ASHLAND

Soil Sampling and New Well Work Plan

Former Ciba-Geigy Site
Glens Falls, NY

Prepared by:

EHS Support
consider it done

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TABLE OF CONTENTS

1.0 Introduction 1
  1.1 Objectives of Work Plan 1
  1.2 Scope of Work Plan 2
  1.3 Standards, Criteria, and Guidance 3

2.0 Background 4
  2.1 Groundwater Conceptual Site Model 4
  2.2 Investigation Areas of Interest 7

3.0 Proposed Sampling Program 9
  3.1 Soil Boring and Sampling 9
  3.2 Well Installation and Sampling 9

4.0 Field Sampling Methodology 11
  4.1 Health and Safety 11
  4.2 Borehole Clearance 11
  4.3 Soil Boring and Sampling 11
  4.4 Groundwater Well Installation and Sampling 12
  4.5 Quality Assurance/Quality Control Program 13
  4.6 Soil Borehole and Well Surveying 14
  4.7 Equipment Decontamination 14
  4.8 Investigation Derived Waste 15

5.0 Analytical Methods 16
  5.1 Subsurface Soil Sample Analysis 16
  5.2 Well Groundwater Sample Analysis 16

6.0 Sampling and Reporting Schedule 17

7.0 References 18

LIST OF TABLES

Report Table within Text:

Table 1-1 Proposed Investigation Sampling and Data Evaluation

Report Tables as Attachments:

Table 2-1 Statistical Results for Soils
Table 2-2 Statistical Results for Leach Test Data Sets
Table 2-3 Groundwater Chromium Analytical Results
Table 5-1 Soil Laboratory Analytical Method Summary
Table 5-2 Groundwater Laboratory Analytical Method Summary

LIST OF FIGURES

Figure 1-1 Site Map
Figure 2-1 Process Areas A1 to A7
Figure 2-2 Proposed Investigation Areas and Soil Bore and Well Locations

LIST OF APPENDICES

Appendix A Photographs of Riverbank Area
Appendix B Groundwater Sampling Methodology

ABBREVIATIONS

amsl	above mean sea level
ASP	Analytical Services Protocol
BASF	BASF Corporation
bgs	below ground surface
CIBA	Ciba-Geigy Corporation
CEC	Cation Exchange Capacity
C-O-C	chain-of-custody
COC	constituent of concern
CSM	Conceptual Site Model
DER	Division of Environmental Remediation
DOC	dissolved organic carbon
DPT	direct push technology
DUSR	Data Usability Summary Report
EDD	electronic data deliverable
EDWS	Electronic Data Warehouse Standards
ELAP	Environmental Laboratory Accreditation Program
foc	fraction of organic carbon
GWES	groundwater extraction system
HSP	Health and Safety Plan
MPS	Main Plant Site
µg/L	micrograms per liter
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
ORP	oxidation reduction potential
PID	photo-ionization detector
POTW	publicly owned treatment works
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
Site	89 Lower Warren Street, Queensbury, NY
SPLP	Synthetic Precipitation Leaching Procedure
SSR	Soil Sampling Report
TOC	total organic carbon
um	micrometers
USCS	United Soil Classification System
USEPA	United States Environmental Protection Agency
WAD	weak acid dissociable
Work Plan	Soil and Well Sampling Work Plan

1.0 INTRODUCTION

This Soil and Well Sampling Work Plan (Work Plan) has been prepared for the former Ciba-Geigy Corporation (CIBA) pigments manufacturing facility located at 89 Lower Warren Street in Queensbury, NY (the Site). The Site was purchased by CIBA from Hercules in 1979, and was historically operated as a pigments manufacturing facility until 1989. Since that time, Hercules Incorporated became a wholly owned subsidiary of Ashland Inc. (Ashland) and BASF Corporation (BASF) acquired CIBA. Site environmental activities are conducted under a Hazardous Waste Management Post Closure Permit issued by the New York State Department of Environmental Conservation (NYSDEC Site No. 557011). Hercules and CIBA are the Site permittees and share responsibility for environmental activities.

The Site area that is the subject of this investigation (and referred to herein as the Site) is in the historical operations area, also known as the Main Plant Site (MPS), located on the south side of Lower Warren Street, extending south to the Hudson River. The Site operations facilities were decommissioned following cessation of operations in 1989 with buildings and on-grade equipment demolished and removed. The concrete slabs of a few former buildings (nos. 56, 45 and 41) and some underground infrastructure (stormwater/other utility piping/sumps) remain.

Extensive remediation has been carried out at the Site including consolidation and capping of impacted soils in the Resource Conservation and Recovery Act (RCRA) regulated unit area (RCRA cap area), construction of a permeable cap across the remainder of the MPS, and installation of an overburden and bedrock groundwater remedy comprising a groundwater extraction system (GWES). The Site layout and locations of the GWES french drain and extraction wells are illustrated on **Figure 1-1**.

The overall objective of the investigation activities outlined in this Work Plan is to collect data to validate and refine components of the Conceptual Site Model (CSM) presented in the Site Conceptualization and Groundwater Corrective Measures Effectiveness Evaluation Report (EHS Support, 2015a). The CSM was developed based on a robust evaluation of existing site investigation and monitoring data to assess current Site conditions, source areas, and the fate and transport of Site-related chemicals in groundwater. Historically assessment of the fate and transport of metals and inorganics at the Site focused entirely on the lateral and vertical distribution of soil and groundwater impacts; limited consideration was provided for geochemical constraints on the fate and transport of inorganics. The CSM development considered the potential mobility of inorganics (metals and cyanide), and incorporated geochemical modelling to assess whether these constituents are soluble under the prevailing groundwater conditions at the Site. This Work Plan describes additional investigation activities recommended based on findings of the conceptualization study (EHS Support 2015a), to validate the CSM and enhance understanding of Site conditions with respect to mechanisms of metal species mobility and source areas.

1.1 Objectives of Work Plan

The overall objectives of the sampling and analysis proposed in this Work Plan are to:

- Identify the potential sources of hexavalent chromium and cyanide in areas of persistent groundwater impacts.
- Assess the leachability of source materials over a range of pH conditions.
- Demonstrate the immobility of trivalent chromium and other metals within fill materials and spent ore on Site under conditions representative of recharge and groundwater conditions.
- Understand the geochemical conditions of the soil [pH, organic carbon, clay content, iron and manganese mineral phases, and cation exchange capacity (CEC)] that effect the leachability and mobility of metals.

1.2 Scope of Work Plan

This Work Plan outlines the rationale and methodology proposed for soil boring and sampling of overburden fill on Site, and installation and sampling of groundwater wells at the southern boundary of the Site to refine understanding of source areas and the fate and transport of inorganics in groundwater. Data collected will be used to evaluate:

- Spatial distribution and attenuation of metal and inorganic species,
- Identification and qualification of source mass areas,
- Mobility of metal species from primary sources (fill), and
- Characterization of groundwater in the mixing zone between the GWES and the Hudson River.

The investigation focuses on the key risk drivers identified at the Site (hexavalent chromium and cyanide, based on potential mobility), but also provides for assessment of other site-related metals of interest (cadmium, lead and mercury) to confirm the findings of the Site conceptualization and CSM (EHS Support 2015a).

The proposed investigation activities include soil boring and sampling to assess overburden source materials of potential impact to groundwater, and groundwater well installation and sampling along the southern boundary of the Site between the GWES and Hudson River to assess water quality and GWES performance. The areas of interest for investigation, field sampling and analytical methodologies, sample analysis schedules, and reporting proposed to meet the objectives of this Work Plan are discussed herein. This Work Plan is organized as follows:

- Section 1 - Introduces the investigation program and objectives
- Section 2 – Presents background information, data quality objectives and investigation areas of interest
- Section 3 – Describes the field sampling program
- Section 4 – Identifies the field sampling methodologies to be employed
- Section 5 - Identifies sample laboratory analytical methods
- Section 5 – Presents the sampling and reporting schedule
- Section 6 – Presents References

An overview of the investigation activities proposed is presented in **Table 1.1** with further details provided in the following sections of this Work Plan.

Table 1.1
Proposed Investigation Sampling and Data Evaluation

Work Task	Sampling and Analysis	Data Evaluation
Soil Boring and Sampling	Overburden Soil Sampling: - Install up to 20 soil borings and collect soil cores for classification of overburden materials. - Sampling of fill materials to assess physical and chemical properties. - Leach testing of fill at various pH ranges (6-8) to assess speciation and mobility of Site-related constituents of interest under Site-specific conditions.	- Assess presence and potential leachability of metals under pH ranges representative of Site conditions. - Identify overburden material that is key source to groundwater impacts, and potential extent of source to groundwater impact.

Well Installation and Sampling	- Install groundwater wells downgradient of key groundwater impact areas and collect groundwater samples. - Analyze groundwater for geochemical properties and site-related constituents of interest.	- Compare data to groundwater and surface water quality criteria. - Assess potential GWES influence (e.g., surface water ingress) and groundwater-surface water mixing zone conditions.

1.3 Standards, Criteria, and Guidance

This Work Plan was prepared with consideration of the following standards and guidance:

- Environmental Conservation Law, Article 27 Titles 3, 5, 13 and 14.
- 6 NYCRR Part 375, Environmental Remediation Programs. December 14, 2006.
- Division of Environmental Remediation (DER-10) Technical Guidance for Site Investigation and Remediation. NYSDEC. May 3, 2010.
- 6 NYCRR Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, Criteria and Guidance (SCGs) for Investigation and Remediation of Sites under Remedial Programs. http://www.dec.ny.gov/regs/4590.html.
- United States Environmental Protection Agency (USEPA) Region II: Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling. March 16, 1998.
- USEPA Region I: Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells. January 19, 2010.
- Analytical Services Protocol (ASP). NYS DEC. http://www.dec.ny.gov/chemical/23842.html
- Program Policy DER-23 Citizen Participation Handbook for Remedial Programs. NYS DEC. January 2010.
- Preparation Aids for the Development of Category I Quality Assurance Project Plans. USEPA. EPA/600/8-91/003. February 1991.

2.0 BACKGROUND

This section provides a summary of the Site conditions and key findings and recommendations from the Site conceptualization study and CSM developed (EHS Support 2015a), and identifies the areas of interest for investigation under this Work Plan.

2.1 Groundwater Conceptual Site Model

Historically evaluation of the fate and transport of metals and inorganics at the Site was focused entirely on the lateral and vertical distribution of soil and groundwater impacts with limited consideration provided for the effects of geochemical reactions on the fate and transport of inorganics. In 2014, a focused assessment of Site investigation and monitoring data for the Site was conducted to aid in the conceptualization of sources, assessment of the fate and transport of site-related chemicals in groundwater and the performance of the Site GWES (EHS Support 2015a). The findings and CSM developed are based on review of the Site operations history and available soil and groundwater data from historical and more recent (2013-2014) investigations completed for the Site. The key findings from the assessment and resulting CSM developed are discussed below.

Extensive remediation has been completed at the Site including consolidation and capping of impacted soils in the RCRA cap area, construction of a permeable cap across the remainder of the MPS, and installation of an overburden and bedrock GWES. The GWES was constructed parallel to the river along the Site southern boundary and comprises a French drain, installed to top of a lacustrine clay unit at the base of the overburden groundwater–bearing zone, and a series of 20 groundwater extraction wells installed in the shallow bedrock (EW-A1 through EW-A14) and intermediate bedrock (EW-B1 through EW-B6). The GWES has been in operation for over 12 years and in combination with soil remedial actions, construction of the RCRA cap and permeable cover systems, and termination of Site operations major changes in groundwater contaminant concentrations have been observed.

The combination of the Site conditions and remedial activities conducted have resulted in decreases in the lateral extent and concentration of key constituents in groundwater and major changes in the ratios of soluble metals to insoluble metals (for example hexavalent to trivalent chromium ratios). However, in select areas of the Site groundwater concentrations of soluble metals and ions (hexavalent chromium and cyanide) persist suggesting the potential presence of ongoing sources.

In development of the hydrogeological CSM the following questions regarding the overburden soil and fill material and groundwater quality at the Site were investigated:

1. What are the historical sources of impact to groundwater and what are the likely contributions from fill and waste materials to groundwater impacts?
2. What are the key geochemical controls on the fate and transport of metals and inorganics at the Site?
3. What temporal changes in groundwater concentrations and lateral and vertical distribution of groundwater impacts have been observed, and how do these relate to the termination of Site operations and implementation of corrective measures including operation of the GWES?
4. How have groundwater extraction activities affected the vertical and lateral movement of groundwater, communication with the Hudson River, and groundwater geochemistry?

These queries were evaluated systematically and hexavalent chromium and cyanide were identified as constituents that could exhibit ongoing mobility, with hexavalent chromium identified as the primary constituent of concern (COC) based on concentrations in groundwater (relative to groundwater and surface water quality standards) and potential flux.

The re-evaluation of the Site geology and hydrogeology determined that the bedrock at the Site can be effectively considered one lithologic unit with groundwater head differences in the shallow, intermediate, and deep bedrock intervals, reflecting the absence of intergranular porosity with groundwater flow occurring in discrete intervals of fracturing. Sub-horizontal fractures dominate at the Site with discrete areas identified where sub-vertical fractures are present. However, the vertical head differences observed and the communication between groundwater and surface water clearly support the dominance of sub-horizontal fracturing in the hydrogeologic CSM.

2.1.1 Soil Conditions

Metals were historically detected at elevated concentrations in soils and fill across the Site. Mercury, chromium, cadmium, barium, lead, and cyanide were ubiquitous in fill materials across the Site and present at concentrations well above the concentrations observed within native soils outside of the main production areas. The highest concentrations of these metals were observed in fill materials located in the area of the current RCRA cap and the southwestern corner of the Site where incineration and chromium ore stockpiling activities occurred. Elevated concentrations of chromium were also observed in the historical chromium process areas, focused around former Buildings 56 and 8. Metals concentrations observed in the native soils are typically orders of magnitude lower than those observed in the fill. Barium and cyanide were generally not detected in native soils at elevated (above screening level) concentrations. A summary of the soil sampling results by operational area is provided in attached **Table 2-1** and a map showing the historical operational areas is provided as **Figure 2-1**.

Leachability assessments historically conducted on fill and native soils have indicated that these constituents are leachable and can impact groundwater at concentrations above applicable groundwater standards (refer attached **Table 2-2**). However, the leachable concentrations detected are orders of magnitude lower than the total concentrations detected and no consideration was historically provided for the highly conservative nature of this testing when considered for Site conditions assessment. Given, the nature of leachability tests (which are acidic) and Site conditions (where soil and bedrock are highly buffered) the potential leachability of the majority of metals is very limited, with the exception of hexavalent chromium and cyanide which are not affected by the alkalinity and buffering within groundwater. Subsequent dilution and attenuation within groundwater, once infiltrating water reaches the water table, will see further reductions in concentration.

