Feasibility Study

Cabot Carbon/Koppers Superfund Site
Gainesville, Alachua County, Florida

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Acknowledgements

Dense Non-aqueous Phase Liquid (DNAPL) presents one of the most difficult challenges in the environmental remediation field. The Site for which this document was prepared has a long operational history with DNAPL substances. That history, combined with the complex geologic features associated with the Site, make this remedial action difficult. A group of professionals were assembled into a Joint Feasibility Study (FS) Committee to address those complexities. The Committee members are listed below, along with their professional affiliations.

Regulatory Representatives	Responsible Party Representatives
Scott Miller (EPA PM*)	Mitchell Brourman (Beazer PM*)
Ed Bates (EPA, retired)	Mike Slenska (Beazer)
Kevin Koporec (EPA)	Jennifer Abrahams (GeoTrans)
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This document is the result of the collective efforts of these individuals. Developing this document involved organizing available reports and documents for the Site, digesting and evaluating this information, and six meetings over a two year period (plus additional phone and email communications) to collectively discuss the pertinent issues. It involved substantial travel and time commitments, numerous discussions, reviews and comment/response cycles. The professional and creative energy of the Committee members has produced a remedial analysis that is focused on protecting human health and the environment. The long hours, creativity, and (most gratefully) cooperative spirit of these individuals made this effort not only a successful endeavor but an enjoyable one, as well.

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Executive Summary

This Feasibility Study (FS) developed and evaluated remedial alternatives for the Koppers portion (the Site) of the Cabot Carbon/Koppers Superfund site (U.S. Environmental Protection Agency [EPA] Identification Number FLD980709356) in Gainesville, Alachua County, Florida. It was prepared in accordance with Federal and State of Florida regulations, and was a collaborative effort by numerous stakeholders, technical experts, and environmental contractors. This FS was prepared to facilitate selection of a final remedial alternative for the Site.

The Site

The Site operated as a wood-treating facility for more than 90 years by various owners/operators. Wood treating operations ceased in 2009. The Site covers approximately 90 acres in a commercial and residential area of the northern part of Gainesville, Florida. Adjacent areas east and south of the Site are now commercial properties. This includes the former Cabot Carbon industrial property (east) and a formerly undeveloped, marshy area (northeast). Areas west and north of the Site are single-family and multi-family residences. A Gainesville Public Works facility, scattered small businesses and a mobile home community are also located to the north/northwest. The Murphree Well Field is located approximately 2 miles northeast. This well field is operated by the Gainesville Regional Utilities and provides public water supply for the City of Gainesville and other areas in Alachua County.

An immense amount of information for this Site has been collected through numerous remedial investigations that began in 1983 and continued through the writing of this FS report. Information and data obtained while the Site's 1990 Record of Decision (ROD) was being implemented suggested that the extent of constituent impacts had been underestimated and that a revised remedial strategy was needed to adequately protect human health and the environment.

The Strategy

One important objective of this FS was to develop and evaluate comprehensive remedies for all media and hydrogeologic units associated with the Site (i.e., Site-wide). Three major environmental media units of the Site (on-Site media, off-Site surface soil, and Upper Floridan Aquifer [UFA] groundwater) were defined and assessed separately. The final remedial plan for the Site will consist of a set of three remedies, one for each of the media units. Another important objective of this FS was to identify technologies, or to develop implementation strategies, that do not cause additional harm to the local environment or create additional constituent migration pathways. Any serious remedial strategy needed to consider remedial actions that cause minimal to no detrimental impacts to downgradient media.

Geologic conditions under the Site consist in part of various layers of low-permeability clays. These may have acted as partial barriers to broader migration of Site-related impacts. Remedial and investigative activities need to maintain the partial protectiveness function of these geologic features. For example, soil boring activities within source area footprints (i.e., locations suspected of having dense non-aqueous phase liquid [DNAPL] source material or groundwater with elevated concentrations) should be carefully considered and minimized to the extent allowed while accomplishing required characterization and remediation at the Site. Preventing migration of constituents to deeper aquifer layers is a primary objective of the remedial work at this Site.

Screening Analysis of Remedial Technologies

Based on the Site conditions, impacted environmental media, and the identified Site constituents, a sub-set of remedial technologies and process options (RTPOs) was selected from the universe of technologies available to risk managers and remediation professionals. The identified RTPOs then were used to develop a suitable range of remedies to address all impacted media. The FS process applied to this Site resulted in a number of technologies for soil and solids media, groundwater and liquid media, source material (i.e., DNAPL), and supplemental support operations that are necessary for primary remedy operations to function effectively. These, in turn, were used as the basis for selecting specific technologies appropriate for all impacted environmental media: surface soil (on-Site and off-Site), subsurface soil (on-Site), shallow and deep groundwater (on-Site), and surface water and sediment.

Development of Remedies

The sub-set of RTPOs identified for this Site was applied to the three environmental units (on-Site media [excluding UFA groundwater], UFA groundwater, and off-Site surface soil). The result was the development of three sets of remedial alternatives (one for each environmental unit): thirteen on-Site remedial alternatives (including the No Action alternative); two UFA remedial alternatives (one of which is the No Action alternative); and four off-Site remedial alternatives (including the No Action alternative). The remedial alternatives were developed and evaluated through a series of meetings and after much discussion and consideration.

The on-Site remedial alternatives are specifically designed to include at least one representative of each of the major remediation processes: removal (excavation or extraction), isolation/containment, in-situ treatment, and ex-situ treatment. They focus primarily on addressing impacted groundwater and sources of constituents in the surface soil, Surficial Aquifer and Upper Hawthorn zones. The on-Site remedial alternatives provide a wide range of remedial costs for evaluation. Each on-Site remedial alternative is described in sufficient detail to allow evaluation and engineering design if selected as part of the preferred alternative. The on-Site remedial alternatives consist of:

- OnR-1: No Action;
- OnR-2: Continue current actions with soil regrading/cover;
- OnR-3A: Surficial Aquifer excavation;
- OnR-3B: Excavation to the Hawthorn Group (HG) middle clay unit;
- OnR-4A: In-situ solidification/stabilization (ISS/S) to the HG middle clay unit;
- OnR-4B: ISS/S to the HG upper clay unit and in-situ biogeochemical stabilization (ISBS) in the Upper Hawthorn;
- OnR-5A: Barrier wall;
- OnR-5B: Barrier wall with ISBS in the Upper Hawthorn;
- OnR-5C: Barrier wall with ISBS in the Surficial Aquifer;
- OnR-5D: Barrier wall with ISS/S in the Surficial Aquifer;
- OnR-5E: Barrier wall with ISBS in the Surficial Aquifer and Upper Hawthorn;
- OnR-5F: Barrier wall with ISS/S in the Surficial Aquifer and Upper Hawthorn; and
- OnR-5G: Barrier wall barrier with ISS/S in the Surficial Aquifer and ISBS in the Upper Hawthorn.

All of the above remedial alternatives, except OnR-1, include monitored natural attenuation (MNA) as a secondary remedial action. Surficial Aquifer hydraulic containment, passive DNAPL recovery, surface covers and/or caps, institutional controls, application of chemical oxidation in the HG, and storm water management are common to many or all of the remedies, as well.

Remedial alternatives for the UFA and the off-Site surface soil environmental units are also considered. A more limited number of remedial alternatives are available for those two environmental units because of the inherent limitations associated with those units (e.g., depth to UFA, preservation of the partially impervious nature of some of the geologic features under the Site, current residential land-use of off-Site areas to the west of the Site). Two remedial alternatives were evaluated for the UFA: no action (UFA-1) or a combination of MNA and hydraulic containment (UFA-2). Four remedial alternatives were evaluated for the off-Site surface soil environmental unit: no action (OfR-1), removal (OfR-2), institutional/engineering controls (OfR-3), and a combination of removal and institutional/engineering controls (OfR-4). Each UFA and off-Site remedial alternative is described in sufficient detail to allow evaluation and engineering design if selected as part of the preferred alternative.

Comparative Evaluation of Remedies

Three sets of remedial alternatives were evaluated to help risk managers determine which remedial alternatives are most suitable to be recommended.

On-Site Remedies. The comparative analysis includes qualitative methods to evaluate the ability of remedial alternatives to meet criteria specified by Superfund regulations. The analysis indicates some variations in protectiveness and predicted effectiveness among the twelve on-Site remedies (excluding the No Action remedy). Both long-term and short-term effectiveness are considered, as well as the implementability of each alternative and the amount of material effectively treated. When remedial cost is introduced into the evaluation, greater differentiation among the remedies is evident.

Upper Floridan Aquifer Remedies. Only two remedies were evaluated for the UFA: no action (UFA-1) or a combination MNA/hydraulic containment remedy (UFA-2). Given that the ultimate goal of the remedial actions at this Site is to protect the Floridan Aquifer water source, UFA-1 is not a realistic option. The comparative analysis process does not apply to the UFA remedies.

Off-Site Surface Soil Remedies. Collection of data for constituents in off-Site soil is still ongoing, and the process used to determine whether constituent concentrations may pose an unacceptable human health risk has not been finalized. In addition, off-Site data collected to date represent a diversity of property uses and analytical results.

At many sampling locations investigated to date, constituent soil concentrations are below all applicable criteria; no action will be necessary in these areas. At other sampling locations, one or more constituents exceed Florida Department of Environmental Protection (FDEP) default residential soil cleanup target levels (SCTLs). Areas with exceedances of SCTLs are being further delineated and assessed.

Once the areas with concentrations exceeding default SCTLs are delineated, one approach that may be utilized to address the potential risks to current and future receptors will be to use risk assessment methods such as those utilized for on-Site soils (AMEC, 2009c). This delineation and assessment process would define whether off-Site areas pose any unacceptable risk assuming Florida's allowable risk limit (i.e. potential excess lifetime cancer risk greater than one in one million) and what areas may require remedial action, if any. Another approach which may be utilized is to compare sample results to default SCTLs and to require remedial action where soil sampling results show exceedances of the default SCTLs.

As discussed in this FS, the anticipated remedial alternatives for off-Site soil are fairly straightforward:

- OfR-1: No Action;
- OfR-2: Removal with replacement of clean fill, with consent of property owner(s);
- OfR-3: Institutional controls (e.g., deed restriction) and/or engineering controls (e.g., surface cover) with consent of property owner(s); and
- OfR-4: Combination of removal, institutional controls, and/or engineering controls, with consent of property owner(s).

Off-Site remedial alternative OfR-1 is applicable at locations where soil concentrations are determined to not pose unacceptable risks. Remedial alternatives OfR-2, OfR-3, and OfR-4 are all protective and would be effective at eliminating any unacceptable risks from direct contact as defined by Florida statute. The implementability and cost of these remedies will vary depending on the estimated potential risks, the type or types of properties with unacceptable risks as defined by Florida statute or regulations, and the preferences of the property owners.

Off-Site remedy OfR-4 allows for a flexible approach that may include institutional and/or engineering controls on properties that (1) are suitable for such controls and (2) have owners that are amenable to such controls. Where institutional/engineering controls are not possible or beneficial, surface-soil removal may be applied, subject to owner approval.

If areas exceeding Florida's allowable risk limit or default SCTLs are identified by soil sampling, Beazer East, Inc., will contact each affected private property owner to discuss possible approaches to address the soil impacts on the private property. The private property owner may decline to allow Beazer to remediate soils. Neither the lead environmental agency (in this instance the EPA) nor Beazer is able require a private property owner to allow access or require remediation to take place if the property owner decides not to do so.

Conclusions

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) process has been implemented to identify and evaluate viable and appropriate remedial alternatives for mitigating potential risk and hazard from chemicals in the environment. The culmination of environmental investigations, field sampling events, analytical data collection and remedy evaluations for this Site is the evaluation of potential remedial alternatives that can be applied to protect human health and the environment and to meet all applicable and appropriate regulations. This evaluation will form the basis for final selection of remedial actions for the Site.

The Next Steps in the Process

The detailed analysis presented in this FS evaluates individual remedies against the first seven of nine CERCLA evaluation criteria listed in the National Contingency Plan (NCP). Generally, EPA conducts the detailed analysis with respect to the final two criteria, State acceptance and Community acceptance, after release of the Final FS and the remedy selection.

EPA will use the analyses in this FS to select and propose a comprehensive Site remedy, called the Proposed Plan. The Proposed Plan will include remedial actions to address: (a) on-Site media (soil and groundwater within the Surficial Aquifer and HG) ("OnR" alternatives), (b) UFA groundwater ("UFA" alternatives), and (c) off-Site surface soil ("OfR" alternatives). Thus, the Proposed Plan will consist of one "OnR" alternative, one "UFA" alternative, and one "OfR" alternative. EPA may modify or combine the alternatives evaluated in this FS in developing the Proposed Plan.

The Proposed Plan document describing the set of three selected remedial alternatives to be implemented will be presented to the public for review and comment. The document will briefly summarize the remedial alternatives evaluated in the FS and will highlight the factors and rationale used to select the preferred set of three alternatives. The information and rationale that led to recommending these three remedial alternatives, along with risk manager decisions and information, will be included in the Proposed Plan document so that the public is informed about the process of arriving at a remedial plan for this Site.

Human health risk assessments for on-Site soils and off-Site soils are being reviewed at this time. Review of those analyses and the results of ongoing delineation activities (e.g. off-Site soil, UFA groundwater) may affect the selection of remedial alternatives and the details of remedy design.

After public comment and final comments from supporting agencies on the Proposed Plan, EPA will document the remedy selection decision in the Site ROD. The original ROD created in 1990 was based on a previous FS and on information available at that time. The remedy selection based on this FS will be documented in an amendment to the existing ROD.

Once the ROD is approved and signed, the conceptual designs for the set of three selected remedies will be converted into more detailed, construction-ready designs and plans. The components of the remedies will be evaluated for best method of implementation, and specific equipment types and sizes will be identified. Once these design documents are completed, reviewed and approved, subcontractor and vendor procurement can proceed. During construction/implementation of the selected remedies, institutional controls and other administrative support requirements will be obtained. Operation and maintenance of applicable components of the remedies (e.g., groundwater extraction and treatment) will commence and proceed until completion of the remedy.

Also, after delineation and ROD approval, affected off-Site property owners will be contacted by the Potentially Responsible Party (PRP) (Beazer East, Inc.) and/or by EPA regarding the need for remediation. All parties will work together to identify an appropriate remedial action that is both protective and acceptable to the property owner. The owner of property will have the right to deny access for sampling and/or remediation.

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Appendices

Acronyms and Abbreviations

ACEPD	Alachua County Environmental Protection Department
ACL	alternative concentration limits
Adventus	Adventus Americas
AMEC	AMEC Earth & Environmental
ARAR	Applicable or Relevant and Appropriate Requirement
AOC	area of contamination
BAP-TEQ	benzo(a)pyrene toxic equivalents
Beazer	Beazer East, Inc.
bgs	below ground surface
Black & Veatch	Black & Veatch Special Projects Corp.
BTEX	benzene, toluene, ethyl benzene, and xylenes
CAMU	corrective action management unit
CCA	chromated copper arsenate
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
ChemOx	chemical oxidation
COC	constituent of concern
cp	centipoises
CSM	conceptual Site model
CTL	cleanup target level
CUP	consumptive use permit
dioxins	polychlorinated dibenzo-p-dioxins
DNAPL	dense non-aqueous phase liquid
dynes/cm	dynes per centimeter
EPA	U.S. Environmental Protection Agency
ERH	electrical resistance heating
ESE	Environmental Science and Engineering, Inc.
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FS	feasibility study
FTS	Field and Technical Services

Acronyms and Abbreviations (continued)

furans	polychlorinated dibenzo furans
GAC	granular activated carbon
GCTL	groundwater cleanup target level
GeoTrans	GeoTrans, Inc.
gpm	gallons per minute
g/cm^3	grams per cubic centimeter
GRA	General Response Action
GRU	Gainesville Regional Utilities
HG	Hawthorn Group
HHRA	human health risk assessment
IRM	interim remedial measure
ISBS	in-situ biogeochemical stabilization
ISS/S	in-situ solidification/stabilization
ISTD	in-situ thermal desorption
KCI	Koppers Company, Inc.
Key	Key Environmental
K_{oc}	organic carbon coefficients
KII	Koppers Industries, Inc.
Koppers	Koppers, Inc.
LANL	Los Alamos National Laboratory
LDR	land disposal restriction
L/kg	liters per kilogram
MCL	maximum contaminant level
MCLG	maximum contaminant level goals
µg/kg	microgram per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mgd	millions of gallons per day
MNA	monitored natural attenuation
NADC	Natural Attenuation Default Concentration
NAVFAC	Naval Facilities Engineering Command
NCP	National Contingency Plan
ncPAH	non-carcinogenic polycyclic aromatic hydrocarbon

Acronyms and Abbreviations (continued)

NEPA	National Environmental Policy Act
NFA	No Further Action
NPL	National Priorities List
NPV	net present value
O&M	operation and maintenance
OfR	Off-Site Surface Soil Remedy
OM&M	operation, maintenance, and monitoring
OnR	On-Site Media Remedy
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
penta	pentachlorophenol
pcPAH	potentially carcinogenic PAH
PPOC	permanent point of compliance
POC	point of compliance
POTW	publicly owned treatment works
PP	Proposed Plan
PRG	Preliminary Remediation Goals
PRP	Potentially Responsible Party
RAO	remedial action objectives
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
RMO	risk management options
ROD	Record of Decision
RTPO	remedial technology and process option
RSL	Risk Screening Levels
SCTL	soil cleanup target level
SJRWMD	St. Johns River Water Management District
S/S	Solidification/stabilization
SVE	soil vapor extraction
TBC	to be considered
TCDD-TEQ	2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalent

Acronyms and Abbreviations (continued)

T/M/V	toxicity, mobility, or volume
TPOC	temporary point of compliance
TRC	TRC Environmental Solutions, Inc.
TSDF	treatment, storage, and disposal facility
UAO	Unilateral Administrative Order
UFA	Upper Floridan Aquifer
UFA-[number]	Upper Floridan Aquifer Remedy
UIC	underground injection control
USACE	U.S. Army Corps of Engineers
USC	United States Code

1.0 Introduction

This Feasibility Study (FS) develops and evaluates comprehensive remedial action alternatives for the Koppers portion of the Cabot Carbon/Koppers Superfund Site (U.S. Environmental Protection Agency [EPA] Identification Number FLD980709356) in Gainesville, Alachua County, Florida. Black & Veatch Special Projects Corp. (Black & Veatch) coordinated completion of this FS for EPA Region 4 under Contract Number EP-S4-09-02, EPA Work Assignment Number 025-RICO-0416. This report fulfills the requirements of Task 12 of the approved EPA project work plan for the Site dated March 18, 2010 (Black & Veatch, 2010). Note that in this document, the word “Site” refers to the Koppers portion of the Cabot Carbon/Koppers Superfund Site, unless otherwise specified.

This document was prepared in accordance with Federal and State of Florida regulations, and was a collaborative effort by numerous stakeholders, technical experts, and environmental contractors. The FS was prepared to facilitate selection of a final remedial strategy for the Site. This report supersedes prior FS reports prepared for the Site (TRC Environmental Solutions, Inc. [TRC], 1999; TRC, 1997a; Environmental Science and Engineering, Inc. [ESE], 1990); it addresses conditions that have been documented since the previous FS efforts. Also, it incorporates information from recent Site-specific analyses of candidate remedial actions (e.g., TRC, 2005; Haley & Aldrich, 2006; Sale, 2006; Adventus Americus [Adventus], 2008a, 2008b, 2009a, 2009b).

1.1 Feasibility Study Objectives

This section presents the purpose and need for the FS within the broader environmental regulatory context, the scope of the specific environmental problem to be addressed by the FS, and the overall remedial strategy developed for this Site. It describes how the results will be used to arrive at a Site-specific remedial action plan. Lastly, it discusses the report's organization and the content of each chapter.

1.1.1 The Role of the Feasibility Study

The National Oil and Hazardous Substances Pollution Contingency Plan (commonly referred to as the National Contingency Plan, or NCP), 40 Code of Federal Regulations (CFR) Part 300, contains the EPA regulations for implementing the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 United States

Code (USC) § 9601(24). Section 300.430 of the NCP, in conjunction with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final (EPA, 1988a) (referred to hereafter as the Remedial Investigation/Feasibility Study [RI/FS] Guidance), identifies the development and evaluation process for remedial alternatives. This process consists of the following steps:

- Perform an RI to collect data necessary to characterize the Site, including potential risks to human health and the environment presented by hazardous substances, for the purpose of developing and evaluating effective remedial alternatives (40 CFR § 300.430(d));
- Establish remedial action objectives (RAOs) specifying constituents and media of concern, potential exposure pathways, and remedial goals. Remediation goals establish acceptable exposure levels that are protective of human health and the environment (40 CFR § 300.430(e)(2));
- Identify and evaluate potentially suitable remedial technologies (40 CFR § 300.430(e)(2)(ii));
- Assemble suitable technologies into alternative remedial actions (40 CFR §300.430(e)(2)(iii));
- Develop and screen potential remedial alternatives based on long-term and short-term effectiveness, implementability, and cost (40 CFR § 300.430(e)(7)); and
- Conduct a detailed analysis of a limited number of alternatives that represent viable approaches to remedial action after evaluation in the screening stage.

The detailed analysis in this FS consists of an assessment of individual remedies against the first seven of the nine CERCLA evaluation criteria listed in the NCP, and a comparative analysis that focuses on the relative performance of each remedy against those criteria (40 CFR § 300.430(e)(9)). Generally, EPA conducts the detailed analysis with respect to the final two criteria, (1) State acceptance and (2) Community acceptance, after release of the Final FS and the remedy selection.

The FS provides the basis for selection of the preferred alternative (not presented in this FS) which may be modified or amended (if necessary) by other risk management decisions. The preferred alternative is presented to the public (for review and comment) via the Proposed Plan document. The Proposed Plan briefly summarizes the alternatives evaluated in the FS and highlights the factors and rationale used to select the preferred alternative. The EPA documents the remedy selection decision in the Site Record of Decision (ROD) after receiving public comments and any final comments from supporting agencies. The original ROD created in 1990 was based on a previous FS and on information available at that time. The remedy selection based on this FS will be documented in an amendment to the existing ROD.

1.1.2 Site-Specific Scope and Strategy

Information and data obtained while the Site's 1990 ROD was being implemented suggested that the extent of constituent impacts had been underestimated and that a revised remedial strategy was needed. One important objective of this FS is to develop and evaluate feasible remedies for the various media and hydrogeologic units associated with this Site comprehensively (i.e., Site-wide). Three major environmental media units are defined for the Site: (1) on-Site media (excluding Upper Floridan Aquifer [UFA] groundwater), (2) UFA groundwater, and (3) off-Site surface soil. Each of these media units are assessed separately, and the final selected remedial plan will consist of a set of three viable alternatives, one for each of the media units. The Site-wide, multi-technology/multi-media remedial strategy will ensure that appropriate and comprehensive remedial actions address all impacted media and hydrogeologic units. Furthermore, remedies for each of the three media units were evaluated and selected so as to provide maximum integration and synergistic interaction.

