 were reviewed. Copies of the aerial photographs and Sanborn maps are included in Appendices B and C, respectively. Due to the size of the Site, individual Sanborn maps show only portions of the Site and need to be viewed together for a more complete evaluation. In addition, some portions of the Site were not mapped by Sanborn. A summary of our observations based on a review of these resources is provided below (note that directional descriptions are based on an assumed plant north as depicted on Site Figures (e.g. Figure 1).

Aerial Photographs

1939 – The 1939 photograph shows a coal conveyor system leading from the river to the coke batteries. The photograph also shows the by-products recovery area to the south of the coke batteries, and the pumphouse and boilerhouse in their current locations to the east. Also shown in the photograph is a former gas holder that was located along the current Site access road in the southeast portion of the Site, south of the office building. Railroad tracks and bulk material storage areas were located along the river. The area currently occupied by Ashland Chemical appears vacant.

1949 – The coke battery was enlarged. Stockpiles of coal and coke are evident along the river. The Site operations appear to have been expanded to the south onto what is now property occupied by Ashland Chemical, including the presence of large storage tanks just south of the current Site property line at the extreme western end of the Site.

1957 – The 1957 photograph shows the Site essentially unchanged from 1949 except that there appears to be a possible wastewater treatment plant constructed immediately north of the pumphouse, and a blast furnace north of the boilerhouse at the east end of the Site.

1967 – The 1967 photograph shows the Site essentially unchanged from 1957 except that there are two dark areas south of the blast furnace and boilerhouse at the east end of the Site in an area where an aboveground fuel storage tank was most recently located.

1973 – The 1973 photograph shows the Site essentially unchanged from 1967 except the two dark areas south of the blast furnace are no longer visible.

1982 – The 1982 photograph shows the Site essentially unchanged from 1973 except the aboveground fuel storage tank at the east end of the Site is now visible.

1990 – The 1990 photograph shows the Site essentially unchanged from 1982.

1993 - The 1993 photograph shows the Site essentially unchanged from 1990 except that several of the structures associated with the blast furnace at the east end of the Site have been demolished.

2005 – The 2005 photograph shows the Site essentially unchanged from 1993 except that several more structures associated with the blast furnace at the east end of the Site have been demolished. In addition, the western portion of the coke battery has also been demolished, as have two large aboveground tanks on the current Ashland Inc. property at the extreme west end of the Site, just south of the Shenango property boundary.

2006 – The 2006 photograph shows the Site essentially unchanged from 2005 except that the large gas holder along the access road south of the office building has been demolished.

2008 and 2010 - The 2008 and 2010 photographs show the Site essentially unchanged from 2006.

CEC also located an undated oblique aerial photograph shot from the northwest that clearly shows the coal conveyors and barges along the river, rail cars and the ore yard and rail crane. The by-products recovery plant, gas holder and blast furnaces can be seen in the background.

Sanborn Maps

1950 – The only portions of the Site mapped by Sanborn were the coke batteries and by-products recovery area and the coal/coke handling areas to the north. The owner of the Site was identified as the Pittsburgh Coke and Iron Co. The map shows that Grand Ave. passed through the current Ashland Inc. property and entered the Site from the west near the main office building. Operations/equipment present in the by-products recovery area included, from west to east:

Ammonia liquor coolers	Mother liquor storage tank	Wash oil coolers
Tar storage tanks	Flushing liquor decanters	Fuel gas holder
Ammonia liquor tanks	Dephenolizing tower	Iron oxide storage boxes
Sulphate storage bin	Benzol washers	Benzol product storage tanks
Acid storage tanks	Final cooler	Caustic soda and acid storage tanks
Primary coolers	Waste lime sump	Crude phenol storage tank
Tar precipitators	Residual drain tank	Meter building
By-products building	Benzol building and benzol pumphouse	Purification building
Tar saturators	Wash oil operating tanks	

The area to the north of the by-products recovery area included the coke oven batteries, quench tower, smoke stacks, coal and coke conveyors and railroad tracks. A conveyor leading to the east is labelled "coke conveyor to blast furnace No. 3". There is also a pumphouse shown to the northeast of the main office building.

1965 – The mapping from 1965 is less clear compared to the 1950 mapping, but appears to show the Site in essentially the same configuration as 1950. The owner of the Site was identified as Shenango Inc. Coke-Iron Ingot Molding.

1.3 SITE CLOSURE AND COMMENCEMENT OF ACT 2

In 2016, Shenango, LLC ceased operations at the Site and began the process of removing residual raw materials and cleaning out process tanks and vessels in anticipation of Site demolition. At that time, Shenango, LLC retained Civil & Environmental Consultants, Inc. (CEC) to act as its environmental consultant to assist with taking the Site through the Act 2 process. As discussed in more detail in Section 3.0, site assessment activities were initiated in late 2016 and continued through 2018. On September 29, 2017, a Notice of Intent to Remediate (NIR) was submitted to the Pennsylvania Department of Environmental Protection (PADEP) indicating that the planned remediation standard for Site soil and groundwater was the Site-Specific standard. Municipal and public notifications were made on September 21 and 25, 2017, respectively. Via letter dated October 4, 2017, the PADEP acknowledged receipt of the NIR and indicated that a 30-day comment period had begun to allow the municipality in which the Site is located (Neville Township) the opportunity to request involvement in the development of remediation and reuse plans for the property. No such request was made by the municipality during the 30-day comment period. Copies of the NIR, municipal and public notifications, and PADEP acknowledgement letter are provided in Appendix D.

Site structures and equipment were demolished in 2018 following the removal of residual raw materials and cleaning of process tanks and equipment.

2.0 INITIAL CONCEPTUAL SITE MODEL

The conceptual site model (CSM) provides a systematic way to identify and summarize potential or suspected sources of contamination at a Site, the types of contaminants detected at a Site, potentially-contaminated media and transport mechanisms, and potential exposure pathways and human receptors to ensure that potential exposures at the Site are accounted for accurately.

The initial CSM identifies all known potential sources of contamination (primary and secondary), transport mechanisms, potential exposure pathways, and potential human receptors that may exist at the Site in order to design a comprehensive site characterization plan that can be used to evaluate the Site. Potential impacts on ecological receptors are evaluated separately using the site characterization data and specific evaluation criteria, as described in Section 6.0. After the site characterization has been completed and the effects of future institutional and/or engineering controls (e.g. land use restrictions) have been incorporated, a final CSM is developed to serve as the basis for a risk assessment. The final CSM for the Site is provided in Section 7.0 of this report.

Figure 4 shows the initial CSM for the Site. As shown on Figure 4, historic site operations have impacted surface soils, subsurface soils and groundwater at the Site, and have resulted in one localized area of light, non-aqueous phase liquids (LNAPL). These media constitute secondary contaminant sources at the Site that may be transported to receptors via different mechanisms. For example, surficial soil contaminants interact with potential receptors via dermal contact, ingestion, or inhalation of dust or vapor emissions. Subsurface soil and/or LNAPL may leach contaminants to groundwater, come into direct contact with receptors, or release vapors into enclosed spaces or open air. Contaminated groundwater can be transported to receptors where it can be contacted directly, ingested, or inhaled, or it may impact surface water via diffuse flow or point-source discharges. Contaminated surface water and sediment can affect receptors through dermal contact or ingestion.

In order to evaluate potential current and future impacts of site contaminants on various receptors, CEC assessed the following as part of the site characterization described in this report:

- Concentration of contaminants in surface soil
- Concentration of contaminants in subsurface soil
- Concentration of contaminants in groundwater

The results of these investigations are described in Sections 3.0 through 7.0. The required site-specific screening-level ecological risk assessment is provided in Section 6.0 of this report. The final CSM, which takes into account the levels of contaminants detected, as well as current and future site use and planned engineering and institutional controls, is provided in Section 7.0 of this report.

3.0 SITE CHARACTERIZATION

Site characterization activities were conducted between September 2016 and October 2018 to satisfy the requirements of 25 Pa Code §250.408 regarding completion of a Remedial Investigation report under the Site-Specific standard. The work completed by CEC on behalf of Shenango was conducted as an iterative approach, whereby investigations were performed in periodic and successive phases to fully characterize the Site.

Prior to development of a site characterization plan, CEC interviewed former Shenango, LLC personnel concerning historic activities at the Site and reviewed various historic resources, such as Sanborn maps, Shenango, LLC drawings and files, aerial photographs, etc. to determine prior land uses and check for evidence of uncontrolled dumping, land disturbance, buildings, and other items of potential environmental significance. In addition, CEC and Shenango, LLC periodically met with PADEP personnel to discuss preliminary results from the site characterization and gain input from PADEP regarding future characterization efforts.

3.1 SITE CHARACTERIZATION METHODOLOGY

3.1.1 Site Assessment Phase I

Soil Boring Investigation – In September 2016, CEC advanced 11 soil borings at the Site (identified as MW-1 through MW-11). The location of each boring is presented on Figure 5. Additional information regarding sample locations, including well construction details, is provided in Table 1. Sample locations from Phase I of the site characterization were generally chosen to 1) provide soil and groundwater data from a variety of locations across the Site, with a focus on conditions near the Site property lines, and 2) provide groundwater elevation data sufficient to begin establishing the direction of groundwater flow at the Site under varying circumstances/seasons.

Prior to drilling activities, each borehole location was cleared with an air-knife to a targeted depth of six feet. Borings were then advanced using 4.25-inch hollow stem augers with split-spoon soil

samples collected continuously to borehole termination. During drilling, each borehole was logged for material description, and soils were screened for evidence of contamination by visual examination (staining), olfactory examination (odors), and by using a photoionization detector (PID). Two soil samples were collected for laboratory analyses from borings MW-1 through MW-3 and MW-7 through MW-11, one from the surface (0-2 feet) and one from the subsurface based on CEC's observations at the time of sampling. At borings MW-4 through MW-6, only a subsurface sample (> 2 ft below ground surface) was collected due to the presence of coal on the ground surface at the time of the investigation (surface soil samples were subsequently collected from the former coal/coke storage yard during a later phase of the site characterization as discussed in Section 3.1.4). Subsurface samples targeted the soil zone exhibiting the greatest evidence of contamination (i.e. elevated PID readings, odors, staining, etc.). If no evidence of contamination was observed, subsurface samples were collected at a depth between two and 15 feet below ground surface (bgs) at the discretion of the CEC field scientist. Soil samples were submitted for laboratory analysis of Target Compound List (TCL) volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), Priority Pollutant (PP) metals, ammonia, phenolics and free cyanide. Sampling of soil for VOCs was conducted in accordance with EPA Method 5035. In addition, a soil sample was collected from below the water table at borings MW-1, MW-3, MW-5 and MW-7 for analyses of total organic carbon (TOC) and bulk density for use in fate and transport analyses. Soil samples were placed in iced coolers upon collection and were submitted to TestAmerica Laboratory of Pittsburgh, Pennsylvania following industry-accepted chain-of-custody procedures.

Drilling equipment was decontaminated between each borehole location using a steam-cleaner (or similar). Split spoons were decontaminated between each use using Alconox and water. A temporary decon pad was constructed using plastic sheeting and berms. Decon water was disposed of along with other wastewater generated at the Site as part of site closure activities.

Cuttings generated during drilling activities were stockpiled at a centralized location by placing the cuttings on a tarp or plastic sheeting and covering them to prevent contact with precipitation and run-on. Following the completion of site characterization, cuttings were spread on the ground surface along with other fill material generated during Site demolition that does not meet the

definition of clean or regulated fill. These materials were subsequently covered with soil cover material to prevent exposure as discussed in greater detail in Section 8.0.

Monitoring Well Installation – Following completion of the soil sampling activities described above, each borehole was advanced approximately seven feet into the water table so that monitoring wells could be installed. The boreholes were advanced using 4.25-inch hollow-stem augers with continuous split-spoon sampling so that the soils could be observed and classified; however, no additional analytical testing of soils was performed below 15 feet with the exception of the TOC and bulk density sampling.

Upon reaching final depth, monitoring wells were installed at each location. With the exception of wells MW-8 and MW-9, monitoring wells were constructed using 15 feet of 2-inch diameter 0.020-inch slot schedule-40 PVC well screen and 2-inch schedule-40 PVC riser pipe. MW-8 and MW-9 were constructed similarly to the other wells, with the exception that stainless steel well screen was used at each location. The annulus around the well screen was filled with clean quartz sand to approximately two feet above the well screen and was capped with a hydrated bentonite seal. The remaining annular space was filled with bentonite chips to the ground surface. Flush mount protective casings were used to complete the monitoring wells. At each location, a post was installed to mark the location of the well.

Following installation, the wells were developed by pumping, bailing and/or surging to clean the filter packs and reduce sample turbidity, and quarterly groundwater sampling was initiated at each well as discussed in greater detail in Section 3.1.6.

A licensed professional surveyor surveyed the horizontal and vertical coordinates of each monitoring well and surveyed the top of each well casing to within 0.01-foot precision. The surveyed point on each well was marked to provide a standard reference point for measuring the depth to water and determining groundwater elevations. A river gauging point was also established and surveyed at one of the mooring cells.

3.1.2 Site Assessment Phase II

Soil Boring Investigation – In January 2017, 15 additional soil borings (SB-1 through SB-15) were advanced at the Site at the locations shown on Figure 5. Sample locations from Phase II of the site characterization were chosen to further characterize soil conditions across the Site, as indicated in Table 1. Prior to drilling activities, each borehole location was cleared with an air-knife to a targeted depth of six feet in an attempt to clear underground utilities. Borings were then advanced using direct-push methods to the top of the water table, with soils collected continuously inside a disposable clear plastic tube. During drilling, each borehole was logged for material description, and soils were screened for evidence of contamination by visual examination (staining), olfactory examination (odors), and by using a PID. Two soil samples were collected for laboratory analyses from borings SB-1 through SB-8 and SB-12 through SB-15, one from the surface (0-2 feet) and one from the subsurface based on CEC's observations at the time of sampling. At borings SB-9 through SB-11, only a subsurface sample was collected due to the presence of coal on the ground surface at the time of the investigation. Subsurface samples targeted the soil zone exhibiting the greatest evidence of contamination (i.e. elevated PID readings, odors, staining, etc.). If no evidence of contamination was observed, subsurface samples were collected at a depth between two and 15 feet bgs at the discretion of the CEC field scientist. Soil samples were submitted for laboratory analysis of TCL-VOCs, PAHs, PCBs, PP metals, ammonia and phenolics. Sampling of soil for VOCs was conducted in accordance with EPA Method 5035.

In addition to the soil sampling activities described above, two additional soil samples (HA-1 and HA-2) were collected from within the concrete containment area associated with the above-ground fuel oil storage tank located on the eastern side of the site. These samples were collected from surface soils (0-2 ft bgs) within the containment structure using a hand-auger and were submitted for laboratory analysis of the same parameters described above. Soil samples were placed in iced coolers upon collection and were submitted to TestAmerica Laboratory of Pittsburgh, Pennsylvania following industry-accepted chain-of-custody procedures.

Drilling equipment was decontaminated between each borehole location using a steam-cleaner (or similar). A temporary decon pad was constructed using plastic sheeting and berms. Decon water was disposed of along with other wastewater generated at the Site as part of site closure activities.

Cuttings generated during drilling activities were stockpiled at a centralized location by placing the cuttings on a tarp or plastic sheeting and covering them to prevent contact with precipitation and run-on. Following the completion of site characterization, cuttings were spread on the ground surface along with other fill material generated during Site demolition that does not meet the definition of clean or regulated fill. These materials were subsequently covered with soil cover material to prevent exposure as discussed in greater detail in Section 8.0.

3.1.3 Site Assessment Phase III

Soil Boring Investigation – In August 2017, seven additional soil borings were advanced at the Site at the locations shown on Figure 5. Six borings (SB-16 through SB-21) were installed to assess the former byproducts area. One boring (MW-12) was installed on the northwest side of the coal yard to further assess groundwater quality in this area. Prior to drilling activities, each borehole location was cleared with an air-knife to a targeted depth of six feet. Borings were then advanced using 4.25-inch hollow stem augers with split-spoon soil samples collected continuously to borehole termination. During drilling, each borehole was logged for material description, and soils were screened for evidence of contamination by visual examination (staining), olfactory examination (odors), and by using a PID. Two soil samples were collected for laboratory analyses from each boring, one from the surface (0-2 feet) and one from the subsurface based on CEC's observations at the time of sampling. Subsurface samples targeted the soil zone exhibiting the greatest evidence of contamination (i.e. elevated PID readings, odors, staining, etc.). If no evidence of contamination was observed, subsurface samples were collected at a depth between two and 15 feet bgs at the discretion of the CEC field scientist. Soil samples were submitted for laboratory analysis of TCL-VOCs, PAHs, PCBs, PP metals, ammonia and phenolics. Sampling of soil for VOCs was conducted in accordance with EPA Method 5035. Soil samples were placed in iced coolers upon collection and were submitted to TestAmerica Laboratory of Pittsburgh, Pennsylvania following industry-accepted chain-of-custody procedures.

Drilling equipment was decontaminated between each borehole location using a steam-cleaner (or similar). Split spoons were decontaminated between each use using Alconox and water. A temporary decon pad was constructed using plastic sheeting and berms. Decon water was disposed of along with other wastewater generated at the Site as part of site closure activities.

Cuttings generated during drilling activities were stockpiled at a centralized location by placing the cuttings on a tarp or plastic sheeting and covering them to prevent contact with precipitation and run-on. Following the completion of site characterization, cuttings were spread on the ground surface along with other fill material generated during Site demolition that does not meet the definition of clean or regulated fill. These materials were subsequently covered with soil cover material to prevent exposure as discussed in greater detail in Section 8.0.

Monitoring Well Installation – Following completion of the soil sampling activities described above, soil borings SB-17, SB-18 and MW-12 were advanced approximately seven feet into the water table so that monitoring wells could be installed (note that soil borings SB-17 and SB-18 were completed as monitoring wells "MW-14" and "MW-13", respectively). The boreholes were advanced using 4.25-inch hollow-stem augers with continuous split-spoon sampling so that the soils could be observed and classified; however, no additional analytical testing of soils was performed below 15 feet.

Upon reaching final depth, monitoring wells were installed at the three locations. Monitoring well MW-12 was constructed using 10 feet of 2-inch diameter 0.020-inch slot schedule-40 PVC well screen and 2-inch schedule-40 PVC riser pipe. MW-13 and MW-14 were constructed similarly to MW-12, with the exception that stainless steel well screen was used at each location. The annulus around the well screen was filled with clean quartz sand to approximately two feet above the well screen and was capped with a hydrated bentonite seal. The remaining annular space was filled with bentonite chips to the ground surface. Flush mount protective casings were used to complete the monitoring wells. At each location, a post was installed to mark the location of the well. Well construction details are provided in Table 1.

Following installation, the wells were developed by pumping, bailing and/or surging to clean the filter packs and reduce sample turbidity, and quarterly groundwater sampling was initiated at each well as discussed in greater detail in Section 3.1.6.

A licensed professional surveyor surveyed the horizontal and vertical coordinates of each monitoring well and surveyed the top of each well casing to within 0.01-foot precision. The surveyed point on each well was marked to provide a standard reference point for measuring the depth to water and determining groundwater elevations.

3.1.4 Site Assessment Phase IV

Soil Boring Investigation – In August 2018, eleven (11) additional soil borings (SB-22 to SB-28 and MW-15 to MW-18) were advanced at the Site at the locations shown on Figure 5. Two borings (SB-22 and SB-23) were installed to further assess the former byproducts area. Five borings (SB-24 through SB-28) were installed to assess the former coal/coke storage yard located in the northwest portion of the Site. The remaining four borings (MW-15 through MW-18) were installed to assess water quality upgradient of monitoring well MW-9 in the vicinity of the former desulfurization plant. Prior to drilling activities, each borehole location was cleared with an air-knife to a targeted depth of six feet. Borings were then advanced using 4.25-inch hollow stem augers with split-spoon soil samples collected continuously to borehole termination. During drilling, each borehole was logged for material description, and soils were screened for evidence of contamination by visual examination (staining), olfactory examination (odors), and by using a PID. Two soil samples were collected for laboratory analyses from each boring, one from the surface (0-2 feet) and one from the subsurface based on CEC's observations at the time of sampling. Subsurface samples targeted the soil zone exhibiting the greatest evidence of contamination (i.e. elevated PID readings, odors, staining, etc.). If no evidence of contamination was observed, subsurface samples were collected at a depth between two and 15 feet bgs at the discretion of the CEC field scientist. Soil samples were submitted for laboratory analysis of TCL-VOCs, PAHs, PCBs, PP metals, ammonia and phenolics. Sampling of soil for VOCs was conducted in accordance with EPA Method 5035. In addition, a soil sample was collected from below the water table at borings MW-16 and MW-17 for analyses of TOC and bulk density for

use in fate and transport analyses. Soil samples were placed in iced coolers upon collection and were submitted to TestAmerica Laboratory of Pittsburgh, Pennsylvania following industry-accepted chain-of-custody procedures.

Drilling equipment was decontaminated between each borehole location using a steam-cleaner (or similar). Split spoons were decontaminated between each use using Alconox and water. A temporary decon pad was constructed using plastic sheeting and berms. Decon water was disposed of along with other wastewater generated at the Site as part of site closure activities.

Cuttings generated during drilling activities were stockpiled at a centralized location by placing the cuttings on a tarp or plastic sheeting and covering them to prevent contact with precipitation and run-on. Following the completion of site characterization, cuttings were spread on the ground surface along with other fill material generated during Site demolition that does not meet the definition of clean or regulated fill. These materials were subsequently covered with soil cover material to prevent exposure as discussed in greater detail in Section 8.0.

Monitoring Well Installation – Following completion of the soil sampling activities described above, soil borings MW-15 through MW-18 were advanced approximately seven feet into the water table so that monitoring wells could be installed. The boreholes were advanced using 4.25-inch hollow-stem augers with continuous split-spoon sampling so that the soils could be observed and classified; however, no additional analytical testing of soils was performed below 15 feet with the exception of TOC and bulk density sampling.

Upon reaching final depth, monitoring wells were installed at the four locations. Each monitoring well was constructed using 10 feet of 2-inch diameter 0.020-inch slot schedule-40 PVC well screen and 2-inch schedule-40 PVC riser pipe. The annulus around the well screen was filled with clean quartz sand to approximately two feet above the well screen and was capped with a hydrated bentonite seal. The remaining annular space was filled with bentonite chips to the ground surface. Flush mount protective casings were used to complete the monitoring wells. Well construction details are provided in Table 1.

Following installation, the wells were developed by pumping, bailing and/or surging to clean the filter packs and reduce sample turbidity, and quarterly groundwater sampling was initiated at each well as discussed in greater detail in Section 3.1.6.

A licensed professional surveyor surveyed the horizontal and vertical coordinates of each monitoring well and surveyed the top of each well casing to within 0.01-foot precision. The surveyed point on each well was marked to provide a standard reference point for measuring the depth to water and determining groundwater elevations.

3.1.5 Site Assessment Phase V

Soil Boring Investigation – In October 2018, two additional soil borings (SB-29 and SB-30) were advanced at the Site in the vicinity of two former coal-tar above-ground storage tanks (Figure 5). Borings were advanced using direct-push methods to approximately 16 feet bgs, with soils collected continuously inside a disposable clear plastic tube. During drilling, each borehole was logged for material description, and soils were screened for evidence of contamination by visual examination (staining), olfactory examination (odors), and by using a PID. Two soil samples were collected from each boring for laboratory analyses, one from the surface (0-2 feet) and one from the subsurface based on CEC's observations at the time of sampling. Subsurface samples targeted the soil zone exhibiting the greatest evidence of contamination (i.e. elevated PID readings, odors, staining, etc.). If no evidence of contamination was observed, subsurface samples were collected at a depth between two and 15 feet bgs at the discretion of the CEC field scientist. Soil samples were submitted for laboratory analysis of TCL-VOCs, PAHs, PCBs, PP metals, ammonia and phenolics. Sampling of soil for VOCs was conducted in accordance with EPA Method 5035. Soil samples were placed in iced coolers upon collection and were submitted to TestAmerica Laboratory of Pittsburgh, Pennsylvania following industry-accepted chain-of-custody procedures.