The ubiquitous nature of soil impacts (particularly in the fill) relative to the more focused distribution of groundwater impacts suggests that the constituents within the fill materials at the time of placement are not a primary source of impact. Groundwater impacts appear to be more likely associated with discrete areas of fill and soil where leachable forms of metals are present. Leachability is a function of the valency of the metal and high concentrations of a metal is not necessarily indicative of potential mobility and leaching to groundwater.

2.1.2 Groundwater Conditions

The geochemical assessment for the CSM provided a framework by which historical and recent supplemental groundwater monitoring data could be assessed. The assessment demonstrated that vanadium, cadmium, trivalent chromium, lead, and mercury exhibited limited to no solubility in groundwater at the Site and were not COCs in terms of dissolved phase transport. Cyanide and hexavalent chromium were identified as the only mobile ions under the carbonate rich conditions observed at the Site.

As noted above, major declines in chromium concentrations in groundwater have been observed between 1987 and 2014, and can be attributed to movement of groundwater and capture by the GWES, but also to the potential conversion of hexavalent chromium into insoluble trivalent chromium forms. This is supported by chromium ratio data, which show a marked increase in the relative concentration of trivalent to hexavalent chromium in groundwater at the Site (based on data from 1987 and 2014). The only exception being a discrete area between Buildings 56 and 8 where hexavalent chromium dominates and persists.

Focused assessment of the distribution and temporal patterns of hexavalent chromium and cyanide in groundwater, based on data collected between 1987 and 2014, has shown major declines in concentrations. This is to be expected given the high solubility of these constituents, which can be readily flushed from soils and captured by the GWES. However, discrete areas exist where elevated concentrations (above 6 NYCRR 703.5 default groundwater standards) of hexavalent chromium and cyanide (MW-OB13) persist in both the overburden and bedrock groundwater on Site. Given the hydrogeologic setting, the persistence of these soluble inorganics suggests both the presence of ongoing sources within the overburden and vertical flux into the bedrock in discrete areas. These areas are proximal to historical chromium processing areas and are likely a result of historical discrete releases in these areas. A summary of historical speciated chromium groundwater analytical results is provided in attached **Table 2-3**, and a map showing the location of wells is provided as **Figure 2-2**.

Based on the absence of primary porosity, within the bedrock the mass of constituents is limited and confined to dissolved mass and colloids within secondary porosity fracture zones. Diffusion of mass into the bedrock is not considered to be a significant mechanism at the Site. On this basis, the presence of mass within the bedrock groundwater likely suggests ongoing flux from impacts in the overburden into the underlying bedrock units. Key areas where this flux is potentially important include locations where the lacustrine clay deposits overlying bedrock are absent, areas where open/transmissive sub-vertical fractures are present, and areas where remnants of the historical sub-surface drainage system exist.

Flux calculations were conducted for the CSM to identify key areas of hexavalent chromium mobility. Calculations were not conducted for trivalent chromium, cyanide or vanadium (also detected in groundwater) as these are not in a soluble form and/or do not exist at the Site boundary at high concentrations. The flux calculations indicate that the majority of hexavalent chromium flux is occurring within very discrete areas of the Site. The calculations indicate that the majority of flux is occurring in the intermediate bedrock in the area of former Buildings 8 and 56. This area makes up more than 90% of the estimated mass flux of total hexavalent chromium to the GWES near the Site boundary. These results are consistent with findings from the hydrogeologic, groundwater quality, and hydrogeochemical evaluations completed that indicate flux of hexavalent chromium from the overburden into bedrock and lateral migration within bedrock is most predominant within the area between former Buildings 56 and 8, and that additional investigation and remediation activities should be focused on this area (EHS Support 2015a).

2.1.3 Recommended Supplemental Investigations

To refine understanding of Site conditions and validate the findings for the CSM, the following investigation activities were recommended (EHS Support 2015a):

1. Additional groundwater sampling from a broader number of existing wells to further:
   - Define the current lateral and vertical extent of the most mobile constituents in groundwater including hexavalent chromium and cyanide;
   - Analyze geochemical parameters and other metals to confirm the immobility and lateral distribution of these constituents in groundwater;
2. Potential installation of new groundwater monitoring wells in historical areas of groundwater impact if needed to define current conditions (where historical impacts were identified).

3. Complete supplemental soil sampling in focused areas of the Site to characterize contribution and refine our understanding of leachable fractions and potential flux from unsaturated and saturated fill to overburden groundwater and potentially bedrock.
4. Installation of wells in the fine overburden materials adjacent to the southern Site boundary in the area of highest flux to confirm the absence or limited transport (and filtering) of fine colloidal materials in groundwater.
5. Reassessment of the preliminary flux calculations to include a broader suite of analytes than previously available for the CSM development and validate the conclusions for hexavalent chromium.

The additional groundwater investigation activities identified in Item 1 are being addressed under the Site Groundwater and Surface Water Monitoring Plan (EHS Support, 2015b) previously submitted to NYSDEC. The need for additional groundwater wells noted in item 2 will be evaluated following completion of the focused groundwater monitoring event conducted in July 2015, and the activities outlined in this Work Plan. This Work Plan outlines the activities proposed to support evaluations noted in Items 3 and 4.

2.2 Investigation Areas of Interest

This Work Plan focuses on sampling of overburden materials in areas of known fill and persistent groundwater impacts, and groundwater sampling at wells to be installed near the Site boundary, downgradient of areas with persistent and elevated groundwater impacts (above groundwater quality standards) and with the highest potential for groundwater flux. The data collected will be used to further understand the spatial distribution, mobility and attenuation of Site constituents of interest (chromium, cadmium, lead, mercury, vanadium and cyanide), and characterize the mixing zone between overburden groundwater and the Hudson River.

Four areas of interest are identified for investigation based on previous investigation findings and the Site conceptualization study (EHS Support 2015a). These areas are expected to represent some of the most impacted areas based on historical and current groundwater results, historical soil boring results and historical process and drainage layouts. The areas encompass locations with waste/chrome ore fill and high potential for groundwater flux based on:

- Historical backfilled spent chrome ore waste,
- Historical chromate/bichromate processing and storage,
- Historically observed river seep locations,
- Historical analytical results of leach Synthetic Precipitation Leaching Procedure (SPLP) tests with concentrations greater than 50 micrograms per liter (µg/L) of total chromium,
- Former Buildings 56 and 8 (acid and chromate storage/handling operations), and former industrial sewer lines locations, and
- Analytical results indicating the persistence of hexavalent chromium in groundwater.

The four areas identified for investigation are denoted as A through D on **Figure 2-2**. The key conditions in each area that provide the basis for selection for investigation are as follows.

- Area A is located in the western area of the site where backfilled spent chrome ore waste has been observed. Historical SPLP test results reported no exceedance of groundwater quality standards.
- Area B is located in the southwestern area of the Site where historical waste incineration and chrome ore storage/backfilling was reported. Historical SPLP test results greater than 50 µg/L for total chromium were reported for fill in this area.
- Area C encompasses the area east, west and south of the former Building 56 where chromate and acid storage handling occurred, historical industrial sewer lines were located, and where SPLP test results greater than 50 µg/L for total chromium were reported. Historically seeps in the riverbank

in this area were observed and analytical results reported hexavalent chromium in seep water samples.

- Area D is located in the vicinity of former Building 8 and encompasses areas with backfilled spent chrome ore waste, historical chromate/bichromate storage/handling areas, and sections of the historical industrial sewer lines. Historically seeps were observed in the southern end of this area. Hexavalent chromium was reported in historical seep water samples, and has been detected in groundwater.

Groundwater wells are proposed for installation at the southern (downgradient) boundary of Areas C and D, where historical seeps have been observed and the highest and persistent hexavalent chromium and cyanide concentrations have been detected in groundwater. Four wells are proposed to be located between the GWES facilities and the Hudson River, two in the each of the green highlighted areas in the southern portions of Area C and D, as shown on **Figure 2-2**. Additional/nested wells (screened at varying depths) may be installed in these locations/areas based on field observations of overburden materials and water levels. It is considered most desirable to install these wells immediately adjacent to the river and down-gradient of the GWES. However, the specific locations of wells and the installation techniques employed will be selected with consideration of Site conditions and work area accessibility to ensure safe drilling and sampling (refer **Appendix A** for photos of grade in proposed installation area).

3.0 PROPOSED SAMPLING PROGRAM

The proposed sampling program includes sampling of overburden materials to characterize lithology, identify potential sources of hexavalent chromium and cyanide, and determine the availability and mobility of leachable materials. The areas proposed for investigation are described in **Section 2.2**, and are expected to represent maximum impact areas based on historical process operations, groundwater quality results, and soil characterization. Wells are proposed to be installed in the overburden soils between the GWES and Hudson River to assess current conditions and trends in water quality and evaluate the potential mixing zone. The scopes of work for these investigation activities are summarized below.

3.1 Soil Boring and Sampling

Sampling within the investigation areas will be focused where chrome ore fill has been observed, in former chromate/bichromate storage areas, and near historical industrial sewer lines as these are the areas of anticipated maximum impacts in overburden fill. The investigation areas are shown on **Figure 2-2**. It is anticipated that boring and sampling in the investigation areas will include:

- Two bores in each Areas A and B;
- Five bores across Area C, in the west, east and south around former Building 56 (where chromium/bichromate/acid materials storage occurred) and along the former industrial sewer line, upgradient of where historical seeps were observed;
- Eleven bores in Area D near the southern boundary, adjacent to the south and east side of former Building 8 and in the vicinity of the historical industrial sewer lines; and
- Based on field observations additional bores may be advanced in Areas C and D to characterize fill materials and identify potential ‘hot spot’ areas of chromium and cyanide impacts.

The bore locations in each area will be generally even spaced over the area with consideration of existing and historical facilities locations, field observations of soils/fill encountered and utilities (proposed boring locations are shown on Figure 2-2).

Soil borings will be drilled to the top of the lacustrine clay/bedrock and continuous soil cores will be collected for visual observation, lithologic classification, and potential laboratory analysis. Further details regarding field methodologies for soil boring and sampling are provided in **Section 4**.

The primary constituents of interest for investigation are hexavalent chromium and cyanide, as these constituents have the highest potential for mobility in groundwater. To confirm the CSM findings, the sampling program will also include analysis of cadmium, chromium, lead, and mercury (metals used in historical site operations). Analysis will include testing of waste/chromium ore fill and other fill materials observed in the overburden and native soils down to and including the top of the lacustrine clay. Samples will be tested for total metals and cyanide to assess the magnitude and distribution of these constituents in fill materials. Additionally (based on the soil analytical results), select samples will be subjected to leach testing under varying pH ranges (i.e., pH of 6, 7 and 8) which are typical of the range of Site groundwater conditions. Samples of the various types of fill material encountered will also be tested for pH, organic carbon, clay content, iron and manganese mineral phases, and CEC to understand the geochemical conditions of the overburden materials that effect the leachability and mobility of metals. Details regarding laboratory analysis methods proposed are provided in **Section 5**.

3.2 Well Installation and Sampling

Groundwater wells are proposed for installation at the southern (downgradient) boundary of Areas C and D, where historical seeps have been observed and the highest and persistent hexavalent chromium and cyanide concentrations have been detected in groundwater. Wells are proposed to be located between the GWES and the Hudson River, with at least two wells installed in each of the green highlighted areas adjacent/within Areas C and D, respectively (refer **Figure 2-2**). Additional or nested wells (discretely screened at varying depths) may be installed in these areas based on field observations of overburden materials and water levels. The specific locations of wells will be selected in the field with consideration of Site conditions and where access allows for safe drilling and sampling.

The river stage is anticipated to be at elevations above bedrock and within range of the overburden unit in the areas proposed for well installation, based on available Site investigation and monitoring data. The ground elevation in the vicinity of the GWES is approximately 240 feet above mean sea level (amsl) and the top of bedrock elevation beneath the GWES ranges between 224 feet and 198 feet amsl, averaging 208 feet amsl between sump A (near former Building 56) and sump B (near former Building 8). The river stage level, based on measurements from gauge SG-9 between Buildings 56 and 8, ranges between 208 and 213 feet amsl (within the overburden unit). The distance between the GWES and the Hudson River between Buildings 56 and 8 (the area of interest for well installation) is approximately 60 to 90 feet. Given this and consideration of the average dip of the bedrock surface, the bedrock elevation at the river is expected to be approximately 5 to 8 feet deeper than where encountered beneath the GWES, and the overburden is expected to thin towards the river. The presence of water in the overburden unit will be verified during drilling.

Wells are proposed to be screened within the overburden, with screens positioned above the contact between the overburden and the underlying bedrock. Where the lacustrine clay horizon (as a low conductivity unit) is encountered, the well will be screened above this unit. The screen lengths of the initial (four) wells will extend from above bedrock/lacustrine clay to an elevation above the anticipated/observed groundwater surface. It is anticipated that based on the desired proximity to the river that these wells will have limited available saturated thickness and five feet of screen will be sufficient for the well completions. Additional discretely screened wells may be installed if significant fill stratification within the saturated zone is encountered.

Groundwater wells will be used to measure water levels and to collect groundwater samples for analysis of Site-related constituents of interest (cadmium, trivalent and hexavalent chromium, lead, mercury, vanadium and cyanide). Samples will be analyzed for total and dissolved concentrations of these constituents, with samples for dissolved analysis filtered in the field with a 1 micrometer (um), 0.45 um and 0.1 um size filters as described in **Appendix A**. The samples will also be analyzed for a suite of geochemical parameters including pH, turbidity and oxidation reduction potential (ORP) (using field instruments) and general water chemistry (cations and anions) to assist in the evaluation of fate and transport. Details regarding laboratory analysis methods proposed are provided in **Section 5**.

4.0 FIELD SAMPLING METHODOLOGY

The methodologies proposed for soil boring, groundwater well installation, and sampling of overburden fill and groundwater are discussed below. The sample laboratory analytical methods and data evaluation proposed for the investigation are discussed in **Sections 5** and **6**.

4.1 Health and Safety

Field activities will be conducted in accordance with the Site-specific Health and Safety Plan (HSP) developed as a separate document. All field personnel will be required to implement the procedures presented in the HSP while conducting fieldwork. A meeting to discuss planned field activities and anticipated health and safety issues will be conducted prior to commencing with daily fieldwork.