Another important objective of this FS is to identify technologies, or to develop implementation strategies, that do not cause additional harm to the environment or create additional constituent migration pathways. Any selected remedial strategy needs to minimize impacts to downgradient media caused by Site-wide remedial actions. The selected remedial strategy may require coordination with the adjacent Cabot Carbon site, given the proximity and partially shared environmental history of these two sites.

Documenting the remedial alternative selection process through the FS document meets a third objective: to provide stakeholders with a mechanism for providing input into the remedial alternative selection process. Based on prior stakeholder input to this FS, the report has been revised. Further stakeholder comment will be considered in developing the Proposed Plan document. The level of detail used to describe and evaluate the remedial alternatives presented in this FS is adequate for supporting the alternative selection process, but does not replace the detailed remedial design phase which will be necessary to implement the remedy selected in the ROD. Both remedial design and remedial action are post-ROD activities.

1.1.3 Feasibility Study Report Organization

CERCLA regulations (40 CFR § 300.430) and the RI/FS Guidance identify the elements of a FS report. This FS report is organized into six sections:

- Section 1 provides introductory material, background Site information based on the remedial investigations and other available data, and the conceptual Site model;
- Section 2 describes the process used to identify and screen technologies on the basis of: Site information, applicable or relevant and appropriate requirements (ARARs), RAOs, and general response actions;
- Section 3 assembles applicable technologies into remedial alternatives for each of the three defined environmental media units;
- Section 4 presents a detailed analysis of remedies using federal (NCP) criteria established to evaluate remedial alternatives during the CERCLA process;
- Section 5 presents the findings and conclusions of this FS evaluation process; and
- Section 6 presents references.

1.2 Site Background

A large amount of information about this Site has been collected through numerous RIs that began in 1983 and have continued to the present (e.g., Koppers Company, Inc. [KCI], 1985; IT Corporation, 1987; Hunter/ESE, 1989; McLaren/Hart, 1993; TRC Environmental Solutions, 2002 and 2003; AMEC Earth & Environmental [AMEC], 2007; and GeoTrans, Inc. [GeoTrans], 2004a, 2004b, 2006a, 2006b, 2007a, 2007b, and 2007c). A more complete listing of this body of work is presented in Appendix A. This section summarizes the information represented by the documents listed in Appendix A. It covers the Site's background, history, and constituents of concern.

1.2.1 Site Description

The Site was operated as a wood-treating facility for more than 90 years by various owners/operators. The Site covers approximately 90 acres in a commercial and residential area of the northern part of Gainesville, Florida (Figures 1-1 and 1-2). The areas adjacent to the Site to the east and south are now commercial properties. This includes the former Cabot Carbon industrial property to the east and a formerly undeveloped area to the northeast. The areas to the west and north are single-family and multi-family residences. A Gainesville Public Works facility and small businesses also are located to the northeast of the Site.

The Murphree Well Field is located approximately 2.5 miles northeast of the Site (Figure 1-1). This 26 million-gallon-per-day (mgd) well field is operated by the Gainesville Regional Utilities (GRU) and provides public water supply for the City of Gainesville and other areas in Alachua County. The Murphree Well Field withdraws water from the UFA, which is a regional, confined, limestone/dolomite aquifer. Under the Site, the UFA is overlain by the Hawthorn Group (HG) and by the Surficial Aquifer. For the purpose of this report, the two transmissive zones in the UFA have been designated the upper and lower transmissive zones of the UFA, and the two moderately transmissive zones in the HG have been designated the Upper Hawthorn and the Lower Hawthorn. Additional details on Site geology and hydrogeology are provided in Sections 1.3.2 and 1.3.3, respectively.

1.2.2 Site Operations

The American Lumber and Treatment Company began treating wood with creosote at the Site in 1916. KCI purchased the plant operations in 1954 while leasing the property from the Seaboard Coastline Railroad; KCI bought the property in 1984. As a result of a corporate transaction in 1988, KCI's name was changed to Beazer Materials and Services, Inc. Beazer Materials and Services sold the wood-treating portions of the former Koppers business, as well as the Koppers name, to a group of former Koppers Company managers who established the company Koppers Industries, Inc. (KII). KII began operating the business, including the Gainesville facility, on January 1, 1989. In 1990, the name Beazer Materials and Services, Inc. was changed to Beazer East, Inc. (Beazer). In January 2003, KII changed the name of their company to Koppers, Inc. (Koppers). Koppers ceased wood treatment operations at the Site in late 2009 and Beazer purchased the property from Koppers, effective March 31, 2010, in order to facilitate remediation.

Wood treating processes at the Site began with a creosote impregnation process in 1916. The treatment processes were modified over the years to include two additional processes: one using chromated copper arsenate (CCA), beginning in the 1960s, and another using pentachlorophenol (penta), beginning in 1969. The use of creosote decreased in the 1970s; its use was completely phased out at the Site by 1992. Penta use was discontinued by 1990. Koppers used only CCA to treat wood at the Site from 1990 through 2009.

Former wood-treatment facilities are located within the southeastern portion of the Site (Figure 1-2). This includes a recently-active process building and adjacent drip tracks where CCA was used to preserve wood. The central and northern portions of the Site were recently used for wood storage, staging, and debarking. The Site is serviced by railroad sidings that enter the facility's property at the northeast corner. A rail spur of CSX Railroad is located along the eastern boundary of the Site.

The Former North Lagoon and Former South Lagoon (Figure 1-2) were used to manage process wastewater. Based on historical aerial photographs, the Former North Lagoon was active from approximately 1956 until the 1970s, and the Former South Lagoon was active from 1943 or earlier through 1975 or 1976. Both former lagoons have been closed, covered and graded. The CCA wood-treating process used most recently at the Site did not generate wastewater.

1.2.3 Environmental Investigations

The Cabot Carbon/Koppers site was proposed for the National Priorities List (NPL) in September 1983 and listed as final on the NPL in September 1984. Hydrogeologic investigations began in 1983. A comprehensive list of documents and reports produced for this Site is presented in Appendix A. Some of the more notable investigations conducted at the Site include:

- Hydrogeologic investigation (KCI, 1985);
- Initial and supplemental RIs (IT Corporation, 1987; Hunter/ESE, 1989);
- Site characterization for soil and groundwater remedies (McLaren Hart, 1993);
- Field investigations of the HG and UFA (TRC, 2002 and 2003; GeoTrans, 2006a, 2007b, 2008a, 2008b, 2009b, and 2009c);
- Source delineation study for former source areas (GeoTrans, 2004b);
- Data summary report for soil and sediment (AMEC, 2007 and 2010a); and
- Surficial Aquifer well redevelopment and sampling (GeoTrans, 2007c).

Site soil and groundwater have been sampled to characterize organic and inorganic impacts. Over 350 soil borings and 1,000 soil samples have been collected and analyzed across the Site since 1984. Groundwater monitoring has been routinely performed since 1984. Over 150 wells have been installed at the Site in the three main hydrogeologic units (Surficial Aquifer, HG, and UFA). Most of the UFA wells are multi-port wells with three or four ports for improved vertical delineation. Groundwater monitoring in the Surficial Aquifer has been reported to EPA in accordance with the Stage 2 Monitoring Program (TRC, 1997b). Additional Surficial Aquifer groundwater monitoring was conducted in August 2007 (GeoTrans, 2007c), and from 2009 to 2010. Recent sampling of the Surficial Aquifer has been conducted in accordance with the proposed comprehensive groundwater monitoring plan (FTS and GeoTrans, 2009).

Upper Hawthorn and Lower Hawthorn monitoring wells have been installed in multiple phases since 2003 (TRC, 2003; GeoTrans, 2004b, 2008a, 2008b, and 2009c). These wells were sampled immediately after installation and periodically since installation. Sampling for the majority of HG wells has been conducted from 2007 to 2010. Recent sampling of Upper Hawthorn and Lower Hawthorn wells has been conducted in accordance with the proposed comprehensive groundwater monitoring plan (FTS and GeoTrans, 2009).

The UFA monitoring wells have been installed in several phases (GeoTrans, 2006a and 2009e). Quarterly groundwater sampling results for the UFA have been reported to EPA in accordance with the UFA Monitoring Plan (TRC, 2004a) and, more recently, in accordance with the proposed comprehensive groundwater monitoring plan (FTS and GeoTrans, 2009).

Potential impacts to off-Site media have been investigated by TRC (TRC, 2004b) and Alachua County (Mousa, 2006; Alachua County Environmental Protection Department [ACEPD], 2006 and 2009). An off-Site soil investigation is currently being conducted by AMEC (2008, 2009a, 2009b, and 2010b).

1.2.4 Previous Remedial Actions

A FS for the Cabot Carbon/Koppers site was prepared in 1989 on behalf of the EPA (ESE, 1990). A remediation plan was selected and a ROD for the Cabot Carbon/Koppers site was signed on September 27, 1990 (EPA, 1990). For the Koppers property, the ROD specified: (1) excavation of soils in the Former North Lagoon and Former South Lagoon to an assumed depth of 4 feet; (2) bioremediation of soils in the Former Process area and Former Drip Track Area by recirculating groundwater with nutrient amendment; (3) installation of a groundwater extraction system in the Surficial Aquifer; and (4) long-term institutional controls on Site use. At the time the ROD was prepared and signed, it was assumed that, based upon then-current information: (1) the HG was a single clay unit that provided an effective hydrologic boundary for groundwater flow and transport and (2) the potential source zones were primarily in the shallow unsaturated zone with groundwater impacts primarily restricted to the Surficial Aquifer.

In March 1991, the EPA issued a Unilateral Administrative Order (UAO) directing development of a remedial design for the Site. A subsequent pre-design investigation revealed Site conditions that were not contemplated by the ROD or UAO. Specifically, groundwater impacts below the water table were greater than expected and the amount of dense non-aqueous phase liquid (DNAPL) below the water table was greater than expected. These discoveries called into question the effectiveness and practicality of the ROD-specified removal actions. A Surficial Aquifer groundwater extraction system was installed, and the system operation began in 1995. Fourteen groundwater extraction wells were installed in the Surficial Aquifer along the northern and eastern Site boundaries (Figure 1-2). The interim remedial measure (IRM) groundwater extraction system was designed to prevent off-Site migration of constituents of concern (COC) in shallow groundwater (McLaren/Hart, 1994).

The UAO was amended in April 1994, based on post-ROD Site data and concerns regarding the technical practicability of the ROD remedy. This amendment required additional Site characterization and development of a supplemental FS that included remedial alternatives appropriate for the expanded extent of Site impacts. Subsequently, studies were conducted to identify a revised remediation strategy based on the then-current understanding of the Site.

A *Supplemental Feasibility Study* (TRC, 1997b) was prepared for the Site in 1997 based on the available information and prevailing understanding of flow and transport mechanisms. A *Revised Supplemental Feasibility Study* (TRC, 1999) was later issued to address comments from both EPA and Florida Department of Environmental Protection

(FDEP) requesting expanded information regarding the Site's background and history, consideration of additional remedies (particularly remedies involving soil treatment), more detailed evaluation sections, and more details for specific remedies. The Revised Supplemental Feasibility Study recognized that potential impacts from source areas were deeper than contemplated by the ROD; however, the potential impacts within and below the HG were assumed to be negligible at that time.

Recent investigations (TRC, 2003; GeoTrans, 2004b and 2006a) have indicated that (1) DNAPL is present in the HG and (2) Site constituents are present in groundwater in the UFA. Ongoing and planned investigations and monitoring are being used to better characterize potential impacts in the Surficial Aquifer, HG, and UFA.

During the post-ROD time period, as investigations have improved the conceptual understanding of the Site, pilot/interim remedial actions and focused studies have been conducted to assist with the selection and evaluation of a final comprehensive remedial strategy for the Site. These activities have included:

1. Pilot testing active DNAPL recovery in the Surficial Aquifer at PW-1 in 1994 and 2004;
2. Studying vertical groundwater circulation at the Former North Lagoon in 1995;
3. Recovering DNAPL passively by periodic bailing in HG monitoring wells on-going since 2004;
4. Evaluating soil excavation feasibility (TRC, 2005);
5. Evaluating in-situ thermal treatment feasibility (Haley & Aldrich, 2006);
6. Evaluating surfactant flushing feasibility (Sale, 2006);
7. Pilot testing active DNAPL recovery in the HG beneath the Former North Lagoon (Key Environmental [Key] and GeoTrans, 2007; Key, 2009);
8. Bench testing and pilot field testing in-situ biogeochemical stabilization (ISBS) of DNAPL using modified permanganate solutions (Adventus, 2008a, 2008b, 2009a, and 2009b);
9. Modifying the Surficial Aquifer IRM to include additional groundwater withdrawal via horizontal collection drains near the base of the Surficial Aquifer in the four primary source areas (GeoTrans, 2009d;);

10. Bench testing and pilot field testing of in-situ solidification/stabilization (ISS/S) using different mixes of cement-based stabilizers (GeoTrans, 2009d); and
11. Pumping of UFA wells to contain constituent concentrations (GeoTrans, 2008c;).

Two five-year reviews for the Site were conducted on behalf of EPA and finalized in 2001 and 2006. The second five-year review report (U.S. Army Corps of Engineers [USACE], 2006) recommended additional studies to support the selection of a new remedial strategy to address the full extent of impacts. Such studies have been undertaken or proposed based on the specific recommendations of the five-year review.

1.2.5 Constituents of Concern

COCs identified for soil and groundwater in the 1990 ROD include phenols (such as penta), polycyclic aromatic hydrocarbons (PAH), arsenic, and chromium. Creosote, which consists mainly of PAHs, is the predominant chemical material historically used for wood treatment at the Site. The EPA and FDEP also required sampling and testing for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo furans (dioxins/furans) in soils. Based on the results of this sampling, dioxins/furans also have been identified as COCs. Relatively low benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations also have been observed in soils and groundwater under the four identified source areas.

1.3 Conceptual Site Model

This section presents a unified description of current Site conditions and an understanding of how Site-related constituents move in the environment and could possibly reach potential environmental receptors. The summary of this information and understanding is called the conceptual Site model (CSM). The CSM provides a concise summary of all pertinent Site knowledge such that key features and their interrelationships can be understood succinctly and in context. A CSM is required in order to identify an effective remedial alternative.

The basis for this CSM is the information collected through environmental investigation and analysis for the past 26 years. Over this time, tens of millions of dollars have been spent to gather and analyze data in order to build a sound scientific understanding of this very complex Site. All of these efforts involved collaborative planning and interpretation between Beazer, the community, and the local, state, and federal agencies. Through this process, the understanding of Site environmental conditions and processes has improved dramatically; however, uncertainty remains regarding the distribution of constituents and DNAPL mobility (Jones Edmunds and Associates, Inc., 2006; GRU, 2008).

Figure 1-3 is a conceptual block diagram that summarizes some important aspects of the CSM, especially as related to constituents in the subsurface and their potential migration. Details of the CSM are presented in the following subsections.

1.3.1 Climate, Topography, and Hydrography

The Site climate is humid subtropical. Average monthly high temperatures range from 66º Fahrenheit in January to 91º Fahrenheit in July. Average monthly low temperatures range from 42º Fahrenheit in January to 71º Fahrenheit in July. Frost and freezing temperatures typically occur several times a year. Mean annual rainfall is approximately 50 inches, with approximately half of that total attributable to intense thunderstorms during the months of June through September.

The Site terrain slopes gently downward toward the north-northeast. Elevations range from approximately 165 to 185 feet above mean sea level (Figure 1-4). There is a low, swampy area east-northeast of the Site. A drainage ditch bisects the Site from south to north, carrying surface run-off toward Springstead Creek located approximately 750 feet to the north (Figure 1-1). Springstead Creek flows westward into Hogtown Creek which flows southward to Haile Sink – a groundwater aquifer recharge source.

1.3.2 Geology

The conceptual block diagram in Figure 1-3 depicts the Site geology. In summary, the main geologic units at the Site, from top-to-bottom, are (1) sandy surficial marine-terrace deposits, (2) clayey HG deposits, (3) the Ocala Limestone, and (4) dolomitized limestone of the Avon Park Formation.

The uppermost geologic unit is a 20- to 30-foot thick unit of Plio-Pleistocene marine terrace deposits consisting primarily of fine- to medium-grained sand with trace amounts of silt and clay.

These surficial marine terrace deposits are underlain by the Miocene age HG deposits, which are approximately 115 to 125 feet thick. The HG is comprised of interbedded and intermixed clays, silty-clayey sand, sandy clay, and occasional carbonate beds.

Three predominant clay units separated by two clayey-sand units have been identified in the HG deposits under the Site. The upper portion of the HG deposits consists of a green-gray clay unit that is undulating and dips generally toward the northeast. This upper clay unit ranges from 0.5 to 7 feet in thickness. Below this clay is a clayey-sand deposit (34 to 42 feet thick), which is underlain by a second clay unit (2 to 15 feet thick). Below this middle clay unit is another clayey-sand deposit (10 to 35 feet thick), which is underlain by a lower clay unit (20 to 38 feet thick). This lower clay unit consists of two to three discernable clay sub-layers (each 1 to 9 feet thick) separated by thin seams of clayey sand and sandy clay.

Below the HG are Eocene age dolomitized limestone formations (Ocala Limestone and Avon Park Formation) that are approximately 470 feet in total thickness. In west-central Florida, two distinct dolomite end-members are recognized in the Ocala Formation: (1) a vertically restricted, poorly cemented, friable sucrosic dolomite with high porosity and permeability and (2) a tightly cemented, indurated dolomite with low porosity and permeability (Gaswirth, 2003; Johnson, 1984). Johnson (1984), who has examined logs from throughout Florida, further indicates that the friable portions can be very soft. Poorly to moderately indurated, friable packstone and grainstone units are observed in other portions of the Upper Floridan Aquifer in South Florida (Bennett and Rectenwald, 2003), including the upper boundary of the Ocala Formation (Bennett and Rectenwald, 2002a). Although referring to other portions of the Floridan Aquifer, Bennett and Rectenwald (2002b) indicate that these friable zones can appear as washouts on a caliper log. Friable, sandy zones within the Ocala Formation are found as far north as Georgia (Stewart et al., 1999), including sandy, clayey, friable, chalky weathered limestone at the top of the Ocala Formation (Warner, 1997).

In the Albany, Georgia area, Warner (1997) subdivides the Upper Floridan Aquifer into an upper water-bearing zone and a much higher permeability lower water-bearing zone. The upper water-bearing zone consists of friable, weathered limestone and the lower water-bearing zone consists of harder, fractured limestone. This description of the Ocala Formation is consistent with what is observed at the Site; that is, in the upper portion of the Upper Floridan Aquifer at the Site, the core demonstrates a soft, poorly-cemented consistency. This material at the top of the Ocala Formation likely behaves more like a porous media than like a fractured media. Deeper portions of the Ocala Formation and the Avon Park Formation can be expected to behave as fractured media.

1.3.3 Hydrogeology

The three principal hydrostratigraphic units at the Site coincide with the major geologic units. As shown in Figure 1-3, the main hydrogeologic units are:

- the Surficial Aquifer;
- the HG deposits; and
- the UFA.

The UFA is used regionally for water supply, including at the Murphree Well Field (Figure 1-1). The HG is an effective low-permeability confining unit for the UFA with yields that are generally too low (less than 1 gallon per minute [gpm]) to be viable for water supply. The Surficial Aquifer is generally not used for water supply due to: (1) low yield (less than 4 gpm); (2) better water source options in the Floridan Aquifer; and (3) potential water quality impacts from anthropogenic activities (e.g. sewers, underground storage tanks, dry-cleaning operations, agricultural land uses and industrial land uses).

The three principal hydrostratigraphic units are subdivided into ten distinct hydrogeologic layers (see labels [1] through [10] in Figure 1-3). These are discussed in more detail in the following sections.

1.3.3.1 Transmissive Zones. Layers depicted in Figure 1-3 as yellow and light blue regions have the highest capacities to transmit water: Surficial Aquifer [1], Upper Transmissive Unit of the UFA [7], and Lower Transmissive Unit of the UFA [9]. In these units the principle direction of groundwater flow is horizontal to the north-northeast (Figures 1-5 and 1-8). Given the predominant horizontal flow, these units create the potential for off-Site migration of Site constituents. At the Murphree Well Field, production of groundwater comes primarily (approximately 85%) from the Lower Transmissive Unit of the UFA [9] (GeoTrans, 2004b). Importantly, pumping in the UFA has lowered water levels beneath the Site to near the bottom of the lower clay of the HG [6]. This has created large vertical gradients through the impacted media beneath the Site. Water levels in key layers are identified by triangles on the right side of Figure 1-3 (see [A] through [D]). The water table is in the Surficial Aquifer and varies spatially and temporally from approximately 5 to 15 feet below ground surface (bgs) on Site.

1.3.3.2 Low-Conductivity Clays. In contrast, the three HG clay units depicted in Figure 1-3 as dark brown regions have very low capacities to transmit water. These are the upper clay unit [2], the middle clay unit [4], and the lower clay unit [6]. Strong empirical evidence for the limited capacities of these HG clay units to transmit water is provided by differences in water levels above and below each clay unit. In each unit the downward head loss across the layer approaches or exceeds the thicknesses of the layer (a hydraulic gradient of 1 or greater). In particular, there is an approximately 90-foot head drop across the 30-foot thick, hard plastic, lower clay unit. This HG lower clay unit is a very effective upper confining unit for the UFA. Given limited surface recharge, the large vertical gradients can only exist if the bulk conductivity of the clay units are very low.

1.3.3.3 Zones of Moderate Transmissivity. Lastly, four layers depicted in Figure 1-3 as light brown and medium blue regions have intermediate capacities to transmit water. These consist of the Upper Hawthorn [3], the Lower Hawthorn [5], and the semi-confining zones of the UFA [8] and [10]. Horizontal flow in these layers is constrained by moderate to low capacities to transmit water, and by preferred horizontal flow paths in adjacent layers with greater transmissivity. Vertical flow in the Upper and Lower Hawthorn is constrained by the low conductivity of the bounding clay layers. As shown in Figure 1-6, flow in the Upper Hawthorn under the Site is toward the north-northeast, as it is in the Surficial Aquifer. In the Lower Hawthorn, there is a lateral groundwater flow divide (Figure 1-7); lateral flow under the western and southern portions of the Site is to the west-northwest while lateral flow under the eastern portions of the Site is to the north-northeast.