Drilling equipment was decontaminated between each borehole location using a steam-cleaner (or similar). Split spoons were decontaminated between each use using Alconox and water. A temporary decon pad was constructed using plastic sheeting and berms. Decon water was disposed of along with other wastewater generated at the Site as part of site closure activities.

Test Pit Investigation – In an effort to delineate the extent of coal tar contamination that was identified in Site soils located in the western portion of the Site near well MW-7 and in the former coal/coke storage yard near soil boring SB-27, test pits were excavated at the Site during Phase V of the Site Assessment. During excavation, a CEC field scientist was present to direct the excavation and assess the areas for the presence of coal tar by visual examination. Following completion of the test pit excavation, the approximate extent of coal tar contamination was recorded using a hand-held global positioning system (GPS) unit with sub-meter accuracy.

3.1.6 Quarterly Groundwater Monitoring

Between October 2016 and October 2018, monitoring wells were sampled on a quarterly basis, with the exception of the second quarter 2018. Samples were not collected during the second quarter 2018 due to safety concerns associated with ongoing Site demolition activities that were occurring at the time. A quarterly sampling frequency was established in order to characterize groundwater conditions across the Site under varying seasons, and assess the potential presence of trends in groundwater quality. Table 2 presents a summary of the quarterly groundwater monitoring events that were performed at the Site, including the number of samples collected from each well.

Prior to sampling, each well was gauged for depth to static water and for the presence of free product (i.e. LNAPL) using an electronic oil-water interface probe, and the wells were purged of three well-volumes of water. During the first five quarterly sampling events, purging and sampling at the Site was conducted with dedicated bailers. However, based on a review of the sampling data and discussions with sampling personnel, it was discovered that samples collected from several wells typically had elevated turbidity and a cloudy appearance as a result of purging and sampling with a bailer. In an effort to improve sample quality and eliminate the introduction of sediment during purging and sampling, starting in the first quarter 2018, purging and sampling at the Site was conducted by pumping three well-volumes of water from each well at low rates that would limit disturbance to the well column, thus reducing the introduction of sample turbidity.

Samples were collected from each well for laboratory analysis of TCL-VOCs, PAHs, dissolved PP metals, ammonia, free cyanide, phenolics and sulfate. Samples collected for dissolved metals analysis were filtered in the field using a 0.45-micron filter. Field tests were conducted for pH, conductivity, temperature, and oxidation-reduction potential (ORP) at the time of sample collection. Groundwater samples were placed in iced coolers upon collection and were submitted to TestAmerica Laboratory of Pittsburgh, Pennsylvania following industry-accepted chain-of-custody procedures. Purge and development water was disposed of along with other wastewater generated at the Site as part of site closure activities.

3.1.7 Groundwater and Surface Water Elevation Monitoring

In October 2016, pressure-transducers were installed in monitoring wells MW-1, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9, MW-10 and MW-11 and at the river gauging location so that water elevations across the Site could be monitored. Following installation, each transducer was programmed to obtain a groundwater elevation reading approximately once every two hours so that the direction of groundwater flow across the Site under varying circumstances/seasons could be determined.

In February 2017, the transducer located at the river gauging location was damaged. Because surface water elevations in the Ohio River adjacent to the Site (as measured by the transducer) showed close agreement with surface water elevations in the Ohio River as measured by USGS gauging station 03085730 – Ohio River at Emsworth Dam Upper Pool, subsequent river elevations were obtained using USGS gauging station 03085730.

In October 2017, the transducer in well MW-7 was damaged. Because the transducers located in the remaining nine wells across the Site were sufficient in establishing groundwater flow conditions across the Site, the transducer was not replaced.

In August 2018, transducers were removed from wells MW-3, MW-4, MW-5 and MW-6 and were relocated to wells MW-15, MW-16, MW-17 and MW-18 to better assess groundwater flow in this portion of the Site.

Monitoring of transducers at the Site continued until October 2018 (eight quarters of data) at which time the transducers were removed.

3.1.8 Single-Well Permeability Tests

Single-well permeability tests (slug tests) were performed on six monitoring wells to estimate formation permeabilities. The wells were chosen to provide an indication of permeabilities in the sand and gravel aquifer at various locations across the Site. The slug tests were performed by rapidly removing a volume of water from the wells and electronically monitoring the relationship between time and water level recovery using a down-hole datalogger (i.e. "rising head" tests). The electronic data was then analyzed using Aqtesolv software to yield formation permeability. Aqtesolv data files are provided in Appendix E.

3.2 SITE CHARACTERIZATION FINDINGS

3.2.1 Site Geology

The Site is located in the Pittsburgh Plateau section of the Appalachian Plateaus Physiographic province. Broad, flat-topped ridges separated by narrow, steep-sided valleys characterize this section. The Site is located on an island at an elevation of approximately 730 ft above mean sea level (MSL) over coarse-grained Quaternary alluvium of the Ohio River. Fill has been placed over the natural ground to varying depths to bring the Site to its existing grade. Bedrock underlying the Site is a part of the Pennsylvanian-age Conemaugh Group and consists of cyclic sequences of sandstone, shale, siltstone, coal, and limestone. The depth to bedrock in the area is reported to range from 36 to 80 feet below grade, although bedrock was not encountered in any of the borings advanced during the site characterization.

Site-specific geologic information was gathered using the 46 soil borings installed by CEC between September 2016 and October 2018 for site characterization, and was used to develop the geologic cross-sections presented in Figures 6A and 6B. Site-specific geologic information indicates that the Site is covered by a mantle of fill material varying in thickness from less than

one foot in the former coal/coke storage yard in the northeast portion of the Site to approximately 27 feet in the eastern portion of the Site near MW-2. The fill primarily consists of sand, with lesser amounts of silt, clay, gravel, coal and slag. Coarse-grained alluvium comprised of sand and gravel underlies the fill material across the majority of the Site, although lenses of fine-grained material (silt and clay) were encountered at a number of locations. The ground surface is generally flat-lying, but there is a low-spot located in the central portion of the Site in the vicinity of the former ore yard (see Figure 3). The ground surface at the Site ranges from approximately 10 to 25 feet above the normal pool elevation of the Emsworth Dam upper pool.

3.2.2 Site Hydrogeology

Between October 2016 and October 2018, groundwater elevations across the Site were monitored using pressure-transducers located in select monitoring wells, and by collection of static water levels from each monitoring well during the quarterly groundwater monitoring events. Results of the groundwater elevation measurements indicate that a water-table aquifer occurs within the alluvium beneath the Site at depths ranging from approximately 11 feet bgs at well MW-11 in the former ore yard to approximately 27 feet bgs at well MW-6 in the former coal/coke storage yard located in the northwest portion of the Site.

Time-trend plots of groundwater elevations are presented on Figure 7, along with the surface water elevation of the Ohio River. As shown on Figure 7, with the exception of brief periods of time when the Ohio River experiences a rapid decrease in elevation, groundwater elevations across the Site are consistently lower than the elevation of the river, indicating that groundwater across the Site is recharged from the river. This is a result of the presence of two dams located on either side of the island (one in the main stem and one in the back channel) approximately ½-mile (north side of island) to 1 mile (south side of island) downstream/west of the Site. A conceptual groundwater contour map for the eastern portion of Neville Island, upstream of the two dams is presented as Figure 8. As this figure shows, the presence of dams located on both sides of Neville Island downstream of the Site has resulted in groundwater flow at the Site that flows radially into the island, prior to flowing in a northwestward direction down the axis of the island. Further west on the island in the area between the two sets of dams, the back channel recharges the groundwater

system because it is maintained at a higher level than the main channel directly across the island. The resulting groundwater flow direction in this area is northward across the island, with discharge to the main channel of the Ohio River.

Figure 9 presents site-specific groundwater contour maps for the Site that were developed using groundwater elevation data gathered from the pressure-transducer monitoring program. The groundwater contour maps were selected to represent a range of river-stage conditions that could potentially effect groundwater flow patterns at the Site as summarized below:

Date	River Stage Condition
December 18, 2016	Gradually falling river elevation
September 24, 2017	Gradually rising river elevation
January 13, 2018	Rapidly rising river elevation
April 2, 2018	Rapidly falling river elevation
August 9, 2018	Relatively static river elevation

As shown on Figure 9, at times when the river elevation is gradually decreasing, groundwater flow across the majority of the Site remains to the northwest down the axis of the island. However, as a result of the falling river elevation, a groundwater high occurs in the eastern portion of the Site, with radial flow away from the groundwater high. Along the eastern edges of the island near the interface with the river, a temporary reversal of groundwater flow occurs and groundwater discharges to the river.

At times when the river elevation is gradually increasing, groundwater at the Site flows radially into the island prior to flowing in a northwestward direction down the axis of the island.

At times when the river elevation rapidly increases, groundwater at the Site flows radially into the island prior to flowing in a northwestward direction down the axis of the island. However, the horizontal gradients during these times increase, particularly along the edges of the island near the interface with the river.

At times when the river elevation rapidly decreases, groundwater flow is similar to the flow patterns shown on December 18, 2016, where flow is to the northwest down the axis of the island across the majority of the Site. However, as a result of the rapidly falling river elevation, the groundwater high that occurs in the eastern portion of the Site extends over a larger area, and the horizontal gradients increase along the edge of the island. Groundwater flows radially away from the groundwater high, and along the eastern edges of the island near the interface with the river, a temporary reversal of groundwater flow occurs with groundwater discharging to the river.

At times when the river elevation remains relatively static, groundwater at the Site flows radially into the island prior to flowing in a northwestward direction down the axis of the island.

As Figures 9 illustrates, regardless of gradual or abrupt changes in river elevation, groundwater across the Site flows into the island prior to flowing in a northwestward direction down the axis of the island, with limited exceptions. During brief periods when the river experiences a decrease in surface water elevation, groundwater along the edges of the island temporarily discharges to the river. In portions of the Site where this temporary flow reversal occurs, groundwater has not been impacted by historic Site operations as discussed in greater detail in Section 5.2.

CEC performed slug tests on six monitoring wells spread across the Site, as described in Section 3.1.8. A summary of the slug test results is presented on Table 3. Raw data is included in Appendix E. These test results indicate that formation permeabilities at the site range from 1.8×10^{-3} cm/sec to 2.9×10^{-2} cm/sec, with an average permeability of 9.1×10^{-3} cm/sec. The distribution of the permeability values suggests that the permeability of the alluvium across the majority of the Site is generally on the order of 10^{-3} cm/sec. Using the average permeability and the hydraulic gradient information displayed on Figure 9, the following groundwater flow rates were estimated as follows:

v = ki/n

Where: v = groundwater velocity

k = Permeability = 9.1×10^{-3} cm/sec

i = hydraulic gradient = the change in hydraulic head divided by the distance. The gradient was estimated using the groundwater elevations in wells MW-3 and MW-8 as presented on Figure 9.

n = porosity = 0.3 (assumed porosity for sand and gravel)

<u>At times when the river elevation is relatively static:</u>

$$i = \frac{709.06\ ft - 708.50\ ft}{1650\ ft} = 0.00034$$

v = 9.1×10^{-3}cm/sec x 0.0003/0.3

v = 1.03×10^{-5} cm/sec = 0.029 ft/day = 11 ft/yr

<u>At times when the river elevation rapidly increases:</u>

$$i = \frac{709.85\ ft - 707.29\ ft}{1650\ ft} = 0.0016$$

v = 9.1×10^{-3}cm/sec x 0.0016/0.3

v = 4.70×10^{-5} cm/sec = 0.133 ft/day = 49 ft/yr

<u>At times when the river elevation rapidly decreases:</u>

$$i = \frac{707.78\ ft - 707.47\ ft}{1650\ ft} = 0.00019$$

v = 9.1×10^{-3}cm/sec x 0.00019/0.3

v = 5.69×10^{-6} cm/sec = 0.016 ft/day = 6 ft/yr

As shown above, the change in hydraulic gradient created by rising or falling river elevations can cause the average groundwater velocity at the Site to vary from as little as six to as much as 49 ft/year; however, because abrupt changes in river elevation occur only sporadically and are of short duration, groundwater velocities at the Site are typically on the order of 11 ft/yr under most circumstances.

3.2.3 Site Analytical Data

The following sections describe the analytical results obtained from soil and groundwater samples collected at the Site. The complete laboratory data packages are presented in Appendix F. Additional discussion regarding the analytical results and their relationship to Act 2 Medium-Specific Concentrations (MSCs) is presented in Section 4.0. The nature and extent of the contaminants is discussed in Section 5.0.

3.2.3.1 Surface Soil

A total of 42 surface soil samples (0-2 feet bgs) were collected from the Site. Analytical results are presented on Table 4. Sample locations are presented on Figure 5.

<u>Volatile Organic Compounds</u>

As shown on Table 4, the majority of the TCL-VOCs were not detected in surface soil samples collected at the Site. Of the 48 VOCs that were analyzed, only eight VOCs (methyl ethyl ketone (MEK), benzene, ethylbenzene, isopropylbenzene, methylcyclohexane, styrene, toluene and total xylenes) were detected at concentrations that were greater than the laboratory method detection limits (MDLs). Surface soil samples from MW-18, SB-13, SB-18 and SB-30 contained low concentrations of one or more VOC that were detected in the 10 part per billion (ppb) range. SB-12, SB-16, SB-17, SB-23 and SB-27 contained higher concentrations of VOCs that were detected in the 1,000 to 100,000 ppb range. Each of these borings were either located in the former byproducts area or in the former coal/coke storage yard in the northwest portion of the Site.

Surface soil samples from the remaining 33 borings did not contain concentrations of VOCs that were greater than the MDLs.

Polynuclear Aromatic Hydrocarbons

All of the analyzed PAHs were detected in surface soil samples at concentrations that were greater than the MDLs. With the exception of boring MW-16, all of the surface soil samples contained detectable concentrations of PAHs; however, it should be noted that the MDLs were elevated at MW-16. Surface soil samples from borings MW-2, MW-11, MW-15, HA-1, HA-2, SB-2, SB-3, SB-4, SB-5, SB-6, SB-8, SB-24 and SB-25 contained concentrations of PAHs that were in the 100 ppb range. The highest concentrations of PAHs (greater than 100,000 ppb) were identified in surface soils at borings SB-16, SB-19, SB-21, SB-27 and SB-30, each of which is either located in the former byproducts area or in the former coal/coke storage yard in the northwest portion of the Site.

Polychlorinated Biphenyls

Of the seven PCBs that were analyzed, only three (PCB-1248, PCB-1254 and PCB-1260) were detected in surface soils at concentrations that were greater than the MDLs. Surface soil samples from 12 borings (MW-2, MW-3, MW-7, MW-12, MW-16, MW-18, SB-4, SB-14, SB-15, SB-19, SB-21 and SB-28) contained low concentrations of PCBs that were generally detected in the 10 ppb range. The remaining 30 surface soil samples did not contain concentrations of PCBs that were greater than the MDLs.

Metals

All 13 of the analyzed metals were detected in surface soil samples collected at the Site, and all 42 surface soil samples contained detectable concentrations of at least one metal. Concentrations of metals in surface soil samples at the Site ranged from non-detect to as great as 460 parts per million (ppm), but were generally present in the one to 10 ppm range.

Ammonia, Cyanide and Phenolics

Ammonia was detected in all but four of the 42 surface soil samples collected at the Site. Concentrations ranged from the less than five to as great as 46,000 ppm, with the greatest concentrations occurring in the former byproducts area.

Total phenolics were detected in 31 of the 42 surface soil samples collected at the Site, and ranged in concentration from less than one ppm to 88 ppm.

Free cyanide was only analyzed in the initial 11 borings advanced at the Site (MW-1 through MW-11), and was not detected in surface soils at concentrations that were greater than the MDL.

3.2.3.2 Subsurface Soil

A total of 46 subsurface soil samples (>2 feet bgs) were collected from the Site. Analytical results are presented on Table 5. Sample locations are presented on Figure 5. Each of the subsurface soil sample results shown on Table 5 were collected from unsaturated soils located above the water table.

Volatile Organic Compounds

As shown on Table 5, the majority of the TCL-VOCs were not detected in subsurface soil samples collected at the Site. Of the 48 VOCs that were analyzed, only 10 VOCs (MEK, 2-hexanone, acetone, benzene, carbon disulfide, ethylbenzene, isopropylbenzene, styrene, toluene and total xylenes) were detected at concentrations that were greater than the MDLs. Subsurface soil samples from MW-16, MW-17, MW-18, SB-12 and SB-27 contained low concentrations of one or more VOC that were detected in the 10 ppb range. Borings MW-7, MW-8, SB-13, SB-16, SB-17, SB-18, SB-20, SB-22 and SB-23, each of which are located in the former byproducts area or in the former coal/coke storage yard in the northwest portion of the Site, contained concentrations of VOCs that ranged from approximately 600 to 470,000 ppb. Subsurface soil samples from the remaining 32 borings did not contain concentrations of VOCs that were greater than the MDLs.

Polynuclear Aromatic Hydrocarbons

All of the analyzed PAHs were detected in subsurface soil samples at concentrations that were greater than the MDLs. With the exception of borings MW-10 and MW-11, all of the subsurface soil samples contained detectable concentrations of PAHs. Subsurface soil samples from the majority of the borings contained low concentrations of PAHs that were in the 10 to 100 ppb range. The highest concentrations of PAHs (greater than 100,000 ppb) were identified in subsurface soils at borings MW-7, MW-8, SB-13, SB-17, SB-18, SB-22, SB-23 and SB-27, each of which is either located in the former byproducts area or in the former coal/coke storage yard in the northwest portion of the Site.

Polychlorinated Biphenyls

Of the seven PCBs that were analyzed, only three (PCB-1248, PCB-1254 and PCB-1260) were detected in subsurface soils at concentrations that were greater than the MDLs. Subsurface soil samples from SB-14 and SB-19 contained low concentrations of one or more PCB that were detected in the 10 ppb range. The remaining 44 subsurface soil samples did not contain concentrations of PCBs that were greater than the MDLs.

Metals

With the exception of silver and thallium, all 13 analyzed metals were detected in subsurface soil samples collected at the Site. All 46 subsurface soil samples contained detectable concentrations of at least one metal. Concentrations of metals in subsurface soil samples at the Site ranged from non-detect to as great as 570 ppm lead at boring MW-2, but were generally present in the one to 10 ppm range.

Ammonia, Cyanide and Phenolics

Ammonia was detected in 32 of 46 subsurface soil samples collected at the Site. Concentrations ranged from less than five to as great as 25,000 ppm, with the greatest concentrations occurring in the former byproducts area.

Total phenolics were detected in 36 of the 46 subsurface soil samples collected at the Site, and with the exception of borings MW-7 and SB-13, were generally present in the low ppm range. Total phenolics at MW-7 and SB-13 were 280 and 1,900 ppm, respectively.

Free cyanide was only analyzed in the initial 11 borings advanced at the Site (MW-1 through MW-11), and was not detected in subsurface soils at concentrations that were greater than the MDL.

3.2.3.3 Groundwater

A total of 111 groundwater samples were collected from the Site over a period of eight calendar quarters. Analytical results are presented on Table 6. Sample locations are presented on Figure 5.

Volatile Organic Compounds

As shown on Table 6, the majority of the TCL-VOCs were not detected in groundwater samples collected at the Site. Of the 48 VOCs that were analyzed, only 15 VOCs (MEK, acetone, benzene, carbon disulfide, cis-1,2-dichloroethene, cyclohexane, ethylbenzene, isopropylbenzene, methylcyclohexane, methylene chloride, styrene, tetrachloroethene (PCE), toluene, trichloroethene and total xylenes) were detected at concentrations that were greater than the MDLs. Groundwater samples from MW-8, MW-9, MW-12, MW-13, MW-14, MW-16, MW-17 and MW-18 routinely contained one or more VOC at concentrations that were greater than the MDLs. VOCs in these wells ranged from non-detect, to as great as 120,000 ppb. Each of these wells are located either in the former byproducts area or in the former coal/coke storage yard in the northwest

portion of the Site. The remaining 10 wells did not routinely contain VOCs at concentrations that were greater than the MDLs.

Polynuclear Aromatic Hydrocarbons

All of the analyzed PAHs were detected in groundwater samples at concentrations that were greater than the MDLs, and were generally detected in each of the 18 monitoring wells at the Site. The majority of monitoring wells contained low concentrations of PAHs that were typically in the one ppb range. The highest concentrations of PAHs were detected in wells MW-8, MW-13, MW-14, MW-16, MW-17 and MW-18, each of which is located in the former byproducts area. PAH concentrations in these wells generally ranged from several hundred ppb in wells MW-8, MW-16, MW-17 and MW-18, to as much as 190,000 ppb naphthalene at MW-14.

Metals

With the exception of antimony, beryllium, silver and thallium, each of the 13 analyzed metals were detected in groundwater samples at concentrations that were greater than the MDLs. Groundwater samples from wells MW-2, MW-3, MW-4, MW-6, MW-11 and MW-12 did not contain metals at concentrations that were greater than the MDLs. The highest concentrations of metals were detected in wells MW-9, MW-10, MW-14, MW-15, MW-16, MW-17 and MW-18, most of which are located in the former byproducts area. Well MW-10 is located in the central portion of the Site near the former wastewater treatment plant. Metals concentrations in these wells ranged from non-detect, to over 1,000 ppm nickel and zinc in the former byproducts area. The remaining wells generally contained low metals concentrations in the 10 ppm range.

Ammonia, Cyanide, Sulfate and Phenolics

Ammonia was routinely detected in groundwater samples collected from each of the 18 monitoring wells at the Site. The majority of monitoring wells contained low concentrations of ammonia that ranged from non-detect to less than 10 ppm. Concentrations of ammonia in excess of 100 ppm

were detected at wells MW-8, MW-9, MW-13, MW-14, MW-15, MW-16, MW-17 and MW-18, each of which is located in the former byproducts area.

Sulfate was detected in all of the monitoring wells except MW-18. Sulfate concentrations at the Site ranged from non-detect to 25,000 ppm. The highest concentrations were detected in the former byproducts area at MW-13. The lowest concentrations were detected at wells MW-9 and MW-18.

Total phenolics were detected in all of the monitoring wells at the Site. The majority of the monitoring wells contained low concentrations of one ppm or less. Concentrations in excess of two ppm were detected at wells MW-13, MW-14 and MW-18.

Free cyanide was only analyzed in the first two quarterly samples collected from the initial 11 wells installed at the Site (MW-1 through MW-11). Free cyanide was not detected in wells MW-4, MW-5, MW-6, MW-8 and MW-11. MW-1, MW-2, MW-3, MW-7, MW-9 and MW-10 contained low concentrations of free cyanide that ranged from approximately five to 110 ppm.

3.2.3.4 LNAPL

Light non-aqueous phase liquids (LNAPL) have been detected in two of the 18 monitoring wells at the Site. A summary of LNAPL thickness measurements is provided in Table 7. As shown on Table 7, a small amount of LNAPL has been detected at MW-9 during two of the eight quarterly monitoring events (less than ½-inch). At MW-14, measurable LNAPL has been detected during each of the five quarterly sampling events in which MW-14 has been sampled. The thickness of LNAPL at MW-14 has ranged from approximately 1 to 14 inches.

4.0 IDENTIFICATION OF CHEMICALS OF CONCERN

The identification of chemicals of concern (COCs) was performed by comparing the soil and groundwater analytical results to the Act 2 non-residential, used-aquifer MSCs for aquifers with total dissolved solids (TDS) concentrations that are less than or equal to 2,500 milligrams/liter (mg/L). For comparison purposes, Tables 4 through 6 provide the respective Act 2 soil MSCs for both direct-contact and soil-to-groundwater pathways. Where a compound was detected at a concentration greater than the MSC, that entry and the respective MSC were highlighted.

The following sections describe the COCs at the Site for soil and groundwater.