4.2 Borehole Clearance

Prior to drilling, a utility clearance survey will be completed. The survey will include calling 811 (New York Public Service Commission dig safely notification line) to report the work, and reviewing available Site utility drawings for each investigation area to identify potential utilities that may be present. At each borehole/well location, manual coring (e.g., hand augering) will be employed to advance to a depth of five feet below gorund surface (bgs). Where the permeable cap is in place, mechanical drilling (direct-push or hollow-stem auger method) may be employed through the cap (as no utilities are present with the constructed cap), followed by manual coring to the requried clearance depth. Where hand-clearing results in refusal, alternative methods may be employed (e.g. air-knife/vacuum excavation) to achieve clearance.

4.3 Soil Boring and Sampling

Soil borings will be drilled using a direct-push technology (DPT) rig equipped with macrocore samplers. Continuous soil cores will be collected from each borehole using macrocore samplers lined with acetate sleeves. Upon reaching the desired sampling depth, the macrocore barrel will be removed from the borehole and the acetate sleeve containing the soil core sample will be removed from the barrel for inspection and logging by the field geologist. For intervals where manual coring or alternative vacuum extraction for utility clearance purposes are required (refer **Section 4.2**), materials removed will be visually inspected and collected to the extent possible with the extraction method employed.

Upon collection, each soil core section will be labeled with the top and bottom depth interval. The acetate liner will be cut and the core section will be screened with an organic vapor monitor equipped with a photo-ionization detector (PID), and photographed. The core section will be inspected for physical characteristics (i.e. moisture content, consistency, odor, color, etc.), and the soil type will be classified in accordance with the Unified Soil Classification System (USCS) by the field geologist. The field observations (PID reading, characteristics and soil type) will be recorded on a field boring log/log book. Data regarding the sample recovery and sampler penetration for each core will also be noted in the log.

Samples representative of various fill/waste types observed in the core will be collected for potential laboratory testing. For each waste/fill type observed, a sample will be sectioned from the core by hand (utilizing clean gloves) or using a clean trowel. To the extent practical, the sample volume needed from material of a given fill type will be collected from a contiguous interval of the core, and the sampled interval and ID will be recorded on the bore log. Where required to collect sufficient sample for analysis of a given fill/waste type, material of the same type may be collected from discontiguous sections of the core. For each sample, the materials collected will be homogenized (by mixing) prior to transfer into clean sample jars. Where discontiguous sections of the core are composited (by mixing) to obtain needed sample volumes, the sampled intervals and sample ID will be recorded on the bore log. Where similar fill is encountered at multiple depths within a given borehole, discrete samples of the material (where sufficient volumes are encountered) will be collected from various depths (e.g., top, middle, bottom portions of core) and each interval sampled and the sample IDs will be recorded on the bore log. Upon collection (filling of sample container), samples for potential laboratory analysis will be sealed (lid closed), labeled with the sample ID, date and time of collection, and placed in a cooler with ice for transport to the laboratory under chain-of-custody (C-O-C) documentation.

Samples will be selected for analysis based on visual observations of fill/waste types encountered, distribution/depth of the fill within the boring, and analytical results for samples already analyzed (during the course of the investigation). Samples for analysis are anticipated to include:

- At least one sample of each distinguishable waste/fill type and the native soils underlying the fill from each borehole will be analyzed for pH and the Site constituents of interest (cadmium, chromium, hexavalent chromium, lead, mercury, vanadium and cyanide).
- Where significant waste/fill is present at various depths, additional samples will be selected to assess the vertical distribution of metals in fill in the investigation areas.

Based on results for metals in samples initially selected for analysis, additional samples may be selected from various locations to further evaluate the magnitude and extent of metals in fill materials.

Following detailed review of the soil analytical results, select samples (based on chemical concentrations and physical properties) will be selected for modified SPLP testing. The modified SPLP testing will including testing of each sample at pH levels of 6, 7 and 8 (reflecting the range of pH conditions in groundwater and the capacity buffering of the soils). Samples for SPLP analysis will be selected based on the following rationale:

- the highest total metals (particularly chromium) and cyanide concentrations reported for the samples (refer Table 5-1 for the specific analytes to be tested and reported); and
- at least one sample of each type of waste/fill encountered in each investigation area.

In addition to SPLP testing, select samples representative of the various types of fill/waste materials encountered will also be analyzed for particle size distribution (clay, silt, and sand fractions), pH, CEC, and fraction of organic carbon (foc). Where possible (sufficient sample volume allows), these analysis will be run on sample portions collected at locations and intervals selected for SPLP analysis.

4.4 Groundwater Well Installation and Sampling

Groundwater wells will be installed using a combination of DPT continuous coring followed by hollow-stem auger (HSA) drilling or HSA drilling with split-spoon samplers for continuous core collection. Consistent with the discussion provided in Section 3, installation of wells as close to the Hudson River as practical is preferred. Where DPT or HSA drilling is employed continuous cores will be collected from the bore using DPT as described in Section 4.3 or using split spoon samplers with HSA drilling. Soil cores collected during HSA drilling will be collected using split-spoon samplers driven ahead of the HSA flight. Upon collection, soil cores (in acetate liners or split spoons) will be screened, photographed, inspected, and classified with data recorded as described in Section 4.3.

Wells will be constructed of 2-inch diameter, schedule 40 polyvinyl chloride (PVC) blank and 0.005-inch mill slotted PVC screen. The length of screen will be selected in the field based on the depth to bedrock and water level encountered. The screened interval will extend from the bottom of the bore to above the water. A filter pack consisting of very fine sand (e.g., type 000) will be placed from the bottom of the bore to the top of the well screen (filling the annular space around the well screen), and a bentonite seal will be placed above the sand filter pack. The remaining annular space will be filled with bentonite cement grout to the ground surface. The well casing will terminate above grade and a protective monument type cover will be installed to protect the PVC casing.

After installation and a minimum of 24 hours, the wells will be developed to remove fines and turbidity resultant from well installation. Development will include measurement of the static water level followed by water extraction via downhole pump. Surging of the well may also be conducted to facilitate the removal of fines from the well and the filter pack. During extraction, extracted water will be visually observed for color and clarity, and periodically monitored for physical water quality parameters including turbidity, conductivity, pH, temperature and ORP using a field multi-variable meter to assess changes and stability of water quality. Pumping will continue until a minimum of three well volumes of water have been removed and visual observation and water quality parameter measurements indicate excess turbidity has been removed. In the event of low water yield (pumping results in drawdown near the pump intake/well goes dry), recovery will be monitored through periodic gauging of the well, and upon recovery to 80 percent of the pre-development level recovered water will be extracted and visually observed for clarity, and water quality parameters will be measured for comparison with the previously purged water readings. If elevated turbidity remains, recovered water may be surged and removed (if pumping alone cannot achieve reduced turbidity) and water quality tested again following subsequent recovery.

After development the wells will be sampled using low flow sampling techniques detailed in **Appendix B**. Groundwater samples will be collected and analyzed as follows:

- Total metals to include cadmium, chromium (trivalent and hexavalent species), lead, mercury, and vanadium.
- Dissolved metals analysis for cadmium, chromium (trivalent and hexavalent species), lead, mercury, and vanadium will be conducted on samples filtered in the field using various size filters, including a 1 micrometer (um) filter, a 0.45 um filter, and 0.1 um filter.
- Total cyanide and weak acid dissociable (WAD) cyanide;
- Free cyanide on samples pre-treated in the field (to remove interferences) using a sample kit provided by the laboratory;
- Major ions to include calcium, sodium, potassium, magnesium, chloride, bromide, and sulfate;
- Hardness and alkalinity (as total, bicarbonate, carbonate); and
- Total and dissolved organic carbon (TOC/DOC)

The data will be used in conjunction with groundwater and surface water data collected during the focused groundwater monitoring event proposed in the Site Groundwater and Surface Water Sampling Plan (EHS, 2015b) to evaluate Site conditions and assess conditions in the groundwater hyperheic zone.

4.5 Quality Assurance/Quality Control Program

The sampling program will incorporate the following QA/QC procedures.

- Field instruments will be calibrated daily (at the start of field activities) in accordance with the manufacturer’s directions. The make and model number of the equipment, date, time and calibration data will be recorded in field log books.
- Duplicate samples will be collected at a frequency of 5 percent (one per 20 samples) for each media sampled (soil and groundwater). Duplicate samples will be collected and handled using the same methodology employed for original samples, and will be analyzed for the same suite of analytes as the original samples.
- MS/MSD samples will be collected at a frequency of one per 20 samples for each media sampled (soil and groundwater). The samples will be collected, handled and analyzed the same as original samples. In the event that insufficient sample volumes can be achieved for MS/MSD sample

collection (due to low yield of groundwater), a request will be submitted to the laboratory to prepare and analyze a MS/MSD sample from existing original sample volumes if possible.
- Equipment blanks will be collected routinely during soil sampling to assess the effectiveness of decontamination procedures. During the soil boring program, equipment blanks will be collected at the start of the program, prior to use of equipment in any bore, and at least twice weekly to confirm the quality of decontamination procedures. Equipment blanks will be collected by pouring laboratory grade water over cleaned equipment (e.g., core barrel and liner, steel trowel or other non-dedicated sampling equipment) with the water collected directly into laboratory supplied containers. Equipment blanks will be analyzed for metals (cadmium chromium, lead, mercury and vanadium) and total cyanide.
- Equipment blanks will be collected daily during groundwater sampling from non-dedicated/re-usable equipment (e.g., bladder pump). The blank will be collected by submerging the pump (equipped with a clean bladder) into a clean container with laboratory grade water. The water will be pumped directly using clean tubing into clean sample containers supplied by the laboratory. The blanks will be analyzed for metals (cadmium, lead, mercury, vanadium, chromium and hexavalent chromium), total and WAD cyanide, and free cyanide.
- Each sample ID, date, and time of collection and sampler initials will be recorded on sample bottles, field sampling logs. In addition, for each equipment blank collected the borings/wells sampled before and after blank collection will be recorded in the field logbook.
- Personnel will don clean gloves prior to collection of each sample (and as needed during sampling process to avoid contamination of samples). Samples will be collected in clean containers provided by the laboratory. Required preservative will be included in the bottles prepared by the laboratory.
- Sample containers will be filled such that no air remains in the container and capped. Immediately following collection, the containers will be sealed (capped/lids closed), labeled with the sample ID, date, time, and filter size (as applicable), put in a resealable plastic bag, and placed in a cooler with ice/ice packs for storage and transport to the laboratory. A temperature blank (if needed) will be included with each cooler of samples for use by the laboratory to document temperature upon receipt.
- Chain-of-custody (COC) documents will be prepared for each container (cooler) of samples transported to the laboratory. The COC will be completed in the field and will accompany the samples from the time of collection through shipment and receipt by the laboratory. Copies of completed COCs will be included in the laboratory reports.

4.6 Soil Borehole and Well Surveying

The soil borings and wells installed under this Work Plan will be surveyed for horizontal and vertical coordinates relative to the State Plane and National Geodetic Vertical Datum to document the boring and sampling locations and support evaluation of Site conditions. Well survey will include top of casing elevations.

4.7 Equipment Decontamination

The decontamination procedures focus primarily on the equipment (e.g., direct push/hollow-stem auger tooling, samplers, sleeves, pumps, etc.) used to collect soil samples and groundwater samples. Sampling equipment will be decontaminated prior to use in each borehole or well. In addition, sampling equipment will be decontaminated between each sampling depth. Cleaning/decontamination will comprise a pre-rinse in potable water, followed by washing in non-phosphate detergent solution (e.g., Alconox wash), and rinsing in clean (potable or laboratory grade) water, and air drying (or wiped dry using clean paper towels). A high-pressure steam cleaner may be utilized to decontaminate larger equipment (i.e. push rods, hand auger, slide hammer, etc.).

4.8 Investigation Derived Waste

Soil cuttings, fluids, and miscellaneous waste generated during the field activities will be temporarily stored on the Site in appropriate containers. Purged water and decontamination water will be collected and transferred to the on-site wastewater system and discharged under the Site permit issued by the local publicly owned treatment works (POTW). Solid waste (packaging material, spent gloves) will be disposed as municipal waste. Results of the laboratory analyses will be used to profile soil cuttings for transport to an appropriate off-site facility for disposal/recycling.

5.0 ANALYTICAL METHODS

All selected soil samples and water samples for analysis will be submitted to a laboratory accredited pursuant to the New York Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP) for the analysis to be conducted. The analytical program including methods, preservation requirements, holding times and quality assurance/quality control (QA/QC) requirements are summarized in **Tables 5-1** and **5-2**. The laboratory deliverables will include DEC Analytical Services Protocol Category B Data Deliverables in accordance with DER-10, Appendix 2B, Guidance for Data Deliverables and Development of Data Usability Summary Reports.

5.1 Subsurface Soil Sample Analysis

In accordance with the soil sampling program outlined in **Sections 3.1** and **4.3**, select soil samples will be submitted for analysis of Site-specific metals [cadmium, chromium (total and hexavalent), lead, mercury, and vanadium), cyanide, cation exchange capacity, fraction organic carbon, and physical properties (e.g., grain size, clay content). Consistent with the program methodology described in **Section 4.3**, leach testing on select samples using modified (variance in pH) SPLP procedures and the leachate will be analyzed for lead, cadmium, mercury, hexavalent chromium, trivalent chromium, cyanide and free cyanide. The samples for leach testing will be selected following receipt of the results for the fill/waste sample metals analysis, with priority selection based on results for hexavalent chromium.

The leachability testing will be conducted on at least one soil sample from each location, and will include samples of each distinguishable waste type encountered during the boring program to understand the mobility of constituents from these waste materials and the potential for immobilization under Site conditions.

The SPLP leaching characterization test procedure is based on an equilibrium approach where pH is established at the beginning of the experiment and not over the entire testing period. Samples will be prepared in the laboratory for leaching evaluation at multiple pH water ranges to include:

- pH 8 - reflective of higher end pH conditions the overburden,
- pH 7 - reflective of lower end pH conditions in the overburden,
- pH 6 - reflective of rainfall discharge conditions.

The leachate will be analyzed for cadmium, lead, mercury, trivalent chromium, hexavalent chromium, vanadium, and free cyanide as described in **Table 5-1**.

5.2 Well Groundwater Sample Analysis

Groundwater samples from the riverbank wells will be submitted for analysis of dissolved metals (cadmium, chromium (trivalent and hexavalent species), lead, mercury, and vanadium), total and free cyanide, and general groundwater chemistry parameters. The field filtered samples (1 um, 0.45 um and 0.1 um) will be submitted for dissolved metals (cadmium, chromium, hexavalent chromium, lead, mercury and vanadium) and total and WAD cyanide. The results of the analysis will be compared to New York Groundwater and Surface Water Quality criteria (6 NYCRR part 703.5). The analytical program including analysis methods, preservation requirements, holding times are summarized in **Table 5-2**.