1.3.4 Source Areas

The origin of constituents at the Site is linked directly to Site operations and historical waste management methods. Releases occurred when wood-treatment chemicals dripped onto the soil or were deposited in unlined lagoons. Site investigations (e.g., GeoTrans, 2004b), including collection of numerous soil borings, have identified four main constituent source areas related to former operations and facilities. These are labeled [a] through [d] in Figure 1-3, and are illustrated in Figure 1-2 and Figures 1-4 through 1-12.

Source areas defined in these figures are the areas in the Surficial Aquifer containing the greatest concentrations of constituents associated with creosote-based, arsenic-based and/or penta-based wood treatment materials. It should be noted that DNAPL impacts are documented outside these boundaries in the Surficial Aquifer and in the HG at some source areas.

The vertical distribution of source area constituents is not known definitively. Analytical data for source area soil borings indicate that DNAPL has migrated down into the Lower Hawthorn, but the extent to which this has occurred (i.e., how homogenous the vertical DNAPL migration patterns are) is uncertain and difficult to determine and is the subject of considerable debate. Over an area of several acres, there are clear indications of residual and/or mobile DNAPL in the Surficial Aquifer, the Upper Hawthorn, and the Lower Hawthorn; however, the extent of DNAPL in the Upper Hawthorn and Lower Hawthorn is not completely defined. GRU cites what they believe is evidence of potentially mobile DNAPL in all aquifer units and clear evidence of mobile DNAPL in the Upper Hawthorn (GRU, 2008). EPA has stated that the remedial actions chosen as part of the proposed plan that will be undertaken will address DNAPL impacts, regardless of DNAPL location or source origination on the Koppers Site. As part of the remedial design process which follows remedy selection, additional characterization in these aquifers will be conducted to fully characterize and address uncertainties related to DNAPL migration and, more importantly, identify vertical and horizontal boundaries for effective future remedy implementation. The selected groundwater remedial option will most likely require active treatment and/or containment for each aquifer affected until such time as remedial cleanup levels are met.

Other, smaller isolated surface soil areas throughout the property show high concentrations of various constituents that are not associated with any particular process area on the property. These are minor locations of elevated constituent concentrations that are not identified as source areas but as locations of constituents that had either migrated from source areas (i.e., by surface runoff, soil dust deposition, or other surface transport mechanism) or are isolated residuals from historic wood treating operations.

1.3.5 Nature and Extent of Site Impacts

1.3.5.1 DNAPL Presence. Soil with visual and olfactory evidence of creosote residue (see [e] in Figure 1-3) was found beneath and adjacent to the historical release areas (locations [a] through [d] in Figure 1-3). Note that Source Area boundaries illustrated in Figure 1-3 are approximate limits in the Surficial Aquifer only. DNAPL has been observed outside these illustrated boundaries in the Surficial Aquifer and the HG. Estimates of the volumes of soil beneath release areas, and of DNAPL-impacted soils in the Surficial Aquifer, are provided in Table 1-1. These estimates are based on a detailed and comprehensive investigation of source areas (GeoTrans, 2004b) that involved: (1) electrical-resistivity surveying to scan for anomalies indicative of DNAPL presence; (2) direct-push borings (a total of 34) in the Surficial Aquifer with laser-fluorescence screening for creosote; (3) additional direct-push soil borings (a total of 50) in the Surficial Aquifer for soil sample collection, visual identification of creosote, and field screening for volatile organic compounds; and (4) drilling of twelve boreholes and installation of ten monitoring wells (nine in the HG and one in the UFA) to investigate vertical extent of DNAPL impacts in source areas. Based primarily on direct observations in soil cores, it is estimated that the four primary source areas cover a total of 5.4 acres and that approximately 100,000 cubic yards of DNAPL-impacted soil is present in the Surficial Aquifer within these source areas.

While Site data clearly show the presence of DNAPL in the Surficial Aquifer, the mobility of this DNAPL is uncertain. No measurable DNAPL was recovered in any of the Site Surficial Aquifer wells that were redeveloped and sampled in 2007 (GeoTrans, 2007c); however, it is not uncommon for monitoring wells installed in DNAPL source zones to produce DNAPL-free water. The active DNAPL recovery pilot test at Surficial Aquifer well PW-1 in the former process area was unsuccessful (RETEC, GeoTrans, and Key, 2005): the induced hydraulic gradient caused by 158 days of pumping led to only minor DNAPL recovery (0.03% DNAPL in withdrawn water; i.e., 90 gallons of DNAPL recovered from 335,000 gallons of groundwater extracted). Regardless of DNAPL mobility, a large portion of the historical DNAPL release is present in the Surficial Aquifer based on the results of the comprehensive source area evaluation (GeoTrans, 2004b).

Small volumes of DNAPL have been recovered from the Upper Hawthorn at the Former North Lagoon, Former Drip Track, and Former Process Area. At the Former South Lagoon, DNAPL appeared in an Upper Hawthorn well (HG-9S) immediately after development, but DNAPL has not been detected since. The presence of DNAPL in the Upper Hawthorn indicates that the HG upper clay unit is an imperfect barrier to DNAPL.

Table 1-1 provides an estimate of the soil volume in the Upper Hawthorn within the Surficial Aquifer source area footprints (an assumption which may not be accurate based on incomplete delineation of impacts as described in Section 1.3.4); portions of this volume have been impacted by DNAPL. At the base of the Upper Hawthorn, sparse local areas of mobile DNAPL are present as indicated by the presence of DNAPL in a few HG wells. This mobile DNAPL has been associated with thin (2- to 3-inch) seams of coarse-grained material just above the middle clay unit.

Efforts to produce mobile DNAPL from the suspected pools in thin course-grained layers at the base of the Upper Hawthorn via active pumping and passive bailing have largely been ineffective. This may be attributed to the limited capacity of the Upper Hawthorn to transmit fluids, the sparse nature of DNAPL zones, limited interconnections between DNAPL zones, and the viscosity difference between DNAPL and groundwater. Currently, DNAPL is being recovered passively from five of the six Upper Hawthorn monitoring wells in the source areas at a total rate of approximately 1.2 gallons of DNAPL per week. A recent pilot test of active DNAPL recovery near one of the five DNAPL-producing monitoring wells in the former North Lagoon area demonstrated that the volume of recoverable DNAPL is low. An 18-inch recovery well was pumped for long durations at various rates and recovered only a trace of DNAPL.

The Lower Hawthorn has similar characteristics to the Upper Hawthorn with the exception that DNAPL is even less common; however, borings and wells penetrating the Lower Hawthorn are fewer so there is less data upon which to make this conclusion. This conclusion is based on data obtained in a few borings and wells in the Lower Hawthorn that are paired with Upper Hawthorn wells. Pooling of DNAPL above the HG middle clay unit illustrates that the middle clay has been an important impediment to vertical migration of Site constituents. On the other hand, the presence of trace DNAPL in the Lower Hawthorn shows that the middle clay unit, like the upper clay unit, is an imperfect barrier. Table 1-1 provides a rough estimate of the soil volume in the Lower Hawthorn within the Surficial Aquifer source area footprints (an assumption which may not be accurate based on incomplete delineation of impacts as described in Section 1.3.4); portions of this volume have been impacted by DNAPL.

No recoverable DNAPL has been observed in the Lower Hawthorn; any DNAPL present there may or may not be at residual saturation and immobile under normal (non-pumped) conditions. The deepest observed penetration of DNAPL is associated with the Former North Lagoon, where DNAPL was found at residual saturation in the upper portion of the HG lower clay unit. Residual DNAPL also was observed in the Lower Hawthorn below the Former Drip Track.

No DNAPL has been observed in the Floridan Aquifer during investigation activities or during quarterly sampling of the 72 UFA monitoring well screens/ports on Site. Visual evidence of residual DNAPL has never been observed in over 4,000 feet of cumulative geologic core collected from the Floridan Aquifer. There is marked disagreement between some Site stakeholders and Beazer East related to potential DNAPL presence in the Floridan Aquifer. Beazer East believes that groundwater concentrations of creosote-related constituents in the Floridan Aquifer are well below concentrations typically used to support the hypothesis of DNAPL presence. Site stakeholders GRU and ACEPD point to some evidence of potential DNAPL in the Upper Floridan, including (1) the boring log for FW-12B indicates faint to strong creosote odors between 217 to 223.5 feet bgs, and (2) COC concentrations at several percent of the solubility limit in FW-6 and FW-21B suggest nearby DNAPL. EPA notes that the absence of observed DNAPL in the Floridan Aquifer does not preclude its existence there. Also, EPA has stated that DNAPL may exist at the site that is immobile under existing conditions, but can become mobilized if conditions change. Therefore, the eventual chosen remedial action for the Floridan Aquifer will take these uncertainties into account.

1.3.5.2 Soil COC Concentrations. On-Site surface and subsurface soil was sampled in 2006 to supplement prior characterization of COC concentrations (AMEC, 2007). Figure 1-9 presents the average concentrations in surface soil (0- to 6-inch) for arsenic, potentially carcinogenic PAHs (expressed as benzo(a)pyrene toxic equivalents [BAP-TEQ]), and dioxins/furans (expressed as 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalents [TCDD-TEQ]). These COCs drive the evaluation of human-health risk for direct soil exposure under current Site use (AMEC, 2009c). The color coding used in Figure 1-9 is based on the Florida default Soil Cleanup Target Levels (SCTL) for direct exposure at a commercial/industrial Site (concentrations shown in green are below the default commercial/industrial SCTL).

The highest arsenic concentrations were detected in the vicinity of the Former South Lagoon; two sample locations had average surface soil concentrations above 1,000 milligrams per kilogram (mg/kg) for arsenic. Elevated PAH concentrations, expressed as BAP-TEQ, were detected in surface soils at all four DNAPL source areas. Dioxins/furans were detected over a significant portion of the Site at levels above the Florida default commercial/industrial SCTL (0.03 micrograms per kilogram [µg/kg]). However, there was only one of 40 locations (SS058 in the former process area) where the TCDD-TEQ concentration was above the EPA default acceptable range for commercial/industrial soils (5 to 20 µg/kg; EPA, 1998).

Concentrations of penta in surface soil were below the Florida default SCTL for commercial/industrial direct exposure (28 mg/kg) over most of the Site. There were five exceptions: three sample locations in the former process area, one location at the former drip tracks, and one location at the former north lagoon.

A Site-boundary and off-Site soil sampling and analysis program is presently being conducted by AMEC (2008, 2009a, 2009b, and 2010b). Initial results from this program show that surface soil immediately adjacent to the western Site boundary had elevated concentrations of PAHs, arsenic, and/or dioxins/furans above Florida default SCTLs for residential direct exposure. In this area four of five sampled locations had dioxin/furan concentrations below the EPA residential preliminary remediation goal for dioxins/furans. Additionally, the average concentration of dioxins/furans was below the EPA residential preliminary remediation goal. This area has been posted to prevent exposure. For samples taken a distance of approximately 100 feet west of the Site, surface-soil concentrations were markedly lower (more than 10 times less than the EPA residential preliminary remediation goal for dioxins/furans), though still above the Florida default residential direct exposure SCTL for dioxins/furans. Further off-Site soil characterizations are under way to the north, south, east, and west of the Site and will continue after remedy selection through the remedial design phase of the project.

1.3.5.3 Surficial Aquifer Groundwater. The predominant PAH compound detected in groundwater is naphthalene, a non-carcinogenic two-ring compound with a relatively low molecular weight and relatively high aqueous solubility (compared to other PAH compounds) that is relatively mobile and degrades relatively easily in the environment. Naphthalene is used as the primary indicator compound that represents the presence of COCs in Site groundwater.

As part of the effectiveness monitoring for the existing groundwater extraction system, groundwater quality is monitored annually at the 14 extraction wells and five monitoring wells. The most recent annual sampling event occurred in December 2008 (Field and Technical Services [FTS], 2009a). A comprehensive round of Surficial Aquifer sampling was conducted in August 2007 to provide a more complete picture of water quality conditions in the Surficial Aquifer (GeoTrans, 2007c). Groundwater samples were analyzed for BTEX, PAHs, phenols, arsenic, and chromium.

Surficial Aquifer naphthalene concentrations measured in August 2007 and December 2008 are shown in Figure 1-10. Several of the wells near the source areas and near the eastern Site boundary have naphthalene concentrations greater than the Florida default groundwater cleanup target level (GCTL) of 14 micrograms per liter (µg/L). In all locations where both a water-table (A-series) well and a deeper Surficial Aquifer (B-series) well were sampled, the groundwater from the water-table well contained significantly lower naphthalene concentrations. Concentrations of other COCs (e.g., penta, arsenic, benzene, carbazole, dibenzofuran) also exceeded their default GCTLs and/or federal maximum contaminant levels (MCLs) in select wells (GeoTrans, 2007c; FTS, 2009a; FTS 2009c).

1.3.5.4 Hawthorn Group Groundwater. Groundwater quality measurements were collected from HG wells on several occasions since the first wells were installed in 2004. The most recent set of wells were installed off-Site to the east and west (GeoTrans, 2008a, 2008b, and 2009c). The most recent sampling event, conducted in November 2009, included sampling most HG wells. Figure 1-11 presents the naphthalene concentrations detected in the HG during the November 2009 event, along with some older data for wells that were sampled in prior years. Wells with a label ending in “D” are completed in the Lower Hawthorn, the others (most ending in “S”) are completed in the Upper Hawthorn. Note that water samples were not collected in November 2009 from the five Upper Hawthorn source-area wells where DNAPL is routinely recovered (HG-10S, HG-11S, HG-12S, HG-15S, and HG-16S), or from several on-Site Upper Hawthorn wells near the western property boundary where concentrations have historically been low to non-detect.

1.3.5.5 Upper Floridan Aquifer Groundwater. Water quality in the UFA beneath and downgradient of the Site is measured on a quarterly basis. The August and May

2009 naphthalene concentrations in the UFA (FTS, 2009b) are presented on Figure 1-12 (FW-9 and MWTP-MW1 are located outside of figure boundaries and were non-detect for naphthalene).

Monitoring wells FW-1 through FW-9 and MWTP-MW1 were completed within the top 30 feet of the UFA. Only one of these wells (FW-6, a source area monitoring well near the Former North Lagoon) currently has organic concentrations above GCTLs, and naphthalene concentrations at this well have decreased substantially since July 2004. There is evidence that cross contamination contributed to the elevated concentrations detected at this well (see Section 1.3.6.5).

Monitoring wells FW-10B through FW-24B are multi-port, quadruple-cased wells completed within the upper 100 feet of the UFA (i.e., the Upper Transmissive Zone). At two of the four source areas (Former Process Area and Former South Lagoon), inorganic and organic constituents are consistently below MCLs and Florida GCTLs in the UFA monitoring wells. Select organic constituents are above GCTLs in the UFA wells north of the Former North Lagoon and north-northeast of the Former Drip Track.

The four Lower Transmissive Zone wells at the northern property boundary (FW-4C, FW-22C, FW-23C, and FW-24C) have been non-detect for organic COCs since installation in 2007.

In some sampling events, arsenic concentrations above the Florida default GCTL (10 μg/L) were found in groundwater collected from a few of the UFA monitoring wells. These observed concentrations likely result from dissolution of naturally occurring minerals in the UFA that occurs when oxygenated water is introduced to the formation during well drilling (GeoTrans, 2007a; EPA, 2007).

1.3.6 Environmental Transport and Fate

Site-specific mechanisms and conditions have acted on constituents in ways that have caused the observed patterns of mobility, reactivity and extent. The following sections discuss mechanisms that have acted and may continue to act on Site constituents, and the general characteristics and behavior of creosote and Site-related constituents, including solubility, mobility, and ability to biodegrade.

1.3.6.1 Fate and Transport Properties of Site Constituents The following subsections describe the properties of the prevalent Site-related constituents that may affect how these constituents move in the environment.

1.3.6.1.1 PAHs. PAHs constitute a class of many semi-volatile organic compounds often associated with the highly viscous creosote preservatives used in wood-treating operations. PAHs are chemical formations of benzene polyring series that range from naphthalene, with two benzene rings, to benzo(g,h,i)perylene, with six benzene rings. Nineteen PAH compounds are analyzed using EPA Method 8270. Eight of these compounds are considered to be potentially carcinogenic (pcPAHs): benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)-anthracene, and indeno(1,2,3-cd)pyrene. It is common to use a toxic equivalency factor to express the total pcPAH concentration, excepting carbazole, in terms of BAP-TEQ.

Excepting carbazole, the pcPAHs have aqueous solubility in the range of less than 1 to 20 µg/L (Montgomery and Welkom, 1996). The pcPAHs have very low mobility as dissolved species in the subsurface due to their hydrophobic nature (low solubility and high organic carbon partition coefficients, [K_{oc}]). Compared to other PAHs, the pcPAHs (excepting carbazole) are more resistant to biodegradation in soil with reported half-lives in soil varying from 80 to 180 days (Cookson, 1995).

The non-carcinogenic PAHs (ncPAHs) and carbazole are less dense, more soluble in water, more mobile in soil/groundwater environments, and more easily biodegraded than the pcPAHs. The ncPAHs listed in the 1990 ROD included naphthalene, acenaphthene, acenaphthylene, anthracene, dibenzofuran, fluorene, phenanthrene, and pyrene.

All PAHs tend to degrade to nontoxic byproducts. Toxicity analyses of bioremediated groundwater, which initially contained PAHs and penta, indicate that the treated water is less toxic than the untreated groundwater (Middaugh et al., 1994). Therefore, the levels of degradation products present in groundwater after biodegradation occurs are less toxic than the parent compounds in the original impacted groundwater.

1.3.6.1.2 Arsenic. Arsenic is a naturally occurring element, generally found at higher concentrations in sedimentary rocks than in other rock types. Shales, clays, and sedimentary iron and manganese oxides can be rich in arsenic. The most common forms of arsenic in groundwater are their oxy-anions, arsenite (As^{+3}) and arsenate (As^{+5}). Under moderately reducing conditions, arsenite is the predominant species. In oxygenated water, arsenate is the predominant species. Arsenic cannot be destroyed in the environment; it can only change its form or become attached to or separated from particles. It may change its form by reacting with oxygen or other molecules present in air, water, or soil, or by the metabolic action of plants or animals.

In soil/groundwater systems, the mobility of arsenic is generally controlled either by co-precipitation or adsorption onto ferric oxides/hydroxides, with the arsenate species being more readily adsorbed, especially at neutral pH. In general, the arsenites tend to be more mobile than arsenates. An increase in the pH to an alkaline condition will cause both arsenite and arsenate to desorb. Accordingly, arsenic can be expected to be more mobile in an alkaline environment. The arsenic oxy-anion speciation is also sensitive to oxidation/reduction conditions (Henkel and Polette, 1999).

1.3.6.1.3 Pentachlorophenol. Penta is a member of the phenolic group of compounds, and is a polar organic compound used as a preservative in wood-treating operations. Penta is a solid at room temperature and is very soluble in water under high pH conditions. In acidic conditions, the solubility is lower (approximately 14,000 µg/L at pH 5.0). When dissolved in alkaline solutions, penta dissociates and forms the pentachlorophenate anion, with an increase in solubility beyond 100,000 µg/L (Davis et al., 1994).

Penta is biodegradable. Degradation products from the breakdown of penta include less-chlorinated phenols and less-chlorinated oxidized derivatives (Davis et al., 1994). The less-chlorinated phenol degradation products may include various isomers of tetrachlorophenol (e.g. 2,3,4,5-TeCP; 2,3,4,6-TeCP), trichlorophenol, dichlorophenol, and monochlorophenol. The oxidized derivatives may include chloroanisoles, chlorocatechols, and chlorohydroquinones (Davis et al., 1994; Suzuki, 1977).

Data from other wood-treating sites indicate that penta degradation products, when present, are detected at concentrations well below the concentration of the parent compound, and do not accumulate in soils or groundwater. This relationship indicates that the degradation products breakdown faster than penta. Laboratory studies are consistent with the observation that penta breakdown products are biodegraded faster than penta and, thus, do not accumulate in soils or groundwater (Middledorp, Briglia, and Salkinoja-Salonen, 1990).

Penta degradation products also are less toxic than the parent compound. As discussed above, toxicity analyses of impacted groundwater after bioremediation has occurred, which initially contained PAHs and penta, also indicate that the post-bioremediation groundwater is less toxic than the pre-bioremediation groundwater (Middaugh et al., 1994). Therefore, the levels of degradation products present in groundwater after bioremediation has occurred are less toxic than the parent compounds present in the original groundwater.

1.3.6.1.4 Dioxins/Furans. Dioxins/furans constitute a class of 210 structurally related chemical compounds, or congeners, that are often present in complex mixtures and have a variety of environmental sources (EPA, 1989). Dioxins/furans have been associated with wood-treating operations due to impurities in penta products. Dioxins/furans are considered insoluble in water with solubilities less than 1 µg/L and are considered immobile in soil due to extremely high K_{oc} values that exceed 10^6 liters per kilogram (L/kg) (Montgomery and Welkom, 1996).

Highly chlorinated dioxin/furan compounds are not susceptible to aerobic (oxidative) biotransformation because they are already highly oxidized. Due to their characteristically low aqueous solubility, dioxin/furan congeners in soil and aquifer sediment are scarcely available for biodegradation by bacteria. This low bioavailability is a primary constraint on their biodegradation. Laboratory studies have determined that the desorbed fraction of dioxin/furan congeners in sediment can be biodegraded under anaerobic conditions via reductive dechlorination (Adriaens, Fu, and Grbic-Galic, 1995). Reductive dechlorination of dioxin/furan presumably occurs preferentially under highly reducing conditions (e.g. methanogenesis), and requires the presence of another more easily degradable electron donor (e.g., natural organic carbon, or BTEX).

1.3.6.2 DNAPL Migration. Potential movement of creosote DNAPL (or DNAPL components) through the subsurface geology is one of the critical issues being addressed by this FS. The following sections describe the properties of DNAPL that are responsible (in part) for how DNAPL has potentially moved, and may potentially move in the future, through the environment at the Site.