4.1 SURFACE SOIL

The non-residential MSCs consider surface soil as soil at depths of less than two feet bgs. As discussed in Section 3.1, surface soil samples were collected from all but six of the 46 boring locations. Referring to Table 4, the following compounds were detected at concentrations that were greater than their respective Act 2 MSCs and are therefore considered COCs for surface soil:

<u>Volatile Organic Compounds</u>

- **Direct Contact –** None
- **Soil-to-Groundwater –** Benzene

<u>Polynuclear Aromatic Hydrocarbons</u>

- **Direct Contact –** Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene and Naphthalene
- **Soil-to-Groundwater –** Anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Chrysene and Naphthalene

<u>Polychlorinated Biphenyls</u>

- **Direct Contact –** None
- **Soil-to-Groundwater –** None

<u>Metals</u>

- **Direct Contact –** Arsenic

- **Soil-to-Groundwater –** Arsenic

Other Compounds

- **Direct Contact –** Ammonia
- **Soil-to-Groundwater –** Ammonia

4.2 SUBSURFACE SOIL

The non-residential MSCs consider subsurface soil as soil at depths from two to 15 feet bgs. As discussed in Section 3.1, subsurface soil samples were collected from all 46 boring locations. Referring to Table 5, the following compounds were detected at concentrations that were greater than their respective Act 2 MSCs and are therefore considered COCs for subsurface soil:

Volatile Organic Compounds

- **Direct Contact –** Benzene
- **Soil-to-Groundwater –** 2-Hexanone, Benzene, Styrene and Toluene

Polynuclear Aromatic Hydrocarbons

- **Direct Contact –** None
- **Soil-to-Groundwater –** Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Fluoranthene and Naphthalene

Polychlorinated Biphenyls

- **Direct Contact –** None
- **Soil-to-Groundwater –** None

Metals

- **Direct Contact –** None
- **Soil-to-Groundwater –** Antimony, Lead and Mercury

Other Compounds

- **Direct Contact –** Ammonia
- **Soil-to-Groundwater –** Ammonia and Total Phenolics

4.3 GROUNDWATER

Referring to Table 6, the following compounds are present at concentrations that are greater than their respective Act 2 groundwater MSCs and are therefore considered COCs for groundwater:

Volatile Organic Compounds

- Benzene, Styrene, Tetrachloroethene and Toluene

Polynuclear Aromatic Hydrocarbons

- Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Chrysene and Naphthalene

Metals

- Arsenic, Cadmium, Chromium, Lead, Nickel, Selenium and Zinc

Other Compounds

- Ammonia and Total Phenolics

Secondary Maximum Contaminant Levels (SMCLs) were also exceeded for sulfate. Additional discussion of which constituents are considered COCs in groundwater is presented in Section 5.2.

5.0 NATURE AND EXTENT OF CONTAMINATION

5.1 SOILS

The following sections describe which COCs were identified in surface soil and subsurface soil, and illustrate where the COCs were present at concentrations that are greater than their respective MSC. Figures 10 and 12 present the results for surface soil and subsurface soil, respectively, and designate exceedances of the direct-contact MSC in orange highlight, exceedances of the soil-to-groundwater MSC in blue highlight, and exceedances of both the direct-contact and soil-to-groundwater MSCs in green highlight. In addition, this section also provides a summary of the extent of COCs when evaluated as a whole.

5.1.1 Surface Soils

As shown on Table 4 and Figure 10, of the 42 locations where surface soil samples were collected, 15 locations contained concentrations of one or more analyzed compound that were greater than their respective Act 2 MSCs as summarized below.

<u>Former Byproducts Area</u>

- MW-17: Contained ammonia at a concentration that was greater than the soil-to-groundwater MSC
- SB-16 and SB-17: Contained benzene and naphthalene at concentrations that were greater than the soil-to-groundwater MSCs
- SB-19 and SB-30: Contained benzeno(a)pyrene at a concentration that was greater than the direct-contact MSC and naphthalene at a concentration that was greater than the soil-to-groundwater MSC
- SB-20: Contained ammonia at a concentration that was greater than both the direct-contact and soil-to-groundwater MSCs
- SB-21: Contained benzo(a)pyrene at a concentration that was greater than both the direct-contact and soil-to-groundwater MSCs

- SB-23: Contained benzene at a concentration that was greater than the soil-to-groundwater MSC
- SB-29: Contained benzeno(a)pyrene at a concentration that was greater than the direct-contact MSC

Former Coal/Coke Storage Yard in Northwest Portion of Site

- SB-25: Contained arsenic at a concentration that was greater than both the direct-contact and soil-to-groundwater MSCs
- SB-27: Contained benzene, anthracene, chrysene and arsenic at concentrations that were greater than the soil-to-groundwater MSCs, benzo(a)anthracene, benzo(k)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene at concentrations that were greater than the direct-contact MSCs, and benzo(a)pyrene, benzo(b)fluoranthene and naphthalene at concentrations that were greater than both the direct-contact and soil-to-groundwater MSCs
- SB-28: Contained benzeno(a)pyrene at a concentration that was greater than the direct-contact MSC

Note that boring SB-27 was located in an area of shallow coal tar contamination that was identified in the former coal/coke storage yard. Based on soil borings and test pits from this location, the tar contamination was limited to the upper two feet of soil in the immediate vicinity of SB-27.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

- SB-12: Contained benzene at a concentration that was greater than the soil-to-groundwater MSC
- SB-13: Contained benzeno(a)pyrene at a concentration that was greater than the direct-contact MSC

Note that borings SB-12 and SB-13 were located in an area of coal tar contamination that was identified in the extreme western end of the Site, just north of several historic above-ground storage tanks that were identified in aerial photographs from 1949 to 1993. The tanks were located just south of the current property line on property that is now occupied by Ashland Inc. Based on soil

borings and test pits from this location, the tar contamination occurred at a depth of approximately two to five feet bgs, was limited to the area surrounding MW-7 and SB-13, and likely originated from the historic offsite tanks. The approximate aerial extent of tar contamination is shown on Figure 11.

Other

- SB-1: Contained benzeno(a)pyrene at a concentration that was greater than the direct-contact MSC. Boring SB-1 was located in the eastern portion of the Site near the former blast furnaces.

5.1.2 Subsurface Soils

As shown on Table 5 and Figure 12, of the 46 locations where subsurface soil samples were collected, 11 locations contained concentrations of one or more analyzed compound that were greater than their respective Act 2 MSCs as summarized below.

Former Byproducts Area

- MW-8, SB-17 and SB-18: Contained benzene and naphthalene at concentrations that were greater than the soil-to-groundwater MSCs
- SB-16: Contained benzene at a concentration that was greater than the soil-to-groundwater MSC
- SB-20: Contained benzene at a concentration that was greater than the soil-to-groundwater MSC and ammonia at a concentration that was greater than both the direct-contact and soil-to-groundwater MSCs
- SB-22: Contained benzene at a concentration that was greater than both the direct-contact and soil-to-groundwater MSCs, and styrene, toluene and naphthalene at concentrations that were greater than the soil-to-groundwater MSCs
- SB-23: Contained benzene, naphthalene and mercury at concentrations that were greater than the soil-to-groundwater MSCs

Former Coal/Coke Storage Yard in Northwest Portion of Site

- SB-27: Contained benzo(a)pyrene and naphthalene at concentrations that were greater than the soil-to-groundwater MSCs

As discussed above, SB-27 was located within an area of limited shallow coal tar contamination in the former coal/coke storage yard.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

- MW-7: Contained 2-hexanone, benzene, styrene, toluene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, naphthalene and total phenolics at concentrations that were greater than the soil-to-groundwater MSCs
- SB-13: Contained benzene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, naphthalene and total phenolics at concentrations that were greater than the soil-to-groundwater MSCs

As discussed above, MW-7 and SB-13 were located in an area of coal tar contamination that was identified in the extreme western end of the Site, just north of several historic above-ground storage tanks that were located on property that is now occupied by Ashland Chemical.

Other

- MW-2: Contained antimony and lead at concentrations that were greater than the soil-to-groundwater MSCs. MW-2 was located in the vicinity of two dark areas that were identified in a 1967 aerial photograph, south of the blast furnace and boilerhouse at the east end of the Site. An aboveground fuel storage tank was most recently located in this area.

5.1.3 Summary of Extent of Soil Contamination

Exceedances of the Act 2 MSCs primarily occurred in the following three areas at the Site: the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, and

the former offsite above-ground storage tank area in the westernmost portion of the Site. A summary of the extent of exceedances of COCs in these areas is provided below.

Former Byproducts Area

Benzene concentrations were greater than the MSC in subsurface soils in the vicinity of SB-16, SB-17, SB-18, SB-20, SB-22, SB-23 and MW-8. Benzene concentrations that were greater than the MSC in surface soils were limited to borings SB-16, SB-17, and SB-23.

Styrene and toluene concentrations that were greater than their respective MSCs were limited to subsurface soils at SB-22.

Benzo(a)pyrene concentrations were greater than the MSC in surface soils in the vicinity of SB-19, SB-21, SB-29 and SB-30. Benzo(a)pyrene impacts in this area appear to be limited to shallow soils, as benzo(a)pyrene was not detected in subsurface soils at concentrations that were greater than the Act 2 MSCs.

Naphthalene was present at concentrations that were greater than the MSC at most of the locations in the former byproducts area. Naphthalene was greater than the MSC in surface soils at SB-16, SB-17, SB-19 and SB-30, and in subsurface soils at SB-17, SB-18, SB-22, SB-23 and MW-8.

Mercury concentrations that were greater than the MSC were limited to subsurface soil at SB-23, while ammonia exceedances occurred in both surface and subsurface soils at SB-20.

Former Coal/Coke Storage Yard in Northwest Portion of Site

The majority of exceedances of Act 2 MSCs in this area occurred at SB-27, located in a limited area of shallow coal tar contamination. Surface soils at this location exceeded the MSCs for benzene and arsenic, as well as numerous PAHs. However, exceedances of Act 2 MSCs at this location did not extend into subsurface soil, with the exception of the PAHs benzo(a)pyrene and naphthalene. Surface soils also exceeded the arsenic MSC at SB-25, while benzo(a)pyrene also

exceeded the MSC in surface soil at SB-28. It is suspected that the analytical results for samples collected at SB-27 were influenced, at least in part, by the presence of tar in the samples.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

The majority of exceedances of Act 2 MSCs in this area were confined to subsurface soil in the vicinity of MW-7 and SB-13, located in an area of coal tar contamination that was identified at approximate depths of two to five feet bgs. Subsurface soils at both locations exceeded Act 2 MSCs for benzene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, naphthalene and total phenolics. In addition, subsurface soil at MW-7 also exceeded MSCs for 2-hexanone, styrene, toluene, benzo(g,h,i)perylene and fluoranthene. It is suspected that the analytical results for samples collected at MW-7 and SB-13 were influenced, at least in part, by the presence of tar in the samples. Exceedances of Act 2 MSCs in surface soils in this area were limited to benzene at SB-12 and benzo(a)pyrene at SB-13.

Other

In addition to the three areas discussed above, exceedances also occurred for benzo(a)pyrene at SB-1 and antimony and lead at MW-2, both of which are located in the eastern portion of the Site.

5.2 GROUNDWATER

The following section describes which COCs were identified in Site groundwater and illustrates where the COCs were present at concentrations that are greater than their respective MSC. Figure 13 presents the results for groundwater and identifies in blue highlight which COCs were present at a particular location at concentrations that were greater than the MSC. In addition, this section also provides a summary of the extent of COCs when evaluated as a whole.

5.2.1 COCs in Groundwater

As shown on Table 6 and Figure 13, of the 18 monitoring wells at the Site, 10 contain one or more constituents detected at concentrations that are greater than their respective Act 2 MSCs.

Former Byproducts Area

- MW-8: Four of eight quarterly samples contained benzene at concentrations that were greater than the MSC. Ammonia concentrations were greater than the MSC in each of the eight samples. Therefore, benzene and ammonia exceed their respective MSCs at this location. During the first five quarterly sampling events, concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i) perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene and naphthalene were slightly greater than their MSCs in at least one sample. As discussed in Section 3.1.6, during the first five quarterly sampling events, purging and sampling at the Site was conducted with dedicated bailers. However, during the first quarter 2018, the methodology was switched to pumping at low rates in an effort to improve sample quality by limiting disturbance to the well column and reducing sample turbidity. Since improving the sampling method, concentrations of each of these constituents have been less than their respective MSC, and generally have not been detected at concentrations greater than the MDLs. Therefore, we believe the exceedances during the earlier sampling events were attributed to the introduction of sediment during sampling, and concentrations of these constituents in groundwater at MW-8 are less than the MSCs.
- MW-9: Concentrations of benzene, arsenic and ammonia were greater than their MSCs in all eight samples, and concentrations of nickel were greater than the MSC in six samples; therefore, these constituents exceed their respective MSCs at this location. Concentrations of benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene and lead were slightly greater than their respective MSCs in one of eight samples, each of which occurred during the first five quarterly sampling events. As discussed above, we believe the exceedances were attributed to the introduction of sediment during sampling, and concentrations of these constituents in groundwater at MW-9 are less than the MSCs.

- MW-13: Concentrations of benzene, naphthalene and ammonia were greater than their MSCs in all five samples; therefore these constituents exceed their respective MSCs at this location. Total phenolics slightly exceeded its MSC in only one of five samples. Therefore, using the 75%/10X rule, total phenolics meets the MSC at this location.
- MW-14: Concentrations of benzene, toluene, naphthalene, arsenic and total phenolics were greater than their MSCs in all five samples. Ammonia was greater than its MSC in all but one sample. Each of these constituents exceed their respective MSCs. Styrene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene and lead were detected at concentrations that were greater than their respective MSCs in at least one sample. Styrene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene and lead were not detected in the remaining samples; however, the MDLs were greater than the MSCs. Because each of these constituents was detected at least one time at a concentration that was greater than its respective MSC, the MDLs in remaining samples were elevated above the MSCS, and each is also a COC in Site soil, as a conservative measure we have assumed that they do not meet the MSCs in groundwater at this location. Ethylbenzene, methylene chloride, total xylenes, acenaphthene, fluorene, phenanthrene and pyrene were detected in one of five samples at concentrations that were greater than their respective MSCs, all of which occurred prior to the first quarter 2018 when the sampling methodology was switched to pumping at low rates as discussed above. In the remaining samples, these constituents were either detected at concentrations that were less than the MSCs, or were not detected at MDLs that in most cases were less than the MSCs. Based on these results and the fact that none of these constituents are COCs in Site soil, we believe the exceedances during the earlier sampling event were attributed to the introduction of sediment during sampling, and concentrations of these constituents in groundwater are less than the MSCs. Fluoranthene and mercury were detected in one of five samples at concentrations that were greater than their MSCs, but were less than the MSCs in the remaining samples. The exceedances occurred prior to the first quarter 2018 when the sampling methodology was switched to pumping at low rates as discussed above. Although they are COCs in Site soil, we believe the exceedances during the earlier sampling events were attributed to the introduction of sediment during sampling, and concentrations of these constituents in groundwater are less than the MSCs..

- MW-15: Benzene, cadmium, lead, nickel and ammonia were detected in at least one of two samples at concentrations that were greater than their MSCs. Therefore, these constituents do not meet the MSCs at this location.
- MW-16: Concentrations of benzene, naphthalene, arsenic, nickel and ammonia were greater than their respective MSCs in both samples collected at this location, and therefore these constituents do not meet the MSCs at this location.
- MW-17: Benzene, naphthalene, arsenic, chromium, nickel, zinc and ammonia were detected in at least one of two samples at concentrations that were greater than their MSCs. Therefore, these constituents do not meet the MSCs at this location.
- MW-18: Benzene, toluene, naphthalene, arsenic, nickel, ammonia and total phenolics were detected in at least one of two samples at concentrations that were greater than their MSCs. Therefore, these constituents do not meet the MSCs at this location.

Former Coal/Coke Storage Yard in Northwest Portion of Site

- MW-12: Tetrachloroethene was detected in all five samples at concentrations that were greater than its MSC.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

- MW-7: During the first five quarterly sampling events, concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i) perylene, benzo(k)fluoranthene, chrysene and dibenz(a,h)anthracene were slightly greater than their MSCs in at least one sample. During the last three quarterly sampling events, these constituents were not detected at MDLs that were less than the MSCs. As discussed above, we believe the exceedances during the earlier sampling events were attributed to the introduction of sediment during sampling, and concentrations of these constituents in groundwater at MW-7 are less than the MSCs.

Other

- MW-10: Selenium was greater than its MSC in four of eight samples; therefore it does not meet the MSC for selenium.

- MW-3, MW-4, MW-5 and MW-6: Each of these wells contained a limited number of constituents that were detected at concentrations that were slightly greater than their MSCs in one of eight samples, each of which occurred during the first five quarterly sampling events. The remaining sample results were less than the MSCs. Based on these data, these locations meet the MSCs for groundwater.

In addition to the above exceedances of groundwater MSCs, numerous locations contained sulfate at concentrations that were greater than the SMCL, including upgradient monitoring wells. SMCLs are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL. Therefore, sulfate is not considered a COC at the Site.

Based on the discussion above, the final list of COCs in groundwater is summarized below:

<u>Volatile Organic Compounds</u>

- Benzene, Styrene, Tetrachloroethene and Toluene

<u>Polynuclear Aromatic Hydrocarbons</u>

- Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Chrysene and Naphthalene

<u>Metals</u>

- Arsenic, Cadmium, Chromium, Lead, Nickel, Selenium and Zinc

<u>Other Compounds</u>

- Ammonia and Total Phenolics

5.2.2 Summary of Extent of Groundwater Contamination

With the exception of an exceedance of the Act 2 MSC for selenium at well MW-10 in the central portion of the Site, exceedances of the Act 2 MSCs in groundwater were limited to the former byproducts area and the former coal/coke storage yard in the northwest portion of the Site. MW-10 was the only location where selenium was detected in groundwater at concentrations that are

greater than the MSC, therefore selenium impacts at the Site appear limited to the immediate vicinity of MW-10. A summary of the extent of exceedances of COCs in groundwater at the Site is provided below.

Former Byproducts Area

Benzene and ammonia were detected in groundwater samples collected from each of the wells installed in the former byproducts area (MW-8, MW-9 and MW-13 through MW-18) at concentrations that were greater than their respective Act 2 MSCs.

With the exception of wells MW-8, MW-9 and MW-15 located along the easternmost and southernmost portion of the byproducts area, naphthalene was detected in groundwater samples collected from each of the wells installed in the former byproducts area at concentrations that were greater than its respective Act 2 MSC.

Toluene and total phenolics concentrations that were greater than the Act 2 MSC were limited to wells MW-14 and MW-18, while exceedances for styrene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene and chrysene were limited to MW-14 only.

With the exception of wells MW-8, MW-13 and MW-15, arsenic was detected in groundwater samples collected from each of the wells installed in the former byproducts area at concentrations that were greater than their respective Act 2 MSCs. Nickel was detected in groundwater samples collected from all of the wells installed in the southern portion of the former byproducts area (MW-9 and MW-15 through MW-18) at concentrations that were greater than the Act 2 MSC. Lead concentrations that were greater than the Act 2 MSC were limited to wells MW-14 and MW-15, exceedances for cadmium were limited to MW-15, and exceedances for chromium and zinc were limited to MW-17.

Former Coal/Coke Storage Yard in Northwest Portion of Site

MW-12 is the only well at the Site where tetrachloroethene was detected in groundwater at concentrations that were greater than the MSC. This is the only constituent in this well that exceeds an MSC.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

Although COCs were identified in soil samples collected in the former offsite above-ground storage tank area in the westernmost portion of the Site, groundwater at MW-7 meets the MSCs.

5.2.3 Groundwater Fate and Transport

5.2.3.1 Overview

As discussed in Section 3.2.2, groundwater across the Site flows into the island prior to flowing in a northwestward direction down the axis of the island, with the following exception: during brief periods when the river experiences a decrease in surface water elevation, groundwater along the edges of the island temporarily discharges to the river. In portions of the Site where this temporary flow reversal occurs, groundwater has not been impacted by historic Site operations as discussed above.

Based on the results of the Site characterization, several monitoring wells located at or near the western/downgradient property boundary contain one or more COC in groundwater at concentrations that are greater than their respective MSC. A summary of the wells located at or near the downgradient property boundary and their associated COCs is as follows:

- MW-7: No COCs in groundwater at concentrations that are greater than Act 2 MSCs
- MW-8: Benzene and ammonia
- MW-9: Benzene, arsenic, nickel and ammonia
- MW-12: Tetrachloroethene

- MW-13: Benzene, naphthalene and ammonia
- MW-18: Benzene, toluene, naphthalene, arsenic, nickel, ammonia and total phenolics

In order to assess offsite COC migration in groundwater, fate and transport modelling was performed using PADEP's Quick Domenico (QD) Groundwater Fate-and-Transport Model. The QD model was developed by the PADEP to solve the groundwater transport equation for dissolved contaminant plumes. It incorporates a constant planar source, one-dimensional advection, three-dimensional dispersion, adsorption, and first-order decay. Solutions are presented at a point, on the centerline, and in a two-dimensional plan-view grid at any simulation time. QD is intended as a simple tool made available to the regulated community for fate-and-transport analyses.

QD is intended for modeling organic contaminants because nonreactive inorganic solutes do not experience natural degradation, and the sorption of inorganics on soil particles is a complex process that is not adequately represented by the linear isotherm of QD. However, as discussed in the QD User's Manual, modelling of inorganic contaminants can be performed, provided the first-order decay constant (l) and the adsorption parameters (K_{oc} and f_{oc}) are set to zero when modeling inorganics.

A brief description of the required input parameters for the QD model are provided below:

Source Concentration (C_0) in mg/L: The aqueous phase concentration at the source of the release, assuming a uniform, constant concentration that does not vary spatially and does not decay with time. The source concentration should be selected from well data that is concurrent with the calibration point data. During model calibration, concentration data should be available for the calibration wells in at least four consecutive quarters. Because concentrations can vary significantly from quarter to quarter, picking a single measurement to calibrate the model may bias the results. For this reason, PADEP recommends averaging a few quarters of data at each well. Model sensitivity to this input variable is high.

Dispersivities (a_x, a_y and **a_z) in ft**: Dispersion is the process of mechanical mixing of a solute in groundwater that causes spreading of the contamination in advance of the advective front as well

as laterally. PADEP recommends an initial longitudinal dispersion value of a_x=0.1x, where x is the distance to a point of interest, such as the property boundary, plume length, distance to calibration points, etc. The transverse dispersion is commonly defined as a_y=0.1a_x. The PADEP recommends a conservative vertical dispersivity of a_z=0.001 ft. Model sensitivity to this input variable is high.

Decay Constant (l) in day^{-1}: The first-order decay rate represents the degradation of the contaminant as it moves through the aquifer with time. PADEP recommends a preliminary value obtained from literature, and in most cases recommends the use of model calibration to establish a site-specific value for l. Starting values are available in 25 Pa. Code, Chapter 250, Appendix A, Table 5A. If the site data do not exhibit transport decay, then the decay constant should be input as zero. Similarly, when modeling inorganic contaminant transport, l should be set to zero. Model sensitivity to this input variable is high.

Source Width (Y) in ft: The maximum width of known or inferred groundwater contamination at the site. This could be indicated by impacted soils from sampling or visual observations, the presence of NAPL, or elevated dissolved concentrations in monitoring wells. Model sensitivity to this input variable is medium.

Source Thickness (Z) in ft: The maximum depth range of contamination in the aquifer at the source (i.e., below the seasonally high water table). Model sensitivity to this input variable is low.

Time (t) in days: Time from the date of the release, either known or estimated. Under typical conditions steady state is realized within a few years. Model sensitivity to this input variable is medium.

Hydraulic Conductivity (K) in ft/day: Contaminant transport is dominated by advective groundwater flow. The groundwater velocity is primarily controlled by hydraulic conductivity and hydraulic gradient. The recommended sources of hydraulic conductivity are the results of pump tests or multiple slug tests at the site coupled with model calibration. Model sensitivity to this input variable is high.