6.0 SAMPLING AND REPORTING SCHEDULE

Overburden soil/fill sampling and well installation and sampling as described in this Work Plan is proposed to commence in the 3rd Quarter of 2015. A Soil Sampling Report (SSR) is proposed to be completed and submitted to New York State Department of Environmental Conservation (NYSDEC) within 60 days following receipt of all analytical reports for the event. The report will include information required per DER-10 on investigation reports including:

- Technical overview and summary of work completed and the results,
- Field information including boring logs, sampling and calibration data, and field notes,
- Findings of the investigation and conclusions, and
- Recommendations and description of additional work, if required.
- A Data Usability Summary Report (DUSR) will also be prepared and submitted with the report or under separate cover (pending timing for receipt of the DUSR).

Analytical data (NYSDEC ASP Category B deliverable) will be submitted as an electronic data deliverable (EDD) to the DER website consistent with DER-10, Section 1.15.

7.0 REFERENCES

EHS Support (2015a). Site Conceptualization and Groundwater Corrective Measures Effectiveness Evaluation Report. January 2015

EHS Support (2015b). Groundwater and Surface Water Monitoring Work Plan Former Ciba Geigy Site. July 2015

TABLES

Table 2-1
Statistical Results for Soils
Former Ciba-Geigy Site
Glens Falls, New York

Analyte	Barium (mg/kg)						Cadmium (mg/kg)					
Area Data Set	**No. Samples**	**No. Detects**	**Min**	**Max**	**Mean**	**Median**	**No. Samples**	**No. Detects**	**Min**	**Max**	**Mean**	**Median**
Fill - All Areas	601	595	<5	51000	4846	255	601	570	<1.8	27000	554	16
Fill - A1	193	191	<5	51000	9063	3100	193	193	0.96	27000	1309	300
Fill - A2	129	128	<5	48000	8290	1550	129	129	1.7	7800	625	87
Fill - A3	62	62	11	7000	960	144	62	62	1.3	188	22	13
Fill - A4	120	118	<5	8100	445	147	120	119	<1.8	280	14	4.1
Fill - A5	24	24	15	310	111	101	24	23	<1.8	64	8.7	4.0
Fill - A6	34	34	14	3000	290	120	34	33	<1.8	27	6.0	3.0
Fill - A7	39	38	<5	330	52	30	39	11	<1.8	21	3.1	1.8
Lacustrine - All Areas	244	244	12	330	111	113	244	236	<1.8	33	4.5	4.0
Lacustrine - A1	56	56	15	330	84	58	56	56	1.3	33	5.7	4.0
Lacustrine - A2	7	7	92	220	136	131	7	7	2.6	4.8	3.2	2.9
Lacustrine - A3	25	25	12	240	83	67	25	25	1.2	6.9	3.6	3.4
Lacustrine - A4	87	87	22	290	141	139	87	84	<1.8	13	4.3	4.1
Lacustrine - A5	27	27	18	270	121	141	27	27	1.0	10	4.9	5.1
Lacustrine - A6	20	20	30	260	124	128	20	20	2.2	8.8	5.2	5.4
Lacustrine - A7	5	5	55	106	85	100	5	0	<1.8	n/a	n/a	n/a

Note: Minimum (Min), maximum (Max), Mean and Median concentrations are in milligrams per kilogram (mg/kg)

Table 2-1
Statistical Results for Soils
Former Ciba-Geigy Site
Glens Falls, New York

Analyte	**Chromium (mg/kg)**						**Lead (mg/kg)**					
Area Data Set	**No. Samples**	**No. Detects**	**Min**	**Max**	**Mean**	**Median**	**No. Samples**	**No. Detects**	**Min**	**Max**	**Mean**	**Median**
Fill - All Areas	601	600	<5	114000	8179	1105	601	546	<5	199000	13070	186
Fill - A1	193	193	23	114000	18284	5100	193	189	<5	199000	32462	1950
Fill - A2	129	129	9	75000	8707	2400	129	122	<5	169000	10326	153
Fill - A3	62	62	10	14800	3026	2650	62	58	<5	65000	4113	171
Fill - A4	120	120	5	7800	809	250	120	106	<5	20000	559	114
Fill - A5	24	24	5	4700	923	111	24	19	<5	1660	164	50
Fill - A6	34	34	5	610	133	52	34	31	<5	2800	539	165
Fill - A7	39	38	<5	5800	208	12	39	21	<5	1880	79	8
Lacustrine - All Areas	244	244	3	10700	305	40	244	98	<5	330	15	5
Lacustrine - A1	56	56	15	4500	263	85	56	52	<5	200	17	5
Lacustrine - A2	7	7	20	38	26	24	7	2	<5	16.8	7	5
Lacustrine - A3	25	25	28	10700	1135	310	25	15	<5	260	37	11
Lacustrine - A4	87	87	15	5000	321	42	87	34	<5	330	13	5
Lacustrine - A5	27	27	3	1060	92	31	27	7	<5	52	10	5
Lacustrine - A6	20	20	16	49	26	25	20	9	<5	43	12	5
Lacustrine - A7	5	5	11	16.8	14	16	5	0	<5	n/a	n/a	n/a

Note: Minimum (Min), maximum (Max), Mean and Median concentrations are in milligrams per kilogram (mg/kg)

Table 2-1
Statistical Results for Soils
Former Ciba-Geigy Site
Glens Falls, New York

Analyte	Cyanide (mg/kg)					
Area Data Set	No. Samples	No. Detects	Min	Max	Mean	Median
Fill - All Areas	42	37	1.3	5760	420	13
Fill - A1	8	8	3.9	5760	1446	56
Fill - A2	6	5	<1.6	5100	955	140
Fill - A3	7	7	1.3	21	8	4
Fill - A4	13	13	2.3	213	51	27
Fill - A5	0	0	n/a	n/a	n/a	n/a
Fill - A6	3	3	1.38	16.2	10	12
Fill - A7	6	2	1.26	1.6	2	2
Lacustrine - All Areas	20	12	0.94	149	14	2
Lacustrine - A1	0	0	n/a	n/a	n/a	n/a
Lacustrine - A2	1	1	1.4	1.4	1.4	1.4
Lacustrine - A3	0	0	n/a	n/a	n/a	n/a
Lacustrine - A4	18	10	ND	149	15	2
Lacustrine - A5	1	1	1.1	1.1	1.1	1.1
Lacustrine - A6	0	0	n/a	n/a	n/a	n/a
Lacustrine - A7	0	0	n/a	n/a	n/a	n/a

Note: Minimum (Min), maximum (Max), Mean and Median concentrations are in milligrams per kilogram (mg/kg)

Table 2-2
Statistical Results for Leach Test Data Sets
Former Ciba-Geigy Site
Glens Falls, New York

Leach Data	No. Samples	No. Detects	Min	Max	Mean	Median
Ba - TCLP	18	2	10	290	26	10
Ba - SPLP	17	13	<0.025	0.33	0.09	0.05
Cd - TCLP	18	7	<0.5	8.2	1.7	0.5
Cd - SPLP	17	8	<0.005	0.26	0.03	0.005
Cr - TCLP	18	5	<2.5	46	6.5	2.5
Cr - SPLP	17	13	<0.01	1.5	0.48	0.19
Pb - TCLP	18	5	<2.5	22	5.8	2.5
Pb - SPLP	17	4	<0.005	0.2	0.04	0.005
Cn - TCLP	2	2	3.0	42	n/a	n/a
Cn - SPLP	17	10	<0.00002	0.39	0.02	0.00005

Note: Minimum (Min), maximum (Max), Mean and Median concentrations are in milligrams per liter (mg/L)

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

WELL ID	SCREENED UNIT	Analyte	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
		GA standard:	0.05	0.05	0.05	0.05
OVERBURDEN WELLS						
AP-2	Overburden	04/17/14	**10**	0.028	<0.01	**10**
BP-3	Overburden	04/18/14	**1.9**	**0.069**	<0.01	**1.9**
IP-4	Overburden	04/16/14	**0.075**	0.0025 J	<0.01	**0.075**
MW-9	Overburden	Sep-88	-	-	**41**	
	Overburden	09/25/13	-	0.0026 J	-	
	Overburden	May/Jun-87	-	-	**46**	
	Overburden	May-92	-	-	**19.4**	
	Overburden	Sep-92	-	-	-	
MW-13	Overburden	Sep-92	-	-	-	
MW-14	Overburden	May-92	-	-	**0.81**	
	Overburden	Sep-92	-	-	**1.23**	
MW-18	Overburden	May-92	-	-	<0.002	
	Overburden	Sep-92	-	-	<0.002	
	Overburden	04/17/14	<0.01	<0.01	<0.01	<0.01
MW-24	Overburden	May-92	-	-	<0.002	
	Overburden	Sep-92	-	-	0.003	
	Overburden	12/17/14	0.014	<0.01	<0.01	0.014
MW-26	Overburden	Apr-87	-	-	**21**	
	Overburden	May/Jun-87	-	-	**17.3**	
	Overburden	May-92	-	-	**14**	
	Overburden	Sep-88	-	-	**13.2**	
	Overburden	Sep-92	-	-	-	
	Overburden	06/12/13	-	**0.24**	-	
	Overburden	12/18/13	-	0.0092 J	-	
	Overburden	12/19/13	**0.29**	0.0034 J	<0.01	**0.29**
	Overburden	04/18/14		**0.35**	-	
	Overburden	06/18/14	-	0.003 J	-	
	Overburden	12/16/14	-	0.0058 J	-	
MW-28	Overburden	Apr-87	-	-	**0.88**	
	Overburden	Sep-88	-	-	**1.39**	
	Overburden	May-92	-	-	**6.9**	
	Overburden	Sep-92	-	-	**6.99**	
	Overburden	09/16/08	-	**0.226**	-	
	Overburden	09/25/13	-	0.011	-	
	Overburden	May/Jun-87	-	-	**1.28**	
MW-30S	Overburden	Sep-92	-	-	<0.002	
MW-31	Overburden	Apr-87	-	-	<0.05	
	Overburden	May-92	-	-	0.003	
	Overburden	Sep-92	-	-	<0.002	
	Overburden	09/15/08	-	0.003	-	
	Overburden	09/26/13	-	0.0076 J	-	
	Overburden	12/20/13	**0.079**	0.008 J	<0.01	**0.079**
	Overburden	May/Jun-87	-	-	<0.05	
MW-34	Overburden	Apr-87	-	-	**7.3**	
	Overburden	Sep-88	-	-	**4.7**	
	Overburden	May-92	-	-	**7.2**	
	Overburden	Sep-92	-	-	-	
	Overburden	May/Jun-87	-	-	**6.6**	

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

WELL ID	SCREENED UNIT	Analyte	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
		GA standard:	0.05	0.05	0.05	0.05
MW-37S	Overburden	May-92	-	-	<0.002	
	Overburden	Sep-92	-	-	-	
MW-OB5	Overburden	09/19/08	-	0.042	-	
	Overburden	09/25/13	-	0.023	-	
	Overburden	12/17/13	**0.13**	0.019	<0.01	**0.13**
MW-OB9	Overburden	09/15/08	-	0.003	-	
	Overburden	09/25/13	-	0.0087 J	-	
MW-OB1	Overburden	May-92	-	-	0.047	
	Overburden	Sep-92	-	-	-	
OB-11	Overburden	May-92	-	-	**0.113**	
	Overburden	Sep-92	-	-	-	
	Overburden	May-92	-	-	**4.5**	
	Overburden	Sep-92	-	-	-	
MW-OB13	Overburden	May-92	-	-	-	
	Overburden	Sep-92	-	-	0.003	
	Overburden	09/16/08	-	0.04	-	
	Overburden	09/25/13	-	0.0041 J	-	
	Overburden	04/16/14	**0.31**	0.05	<0.010	**0.31**
MW-OB14	Overburden	May-92	-	-	-	
	Overburden	Sep-92	-	-	**35**	
	Overburden	06/13/13	-	**1.3**	-	
	Overburden	12/16/13	-	**5**	-	
	Overburden	04/16/14	**13**	**11**	**0.26**	**13**
	Overburden	04/16/14	-	**8.3**	-	
	Overburden	06/17/14	-	**0.76**	-	
	Overburden	12/16/14	-	**4.2**	-	
MW-OB15	Overburden	May-92	-	-	-	
	Overburden	Sep-92	-	-	<0.002	
	Overburden	04/17/14	0.028	<0.010	<0.010	0.028
MW-OB16	Overburden	May-92	-	-	-	
	Overburden	Sep-92	-	-	<0.002	
	Overburden	12/20/13	**0.86**	0.0028 J	<0.01	**0.86**
MW-OB2	Overburden	May-92	-	-	**0.06**	
	Overburden	Sep-92	-	-	-	
MW-OB24	Overburden	09/27/13	**0.07**	-	-	
MW-OB25	Overburden	12/19/13	**1.6**	-	**0.68**	
MW-OB26	Overburden	04/17/14	**2.6**	-	<0.05	**2.6**
	Overburden	04/18/14	-	0.035	-	-
MW-OB27	Overburden	04/17/04	**0.061**	0.015	<0.01	**0.061**
	Overburden	06/13/14	-	0.015	-	
	Overburden	06/17/14	0.037**	-	-	
	Overburden	12/16/14	-	0.014	-	
MW-OB3	Overburden	May-92	-	-	**3.9**	
	Overburden	Sep-92	-	-	-	
MW-OB5	Overburden	May-92	-	-	**0.152**	
	Overburden	Sep-92	-	-	**1.03**	
MW-OB6	Overburden	May-92	-	-	<0.002	
	Overburden	Sep-92	-	-	0.016	