1.3.6.2.1 Creosote DNAPL Properties. Creosote is a viscous mixture of hundreds of chemical compounds, mainly PAHs. Depending on how it is formulated, creosote has a specific gravity between 1.04 and 1.11, slightly denser than water. Relevant physical properties of creosote DNAPL recovered from Site wells are summarized below:

Sample Location	Density (g/cm^3) at 60°C	Viscosity (cp) Absolute at 40°C	Interfacial Tension (dynes/cm) at 22°C
Former Process Area			
PW-1 (Surficial Aquifer)	1.031	13.6	19.12
HG-11S (Upper Hawthorn)	1.069	4.9	17.80
HG-15S (Upper Hawthorn)	1.043	8.7	17.46
Former Drip Track			
HG-12S (Upper Hawthorn)	1.092	13.9	21.30
Former North Lagoon			
HG-10S (Upper Hawthorn)	1.094	11.2	20.25
HG-16S (Upper Hawthorn)	1.033	25.2	23.33
HG-16S (Upper Hawthorn)	1.099	25.5	Not analyzed

g/cm^3 – grams per cubic centimeter
cp – centipoise
dynes/cm – dynes per centimeter

The absolute viscosity for Site creosote ranges from approximately 5 to 25 centipoise (cp) at 40°C, with the value at HG-16S higher than the viscosity at other wells by a factor of 2 or higher. The groundwater temperature at the Site ranges from about 25 to 30°C (GeoTrans, 2004b). Groundwater temperature changing from 40°C to 30°C causes about a 45% increase in viscosity (Davis et al., 1997), or a range of about 7 to 36 cp for ambient groundwater temperatures. That is much greater than the viscosity of water (0.8 cp at 30°C).

The interfacial tension refers to the tensile force that exists in the interface separating two immiscible fluids (e.g., creosote and water). The interfacial tension for Site creosote ranges from approximately 17 to 23 dynes per centimeter (dynes/cm) at 22°C. Lower values of interfacial tension tend to decrease the spread of a DNAPL perpendicular to its primary migration direction and decrease the force needed for DNAPL to displace water, or vice versa, in saturated porous media.

Wettability testing was also performed with Site media. Measured contact angles of creosote on Surficial Aquifer sand below water were indicative of water-wet conditions. Creosote contact angles on HG clay and glass slides below water typically ranged from 35° to 40°, also indicative of water-wet conditions. Creosote wet the glass slide (contact angle ~170°) in the air-creosote system. Measured contact angles did not change with aging over 42 days, but rapid formation of a semi-rigid interfacial film on the creosote drops may have constrained creosote spreading over time. Qualitative bottle tests confirmed the contact-angle results. In these tests, Surficial Aquifer sand and commercial quartz sands were water-wet in all cases, including a test where the aqueous pH was maintained below 4.5. Creosote adherence to glass vials, but not quartz sand, was observed in most of the tests.

1.3.6.2.2 DNAPL Movement. Movement of creosote DNAPL is governed by driving force, capillary barriers, DNAPL saturations, and DNAPL dissolution (Cohen and Mercer, 1993). In more detail:

- Driving forces include hydraulic gradients and gravity. At the Site both of these act in a downward direction. When the wastewater lagoons were closed over 30 years ago, the driving force forces for downward DNAPL migration were decreased but not eliminated.

- Capillary barriers reflect the fact that DNAPL preferentially enters large pores first and can only enter small pores when large static-pool heights develop. The primary capillary barriers at the Site are the upper, middle, and lower clay units in the HG. However, these capillary barriers may have been breached in some areas, forming natural migration pathways for DNAPL. Such natural pathways can include fractures and bioturbation tubes.

- With time DNAPL is depleted by drainage and/or dissolution. As this occurs the fraction of pore space containing DNAPL decreases. DNAPL may drain through fingers to form continuous bodies (pools). Ultimately, DNAPL in pores and continuous bodies of DNAPL will become discontinuous blobs and ganglia that are no longer mobile as a separated liquid phase.

- Discontinuous blobs and ganglia form at the trailing end of a mass of mobile DNAPL; therefore, DNAPL at the trailing edge of a DNAPL mass is less likely to be mobile. Stated alternatively, the most likely place for mobile DNAPL to exist is at the leading (deeper) end of the DNAPL mass.

- Formation of dissolved constituent plumes comes about through dissolution of DNAPL. With this dissolution, DNAPL is depleted. The rate at which DNAPL is depleted is dependent on the architecture of the DNAPL and the aqueous solubility. In general, rates of natural DNAPL depletion will be greatest when DNAPL is sparsely distributed in small fingers. In contrast, DNAPL in areas where more extensive DNAPL is present (e.g. the Surficial Aquifer) will likely persist for longer periods.

Experiments on the migration behavior of chlorinated DNAPL compounds in an air/water-filled porous medium have been conducted by Schwille (Schwille, 1988). In cases where sufficient DNAPL reaches the water table, the denser liquid may move downward to the base of the aquifer, locally accumulating on lower-permeability horizons within the aquifer zone. Under such conditions, a relatively high-concentration aqueous-phase plume may extend downgradient from the source area.

Due to the residual saturation, relatively high concentrations of dissolved-phase constituents of creosote (e.g., PAHs) may persist in soil and in groundwater even if the DNAPL is no longer present in a mobile form. In addition, because of the low solubility and slow dissolution rates of some creosote DNAPL constituents, the residual saturation may persist for an extended length of time, even after DNAPL migration has ceased (Johnson and Pankow, 1992; Cohen and Mercer, 1993). The residual saturation cannot be reduced without significantly changing the DNAPL interfacial tension or viscosity, or the porous-medium capillary properties.

There is uncertainty regarding the current, overall stability (immobility) of DNAPL at the Site. In large part this is due to the complexities of the related processes and practical constraints on the types of Site data that can be collected.

1.3.6.3 Leaching. Constituent leaching may occur as rainwater percolates through areas with high concentrations of soluble constituents in unsaturated soil. The constituents may be in residual DNAPL in the unsaturated pore space or the constituents may be adsorbed onto soil particles. Leaching occurs as constituents are dissolved from residual DNAPL and desorbed from soil. It is important to understand if and where such leaching may result in a significant source of ongoing groundwater impacts. In areas where leaching is significant, the unsaturated soil is considered to be a “secondary source” of groundwater impacts; the “primary source” is the original release of chemicals to the soil.

At this Site, the primary-source releases occurred several decades ago when process wastewater was directed or pumped to on-Site lagoons that are now closed, and when treated wood was allowed to drip dry without containment or collection of the residual chemicals. The most recent wood-treatment processes and practices by Koppers mitigated discharge of chemicals to soil. Due to the approximate 20 years since the primary releases, any significant and ongoing leaching would be clearly manifested in the shallow groundwater concentrations observed at the Site. Thus, leaching is only a potential issue if and where shallow groundwater concentrations of constituents are relatively high, and where these high concentrations correlate with elevated soil concentrations.

Based on the latest Surficial Aquifer groundwater-concentration data (GeoTrans, 2007c), the following constituents are found in multiple shallow water-table (A-series) wells at levels above Florida default GCTLs:

- Naphthalene (see Figure 1-10);
- Acenaphthene;
- 2-methlynaphthalene;
- Dibenzofuran;
- Carbazole;
- Penta; and
- Arsenic.

For the PAHs listed above (naphthalene, acenaphthene, 2-methylnaphthalene, dibenzofuran, and carbazole), there are several shallow (water-table) monitoring wells that have concentrations exceeding GCTLs: M-16A, M-17, M-20A, M-22A, M-23AR, M-24A, and M-25A (carbazole alone also exceeds its GCTL at M-32AR). Figure 1-10 shows the naphthalene concentrations. However, these shallow Surficial Aquifer (A-series) wells have observed PAH concentrations that are significantly lower than the deeper Surficial Aquifer (B-series) wells which are screened near the base of the Surficial Aquifer (GeoTrans, 2007c). This pattern indicates that ongoing leaching is not the most significant source for PAHs. The data are consistent with a CSM in which the primary source of PAHs in groundwater is creosote-residual DNAPL that resides primarily below the water table. The shallow wells with GCTL exceedances are near the Former Process Area, Former Drip Track, or southeastern property-boundary extraction wells.

Default leachability-based SCTLs have been established by FDEP for many constituents, including the PAHs discussed above. Of over 80 locations sampled on Site in 2006 (AMEC, 2007), seven have soil concentrations of naphthalene, acenaphthene, 2-methylnaphthalene, and/or dibenzofuran exceeding their default leachability-based SCTLs. The four highest-concentration locations are within the Former North Lagoon (SS094 and SS101) and Former Drip Track (SS077 and SS100). Two locations along the eastern property boundary (SS082 and SS086) also have at least one depth interval exceeding the leachability-based default SCTLs for these PAHs. Finally, one depth interval for a location in the western part of the Former Process Area (SS058) has a measured naphthalene concentration above the leachability-based SCTL.

For carbazole, over two-thirds of the 2006 soil sampling locations (AMEC, 2007) have at least one depth interval exceeding the default leachability-based SCTL of 0.2 mg/kg. However, the groundwater data do not indicate widespread exceedances of the carbazole GCTL (GeoTrans, 2007). The seven soil sampling locations with the highest carbazole concentrations (4.4 mg/kg and higher) correspond with the seven locations, identified above, that have exceedances of default leachability SCTLs for the other PAHs.

There are only five water-table (A-series) wells with penta exceedances of the 1 μg/L GCTL, all within and northeast of the Former Process Area (GeoTrans, 2007). This is despite the fact that all but one of 91 soil-sample locations (in 2006) have penta concentrations above the default leachability-based SCTL of 0.03 mg/kg (AMEC, 2007). The highest penta soil concentration was at sample location SS058 at the western edge of the Former Process Area.

Arsenic is different from the organic COCs discussed above in that there is not a general pattern of increased concentration with depth. At several locations with paired Surficial Aquifer wells, the water-table (A-series) well has a concentration that is similar to or higher than the deeper (B-series) well. The highest measured water-table concentration is from a well on the eastern property boundary (1,140 µg/L arsenic at M-23AR). The two water-table wells with the next highest measured arsenic concentrations are located just north of the Former South Lagoon (796 µg/L at M-32AR and 505 µg/L at M-21A). The remaining water-table wells have arsenic concentrations of 50 µg/L or below, with a total of ten wells above the 10 µg/L GCTL. There is no default leachability SCTL for arsenic. Five of the six highest soil-sample concentrations measured in 2006 (see Figure 1-9) were within or near the northern portion of the Former South Lagoon (SS095, SS096, SS021, SS038, and SS040). Hence, the on-Site soil data coupled with groundwater sample data appear to indicate that there may be a secondary source of arsenic near or within the northern portion of the Former South Lagoon.

In summary, while there is some spatial correlation between measured soil concentrations and measured shallow groundwater concentrations, the groundwater concentrations provide the most direct information regarding the potential for significant secondary-source soil leaching. For the organic COCs, the water-table groundwater concentrations are generally low relative to the concentrations from deeper intervals in the Surficial Aquifer. This indicates that the main ongoing source of dissolved organic constituents in the Surficial Aquifer is DNAPL near the base of the Surficial Aquifer. Conversely, there appears to be limited ongoing leaching of arsenic from soil within and near the northern half of the Former South Lagoon. There could also be some leaching from shallow soil in other source areas. A more formal assessment of leaching potential (including development of alternative leachability-based SCTLs using Site data) is ongoing and should be factored into remedy selection and design. One implication of leachability for remediation is the potential need to excavate (remove) or place an impermeable cover over soil that is judged to result in exceedances of GCTLs in groundwater.

1.3.6.4 Groundwater Migration and Attenuation. The Site constituents that are frequently detected in dissolved phase in groundwater are those that readily leach from DNAPL and soil. Conversely, dioxins/furans and pcPAHs (excepting carbazole) are practically immobile in groundwater.

1.3.6.4.1 Migration and Attenuation Process. Once dissolved into groundwater, constituents are affected by the processes of advection, dispersion, sorption, and matrix diffusion. The organic constituents are also affected by natural biodegradation. Arsenic may chemically precipitate from solution under certain geochemical conditions.

Advection is the downgradient movement of constituents in the direction groundwater flow, which is sometimes conceptually depicted with “particle” transport paths. The advective rate of groundwater in a porous medium depends on the hydraulic conductivity of the medium, the hydraulic gradient, and the effective (interconnected) porosity of the medium.

Dispersion is the spreading of constituents in groundwater caused by small-scale heterogeneities in flow which leads to constituents moving from areas of high concentration to areas of low concentration. Dispersion results in the spreading of a small, concentrated source of constituents into a larger, less-concentrated plume. These plume-spreading effects of dispersion increase with distance from the source.

Sorption occurs when constituents become chemically or biochemically attached (adsorbed) to the solid particles of the porous medium. Sorption rates vary by constituent and sorption is typically reversible. The main practical effect of sorption is to slow (retard) the downgradient movement (advection) of a constituent in groundwater. In many cases, sorption allows other processes such as dispersion and biodegradation to have greater effect. For most constituents, sorption is more significant in media with relatively high organic content. For many inorganic constituents (e.g., arsenic) the degree of sorption depends on the geochemical conditions (Eh and pH) in the subsurface.

Matrix diffusion occurs in fractured media and in porous media that have significant “non-connected” pore space (e.g., clays). While advection occurs primarily in the connected portion of the pore space, constituents may diffuse into the non-connected pore space. Matrix diffusion retards the movement of solute and can cause a dispersive effect.

The solubility of arsenic in groundwater may change if/as the groundwater geochemical conditions change. If the solubility becomes much lower (e.g., due to changing mineralogy, pH, and/or Eh encountered by moving groundwater), then some of the arsenic may chemically precipitate into solid form. This process also typically results in constituent retardation, though it may cause some of the arsenic to become permanently mineralized and immobile.

Natural biodegradation refers to the processes wherein native bacteria in the subsurface breakdown the chemical bonds of constituents as part of metabolism. Such chemical altering results in the formation of degradation byproducts that may, in turn, be further degraded. All of the organic constituents that are present in Site groundwater have a known propensity for biodegradation and can biodegrade in both aerobic and anaerobic conditions (GeoTrans, 2004b), and in all cases biodegradation results in less toxic and/or more readily degraded byproducts (Middaugh et al., 1994). TRC (1999) coordinated a laboratory study to determine naphthalene half-life for Site groundwater samples. Results of this study indicate that the naphthalene half-life for Site groundwater ranged from 627 to 1,119 days. Shorter half-lives are reported in the literature (Howard et al., 1991)

The term "natural attenuation" includes all of the chemical migration and fate processes discussed above that result in decreasing concentrations of constituents. Thus, the processes of biodegradation, dispersion, sorption, and matrix diffusion all result in natural attenuation of constituents.

1.3.6.4.2 Model Analysis of Groundwater Migration and Attenuation. In 2004, a three-dimensional numerical groundwater model was developed to evaluate groundwater flow and solute transport in the Surficial Aquifer, HG, and UFA (GeoTrans, 2004a). The modeling was carried out in three major steps: (1) development of the groundwater flow model and calibration of the model to observed data, (2) particle-tracking analysis to estimate advective flow paths from source areas to off-Site points of interest (e.g., the Murphree Well Field), and (3) solute transport simulations to estimate potential future concentrations of Site COCs in groundwater. The Site model development incorporated the major hydrostratigraphic units and hydrologic stresses in the region. The transient model was calibrated to measured groundwater levels. The Site model provides a sophisticated and technically sound analysis tool for evaluating COC fate and transport.

After calibrating the groundwater flow model, the direction and velocity of groundwater flow from source areas was estimated through particle-tracking simulations. In these simulations, hypothetical particles of a conservative-tracer were "released" within the groundwater flow field near sources, and the predicted downgradient movement of these particles through time was calculated by the model. These model simulations served to establish numerical bounds for the potential advective movement of dissolved constituents without accounting for attenuation mechanisms that affect Site-related constituents (e.g., sorption, chemical precipitation, dispersion and biodegradation).

The particle tracking simulations indicate that the vertical groundwater travel time from the Surficial Aquifer, through the various clay aquitard and water-bearing units, and into the UFA can be more than 85 years. Once groundwater reaches the UFA, the model simulations estimated that an additional 59 to 118 years would be required to reach the Upper Transmissive Zone under the Murphree Well Field. This travel time was predicted using an effective porosity value based on a homogenous aquifer matrix. The model simulations also indicate that groundwater may be delayed from migrating to the Lower Transmissive Zone by the semi-confining unit separating the Upper and Lower Transmissive Zones.

EPA acknowledges uncertainty in the true value of effective porosity for the area of the Site due to actual subsurface conditions. Site stakeholder GRU believes that using an effective porosity based on a homogeneous aquifer matrix in the model may over-estimate travel time. GRU believes the groundwater travel time may be closer to 4 to 5 years.

Solute-transport simulations also were conducted to predict constituent concentrations (GeoTrans, 2004a). These simulations take attenuation mechanisms such as dispersion, sorption, and biodegradation into account. Constituent transport simulations were made to assess the potential groundwater concentrations of naphthalene and arsenic released at the Site.

Naphthalene was simulated because it is one of the most potentially mobile and widespread COCs at the Site. In the baseline simulation, the model was run assuming a constant dissolved naphthalene concentration of 10,000 μg/L at each DNAPL source area in the Surficial Aquifer and an additional slug source in the Floridan Aquifer near monitoring well FW-6. Biodegradation was simulated as a first-order decay process using a conservative half life estimate (3 years) from relevant literature and Site studies.

Due to biodegradation and other natural attenuation processes, the lateral and vertical extent of a naphthalene plume (at its GCTL) was projected by the model results to not extend any farther than potentially a few hundred feet off Site in the Surficial Aquifer and HG. A worst-case model simulation, assuming a constant injection of naphthalene into the UFA beneath the footprint of the Former North Lagoon, estimated that a 1 µg/L naphthalene concentration contour would not extend any farther than approximately 1,500 feet downgradient of the Site. These model predictions are consistent with current groundwater data from monitoring wells at the Site boundary. The groundwater transport simulations predict no future PAH impacts at the Murphree Well Field.

Groundwater transport simulations for arsenic indicate that lateral and vertical migration of this constituent will be very limited because it is highly adsorptive. The Site model results are consistent with current groundwater monitoring data, with only a few Surficial Aquifer monitoring wells detecting elevated arsenic concentrations. A model simulation was run assuming a hypothetical "worst-case" constant source of arsenic in the Surficial Aquifer under the Former Process Area. After a period of 100 years, the model results indicated that the arsenic plume would not migrate beyond 1,000 feet downgradient of the simulated source area. Another model simulation, this time assuming a constant source of arsenic in the UFA at well FW-3, predicted that a 1 µg/L arsenic concentration contour would not extend beyond 1,500 feet downgradient from well FW-3 after 100 years.

1.3.6.5 Aquifer Cross Contamination. Drilling in source areas, especially DNAPL source areas, produces risks of cross contamination, potentially spreading source material to previously unimpacted depths and hydrogeologic units. Even when the locations of DNAPL areas and the geology are relatively well known, the installation of wells in or near DNAPL areas using the best available technology has risks (EPA, 1992). EPA (1992) indicates that in order to circumvent these risks, it may be appropriate to avoid drilling directly within areas of known or suspected DNAPL impacts and focus on characterizing dissolved constituent plumes migrating from source areas.

The risks of causing cross contamination when drilling into DNAPL source zones is exacerbated at this Site due to the approximately 120-foot head drop from the Surficial Aquifer to the UFA. Even though proper precautions are taken during drilling and well construction, there are two possible mechanisms that can lead to cross contamination: (1)

a short-term loss of drilling fluids, including drilling mud, and (2) a long-term continuous leakage of impacted groundwater via preferential pathway due to incomplete seals in the annular cement grout. Though the wells on Site were designed and constructed to minimize the potential for cross contamination, the potential risk cannot be totally eliminated. Due to the large vertical hydraulic gradient across the HG clay units (Figure 1-3), even a very small crack (on the order of microns) in the borehole/well seals can lead to migration of potentially substantial concentrations of constituents between units (Hinchee, Foster, and Larson, 2008).

There is some Site evidence that cross contamination has led to limited impacts in the UFA. In particular, at the UFA well with highest constituent concentrations, FW-6, drilling mud mixed with Site soil and groundwater was lost during drilling. Measured concentrations of Site constituents (e.g., naphthalene) at this well were at their highest levels immediately after installation, and declined in subsequent measurements. The continued observation of elevated concentrations (though lower than the initial concentrations) at this well could indicate some ongoing potential leakage along the borehole (Hinchee, Foster, and Larson, 2008); however, that hypothesis is rejected by some stakeholders. EPA believes that this is one possible explanation for some, but by no means all of the constituent concentrations observed in the UFA.

Also, elevated pH measurements at some UFA wells, notably FW-3 (pH over 12 in 2005), likely resulted from high-pH cement grout used in well construction. Because the cement grout was only used above the lower clay unit of the HG at this well, it is likely that groundwater has moved and is moving downward along the borehole.

It is difficult to assess and precisely quantify the degree of aquifer cross contamination or flow via natural discontinuities through the HG clays at the Site. A number of approaches are discussed in the literature, but none appear to allow unambiguous differentiation between drilling-induced cross contamination versus constituent migration via natural-pathways. However, based on the Site conditions and the conclusions of EPA (1992) and Hinchee, Foster, and Larson (2008), care should be taken not to drill through the low-permeability HG clay units (particularly the lower clay and middle clay units) in DNAPL-impacted areas. These clay units are presently providing protection to the UFA and maintaining their integrity is very important. It is noted that there will be remedy performance monitoring wells that will most likely have to be installed in or near DNAPL-impacted areas as part of the remedial design/remedial action implementation.

1.3.6.6 Runoff. Storm water runoff at the Site flows generally to the northeast. Much of the Site runoff flows in the Site storm water ditch along with storm water from land parcels to the south of the Site. All Site runoff eventually flows into Springstead Creek.

Based on Site topography (Figure 1-4), there may be some runoff from the Site to the north toward off-Site portions of the Site storm water ditch. There may also be runoff to the east, but the raised ballast of the adjacent railroad spur prevents runoff from moving farther east. There is little or no runoff toward the south. There may be small areas of limited runoff toward the west into a drainage swale along the western property boundary. This area had relatively high concentrations of Site COCs in surface soil, as compared to other off-Site areas, though observations made during the sampling event did not suggest that current topographic features and surface runoff were likely to be responsible for the elevated concentrations (AMEC, 2009a).

Measured concentrations of Site COCs in the surface water of Springstead Creek are low (ACEPD, 2006) and measured concentrations of most Site COCs in Springstead Creek sediment are much lower than on-Site concentrations (ACEPD, 2009; AMEC, 2007). PAHs are the potentially Site-related COCs measured in the highest concentrations in Springstead and Hogtown Creek sediments; however, these likely are the result of a release from the adjacent Cabot Carbon property that occurred 40 years ago (ACEPD, 2009).

1.3.6.7 Dust. Past transport of COCs via dust likely caused the detections of Site COCs in off-Site surface soil west of the Site (AMEC, 2009a, 2009b, and 2010b). Continuing off-Site transport of COCs via dust is less likely due to more limited activity on the Site and to improved dust-control practices. Air dispersion modeling (AMEC, 2009d) suggests that dust at the property boundary is currently well below appropriate EPA ambient air screening levels; therefore, no unacceptable health risks are predicted to be present on the facility, at the fence line of the facility, or beyond the facility boundary (this study is still under review). All of the modeling assumes current conditions and does not reflect reduced fugitive dust emissions or reduced constituent concentrations in surface soil that would result if surface soil in portions of the Site were covered. Dust modeling results have not been accepted by EPA as representative of actual Site conditions.