Hydraulic Gradient (i) in ft/ft: Hydraulic gradient is the slope of the potentiometric surface in the direction of groundwater flow. It is calculated from static water level measurements at monitoring wells. The groundwater flow velocity is proportional to the hydraulic gradient. The gradient should not be a calibration variable in the QD model because the uncertainty in the flow velocity is accounted for by varying the hydraulic conductivity K. Model sensitivity to this input variable is medium.

Effective Porosity (n_e): Effective porosity is the non-dimensional ratio of interconnected void space to the bulk volume of the aquifer material. Values for unconsolidated sediments can vary greatly, from 0.01 to ~0.40. According to the QD User's manual, an appropriate value for porous media is 0.3, but the user should select a porosity corresponding to the aquifer material at the site. Model sensitivity to this input variable is low.

Bulk Density (p_b) in g/cm^3: Bulk density of the aquifer material calculated on a dry basis. A typical value for unconsolidated materials is 1.7 g/cm^3. Model sensitivity to this input variable is low.

Organic Carbon Partition Coefficient (K_{oc}) in L/kg: The partition coefficient relates the affinity of the dissolved contaminant for organic carbon in the soil. Values are chemical specific. PADEP recommends using values found in 25 Pa Code Chapter 250, Appendix A, Table 5A. For inorganic solutes $K_{oc} = 0$. Model sensitivity to this input variable is low.

Fraction of Organic Carbon (f_{oc}): The weight fraction of natural organic carbon in the uncontaminated aquifer soil matrix. Typical values are 0.0002–0.005. According to the QD User's Manual, an appropriate default value is 0.002. For inorganic solutes $f_{oc} = 0$. Model sensitivity to this input variable is low.

Of the various input parameters, source concentration, dispersivity, decay constant and hydraulic conductivity are the dominant factors affecting the modelled concentrations. PADEP recommends calibrating the model by running a series of models, systematically changing hydraulic conductivity (K) and longitudinal dispersivity (a_x) within their plausible ranges (assuming an

uncertainty in both K and a_x of up to a factor of ten) and varying l as necessary until the model solution fits the site data. Although PADEP recommends the use of calibration points, in some cases it may be acceptable to use QD without a calibration, as it is not always feasible to install calibration wells at the site, and an uncertainty analysis may demonstrate that conservative parameter values result in a satisfactory outcome.

5.2.3.2 Model Calibration

As discussed in previous sections of this report, the Site has operated as a coke making and byproducts recovery operation since approximately 1920, and historic site operations have impacted surface soils, subsurface soils and groundwater at the Site. Due to the long history of operations at the Site, it is likely that multiple releases of COCs have occurred at various locations at the Site, primarily within the byproducts area. While this makes it more difficult to calibrate the QD model due to the difficultly in establishing a single source location from which downgradient well data can be compared to modelled concentrations, model calibration was performed using available Site data as discussed below.

Model calibration was performed primarily using benzene data from wells MW-14, MW-13 and MW-8 located in the byproducts area. Well MW-14 is located in the immediate vicinity of the former light-oil tanks and benzol building, which were likely a primary source of benzene releases in the byproducts area. Wells MW-13 and MW-8 are located approximately 150 and 360 feet west of MW-14, respectively, and are downgradient of MW-14. In addition, MW-13 and MW-8 are generally located near the centerline of a plume originating at MW-14. In order to calibrate the QD model, a series of models were run that systematically changed hydraulic conductivity (K) and longitudinal dispersivity (a_x) within their plausible ranges. The results of each model run were then compared to benzene data from wells MW-14, MW-13 and MW-8 to identify which model run best matched the existing Site data. A summary of the input parameters and assumptions used to calibrate the model are provided below.

As recommended in the QD User's Manual, the average benzene concentration from quarterly samples collected at MW-14 (89.8 mg/L) was input as the source concentration (C_0). Similarly,

average benzene concentrations from quarterly samples collected at MW-13 (6.56 mg/L) and MW-8 (0.04 mg/L) were used for the calibration well benzene concentrations. For the purpose of calculating averages, non-detected results were input as one-half the detection limit.

PADEP recommends an initial longitudinal dispersion value of a_x=0.1x, where x is the distance to a point of interest, such as the property boundary, plume length, distance to calibration points, etc. For model calibration, the distance (x) from MW-14 to calibration well MW-8, located downgradient of MW-14 and adjacent to the property boundary, was used. Whereas, x=360ft; a_x = 0.1x = 36ft. Because the uncertainty in a_x may vary by a factor of 10, a reasonable range for a_x is a_x = 0.01x = 3.6 to a_x = 1x = 360 ft. The transverse dispersion was defined as a_y=0.1a_x, and the PADEP-recommended vertical dispersivity of a_z=0.001 ft was used.

As shown on Table 3, the average hydraulic conductivity (K) for the Site based on 11 slug tests is 25.8 ft/day. As discussed in the QD User's Manual, site-specific values are not exact measurements of conductivity, which can vary spatially and with depth, and the uncertainty in K may be as great as a factor of 10. Therefore, slug test results at a site should not be used to determine an absolute, average value of K for input to QD. Instead, the test results should be evaluated to define a range of reasonable conductivities for the aquifer. This is a conservative approach that accounts for local heterogeneity and anisotropy. The QD User's Manual indicates the range of reasonable conductivities may be defined as the minimum and maximum values at the Site, the average plus or minus the standard deviation, or the 95% lower and upper confidence limits of the mean. Therefore, the average (25.8 ft/day), minimum (5.1 ft/day) and maximum (81.1 ft/day) K values from the 11 slug tests at the Site were used for model calibration.

The first-order decay rate (l) was obtained at 25 Pa. Code, Chapter 250, Appendix A, Table 5A. For benzene, $l=0.35yr^{-1}=0.00096day^{-1}$

Source width (Y) was input as 200 feet, which is the approximate width of the byproducts area, and source thickness (Z) was input as 60 feet, which represents the entire saturated thickness of the aquifer, assuming an average depth to groundwater of 20 feet bgs and an assumed depth to bedrock of approximately 80 feet bgs. These are both conservative assumptions.

Time (t) from the date of the release is not known. However, under typical conditions steady state is realized within a few years. Therefore, a time of 1,000 days (approximately 3 years) was used in the model.

Hydraulic gradient (i) is the slope of the potentiometric surface across the Site in the direction of groundwater flow. It was calculated using the average of the static quarterly water level measurements at monitoring well MW-3 located in the upgradient portion of the Site and MW-8 located downgradient of the byproducts area, where i = (MW-3 average groundwater elevation – MW-8 average groundwater elevation)/distance from MW-3 to MW-8. Therefore, i = (709.20 – 708.32)/1,650 = 0.00053

An effective porosity (n_e) for porous media of 0.3 was used per the QD User's Manual.

The average bulk density (p_b) of the aquifer material (2.17 g/cm^3) was calculated from six samples collected at the Site from beneath the water table (Table 8).

The Organic Carbon Partition Coefficient (K_{oc}) was obtained from 25 Pa Code Chapter 250, Appendix A, Table 5A. For benzene, K_{oc}=58

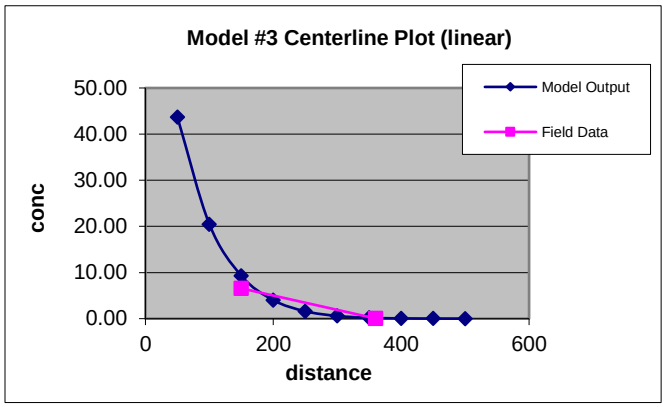
The Fraction of Organic Carbon (f_{oc}) was input as 0.002 in accordance with the QD User's Manual.

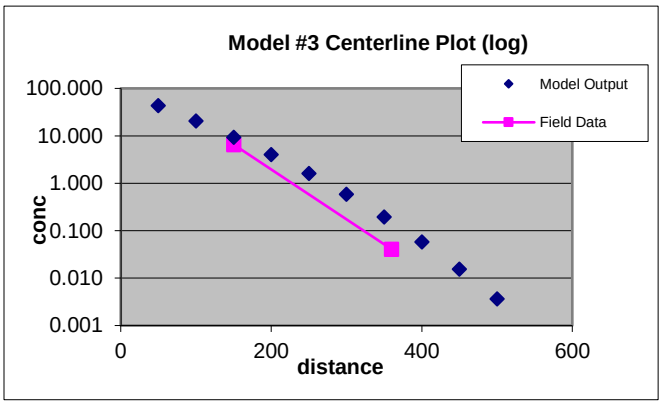
Using the input parameters described above, nine models were run that systematically changed hydraulic conductivity (K) and longitudinal dispersivity (a_x) within their plausible ranges as summarized in the following table.

Model	K (ft/day)	Comment	a_x (ft)	Comment
1	25.8	Average of 11 slug tests performed at Site	36	a_x = 0.1x
2	25.8		3.6	Lower bound of reasonable a_x
3	25.8		360	Upper bound of reasonable a_x
4	5.1		36	a_x = 0.1x
5	5.1		3.6	Lower bound of reasonable a_x

Model	K (ft/day)	Comment	a_x (ft)	Comment
6	5.1	Lower bound of reasonable K values (Site minimum)	360	Upper bound of reasonable a_x
7	81.1	Upper bound of reasonable K values (Site maximum)	36	$a_x = 0.1x$
8	81.1		3.6	Lower bound of reasonable a_x
9	81.1		360	Upper bound of reasonable a_x

Average benzene concentrations at wells MW-8 and MW-13 were then compared to modelled benzene concentrations from the nine model runs to determine which model most accurately matched Site conditions. Output files from the QD model are provided in Appendix G. As shown in the QD model files and in the figures shown below, model run #3 (K value of 25.8 ft/day and a_x value of 360 ft) most accurately modelled benzene concentrations in calibration wells MW-8 and MW-13.





This model predicted a plume centerline concentration of 9.3 mg/L 150 feet downgradient of MW-14, compared to an average benzene concentration of 6.6 mg/L at MW-13 located approximately 150 feet downgradient of MW-14, and a plume centerline concentration of 0.16 mg/L 360 feet downgradient of MW-14, compared to an average benzene concentration of 0.04 mg/L at MW-8 located approximately 360 feet downgradient of MW-14. While further calibration of the model could be attempted by varying l within its reasonable range, because model run #3 is a conservative model (i.e. the modelled concentrations are slightly greater than actual concentrations in the calibration wells), no further calibration was attempted.

With the exception of model run #7, none of the other model runs produced modelled benzene concentrations that approximated Site conditions. Model #'s 1, 2, 4, 5, 6 and 8 predicted downgradient benzene concentrations that were considerably less than concentrations in the calibration wells. Therefore, these models underestimated downgradient benzene concentrations compared to Site data and are not sufficiently conservative. Model #9 predicted downgradient benzene concentrations that were considerably greater than concentrations in the calibration wells. Therefore, while this is the most conservative model, it was not selected for predictive modelling because it is overly conservative based on actual Site date.

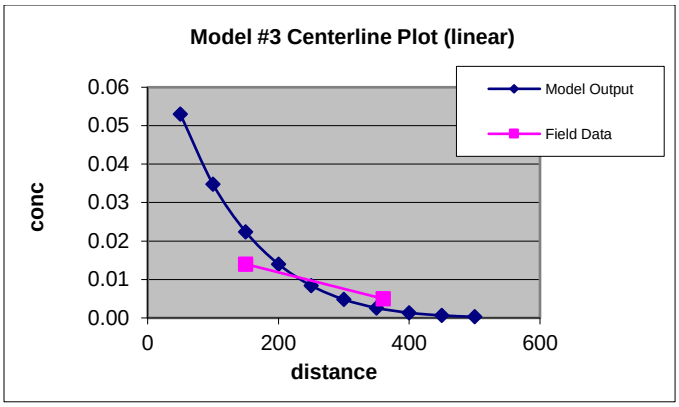
Model run #7 produced modelled concentrations that were reasonably accurate compared to the calibration wells; however, with increasing distance, the model underestimated benzene concentrations compared to calibration well MW-8. Because this model is not as conservative as model #3, we believe model #3 produces the best fit to actual Site data.

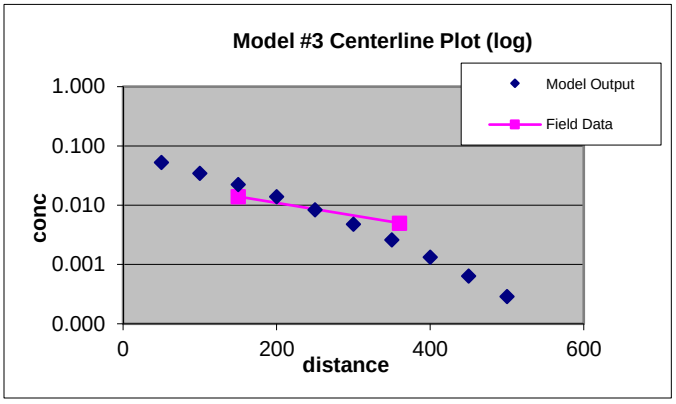
For the remaining COCs at MW-14, because of the large amount of non-detect results in MW-14 and/or calibration wells MW-8 and MW-13, further model calibration was not attempted with the following exceptions.

Naphthalene was routinely detected in wells MW-8, MW-13 and MW-14; therefore, nine model runs were performed for naphthalene using the inputs and assumptions described above for benzene, only substituting average naphthalene concentrations in wells MW-8, MW-13 and MW-14 and naphthalene-specific l and K_{oc} values. Per 25 Pa Code Chapter 250, Appendix A, Table

5A, $l=0.98yr^{-1}=0.0027day^{-1}$ and $K_{oc}=950$ for naphthalene. Average naphthalene concentrations in wells MW-8, MW-13 and MW-14 were 0.07, 0.96 and 41.0 mg/L, respectively. Output files from the QD model are provided in Appendix G. Similar to benzene, model #'s 3, 7 and 9 most accurately reflected actual Site conditions; however, all of the model runs for naphthalene produced modelled concentrations that were less than actual concentrations in calibration wells MW-8 and MW-13. This is likely due to the presence of multiple sources of naphthalene releases in the byproducts area, as opposed to as single source near MW-14. For example, the highest naphthalene concentration in subsurface soils within the byproducts area was identified at MW-8, indicating that releases of naphthalene have occurred in this area. Therefore, it would be expected that naphthalene concentrations in groundwater at MW-8 are greater than modelled concentrations assuming a single source at MW-14.

To calibrate the QD model for inorganics, calibration was performed using arsenic and ammonia data from wells MW-8, MW-13 and MW-14. Of the COCs in groundwater, arsenic is the only metal that was routinely detected at MW-14. Although arsenic was not routinely detected in downgradient wells MW-8 and MW-13, thus making calibration more difficult, calibration was performed by calculating average arsenic concentrations at these wells using one-half the detection limit for non-detect values. Nine model runs were performed for arsenic using the inputs and assumptions described above, average arsenic concentrations at MW-8, MW-13 and MW-14, and l, K_{oc} and f_{oc} values that were set to zero in accordance with recommendations in the QD User's Manual. Output files from the QD model are provided in Appendix G. Similar to benzene, model runs #3 and #7 again accurately modelled arsenic concentrations in calibration wells MW-8 and MW-13, with model #3 again being slightly more conservative with increasing distance from the source. Graphical outputs of model run #3 modelled concentrations versus field data from MW-8 and MW-13 are shown below.

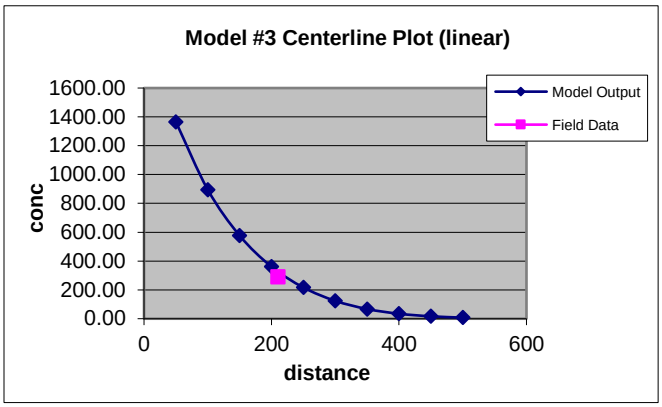


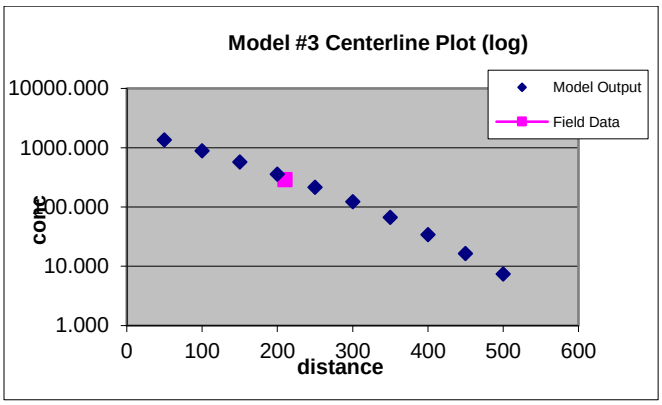


Model runs 1, 2, 4, 5, 6 and 8 again predicted downgradient arsenic concentrations that were considerably less than average concentrations in the calibration wells, and model #9 predicted downgradient arsenic concentrations that were greater than concentrations in the calibration wells and were overly conservative.

For ammonia, the model was calibrated using data from wells MW-8 and MW-13 only. This was performed because well MW-13 is located near the former ammonia-sulfate storage building, which was likely a primary source of ammonia releases in the byproducts area. Furthermore, because MW-14 has lower ammonia concentrations than MW-13, it is clearly not the source of ammonia at well MW-13. Therefore, using average ammonia concentrations at MW-8 and MW-13, l, K_{oc} and f_{oc} values that were set to zero in accordance with recommendations in the QD User's Manual for inorganic contaminants, and the other inputs and assumptions described for benzene, nine model runs were performed for ammonia. Output files from the QD model are provided in Appendix G. Similar to benzene and arsenic, model run #3 most accurately produced modelled concentrations of ammonia that matched concentrations in the calibration well, with a calculated

plume centerline concentration of 327 mg/L 210 feet downgradient of the source, compared to an average ammonia concentration of 290 mg/L at MW-8 located approximately 210 feet downgradient of MW-13 as shown in the figures below.





Model #3 was again conservative as it slightly overestimated ammonia concentrations compared to the calibration well data. Model runs 1, 2, 4, 5, 6 and 8 predicted downgradient ammonia concentrations that were considerably less than average concentrations in well MW-8, while models 7 and 9 overestimated downgradient ammonia concentrations compared to the calibration well and were overly conservative.

Based on the calibration results described above, model run #3 consistently produced modelled concentrations of COCs that most accurately matched Site data, while also being slightly conservative compared to actual Site conditions. Therefore, the use of the inputs and assumptions for model run #3 were used in the predictive modelling described in the following section, where K was set to 25.8 ft/day (the average of 11 slug tests), a_x was set at the upper bound of the

reasonable range (a_x = 1x; in this case 360 feet), and values for l and K_{oc} were obtained from 25 Pa Code Chapter 250, Appendix A, Table 5A, or were set to zero for inorganics.

5.2.3.3 Predictive Modelling

As discussed in this section, QD modelling was performed at monitoring wells located at or near the downgradient property line using the calibrated model to assess potential offsite COC migration. Modelling was performed for COCs that exceed their respective Act 2 MSC in a given well to determine the extent to which offsite migration of groundwater may contain COCs that exceed the MSCs. In addition, as a conservative measure, additional modelling was performed for constituents that were not detected in groundwater, but had MDLs in downgradient property line wells that were greater than Act 2 MSCs.
A summary of each well located at or near the downgradient property boundary and its associated COCs is as follows:

- MW-7: No COCs in groundwater at concentrations that are greater than Act 2 MSCs
- MW-8: Benzene and ammonia
- MW-9: Benzene, arsenic, nickel and ammonia
- MW-12: Tetrachloroethene
- MW-13: Benzene, naphthalene and ammonia
- MW-18: Benzene, toluene, naphthalene, arsenic, nickel, ammonia and total phenolics

The following discussion provides the results of the predictive modelling performed at each well. In each case, the inputs and assumptions from model run #3 from the calibrated modelling discussed above were used in the predictive modelling as summarized below:

- C_0: average COC concentration in downgradient property line well (mg/L)
- a_x: 360 ft
- a_y: 36 ft
- a_z: 0.001 ft
- K: 25.8 ft/day

- l: obtained from 25 Pa Code Chapter 250, Appendix A, Table 5A, or set to zero for inorganic parameters
- Y: 200 feet
- Z: 60 feet
- t: 1,000 days
- i: 0.00053 ft/ft
- n_e: 0.3
- p_b: 2.17 g/cm^3
- K_{oc}: obtained from 25 Pa Code Chapter 250, Appendix A, Table 5A, or set to zero for inorganic parameters
- f_{oc}: 0.002 or set to zero for inorganic parameters

Output files from the predictive QD modelling are provided in Appendix H.

Former Byproducts Area

MW-8: Benzene and ammonia were detected in MW-8 at concentrations that were greater than the Act 2 MSCs. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene and ammonia in the vicinity of MW-8, using the average concentrations of benzene and ammonia from the quarterly samples collected at MW-8 as the source concentration. A summary of the modelling results for MW-8 are provided in the following table.

COC	**MSC (mg/L)**	**MW-8 Avg. (mg/L)**	**Distance from MW-8 until modelled centerline concentration is less than the MSC**
Benzene	0.005	0.04	150 feet
Ammonia	30	290	250 feet

As shown above, modelling indicates that groundwater containing COCs at concentrations that are greater than the MSCs is migrating offsite (based on an approximate distance to the property boundary of 50 feet), but does not extend beyond the immediately downgradient Parcel #159-E-50 (Ashland Inc.), on which groundwater use is prohibited "for any purpose, including, but not

limited to, drinking water supplies, agricultural operations, irrigation of crops or vegetation, cooling water, and industrial or manufacturing operations" (see Section 1.0). Modelling indicates that for benzene and ammonia the MSCs are being met approximately 100 and 200 feet beyond the property boundary, respectively, compared to an approximate distance of 670 feet to the downgradient property line for Parcel #159-E-50 following the direction of groundwater flow. The results for ammonia are shown on Figure 14, which depicts the modelled ammonia plume at MW-8. Note that the plume depicted on Figure 14 assumes a source width of 200 feet as discussed in Section 5.2.3.2. This is a highly conservative assumption; therefore, the modelled plume likely over-estimates plume width.

In addition to the COCs noted above, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, antimony, lead and thallium were not detected in groundwater at concentrations that were greater than the laboratory MDLs; however, the MDLs were greater than the Act 2 MSCs in each of the samples collected from this well. Therefore, as a conservative measure these constituents were modelled using the calibrated QD model to determine a "worst-case" scenario for the potential offsite migration of these constituents in groundwater. For the purposes of the QD model, the source concentration C_0 was input as the lowest MDL that was achieved. A summary of the modelling results are provided in the following table.

Constituent	**MSC (mg/L)**	**Lowest MDL (mg/L)**	**Distance from MW-8 until modelled centerline concentration is less than the MSC**
1,2-dibromo-3-chloropropane	0.0002	0.002	150 feet
1,2-dibromoethane	0.00005	0.001	150 feet
Antimony	0.006	0.01	50 feet
Lead	0.005	0.01	50 feet
Thallium	0.002	0.02	250 feet

For the constituents that weren't detected in groundwater, but had MDLs that were greater than the MSCs, modelling shows that even assuming that these constituents are present in MW-8 at the MDL, groundwater containing these constituents at concentrations that are greater than the MSCs extends, at most, 200 feet beyond the property boundary, and would not extend beyond the

immediately downgradient Parcel #159-E-50. As discussed above, groundwater use on Parcel #159-E-50 is prohibited.