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

WELL ID	SCREENED UNIT	Analyte	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
		GA standard:	0.05	0.05	0.05	0.05
MW-OB7	Overburden	May-92	-	-	0.029	
	Overburden	Sep-92	-	-	-	
	Overburden	12/18/13	**0.85**	**0.55**	<0.025	**0.85**
MW-OB9	Overburden	May-92	-	-	0.004	
	Overburden	Sep-92	-	-	0.005	
WP-0-50	Overburden	12/16/13	-	0.0046 J	-	
	Overburden	06/12/14	-	0.009 J	-	
	Overburden	06/17/14	-	0.0035 J	-	
	Overburden	12/17/14	-	0.011	-	
SHALLOW BEDROCK WELLS						
AW-A1	Shallow Bedrock	May-92	-	-	<0.002	
	Shallow Bedrock	Sep-92	-	-	0.003	
	Shallow Bedrock	12/17/13	0.0058 J	<0.01	<0.01	0.0058 J
AW-A2	Shallow Bedrock	May-92	-	-	<0.002	
	Shallow Bedrock	Sep-92	-	-	<0.002	
	Shallow Bedrock	12/18/13	0.0028 J	0.0022 J	<0.01	0.0028 J
	Shallow Bedrock	12/18/13	-	0.0023 J	-	
	Shallow Bedrock	06/12/14	-	<0.01	-	
	Shallow Bedrock	06/18/14	-	<0.01	-	
	Shallow Bedrock	12/16/14	-	<0.01	-	
AW-A3	Shallow Bedrock	May-92	-	-	0.003	
	Shallow Bedrock	Sep-92	-	-	-	
	Shallow Bedrock	12/18/13	<0.01	<0.01	<0.01	<0.01
AW-A4	Shallow Bedrock	May-92	-	-	-	
	Shallow Bedrock	Sep-92	-	-	<0.002	
	Shallow Bedrock	12/16/13	-	<0.01	-	
	Shallow Bedrock	06/12/14	-	<0.01	-	
	Shallow Bedrock	06/17/14	-	<0.01	-	
	Shallow Bedrock	12/17/14	-	<0.01	-	
AW-A6	Shallow Bedrock	04/16/14	**0.97**	**0.25**	<0.01	**0.97**
	Shallow Bedrock	04/16/14	-	0.28*	-	
	Shallow Bedrock	06/18/14	0.011**	-	-	
AW-A7	Shallow Bedrock	12/19/13	**0.17**	0.0061 J	<0.01	**0.17**
AW-A13	Shallow Bedrock	12/19/13	**0.071**	0.0027 J	<0.01	**0.071**
AW-A15	Shallow Bedrock	09/16/08	-	ND	-	
	Shallow Bedrock	09/25/13	-	<0.010	-	
	Shallow Bedrock	04/17/14	0.014	<0.01	<0.01	0.014
AW-A16	Shallow Bedrock	09/16/08	-	**0.22**	-	
	Shallow Bedrock	09/26/13	-	0.0057 J	-	
	Shallow Bedrock	12/17/13	0.016	0.004 J	<0.01	0.016
MW-6	Shallow Bedrock	Apr-87	-	-	**3.1**	
	Shallow Bedrock	May/Jun-87	-	-	**2.6**	
	Shallow Bedrock	May-92	-	-	**2.8**	
	Shallow Bedrock	Sep-92	-	-	-	
MW-8	Shallow Bedrock	Apr-87	-	-	**1.15**	
	Shallow Bedrock	Sep-88	-	-	0.018	
	Shallow Bedrock	May-92	-	-	**1.46**	
	Shallow Bedrock	Sep-92	-	-	-	
	Shallow Bedrock	May/Jun-87	-	-	**0.13**	

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

WELL ID	SCREENED UNIT	Analyte GA standard:	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
			0.05	0.05	0.05	0.05
MW-19	Shallow Bedrock	Apr-87	-	-	**1.58**	
	Shallow Bedrock	Sep-88	-	-	**2.4**	
	Shallow Bedrock	May-92	-	-	**0.45**	
	Shallow Bedrock	Sep-92	-	-	-	
	Shallow Bedrock	09/16/08	-	0.028	-	
	Shallow Bedrock	09/25/13	-	<0.01	-	
	Shallow Bedrock	04/17/14	**0.16**	<0.01	<0.01	**0.16**
	Shallow Bedrock	May/Jun-87	-	-	**6.4**	
MW-20S	Shallow Bedrock	May-92	-	-	0.026	
	Shallow Bedrock	Sep-92	-	-	0.002	
MW-23S	Shallow Bedrock	May-92	-	-	<0.002	
	Shallow Bedrock	Sep-92	-	-	<0.002	
	Shallow Bedrock	12/17/13	<0.01	<0.01	<0.01	<0.01
MW-25S	Shallow Bedrock	May-92	-	-	0.003	
	Shallow Bedrock	Sep-92	-	-	0.002	
	Shallow Bedrock	12/19/13	**0.12**	0.0055 J	<0.01	**0.12**
MW-27S	Shallow Bedrock	09/16/08	-	0.05	-	
	Shallow Bedrock	May-92	-	-	0.003	
	Shallow Bedrock	Sep-92	-	-	-	
	Shallow Bedrock	09/25/13	-	**0.097**	-	
MW-29S	Shallow Bedrock	Apr-87	-	-	**0.99**	
	Shallow Bedrock	May/Jun-87	-	-	<0.05	
MW-35S	Shallow Bedrock	Apr-87	-	-	**0.68**	
	Shallow Bedrock	May/Jun-87	-	-	**0.87**	
	Shallow Bedrock	Sep-88	-	-	**1.32**	
	Shallow Bedrock	May-92	-	-	**2.6**	
	Shallow Bedrock	Sep-92	-	-	**1.1**	
MW-36S	Shallow Bedrock	May-92	-	-	0.002	
	Shallow Bedrock	Sep-92	-	-	-	
	Shallow Bedrock	09/19/08	-	0.01	-	
	Shallow Bedrock	09/25/13	-	<0.01	-	
	Shallow Bedrock	12/17/13	0.0042 J	0.0045 J	<0.01	0.0042 J
INTERMEDIATE BEDROCK WELLS						
AW-B1	Intermediate Bedrock	May-92	-	-	<0.002	
	Intermediate Bedrock	Sep-92	-	-	<0.002	
AW-B15	Intermediate Bedrock	04/16/14	0.041	0.036	0.038	0.003
AW-B16	Intermediate Bedrock	04/16/14	**5.4**	0.049	**0.24**	**5.2**
AW-B18	Intermediate Bedrock	09/16/08	-	0.009	-	
	Intermediate Bedrock	09/26/13	-	<0.01	-	
	Intermediate Bedrock	04/17/14	0.022	<0.01	<0.01	0.022
AW-B19	Intermediate Bedrock	09/16/08	-	<0.05	-	
	Intermediate Bedrock	09/25/13	-	<0.01	-	
	Intermediate Bedrock	04/16/14	<0.01	<0.01	<0.01	<0.01
	Intermediate Bedrock	04/16/14	-	<0.01	-	
AW-B2	Intermediate Bedrock	May-92	-	-	<0.002	
	Intermediate Bedrock	Sep-92	-	-	-	
	Intermediate Bedrock	12/18/13	<0.01	<0.01	<0.01	<0.01
	Intermediate Bedrock	12/18/13	-	<0.01	-	
	Intermediate Bedrock	06/12/14	-	<0.01	-	
	Intermediate Bedrock	06/18/14	-	<0.01	-	
	Intermediate Bedrock	12/16/14	-	<0.01	-	

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

		Analyte	**Total Chromium (mg/L)**	**Dissolved Chromium (mg/L)**	**Hexavalent Chromium (mg/L)**	**Trivalent Chromium (mg/L)**
WELL ID	**SCREENED UNIT**	**GA standard:**	0.05	0.05	0.05	0.05
AW-B20	Intermediate Bedrock	04/16/14	**0.79**	**0.8**	<0.01	**0.79**
AW-B3	Intermediate Bedrock	May-92	-	-	0.007	
	Intermediate Bedrock	Sep-92	-	-	-	
	Intermediate Bedrock	06/12/13	-	<0.01	-	
	Intermediate Bedrock	12/18/13	<0.01	<0.01	<0.01	<0.01
	Intermediate Bedrock	06/17/14	-	<0.01	-	
	Intermediate Bedrock	12/17/14	-	<0.01	-	
	Intermediate Bedrock	12/18/14	-	<0.01	-	
AW-B4	Intermediate Bedrock	May-92	-	-	<0.002	
	Intermediate Bedrock	Sep-92	-	-	-	
	Intermediate Bedrock	09/15/08	**11**	0.01	<0.01	**11**
	Intermediate Bedrock	09/26/13	-	0.039	-	
	Intermediate Bedrock	12/18/13	**0.37**	**0.063**	**0.26**	**0.11**
AW-B8	Intermediate Bedrock	May-92	-	-	-	
	Intermediate Bedrock	Sep-92	-	-	<0.002	
AW-B9	Intermediate Bedrock	12/19/13	**1.6**	0.0073 J	<0.01	**1.6**
MW-10	Intermediate Bedrock	Apr-87	-	-	0.05	
	Intermediate Bedrock	May-92	-	-	**0.062**	
	Intermediate Bedrock	Sep-92	-	-	-	
	Intermediate Bedrock	May/June-87	-	-	<0.05	
MW-10B	Intermediate Bedrock	May-92	-	-	-	
	Intermediate Bedrock	Sep-92	-	-	0.002	
	Intermediate Bedrock	12/16/13	-	0.0025 J	-	
	Intermediate Bedrock	04/17/14	0.0055 J	<0.01	<0.01	0.0055 J
	Intermediate Bedrock	06/12/14	-	<0.01	-	
	Intermediate Bedrock	06/17/14	-	<0.01	-	
	Intermediate Bedrock	12/17/14	-	<0.010	-	
MW-13	Intermediate Bedrock	Apr-87	-	-	<0.05	
	Intermediate Bedrock	May/Jun-87	-	-	**9**	
	Intermediate Bedrock	May-92	-	-	**44**	
MW-20D	Intermediate Bedrock	May-92	-	-	<0.002	
	Intermediate Bedrock	Sep-92	-	-	<0.002	
	Intermediate Bedrock	09/16/08	-	0.005	-	
	Intermediate Bedrock	09/26/13	-	<0.01	-	
	Intermediate Bedrock	12/17/13	<0.01	<0.01	<0.01	<0.01
MW-21	Intermediate Bedrock	Apr-87	-	-	**49**	
	Intermediate Bedrock	May/Jun-87	-	-	**50**	
MW-22	Intermediate Bedrock	Apr-87	-	-	**15.5**	
	Intermediate Bedrock	May/Jun-87	-	-	**13.2**	
MW-23D	Intermediate Bedrock	12/17/13	0.0081 J	.0079 J	<0.01	0.0081 J
MW-25D	Intermediate Bedrock	May-92	-	-	0.034	
	Intermediate Bedrock	Sep-92	-	-	-	
	Intermediate Bedrock	12/19/13	0.013	0.0047 J	<0.01	0.013
MW-25S	Intermediate Bedrock	Apr-87	-	-	<0.05	
	Intermediate Bedrock	Sep-88	-	-	<0.005	
	Intermediate Bedrock	May/Jun-87	-	-	<0.05	
MW-27D	Intermediate Bedrock	May-92	-	-	<0.002	
	Intermediate Bedrock	Sep-92	-	-	-	
	Intermediate Bedrock	09/16/08	-	**0.083**	-	
	Intermediate Bedrock	09/26/13	-	<0.01	-	

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

WELL ID	SCREENED UNIT	Analyte	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
		GA standard:	0.05	0.05	0.05	0.05
MW-27S	Intermediate Bedrock	Apr-87	-	-	0.03	
	Intermediate Bedrock	Sep-88	-	-	<0.005	
	Intermediate Bedrock	May/Jun-87	-	-	<0.05	
MW-30D	Intermediate Bedrock	Apr-87	-	-	<0.05	
	Intermediate Bedrock	Apr-87	-	-	<0.05	
	Intermediate Bedrock	Sep-88	-	-	<0.05	
	Intermediate Bedrock	06/25/13	-	0.023	-	
	Intermediate Bedrock	12/19/13	0.03	0.028	<0.01	
	Intermediate Bedrock	12/19/13	-	0.026	-	
	Intermediate Bedrock	06/17/14	-	0.0037	-	
	Intermediate Bedrock	12/18/14	-	0.0028 J	-	
	Intermediate Bedrock	May/Jun-87	-	-	<0.05	
MW-30S	Intermediate Bedrock	Apr-87	-	-	<0.05	
	Intermediate Bedrock	May-92	-	-	<0.002	
	Intermediate Bedrock	06/25/13	-	<0.01	-	
	Intermediate Bedrock	12/19/13	-	<0.01	-	-
	Intermediate Bedrock	12/19/13	<0.01	<0.01	0.0066 J	<0.01
	Intermediate Bedrock	06/17/14	-	<0.01	-	
	Intermediate Bedrock	May/Jun-87	-	-	<0.05	
MW-35D	Intermediate Bedrock	May-92	-	-	0.002	
	Intermediate Bedrock	Sep-92	-	-	0.002	
MW-36D	Intermediate Bedrock	May-92	-	-	0.006	
	Intermediate Bedrock	Sep-92	-	-	<0.002	
	Intermediate Bedrock	09/19/08	-	**0.12**	-	
	Intermediate Bedrock	09/25/13	-	0.026	-	
	Intermediate Bedrock	12/17/13	0.025	0.023	<0.01	0.025
MW-40B	Intermediate Bedrock	May-92	-	-	-	
	Intermediate Bedrock	Sep-92	-	-	<0.002	
	Intermediate Bedrock	12/18/14	0.033	-	<0.01	0.033
MW-40S	Intermediate Bedrock	May-92	-	-	<0.002	
	Intermediate Bedrock	Sep-92	-	-	-	
DEEP BEDROCK WELLS						
AW-C1	Deep Bedrock	May-92	-	-	0.006	
	Deep Bedrock	Sep-92	-	-	-	
	Deep Bedrock	12/20/13	**0.064**	<0.01	<0.01	**0.064**
AW-C2	Deep Bedrock	12/18/13	-	0.02	-	-
	Deep Bedrock	12/18/13	0.044	0.02	<0.01	0.044
	Deep Bedrock	06/12/14	-	0.014	-	
	Deep Bedrock	06/18/14	-	0.015	-	
	Deep Bedrock	12/16/14	-	0.021	-	
	Deep Bedrock	May-92	-	-	**16.8**	
	Deep Bedrock	Sep-92	-	-	-	
	Deep Bedrock	May-92	-	-	<0.002	
	Deep Bedrock	Sep-92	-	-	**0.27**	
AW-C7	Deep Bedrock	May-92	-	-	**0.64**	
	Deep Bedrock	Sep-92	-	-	**0.96**	
	Deep Bedrock	12/18/13	0.044	0.02	<0.01	0.044
	Deep Bedrock	12/18/13	-	0.0028 J	-	
	Deep Bedrock	06/12/14	-	<0.01	-	
	Deep Bedrock	06/17/14	-	0.0026 J	-	
	Deep Bedrock	12/17/14	-	0.0033 J	-	

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Former Ciba-Geigy Site
Glens Falls, New York