EPA acknowledges concerns that the AMEC evaluation described above does not accurately evaluate all variables in such a way as to accurately state that there are no unacceptable health risks. Since the Koppers Facility closure, Beazer East has begun interim measures to reduce dust including planting of vegetation over former operations. As part of Site building demolition activities, Beazer East is implementing dust controls in the form of dust suppression through continuous water application. During the remedial design of the Site remedy, Beazer East will design and implement an ambient air monitoring network at the fenceline.

1.3.7 Potentially Complete Exposure Pathways

Potential receptors and exposure media were examined in conjunction with the CSM presented above. Figure 1-13 is a conceptual diagram showing potential routes of human/environmental exposure to Site constituents. The terminal point of each migration pathway is a potential receptor addressed by the proposed remedies evaluated in this FS.

1.3.7.1 Potential Receptors. The Site has been an industrial facility for over 90 years; the nearest residences are adjacent to the western and northwestern Site boundaries. The use of the Site is anticipated to remain commercial/industrial in the future, though it is possible that portions of the Site could be developed for other purposes (e.g., recreational) as well. The EPA acceptable risk range for human health is a potential excess lifetime cancer risk of $1x10^{-6}$ to $1x10^{-4}$ (i.e. between one additional cancer case in a population of ten thousand, to one additional cancer case in a population of one million). Acceptable risks for non-carcinogenic constituents must result in a hazard index of less than or equal to 1. On-Site trespassers are potential receptors, but their frequent presence on the Site is unlikely because the Site has fences and gates to limit access. Reasonable future receptors include on-Site workers and recreational users.

On-Site residential exposure scenarios are not applicable based on the expected commercial/industrial and/or recreational use of the property. Evaluation of potential risks associated with nonresidential use scenarios is consistent with federal guidance (EPA, 1995), in which EPA proposes to address potential risks consistent with current and plausible future land-use patterns. Note that this assumption does not prevent consideration of future Site development that does include residential use. Future residential site development would need to address the appropriate potential exposure pathways as part of the development design (see Section 1.5).

There is currently no use of groundwater from the Surficial Aquifer or HG for drinking water; however, the UFA is a drinking water aquifer. The Murphree Well Field, a public water supply well-field, is located approximately 2.5 miles northeast of the Site.

Off-Site receptors to be protected consist of the residential population located west of the Site property. Surface soil within the residential properties contains detected concentrations of COCs, a portion of which is assumed to be Site related.

1.3.7.2 Exposure Media. Based on RI data, potential exposure to Site constituents may be possible via contact with the following media:

- On-Site surface soil (including dust);
- On-Site subsurface soil;
- On-Site sediment;
- On-Site surface water (storm water);
- Off-Site surface soil (residential areas west of facility);
- Off-Site sediment and surface water (north and west of the Site including Springstead Creek); and
- Groundwater.

Groundwater is further divided by hydrogeologic unit (see Section 1.2.2.2) into:

- Surficial Aquifer Groundwater;
- Upper Hawthorn Groundwater;
- Lower Hawthorn Groundwater; and
- UFA Groundwater.

To better organize and evaluate remedies for this complex Site, it was decided to develop and assess remedies for the three defined environmental units (on-Site media [excepting UFA groundwater], off-Site surface soil, and UFA groundwater) separately and to facilitate selection of one remedy for each environmental unit. The recommended remedial alternative will consist of the set of three remedies, one for each environmental unit.

1.3.7.2.1 On-Site Surface Soil. Potential exposure of current and future trespassers, construction workers and utility workers, and future on-Site workers and recreational users to COCs in surface soil via direct contact is considered a potentially complete pathway. Because surface soil provides a potentially complete exposure pathway and is a potential source of COCs to surface water and sediment, addressing impacted surface soil is a key to controlling other potentially impacted media.

1.3.7.2.2 On-Site Subsurface soil. Potential exposure of future on-Site construction workers to constituents in subsurface soil (deeper than 6 inches) is also considered a potentially complete pathway.

1.3.7.2.3 On-Site Sediment. Potential exposure of current and future trespassers and future on-Site workers to COCs in sediments via direct contact is considered a potentially complete pathway. Based upon data collected in 2006, sediment, present in the ephemeral drainage ditch that bisects the Site from southwest to northeast, contains COC concentrations in excess of default commercial/industrial SCTLs.

1.3.7.2.4 On-Site Surface Water and Storm Water. The drainage ditch at the Site only flows after heavy storm events; surface runoff is carried northeast off the Site toward Springstead Creek. Also, groundwater in the Surficial Aquifer may discharge to the Site ditch or downgradient wetlands adjacent to Springstead Creek. There is a potential for surface water to become impacted either by runoff or by shallow groundwater discharge.

1.3.7.2.5 Off-Site Surface Water and Sediment. During and after storm events, surface runoff is carried northeast off the Site toward Springstead Creek. Also, groundwater in the Surficial Aquifer may discharge to the Site ditch or downgradient wetlands adjacent to Springstead Creek. There is a potential for surface water to become impacted either by runoff or by shallow groundwater discharge. There is also a potential that on-Site soil and sediment could be transported downstream during storm events. The potential for ecological risk due to Site-related constituents in off-Site sediment is currently being evaluated; although based upon constituent concentrations detected in off-Site sediments, potential risks to benthic invertebrates appear unlikely. Potential exposure to Site-related constituents in off-Site sediments is considered at this time to be a potentially complete exposure pathway.

1.3.7.2.6 Off-Site Surface Soil. Another potentially complete exposure pathway consists of off-Site residents (living in areas immediately west of the facility) exposed to COCs in off-Site surface soil in yards and public easements. Exposure can occur through direct contact, ingestion or inhalation. Off-Site surface soil contains concentrations of COCs that exceed default SCTLs. Further off-Site soil characterizations are under way to the North, South, East, west of the Site are ongoing and will continue after remedy selection through the remedial design phase of the project.

1.3.7.2.7 Groundwater. Concentrations in groundwater exceed GCTLs for certain constituents (FTS, 2009a, 2009c, and 2009c; GeoTrans, 2007c and 2009b) and in the following hydrogeologic units (Figures 1-10, 1-11 and 1-12):

- Surficial Aquifer;
- Upper Hawthorn;
- Lower Hawthorn; and
- UFA.

Of these units, only the UFA is used as a drinking water source in the vicinity of the Site. This aquifer is the primary source of drinking water in Gainesville via the Murphree Well Field. The UFA is the least impacted of the four hydrogeologic units; however, exposure via groundwater ingestion is considered to be a potentially complete exposure pathway because there is a possibility that groundwater could be withdrawn downgradient of the Site and used as a private drinking water supply.

1.3.8 Estimates of Impacted Media Dimensions

The dimensions of potentially impacted media serve as one of the important basis-criteria for comparing remedial alternatives. A few of the investigations and studies performed at the Site (e.g., TRC, 1999; GeoTrans, 2004b; TRC, 2005; and Jones Edmunds and Associates, Inc., 2006) have proposed estimates of impacted media volumes. These estimates vary in magnitude, depending on factors such as the definition of "impacted" (e.g., exceedence of 1990 ROD remedial goals, presence of staining in soil cores, analytical detection at concentrations above detection limits, etc.) or the selected constituent on which the extent of elevated concentrations is based (e.g., potentially carcinogenic PAHs, naphthalene, penta, arsenic, etc.). The various criteria used to delineate impacted media volumes resulted in variations by factors of approximately 2 to 6.

The primary ongoing source for groundwater impacts is DNAPL and DNAPL-impacted soil within the Surficial Aquifer down to the HG. Table 1-1 presents the estimate of DNAPL-impacted soil volumes in the Surficial Aquifer in each potential source area. It also provides estimates of the soil volume in the Upper Hawthorn and Lower Hawthorn within the Surficial Aquifer source area footprints; portions of this volume have been impacted by DNAPL. They are based on the dimension analysis of Surficial Aquifer DNAPL Source Areas, presented in the *Data Report for Additional Investigation of Hawthorn Group DNAPL Source Evaluation* (Section 4.2.5 in GeoTrans, 2004a) and other information obtained from other Site reports. These volumes were derived by multiplying estimated surface areas of lateral dissolved phase or DNAPL extent (estimated by AutoCAD analysis of sample locations and analytical results) and average thickness of corresponding units.

1.4 Baseline Risk Assessment

AMEC (2009c) submitted a human-health risk assessment (HHRA) for on-Site soils and sediment. This HHRA was initially submitted in January 2009, then revised to address EPA comments in August 2009. The January/August 2009 assessment is currently being updated again to reflect new assumptions about present and future land-use scenarios. The HHRA includes both a deterministic (traditional) evaluation of potential risks and a more refined probabilistic model for potential risk evaluation. The assessment shows that pcPAHs, arsenic, and dioxins/furans are the COCs that have the potential to make the largest contribution to the overall potential excess lifetime cancer risk associated with the Site. Potential exposure to penta makes a small contribution to total potential excess lifetime cancer risk.

If the conditions at the Site change, that could trigger a re-evaluation of potential risks using updated exposure and toxicity assumptions, as explained in Section 1.5.

AMEC (2009e) also evaluated potential ecological risks associated with sediment. The study suggests that the measured concentrations of COCs in Springstead Creek sediment are far lower than thresholds that would lead to toxicity in benthic invertebrates. EPA has rejected this evaluation and is working with Beazer East to complete an acceptable ecological risk evaluation.

1.5 Potential Future Conditions

A key uncertainty that affects estimates of potential risk is the assumed future use of the Site. The estimates of potential risk presented in the original HHRA (AMEC, 2009c) assume that the reasonably foreseeable future use of the Site is a wood-treatment site. That assumption is no longer valid; thus, the HHRA is presently being revised.

A critical aspect of the probabilistic model developed for the Site (as well as the deterministic risk assessment presented in the HHRA) is that it allows for evaluation of future on-Site conditions that differ from the future conditions assumed by the on-Site risk assessment. As long as those future conditions can be characterized (e.g., the potential receptors expected to be on the Site in the future can be identified; the distribution of concentrations of constituents in on-Site soil can be predicted; etc.), potential risks associated with those conditions can be estimated. Developing estimates of the potential risk associated with future conditions does not require changing the equations used in the risk assessment; rather, the inputs are changed such that the risk assessment will estimate potential risk for any potential future use of the Site.

Some examples of changes in assumed future conditions that the probabilistic risk model and deterministic risk assessment can account for are presented below.

- Evaluation of multiple future use scenarios. The probabilistic risk model can be run several times to estimate the potential risks associated with as many different potential future uses as necessary. Such scenarios can include potential future risks associated with continued use of the Site for commercial/industrial development or represent entirely different land uses than are currently present at the Site, such as development of the Site for recreational and/or residential use.

- Addition of new receptors. If future use of the Site changes and additional receptors are assumed to be present, the potential risks associated with different receptors can be modeled by inputting alternative distributions appropriate for their exposure assumptions. If more than one type of receptor is assumed to be present under future conditions (or several potential future conditions need to be evaluated), the probabilistic risk model (and deterministic risk assessment) can accommodate that as well.

- Revised exposure assumptions. If the probabilistic risk model is updated to include new receptors, relevant exposure assumptions can be updated as well (e.g., lower exposure intensity if the Site were developed for retail purposes where the workers are inside and not exposed to soil for the same duration as outdoor workers).

- Changed constituent concentrations. If portions of the Site are covered (as contemplated in most of the remedial alternatives presented in Section 3), thereby changing the constituent concentrations to which receptors may potentially be exposed, alternative distributions of on-Site soil concentrations can be developed and input into the probabilistic risk model and a revised distribution of potential risk can be estimated for all appropriate future receptors. Similarly, if new constituent concentration data were to become available, the existing distributions of on-Site soil concentrations could be updated and revised distributions of potential risk developed.

- Updated toxicity assumptions. As new information about the potential toxicity and bioavailability of constituents becomes available, toxicity assumptions used in the existing probabilistic risk model may be revised. The model can be rerun using the revised toxicity assumptions, if needed.

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2.0 Identification and Screening of Remedial Options

This section identifies and screens remedial technologies based on their potential effectiveness in achieving specific requirements and in protecting human health and the environment. First, this section reviews the ARARs that must be considered during development of preliminary remediation goals and remedies. Site RAOs are developed based upon a number of factors, including ARARs, potential exposure pathways, and information about potential environmental risk. General response actions are identified for different Site media and zones; these general response actions include removal, treatment, and containment. Next, specific technologies and process options are presented that can potentially be used to carry out the general response actions for the different Site media and zones. These technologies are screened, based on effectiveness and implementability, for each of the three defined environmental units to be addressed: on-Site media (excluding UFA groundwater), off-Site surface soil, and Floridan Aquifer groundwater. The result of this screening process is a short list of remedial technologies used in Section 3 for developing remedies for each of the three environmental units.

2.1 Applicable or Relevant and Appropriate Requirements

Selected remedial actions must be protective of human health and the environment. The remedial actions must comply with ARARs, as required by Section 121(d) of CERCLA, 42 USC § 9621(d). CERCLA also requires identification of potentially applicable regulatory guidance as information items to be considered (TBCs).

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, remedial action, location, or other circumstance at a Site. Relevant and appropriate requirements are those same standards mentioned above that, while not directly applicable, address problems or situations sufficiently similar to those encountered that their use is well suited to the particular Site (EPA, 1988b).

One objective of this section is to identify applicable cleanup criteria and targets from Federal and State regulations and guidance. A cleanup target is considered applicable based on a determination that the requirement specifically addresses a hazardous substance, pollutant, remedial action, location or other circumstance.

Regulatory standards, including Federal and State of Florida regulations and guidance, were evaluated and considered in the development of cleanup targets. Local regulations from Alachua County and the City of Gainesville were also reviewed. Consistent with CERCLA guidance and the NCP, regulatory standards are divided into three broad categories as described below:

- Location-Specific regulations relate to natural and man-made features that include wetlands, nature preserves, floodplains, and historic archeological features.
- Action-Specific regulations relate to the implementation of a corrective measure or remedial action. Different action-specific regulations may apply for different remedial actions. Examples of action-specific regulations include effluent discharge limits, surface water discharge limits, manifesting hazardous wastes, and occupational health and safety requirements.
- Chemical-specific regulations and guidance may relate to the extent of Site remediation required. These regulations may be concentration-based remediation levels or may provide a scientific or policy basis for calculating these levels.

The location-specific, action-specific, and chemical-specific regulations and guidance are summarized in Tables 2-1, 2-2 and 2-3, respectively. Summary discussions of the applicable regulations and guidance are provided below.

2.1.1 Location-Specific Regulations

Certain location-specific regulations apply to protected areas such as historic areas, flood plains, fault zones, wetlands, or other sensitive ecosystems. No wetlands have been identified and the Site is outside of identified areas prone to flooding, according to the Alachua Flood Insurance Rate floodplain maps produced by the Federal Emergency Management Agency in June 2006.

The Site is located within the Tertiary Murphree Well Protection Zone, adopted by the City of Gainesville. The Well-field Protection Code regulates development and activities within the Well Protection Zone, in addition to regulating wells and hazardous materials.

The Site is also within an Area of Special Concern as defined by the City. Development in this area requires special review by the City, FDEP, EPA, and Site Potentially Responsible Parties (PRPs).

Finally, the Site is also within a state "delineated area" of groundwater contamination as regulated by Chapter 62-524 Florida Administrative Code (FAC). Restrictions and special procedures are imposed in such areas for constructing wells and for using groundwater.

Table 2-1 presents the location-specific regulations that have been identified as ARARs or TBCs. No other potential location-specific regulations (Federal, State, or Local) have been identified that merit consideration herein.

2.1.2 Action-Specific Regulations

Action-specific regulations are requirements, limitations, or conditions that become applicable when certain technologies are deployed or when certain remedial actions are taken. This class of regulations includes potentially applicable Resource Conservation and Recovery Act (RCRA) and CERCLA regulations for managing and remediating hazardous wastes. It also includes Florida regulations related to hazardous waste management, site cleanup, and active remediation criteria.

Table 2-2 presents action-specific regulations that have been identified as ARARs or TBCs for one or more remedial technologies, actions, or disposal options under consideration (as described in later subsections). Some of the potential action-specific regulations for the Site include:

- National Pollutant Discharge Elimination System; 40 CFR parts 122/125 (in accordance with the Clean Water Act: 33 USC 1251);
- RCRA; 40 CFR parts 144 through 147 – Underground Injection Control (UIC);
- Safe Drinking Water Act; 42 USC 300(h);
- RCRA, Subtitle C; Land Disposal Restrictions (LDRs) restrict land disposal of hazardous wastes that exceed criteria within the regulation. The LDR establishes Universal Treatment Standards to which waste must be treated prior to disposal. The Phase IV rule establishes Alternative Treatment Standards for soils containing hazardous waste;

- RCRA, Corrective Action Management Units (CAMUs) allow for an area of a facility that is used only for managing CAMU eligible wastes for implementing corrective action or cleanup. The placement of the waste into CAMUs does not trigger LDR regulations or land disposal unit minimum technologies, but may be subject to treatment requirements;
- Area of Contamination (AOC). Per NCP policy (55 FR 8758-8760), the EPA may designate an AOC as an existing area of continuous contamination of varying amounts and types. AOCs are identified on a case-by-case basis and are delineated by the extent of continuous contamination. LDRs are not triggered if material is moved within an AOC, treated in place, or consolidated within an AOC;
- Contaminated Site Cleanup, Chapter 62-780 FAC, presents the Risk-Based Corrective Action (RBCA) framework for remediation in Florida. This regulation provides criteria and procedures for obtaining a No Further Action (NFA) or NFA with Controls designation. The regulation provides three Risk Management Options (RMO) for attaining Site closure:
    - RMO I: GCTLs are achieved throughout the Site and no controls are required;
    - RMO II: GCTLs are achieved beyond the Site property boundary and institutional controls are required for the Site property; and
    - RMO III: GCTLs are achieved beyond an institutional control boundary that is partially off-Site, requiring agreements with other property owners; and
- Alachua County Water Quality Code prohibits the discharge of any material into surface water, groundwater or storm water systems that results in a violation of the State of Florida Surface Water Quality Standards, Groundwater Standards, or GCTLs.

2.1.3 Chemical-Specific Regulations

Chemical-specific regulations include health- or risk-based numerical concentration targets or methodologies used to determine such targets. Table 2-3 presents chemical-specific regulations that have been identified as ARARs or TBCs.

2.1.3.1 Federal Regulations and Guidance. The National Primary Drinking Water Regulations (40 CFR Part 141) set forth maximum contaminant level goals (MCLG) and MCLs in drinking water. These standards are applicable to groundwater or surface water that may be potentially used as a drinking water source. CERCLA also provides for use of background concentrations as cleanup targets for any constituent that has a background concentration greater than its MCL. Calculation of Site-specific alternative concentration limits (ACL) is also permissible under CERCLA provided that human health and the environment are protected.

When evaluating existing concentrations of constituents with potential carcinogenic effects, or when developing ACLs, the NCP specifies an allowable "excess cancer" risk range of $1x10^{-4}$ to $1x10^{-6}$ (i.e. between one additional cancer case in a population of ten thousand, to one additional cancer case in a population of one million) for upper-bound exposures. This federal risk range applies to exposures from all media (e.g., soil, groundwater, and sediment).

For evaluation of soil concentrations, EPA Regions 3, 6, and 9 publish default Risk Screening Levels (RSL) (formerly known as Preliminary Remediation Goals [PRGs]). These soil concentrations are not formal ARARs, but can be used as an initial screening tool.

OSWER Directive 9200.4-26 specifies that the dioxin cleanup standard for industrial facilities should range from 5 to 20 µg/kg TCDD-TEQ in soils (EPA, 1998).

2.1.3.2 State Regulations and Guidance. Additional chemical-specific regulations and guidance include Chapter 62-777 FAC Contaminant Cleanup Target Levels,. This chapter presents default groundwater, surface water, and soil cleanup target levels (CTLs).

Default GCTLs are based on applicable federal and state water quality standards. Where standards do not exist, GCTLs are based on: (1) a lifetime cancer risk of $1x10^{-6}$ (i.e. one in one-million) or less; (2) the expected absence of non-cancer health effects (hazard index (HI) of 1 or less); and (3) nuisance, organoleptic, and aesthetic considerations. GCTLs are available for many compounds that do not have an MCL.

Similarly, default SCTLs were developed for human exposure to soil, based on a lifetime cancer risk of $1x10^{-6}$ or a HI of 1. For each chemical constituent, two default SCTLs are presented for direct exposure, one for residential exposure scenarios and one for commercial/industrial exposure scenarios. Leachability-based default SCTLs are also presented based on achieving GCTLs below and adjacent to potential source areas.

Chapter 62-780 FAC allows for developing alternate CTLs based on Site-specific data as long as cancer risks do not exceed $1x10^{-6}$ and non-cancer HIs do not exceed 1.

2.2 Remedial Action Objectives

This subsection presents the RAOs for the Site. The Site RAOs are based on potential migration/exposure pathways for Site constituents and ARARs. Because of the connections and relationships between the three defined environmental units, the RAOs for all three are presented and discussed together.

2.2.1 Generalized RAOs

The RAOs provide media-specific and action-specific requirements to protect human health and the environment. Based on the potential receptors, potential media of concern and identified COCs for the Site, the RAOs identified for the Site include:

- Mitigate risks to potential receptors exposed to Site-related constituents in:
  - Surface soils;
  - Groundwater in the Surficial Aquifer, Upper Hawthorn, Lower Hawthorn, and Upper Floridan Aquifer;
  - Subsurface soils;
  - Sediment; and
  - Surface water.
- Mitigate further migration of impacted groundwater.
- Reduce the mobility, volume, and toxicity of DNAPL to the extent practicable.

2.2.2 Cleanup Target Levels

Specific cleanup targets for COCs in Site media (i.e. for surface soil and groundwater) are established in order to evaluate and implement the generalized RAOs. It is also necessary to determine whether shallow (unsaturated) soils are a significant ongoing source of impacts to groundwater via leaching.