MW-9: Benzene, arsenic, nickel and ammonia were detected in MW-9 at concentrations that were greater than the Act 2 MSCs. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene, arsenic, nickel and ammonia in the vicinity of MW-9, using the average concentrations from the quarterly samples collected at MW-9 as the source concentration. A summary of the modelling results for MW-9 are provided in the following table.

COC	MSC (mg/L)	MW-9 Avg. (mg/L)	Distance from MW-9 until modelled centerline concentration is less than the MSC
Benzene	0.005	0.77	350 feet
Arsenic	0.01	0.03	100 feet
Nickel	0.1	0.19	50 feet
Ammonia	30	315	250 feet

As shown above, modelling indicates that groundwater containing benzene, arsenic and ammonia at concentrations that are greater than the MSCs is migrating offsite (based on an approximate distance to the property boundary of 60 feet), but does not extend beyond the immediately downgradient Parcel #159-E-50 (Ashland Inc.), on which groundwater use is prohibited. Modelling indicates that for benzene, arsenic and ammonia, the MSCs are being met approximately 290, 40 and 190 feet beyond the property boundary, respectively, compared to an approximate distance of 940 feet to the downgradient property line for Parcel #159-E-50 following the direction of groundwater flow. The results for benzene are shown on Figure 15, which depicts the modelled benzene plume at MW-9. As noted above, the plume depicted on Figure 15 assumes a source width of 200 feet, and likely over-estimates plume width.

In addition to the COCs noted above, 1,1,2,2-tetrachloroethane, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, vinyl chloride, antimony, lead and thallium were not detected in groundwater at concentrations that were greater than the laboratory MDLs; however, the MDLs were greater than the Act 2 MSCs in each of the samples collected from this well. Therefore, as a conservative measure these constituents were modelled using the calibrated QD model to determine a "worst-case" scenario for the potential offsite migration of these constituents in groundwater. For the

purposes of the QD model, the source concentration C_0 was input as the lowest MDL that was achieved. A summary of the modelling results are provided in the following table.

Constituent	MSC (mg/L)	Lowest MDL (mg/L)	Distance from MW-9 until modelled centerline concentration is less than the MSC
1,1,2,2-tetrachloroethane	0.0043	0.005	50 feet
1,2-dibromo-3-chloropropane	0.0002	0.005	150 feet
1,2-dibromoethane	0.00005	0.005	200 feet
Vinyl chloride	0.002	0.005	100 feet
Antimony	0.006	0.01	50 feet
Lead	0.005	0.01	50 feet
Thallium	0.002	0.02	250 feet

For the constituents that weren't detected in groundwater, but had MDLs that were greater than the MSCs, modelling shows that even assuming that these constituents are present in MW-9 at the MDL, groundwater containing these constituents at concentrations that are greater than the MSCs extends, at most, 190 feet beyond the property boundary, and would not extend beyond the immediately downgradient Parcel #159-E-50.

MW-13: Benzene, naphthalene and ammonia were detected in MW-13 at concentrations that were greater than the Act 2 MSCs. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene, naphthalene and ammonia in the vicinity of MW-13, using the average concentrations from the quarterly samples collected at MW-13 as the source concentration. A summary of the modelling results for MW-13 are provided in the following table.

COC	MSC (mg/L)	MW-13 Avg. (mg/L)	Distance from MW-13 until modelled centerline concentration is less than the MSC
Benzene	0.005	6.56	400 feet
Naphthalene	0.1	0.96	50 feet
Ammonia	30	3080	450 feet

As shown above, modelling indicates that groundwater containing COCs at concentrations that are greater than the MSCs is migrating offsite (based on an approximate distance to the property boundary of 20 feet), but does not extend beyond the immediately downgradient Parcel #159-E-50, on which groundwater use is prohibited. Modelling indicates that for benzene, naphthalene and ammonia, the MSCs are being met approximately 380, 30 and 430 feet beyond the property boundary, respectively, compared to an approximate distance of 880 feet to the downgradient property line for Parcel #159-E-50 following the direction of groundwater flow. The results for ammonia are shown on Figure 16, which depicts the modelled ammonia plume at MW-13. As noted above, the plume depicted on Figure 16 assumes a source width of 200 feet, and likely over-estimates plume width.

In addition to the COCs noted above, 1,1,2,2-tetrachloroethane, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, vinyl chloride, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenz(a,h)anthracene, antimony, lead and thallium were not detected in groundwater at concentrations that were greater than the laboratory MDLs; however, the MDLs were greater than the Act 2 MSCs in each of the samples collected from this well. Therefore, as a conservative measure these constituents were modelled using the calibrated QD model to determine a "worst-case" scenario for the potential offsite migration of these constituents in groundwater. For the purposes of the QD model, the source concentration C_0 was input as the lowest MDL that was achieved. A summary of the modelling results are provided in the following table.

Constituent	**MSC (mg/L)**	**Lowest MDL (mg/L)**	**Distance from MW-13 until modelled centerline concentration is less than the MSC**
1,1,2,2-tetrachloroethane	0.0043	0.005	50 feet
1,2-dibromo-3-chloropropane	0.0002	0.005	150 feet
1,2-dibromoethane	0.00005	0.005	200 feet
Vinyl chloride	0.002	0.005	100 feet
benzo(a)pyrene	0.0002	0.00091	50 feet
benzo(g,h,i)perylene	0.00026	0.00091	50 feet
benzo(k)fluoranthene	0.00055	0.00091	50 feet
dibenz(a,h)anthracene	0.0006	0.00091	50 feet
Antimony	0.006	0.01	50 feet

Constituent	MSC (mg/L)	Lowest MDL (mg/L)	Distance from MW-13 until modelled centerline concentration is less than the MSC
Lead	0.005	0.01	50 feet
Thallium	0.002	0.02	250 feet

For the constituents that weren't detected in groundwater, but had MDLs that were greater than the MSCs, modelling shows that even assuming that these constituents are present in MW-13 at the MDL, groundwater containing these constituents at concentrations that are greater than the MSCs extends, at most, 230 feet beyond the property boundary, and would not extend beyond the immediately downgradient Parcel #159-E-50.

MW-18: Benzene, toluene, naphthalene, arsenic, nickel, ammonia and total phenolics were detected in MW-18 at concentrations that were greater than the Act 2 MSCs. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene, toluene, naphthalene, arsenic, nickel, ammonia and total phenolics in the vicinity of MW-18, using the average concentrations from the quarterly samples collected at MW-18 as the source concentration. Note that for total phenolics, there are no values for l or K_{oc} published in 25 Pa Code Chapter 250, Appendix A, Table 5A, therefore the values for phenol were used. A summary of the modelling results for MW-18 are provided in the following table.

COC	MSC (mg/L)	MW-18 Avg. (mg/L)	Distance from MW-18 until modelled centerline concentration is less than the MSC
Benzene	0.005	14.6	450 feet
Toluene	1.0	3.8	50 feet
Naphthalene	0.1	0.17	50 feet
Arsenic	0.01	0.33	350 feet
Nickel	0.1	0.14	50 feet
Ammonia	30	1,187	350 feet
Phenolics*	2	2.8	50 feet

* MSC is for phenol

As shown above, modelling indicates that groundwater containing benzene, arsenic and ammonia at concentrations that are greater than the MSCs is migrating offsite (based on an approximate

distance to the property boundary of 50 feet), but does not extend beyond the immediately downgradient Parcel #159-E-50, on which groundwater use is prohibited. Modelling indicates that for benzene, arsenic and ammonia, the MSCs are being met approximately 400, 300 and 300 feet beyond the property boundary, respectively, compared to an approximate distance of 950 feet to the downgradient property line for Parcel #159-E-50 following the direction of groundwater flow. The results for benzene are shown on Figure 17, which depicts the modelled benzene plume at MW-18. As noted above, the plume depicted on Figure 17 assumes a source width of 200 feet, and likely over-estimates plume width.

In addition to the COCs noted above, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,2,4-trichlorobenzene, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, 1,2-dichloroethane, 1,2-dichloropropane, 1,4-dichlorobenzene, 2-hexanone, bromoform, bromomethane, carbon tetrachloride, chlorobenzene, chlorodibromomethane, chloroform, chloromethane, cis-1,2-dichloroethene, dichlorobromomethane, methyl tert-butyl ether, methylene chloride, styrene, tetrachloroethene, trans-1,2-dichloroethene, trichloroethene, vinyl chloride, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz(a,h)anthracene, indeno[1,2,3-cd]pyrene, antimony, lead and thallium were not detected in groundwater at concentrations that were greater than the laboratory MDLs; however, the MDLs were greater than the Act 2 MSCs in each of the samples collected from this well. Therefore, as a conservative measure these constituents were modelled using the calibrated QD model to determine a "worst-case" scenario for the potential offsite migration of these constituents in groundwater. For the purposes of the QD model, the source concentration C_0 was input as the lowest MDL that was achieved. A summary of the modelling results are provided in the following table.

Constituent	**MSC (mg/L)**	**Lowest MDL (mg/L)**	**Distance from MW-18 until modelled centerline concentration is less than the MSC**
1,1,2,2-tetrachloroethane	0.0043	0.2	250 feet
1,1,2-trichloroethane	0.005	0.2	250 feet
1,1-dichloroethane	0.16	0.2	50 feet
1,1-dichloroethene	0.007	0.2	250 feet
1,2,4-trichlorobenzene	0.07	0.2	50 feet

Constituent	MSC (mg/L)	Lowest MDL (mg/L)	Distance from MW-18 until modelled centerline concentration is less than the MSC
1,2-dibromo-3-chloropropane	0.0002	0.4	300 feet
1,2-dibromoethane	0.00005	0.2	350 feet
1,2-dichloroethane	0.005	0.2	300 feet
1,2-dichloropropane	0.005	0.2	300 feet
1,4-dichlorobenzene	0.075	0.2	50 feet
2-hexanone	0.26	2	150 feet
bromoform	0.08	0.2	50 feet
bromomethane	0.01	0.2	50 feet
carbon tetrachloride	0.005	0.2	200 feet
chlorobenzene	0.1	0.2	50 feet
chlorodibromomethane	0.08	0.2	50 feet
chloroform	0.08	0.2	100 feet
chloromethane	0.03	0.2	100 feet
cis-1,2-dichloroethene	0.07	0.2	100 feet
dichlorobromomethane	0.08	0.2	50 feet
methyl tert-butyl ether	0.02	0.2	200 feet
methylene chloride	0.005	1	200 feet
styrene	0.1	0.2	50 feet
tetrachloroethene	0.005	0.2	200 feet
trans-1,2-dichloroethene	0.1	0.2	50 feet
trichloroethene	0.005	0.2	250 feet
vinyl chloride	0.002	0.2	400 feet
benzo[a]anthracene	0.0049	0.0057	50 feet
benzo[a]pyrene	0.0002	0.0057	50 feet
benzo[b]fluoranthene	0.0012	0.0057	50 feet
benzo[g,h,i]perylene	0.00026	0.0057	50 feet
benzo[k]fluoranthene	0.00055	0.0057	50 feet
chrysene	0.0019	0.0057	50 feet
dibenz(a,h)anthracene	0.0006	0.0057	50 feet
indeno[1,2,3-cd]pyrene	0.0028	0.0057	50 feet
antimony	0.006	0.01	50 feet
lead	0.005	0.01	50 feet
thallium	0.002	0.02	250 feet

For the constituents that weren't detected in groundwater, but had MDLs that were greater than the MSCs, modelling shows that even assuming that these constituents are present in MW-18 at the MDL, groundwater containing these constituents at concentrations that are greater than the

MSCs extends, at most, 350 feet beyond the property boundary, and would not extend beyond the immediately downgradient Parcel #159-E-50.

Former Coal/Coke Storage Yard in Northwest Portion of Site

MW-12: Tetrachloroethene was detected in MW-12 at concentrations that were greater than the Act 2 MSC. Therefore, the calibrated QD model was used to assess the extent of offsite migration of tetrachloroethene in the vicinity of MW-12, using the average concentration from the quarterly samples collected at MW-12 as the source concentration. A summary of the modelling results for MW-12 are provided in the following table.

COC	MSC (mg/L)	MW-12 Avg. (mg/L)	Distance from MW-12 until modelled centerline concentration is less than the MSC
Tetrachloroethene	0.005	0.035	100 feet

As shown above, modelling shows that groundwater containing tetrachloroethene at a concentration that is greater than the MSC does not appear to be migrating offsite, as the approximate distance from MW-12 to the property line is 100 feet. The modelled tetrachloroethene plume at MW-12 is shown on Figure 18. Note that the plume depicted on Figure 18 suggests that PCE concentrations that are slightly greater than the MSC may extend offsite in the cross-gradient direction, but this is assuming a source width of 200 feet which likely over-estimates plume width. Regardless, groundwater containing tetrachloroethene at concentrations that are greater than the MSC would not extend beyond Parcel #159-E-50, on which groundwater use is prohibited.

In addition to the COCs noted above, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, antimony, lead and thallium were not detected in groundwater at concentrations that were greater than the laboratory MDLs; however, the MDLs were greater than the Act 2 MSCs in each of the samples collected from this well. Therefore, as a conservative measure these constituents were modelled using the calibrated QD model to determine a “worst-case” scenario for the potential offsite migration of these constituents in groundwater. For the purposes of the QD model, the

source concentration C_0 was input as the lowest MDL that was achieved. A summary of the modelling results are provided in the following table.

Constituent	MSC (mg/L)	Lowest MDL (mg/L)	Distance from MW-12 until modelled centerline concentration is less than the MSC
1,2-dibromo-3-chloropropane	0.0002	0.002	150 feet
1,2-dibromoethane	0.00005	0.001	150 feet
Antimony	0.006	0.01	50 feet
Lead	0.005	0.01	50 feet
Thallium	0.002	0.02	250 feet

For the constituents that weren't detected in groundwater, but had MDLs that were greater than the MSCs, modelling shows that even assuming that these constituents are present in MW-12 at the MDL, groundwater containing these constituents at concentrations that are greater than the MSCs extends, at most, 150 feet beyond the property boundary, and would not extend beyond the immediately downgradient Parcel #159-E-50. Modelling indicates that at most, the MSCs would be met 250 feet downgradient of well MW-12, compared to a distance of approximately 360 feet to the downgradient property line for Parcel #159-E-50 following the direction of groundwater flow.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

MW-7: Based on the quarterly data, MW-7 did not contain COCs in groundwater detected at concentrations that were greater than the Act 2 MSCs. 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, antimony, lead and thallium were not detected in groundwater, but the MDLs were greater than the Act 2 MSCs in each of the samples collected from this well. Therefore, as a conservative measure these constituents were modelled using the calibrated QD model to determine a "worst-case" scenario for the potential offsite migration of these constituents in groundwater. For the purposes of the QD model, the source concentration C_0 was input as the lowest MDL that was achieved. A summary of the modelling results are provided in the following table.

Constituent	MSC (mg/L)	Lowest MDL (mg/L)	Distance from MW-7 until modelled centerline concentration is less than the MSC
1,2-dibromo-3-chloropropane	0.0002	0.002	150 feet
1,2-dibromoethane	0.00005	0.001	150 feet
Antimony	0.006	0.01	50 feet
Lead	0.005	0.01	50 feet
Thallium	0.002	0.02	215 feet

For the constituents that weren't detected in groundwater, but had MDLs that were greater than the MSCs, modelling shows that even assuming that these constituents are present in MW-7 at the MDL, groundwater containing these constituents at concentrations that are greater than the MSCs may extend offsite (based on an approximate distance to the property boundary of 40 feet), but would not extend beyond the immediately downgradient Parcels #159-E-50 or #159-E-100, on which groundwater use is prohibited. Modelling indicates that at most the MSCs would be met approximately 215 feet downgradient of well MW-7 (in this case thallium), compared to a distance of approximately 250 feet to the downgradient property line for Parcel #159-E-50 following the direction of groundwater flow. These results are shown on Figure 19, which depicts the modelled thallium plume at MW-7.

Based on the results of the predictive modelling using the QD model, groundwater containing COCs at concentrations that are greater than the Act 2 MSCs is migrating offsite in the vicinity of wells MW-8, MW-9, MW-13 and MW-18, and is potentially migrating offsite in the vicinity of wells MW-7 and MW-12, but due to elevated MDLs this cannot be determined with certainty. Regardless, predictive modelling using the QD model shows that modelled concentrations of COCs and constituents with elevated MDLs decrease to concentrations that are less than the MSCs prior to reaching the downgradient property line of the immediately adjacent parcels #159-E-50 and #159-E-100, both of which have restrictions on groundwater usage. In addition, as discussed in Section 1.0, groundwater in the vicinity of the Site is not used as a drinking water source, as the Township of Neville Ordinance No. 846 (Appendix A) requires that owners of property abutting the Neville Township water supply system shall connect with and use the system and prohibits

groundwater usage for human consumption. Furthermore, the by-products recovery processes, which are the main source of environmental contaminants at the Site, have not been in operation for several years. Therefore, with the shutdown and demolition of the plant in recent years, these sources are no longer active and therefore cannot contribute additional contaminants to the environment. As a result, the volume and concentration of contaminants previously released at the Site are expected to remain steady or decrease with time.

5.2.3.4 Diffuse Groundwater Flow to the Ohio River

As discussed above, under most circumstances groundwater across the Site flows into the island prior to flowing in a northwestward direction down the axis of the island. Eventually, groundwater leaving the Site discharges back to the Ohio River in the vicinity of the dam located in the main stem of the Ohio River, approximately 3,600 feet beyond the Site boundary (see Figure 8). In addition, during brief periods when the Ohio River experiences a decrease in surface water elevation, groundwater along the edges of the island temporarily discharges to the river. Therefore, in accordance with 25 Pa Code 250.309 and 250.406, a determination for compliance with surface water quality standards from a diffuse groundwater discharge must be made. The following summarizes the results of this determination under the two scenarios described above.

<u>Diffuse Groundwater Discharge to Ohio River during Falling River Elevations</u>

As discussed above, in the northern portion of the Site near the island's interface with the Ohio River, groundwater occasionally discharges to the river at times when the river elevation is falling. In order to determine if groundwater discharges under this scenario comply with surface water quality standards, we have modeled the diffuse flow of COCs in groundwater into the Ohio River and the corresponding concentrations within the river in accordance with the methods and models of the PADEP Office of Water Management by using a basic mass balance equation as follows:

$$C_{sw} = \frac{(Q_{sw} \times Yc \times C_{sw}) + (Q_{gw} \times C_{gw})}{(Q_{sw} \times Yc) + Q_{gw}}$$

Where: C_{sw} = surface water concentration

C_{gw} = groundwater concentration entering surface water

Q_{sw} = flow rate of surface water

Q_{gw} = flow rate of groundwater entering surface water

Yc = the partial mix factor (decimal per cent)

Appendix I presents the calculations used to determine calculated concentrations in the Ohio River (Csw) for COCs in groundwater. A summary of the methodology and assumptions used in these calculations is presented below.

Ohio River stream flow data was obtained using the USGS Selected Streamflow Statistics for Streamgage Locations in and near Pennsylvania (Open File Report 2011-1070) in order to determine Qsw. The 7-day, 10-year low flow statistic (Q7-10) was used for Qsw. This statistic is the average minimum flow expected for seven consecutive days once every ten years. We believe that using this statistic for Qsw provides a conservative determination of potential impacts to surface water by modeling potential impacts during low-flow conditions. The Q7-10 for the Site was determined utilizing published flow statistics for USGS Gage 03086000 in the Ohio River at Sewickley, Pennsylvania, located approximately 7.5 miles downstream of the Site, and calculating a Q7-10 at the Site utilizing drainage area ratios in accordance with the USGS guidance document "Computing Low-Flow Statistics for Ungaged Locations on Pennsylvania Streams by Use of Drainage-Area Ratios". The calculated Q7-10 of 3,044 ft^3/sec was input as Q_{SW}.

The quantity of groundwater discharging into the Ohio River (Qgw) was estimated utilizing Darcy's Law (Q=KIA). A conservative hydraulic gradient (I) was determined using site-specific groundwater elevation data from well MW-5 and the river elevation during a time period when the river elevation was rapidly decreasing (4/2/2008) as shown on Figure 9. Hydraulic conductivity (K) was determined as discussed in Section 3.2.2 using slug-test results from the Site ($K = 9.1 \times 10^{-3}$ cm/sec). The area of diffuse discharge (A) was overestimated by assuming that the discharge

occurs across the entire depth of the river (estimated as 30 feet under low flow) along the entire length of the Site's interface with the river (approximately 1,200 feet). Each of these assumptions is highly conservative with regard to determining potential impacts to the river. Using these assumptions, Q_{GW} = 0.17 ft^3/sec.

Partial Mix Factors (PMF) were calculated using the Pennsylvania Single Discharge Wasteload Allocation Program for Toxics Version 2.0 (PENTOXSD) model in accordance with the TGM and were input for Yc. Four PMFs are calculated in PENTOXSD, depending on which surface water criteria are being applied, and ranged from 0.01 to 0.105. For the purposes of the calculation, the PMF that corresponded to the most stringent Water Quality Based Effluent Limit (WQBEL) for each COC was selected for Yc. For example, the most stringent WQBEL for discharges of anthracene is based on the threshold human health (THH) criterion; therefore, a PMF of 0.074 which corresponds to the THH criteria was used in the calculation for anthracene. The PENTOXSD output data is provided in Appendix I.

In accordance with the PADEP's Implementation Guidance for the Determination and Use of Background/Ambient Water Quality in the Determination of Wasteload Allocations and NPDES Effluent Limitations for Toxic Substances (391-2000-022), for COCs that do not occur naturally, it is assumed that the background concentration in the Ohio River (C_{bsw}) is equal to zero. In accordance with this guidance document, naturally-occurring COCs in groundwater at the Site include ammonia, dissolved lead, phenols, dissolved selenium and dissolved zinc, while the remaining COCs are not considered by PADEP to be naturally occurring in the aquatic environment. For the naturally occurring COCs, if site-specific surface water data are available, the site-specific data should be used as C_{bsw}. If site-specific data are not available, but regional data are, the regional data should be used for C_{bsw}. Otherwise, it can be assumed that the background surface water concentration is zero. Site-specific data from the Ohio River are not available. Regional data from the Ohio River Valley Water Sanitation Commission (ORSANCO) website (www.orsanco.org/data) were available for a sample station in the Ohio River located at the New Cumberland lock and dam, approximately 50 miles downstream of the Site. Although this site is not located in the immediate vicinity of the Site, in the absence of other regional data, and in-lieu of assuming that the background surface water concentration is zero, the average of the

most recent data available online (2017 data) were used for C_{bsw} for the five naturally-occurring COCs. For constituents that were not detected in the ORSANCO study, the ORSANCO MDL was input as C_{bsw}.

Site data were utilized to determine Cgw for COCs in groundwater by using the highest concentration of each COC that has been detected in the wells located along the northern property boundary where groundwater occasionally discharges to the river when the river elevation is falling (MW-4, MW-5 and MW-6). It was then assumed that this maximum concentration is the concentration diffusing into the river across the entire area of the seepage face. While the actual concentrations of COCs discharging to the river under diffuse flow conditions (Cgw) are lower than these values, using the maximum values in the calculation provides an extremely conservative estimation of concentrations in the Ohio River.

The results of our calculations are summarized below and are compared to the Chapter 93 lowest surface water criteria (LSWC). The complete calculations are provided in Appendix I.