WELL ID	SCREENED UNIT	Analyte	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
		GA standard:	0.05	0.05	0.05	0.05
AW-C8	Deep Bedrock	May-92	-	-	**2.7**	
	Deep Bedrock	Sep-92	-	-	-	
	Deep Bedrock	12/19/13	-	<0.01	-	
	Deep Bedrock	12/19/13	0.0023 J	<0.01	0.0057 J	<0.01
	Deep Bedrock	06/12/14	-	<0.01	-	
	Deep Bedrock	06/18/14	-	<0.01	-	
	Deep Bedrock	12/16/14	-	0.007 J	-	
AW-C9	Deep Bedrock	Sep-92	-	-	**6.89**	
	Deep Bedrock	12/16/13	-	<0.01	-	
	Deep Bedrock	04/17/14	0.0033 J	<0.01	<0.01	0.0033 J
	Deep Bedrock	04/17/14	-	<0.01	-	
	Deep Bedrock	06/13/13	-	<0.01	-	
	Deep Bedrock	06/18/14	-	<0.01	-	
	Deep Bedrock	12/17/14	-	<0.01	-	
AW-C10	Deep Bedrock	May-92	-	-	-	
	Deep Bedrock	Sep-92	-	-	<0.002	
	Deep Bedrock	06/13/13	-	<0.01	-	
	Deep Bedrock	12/16/13	-	<0.01	-	
	Deep Bedrock	04/17/14	0.0035 J	<0.01	<0.01	0.0035 J
	Deep Bedrock	06/17/14	-	<0.01	-	
	Deep Bedrock	12/17/14	-	<0.010	-	
AW-C11	Deep Bedrock	06/13/13	-	**0.26**	-	
	Deep Bedrock	12/19/13	**1.1**	**1.3**	**0.64**	**0.46**
	Deep Bedrock	06/18/14	-	**0.061**	-	
	Deep Bedrock	12/16/14	-	**0.15**	-	
MW-17	Deep Bedrock	May-92	-	-	<0.002	
	Deep Bedrock	Sep-92	-	-	-	
MW-17C	Deep Bedrock	May-92	-	-	-	
	Deep Bedrock	Sep-92	-	-	<0.002	
	Deep Bedrock	04/18/14	0.003 J	<0.01	<0.01	0.003 J
MW-20C	Deep Bedrock	May-92	-	-	<0.002	
	Deep Bedrock	Sep-92	-	-	0.004	
	Deep Bedrock	06/14/13	-	<0.01	-	
	Deep Bedrock	12/17/13	-	<0.01	-	
	Deep Bedrock	12/18/13	0.0049 J	<0.01	<0.01	0.0049 J
	Deep Bedrock	06/18/14	-	0.01	-	
	Deep Bedrock	12/17/14	-	0.01	-	
MW-36C	Deep Bedrock	May-92	-	-	**1.21**	
	Deep Bedrock	Sep-92	-	-	-	
	Deep Bedrock	06/14/13	-	0.0045 J	-	
	Deep Bedrock	12/17/13	-	0.015	-	-
	Deep Bedrock	12/17/13	0.018	0.015	<0.01	0.018
	Deep Bedrock	06/18/14	-	0.0084 J	-	
	Deep Bedrock	12/17/14	-	0.007 J	-	
TW-1	Deep Bedrock	04/16/14	<0.01	<0.01	<0.01	<0.01
TW-2	Deep Bedrock	02/06/14	**1.5**	**1.5**	-	
	Deep Bedrock	04/16/14	0.016	0.0052 J	0.0068 J	0.0092
TW-3	Deep Bedrock	04/16/14	0.0026 J	<0.01	0.0052 J	<0.01

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

		Analyte	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
WELL ID	**SCREENED UNIT**	**GA standard:**	0.05	0.05	0.05	0.05
EXTRACTION WELLS						
EW-B1	Intermediate Bedrock	12/11/13	<0.01	<0.01	<0.01 H	<0.01
	Intermediate Bedrock	01/09/14	-	-	0.0066J	
	Intermediate Bedrock	04/14/14	<0.01	<0.01	<0.01	<0.01
EW-B2	Intermediate Bedrock	12/17/13	0.0021 J	0.0018 J	<0.01 H	
	Intermediate Bedrock	01/09/14	-	-	<0.01	
	Intermediate Bedrock	04/15/14	0.0065 J	<0.01	<0.01	0.0065 J
EW-B3	Intermediate Bedrock	12/12/13	**0.076**	**0.067**	0.063 H	0.013
	Intermediate Bedrock	04/15/14	**0.15**	**0.055**	0.035	**0.115**
EW-B4	Intermediate Bedrock	12/11/13	**0.87**	**0.92**	0.83 H	0.04
	Intermediate Bedrock	04/15/14	**0.44**	**0.44**	**0.37**	**0.07**
EW-B5	Intermediate Bedrock	12/11/13	**49**	**52**	43 H	**4**
	Intermediate Bedrock	04/15/14	**56**	**60**	**56**	0.0
EW-B6	Intermediate Bedrock	12/11/13	0.027	0.0048 J	0.01 H	0.027
	Intermediate Bedrock	04/15/14	0.011	0.0037 J	<0.01	0.011
EW-A1	Shallow Bedrock	12/11/13	0.0014 J	<0.01	<0.01 H	
	Shallow Bedrock	01/09/14	-	-	<0.01	
	Shallow Bedrock	04/14/14	0.0054 J	<0.01	<0.01 H	
EW-A2	Shallow Bedrock	12/11/13	0.0022 J	0.0027 J	<0.01 H	0.0022 J
	Shallow Bedrock	01/09/14	-	-	<0.01	
	Shallow Bedrock	04/14/14	0.0086 J	<0.01	0.0056 J	0.0030
EW-A3	Shallow Bedrock	12/11/13	0.0044 J	0.0037 J	<0.01 H	0.0044 J
	Shallow Bedrock	01/09/14	-	-	<0.01	
	Shallow Bedrock	04/14/14	**1.1**	0.0065 J	<0.01	**1.1**
EW-A4	Shallow Bedrock	12/11/13	0.047 J	0.032 J	0.0032 J H	0.044
	Shallow Bedrock	01/09/14	-	-	0.044	
	Shallow Bedrock	04/14/14	**0.11**	0.035	0.021	**0.089**
EW-A5	Shallow Bedrock	12/12/13	0.0076 J	0.0052 J	0.0039 J H	
	Shallow Bedrock	01/09/14	-	-	<0.01	
	Shallow Bedrock	04/14/14	**0.53**	0.0082 J	<0.01	**0.53**
EW-A6	Shallow Bedrock	12/12/13	0.006 J	0.0044 J	0.0035 J H	
	Shallow Bedrock	01/09/14	-	-	<0.01	
	Shallow Bedrock	04/15/14	0.006 J	0.0038 J	<0.01	0.006 J
EW-A7	Shallow Bedrock	12/12/13	0.011	0.0094 J	<0.01 J H	
	Shallow Bedrock	01/09/14	-	-	<0.01	
	Shallow Bedrock	04/14/14	0.017	0.0088 J	<0.01	0.017
EW-A8	Shallow Bedrock	12/12/13	0.0083 J	0.0071 J	0.0034 J H	0.0049
	Shallow Bedrock	01/09/14	-	-	0.0066 J	
	Shallow Bedrock	04/15/14	0.011	0.0086 J	<0.01	0.011
EW-A9	Shallow Bedrock	12/12/13	**0.74**	**0.76**	**0.70 H**	0.04
	Shallow Bedrock	01/09/14	-	-	**0.64**	
	Shallow Bedrock	04/15/14	**0.58**	**0.94**	**0.11**	**0.47**
EW-A10	Shallow Bedrock	12/11/13	**0.91**	**0.94**	**0.89 H**	0.02
	Shallow Bedrock	01/09/14	-	-	**0.54**	
	Shallow Bedrock	04/15/14	**0.61**	**0.71**	**0.47**	**0.14**
EW-A11	Shallow Bedrock	12/11/13	0.011	0.0047 J	0.0038 J H	0.0062
	Shallow Bedrock	01/09/14	-	-	0.0084 J	
	Shallow Bedrock	04/15/14	**0.077**	0.0027 J	<0.01	**0.077**
EW-A12	Shallow Bedrock	12/11/13	**0.096**	**0.086**	0.097 H	0.01
	Shallow Bedrock	01/09/14	-	-	**0.2**	
	Shallow Bedrock	04/15/14	**2.1**	**1.6**	**1.4**	**0.7**

Table 2-3
Groundwater Chromium Analytical Results
Former Ciba-Geigy Site
Glens Falls, New York

WELL ID	SCREENED UNIT	Analyte GA standard:	Total Chromium (mg/L)	Dissolved Chromium (mg/L)	Hexavalent Chromium (mg/L)	Trivalent Chromium (mg/L)
			0.05	0.05	0.05	0.05
EW-A13	Shallow Bedrock	12/11/13	**0.13**	**0.13**	0.11 H	0.02
	Shallow Bedrock	01/09/14	-	-	**0.15**	
	Shallow Bedrock	04/15/14	**0.69**	**0.68**	**0.32**	**0.37**
EW-A14	Shallow Bedrock	12/11/13	**0.56**	**0.58**	**0.54 H**	0.02
	Shallow Bedrock	01/09/14	-	**0.69**	-	
	Shallow Bedrock	04/15/14	**1.4**	**1.3**	**1.1**	**0.3**

Notes:

"<" - indicates not detected above laboratory reporting limit shown

" - " indicates not sampled/not analyzed

** Due to limited recovery samples weren't field filtered; analyzed for total chromium & vanadium only

(20M) in sample ID indicates sample filtered with 0.20 micrometer (um) filter; other samples for dissolved analysis were filtered using 0.45 um filers.

GA standard - Groundwater quality standard for fresh groundwater; 6 NYCRR 703.5

H - Sample analyzed outside of hold time (Dec. 2013 hexavalent chromium); resampled Jan. 2014.

mg/L: milligrams per Liter (parts per million)

TABLE 5-1
Soil Laboratory Analytical Method Summary
Former Ciba-Geigy Site
Glens Falls, New York

Analyte	Method Number	Anticipated Reporting Limit	Target Minimum Reporting Limit	Sample Container Type	Preservation	Holding Time
pH	SW846 9045D	n/a S.U.	n/a S.U.	4 oz glass	Cool, < 6 deg. C.	ASAP
Cation Exchange Capacity (CEC)	SW846 9081 / 6010C	not specified	not specified		Cool, < 6 deg. C.	28 Days
Fraction Organic Carbon (foc)	Loyd Kahn	calculated	not specified		Cool, < 6 deg. C.	28 Days
Moisture Content	ASTM 160.3/ASTM4643	calculated %	not specified		Cool, < 6 deg. C.	7 days
Grain Size Distribution	ASTM D422	n/a	n/a	8 oz glass	none	n/a
Metals and Cyanide						
Chromium	SW846 6010C/6020A	1.0 mg/kg	30 mg/kg	4 oz glass	Cool, < 6 deg. C.	180 days
Cadmium		0.5 mg/kg	2.5 mg/kg			
Lead		2.0 mg/kg	63 mg/kg			
Vanadium		5.0 mg/kg	not specified			
Mercury	SW846 7174B	0.033 mg/kg	0.18 mg/kg		Cool, < 6 deg. C.	28 Days
Hexavalent Chromium, and Trivalent Chromium calculation	SW846 7199	0.4 1 mg/kg	30 1 mg/kg	4 oz glass	Cool, < 6 deg. C.	30 days extraction /7 days analysis
Total Cyanide	SW846 9012B	0.1 mg/kg	27 mg/kg	4 oz glass	Cool, < 6 deg. C.	14 Days
Leach Testing						
SPLP Leach Test*	MODIFDIED SW846 1312	not applicable	not applicable	8 oz glass	n/a	14 days
Chromium	SW846 6010C/6020A	2.0 µg/L	2.0 µg/L	leachate	HNO_3 to pH<2	180 days
Cadmium		1.0 µg/L	1.0 µg/L			
Lead		1.0 µg/L	2.0 µg/L			
Vanadium		2.0 µg/L	2.0 µg/L			
Mercury	SW846 7471B	0.2 µg/L	0.77 µg/L			28 days
Hexavalent Chromium, and Trivalent Chromium calculation	SW846 7199	10 µg/L	11 µg/L		Cool, < 6 deg. C.	24 hours
Total Cyanide	SW846 9012B	10 µg/L	200 µg/L		NaOH to pH>12, Cool, < 6 deg. C.	14 Days
WAD Cyanide	SM 4500-CN-I/CN-E Modified	10 µg/L	not specified			14 Days
Free Cyanide	OIA-1677	2 µg/L	5.2 µg/L		Kit; NaOH to pH>12, Cool, < 6 deg. C.	14 Days

Notes:

* Modified to extration fluid of pH 6, 7 and 8

mg/L = milligrams per liter

g = grams

oz = ounces

µg/L = microgram per liter

TABLE 5-2
Groundwater Laboratory Analytical Method Summary
Former Ciba-Geigy Site
Glens Falls, New York