2.2.2.1 Surface Soil and Sediment. An assessment of potential human health risks due to exposure to COCs in Site soils and sediment (AMEC, 2009c) has been submitted to EPA and is being updated to account for changes in future land use as of this writing. The refined probabilistic risk assessment in the HHRA concludes that concentrations of COCs in on-Site surface soil (0 to 6 inches) do not pose an unacceptable potential risk assuming a commercial/industrial use and the EPA allowable risk range but exceed the FDEP allowable risk limit of $1x10^{-6}$. COCs for potential soil exposure are arsenic, pcPAHs (expressed as BAP-TEQ), dioxins/furans (expressed as TCDD-TEQ), and penta. Potential exposure to other constituents does not result in exceedance of FDEP or EPA risk limits.

The FDEP $1x10^{-6}$ risk level is the most stringent criterion for surface soil remediation. Any selected remedy will be evaluated by estimating post-remediation risks using the methods described by AMEC (2009c). The $1x10^{-6}$ risk level is applicable to on-Site and off-Site soils.

2.2.2.2 Groundwater. For groundwater, the cleanup target levels assumed in this FS are the Florida default GCTLs (Table 2-4) or background concentrations for constituents that have a GCTL above background. As shown in Table 2-4, the Florida GCTLs are as stringent as, or more stringent than, federal MCLs and are established for more Site COCs.

2.2.3.3 Points of Compliance. As required by Florida rules (FAC 62-780), temporary and permanent points of compliance (TPOC and POC, respectively) will be used to monitor the migration of constituents and to define remediation success. Based on potential groundwater migration patterns, a system of groundwater monitoring wells will be created from monitoring wells at locations where GCTLs are to be met. The TPOC monitoring wells represent locations where GCTLs may not be exceeded while remediation is in progress. Conversely, full Site closure (NFA with Controls status) requires that groundwater cleanup targets be met at POC monitoring wells after remediation activities are complete. These POCs will be: (1) no further downgradient than the TPOCs and (2) no further downgradient than the limit of institutional controls.

If any off-Site monitoring wells are included in the POC system, proper notification of Site monitoring and rehabilitation status will be given to affected property owners and occupants.

2.2.2.4 Subsurface Soil. Leachability-based soil cleanup targets are used for unsaturated soils that act as a significant source of constituents in groundwater. Monitoring of the Surficial Aquifer (GeoTrans, 2007c) indicates that the upper portions of the Surficial Aquifer have relatively low concentrations of organic constituents; much higher COC concentrations are observed in the deeper portion of this aquifer. This indicates that residual DNAPL below the water table is the main source of organic COCs in groundwater. Based on groundwater and soil concentration data, unsaturated soils do pose a potential leachability concern at the four source areas and, for arsenic, north and west of the Former South Lagoon.

The Florida cleanup standards in Chapter 62-780 FAC allow for development of alternative leachability-based SCTLs based on Site specific data, including groundwater and soil concentrations. Based on available data and an ongoing analysis, it is anticipated that alternative SCTLs will be developed for arsenic and penta during the remedial design. Once approved, those leachability-based cleanup-targets will be applied to the selected remedy.

Below the water table, areas of soil with residual DNAPL are the primary continuing sources of groundwater COCs. Remedial actions that address the DNAPL-impacted zones will be effective in mitigating future groundwater impacts.

2.3 General Response Actions

This section identifies available GRAs that may achieve the RAOs for the different types of impacted Site media and the nature of the impacts. For the purpose of identifying viable and feasible technologies, the Site media have been grouped as follows:

- Surface and shallow subsurface soil;
- DNAPL in soil above or below the water table; and
- Groundwater.

The media are separated into groups for the remedial alternative discussions; however, remediation actions in one medium can have impacts on other media. For example, technologies discussed for surface and shallow soils are anticipated to encompass Site sediment and will also be designed to account for surface water and storm water. The GRA categories identified for the impacted Site media generally include:

- Removal actions;
- Treatment actions (in-situ);
- Containment actions (in-situ); and
- Exposure prevention actions.

Removal actions include physically removing the impacted materials for ex-situ treatment and/or disposal. Treatment technologies are intended to remove constituents from the media, or to alter constituent toxicity or mobility so that they are no longer hazardous. Containment technologies are intended to minimize, prevent, or reduce migration of constituents from soil and groundwater to potential receptors. Exposure prevention actions, such as institutional controls, are intended to limit access to impacted media. Typical institutional controls limit Site access and provide land use restrictions.

The subsections below present GRAs for specific Site media. A short-list of viable remedial technologies and process options (RTPOs) was identified for each GRA from the universe of current RTPOs used for environmental remediation. These RTPOs are described in more detail and are further screened in Section 2.4.

2.3.1 Soil and Impacted Solids

The universe of current RTPOs associated with solid media were considered and screened for applicability to soil and other impacted solid media. The more common RTPOs identified for these media are discussed in the following sections.

2.3.1.1 Removal. Shallow soil with elevated constituent concentrations can be excavated from its current location. The excavated soil can be placed in a permanently secure on-Site management unit (i.e. AOC), or the material can be staged on-Site for ex-situ treatment and/or later off-Site disposal (TRC, 2005). This general approach is sometimes viewed as most environmentally beneficial because impacted areas are physically removed. However, application of soil removal technologies can sometimes be impractical and ineffective and can create consequences or potential risks that outweigh the benefits of the action (Naval Facilities Engineering Command [NAVFAC], 2006). Impacted soil below a technically feasible depth cannot be excavated. CERCLA specifically discourages selection of remedies that rely on removal and off-Site disposal without treatment.

2.3.1.2 In-Situ Treatment. Soils may be treated in place by a variety of physical, chemical and biological technologies. These technologies can potentially be used to reduce the volume of impacted soil, reduce the toxicity of COCs in soil, or reduce the potential for COC migration. Potentially applicable in-situ treatment technologies include:

- Solidification/stabilization;
- Chemical oxidation; and
- Bioremediation.

2.3.1.3 Containment. Containment technologies prevent migration of COCs from impacted soil. In the unsaturated zone, leaching and downward infiltration is the primary potential migration pathway. This pathway can be limited by installation of a low-permeability surface cover or cap.

2.3.1.4 Exposure Prevention. Direct exposure to surface soil can be managed with engineering or institutional controls. An engineered soil cover or cap can eliminate direct exposure to surface and shallow soil. Site access controls such as fencing also limit potential exposures. Potentially applicable institutional controls include: (1) land use/activity restrictions (attached to the deed or part of local land use regulation), (2) community awareness programs, and (3) prudent Site health and safety programs and practices.

2.3.2 DNAPL and DNAPL-Impacted Soils

Residual DNAPL has been identified in the Surficial Aquifer, Upper Hawthorn, and Lower Hawthorn. Some mobile DNAPL is present in the Upper Hawthorn and perhaps in the Surficial Aquifer. The universe of current RTPOs associated with free-product constituents such as DNAPL were considered and screened for applicability to DNAPL impacts.

The total volume of soil in the Surficial Aquifer that underlies the footprint of the source areas shown on Figure 1-2 is approximately 200,000 cubic yards; as identified in Table 1-1, the total portion impacted is unknown, but it is assumed that approximately one-half of this volume is impacted by residual DNAPL. The total volume of soil in the HG beneath the footprint of source areas shown in Figure 1-2 and above the lower clay unit is approximately 840,000 cubic yards; the portion of this volume that is impacted is not known, though impacts generally decrease with increasing depth and very little DNAPL-impacted soil has been identified in the Lower Hawthorn.

The most common RTPOs identified for this medium are discussed in the following sections.

2.3.2.1 Removal. DNAPL-impacted soils can potentially be removed by excavation (see Section 2.3.1.1). However, application of soil removal technologies can sometimes be impractical and ineffective and can create consequences or risks that outweigh the benefits of the action (NAVFAC, 2006). Excavation activities would have to overcome existing Site impediments, including: (1) shallow groundwater and (2) limited work area for grading or material handling/treatment.

Another potential removal action is DNAPL recovery from wells. Presently, DNAPL is recovered passively by manually bailing DNAPL from five source area monitoring wells in the Upper Hawthorn (Figure 1-11). Active DNAPL recovery involves pumping groundwater and DNAPL to induce flow to the recovery well. The active recovery may be accomplished in a mixed-phase (one pump for groundwater and DNAPL) or dual-phase (separate pumps) withdrawal system. Also, extracted groundwater from a dual-phase withdrawal system may be re-circulated in order to further enhance the hydraulic forces.

2.3.2.2 DNAPL Mobilization for Removal. DNAPL removal can potentially become more efficient if an in-situ physical/chemical or thermal process is used to mobilize residual DNAPL and adsorbed constituents. This general response action is a combination of soil treatment and DNAPL/COC removal. Specific technologies to consider include soil flushing technologies and thermal desorption technologies. Soil flushing technologies with potential Site applicability include:

- Surfactant flushing; and
- Solvent flushing.

Potentially applicable thermal desorption options for mobilizing DNAPL include:

- Thermal wells;
- Electrical resistance heating; and
- Steam injection.

It should be noted that mobilization of DNAPL for removal carries risks because of the potential that not all of the mobilized DNAPL would be recovered and that the mobilized DNAPL would migrate to previously non-impacted areas, both vertically and horizontally.

2.3.2.3 In-Situ Treatment. DNAPL-impacted, water-saturated soils may be treated in place by a variety of physical, chemical and biological technologies. These technologies can potentially be used to reduce the volume of impacted soil, reduce the toxicity of COC in soil, or reduce the potential for migration. Potentially applicable in-situ treatment technologies for DNAPL-impacted soils include:

- Solidification/stabilization;
- Chemical oxidation;
- Bioremediation; and
- ISBS.

2.3.2.4 Containment. Containment of DNAPL limits the potential for further lateral or downward migration. A variety of subsurface physical barriers may be considered for this purpose including:

- Slurry wall;
- Sheet-pile wall;
- Stabilized/solidified soil wall; and
- Injected grout wall (vertical) or floor (horizontal).

Hydraulic control may also be used to attain containment of DNAPL. However, for this FS, hydraulic control is considered to be a groundwater response action.

2.3.3 Groundwater

Groundwater with concentrations of COCs above GCTLs has been identified in the Surficial Aquifer, Upper Hawthorn, Lower Hawthorn, and UFA (Figures 1-10, 1-11 and 1-12). These data indicate that relatively high concentrations of COCs are present in the Surficial Aquifer and HG and only limited impacts are present in the UFA.

The universe of current RTPOs associated with liquid media were considered and screened for applicability to groundwater. The more common RTPOs identified for this medium are discussed in the following sections.

2.3.3.1 Removal. Dissolved COCs can be removed by groundwater extraction in impacted areas. Groundwater extraction can be accomplished via conventional (vertical) wells, directional (e.g. horizontal) wells, or groundwater collection trenches/drains. The extracted groundwater may require treatment prior to disposal. When groundwater extraction takes place in highly impacted areas for the purpose of overall COC mass reduction, the extraction is considered a removal action. Groundwater extraction may also be used for hydraulic containment and groundwater extraction may be used for hydraulic control inside a physical-barrier containment system.

Note that removal actions targeted at potential sources of COCs are presented in previous sections dealing with soil and DNAPL.

2.3.3.2 In-Situ Treatment. Several in-situ groundwater treatment technologies are potentially applicable, including:

- Air sparging;
- Chemical oxidation;
- Enhanced bioremediation (biological amendments to promote aerobic or anaerobic degradation); and
- Phytoremediation.

These technologies use physical, chemical or biological processes to remove COCs from groundwater through chemical transformation or volatilization.

2.3.3.3 Monitored Natural Attenuation. Monitored natural attenuation (MNA) relies on natural processes to attenuate impacts in groundwater. The appropriate conditions must exist for natural attenuation to remediate Site impacts in an acceptable time frame. Natural attenuation occurs through: microbes digesting constituents and changing them to water and non-toxic compounds; constituents adsorbing to soil; dilution of Site constituents through contact with un-impacted groundwater; and volatilization (from liquids to gases) within the soil. MNA is a treatment option but it is broken out as a separate general response action because it does not involve any engineered modifications to the natural environment.

Consistent with EPA (1999) policy, MNA is not considered to be a primary or presumptive remedy for the Site. Rather, MNA is viewed as a potential remedy component to be employed in conjunction with other measures such as source control. Further, MNA is not a “walk-away” remedy, but rather requires ongoing monitoring and analysis of data. MNA is viable if and where it is expected to achieve RAOs within time frames that are reasonable as compared to other technologies.

2.3.3.4 Containment. Groundwater containment is accomplished by establishing a groundwater management/attenuation zone using engineering controls. The controls prevent groundwater impacts from spreading beyond the boundaries of the management zone. Institutional controls are established inside the management zone to prevent exposure to COCs.

Groundwater containment may be achieved by installing subsurface barriers around the impacted groundwater, by extracting groundwater at the downgradient edge of the management zone, or by setting up an in-situ treatment curtain at the downgradient edge of the treatment zone.

A variety of subsurface physical barriers may be considered for groundwater containment including:

- Slurry wall;
- Sheet-pile wall;
- Stabilized/solidified soil wall; and
- Injected grout wall or floor.

A cover or cap, designed to be impermeable where leachability and/or infiltration is a concern, will be used with subsurface barriers in order to limit infiltration into the containment zone.

Groundwater extraction within highly-impacted areas is considered a removal action, as previously explained. However, if the purpose of groundwater extraction is primarily hydraulic-gradient control to prevent migration beyond a management zone, then the groundwater extraction is considered a containment action. Similarly, if any of the treatment technologies discussed previously is applied at the downgradient edge of a management zone, then such treatment is also a containment action.

2.3.3.5 Exposure Prevention. The potential for groundwater exposure may be reduced by establishing a water-use restriction for impacted groundwater. Such an institutional control may be applied through deed restrictions, zoning restrictions, or by regulation.

2.4 Screening of Remedial Technologies and Process Options

This section screens the viable RTPOs identified for each GRA in Section 2.3 to identify specific technologies that (1) achieve the RAOs identified in Section 2.2 and (2) will be used to develop remedies for the three environmental media units. To determine whether to carry the technology forward into remedy development and the detailed evaluation, RTPOs are screened based upon three screening criteria:

- Effectiveness (ability to meet the RAOs);
- Implementability; and
- Relative Cost.

The RAOs address: mitigating potentially unacceptable risks to potential receptors via exposure to impacted Site media; mitigating further migration of impacted groundwater; and reducing the mobility/volume and/or toxicity of DNAPL. The selected cleanup targets for soil, groundwater, and sediments (Section 2.2.2) are also considered to achieve RAOs. Effectiveness is evaluated based on a technology's adequacy and reliability to achieve the RAOs. Obstacles encountered are considered during the implementability evaluation of a technology. This includes practical/logistical limitations, permitting limitations, and coordination with anticipated Site use. If multiple technologies for a given medium and GRA are likely to be effective and implementable, then relative cost levels may be used to identify the most cost effective of the candidate technologies.

The RTPOs are organized according to impacted media. Within each medium, removal technologies are presented first, then treatment technologies, and finally containment and exposure-prevention technologies. Some actions (e.g., institutional control, Site access control, storm water management, and monitoring) are considered generic components of all remedies and are discussed separately.

2.4.1 Surface Soil and Shallow Subsurface Soil

The list of potential remedial technologies and process options identified for soil and solids (Section 2.3.1) were screened to identify the most viable and feasible RTPOs for impacted on-Site surface soil and shallow subsurface soil. The more common remediation technologies identified for those media are discussed in the following sections.

2.4.1.1 Excavation. Excavation physically removes some or all of the potentially impacted surface and shallow (unsaturated) soil. This is the only removal technology being considered for this medium.

Excavated soils require extensive storage and handling areas for ex-situ treatment or assessment. Implementation of this technology would require ex-situ treatment and/or off-Site disposal. Ex-situ treatment technologies and disposal/re-use options are discussed separately (Section 2.4.6). Off-Site treatment or disposal would require transportation of excavated soil volumes.

Excavation of surface and shallow soil is potentially effective at meeting certain RAOs. Specifically, excavation of soil could mitigate risks associated with potential direct-contact exposure to surface soil, provided that the material that is exposed by excavating surface soils has concentrations of soil COCs that result in estimated potential excess lifetime cancer risks equal to or less than applicable risk limits. Excavation and proper grading could also prevent potential future surface-water/sediment impacts.

Excavation of surface and shallow soil is retained for consideration in the detailed analysis of remedies. The technology may be: (1) applied to small, isolated high-concentration areas (hot spots); (2) applied in larger areas for elimination of potential surface-soil exposure risks; (3) used to consolidate materials within a management zone (AOC); and/or (4) used to improve grades for storm water control.

2.4.1.2 In-Situ Solidification/Stabilization. Solidification/stabilization (S/S) processes involve applying additives, such as cement, lime, fly ash, or polymers, to bind with the soil particles to reduce the mobility of the constituents. S/S agents can be applied in-situ with auger drilling/mixing equipment. The desired result is a solidified soil matrix of low permeability and high strength. The reduced permeability significantly reduces mass flux of all COCs during precipitation infiltration. Chemical fixation of certain COCs to the S/S matrix may also occur.

In-situ S/S is a proven technology that would be implementable. A treatability study would be necessary to evaluate the appropriate additives for Site soils. In-Situ S/S of unsaturated soil could be an effective component in preventing potential future surface-water impacts due to runoff. Also, by limiting infiltration, in-situ S/S could be a beneficial component of a groundwater remedy. In-situ S/S is retained for consideration in the detailed analysis of remedies.

2.4.1.3 In-Situ Chemical Oxidation. Chemical oxidation (ChemOx) involves applying reactive chemicals, such as hydrogen peroxide, sodium permanganate, potassium permanganate, or ozone, to chemically transform organic COCs into non-toxic or immobile substances. Complete breakdown usually results in carbon dioxide and water, while incomplete breakdown could create other toxic or non-toxic by-products. A treatability study would be necessary to evaluate the appropriate additives for Site soils. The key to a successful chemical treatment system is achieving good contact between the applied chemical and the Site constituents.

For shallow soils treatment, implementation of ChemOx could be accomplished using a variety of simple delivery mechanisms. Areas with relatively high concentrations of organic constituents, but not arsenic, would be better candidates for ChemOx than areas with relatively high arsenic impacts. However, the high natural oxidant demand of shallow Site soil (Adventus, 2004; Adventus, 2008a) may limit ChemOx effectiveness. Chemical oxidation is retained for consideration in the detailed analysis of remedies.

2.4.1.4 In-Situ Bioremediation. Biological treatment involves creating suitable environmental conditions for microorganisms to break down organic constituents into non-toxic chemicals. Aerobic enhanced bioremediation would be the most appropriate biological treatment technology for unsaturated soils and Site organic COCs. This technology involves adding oxygen, nutrients, and/or microbes to the unsaturated zone, typically via percolation of oxygen-saturated and amended water.

The breakdown products depend on the biological populations that are present. The key to a successful biological treatment system is achieving the right environment for the microorganisms that are suitable for the constituents present. A treatability study would be required. While bioremediation could be effective in immobilizing arsenic, the effectiveness of this technology for inorganic constituents is uncertain.

In-situ aerobic enhanced bioremediation of unsaturated soils is retained for consideration in the detailed analysis of remedies.

2.4.1.5 Surface Covers and Caps. Engineered caps and covers are proven technologies that would be effective at preventing potential human contact with impacted surface soils and could also prevent or minimize precipitation from infiltrating through the impacted materials.

The term cap often is associated with an impermeable engineered structure that satisfies specific construction and performance requirements, such as landfill closure requirements defined in the FAC 62-701.600(5). A cap structure is typically maintained to preserve its integrity, and other development features would not be allowed in a capped area.

A cover refers to materials placed over an area to prevent dermal contact, and to limit, but not necessarily eliminate, surface water from entering the subsurface. This approach may be practical for the Site because it would complement groundwater response actions under consideration.

Engineered surface caps and covers are considered viable technologies for the Site and will be carried forward in the evaluations. The range of types of covers and caps can extend from a one-layer vegetated soil cover to a composite multi-layer cap of soils and geotextile materials. The specific types of engineered covers and caps considered for inclusion in on-Site remedies consist of:

- Vegetative soil cover (1 to 2 feet of clean soil with grass);
- Road-base and/or gravel cover;
- Asphalt or chip seal cap;
- Concrete cap; and
- Composite (multi-layer) clay or geosynthetic clay cap.

All of the cap and cover types require continued care and maintenance. The caps and covers differ in their durability for industrial uses and in their effectiveness at preventing infiltration. The costs associated with constructing caps and covers depend upon the acreage to be covered and the type of cap or cover.

It is likely that the most appropriate cover/cap design for different areas will depend on the expected future land use at that area. For unused areas where leachability or infiltration is not a concern, a vegetative soil cover may be appropriate. Asphalt or concrete caps could be used in moderate- and high-use areas. Where needed for groundwater control, impermeable cover types are preferred. Other types of caps or covers may be appropriate and should be considered, depending on the contemplated land use.

2.4.2 DNAPL and DNAPL-Impacted Soils

The list of potential remedial technologies and process options identified for non-aqueous phase liquids such as DNAPL (Section 2.3.2) were screened to identify the most viable and feasible RTPOs. The more common remediation technologies identified for DNAPL are discussed in the following sections.

2.4.2.1 Excavation. Excavation physically removes some or all DNAPL-impacted soil, including areas of potentially mobile and residual DNAPL. Shallow excavations are described in Section 2.4.1.1. Deeper excavations can be used to remove source areas in the Surficial Aquifer, and potentially in deeper units.

Excavated soils require extensive storage and handling areas for ex-situ treatment or assessment. Dewatering requirements will be important considerations for any excavation in the saturated subsurface soil zone. Also, slope stability and shoring will be critical. In some source areas of the Site (e.g., the Former Process Area), shoring walls may be required in order to keep the limits of excavation on Site.

Beazer performed a detailed evaluation of the feasibility of soil excavation at this Site (TRC, 2005). The Source Removal Assessment Report concluded that there are no reasonable excavation options for DNAPL-impacted soils. That conclusion is based on the following:

- Large volumes of soil in the Surficial Aquifer (approximately 440,000 cubic yards) would need to be excavated and handled on-Site in order to remove the approximately 100,000 cubic yards of DNAPL-impacted soils in the Surficial Aquifer. The apparent "over-excavation" would be required to comply with Occupational Safety and Health Administration (OSHA) regulations for shoring and sloping. This large volume of soil would need to be managed on-Site with relatively little area for staging and treatment. Some or all of the excavated soil could be treated as RCRA hazardous waste.
- Off-Site incineration or disposal of the excavated material would be impractical due to: (a) regulatory land disposal restrictions, (b) limited/no availability of disposal facilities within a reasonable distance of the Site, and (c) increased environmental and safety risks associated with off-Site transportation of excavated soil.
- Excavation into the deeper HG soils is cost prohibitive (over $100M) and/or technically infeasible due to the combination of dewatering and shoring requirements as well as the depth of DNAPL impacts (to approximately 125 feet bgs).
- Source removal would not likely result in elimination of potential Site risks associated with migration of constituents into drinking water aquifers. The source removal of Surficial Aquifer materials would have no effect on the distribution and concentrations of Site-related constituents in the HG and UFA.