COC	Max. Potential Concentration in the Ohio River (mg/L)	Chapter 93 LSWC (mg/L)
Arsenic	0.0000074	0.01
Ammonia	0.05	0.26
Anthracene	0.00000013	8.3
Benzene	0.0000026	0.0012
Benzo(a)anthracene	0.00000017	0.0000038
Benzo(a)pyrene	0.00000018	0.0000038
Benzo(b)fluoranthene	0.0000002	0.0000038
Cadmium	0.000027	0.00025*
Chromium	0.0000037	0.074*
Chrysene	0.00000028	0.0000038
Lead	0.001	0.0025*
Naphthalene	0.000021	0.043
Nickel	0.00022	0.052*
Selenium	0.001	0.0046
Styrene	0.000027	No SWC; MSC = 0.1
Tetrachloroethylene	0.0000026	0.00069
Toluene	0.000027	0.33
Phenolics	0.00011	0.005
Zinc	0.0024	0.12*

* Assumes an instream hardness of 100 mg/L

Ammonia LSWC obtained from Table 6, Maximum In-Stream Ammonia of PADEP's Implementation Guidance of Section 93.7 Ammonia Criteria. The most conservative criteria was selected.

As shown on the table above, the calculated concentrations of COCs in the Ohio River are substantially less than the LSWCs even using highly conservative assumptions. These results are corroborated by the PENTOXSD model which shows that the maximum expected daily discharge concentration for each COC is less than the most stringent WQBEL. Therefore, these data demonstrate compliance with surface water quality standards from diffuse groundwater discharge from the Site during times when the river elevation is falling.

Diffuse Groundwater Discharge to Ohio River Downstream of Dam

As discussed above, under most circumstances groundwater across the Site flows into the island prior to flowing in a northwestward direction down the axis of the island. Eventually, groundwater leaving the Site discharges back to the Ohio River in the vicinity of the dam located in the main stem of the Ohio River, approximately 3,600 feet beyond the Site boundary. In order to determine if groundwater discharges under this scenario comply with surface water quality standards, we have modeled the diffuse flow of COCs in groundwater into the Ohio River using PADEP's SWLOAD5B in accordance with the TGM. The SWLOAD5B model is used to calculate the "maximum average concentration" for decaying and non-decaying plumes emanating from a constant source. These concentrations are then compared to the contaminant-specific "edge criterion", which is the concentration at or above which the maximum average concentration and associated flow must be determined for the plume in question. This is used to ensure that concentrations below the "edge criterion" are not used to dilute the maximum average concentration. "Maximum average concentrations" and flow for input into the PENTOXSD surface water mixing model need only be calculated for portions of a groundwater plume that exceed the "edge criterion" for the compound being evaluated. If no portion of a plume entering a stream at the time of maximum average concentration exceeds the "edge criterion", no further demonstration of surface water attainment is needed. The SWLOAD5B model is constructed so that the "maximum average concentration" of a COC is compared to the "edge criterion" for that

COC and a determination is automatically made regarding whether a PENTOXSD analysis is required.

The following discussion provides the results of SWLOAD5B modelling for each COC in Site groundwater. The inputs and assumptions used in the SWLOAD5B model are discussed below. Site-specific geologic and hydrogeologic inputs used in the SWLOAD5B model were the same as those from model run #3 of the calibrated QD model discussed previously.

- C_0: source concentration. The average COC concentration in wells at the downgradient property boundary (MW-7, MW-8, MW-9, MW-12, MW-13 and MW-18) was determined, and the well exhibiting the highest average concentration was used in the model as summarized below. For calculating averages, the MDL was input for non-detect results.

COC	Source Concentration (mg/L)	Comment
Arsenic	0.33	MW-18 average
Ammonia	3,080	MW-13 average
Anthracene	0.0028	MW-8 average
Benzene	14.6	MW-18 average
Benzo(a)anthracene	0.0038	MW-8 average
Benzo(a)pyrene	0.0022	MW-8 average
Benzo(b)fluoranthene	0.0026	MW-8 average
Cadmium	0.005	ND at property line; MDL used
Chromium	0.0075	MW-18 average
Chrysene	0.0023	MW-8 average
Lead	0.0125	MW-9 average
Naphthalene	0.962	MW-13 average
Nickel	0.188	MW-9 average
Selenium	0.021	MW-18 average
Styrene	2.5	ND at property line; MDL used
Tetrachloroethylene	0.0354	MW-12 average
Toluene	3.8	MW-18 average
Phenolics	2.8	MW-18 average
Zinc	0.076	MW-9 average

- a_x: longitudinal dispersion; a_x = 1x per the calibrated QD model; distance (x) from Site to Ohio River is approximately 3,600 feet; a_x = 3600 ft
- a_y: transverse dispersion; $a_y = 0.1a_x$ per the calibrated QD model; a_y = 360 ft

- a_z: vertical dispersion; a_z = 0.001 ft used in calibrated QD model per PADEP guidance
- λ: 1st order decay constant; obtained from 25 Pa Code Chapter 250, Appendix A, Table 5A, or set to zero for inorganic parameters per PADEP guidance
- S_w: width of the source area; S_w = 200 feet; conservative assumption from QD model
- Sz: depth of source area; Sz = 60 feet; conservative assumption from QD model
- K: hydraulic conductivity; average of slug tests used in the calibrated QD model; K = 25.8 ft/day
- i: hydraulic gradient; i = 0.00053 ft/ft used in the calibrated QD model
- n_e: effective porosity; n_e = 0.3 used in the calibrated QD model per PADEP guidance
- p_b: 2.17 g/cm^3; average of six soil samples used in the calibrated QD model
- K_{oc}: Organic Carbon Partition Coefficient; obtained from 25 Pa Code Chapter 250, Appendix A, Table 5A, or set to zero for inorganic parameters per PADEP guidance
- f_{oc}: Fraction of organic carbon; value used in the calibrated QD model; f_{oc} = 0.002 or set to zero for inorganic parameters per PADEP guidance
- Edge criterion: the Act 2 non-residential, used aquifer MSCs for aquifers with ≤ 2,500 mg/L TDS or the LSWC, whichever was less
- Distance to stream: 3,600 feet; approximate distance from Site to the Ohio River following groundwater flow path
- Plume view width: 8,000 feet; approximation of dispersed plume width at groundwater/surface water interface. Established by adjusting width until the outer boundaries of the plume show very low but positive concentrations in accordance with the SWLOAD5B user's manual.
- Plume view depth: 30 feet; approximate depth of the Ohio River

Output files from the SWLOAD5B modelling are provided in Appendix J. As shown in the SWLOAD5B model output files, no further evaluation for compliance with surface water quality criteria in the Ohio River is needed for the following COCs, as the maximum modelled plume concentrations at the groundwater/surface water interface with the river were less than the Act 2 MSCs and LSWCs:

Anthracene	Cadmium	Nickel	Toluene
Benzene	Chromium	Tetrachloroethylene	Zinc
Benzo(a)anthracene	Chrysene	Total Phenolics	
Benzo(a)pyrene	Lead	Selenium	
Benzo(b)fluoranthene	Naphthalene	Styrene	

SWLOAD5B modelling indicates that further evaluation is required for ammonia and arsenic. It should be noted that the SWLOAD5B model likely overestimates modelled concentrations of ammonia and arsenic at the groundwater/surface water interface with the river, because the model was designed primarily for use with organic contaminants whose fate and transport can be described or influenced by first order decay and reaction with organic carbon in the soil. Because arsenic and ammonia are inorganic contaminants, the first order decay constant, organic carbon partition coefficient and fraction of organic carbon were set to zero in the model as an extremely conservative assumption. Regardless, to further evaluate compliance with surface water quality criteria in the Ohio River for ammonia and arsenic, the basic mass balance equation discussed above was used to model the diffuse flow of COCs in groundwater into the Ohio River as follows:

$$C_{sw} = \frac{(Q_{sw} \times Yc \times C_{sw}) + (Q_{gw} \times C_{gw})}{(Q_{sw} \times Yc) + Q_{gw}}$$

Where: C_{sw} = surface water concentration

C_{gw} = groundwater concentration entering surface water

Q_{sw} = flow rate of surface water

Q_{gw} = flow rate of groundwater entering surface water

Yc = the partial mix factor (decimal per cent)

Appendix J presents the calculations used to determine calculated concentrations of ammonia and arsenic in the Ohio River (Csw). A summary of the methodology and assumptions used in these calculations is presented below.

As discussed previously, Q_{sw} was determined using the published Q7-10 for USGS Gage 03086000 at Sewickley, Pennsylvania, and calculating a Q7-10 at the Site utilizing drainage area ratios.

Q_{gw} was obtained from the SWLOAD5B model in accordance with the TGM, and represents the modelled plume discharge to the Ohio River.

Partial Mix Factors (PMF) were calculated using PENTOXSD and were input for Yc. For the purposes of the calculation, the PMF that corresponded to the most stringent WQBEL for each COC was selected for Yc as discussed above. The PENTOXSD output data is provided in Appendix J.

As discussed above, for COCs that do not occur naturally per PADEP's Implementation Guidance for the Determination and Use of Background/Ambient Water Quality in the Determination of Wasteload Allocations and NPDES Effluent Limitations for Toxic Substances (arsenic), it was assumed that the background concentration in the Ohio River (C_{bsw}) is zero. For ammonia, which the PADEP considers naturally-occurring in the aquatic environment, the average of the most recent data available online (2017 data) from the USGS New Cumberland sample station were used for C_{bsw}.

The results of the SWLOAD5B models were utilized to determine Cgw at the groundwater/surface water interface in accordance with the TGM. This concentration represents the "maximum average concentration" of the modelled plume entering the river.

The results of our calculations are summarized below and are compared to the Chapter 93 lowest surface water criteria (LSWC). The complete calculations are provided in Appendix J.

COC	Max. Potential Concentration in the Ohio River (mg/L)	Chapter 93 LSWC (mg/L)
Arsenic	0.0000012	0.01
Ammonia	0.13	0.26

As shown on the table above, the calculated concentrations of arsenic and ammonia in the Ohio River are below the LSWCs even using highly conservative assumptions. These results are corroborated by the PENTOXSD model which shows that the maximum average concentration for each COC is less than the most stringent WQBEL. It should also be noted that the LSWC that is shown for ammonia is highly conservative. Surface water criteria for ammonia are pH and temperature dependent. Table 6, Maximum In-Stream Ammonia of PADEP's Implementation Guidance of Section 93.7 Ammonia Criteria lists a range of ammonia criteria for a representative range of temperature (15 to 30°C) and pH values (6.0 to 9.0). As pH and temperature increase, the ammonia limit decreases. The LSWC shown above and input into the PENTOXSD model corresponds to the most conservative ammonia limit presented on Table 6, and was calculated based on a pH of 9.0 and a temperature of 30°C. It is highly unlikely that the pH and temperature in the Ohio River ever reach these extreme limits. A more reasonable estimation of pH (7.5) and temperature (20°C) in the river would yield a limit of 5.85. Regardless, the calculated ammonia concentrations in the river are less than the most conservative ammonia surface water criteria. Therefore, these data demonstrate compliance with surface water quality standards from diffuse groundwater discharge to the Ohio River downgradient of the dam located approximately 3,600 feet downgradient of the Site.

5.3 Vapor Intrusion

5.3.1 Introduction

Releases of volatile and some semi-volatile regulated substances to soil or groundwater can result in vapor-phase intrusion (VI) of these regulated substances into indoor air. The resulting impacts to indoor air may pose a threat to human health in inhabited buildings. For this exposure pathway to exist there must be a source of volatile substances in the unsaturated zone soil or groundwater at the water table, current or future inhabited buildings, and a transport pathway along which vapors may migrate from the source into the inhabited building(s). Inhabited buildings are defined as buildings with enclosed air space that are used or planned to be used for human occupancy. Structures that are not routinely occupied, such as storage sheds or confined spaces, are not

considered inhabited buildings. Structures that are not fully enclosed (e.g., carports, shelters) are also not inhabited buildings.

Title 25 Pa. Code § 250.404 requires an assessment of the VI exposure pathway under the site-specific standard. VI must be addressed for existing inhabited buildings and undeveloped areas of the property where inhabited buildings are planned to be constructed in the future. As discussed in the PADEP Land Recycling Program Technical Guidance Manual for Vapor Intrusion into Buildings from Groundwater and Soil under Act 2 (TGMVI) dated January 18, 2017, mitigation measures may be used to eliminate unacceptable risks associated with VI under the site-specific standard at any time in the evaluation process. Mitigation can be used in lieu of a complete evaluation of the VI pathway. When choosing preemptive mitigation, post-remediation care must be implemented to ensure: (1) that potential risks associated with VI will be evaluated and addressed when an inhabited building is constructed in the future or (2) that appropriate mitigation measures will be taken, in lieu of a complete evaluation, in buildings that exist or are constructed on the property.

5.3.2 Identification of Constituents of VI Concern

In order to determine if releases of volatile and semi-volatile organic substances at the Site have created a potential VI risk, soil and groundwater samples were screened against the PADEP nonresidential Statewide Health Standard screening values for soil (SV_{Soil}) and groundwater (SV_{GW}). In accordance with the TGMVI, the Statewide Health Standard screening values cannot be used as-is for screening under the site-specific standard because the Statewide Health Standard screening values are based on a 10^{-5} target cancer risk and a 1.0 target hazard quotient, whereas attainment for the site-specific standard is demonstrated for cumulative risks to receptors from all substances, media, and pathways. As such, the Statewide Health Standard screening values were reduced by a factor of 10 for purposes of screening under the site-specific standard as described in the TGMVI.

The following sections describe the analytical results obtained from soil and groundwater samples collected at the Site and compare the results to the adjusted Statewide Health Standard screening

values (i.e. reduced by a factor of 10). Where a compound was detected at a concentration greater than the screening value, that entry and the respective screening value were highlighted. The complete laboratory data packages are presented in Appendix F.

Site Soil

Analytical results for surface and subsurface soil samples are presented in Tables 9 and 10, respectively, and are compared to the SV_{Soil}. As shown on Table 9, of the 42 locations where surface soil samples were collected, 25 locations contained concentrations of one or more analyzed compound in surface soil that were greater than their respective SV_{Soil} as summarized below.

<u>Former Byproducts Area</u>

- Benzene: Was detected in surface soils at SB-16, SB-17 and SB-23 at concentrations that were greater than the SV_{Soil}.
- Ethylbenzene: Was detected in surface soil at SB-16 at a concentration that was greater than the SV_{Soil}.
- Toluene: Was detected in surface soils at SB-16 and SB-23 at concentrations that were greater than the SV_{Soil}.
- Naphthalene: Was detected in surface soils at MW-8, SB-16, SB-17, SB-18, SB-19, SB-21, SB-29 and SB-30 at concentrations that were greater than the SV_{Soil}.
- Ammonia: Was detected in surface soils at MW-8, MW-15, MW-16, MW-17, MW-18, SB-16, SB-17, SB-18, SB-19, SB-20, SB-29 and SB-30 at concentrations that were greater than the SV_{Soil}.

<u>Former Coal/Coke Storage Yard in Northwest Portion of Site</u>

- Benzene: Was detected in surface soil at SB-27 at a concentration that was greater than the SV_{Soil}.
- Toluene: Was detected in surface soil at SB-27 at a concentration that was greater than the SV_{Soil}.
- Naphthalene: Was detected in surface soils at SB-26, SB-27 and SB-28 at concentrations that were greater than the SV_{Soil}.

- Ammonia: Was detected in surface soils at MW-12 and SB-28 at concentrations that were greater than the SV_{Soil}.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

- Benzene: Was detected in surface soils at SB-12 and SB-13 at concentrations that were greater than the SV_{Soil}.
- Naphthalene: Was detected in surface soils at MW-7, SB-12 and SB-13 at concentrations that were greater than the SV_{Soil}.

Other

- Naphthalene: Was detected in surface soils at MW-1 and SB-1 at concentrations that were greater than the SV_{Soil}.
- Ammonia: Was detected in surface soils at MW-3, SB-2 and SB-3 at concentrations that were greater than the SV_{Soil}.

Each of the "other" locations are in the eastern portion of the Site.

As shown on Table 10, of the 46 locations where subsurface soil samples were collected, 17 locations contained concentrations of one or more analyzed compound in subsurface soil that were greater than their respective SV_{Soil} as summarized below.

Former Byproducts Area

- Benzene: Was detected in subsurface soils at MW-8, SB-16, SB-17, SB-18, SB-20, SB-22 and SB-23 at concentrations that were greater than the SV_{Soil}.
- Ethylbenzene: Was detected in subsurface soils at SB-16 and SB-17 at concentrations that were greater than the SV_{Soil}.
- Styrene: Was detected in subsurface soils at SB-22 and SB-23 at concentrations that were greater than the SV_{Soil}.
- Toluene: Was detected in subsurface soils at SB-17, SB-22 and SB-23 at concentrations that were greater than the SV_{Soil}.

- Total Xylene: Was detected in subsurface soil at SB-22 at a concentration that was greater than the SV_{Soil}.
- Naphthalene: Was detected in subsurface soils at MW-8, SB-16, SB-17, SB-18, SB-22 and SB-23 at concentrations that were greater than the SV_{Soil}.
- Ammonia: Was detected in subsurface soil samples at MW-8, MW-16, MW-17, MW-18, SB-16, SB-17, SB-18, SB-19, SB-20, SB-21, SB-22, SB-23 and SB-30 at concentrations that were greater than the SV_{Soil}.

Former Coal/Coke Storage Yard in Northwest Portion of Site

- Naphthalene: Was detected in subsurface soil at SB-27 at a concentration that was greater than the SV_{Soil}.
- Ammonia: Was detected in subsurface soil at MW-12 at a concentration that was greater than the SV_{Soil}.

Former Offsite Above-Ground Storage Tank Area in Westernmost Portion of Site

- 2-Hexanone: Was detected in subsurface soil at MW-7 at a concentration that was greater than the SV_{Soil}.
- Benzene: Was detected in subsurface soils at MW-7 and SB-13 at concentrations that were greater than the SV_{Soil}.
- Styrene: Was detected in subsurface soil at MW-7 at a concentration that was greater than the SV_{Soil}.
- Toluene: Was detected in subsurface soils at MW-7 and SB-13 at concentrations that were greater than the SV_{Soil}.
- Total Xylene: Was detected in subsurface soil at MW-7 at a concentration that was greater than the SV_{Soil}.
- Naphthalene: Was detected in subsurface soils at MW-7 and SB-13 at concentrations that were greater than the SV_{Soil}.
- Ammonia: Was detected in subsurface soils at MW-7 and SB-13 at concentrations that were greater than the SV_{Soil}.
- Total Phenolics: Was detected in subsurface soil at SB-13 at a concentration that was greater than the SV_{Soil}.

Site Groundwater

Analytical results for groundwater samples are presented in Table 11 and are compared to the SV_{GW}. As shown on Table 11, of the 18 monitoring wells at the Site, seven contain concentrations of one or more analyzed compound in groundwater that were greater than their respective SV_{GW}, all of which were located in the former byproducts area. A summary is provided below.

<u>Former Byproducts Area</u>

- Benzene: Was detected in groundwater at MW-8, MW-9, MW-13, MW-14, MW-16, MW-17 and MW-18 at concentrations that were greater than the SV_{GW}.
- Ethylbenzene, Isopropylbenzene and Total Xylenes: Were detected in groundwater at MW-14 at concentrations that were greater than the SV_{GW}.
- Naphthalene: Was detected in groundwater at MW-13, MW-14, MW-16, MW-17 and MW-18 at concentrations that were greater than the SV_{GW}. Although the initial sample collected at MW-8 contained naphthalene at a concentration that was greater than the SV_{GW}, naphthalene concentrations in seven subsequent samples were less than the SV_{GW}; therefore, naphthalene concentrations at MW-8 meet the SV_{GW}.
- Ammonia: Was detected in groundwater at MW-8, MW-9, MW-13, MW-16, MW-17 and MW-18 at concentrations that were greater than the SV_{GW}.

As discussed above, site soil and groundwater contain several constituents at concentrations that are greater than the SV_{Soil} and SV_{GW} (reduced by a factor of 10 as described above), and as such are constituents of VI concern. A summary of constituents of VI concern are as follows:

Site Soils – 2-Hexanone, Benzene, Ethylbenzene, Styrene, Toluene, Total Xylene, Naphthalene, Ammonia and Total Phenolics

Site Groundwater – Benzene, Ethylbenzene, Naphthalene and Ammonia

Figures 20 and 21 provide the locations where constituents of VI concern were detected in soil and groundwater, respectively, at concentrations that are greater than the SV_{Soil} and SV_{GW}.

5.3.3 Identification of Potential VI Sources

According to the TGMVI, contamination by a constituent of VI concern under any one of the following conditions constitutes a potential VI source:

- In the unsaturated zone, the presence of constituents of VI concern in soil at concentrations that are greater than the SV_{Soil} within prescribed proximity distances;
- In the saturated zone, the presence of constituents of VI concern in groundwater at concentrations that are greater than the SV_{GW} within prescribed proximity distances;
- As separate phase liquid (SPL) within prescribed proximity distances; and
- Associated with a preferential pathway.

Proximity distance is the minimum distance, in the absence of a preferential pathway, that a potential VI source must be from an inhabited building or future inhabited building to not pose an unacceptable VI risk. Proximity distances are a function of the mobility and persistence of the constituent of VI concern as well as, in the case of petroleum substances, the depth of the source and the characteristics of the subsurface materials. There are distinct proximity distances for petroleum and non-petroleum regulated substances as summarized below:

- For contamination associated with non-petroleum substances present in soil and/or groundwater, a horizontal proximity distance of 100 feet applies between the building and SPL or soil/groundwater concentrations that are greater than the screening values; and
- For soil and/or groundwater contamination associated with petroleum substances and related hydrocarbons, a horizontal proximity distance of 30 feet and a vertical proximity distance of five feet apply between the building and soil/groundwater concentrations that are greater than the screening values. For petroleum SPL, a vertical proximity distance of 15 feet applies between the SPL and foundation level.

Note that the petroleum proximity distances apply to any petroleum substance, not just substances listed on the Petroleum Short List from the Land Recycling Program Technical Guidance Manual. Petroleum substances are either aliphatic or aromatic compounds. Aliphatic compounds are

composed of straight-chained, branched, or cyclic compounds and can be saturated (alkanes) or unsaturated (alkenes, alkynes, and others). Aromatic compounds have one or more conjugated, benzene or heterocyclic rings within their structures. If there is no SPL or no exceedances of soil and groundwater screening values within proximity distances to inhabited buildings, then no VI sources are present that pose an unacceptable VI risk, and further evaluation is not warranted.

With the exception of 2-Hexanone, each of the constituents of potential VI concern identified at the Site are considered petroleum substances as defined above. As discussed in Section 1.1.3, in a coke plant, these constituents originate as impurities in the coal. During the coke-making process, these impurities are driven off as a gas, which is then processed to remove tar, ammonia, phenol, naphthalene, light oil, etc. before the gas is used as fuel for heating the ovens. Benzene, ethylbenzene, styrene, toluene, xylene, naphthalene and phenol/phenolics are all aromatic compounds, and most are listed on the Petroleum Short List from the Land Recycling Program Technical Guidance Manual. Although ammonia is not an organic petroleum substance (i.e. it is not an aliphatic or aromatic organic compound), in a coke plant it is created simultaneously with the organic petroleum substances from the burning of coal. Similar to the organic petroleum substances, ammonia is not persistent in the environment, as it is rapidly taken up by plants, bacteria and animals, and is part of the nitrogen cycle. Therefore, benzene, ethylbenzene, styrene, toluene, xylene, naphthalene, phenolics and ammonia have a horizontal proximity distance of 30 feet and a vertical proximity distance of five feet between inhabited buildings and soil/groundwater concentrations that are greater than the screening values, and 2-hexanone has a horizontal proximity distance of 100 feet between inhabited buildings and soil/groundwater concentrations that are greater than the screening value.