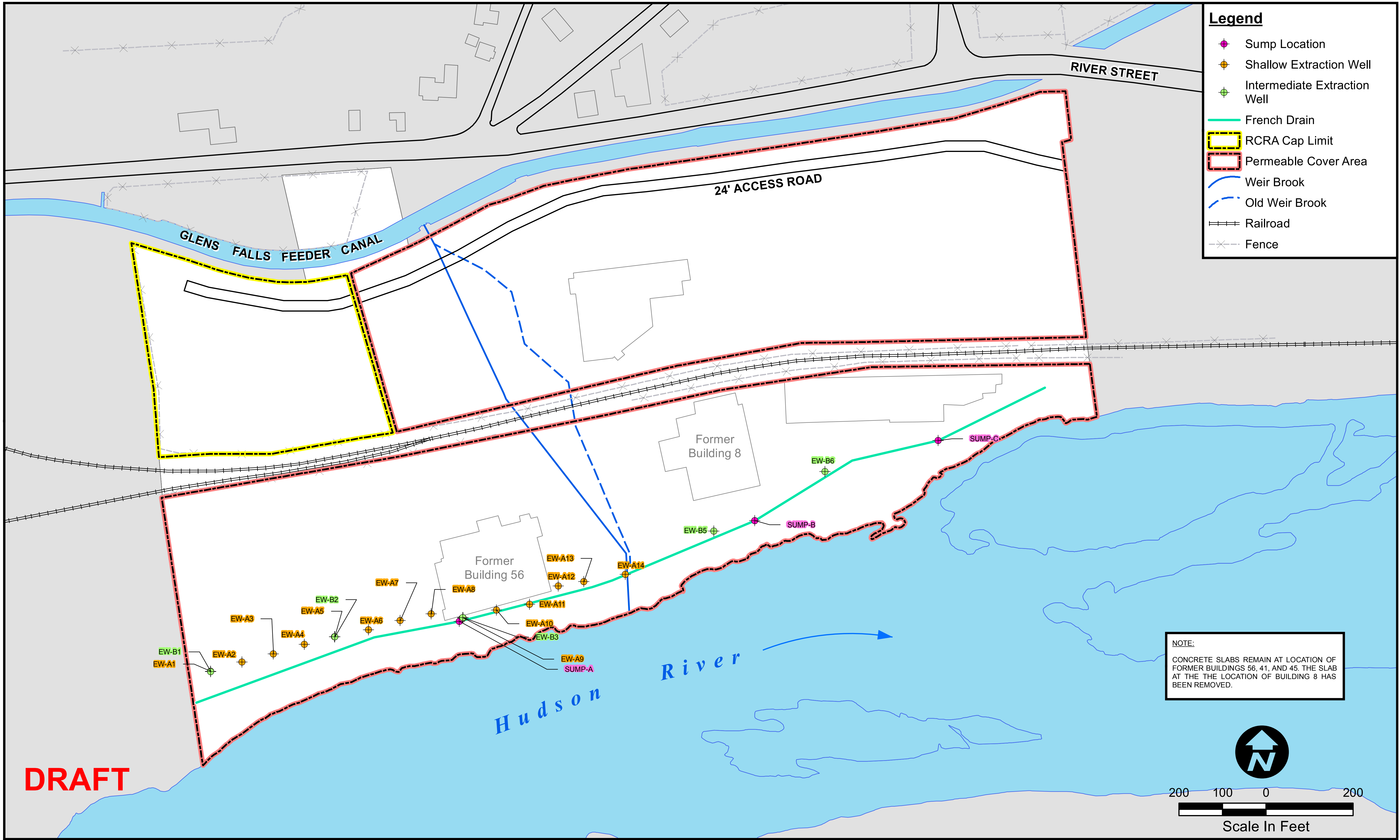
Analyte	Groundwater Quality Standard GA standard[1] (µg/L)	Surface Water Quality Standard[1] Class A, B, C (µg/L)	Method Number	Target Reporting Limit	Sample Container Type	Container Volume (each in ml)	No. Containers per sample	Preservation	Holding Time
Major Ions and Geochemistry Parameters									
Calcium	not screened	not screened	SW 846 6020A	110 µg/L	Plastic	in total metals bottle		HNO_3 to pH<2	6 Months
Sodium	not screened	not screened		110 µg/L					
Potassium	not screened	not screened		110 µg/L					
Magesium	not screened	not screened		110 µg/L					
Chloride	not screened	not screened	SW846 9056A	1,000 µg/L	Plastic	500	1	Cool, < 6 deg. C	28 Days
Bromide	not screened	not screened		300 µg/L				Cool, < 6 deg. C	28 Days
Sulfate (as S04)	not screened	not screened		1,000 µg/L				Cool, < 6 deg. C	28 Days
Total Dissolved Solids	not screened	not screened	SM2540C	5,000 µg/L				Cool, < 6 deg. C.	7 days
Total Organic Carbon	not screened	not screened	SM 5310B	1,000 µg/L	Amber Glass	250	1	HCl 4 to pH<2, Cool, < 6 deg. C.	28 Days
Dissolved Organic Carbon	not screened	not screened		1,000 µg/L	Amber Glass	250	1	Filtration + HCl 4 to pH<2, Cool, < 6 deg. C.	
Alkalinity (total, bicarbonate, carbonate)	not screened	not screened	SM2320 B-11	2,000 µg/L	Plastic	250	1	Cool, < 6 deg. C, no headspace	14 Days
Hardnness	not screened	not screened	SM 2340C	5,000 µg/L	Plastic	in total metals bottle		HNO3 to pH<2	6 Months
Total Metals									
Chromium	50	n/a	SW 846 6020A	2.2 µg/L	Plastic	500	1	HNO_3 to pH<2	6 Months
Cadmium	5	n/a		1.1 µg/L					
Lead	25	n/a		2.2 µg/L					
Vanadium	n/a	n/a		2.2 µg/L					
Mercury	0.7	n/a	SW846 7470A	0.5 µg/L					28 Days
Dissolved Metals									
Chromium	50	calculated*	SW 846 6020A	2.0 µg/L	Plastic	500	1	Filtration + HNO_3 to pH<2	6 Months
Cadmium	n/a	calculated*		1.0 µg/L					
Lead	n/a	calculated*		2.0 µg/L					
Vanadium	n/a	190 A(A) 14 A(C)		2.0 µg/L					
Mercury	n/a	$7x10^{-4}$ H(FC) 1.4 A(A) 0.77 A(C)	SW 846 7470A	0.5 µg/L					28 Days
Hexavalent Chromium	50	16 A(A) 11 A(C)	SW846 7199	10 µg/L	Plastic	250	1	Filtration + Cool, < 6 deg. C	24 hrs
Cyanide									
Total Cyanide	200	9000 H(FC)	SW846 9012B	10 µg/L	Plastic	250	1	NaOH to pH>12, Cool, < 6 deg. C.	14 Days
Weak Acid Dissociable (WAD) Cyanide	n/a	n/a	SM 4500 CN-I	10 µg/L					
Free Cyanide	n/a	5.2 A(A) 22 A(C)	OIA-1677	2 µg/L	Plastic	250	1	Pre-treatment (kit), NaOH to pH>12, Ascorbic Acid, Cool, < 6 deg. C.	14 Days

Notes:

TABLE 5-2
Groundwater Laboratory Analytical Method Summary
Former Ciba-Geigy Site
Glens Falls, New York

1) 6 NYCCR 703.5, Table 1 Water Quality Standards Surface Waters (or Water Quality Guidance Values from NYS Dept. of Water TOGS 1.1.1 as noted).
   not screened - indicates not a site-related constituent; data used for geochemical assessment/developing surface water criteria only
   n/a indicates no screening value available. Total metals criteria may be used for screening dissolved metals that have no screening value available.
   A(C) - protective of fish propogation in fresh waters - applicable to dissolved phases only (acid soluble phase for vanadium)
   A(A) - protective of fish survival in fresh waters - applicable to dissolved phases only (acid soluble phase for vanadium)
   * indicates A(A) and A(C) values are calculated based on hardness
   GA - protective of fresh groundwaters for drinking water source
   H(WS) protective of health for water drinking water source
   H(FC) - protective of human health for fish consumption
µg/L - micrograms per liter
ml - milliliters

FIGURES



NOTE:

CONCRETE SLABS REMAIN AT LOCATION OF FORMER BUILDINGS 56, 41, AND 45. THE SLAB AT THE THE LOCATION OF BUILDING 8 HAS BEEN REMOVED.

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ASHLAND
FORMER CIBA-GEIGY / HERCULES SITE
GLENS FALLS, NY

SITE MAP

FIGURE 1-1

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Historical Process Areas
Ashland
Former CIBA-Geigy / Hercules Site
Glens Falls, NY

PROJECT NO. 2430805419	PREPARED BY ACS	REF SCALE 1:3,900
DATE 11/28/2014	REVIEWED BY AL	MAP SCALE 1 inch = 325 feet

anteagroup

Document Path: \\gis-s3\GIS_Data\Sandbox\!Projects\A-E\Ashland_GlensFalls\2430805419\Layout\2014_1121_AddedBorings_EastArea\Wells_by_ProcessArea_11x17.mxd

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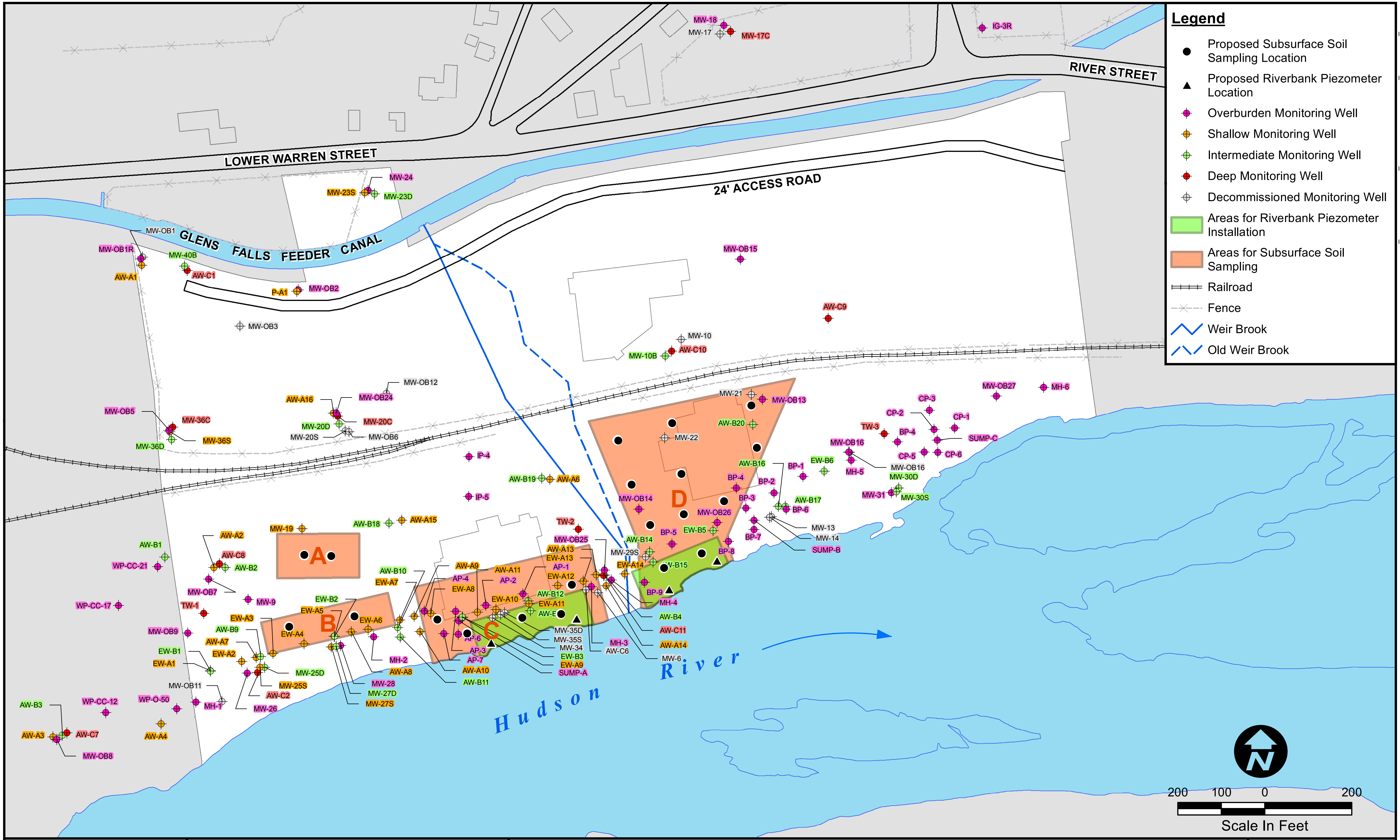
GLENS FALLS, NY
FORMER PIGMENT
MANUFACTURING SITE

PROCESS AREAS A1 TO A7

Figure 2-1



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ASHLAND
FORMER CIBA-GEIGY / HERCULES SITE
GLENS FALLS, NY

PROPOSED INVESTIGATION AREAS AND SOIL BORE AND PIEZOMETER LOCATIONS

FIGURE 2-2

APPENDIX A – PHOTOGRAPHS OF RIVERBANK AREA

Photographs of River Bank in Proposed Piezometer Areas

APPENDIX B – GROUNDWATER SAMPLING METHDOLOGY

1.0 PIEZOMETER GROUNDWATER SAMPLING METHODOLOGY

The field methodologies for groundwater gauging and sampling using low-stress (low-flow) methods and quality assurance/quality control (QA/QC) sampling included in the field program are described below. This procedure is applicable to sampling of wells and piezometers (collectively referred to as wells).

1.1 Water Level Gauging

Water level gauging is conducted using an electronic level meter/interface probe that emits an audible/visual signal when in contact with water. At each location, remove the well/gauge cap and allow any pressure/vacuum in the casing to equilibrate prior to water level measurement. Slowly lower the gauge into the casing, avoiding contact with the casing wall until reaching the water surface. The depth to water is measured relative to the top of casing (TOC) at the marked reference point (survey point). If a reference mark is not found on the TOC, reference the measurement to the north side of the TOC (standard reference for survey). Measure the total well depth by lowering the probe to the bottom of the well, making gentle contact to minimize potential for disturbance of bottom sediments. The interface probe (and probe measure tape line) should be cleaned prior to use in each well.

The date, time, and depth to water and total depth measurements (to the nearest 0.01 foot) are recorded in field log books. The depth to water data is used in conjunction with TOC survey data to evaluate water potentiometric surface levels and groundwater flow direction. The total well depths are compared to well construction data to assess changes in well conditions (e.g., accumulation of sediment), and confirm pump level depth for purging and sampling.

Visual observations of the on-grade facilities (e.g., risers, monuments, well pads) should be made and signs of damage/conditions that may affect function recorded in field log books, along with any other observations (e.g., blockage/other issues encountered during gauging) that indicate repair/maintenance may be needed.

1.2 Groundwater Sampling

Low flow sampling methods are employed to minimize disturbance, turbidity and changes in water chemistry during sample collection, filtering and bottling. Low flow sampling will be conducted in accordance with USEPA low flow purging and sampling guidelines (USEPA, 1998 and 2010). The goal of the low flow sampling is to collect samples that reflect inorganic loads (dissolved and colloidal sized fractions) that are transported through the subsurface under ambient flow conditions with minimal chemical and physical alterations due to sampling. The sampling methodology aims to minimize hydraulic stress at the well aquifer interface by maintaining low water level drawdowns and using low pumping rates during purging and sampling. Indictor field parameters (turbidity, dissolved oxygen, specific conductivity, temperature, pH and oxidation-reduction potential (Redox)) will be used to assess stabilization in water quality and determine when sampling will begin.

Purging and sampling is conducted using bladder pumps (with adjustable flow control), and disposable bladders and polyethylene tubing. The clean tubing placed in a given well may be left in-place (dedicated) for use in future sampling events. Monitoring of field parameters will be conducted using a flow through cell (closed system) and multi-parameter meter. Filtration will be conducted using disposable in-line filters. Thus, the only non-disposable/non-dedicated equipment used at each well will be the bladder pump, which will be cleaned prior to use in each well.

Groundwater purging and sampling is conducted as follows.