- Costs associated with excavation of only the Surficial Aquifer are high (estimates ranged from \$35M to over \$500M) compared to other viable risk-reduction technologies/strategies, and excavation does not result in meaningful risk reductions.

Despite the pessimistic conclusions of the source removal evaluation, excavation would result in reduction of DNAPL volume, which achieves one of the RAOs. Additionally, partial excavation may be, theoretically, technically feasible. Excavation depths up to 70 feet (approximately the top of the middle clay of the HG) are considered technically feasible. Therefore, this option is retained for further consideration in the detailed analysis of remedies.

2.4.2.2 DNAPL Recovery. The subsurface movement of DNAPL is controlled substantially by the nature of the release, the DNAPL density, interfacial tension, viscosity, porous media capillary properties, and usually to a lesser extent, hydraulic forces (Cohen and Mercer, 1993). Subsurface DNAPL may be physically removed by active or passive extraction systems. A passive recovery system allows DNAPL to naturally flow into a well bore or other collection location where it is removed. An active recovery system involves groundwater extraction to increase the hydraulic gradient toward the collection point, thereby mobilizing additional DNAPL and increasing recovery volumes. The most viable option for handling removed DNAPL is off-Site disposal. If groundwater is removed along with DNAPL, it may require treatment and disposal (see Section 2.4.5).

DNAPL has been passively recovered from five Upper Hawthorn wells as an interim action since July 2004. Approximately 1.5 gallons per week of DNAPL (total) are removed from these five wells by this passive recovery system.

An active DNAPL recovery pilot test was conducted at well PW-1 in the Surficial Aquifer from November 2004 through April 2005 (RETEC, GeoTrans, and Key, 2005). During this test, 90 gallons of DNAPL were removed (average of 4 gallons per week) and 335,000 gallons of groundwater were extracted for ex-situ treatment and publicly owned treatment works (POTW) disposal. The DNAPL to water ratio for this pilot test (0.03%) was much lower than the typical ratio (1% to 3%) for efficient DNAPL recovery systems. No measurable DNAPL accumulated in the extraction well during the 2-week monitoring period after the end of the pilot test. This indicates that DNAPL in the vicinity of PW-1 is not mobile under natural (non-pumped) conditions.

An additional active DNAPL recovery pilot was conducted in the HG at the Former North Lagoon (Key and GeoTrans, 2007; Key, 2009). Unlike the test at PW-1, the more recent pilot test used a specially-designed large diameter recovery well and a reinjection well to re-circulate recovered groundwater near the extraction point. This type of system increases hydraulic gradients, thereby enhancing DNAPL mobilization and recovery. Also, recirculation eliminates the need to treat and dispose of co-produced groundwater. During the pilot test, only a trace of DNAPL was recovered. After attempting active recovery with this system for many months, it was concluded that active DNAPL recovery was not effective at this location and depth.

The active DNAPL pilot tests were not successful, and active DNAPL recovery systems will not be carried forward in the detailed analysis of remedies. The passive DNAPL system will be carried forward, however.

2.4.2.3 In-Situ Soil Flushing. Soil flushing is a technology that enhances recovery of DNAPL, particularly DNAPL at residual saturation, in porous media. Soil flushing enhances DNAPL recovery through mobilization and/or enhanced dissolution. Chemical additives may be injected to increase DNAPL mobility by either (a) enhancing DNAPL dissolution (solvent soil flushing) or (b) reducing DNAPL viscosity using surfactants (surfactant soil flushing). Mobilized DNAPL is then captured via an active recovery system as described in Section 2.4.2.2. However, such mobilization of DNAPL can increase downgradient impacts if the entire chemically treated zone is not captured by the extraction system.

Beazer performed a screening analysis of surfactant flushing technologies for the Site and concluded that use of these technologies does not appear warranted at this Site (Sale, 2006). Surfactant-enhanced flushing in the Surficial Aquifer would be anticipated to deplete approximately 70 to 90 percent of the DNAPL, thus, 10 to 30 percent of the DNAPL would remain. Additionally, approximately 10 percent of the surfactant would be anticipated to remain in the Surficial Aquifer, creating highly reduced conditions in the aquifer that may have the adverse result of expanding plumes of aqueous-phase impacts. The approximate costs associated with surfactant flushing in the Surficial

Aquifer are very high (ranging from approximately \$100M to \$200M) when compared to other viable options. Surfactant delivery is considered technically infeasible in the lower-permeability HG.

Therefore, based on this Site-specific study, chemically-enhanced soil flushing is eliminated from further consideration in this FS.

2.4.2.4 In-Situ Thermal Desorption. Thermal treatment involves exposing the Site constituents to elevated temperatures in order to mobilize constituents for active recovery. In some cases, thermal treatment also could breakdown organic constituents into non-toxic chemicals. Waste streams such as off-gases can be created by application of thermal treatment technologies.

Beazer evaluated thermal remediation technologies for the Site to assess the potential for these technologies to enhance the overall effectiveness of remediation of mobile DNAPL and elevated concentrations of Site constituents in soil and groundwater (Haley & Aldrich, 2006). The thermal technologies evaluated include in-situ thermal desorption (ISTD), electrical resistance heating (ERH), and in-situ steam injection. In each case, DNAPL constituents are mobilized by one or more processes including dissolution, volatilization, desorption, and decreased viscosity. Mobilized constituents are collected in DNAPL extraction, groundwater extraction, and/or vapor extraction systems as required. Elevated temperatures of recovered water and vapor must be considered for design of aboveground treatment systems.

The ISTD process destructs and vaporizes constituents via thermal conduction induced by electrical heaters in “thermal wells.” The typical spacing of the “thermal wells” is approximately 5 to 10 feet apart. This technology has the advantage that very high temperatures are possible (over 300º Celsius) which can lead to complete destruction of some constituents. However, ISTD is less effective in saturated conditions and prior applications of ISTD have been small (less than 0.75 acres). In practice, uniform heating of the treatment zone is very challenging and the operating power requirements for the heating elements are significant.

More uniform heating is possible with ERH which uses subsurface electrodes to induce three- or six-phase current through the target zone. Resistance in the soil generates heat that enhances constituent mobility through increased solubility, increased desorption, decreased viscosity, and increased volatility. ERH is possible only under saturated conditions; water drips may be needed to avoid dry-out conditions. ERH preferentially heats low-permeability clays due to their physical properties. Subsurface temperatures near the boiling point of water (100º Celsius) are typical, therefore most compounds are not destroyed in-situ and require extraction and above ground treatment. Prior applications of ERH have been relatively small (less than 1.5 acres). Challenging factors of ERH include significant power supply requirements, incomplete or non-uniform heating of target area, insufficient temperatures to address high-boiling point constituents, condensation of mobilized vapor constituents in lower temperature zones, and mobilization of constituents to previously un-impacted areas.

In contrast to ERH, steam injection preferentially affects high-permeability zones. Steam is injected at wells that are screened across the target zone. As the steam zone grows, the subsurface is heated to approximately 100º Celsius. A steam zone spherically expands from the injection zone, but the exact shape and velocity of the steam zone varies depending on subsurface heterogeneities. Therefore, it is necessary to monitor subsurface temperatures in the treatment area and vicinity during steam injection. Steam and groundwater/DNAPL are then extracted. Fluids must be extracted before, during, and after steam injection to provide removal of mobilized constituents for aboveground treatment. Condensation can occur in relatively cool zones, which can cause increased constituent concentrations in those areas.

Site conditions important for the success of steam injection include availability of utilities (such as boiler fuel), and unlimited and safe access to all areas of the Site throughout application. Challenging factors for steam injection include maintaining proper steam injection rates to achieve target temperatures, designing treatment equipment to treat collected vapor and liquid flows with changing input temperatures and chemical conditions, control of steam front growth to prevent undesired conditions such as venting up to the ground surface, downward flow, or unintended constituent migration, and mobilization of constituents to previously un-impacted areas. The low-permeability units are poorly suited for treatment by this method.

Like chemically-enhanced extraction (soil flushing), all of the thermal technologies increase the mobility of DNAPL and DNAPL constituents. This allows easier extraction of DNAPL and removal of constituents from soil, but it also creates a potential for undesired constituent migration. Also, the thermal technologies all potentially require soil vapor extraction (SVE) and treatment and can cause the release of harmful steam or soil vapors to the surface.

Beazer's evaluation concluded that none of the thermal remediation technologies are applicable to the HG because: (1) vapor recovery via SVE is not possible due to the relatively low overall permeability of this unit; (2) the HG is too thick and heterogeneous to uniformly heat the entire zone to temperatures required for in-situ constituent destruction; and (3) the risk of increased migration to the UFA is too great.

A combination steam injection/ERH strategy for the Surficial Aquifer was identified as a possible remediation technology (Haley and Aldrich, 2006), including the upper clay (top five feet) of the HG. This is identified as the most viable thermal remediation strategy because it is the only strategy that has been applied at the scale of the DNAPL-impacted source areas of the Site (approximately 1 to 3 acres each). For this strategy, each of the four potentially impacted DNAPL areas would be treated in succession using the same equipment. For each area, an impermeable cap would be required to protect against steam escape, 40 to 90 steam injection wells would be needed, approximately 60 extraction wells would be needed, and a sophisticated monitoring system involving approximately 100 thermocouple strands would be installed to monitor the steam zone. The total time for remediation would be approximately 8 years. ERH would be applied in the uppermost part of the HG to prevent condensation (and increased concentrations) in the upper clay. The approximate cost for applying this thermal remediation technology was high (ranging from $50M to $100M) relative to other viable treatment technologies; the application costs would be very sensitive to rising costs of electricity and fuel and do not include potential costs for waste disposal, including water and DNAPL.

Beazer's detailed evaluation and conclusions eliminated thermally-enhanced recovery as a remedial technology for consideration (Haley and Aldrich, 2006). The decision to screen out this technology is based on: (1) the significant risk of negative effects from increased DNAPL/constituent migration; (2) the fact that the technology is not applicable in the HG where mobile DNAPL has been observed; (3) the difficulty in collecting vapors and preventing potentially harmful releases to the surface; and (4) the long remediation time that would be required.

2.4.2.5 In-Situ Solidification/Stabilization. S/S processes involve applying additives, such as cement, lime, fly ash, or polymers, to bind with the soil particles to reduce the mobility of the constituents. S/S agents can be applied in-situ with auger drilling/mixing equipment. The desired result is a solidified soil matrix of low permeability and high strength. The reduced permeability significantly reduces mass flux of all COCs during precipitation infiltration. Chemical fixation of certain COCs to the S/S matrix may also occur.

In-situ S/S is a proven technology that would be implementable. Implementability challenges increase, and costs significantly increase, with increasing depth. Smaller diameter augers (and therefore more individual application points) are required for deeper (over 25 ft) applications. A treatability study would be necessary to evaluate the appropriate additives for Site soils.

In-situ S/S of DNAPL-impacted soil could significantly reduce the mobility of DNAPL and Site COCs and the technology is implementable. Therefore, in-situ S/S is retained for consideration in the detailed analysis of remedies. The technology is considered implementable to a depth of approximately 70 feet (the top of the middle clay of the HG). Penetration of the middle clay in source areas should be avoided because of the risk of causing deeper migration of constituents.

2.4.2.6 In-Situ Bioremediation. Biological treatment involves creating suitable environmental conditions for microorganisms to breakdown organic constituents into non-toxic chemicals. Several technologies are available for aerobic or anaerobic treatment.

While potentially implementable, bioremediation in DNAPL zones would be ineffective at significantly reducing mass or rendering COCs less toxic or mobile. The time frames that would be required are extremely long compared to other potential technologies such as in-situ S/S and ISBS. Additionally, DNAPL concentrations may be toxic to the microbial populations and effective biological treatment may be limited to the aqueous-phase constituents.

Due to this likelihood of ineffectiveness, in-situ bioremediation of DNAPL zones is screened out and will not be considered in the detailed analysis of remedies.

2.4.2.7 In-Situ Chemical Oxidation. ChemOx involves applying reactive chemicals, such as hydrogen peroxide, sodium permanganate, potassium permanganate, or ozone, to chemically transform organic COCs into non-toxic or immobile substances. Complete breakdown usually results in carbon dioxide and water, while incomplete breakdown could create other toxic or non-toxic by-products. The key to a successful chemical treatment system is achieving good contact between the applied chemical and the Site constituents.

For DNAPL-impacted soils treatment, implementation of ChemOx could be accomplished using many wells screened in the target zone. The high natural oxidant demand of Surficial Aquifer Site soil (Adventus, 2004; Adventus, 2008a) would likely limit ChemOx effectiveness at reducing DNAPL volume or toxicity.

Nevertheless, because of its potential for applicability in small, isolated DNAPL hot spots, chemical oxidation is retained for the detailed analysis of remedies.

2.4.2.8 In-Situ Biogeochemical Stabilization. Combining the chemical and biological technologies, ISBS (Adventus, 2004, 2008a, 2009a, and 2009b), is a potential remediation approach for the Site. The ISBS technology uses a buffered solution of sodium permanganate and catalysts injected into the target zone to reduce the flux of COCs from residual DNAPL into the aqueous phase and to enhance the bioremediation of the aqueous-phase COCs. The ISBS technology involves the beneficial mechanisms described below:

1. Chemical and biological oxidation of DNAPL constituents, especially relatively low molecular weight constituents such as naphthalene;
2. Chemical hardening of remaining DNAPL due to proportionally higher fractions of high molecular weight constituents; and
3. Precipitation of manganese dioxide complexes at the DNAPL interface to encrust the DNAPL, thereby inhibiting dissolution of constituents into groundwater (the manganese dioxide precipitate also effectively reduces the

porosity of the aquifer matrix, thus reducing the water flux through DNAPL-impacted material).

The ISBS solution would be delivered into the target zone using an array of injection points. Relatively low injection rates would be used to avoid mobilization of DNAPL. The amount of reagent required for ISBS is approximately 5% or less of the amount of reagent required for an oxidation-only technology (Adventus, 2004; Adventus, 2008a).

ISBS bench tests using Site soil had promising results, and an ISBS pilot test was recently implemented (Adventus, 2009a and 2009b). The bench testing involved treating columns of Site soil with different solutions of potassium permanganate and sodium permanganate. The optimal combination of sodium permanganate and catalysts resulted in a substantial (95%) decrease in water flux through the treated soil column and also resulted in significantly reduced concentrations of constituents of interest (PAHs and chlorophenols).

The ISBS technology is the most feasible and promising chemical or biological treatment technology for DNAPL-impacted soils and will be considered in development of on-Site remedies. The ISBS is an innovative technology that has promise for wider applicability. If selected for inclusion in the final remedial approach, specifics regarding ISBS application will be included in the remedial design.

2.4.2.9 Physical Flow Barriers. Subsurface barriers can be installed around or downgradient of an impacted source area to prevent constituent migration. As a containment technology, this technology does not reduce the source zone mass, concentration, or toxicity unless it is used in combination with treatment technologies. Barrier systems can be used to contain any constituents that are not expected to react with or leach through the components of the containment system.

Vertical barriers (barrier walls) are created by placing impermeable subsurface vertical barriers around potentially impacted materials, thus preventing horizontal migration. Vertical barriers are typically used when the impacted materials are relatively shallow but have been successful to depths of 100 feet bgs. Barrier walls are most effective when they are keyed into an underlying aquitard. Barrier walls can be constructed as slurry walls, grout curtains, sheet pile walls, or a series of adjacent in-situ S/S points.

- Slurry wall construction involves excavating a narrow trench that is kept full of an engineered fluid or slurry. The slurry exerts hydraulic pressure against the trench walls and acts as shoring to prevent collapse.
    - Slurry wall excavations can be performed in all types of soils and below the groundwater table. In most cases the excavation will key into a low permeability layer such as clay or bedrock to assure minimal leakage under the final wall. Bentonite slurry is the most common excavation fluid used in a slurry trench. In addition to stabilizing the excavation, bentonite slurry forms a filter cake on the slurry trench walls that reduces the slurry wall's final soil permeability.
    - Slurry wall construction requires the use of heavy construction equipment and involves excavation; therefore, workroom is a factor that must be considered. Another factor to consider is slurry compatibility with Site constituents. Bentonite slurry and soil-bentonite backfills may not be able to withstand the interaction of some chemicals, although alternate slurry materials may be available to satisfy specific project compatibility requirements.
    - Slurry walls are considered to be technically effective at preventing horizontal migration and could be keyed into low permeability units in the HG. This technology will be retained for detailed evaluations.
- Grout curtains are thin, vertical, grout walls installed in the ground. They are constructed by pressure-injecting grout directly into the soil at closely spaced intervals. The spacing is selected so that each "pillar" of grout intersects the next, thus forming a continuous wall or curtain. Typical grouting materials include hydraulic cements, clays, bentonite and silicates. However, these materials may crack or may not be durable or chemically compatible. Grout curtains are similar to slurry walls although they do not require as extensive trenching. This technology will be retained for detailed evaluations.
- Sheet piles can be driven into the ground to provide a rigid barrier to contain constituents. Each sheet is designed to lock into the next sheet, and grout or gaskets are used to seal joints and minimize leaks. The use of sheet piles is limited to soils into which the sheets can be driven (that is, areas with no cobbles or boulders) and to depths of approximately 100 feet. The lifetime of steel sheet pile may be limited by corrosion, although corrosion tends to be significant only under oxidizing conditions, and subsurface impacts frequently create reducing

conditions in the aquifer. Although sheet pile barriers are an effective technology, the cost of constructing this type of barrier is usually much greater than other options. Nonetheless, this technology is retained as a potential barrier option where Site conditions preclude implementation of more cost-effective designs.

- In-situ S/S walls are constructed by applying the in-situ S/S points along a line to set up a low-permeability flow barrier. This technology would be similar in effectiveness to a grout curtain, and it could be applied down to approximately 70 feet. This technology will be retained for detailed evaluations.

It may also be advantageous to construct a horizontal physical barrier below DNAPL-impacted zones to prevent downward migration. Such a horizontal barrier could most effectively be implemented using a jet grouting technology.

2.4.3 Surficial and Hawthorn Group Groundwater

The list of potential remedial technologies and process options identified for groundwater (Section 2.3.3) were screened to identify the most viable and feasible RTPOs for groundwater in the Surficial Aquifer and HG deposits. The more common RTPOs identified for those media are discussed in the following sections.

2.4.3.1 Groundwater Extraction. Groundwater extraction is the removal of impacted groundwater via wells or drains. Extracted groundwater must be disposed of in accordance with local, state, and federal regulations and may require treatment prior to disposal. Ex-situ groundwater treatment technologies are described in Section 2.4.7.

Groundwater extraction can be employed in source areas for mass removal or groundwater extraction can be deployed as a means of hydraulic containment. Hydraulic containment consists of extracting groundwater from wells or drains that are placed such that their capture areas overlap and cover the width of the zone of impacted groundwater.

A groundwater extraction and treatment system consisting of fourteen Site-perimeter groundwater extraction wells and four source-area horizontal groundwater collection drains currently operates along the northern and eastern property boundaries in the Surficial Aquifer (Figure 1-2). The perimeter-well system, designed to control downgradient migration of Site constituents, began operation in 1995. The four horizontal groundwater collection drains were added in 2009 to reduce the potential for downward COC migration. Groundwater extraction systems are not present in the HG.

Groundwater extraction is an effective technology that can mitigate migration of impacted groundwater. It is implementable in aquifers that have moderate to large transmissivity. The permeability of the Surficial Aquifer will support effective groundwater extraction rates and corresponding zones of capture, but the hydraulic conductivity of the HG may be too low to be considered appropriate for effective groundwater extraction. Groundwater extraction in the Surficial Aquifer may be accomplished by means of traditional vertical extraction wells. Horizontal extraction wells or trenches and interceptor ditches or drains would also be appropriate for the Surficial Aquifer. Groundwater extraction is retained for consideration in remedial alternatives.

2.4.3.2 Air Sparging. Air sparging involves injecting air or oxygen into a groundwater system to accelerate dissolution of volatile compounds. Air sparging for the purpose of promoting bioremediation is treated as a separate technology (Section 2.4.3.4). A soil vapor extraction system is sometimes used in conjunction with air sparging to remove the generated vapor phase constituents from the vadose zone. Air sparging is not effective for remediating arsenic or low-volatility PAHs and would not be implementable at significant depth. Therefore, this technology is eliminated from further consideration.

2.4.3.3 In-Situ Chemical Oxidation. ChemOx involves applying reactive chemicals, such as hydrogen peroxide, sodium permanganate, potassium permanganate, or ozone, to chemically transform organic COCs into non-toxic or immobile substances. Complete breakdown usually results in carbon dioxide and water, while incomplete breakdown could create other toxic or non-toxic by-products. The key to a successful chemical treatment system is achieving good contact between the applied chemical and the Site constituents.

For groundwater, implementation of ChemOx could be accomplished using wells screened in the target zone. One or more wells could be used to set up a treatment curtain at the downgradient edge of a groundwater management zone. The high natural oxidant demand of Surficial Aquifer Site soil (Adventus, 2004; Adventus, 2008a) would likely limit ChemOx effectiveness at reducing DNAPL volume or toxicity. Successful delivery and distribution of treatment chemicals into the Upper Hawthorn or Lower Hawthorn would be difficult due to the low permeability of these units.

Nevertheless, because of its potential for applicability in small, isolated groundwater hot spots, chemical oxidation is retained for consideration in the detailed analysis of remedies. Potassium permanganate or sodium permanganate would likely be the best oxidants for Site COCs.

2.4.3.4 In-Situ Bioremediation. Biological treatment involves creating suitable environmental conditions for microorganisms to break down organic constituents into non-toxic chemicals. The breakdown products depend on the biological systems. The key to a successful biological treatment system is achieving the right environment for the microorganisms that are suitable for the constituents present at the Site. A treatability study would be required. While bioremediation could be effective in immobilizing arsenic, the effectiveness of this technology for inorganic constituents is uncertain.

Bioremediation technologies applicable to Site groundwater include:

- Aerobic enhanced bioremediation: this technology involves adding oxygen, nutrients, and/or microbes to the target groundwater zone, typically via injection of oxygen-saturated and amended water. It may also be feasible to emplace materials in wells or trenches that slowly release amendments over time. Aerobic enhanced remediation may be appropriate in aerobic groundwater zones; this technology is retained for further consideration.
- Biosparging: this is a variant of air sparging with the purpose of stimulating aerobic biological activity. The injected air may be amended with nutrients to improve performance. This technology is implementable in the Surficial Aquifer but not in deeper hydrogeologic units. It is retained for the Surficial Aquifer only.
- Anaerobic enhanced bioremediation: this technology involves adding nutrients, microbes, and/or other amendments to the target zone, typically via injection of amended water. This technology may be appropriate in anaerobic groundwater zones and is retained for further consideration.