5.3.4 Onsite VI Evaluation

As discussed in Section 1.0, site structures were demolished in 2018 with the exception of a guard shack and an unused/vacant warehouse building in the southern portion of the Site. Therefore, with the exception of the guard shack located in the southern portion of the Site, there are currently no inhabited buildings at the Site. The location of the guard shack is shown on Figures 20 and 21, along with the 30-foot proximity distance surrounding the guard shack. Note that only the 30-foot

proximity distance is shown because, with the exception of 2-hexanone in soil at MW-7 located in the northwest portion of the Site, only petroleum substances were identified at the Site at concentrations that were greater than the SV_{Soil} or SV_{GW}. As shown on Figures 20 and 21, there were no exceedances of the SV_{Soil} or SV_{GW} within the 30-foot proximity distance from the guard shack, and there is no SPL (i.e. LNAPL) in this portion of the Site. Therefore, there is currently no complete VI pathway onsite, and further assessment is not warranted.

Although there are not currently any specific plans for future construction of inhabited buildings onsite, there is the potential that inhabited buildings may be constructed onsite at some point in the future. In order to prevent impacts to indoor air in future buildings from onsite VI sources in soil and groundwater, engineering and institutional controls will be imposed at the Site through a Uniform Environmental Covenant (UEC). Engineering and institutional controls will include the following:

- Further evaluating potential VI sources at the time future buildings are planned/constructed to determine if a complete VI pathway exists.
- If further evaluation indicates a complete VI pathway exists for planned future buildings, or in lieu of further evaluation, the use of mitigation as a means of eliminating or reducing vapor migration into future onsite buildings. Mitigation may involve the installation of an active sub-slab depressurization system or the installation of a vapor barrier to prevent VI into future buildings.
- Prohibiting construction of inhabited basements in the former byproducts area.

The UEC will include conditions that require ongoing maintenance of the mitigation system, as appropriate.

5.3.5 Offsite VI Evaluation

Although there are currently no complete VI exposure pathways in onsite inhabited buildings, there is the potential for onsite VI sources in soil and groundwater to create a VI risk in existing offsite buildings. In order to evaluate the presence of a potential VI risk in existing offsite

inhabited buildings, aerial photographs were used to identify the presence of offsite structures that may qualify as inhabited buildings. Once identified, a proximity distance was transcribed around the structure/potentially inhabited building, and existing soil and groundwater data from the Site were screened to determine if a potential VI source was present within the proximity distance. Note that simply because a structure was identified on an aerial photograph does not indicate that it is an inhabited building, as these structures may not be routinely occupied, such as storage sheds, process buildings, etc. For example, during a site visit it was observed that the structure located just across the property boundary to the south of monitoring well MW-9 was a three-sided storage structure (see Figures 20 and 21). Similarly, the two structures located just across the property boundary to the west and northwest of monitoring well MW-18 appear to be process buildings, and may not be routinely inhabited.

The locations of offsite structures/potentially inhabited buildings are identified on Figures 20 and 21, along with the 30-foot proximity distance surrounding the structures. As discussed above, only the 30-foot proximity distance is shown because, with the exception of 2-hexanone in soil at MW-7 located in the northwest portion of the Site, petroleum substances were the only constituents of VI concern that were identified at the Site at concentrations that were greater than the SV_{Soil} or SV_{GW}. Review of aerial photographs reveals that there are no structures located within 100 feet of MW-7.

As shown on Figure 20, there were no exceedances of the SV_{Soil} within the 30-foot proximity distance from offsite structures/potentially inhabited buildings. Therefore, there is no complete offsite VI pathway from VI sources in onsite soil.

As shown on Figure 21, there were no exceedances of the SV_{GW} within the 30-foot proximity distance from offsite structures/potentially inhabited buildings; however, as discussed in Section 5.2.3, the results of the predictive QD modelling indicate that impacted groundwater is migrating offsite. In order to determine if groundwater containing constituents of VI concern is potentially creating an offsite VI risk, the QD model was used to calculate concentrations of constituents of VI concern in groundwater to determine if a potential VI source is located within the proximity distance from offsite structures/potentially inhabited buildings. The predictive QD modelling used

the same inputs and assumptions from model run #3 from the calibrated model discussed above in Section 5.2.3. Output files from the predictive QD modelling are provided in Appendix H.

MW-8: Benzene and ammonia were detected in MW-8 at concentrations that were greater than the SV_{GW}. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene and ammonia in the vicinity of MW-8, using the average concentrations of benzene and ammonia from the quarterly samples collected at MW-8 as the source concentration. A summary of the modelling results for MW-8 are provided in the following table.

Constituent of VI Concern	**SV_{GW} (mg/L)**	**MW-8 Avg. (mg/L)**	**Distance from MW-8 until modelled centerline concentration is less than the SV_{GW}**
Benzene	0.035	0.04	10 feet
Ammonia	290	290.125	10 feet

As shown above, modelling shows that groundwater containing benzene and ammonia at concentrations that are greater than the SV_{GW} is not migrating offsite, as the approximate distance from MW-8 to the property line is 50 feet, and does not intersect the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings.

MW-9: Benzene and ammonia were detected in MW-9 at concentrations that were greater than the SV_{GW}. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene and ammonia in the vicinity of MW-9, using the average concentrations of benzene and ammonia from the quarterly samples collected at MW-9 as the source concentration. A summary of the modelling results for MW-9 are provided in the following table.

Constituent of VI Concern	**SV_{GW} (mg/L)**	**MW-9 Avg. (mg/L)**	**Distance from MW-9 until modelled centerline concentration is less than the SV_{GW}**
Benzene	0.035	0.77	200 feet
Ammonia	290	315	50 feet

As shown above, modelling shows that groundwater containing benzene at concentrations that are greater than the SV_{GW} is migrating offsite and may intersect the 30-foot horizontal proximity

distance from existing offsite structures/potentially inhabited buildings. Groundwater containing ammonia at concentrations that are greater than the SV_{GW} does not appear to migrate offsite or intersect the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings.

MW-13: Benzene, naphthalene and ammonia were detected in MW-13 at concentrations that were greater than the SV_{GW}. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene, naphthalene and ammonia in the vicinity of MW-13, using the average concentrations from the quarterly samples collected at MW-13 as the source concentration. A summary of the modelling results for MW-13 are provided in the following table.

Constituent of VI Concern	**SV_{GW} (mg/L)**	**MW-13 Avg. (mg/L)**	**Distance from MW-13 until modelled centerline concentration is less than the SV_{GW}**
Benzene	0.035	6.56	350 feet
Naphthalene	0.13	0.96	50 feet
Ammonia	290	3080	250 feet

As shown above, modelling shows that groundwater containing benzene and ammonia at concentrations that are greater than the SV_{GW} is migrating offsite and appears to intersect the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings. Groundwater containing naphthalene at concentrations that are greater than the SV_{GW} does not appear to migrate offsite or intersect the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings.

MW-18: Benzene, naphthalene and ammonia were detected in MW-18 at concentrations that were greater than the SV_{GW}. Therefore, the calibrated QD model was used to assess the extent of offsite migration of benzene, naphthalene and ammonia in the vicinity of MW-18, using the average concentrations from the quarterly samples collected at MW-18 as the source concentration. A summary of the modelling results for MW-18 are provided in the following table.

Constituent of VI Concern	SV_{GW} (mg/L)	MW-18 Avg. (mg/L)	Distance from MW-18 until modelled centerline concentration is less than the SV_{GW}
Benzene	0.035	14.6	350 feet
Naphthalene	0.13	0.17	50 feet
Ammonia	290	1,187	150 feet

As shown above, modelling shows that groundwater containing benzene and ammonia at concentrations that are greater than the SV_{GW} is migrating offsite and appears to intersect the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings. Groundwater containing naphthalene at concentrations that are greater than the SV_{GW} does not appear to migrate offsite, but may intersect the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings.

Based on fate and transport modelling with the QD model, groundwater downgradient of wells MW-9, MW-13 and MW-18 contain modelled concentrations of benzene and/or ammonia that may be greater than the SV_{GW} within the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings. However, as discussed above, each of these constituents are petroleum substances, and therefore also have a vertical proximity distance of five feet. Site data collected between October 2016 and October 2018 from monitoring wells MW-8, MW-9, MW-13 and MW-18 indicate that the depth to groundwater in the portion of the Site where SV_{GW} concentrations were exceeded ranges from 14.99 to 21.43 feet below ground surface. Therefore, groundwater containing constituents of VI concern is not present within the five foot vertical proximity distance from offsite structures/potentially inhabited buildings. In addition, although SPL (i.e. LNAPL) has been identified in wells MW-9 and MW-14, SPL associated with petroleum substances has a vertical proximity distance of 15 feet. Based on depth to SPL measurements obtained from the Site (Table 7), the minimum depth to SPL measured at the Site is 17.02 feet below ground surface. Therefore, SPL is not present within the 15 foot petroleum SPL vertical proximity distance from offsite structures/potentially inhabited buildings. Therefore, there is no complete offsite VI pathway from VI sources in groundwater or SPL.

Based on the screening of soil and groundwater data versus the reduced SV_{Soil} and SV_{GW} concentrations, there are no potential VI sources in soil within the applicable horizontal proximity distances from offsite structures/potentially inhabited buildings, and no potential VI sources in groundwater or SPL within the applicable vertical proximity distances from offsite structures/potentially inhabited buildings. Therefore, there is no complete offsite VI pathway and further evaluation is not warranted.

6.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

A screening-level ecological risk assessment was performed for the Site, the objective of which is to quickly evaluate whether surface soil or sediments at the Site have the potential to pose significant ecological impact or impacts requiring further evaluation. Ecological receptors include:

- Individuals of threatened or endangered species as designated by the U.S. Fish and Wildlife Service under the Endangered Species Act.
- Exceptional value wetlands as defined in 25 Pa. Code § 105.17 (relating to wetlands).
- Habitats of concern as defined in 25 Pa. Code § 250.1.
- Species of concern as identified in the PNDI.

When conducting an ecological risk assessment under the site-specific standard, a screening level ecological risk assessment should be performed to determine if an impact has occurred or will occur if a release of a regulated substance goes unabated. If the screening level ecological risk assessment shows that an impact has or will occur, the following are then necessary: a site-specific ecological risk assessment conducted in accordance with Department-approved EPA or ASTM guidance to establish acceptable remediation levels or alternative remedies based on current and future use that are protective of ecological receptors.

To determine if a site-specific risk assessment is necessary, a conceptual site model should be developed that defines potential exposure scenarios and pathways. The exposure scenario (e.g., residential, industrial, recreational), which will define the exposure pathways, must be based on site-specific land use considerations. The pathways, which describe the mechanism by which receptors may be exposed to a source, are also site-specific. Engineering or institutional controls that are to be implemented which will eliminate exposure pathways should be incorporated into the conceptual site model. Then, a site-specific risk assessment only needs to be performed if complete exposure pathways for ecological receptors exist under current or future planned conditions.

The objectives of the site-specific ecological risk procedure are to:

- Evaluate the threat posed by regulated substances to species and habitats of concern through a series of steps which progressively focus the assessment with an emphasis on developing site-specific empirical data and a weight-of-evidence.
- Compile a site-specific weight-of-evidence to determine if a substantial impact has occurred to species or habitats of concern.
- Develop the information necessary to determine what remedial action, if any, could be taken to reduce substantial impacts, if present, without causing greater injury to species or habitats of concern than no further action or less disruptive remedial alternatives.

The PADEP recommends the use of EPA's interim final guidance on Ecological Risk Assessment Guidance for Superfund (EPA, 1997), with some modification, as the process for designing and conducting site-specific ecological risk assessments. The EPA ecological risk assessment process is comprised of as many as eight steps. At the end of Steps 2 and 7, a decision is made regarding whether a substantial impact has resulted from regulated substances. The screening-level ecological risk assessment includes Steps 1 and 2 of the EPA ecological risk assessment process, and is necessary for all sites which are to attain the site-specific standard.

6.1 STEP 1 – FUNDAMENTAL COMPONENTS

Items considered as fundamental components in Step 1 of the ecological risk assessment process include: environmental setting and site history, an evaluation of wetlands via the wetlands mapping tool/national wetlands inventory, a Pennsylvania Natural Diversity Inventory (PNDI) search for habitats and species of concern, a site visit, contaminant fate and transport evaluation, preliminary ecotoxicity evaluation, preliminary exposure pathway analysis, review of similar case studies, and selection of species or habitats of concern for assessment endpoints.

6.1.1 Environmental Setting and Site History

Environmental Setting

The Site is located in an industrial setting near the eastern (upstream) tip of Neville Island, an island within the Ohio River approximately five miles west of downtown Pittsburgh, Pennsylvania. The Site is comprised of an approximate 49.6-acre, irregularly-shaped parcel of land that generally spans the entire width of the island in the north-south direction. The main channel of the Ohio River is located along the northern boundary of the Site; the "back channel" is located to the south. The Site is generally flat except near the river where it is steeply sloped to the river. Historically, the Site included buildings, tanks, coke ovens, and other associated facilities from the now-demolished former coke plant. During operation, approximately half of the Site was covered with buildings, process equipment, or concrete/asphalt paving and parking areas. The remainder of the Site, including most of the western and northern portions, was used for storage of various types of equipment and miscellaneous materials such as coke breeze, coal and ore. Site demolition activities conducted in 2018 removed most of the structures at the Site, leaving the Site primarily vacant.

The area surrounding the Site is developed with heavy and light industry. The closest residence on the island is approximately 2.7 miles west of the Site.

Site History

The Site was originally utilized for agriculture prior to 1900. In 1900, 182 acres of land on the eastern portion of Neville Island, including the current ±49.6-acre Shenango Site and adjacent properties, were operated as a steel-making from 1900 to circa the 1920's. During the late 1920's, coking operations were initiated on the 182-acre parcel of which the Site was a part. In 1935, operations at the Site were expanded to include iron and coke production, miscellaneous chemicals production, and cement and activated carbon production. In 1962, approximately 70 acres of the original 182-acre parcel, including a blast furnace and coke operations, were acquired by Shenango Incorporated or "Shenango". By the end of 1990, the blast furnace and iron production at the Site

permanently ceased operations, while coking operations continued. In 1994, Shenango sold two parcels from their original 70-acre tract, leaving it with the approximately ±49.6 acres that currently comprise the Site. In 2008, Shenango, LLC purchased the ±49.6-acre Site and continued to operate the Site as a coke-making and by-products recovery operation until 2016.

In 2016, Shenango, LLC ceased operations at the Site and began the process of removing residual raw materials and cleaning out process tanks and vessels in anticipation of Site demolition. Site buildings and structures were demolished in 2018.

For additional information on the environmental setting and Site history, refer to Section 1.0.

6.1.2 Constituents of Potential Ecological Concern

The initial list of Constituents of Potential Ecological Concern (CPECs) include all the constituents detected in surface soil samples at the Site. Including a constituent as a CPEC does not imply that the constituent poses a risk to ecological receptors, but only that it is being considered as part of the evaluation process. The CPECs identified in surface soil include VOCs, PAHs, PCBs, metals, ammonia-nitrogen and total phenolics.

6.1.3 Receptors and Chemical Migration Pathways

Ecological receptors at the Site include vegetation and terrestrial receptors such as birds, bats, deer and rodents. Terrestrial receptors would likely be seasonal or transient occupants of the Site that would not be continuously exposed to Site contaminants.

Exposure pathways for ecological receptors at the Site include inhalation of vapors or fugitive dust, contact with and/or ingestion of surface soil, and ingestion of plants and animals exposed to site contaminants. Site topography precludes erosion and transport of surface soil constituents from the site to the river.

As discussed in Section 3.2, with few exceptions, groundwater at the Site does not discharge to the Ohio River. Groundwater at the Site flows into the island prior to flowing in a westward direction down the axis of the island. In portions of the Site where groundwater temporarily discharges to the river as a result of falling river elevations (i.e. along the islands edge), groundwater has not been impacted by historic Site operations (see Section 5.2). Therefore, contact by ecological receptors with contaminated groundwater or surface water in the Ohio River is not considered a potential exposure pathway for ecological receptors.

6.1.4 Habitats and Species of Concern

Habitats of concern, as defined in 25 Pa. Code § 250.1, includes the following: typical wetlands with identifiable function and value, except for exceptional value wetlands as defined in § 105.17 (relating to wetlands), breeding areas for species of concern., migratory stopover areas for species of concern, wintering areas for species of concern, habitat for State endangered plant and animal species, Federal, State and local parks and wilderness areas, and areas designated as wild, scenic or recreational, and areas otherwise designated as critical or of concern by the Game Commission, the Fish and Boat Commission or the Department of Conservation and Natural Resources.

A search for habitats and species of concern in the vicinity of the Site was conducted using the Pennsylvania Natural Diversity Inventory (PNDI) Environmental Review Tool available at the Pennsylvania Natural Heritage Program's Pennsylvania Conservation Explorer website and a Site visit. The PNDI database includes information from four different agencies and was used to determine if there are any rare, threatened, or endangered species, and special concern species on the Site. State-listed species information is provided by the Pennsylvania Game Commission (PGC), the Pennsylvania Department of Conservation and Natural Resources (DCNR), and the Pennsylvania Fish and Boat Commission. In addition, information related to federally-listed species is provided by the U.S. Fish and Wildlife Service (USFWS). According to the PNDI search, PNDI records indicate there are "no known impacts to threatened and endangered species and/or special concern species and resources within the project area". Therefore based on the information provided, no further coordination is required with the jurisdictional agencies. A copy

of the PNDI search results is provided in Appendix K. Additionally, as discussed in Section 6.1.6, no species or habitats of concern were identified during the Site visit.

6.1.5 Wetlands Evaluation

An evaluation of onsite wetlands was conducted during the Site visit and using the web-based wetlands mapping tool/national wetlands inventory provided by the US Fish and Wildlife Service. According to the wetlands mapping tool/national wetlands inventory and Site visit, there are no wetlands located on the Site. A copy of the national wetlands inventory map is provided in Appendix L.

6.1.6 Site Visit

On October 16, 2018, a CEC ecologist performed a site reconnaissance to qualitatively assess habitat within the approximate 50-acre site. The following provides a description of the habitats observed during the site visit and presents the ecologist's opinion as to the ecological value of the former coke plant.

Description of Existing Habitat

The majority of the Site has been significantly disturbed from historic industrial activities and more recent site cleanup/demolition activities. For the most part, former building foundations, roads, and fills have replaced/covered natural soils that originally existed at the Site. Because of this high level of disturbance related to historic use, vegetation at the Site is sparse. Based on the site reconnaissance and review of recent aerial photography, it is estimated that approximately 8% of the Site is vegetated. An aerial photograph depicting vegetated habitats is provided as Figure 22. Photographs taken during the October 16, 2018 site visit are provided in Appendix M.

The habitats within the approximate 50-acre Site include open/grassy areas and shrub/tree habitat. The majority of the vegetation that exists within these areas consists of thoroughwort (*Eupatorium*

sp.), little bluestem (*Schizachyrium scoparium*), and Japanese knotweed (*Polygonum cuspidatum*). These species are invasive, aggressively grow in disturbed areas, and have low wildlife value.

Trees within the Site include species such as tree of heaven (*Ailanthus altissima*), staghorn sumac (*Rhus typhina*), and boxelder maple (*Acer negundo*). These early successional tree species are fast-growing, fairly short-lived, and typically inhabit disturbed sites. More mature tree species including American sycamore (*Platanus occidentalis*) and black locust (*Robinia pseudoacacia*) were observed along the banks of the Ohio River in the northern portion of the Site.

The developed areas at the Site include areas related to the historic production, processing, and storage of materials previously used in the coking process, paved or gravel access roads, etc. These areas occupy the majority (92%) of the Site. There is little to no vegetation within these areas, and these areas provide negligible habitat for birds and/or other species of wildlife.

An open water sedimentation pond that receives drainage from a large portion of the Site was observed in the central portion of the Site. No wildlife or fish were observed within or around the sedimentation pond.

No wetlands, streams, or other natural aquatic features were observed within the Site boundary. Federal, state and local parks and wilderness areas; areas designated as wild, scenic or recreational; and areas otherwise designated as critical or of concern by the Game Commission, the Fish and Boat Commission, the Department of Conservation and Natural Resources, or the U.S Fish and Wildlife Service were not observed during the Site visit.

Habitat Summary and Opinion

From an ecological perspective, the overall value of the Site is extremely low. This is mainly due to significant site disturbance associated with historic coke plant operations and recent site remediation operations. The lack of natural soils, sparse vegetation, and overall low quality of existing vegetation further detracts from the Site's ecological value. In addition, the adjacent

properties, which have also been significantly disturbed from past industrial uses, do not provide ecologically meaningful habitats near the Site.

The vegetation that remains at the Site is in the early stages of succession. Invasive species comprise a significant portion of the vegetation that exists and these areas provide negligible value to wildlife.

6.1.7 Preliminary Exposure Pathway Analysis

The TGM site-specific ecological risk assessment guidance (TGM Section III.I) indicates that a preliminary exposure pathway analysis should be performed to evaluate the potential for completed pathways to impact species or habitats of concern. As discussed above, based on the results of the PNDI search, review of the web-based wetlands mapping tool/national wetlands inventory, and the Site visit, no species or habitats of concern have been identified at the Site. Therefore, no ecological impacts requiring further evaluation exist at the Site. Furthermore, the only potentially complete exposure pathways for ecological receptors at the Site include inhalation of vapors or fugitive dust, contact with and/or ingestion of surface soil, and ingestion of plants and animals exposed to site contaminants. As discussed in greater detail in Section 8.0, areas of surface soil contamination at the Site have been covered to prevent contact with Site contaminants, thus eliminating these potentially complete exposure pathways.

6.2 STEP 2 – PRELIMINARY EXPOSURE ESTIMATE AND RISK ASSESSMENT

If complete exposure pathways are identified during Step 1, the exposure and risk to selected endpoints is to be further evaluated in Step 2. As discussed above, based on the results of the PNDI search, review of the web-based wetlands mapping tool/national wetlands inventory, and the Site visit, no species or habitats of concern have been identified at the Site, and engineering controls will be implemented to prevent exposure to contaminants in Site surface soils by ecological receptors. Therefore, the screening-level ecological risk assessment has determined that no substantial ecological risk exists at the Site, and no further assessment is needed.

7.0 HUMAN HEALTH RISK ASSESSMENT

A risk assessment for human exposure from contaminated sites generally consists of the following four steps:

- Site characterization
- Exposure assessment
- Toxicity assessment
- Risk characterization that evaluates if the risks meet human health protection goals.

The following section provides the results of a human health risk assessment for the Site.

7.1 SITE CHARACTERIZATION

The initial steps of the site characterization are to review the analytical data and to select the COCs that are identified in distinct areas of contamination at a site. Under Act 2 there are two possible situations in determining the COCs in a baseline risk assessment under the site-specific standard: (1) strictly using the site-specific standard, or (2) a combination of standards using site-specific and statewide health, site-specific and background, or all three standards. When using a combination of the site-specific standard with one or both of the other two standards, the COCs to be addressed in the risk assessment should include those chemicals that cannot be addressed using either the SHS or the background standard.

7.1.1 COCs

As discussed in greater detail in Sections 4.0 and 5.0, the following constituents were detected in Site soils and/or groundwater at concentrations that are greater than the Act 2 MSCs and are therefore COCs at the Site:

Surface Soil: Ammonia, anthracene, arsenic, benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene and naphthalene.

Subsurface Soil: Ammonia, anthracene, antimony, benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, 2-hexanone, lead, mercury, naphthalene, styrene, toluene and total phenolics.

Groundwater: Ammonia, anthracene, arsenic, benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, cadmium, chromium, chrysene, lead, naphthalene, nickel, selenium, styrene, tetrachloroethene, toluene, total phenolics and zinc.

7.1.2 Nature and Extent of Contamination

Soil – With the exception of limited exceedances of Act 2 MSCs in the eastern portion of the Site for benzo(a)pyrene in surface soil at SB-1 and antimony and lead in subsurface soil at MW-2, exceedances of the Act 2 MSCs in Site soils were limited to the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, and the former offsite above-ground storage tank area in the westernmost portion of the Site (Figures 10 and 12).