1. A field purging and sampling log is used to record the well ID, date, time, name of personnel conducting sampling and site conditions (weather, rainfall, barometric pressure). Details regarding sampling equipment used (e.g., pump type, pump depth, field parameter instruments, filters), field measurements made, sample names, and QC sample information including data for duplicate or matrix spike/matrix spike duplicate (MS/MSD) samples collected, and equipment blank samples and wells sampled before/after the blank collection are also recorded.
2. The well cap is removed and a water level probe is lowered into the well until the water surface is detected, and the depth to water (relative to TOC) is recorded. The level probe should remain in the well throughout purging and sampling.
3. The bladder pump with a clean, disposable bladder and tubing is slowly lowered into the well to a depth at which the pump intake is at approximately the mid-level of the water column (calculated based on the depth to water and the total well depth measured during pre-sample gauging).
    a. Pumps will be placed in the middle of the water column or the middle of the well screen where the water column is above the top of screen, and at least two feet above the bottom of the well where possible.
    b. The pump is secured to the well casing (or other non-movable fixed point) using the safety cable and the depth to the pump intake (relative to TOC) recorded on the sampling log. The pump is to remain in the well throughout purging and sampling.
    c. The pump may be lowered if necessary to maintain sufficient water column above the pump for operation.
4. The pump discharge tubing is connected to the flow through cell, and discharge tubing from the cell set to discharge to a bucket/other container for purge water collection. Tubing length from the well to monitoring equipment shall be minimized to reduce impact of ambient environment (e.g., temperature variance from downhole conditions). Connection to the flow through cell may be delayed as appropriate to minimize potential for significant particulate/sediment discharge into the cell.
5. Start the pump, operating at a low rate, increasing speed until discharge is achieved and a target rate within approximately 100-250 milliliters per minute (mL/min) for slow flowing wells; rates of 250-500 may be used where sufficient well flow can be maintained. Monitor the tubing to ensure pump suction is not broken and to avoid kinking the line. Record pumping rate adjustments and time made.
    a. Actively monitor the water level for drawdown, and adjust the pumping rate to achieve steady pumping and stable drawdown of less than 0.3 feet; reduce the pump rate if needed to minimize/achieve stable drawdown. If drawdown at the minimum flow rate achievable exceeds 0.3 feet, continue to monitor for stable drawdown. Record any pumping rate adjustments.
    b. Confirm flow rates using a timer and graduated cylinder/bucket to collect purged.
6. Record water level at maximum intervals of 2-3 minutes during first 10 minutes of pumping, and at approximately 5-10 minute (or as appropriate) intervals thereafter to assess drawdown stability.
7. During purging, monitor and record the field indicator parameters (turbidity, temperature, specific conductance, pH, DO, Redox) at approximately 5-minute intervals (or such interval that allows complete cell volume change-out based on pump rate and cell volume).
    a. During purging the flow through cell should remain full (no draining/entrainment of air to ensure proper probe function).
    b. Conditions will be considered stabilized and ready for sample collection when the indicator parameters are stabilized three consecutive readings as follows (USEPA 2010 and Puls and Barcelona, 1992):
        i. ±0.1 for pH
        ii. ±3% for specific conductance (conductivity)
        iii. ±3% for temperature
        iv. ±10 mv for redox potential

        v. ±10% for DO and turbidity
    c. Observations for stabilization should follow stabilization of drawdown. Final purge volume should be greater than the stabilized drawdown plus the pump's tubing volume.
    d. Visual observations of water conditions (e.g., clear, cloudy) will also be recorded.
8. Sample collection should occur at the same rate as purging. The time and depth to water should be recorded when sample collection begins.
    a. Samples will be collected directly from the pump tubing line, and containers should be filled with minimal turbulence by allowing the water to flow from the tubing gently down the inside of the container. The bottom of the tubing should be held near the base/side of the sample container to minimize oxygenation and splashing of the sample, taking care not to bring the tubing in contact with the bottle or preservative that may be present in the bottle. Upon sample collection, sample containers will be sealed, labeled and stored in a cooler with ice for transport to the laboratory under chain-of-custody (COC) documentation.
    b. Sample filtering will be conducted using disposable in-line cartridge filters, connected directly to the pump discharge line, and the sample filtrate will be discharged directly (via tubing) into sample containers (as noted above). Alternatively, if in-line filtration cannot be achieved vacuum assist filters (hand pump and cylinder apparatus) may be used.
9. When sampling is completed, the time and depth to water will be recorded and the level meter and pump will be removed from the well, and the well cap closed. If desired the tubing may be disconnected from the pump and remain in the well (hung by securing the top end to the well casing/cap) for re-use in future sampling events.

1.2.1 Response to Low Well Yield and Absence of Stabilization

If a well exhibits low/insufficient yield (recharge rate less than minimum achievable pump rate), drawdown may exceed 0.3 feet and the well may dewater to a level approaching the pump intake during purging. Where insufficient yield is encountered, pumping will cease, and the pump depth will be adjusted to a maximum depth of two feet above the measured bottom, and pumping will recommence when sufficient water for sampling is recovered. Pumping a well dry will be avoided to the extent possible (by pumping at the lowest rate achievable and actively monitoring drawdown). Where minimal water column (less than 2 feet) is encountered pumps will be held above the bottom of the well as near to the water surface as practicable in an attempt to complete purging and sampling.

If one or more key indicator parameters fails to stabilize after 90 minutes or there is insufficient yield to achieve stabilization and then sampling, the following options will be considered in consultation with the EHS Support Project Manager:

- Continue purging in an attempt to achieve stabilization;
- Discontinue purging, do not collect samples, and document attempts to reach stabilization in the log book;
- Discontinue purging, collect samples, and document attempts to reach stabilization in the log book;
- Secure the well, and collect samples the next day if the well has sufficiently recharged to allow sample collection (sufficient volume available for collection),
- Discontinue purging and collect samples over next 48 hours, as sufficient water is recharged for collection of required volumes for a given analysis, and water quality is of sufficiently low turbidity based on field visual observation (color, cloudiness) and field measurement using flow-through cell.
    - Priority for sample collection will be total metals, dissolved metals (0.45 um filter), total cyanide, free cyanide, WAD cyanide, hardness, major ions, alkalinity, TDS, TOC, DOC, and VOC, then sequential filtering samples.

The response to low yield/insufficient water conditions will be determined based on field observations of drawdown, field parameter water quality measurements and rate of recharge for each well circumstance.

1.3 Field Filtering for Dissolved Analysis

The common standard for field filtering to prepare samples for dissolved analysis uses a 0.45 micrometer (µm) filter. The goal of filtering is to remove all particulates and yield a filtered portion of the sample that is representative of the mobile and biologically available phases of inorganics. This assumes that all particulates are greater than 0.45 µm, which is not always the case. The filtered dissolved fraction can be comprised of colloidal mass, which behaves differently to truly dissolved ionic species (for which a chemical potential can be defined). Colloids are dynamic particles that are continuously generated and removed, and undergo compositional changes within groundwater (and surface water) by physical chemical and biochemical reactions. Thus filtration can underestimate mobility and overestimate the truly dissolved species (Puls and Powell, 1992; Horowitz et al, 1994; Saar, 1997).

If colloidal transport is suspected to have an influence on the transport of a particular metal or metal species, a sequential filtering process can be carried out at locations where the metal is detected or elevated in concentration. As colloids are generally expected to range in size from 1 µm to 0.001 µm, a two-step sequential filtering process could be used to explore this distribution. This would incorporate a standard filtration step (0.45 µm) and incorporation of a coarser filtration step (1 µm) and a finer filtration step (ideally 0.01 µm but for field practicality 0.1 µm) to understand the distribution of solids and colloids within water samples.

For the purposes of assessing potential mobility of constituents, standard filtering (0.45 µm) and additional filtering with 1 µm and 0.1 µm filters will be conducted on groundwater samples (refer **Table 4-1**). It is unlikely that filtering through 0.01 µm filters under field conditions would be feasible, thus the filter sizes proposed and composition and mobility considerations for the study are summarized in Table 4-1.

Table 4-1 Sequential Filtration and Influence on Sample Composition

Representative Solution	**Filter Size**		
	> 1 µm	**1 – (0.45) – 0.01 µm (practically 0.1 µm)**	**< 0.01 µm (practically 0.1 µm)**
Composition	Suspended particles (including large colloids or aggregated colloids)	Majority of mobile colloidal species[1]	Truly dissolved[1]
Mobility	Negligible, unlikely to be mobile due to size	High for sorbed anionic metal species Moderate to low for sorbed cationic metal cations due to solubility constraints under oxidizing and circum-neutral conditions	Low for metal cations under oxidizing and moderately alkaline conditions High for anionic metal species under oxidizing and circum-neutral conditions

1) Stumm and Morgan, 1996
2) In reality, truly dissolved species and polynuclear species are expected to be < 1 nanometer

1.3.1 Filtering for Groundwater Sampling

As described above, filtering with 1 µm, 0.45 µm and 0.1 µm is proposed for groundwater samples. Groundwater samples will be subjected to the following sequential filtering and analysis process:

1. Filtering of groundwater samples with 1.0 µm filter and submission of the filtrate for analysis of dissolved chromium, dissolved hexavalent chromium, and dissolved weak acid dissociable (WAD) cyanide. Free cyanide is not included as the required pretreatment in the field (for preservation and removal of interferences) utilizes a smaller (0.45 um) filter;
2. Filtering of groundwater samples with a 0.45 µm filter and submission of the filtrate for analysis of dissolved chromium, dissolved hexavalent chromium, dissolved WAD cyanide and dissolved free cyanide; and followed by
3. Adding a 0.1 µm filter after the 0.45 µm filter (or direct filtering through the 0.1 um size if achievable) and submission of the resultant filtrate for analysis of dissolved chromium, dissolved hexavalent chromium, dissolved WAD cyanide and dissolved free cyanide.

1.3.2 Field Filtering Methodology

Direct in-line filtering of groundwater from the low flow pump discharge line is preferred. For in-line filtering pump flow rates should be as low as possible (based on the well purge methodology described above). Sequential filtering has been described although it may not be possible to undertake both filtration steps using a single in-line filter array. This will depend on the observed turbidity of the groundwater and will vary from location to location. Disposable Millipore vacuum pump filtration units (or similar) should be available if in-line filtration is not feasible. At least two filters of each size should be allocated for every well location where sequential filtering is to occur. If turbidity levels are elevated the filter may need to be changed before the required amount of groundwater sample is collected. Polyethylene or polypropylene tubing should be used for the collection of samples for inorganics analysis.

- When groundwater field parameters have stabilized the pump discharge line is disconnected from the flow through cell for sampling, and connected to the in-line filter assembly’
- Ensure the filters are pre-rinsed with groundwater and there are no air bubbles within the tubing or filter;
- Samples for the 1 µm filtration step should be collected first;
- After the 1 µm samples have been collected, the 0.45 µm filter assembly replaces the 1 µm filter and samples for the 0.45 µm filtration step are collected;
- After the 0.45 µm samples have been collected, the tubing and 0.1 µm filter assembly is added after the 0.45 µm filter – this is to prevent early clogging of the 0.1 µm filter (if achievable the 0.1 um filter may be used directly);
- Samples for the 0.1 µm filtration step are collected;
- Ensure sample bottles have preservative as required per analyte/analysis;
- Each sample container is overfilled and immediately sealed with no air bubbles;
- All sample containers filled with filtered groundwater will be labelled with the sample location, date, time and filtration size;
- The samples will be placed in a cooler with ice for transport to the laboratory under chain-of-custody (COC) documentation;
- Filters (or filtration units) are to be used at one location only and disposed appropriately.

All sample collection and filtering activities are to be undertaken using the above methodology in conjunction with the USEPA low flow purging and sampling guidelines (USEPA, 1998 and 2010) and the USGS Protocol for the collection of Filtered Samples (1994).

Groundwater and surface water sample containers will be pre-preserved as required to retard chemical and biological changes that may occur in response to changes in physical conditions. The chemical preservative will be added to the sample containers by the laboratory prior to shipment to the field. Once samples are collected in the pre-preserved containers, the containers will be checked for tightness, labeled, placed in resealable plastic storage bags, and stored in a cooler containing ice/ice packs pending transport to the laboratory.

1.4 Quality Assurance/Quality Control (QA/QC)

The sampling program will incorporate the following QA/QC procedures.

- Field instruments will be calibrated daily (at the start of field activities) in accordance with the manufacturer's directions. The make and model number of the equipment, date, time and calibration data will be recorded in field log books.
- At least one equipment blank will be collected daily to assess the effectiveness of decontamination procedures. Following decontamination of the bladder pump, a clean bladder and tubing will be installed and a blank will be collected by submerging the pump into laboratory grade water and pumping water through the sample train, to comprise tubing only for total metals sample, and tubing plus a 0.45 um filter (as a representative sample of a clean filter for dissolved analysis), into sample containers provided by the laboratory. The blank sample ID, date and time of collection, and note of wells in which the pump was used before and after the blank collection will be recorded in the field logbook. As this blank will be collected in the field, it will also serve as a field blank.
- Duplicate groundwater and surface water samples will be collected at a frequency of 5 percent (one per 20 sampling locations). Duplicate samples will be collected and handled using the same methodology employed for original samples, and will be analyzed for the same suite of analytes as the original samples.
- MS/MSD samples will be collected at a frequency of one per 20 sample locations. The samples will be collected, handled and analyzed the same as original samples. In the event that sufficient sample volumes cannot be achieved for MS/MSD sample collection (due to low yield of groundwater), a request will be submitted to the laboratory to prepare and analyze a MS/MSD sample from existing original sample volumes if possible.
- Personnel will don clean gloves prior to collection of samples in each location (and as needed during sampling process to avoid contamination of samples). Samples will be collected in clean containers provided by the laboratory. Required preservative will be included in the bottles prepared by the laboratory.
- Sample containers will be filled such that no air remains in the container and capped. Immediately following collection, the containers will be sealed (lids closed), labeled with the sample ID, date, time, and filter size (as applicable), put in a resealable plastic bag, and placed in a cooler with ice for storage and transport to the laboratory. A temperature blank (if needed) will be included with each cooler of samples for use by the laboratory to document temperature upon receipt.
- COC documents will be prepared for each container (cooler) of samples transported to the laboratory. The COC will be completed in the field and will accompany the samples from the time of collection through shipment and receipt by the laboratory. Copies of completed COCs will be included in the laboratory reports.

1.4.1 Decontamination and Waste Management

Non-disposable/non-dedicated equipment that will be used downhole and/or come in contact with groundwater to be sampled will be cleaned prior to use at each sample location. Cleaning/decontamination will comprise a pre-rinse in potable water, followed by washing in non-phosphate detergent solution (e.g., Alconox wash), and rinsing in clean (potable or laboratory grade) water, and air drying (or wiped dry using clean paper towels).

Purged water and decontamination water will be collected and transferred to the on-site wastewater system and discharged under the Site publicly owned treatment works (POTW) permit. Solid waste (packaging material, spent gloves) will be disposed as municipal waste.

2.0 REFERENCES

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