Groundwater – With the exception of an exceedance of the Act 2 MSC for selenium at well MW-10 in the central portion of the Site, exceedances of the Act 2 MSCs in groundwater were limited to the former byproducts area and the former coal/coke storage yard in the northwest portion of the Site (Figure 13). As shown on Figures 14 through 19, the results of groundwater fate and transport modelling using the QD model indicate that groundwater containing COCs at concentrations that are greater than the Act 2 MSCs is migrating offsite downgradient of the former byproducts area (wells MW-8, MW-9, MW-13 and MW-18) and possibly in the former coal/coke storage yard (MW-12); however, modelling indicates that exceedances of the Act 2 MSCs do not extend beyond the immediately downgradient Parcels #159-E-50 or #159-E-100, on which groundwater use is prohibited.

7.1.3 Conceptual Site Model

As discussed in Section 2.0, an initial CSM was developed prior to performing the remedial investigation of the Site (Figure 4). Development of a CSM is an important step in identifying data needs in site characterization and in defining exposure. A CSM identifies all potential or suspected sources of contamination, types and concentrations of contaminants detected at a site, potentially contaminated media, and potential exposure pathways and receptors. The CSM provides a systematic way to identify and summarize this information to ensure that potential exposures at a site are accounted for accurately. Utilizing the data obtained during the site characterization, the initial CSM has been revised to reflect the identified sources of contamination at the Site, the types and concentrations of contaminants detected at the Site, the contaminated media, and the completed exposure pathways and receptors identified during the site characterization (Figure 23). The revised CSM provides the basis for completed pathways to be evaluated as part of the site-specific exposure assessment discussed below. The effects of engineering or institutional controls that are to be implemented, which will eliminate exposure pathways, are also considered and discussed in the following section, and will be incorporated into the final CSM. Realistic current and future land use scenarios (i.e., non-residential) provide the basis for selecting the controlling exposure scenarios/pathways shown in Figure 23.

7.2 EXPOSURE ASSESSMENT

The exposure assessment determines or estimates (qualitatively or quantitatively) the magnitude, frequency, duration and routes of exposure. The assessment typically includes an evaluation of the following:

(1) Exposure Scenarios based on land use (current and future).

(2) Potential receptors based on land use (current and future).

(3) Summary of complete pathways (including fate and transport considerations). Complete pathways exist when all components of exposure are present (i.e. source, transport mechanism, route of exposure and receptor).

(4) Quantification of exposure (not required if all exposure pathways will be eliminated through pathway elimination measures).

7.2.1 Exposure Scenario

The Site is located in an industrial setting near the eastern (upstream) tip of Neville Island, an island within the Ohio River approximately five miles west of downtown Pittsburgh, Pennsylvania. The Site is comprised of an approximate 49.6-acre, irregularly-shaped parcel of land that generally spans the entire width of the island in the north-south direction. The main channel of the Ohio River is located along the northern boundary of the Site; the "back channel" is located to the south. The Site is generally flat except near the river where it is steeply sloped to the river. During operation, approximately half of the Site was covered with buildings, process equipment, or concrete/asphalt paving and parking areas. The remainder of the Site, including most of the western and northern portions, was used for storage of various types of equipment and miscellaneous materials such as coke breeze, coal and ore. In 2016, Shenango, LLC ceased operations at the Site and began the process of removing residual raw materials and cleaning out process tanks and vessels in anticipation of Site demolition. Site buildings and structures were demolished in 2018, leaving the Site primarily vacant.

The area surrounding the Site is developed with industrial properties, including Lindy Paving to the northeast of the Site, West View Water Authority to the east of the Site, Calgon Carbon Corporation to the southeast of the Site, Kosmos Cement Company to the south of Calgon, Pittsburgh Activated Carbon to the southwest of Kosmos Cement, Ashland Inc. to the west of the Site, and CSX Railroad to the south of the Ashland site. The closest residence on the island is approximately 2.7 miles west of the Site. For additional information on the environmental setting, refer to Section 1.0.

7.2.2 Potential Receptors

Based on the current exposure setting and planned future land use scenarios, potential receptors at the Site include onsite workers and constructions workers, and offsite workers.

7.2.3 Summary of Complete Exposure Pathways

Identification of complete exposure pathways includes a sources of contamination, receiving media, fate and transport in the affected media, routes of exposure, and potential receptors. Complete pathways exist when all components are present.

The primary source of contamination at the Site is historic site operations that have resulted in releases of contaminants at the Site. With the closure and demolition of the plant, these primary sources of contamination have been eliminated.

The historic releases at the Site have impacted surface soils, subsurface soils and groundwater at the Site, and have resulted in one localized area of LNAPL. These media constitute secondary contaminant sources at the Site that may be transported to receptors via various mechanisms as discussed below.

7.2.3.1 Surface Soil

COCs have been identified in surface soils in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, the former offsite above-ground storage tank area in the westernmost portion of the Site, and at boring SB-1 located in the eastern portion of the Site (Figure 10). Contaminated surface soils can be transported at the Site via erosion and atmospheric dispersion. Routes of exposure to contaminated surface soil by potential human receptors include dermal contact, ingestion of soil particles, inhalation of dust, or inhalation of vapor emissions. Each of these scenarios is discussed below.

<u>Dermal contact, ingestion of soil particles and dust inhalation</u>: As discussed in greater detail in Section 8.0, in order to prevent contact with, or ingestion and/or inhalation of contaminated surface soils at the Site, areas of surface soil contamination have been nominally covered with a six inch cap of cover material consisting of construction/demolition debris from Site demolition (e.g. uncontaminated concrete, brick, block, etc.) or commercially-purchased cover material. Furthermore, because contaminated surface soil may be encountered during future excavation at

the Site, Site contractors, construction workers and employees performing construction tasks in the future that could result in contact with, or exposure to, contaminated media must have a Site Health and Safety Plan (HSP) that will be followed during those activities. In addition, a Site soil management plan (SMP) will be required that describes the methods to field screen soils excavated from the Site and determine the applicability for site re-use or off-site disposal. The requirements for a HSP and SMP will be reflected in a UEC attached to the Site. Additional information on the HSP and SMP requirements are provided in a post-remedial care plan that was prepared for the Site.

Vapor Inhalation: As discussed in Section 5.2.4, surface soils at the Site contain several constituents of VI concern at concentrations that are greater than the SV_{Soil}, primarily in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, and the former offsite above-ground storage tank area in the westernmost portion of the Site. There is currently no complete VI pathway onsite as most site structures were demolished in 2018 and VI sources were not identified within the proximity distance of remaining structures. Similarly, there is no complete offsite VI pathway because potential VI sources in Site soil have not been identified within the proximity distance of offsite structures/potentially inhabited buildings. However, there is the potential that inhabited buildings may be constructed onsite at some point in the future. In order to eliminate the VI exposure pathway in future onsite buildings from VI sources in surface soil, engineering and institutional controls will be imposed at the Site through a UEC. Engineering and institutional controls will include the following:

- Further evaluating potential VI sources at the time future buildings are planned/constructed to determine if a complete VI pathway exists.
- If further evaluation indicates a complete VI pathway exists for planned future buildings, or in lieu of further evaluation, the use of mitigation as a means of eliminating or reducing vapor migration into future onsite buildings. Mitigation may involve the installation of an active sub-slab depressurization system or the installation of a vapor barrier to prevent VI into future buildings.
- Prohibiting construction of inhabited basements in the former byproducts area.

Summary: As summarized above, complete exposure pathways for current or future onsite workers and construction workers coming into contact with contaminated surface soil via dermal contact, ingestion of soil particles, and inhalation of dust or vapor emissions have been eliminated through pathway elimination measures involving engineering and institutional controls. Engineering controls include placement of a soil cap and the use of vapor mitigation measures for future buildings constructed onsite. Institutional controls include requirements for land usage at the Site to remain non-residential, and requirements for a HSP and SMP during future construction activities.

7.2.3.2 Subsurface Soil

COCs have been identified in subsurface soils in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, the former offsite above-ground storage tank area in the westernmost portion of the Site, and at boring MW-2 located in the eastern portion of the Site (Figure 12). Contaminants in subsurface soil can be transported at the Site via leaching and groundwater transport, or via release of vapors into enclosed spaces or open air. Routes of exposure to contaminated subsurface soil by potential human receptors include dermal contact, ingestion of soil particles, inhalation of dust, or inhalation of vapor emissions. Each of these scenarios is discussed below.

Dermal contact, ingestion of soil particles and dust inhalation: Because subsurface soils are defined as soils greater than two feet below ground surface, there is not currently a complete exposure pathway via the dermal contact, ingestion, or dust inhalation routes of exposure. However, because contaminated subsurface soil may be encountered during future excavation at the Site, Site contractors, construction workers and employees performing construction tasks in the future that could result in contact with, or exposure to, contaminated media must have a Site HSP that will be followed during those activities, and a Site SMP that describes the methods to field screen soils excavated from the Site and determine the applicability for site re-use or off-site disposal. The requirements for a HSP and SMP will be reflected in a UEC attached to the Site.

Vapor Inhalation: As discussed in Section 5.2.4, subsurface soils in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, and the former offsite above-ground storage tank area in the westernmost portion of the Site contain several constituents of VI concern at concentrations that are greater than the SV_{Soil}. There is currently no complete VI pathway onsite as most site structures were demolished in 2018 and VI sources were not identified within the proximity distance of remaining structures. Similarly, there is no complete offsite VI pathway because potential VI sources in Site soil have not been identified within the proximity distance of offsite structures/potentially inhabited buildings. However, there is the potential that inhabited buildings may be constructed onsite at some point in the future. In order to eliminate the VI exposure pathway in future onsite buildings from VI sources in subsurface soil, engineering and institutional controls will be imposed at the Site through a UEC as discussed above.

Summary: As summarized above, complete exposure pathways for current or future onsite workers and construction workers coming into contact with contaminated subsurface soil via dermal contact, ingestion of soil particles, and inhalation of dust or vapor emissions have been eliminated through pathway elimination measures involving engineering and institutional controls. Engineering controls include the use of vapor mitigation measures for future buildings constructed onsite. Institutional controls include requirements for land usage at the Site to remain non-residential, and requirements for a HSP and SMP during future construction activities.

7.2.3.3 Groundwater

COCs have been identified in groundwater in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, and in well MW-10 located in the central portion of the Site (Figure 13). Contaminants in groundwater can be transported to receptors via groundwater migration, discharge to surface water, or via release of vapors into enclosed spaces. Routes of exposure to contaminated groundwater by potential human receptors include dermal contact, ingestion, direct inhalation, or inhalation of vapor emissions. Each of these scenarios is discussed below.

Dermal contact, ingestion and direct inhalation: Groundwater is not currently used at the Site; therefore, there is not currently a complete exposure pathway to onsite workers via the dermal contact, ingestion, or direct inhalation routes of exposure. The results of groundwater fate and transport modelling using the QD model indicate that groundwater containing COCs at concentrations that are greater than the Act 2 MSCs is migrating offsite downgradient of the former byproducts area (wells MW-8, MW-9, MW-13 and MW-18) and possibly in the former coal/coke storage yard (MW-12); however, groundwater containing COCs at concentrations that are greater than the Act 2 MSCs does not migrate beyond the immediately downgradient Parcels #159-E-50 or #159-E-100, on which groundwater use is prohibited. Therefore, there is no complete exposure pathway to offsite workers via the dermal contact, ingestion, or direct inhalation routes of exposure.

In order to ensure that future onsite workers are not exposed to contaminated groundwater via the dermal contact, ingestion, or direct inhalation routes of exposure, groundwater usage at the Site will be prohibited via a UEC.

Vapor Inhalation: As discussed in Section 5.2.4, groundwater in the former byproducts area contains several constituents of VI concern at concentrations that are greater than the SV_{GW}. There is currently no complete VI pathway onsite as most site structures were demolished in 2018 and VI sources in groundwater were not identified within the proximity distance of remaining structures. However, there is the potential that inhabited buildings may be constructed onsite at some point in the future. In order to eliminate the VI exposure pathway in future onsite buildings from VI sources in groundwater, engineering and institutional controls will be imposed at the Site through a UEC as discussed above.

Based on fate and transport modelling with the QD model, groundwater downgradient of wells MW-9, MW-13 and MW-18 contain modelled concentrations of benzene and/or ammonia that may be greater than the SV_{GW} within the 30-foot horizontal proximity distance from existing offsite structures/potentially inhabited buildings. However, groundwater containing constituents of VI concern is not present within the five foot vertical proximity distance for petroleum substances from offsite structures/potentially inhabited buildings (depth to groundwater in this

portion of the Site ranges from 14.99 to 21.43 feet below ground surface). Therefore, there is no complete offsite VI pathway because potential VI sources in groundwater have not been identified within the vertical proximity distance of offsite structures.

Summary: As summarized above, complete exposure pathways for future onsite workers coming into contact with contaminated groundwater via dermal contact, ingestion, and inhalation have been eliminated through pathway elimination measures involving engineering and institutional controls. Engineering controls include the use of vapor mitigation measures for future buildings constructed onsite. Institutional controls include requirements for land usage at the Site to remain non-residential, and restrictions on groundwater usage via a UEC.

7.2.3.4 LNAPL

A limited amount of LNAPL has been identified in well MW-14, and to a lesser extent MW-9. Based on the results of the site assessment, LNAPL does not appear to be migrating offsite. Contaminants in LNAPL may leach to groundwater and be transported to receptors via groundwater migration, or may reach receptors via release of vapors into enclosed spaces. Routes of exposure to LNAPL by potential human receptors include dermal contact, ingestion, or inhalation of vapor emissions. Each of these scenarios is discussed below.

Dermal contact and ingestion: Because LNAPL at the Site is present in the subsurface at a minimum depth of approximately 17 feet below ground surface, there is not currently a complete exposure pathway to onsite or offsite workers via the dermal contact or ingestion routes of exposure. As discussed above, contact with COCs in LNAPL that leach to groundwater will be eliminated by restricting groundwater usage at the Site via a UEC. Groundwater usage is already prohibited on the immediately downgradient Parcel #159-E-50.

Vapor Inhalation: There is currently no complete VI pathway onsite as most site structures were demolished in 2018 and LNAPL is not present within the proximity distance of remaining structures. However, there is the potential that inhabited buildings may be constructed onsite at some point in the future. In order to eliminate the VI pathway in future onsite buildings from VI

sources in LNAPL, engineering and institutional controls will be imposed at the Site through a UEC as discussed above.

LNAPL has not been identified within the 30 foot horizontal proximity distance from offsite structures/potentially inhabited buildings. Furthermore, LNAPL associated with petroleum substances has a vertical proximity distance of 15 feet. Based on depth to LNAPL measurements obtained from the Site (Table 7), the minimum depth to LNAPL measured at the Site is 17.02 feet below ground surface. Therefore, LNAPL is not present within the 15 foot petroleum SPL vertical proximity distance from offsite structures/potentially inhabited buildings. Therefore, there is no complete offsite VI pathway because potential VI sources in LNAPL are not present within the vertical or horizontal proximity distances from offsite structures.

Summary: There are no current complete exposure pathways to LNAPL for onsite or offsite workers via the dermal contact, ingestion or inhalation routes of exposure. As summarized above, complete exposure pathways for future onsite workers coming into contact with COCs in LNAPL via dermal contact, ingestion, and inhalation have been eliminated through pathway elimination measures involving engineering and institutional controls. Engineering controls include the use of vapor mitigation measures for future buildings constructed onsite. Institutional controls include requirements for land usage at the Site to remain non-residential, and restrictions on groundwater usage via a UEC.

7.2.3.5 Surface Water

Contaminated surface water can affect receptors through dermal contact, ingestion or inhalation. With the exception of a stormwater sedimentation pond located in the central portion of the Site, there are not any surface waters located on the Site. Based on Site topography, stormwater at the Site infiltrates into the ground surface, discharges to the sedimentation pond from which it infiltrates into the ground surface, or discharges to stormwater catch basins prior to discharge to the Ohio River under the terms of a National Pollutant Discharge Elimination System (NPDES) permit (PA0002437).

As discussed in Section 3.2.2, under most conditions groundwater across the Site consistently flows from the Ohio River into the island prior to flowing in a westward direction down the axis of the island. In portions of the Site where groundwater occasionally discharges to the river as a result of periodic fluctuations in river elevations (i.e. along the edge of the island), groundwater has not been impacted by historic Site operations.

Based on the above, there are no complete exposure pathways to potential COCs in surface water for onsite or offsite receptors via the dermal contact, ingestion or inhalation routes of exposure.

7.2.3.6 Summary and Final CSM

As discussed above, all current and future exposure pathways to human receptors have been eliminated through pathway elimination measures, including both engineering and institutional controls. Therefore, a quantification of exposure is not required. Engineering controls to be implemented at the Site include the placement of a soil cap over areas of surface soil contamination and the use of vapor mitigation measures for future buildings constructed onsite. Institutional controls include requirements for land usage at the Site to remain non-residential, requirements for a HSP and SMP during future construction activities, and restrictions on groundwater usage, all of which will be required through implementation of a UEC. As discussed in Section 6.0, the screening-level ecological risk assessment has determined that no substantial ecological risk exists at the Site, and no further assessment is needed. A final CSM for the Site which incorporates the effects of engineering and institutional controls that are to be implemented to eliminate exposure pathways to potential human receptors is provided in Figure 24.

8.0 CLEANUP PLAN

Onsite surface soils, subsurface soils and groundwater have been demonstrated to contain COCs at concentrations that are greater than the Act 2 MSCs, SV_{Soil} and SV_{GW} in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, the former offsite above-ground storage tank area in the westernmost portion of the Site, and in other limited areas of the Site (SB1, MW-2 and MW-10). Dermal contact, ingestion, and inhalation of contaminated media (soil, air and water) could pose a risk to potential human receptors at the Site. The purpose of the remedial activities at the Site, as summarized below, is to eliminate potential exposure of onsite workers, contractors, and construction workers to contaminated media.

8.1 SITE DEMOLITION AND CLEANUP

Following facility closure in 2016, Shenango, LLC removed residual raw materials and waste products from the Site, cleaned out process tanks, vessels and trenches, demolished onsite structures and equipment, and backfilled trenches and basements with clean material to bring the Site to level grade.

During the course of Site demolition activities, interior walls in the former powerhouse were determined to contain lead-based paint (LBP). Analytical results are provided in Appendix N. With the concurrence of PADEP, in order to prevent potential exposure to LBP by future onsite workers, demolition debris containing LBP was placed within the basement of the former pumphouse and was covered with uncontaminated demolition debris from the Site (e.g. uncontaminated concrete, brick, block, etc.). Additional information on the location of this material is provided in the following section.

A historic pile of fill material was located in the eastern portion of the Site, east of the former boiler house. Analytical testing of this material indicated that it did not meet clean fill limits for unrestricted onsite use (Appendix N). With the concurrence of PADEP, the historic pile of fill was levelled by being spread onsite and was nominally covered by a six inch cap of cover material consisting of construction/demolition debris from Site demolition (e.g. uncontaminated concrete,

brick, block, etc.) or commercially-purchased cover material to prevent potential exposure to future onsite workers. Additional information on the location of this material is provided in the following section.

8.2 PLACEMENT OF COVER MATERIAL

In order to eliminate potential dermal contact, ingestion, and/or inhalation of COCs in 1) surface soil in the former byproducts area, the former coal/coke storage yard in the northwest portion of the Site, the former offsite above-ground storage tank area in the westernmost portion of the Site, and near SB-1 where MSCs were exceeded; 2) soil cuttings generated during site characterization; and 3) present in the historic fill material excavated from the eastern portion of the Site not meeting the definition of "clean fill", a nominal six inch cap of cover material consisting of construction/demolition debris from the Site (e.g. uncontaminated concrete, brick, block, etc.) or purchased cover material has been installed at the Site at the locations shown on Figure 25. The location of demolition debris containing LBP that was placed in the basement of the former pumphouse is also provided on Figure 25. Commercially-purchased cover material included crushed concrete obtained from Lindy Paving and gravel/limestone obtained from Neville Aggregates.

Surface soils containing COCs at concentrations that are greater than the Act 2 MSCs at borings MW-17, SB-22, SB-23 and SB-30 were located in areas that are covered by asphalt or concrete. The asphalt and concrete barriers remain in place to serve as a contact barrier.

The cover material prevents dermal contact, ingestion, and inhalation of contaminated soils. The maintenance of these barriers in the future, along with requirements for a HSP and SMP as discussed below, will prevent potential future exposure to contaminated soils.

8.3 UNIFORM ENVIRONMENTAL COVENANT

A UEC for the Site will eliminate potential future exposure pathways to COCs in soil, air and groundwater. The UEC will require implementation of the following engineering and institution controls at the Site:

1) Groundwater usage at the Site will be prohibited for any and all purposes
2) Land usage at the Site will be restricted to non-residential use
3) Construction of future buildings at the Site will require the following controls:
    - An evaluation of potential VI sources at the time future buildings are planned/constructed to determine if a complete VI pathway exists.
    - If further evaluation indicates a complete VI pathway exists for planned future buildings, or in lieu of further evaluation, the use of mitigation as a means of eliminating or reducing vapor migration into future onsite buildings. Mitigation will involve the installation of an active sub-slab depressurization system or the installation of a vapor barrier to prevent VI into future buildings.
    - Prohibiting construction of inhabited basements in the former byproducts area.
4) Prior to future construction activities at the Site, preparation of a HSP will be required to protect onsite workers during construction activities.
5) Prior to future excavation activities at the Site, preparation of a SMP will be required that describes the methods to field screen soils excavated from the Site and determine the applicability for site re-use or off-site disposal.
6) The soil cover areas, consisting of nominally six inches of cover material comprised of construction/demolition debris from the Site (e.g. uncontaminated concrete, brick, block, etc.) or commercially-purchased cover material, located over soil that is impacted with COCs shall remain in place and be properly maintained to prevent direct contact to the soil underneath.
7) The UEC will also provide notice of the presence, location, type and concentration of existing contaminants.

8.4 POST-REMEDIAL CARE PLAN

Post-remedial care will involve the institution of the UEC and confirming that the institutional and engineering controls are maintained as necessary. The Site owner will annually inspect the Site to confirm that the asphalt and cover material barriers are still in place, and that groundwater is not being used at the Site. A completed checklist will be provided to the PADEP following each annual inspection. A copy of the proposed Post-Remedial Care Plan is included as Appendix O.

9.0 LIMITATIONS

This report has been prepared in keeping with accepted standards of practice for the preparation of environmental investigations and using CEC's professional judgment. CEC makes no claim as to the presence or absence of contamination except at the time of sampling and for the specific locations and parameters tested during the investigation. No warranties, either expressed or implied, are made herein.

The boring logs and related information presented in this report depict subsurface conditions at the test boring locations and at the time of drilling. Soil conditions at other locations may differ. Geologic correlations shown between borings generally are based on straight-line interpolation. Actual conditions between test borings may differ.

Chemical data presented in this report are applicable to the location, time of sample collection, and the parameters analyzed. Chemical conditions may change with time. Reported conditions may not represent current or future conditions.

Water levels may fluctuate through time. Water table contour maps generated from this data are constructed by interpolation between points of known static water levels elevations and using knowledge of specific site conditions. Actual static water levels at locations between the monitoring points may differ from those depicted.

10.0 REFERENCES

ARCADIS, 2007. Phase I Environmental Site Assessment; Shenango Incorporated, 200 Neville Road Pittsburgh, Pennsylvania.

Pennsylvania Department of Environmental Protection (PADEP), 2017. Land Recycling Program Technical Guidance Manual for Vapor Intrusion into Buildings from Groundwater and Soil under Act 2. PADEP document 261-0300-101.

Pennsylvania Department of Environmental Protection (PADEP), 2019. Land Recycling Program Technical Guidance Manual. PADEP document 261-0300-101.

United States Environmental Protection Agency (USEPA), 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final). USEPA document 540-R-97-006.

11.0 SIGNATURES AND CERTIFICATIONS

By affixing my seal to this, I do hereby certify to the best of my knowledge, information, and belief that the information contained in this report is true and correct. I further certify I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

Robert A. Eaton

Signature: _____

Date: 4/17/2019

Martin C. Knuth, P.G. License Number: PG002633G Expiration Date: 09/30/2019

Signature: _____

Date: 4/17/2019