As with other treatment technologies, bioremediation may be deployed as a containment action at the downgradient edge of a groundwater management zone.

2.4.3.5 Phytoremediation. Phytoremediation employs plants to remediate groundwater in the root zone. A variety of beneficial mechanisms can occur: (1) hydraulic containment via groundwater uptake; (2) stimulation of bioremediation in the root zone due to the natural release of nutrients from plants; (3) metabolism and degradation of COCs within plant tissue; and (4) volatilization of COCs through plant uptake and transpiration. Phytoremediation is potentially effective for Site COCs, but it would only be implementable in the Surficial Aquifer and would potentially be limited by Site activities and use. This technology is retained for consideration for the Surficial Aquifer only.

2.4.3.6 Monitored Natural Attenuation. MNA relies on natural processes to attenuate impacts in groundwater. The appropriate conditions must exist for natural attenuation to remediate Site impacts in an acceptable time frame. Natural attenuation occurs through: microbes digesting constituents and changing them to water and non-toxic compounds; constituents adsorbing to soil; dilution of Site constituents through contact with un-impacted groundwater; and volatilization (from liquids to gases) within the soil.

At this Site, natural attenuation mechanisms appear to already be limiting the area of constituent impact in groundwater caused by releases that occurred decades ago. MNA is not considered to be the primary remedy for the Site, but it may be a viable remedy component when combined with other technologies. MNA is retained as a potential groundwater action in all hydrogeologic units.

2.4.3.7 Physical Barriers to Flow. Subsurface barriers can be installed around or downgradient of an impacted area to prevent constituent migration. All of the vertically-oriented subsurface barriers (barrier walls) discussed for DNAPL containment in Section 2.4.2.9 are retained for consideration as groundwater containment technologies.

Additionally, low-permeability surface covers and caps (Section 2.4.1.5) are potentially useful in controlling inflow to management zones. Accordingly, low-permeability surface covers and caps are retained for further consideration.

2.4.3.8 Groundwater Injection for Hydraulic Control. Another means of hydraulic control is injection of clean groundwater just beyond the downgradient edge of the groundwater management zone. This can create a pressure "wall" to limit downgradient movement of impacted groundwater. However groundwater injection may promote downward migration of constituents and would not likely be as effective as other containment technologies. Therefore, groundwater injection for containment is eliminated as a technology for further consideration.

2.4.4 Surface Water and Sediment

The surface water and sediment associated with the Site includes the drainage ditch traversing through the facility property carrying surface run-off toward Springstead Creek located approximately 750 feet to the north (Figure 1-2). Constituents that may have been present in the ditch have been addressed by a recent removal action designed to remove flow impediments and sediment build-up. Other technologies may be applied to mitigate any potential future impact to surface water or sediment. The list of potential remedial technologies and process options identified for liquid media and solid media were screened to identify the most viable and feasible RTPOs for surface water and sediment, respectively. Additional sediment removal actions could be incorporated into the remedy design if appropriate, or the existing Site ditch could be abandoned (filled) and replaced by a new water conveyance system.

2.4.5 Ex-Situ Water Treatment

If groundwater extraction is part of an on-Site remedy, then the extracted groundwater may require ex-situ treatment. The need for treatment will depend on effluent limitations of the reuse/disposal option selected. Currently, groundwater extracted from the Surficial Aquifer containment system is pre-treated on Site prior to discharge to the POTW sewer system. Potential ex-situ treatment technologies for Site COCs must take into consideration the potential presence of both organic (e.g., PAHs) and inorganic (e.g., arsenic) constituents in the extracted groundwater. This may require multiple technologies to be applied in series. Treatment options generally result in treatment residuals that must be managed and disposed.

2.4.5.1 Adsorption/Absorption. Currently, treatment of Surficial Aquifer groundwater is accomplished by adsorption with granular activated carbon (GAC). In a typical GAC design, GAC is placed in a contact vessel and untreated water (influent) is allowed to flow through this vessel. The flow rate and vessel size are designed to allow for the appropriate contact time for the constituents and concentrations in the water. Multiple GAC contact vessels are often used in series and parallel treatment trains are often used. Once spent, GAC may be regenerated or disposed. This technology is relatively straightforward to implement and has been proven effective at the Site.

Another potentially applicable adsorption/absorption medium is adsorptive clay. This medium could offer improved removal efficiency over GAC, particularly if DNAPL is present in the influent. Other adsorption/absorption media, including activated alumina, forage sponge, and synthetic resins, are screened out from further consideration because they are less effective for Site COCs.

2.4.5.2 Chemical Precipitation, Coagulation/Flocculation and Physical Separation. The existing groundwater treatment system also includes an arsenic removal process consisting of chemical precipitation, coagulation/flocculation, and physical separation. A polymer is added to serve as a catalyst for precipitation and coagulation; this causes arsenic to precipitate out of solution and coagulate into relatively large suspended particles. Separation occurs when the water passes through a holding tank that serves as a clarifier; precipitate sludge containing arsenic settles at the bottom of the tank. Additional physical separation occurs through filtration in the GAC unit. These technologies are effective and implementable for inorganic COCs (i.e. arsenic). They are retained for consideration.

2.4.5.3 Ion Exchange. Ion exchange is a viable treatment option for inorganic COCs (arsenic) instead of chemical precipitation and separation. This technology employs synthetic resins that remove dissolved inorganic constituents through an anion exchange process. There are disposable synthetic resins available that specifically target arsenic. This technology could be cost effective compared to the current arsenic removal process and is retained for consideration.

2.4.5.4 Oxidation. Oxidation transforms organic COCs into non-toxic or immobile substances. Complete breakdown usually results in carbon dioxide and water. Chemical oxidation can be accomplished using ozone or hydrogen peroxide (chlorine oxidation is also feasible but would be less effective). Ultraviolet light oxidation is also viable. This technology is retained for consideration.

2.4.5.5 Aerobic Bioreactor. Aerobic bioreactors promote biodegradation of organic COCs. Trickling-filter bioreactors can be created by promoting biological growth and activity on a stationary flow-through medium (e.g., gravel, GAC). Aeration basins can also serve as aerobic bioreactors. This technology is implementable and can be cost-effective compared to adsorption/absorption. It is retained for further consideration.

2.4.5.6 Constructed Wetlands. Constructed wetlands are used to remove organic and inorganic COCs from water through natural biological and physical/chemical processes. While potentially effective for all Site constituents, Site use and layout make this technology difficult or impossible to implement. Therefore, this technology is screened out from further consideration.

2.4.6 Ex-Situ Soil/Solids Treatment

If Site soil or sediment is excavated as part of a remedial action, then it may be necessary to treat the removed solids prior to reuse/disposal. Solid residue from water treatment may also be treated. In this discussion, potential on-Site, ex-situ treatment options are discussed assuming that the treated material will be reused as fill material on Site. Off-Site treatment, such as incineration, is considered to be a disposal method for untreated soils.

2.4.6.1 Solidification/Stabilization. The S/S processes involve applying additives, such as cement, lime, fly ash, or polymers, to bind with the soil particles to reduce the mobility of the constituents. S/S agents can be applied ex-situ using a pug mill for homogenization. The desired result is a solidified soil matrix of low permeability and high strength. Chemical fixation of certain COCs to the S/S matrix may also occur.

The reduced permeability and high strength of the S/S soil makes it amenable for use as Site fill, particularly as part of a low-permeability cover or cap. Ex-situ S/S is a proven technology that would be implementable at the Site. A treatability study would be necessary to evaluate the appropriate additives for Site soils. Ex-Situ S/S of DNAPL-impacted soil could significantly reduce the mobility of Site COCs and the technology is implementable. Therefore, ex-situ S/S is retained for consideration in the detailed analysis of remedies.

2.4.6.2 Soil Washing and Solvent Extraction. Ex-situ soil washing involves flushing water through the matrix to remove dissolved COCs, adsorbed COCs, and DNAPL. A desorption/dissolution agent is often added to the water. The process can also result in separation of fine-grained soil containing relatively high COC concentrations from coarse-grained, low-concentration material.

This technology has shown very little success in effectively and efficiently removing COCs associated with the Site. The process generates a large amount of wastewater likely requiring treatment and often does not result in acceptable soil concentrations. Other, more effective technologies are available; therefore, this technology is screened out from further consideration.

Solvent extraction is similar to soil washing, but it involves non-aqueous solvent flushing. This technology has similar effectiveness issues and is also screened out from further consideration.

2.4.6.3 Chemical Oxidation. ChemOx involves applying reactive chemicals, such as hydrogen peroxide, sodium permanganate, potassium permanganate, or ozone, to chemically transform organic COCs into non-toxic or immobile substances. Complete breakdown usually results in carbon dioxide and water, while incomplete breakdown could create other toxic or non-toxic by-products. The key to a successful chemical treatment system is achieving good contact between the applied chemical and the Site constituents.

For removed soils treatment, implementation of ChemOx could be accomplished by passing an oxidant solution through the soil matrix in a controlled reactor. Wastewater requiring treatment would likely be generated. The high natural oxidant demand of Surficial Aquifer Site soil (Adventus, 2004; Adventus, 2008a) would likely limit ChemOx effectiveness at reducing COC volume or toxicity in DNAPL-impacted soils.

Nevertheless, because of its potential effectiveness for small batches of removed soil, chemical oxidation is retained for consideration in the detailed analysis of remedies.

2.4.6.4 Thermal Desorption and Incineration. On-Site thermal treatment of excavated soils could be accomplished using an on-Site thermal desorption and/or incineration process. These processes remove COCs from the water/soil matrix by volatilization, desorption, and/or combustion.

This would require construction of a significant thermal treatment facility on Site. During treatment, off-gasses would need to be monitored, collected, and treated. The final residue would be a smaller-volume, concentrated solid waste.

Though costly to implement and likely to generate community opposition, this technology is effective and implementable. Therefore, it is retained for potential consideration in the detailed analysis of remedies.

2.4.6.5 Biological Treatment. Biological treatment of soil can be accomplished by setting up aerobic biological reactors on lined beds. Land-farming is the simplest method; the soil is placed in shallow beds (approximately 18 inches) and is tilled and turned periodically for aeration. Biopiles are similar cells, but are typically thicker and involve forcing air through the soil matrix using blowers and/or vacuums. In either case, soil amendments are often applied to promote biological activity. Leachate is collected and would likely require treatment.

These technologies are implementable, though the volumetric rate of treatment will be limited by the available open-land space on Site. Also, while these technologies will be somewhat effective on organic COCs, the degree of concentration reduction is uncertain. A treatability study would be required. Land-farming and biopile treatment are retained for consideration the detailed analysis of remedies.

2.4.7 Upper Floridan Aquifer Groundwater

The list of potential remedial technologies and process options identified for groundwater (Section 2.3.3) were screened to identify the most viable and feasible RTPOs for groundwater in the UFA. Feasible RTPOs identified for the UFA are discussed in the following sections. The depth to this aquifer limits the number of viable technologies available for addressing UFA impacts.

2.4.7.1 Groundwater Extraction. Groundwater extraction is the removal of impacted groundwater via wells or drains. Extracted groundwater must be disposed of in accordance with local, state, and federal regulations and may require treatment prior to disposal. Ex-situ groundwater treatment technologies are described in Section 2.4.5.

Groundwater extraction can be employed in source areas for mass removal or groundwater extraction can be deployed as a means of hydraulic containment. Hydraulic containment consists of extracting groundwater from wells or drains that are placed such that their capture areas overlap and cover the width of the zone of impacted groundwater.

Groundwater extraction is an effective technology that can mitigate migration of impacted groundwater. It is implementable in aquifers that have moderate to large transmissivity. The permeability of the UFA will support effective groundwater extraction rates and corresponding zones of capture. Groundwater extraction in the UFA may be accomplished by means of traditional vertical extraction wells. Horizontal extraction wells or trenches and interceptor ditches or drains would not be appropriate for the UFA due to the depth of the aquifer. Therefore, groundwater extraction is retained for consideration in the detailed analysis of remedies

2.4.7.2 In-Situ Chemical Oxidation. ChemOx involves applying reactive chemicals, such as hydrogen peroxide, sodium permanganate, potassium permanganate, or ozone, to chemically transform organic COCs into non-toxic or immobile substances. Complete breakdown usually results in carbon dioxide and water, while incomplete breakdown could create other toxic or non-toxic by-products. The key to a successful chemical treatment system is achieving good contact between the applied chemical and the Site constituents.

For groundwater, implementation of ChemOx could be accomplished using wells screened in the target zone. One or more wells could be used to set up a treatment curtain at the downgradient edge of a groundwater management zone.

Because of its potential for applicability in small, isolated groundwater hot spots, chemical oxidation is retained for consideration in the detailed analysis of UFA groundwater remedial alternatives. Potassium permanganate or sodium permanganate would likely be the best oxidants for Site COCs.

2.4.7.2 Monitored Natural Attenuation. MNA relies on natural processes to attenuate impacts in groundwater. See Section 2.4.3.6 for additional details. MNA is retained for consideration in development of UFA groundwater remedial alternatives

2.4.8 Off-Site Surface Soil

The list of potential remedial technologies and process options identified for surface soil and shallow subsurface soil (Section 2.3.1) were screened to identify the most viable and feasible RTPOs for impacted off-Site surface soil. Along with institutional controls, excavation (Section 2.4.1.1) and surface covers/caps (Section 2.4.1.5) are the most feasible remediation technologies identified for off-Site surface soil.

2.5 Generic Components and Mandatory Considerations

In addition to the specific technologies identified for the various zones and impacted media, there are a number of activities that are included in most remedial strategies. The universe of remedy support options was considered and screened for applicability to the Site. Two are mandated (by statute) to be included in all remediation feasibility studies: the No Action remedy and a periodic progress review (no more than every five years) of the remedial actions implemented at a CERCLA site. Others are supplemental activities that provide generic support to achieving remedial goals at a site.

2.5.1 No Action Remedy

The no action response action is considered as a baseline for comparison and as a requirement in the EPA RI/FS Guidance (EPA, 1988a). This response action will be carried forward into the detailed analysis of remedies, in spite of the fact that this response action will not achieve Site RAOs. Applying this remedy would require shutting down the Surficial Aquifer hydraulic containment system and discontinuation of passive DNAPL recovery. Demonstration of MNA through monitoring is also not part of this remedy.

2.5.2 Five-Year Reviews

The five-year review and report evaluates the implementation and performance of a remedy in order to determine if the remedy is or will be protective of human health and the environment. Evaluation of the remedy and the determination of protectiveness should be based on, and sufficiently supported by, data and observations. The five-year reviews should be conducted either to meet the statutory mandate under CERCLA

§121(c) or as a matter of EPA policy. Consequently, five-year reviews are classified as either "statutory" or "policy." The five-year-review requirement applies to all remedial actions selected under CERCLA §121. Regions may also conduct other five-year reviews at their discretion. In general, the reviews are required whenever a remedial action results in hazardous substances, pollutants, or constituents remaining on Site above levels that allow for "unlimited use and unrestricted exposure" (40 CFR §300.430(f)(4)(ii)).

2.5.3 Institutional Controls

Institutional controls supplement an active remedy to minimize or prevent exposure to constituents that remain at a site after implementing the active remedy (EPA, 2002). The NCP emphasizes that institutional controls, such as land or water use limits imposed through administrative or political deed restrictions, are meant to supplement engineering controls during all phases of cleanup and may be a necessary component of the completed remedy.

Institutional controls potentially applicable during and after remediation of the Site include:

- Land use restrictions imposed by deed or local land-use policy. These controls can limit Site land uses to industrial/commercial uses to protect human health and eliminate potential exposure scenarios. Unrestricted residential development, day care centers, hospitals, and schools are examples of land uses that could be prohibited based on the constituents that remain on the property.
- Deed requirements for future Site development. These types of controls could impose specific improvements prior to future land uses and could impose limitations on areas of construction.
- Deed requirements for on-Site education training and safety measures. This could include OSHA safety training for Site personnel, construction worker training, and personal protection measures.
- Water use restrictions imposed by deed or regulation. Institutional controls could also limit groundwater use on Site, such as restricting the use or construction of domestic wells on Site or in an area of impacted groundwater.
- Information and education. Site signage can be required to inform the on-Site personnel/visitors and the public of potential Site hazards. A community

awareness/education program can also be set up to help the local community avoid exposure.

- Limitations on Site access. The property deed could require maintenance of the Site fence and implementation of any necessary long-term Site access controls. Fencing is currently in place to physically set the Site apart from adjacent residences and deter trespassing. The fence is effective in this function.

2.5.4 Storm Water Management

Storm water flows through the Site via the on-Site drainage ditch. Runoff from the Site, and from land parcels south of the Site (i.e., upgradient of the Site), flows into this ditch and then into Springstead Creek. In the past, there have been some measured exceedances of benchmark values specified in the Site's storm water permit; these exceedances have prompted several actions, including: (a) excavation of some sediment from the ditch in order to improve flow conditions and mitigate the potential for future water-quality exceedances, (b) revisions to the facility's stormwater management plan, (c) installation of small berms and depressions to change flow patterns, and (d) seeding of open areas to reduce erosion of sediment (and reduce dust). Additional interim measures are currently being planned to further improve stormwater (and dust) management prior to full-remedy implementation.

Comprehensive remedial strategies at CERCLA sites include long-term management of storm water to limit or control the co-migration of constituents with water flow (either overland surface run-off or subsurface groundwater/leachate). Storm water management is a generic remedy component that prevents water caused by storm runoff from coming into contact with contaminated media (e.g., surface soil or source material). Any land disturbance that results from remedy implementation will require consideration of effects on runoff quantity and quality. Proper storm water management mitigates flash runoff events from the Site and prevents surface water from contacting media with elevated constituent concentrations.

2.5.4.1 Grading and Contouring. Storm water runoff can be managed by controlling the direction and location of its flow within the Site. This often consists of grading and contouring the Site's topography to divert storm water toward collection points, away from constituent sources, and into pathways that carry it off-Site before it can infiltrate through subsurface media with elevated constituent concentrations. Both natural and/or engineered water pathways (e.g., drainage ditches, drainage trenches, leachate collection features, culverts, etc.) are used for this purpose. Grading and contouring likely will occur after completion of other surface soil remedies (e.g., excavation, capping, etc.), so this storm water management option could be implemented anyway.

2.5.4.2 Engineered Storm Water Conveyance. Another storm water management option is construction of new engineered storm water conveyances. New conveyance systems might include ditches, underground pipes (culverts) and/or a storm surge energy dissipation devices to control erosion and/or prevent flash flooding. Construction of underground conveyances for storm water flow could be accomplished in conjunction with other remedial construction activities.

2.5.4.3 Storm Water Retention/Detention Pond. High storm water volumes in relatively impervious areas often cause flash flooding and erosion problems if not addressed. Two methods for addressing high-volume storm water flows are detention ponds and retention ponds. Detention ponds detain water in low lying areas and are designed to collect large volumes of storm water during peak storm events thereby slowing its flow rate. When the storm event ends, detention ponds slowly empty by natural infiltration and percolation into groundwater. In contrast, retention ponds are designed to not dry out; they allow water to drain through an outlet toward downgradient locations. With either technology, sediment that potentially carries chemical constituents would settle into the base of the pond, limiting any downstream water-quality impacts.

The appropriateness of detention ponds versus retention ponds is dictated by the normal flow conditions of the surface water body being controlled: perennial streams would typically be managed by retention ponds but ephemeral (intermittent) streams usually call for detention ponds. Both types of ponds retain suspended sediment. The drainage ditch at the Site is normally dry; therefore, a detention pond design would likely be most appropriate, provided that infiltration from the pond does not result in leaching of COCs to groundwater.

2.5.5 Monitoring

Monitoring (i.e. sampling and analysis) of constituent concentrations in environmental media is the established method for tracking the progress of remediation or the trends in Site conditions. Monitoring for soil may include confirmation sampling done to demonstrate removal of the soil with elevated concentrations. Long-term monitoring of groundwater is a common method for tracking remediation progress.

2.5.6 Post-Remedy Site Restoration

Comprehensive remedial strategies at CERCLA sites address post-remedy disposition of the Site. This may consist of Site grading and contouring to return the Site to some useable or aesthetically acceptable condition. Other post-remedy activities may include abandonment of unneeded wells and treatment facilities.

2.6 Selection of Representative Technologies

This subsection summarizes the technologies that will be carried forward in the evaluations based on the screening evaluations presented in Sections 2.4 and 2.5. These technologies may be combined into more complex remedies.

2.6.1 On-Site Surface Soil and Shallow Subsurface Soil

The remediation technologies identified through the screening process for on-Site surface and shallow subsurface soils with COC concentrations resulting in potential risks that exceed applicable risk limits include: excavation, in-situ S/S, in-situ ChemOx, in-situ bioremediation, and surface caps and covers.

2.6.2 DNAPL and DNAPL-Impacted Soils

The remediation technologies identified through the screening process for DNAPL, and DNAPL-impacted soil, include:

- Excavation (up to 70 ft deep);
- Passive DNAPL recovery;
- In-situ S/S (up to 70 ft deep);
- In-situ ChemOx;
- ISBS; and
- Subsurface physical flow barriers (up to 70 ft deep).

2.6.3 Surficial and Hawthorn Group Groundwater

The remediation technologies identified through the screening process for groundwater with impacts greater than GCTLs include:

- Groundwater extraction;
- In-situ ChemOx;
- In-situ bioremediation;
- Phytoremediation (Surficial Aquifer only);
- MNA; and
- Subsurface physical flow barriers (up to 70 ft deep).

2.6.4 Surface Water and Sediment

Specific technologies for managing surface water (e.g., storm water flow) quantity and quality, and for managing sediment, were evaluated and screened (Section 2.5.4). Potential future exposures to COCs in surface water/storm water and sediment may be mitigated through use of the following technologies:

- Engineered water conveyances;
- Sediment removal;
- Engineered detention/retention ponds; and
- Sediment cover.

2.6.5 Ex-Situ Water Treatment and Disposal

Potential technologies for treatment of extracted groundwater and remediation-byproduct wastewater include:

- Adsorption/absorption using GAC or adsorptive clay;
- Chemical precipitation, coagulation/flocculation, and physical separation;
- Ion exchange;
- Oxidation; and
- Aerobic bioreactor.

The need for treatment and degree of required treatment will depend on effluent limitations appropriate for the disposal method. Potential disposal options for untreated or treated water are:

- Reclaim for on-Site use as process make-up water;
- Reclaim for on- or off-Site non-potable use (e.g. irrigation);
- Reintroduction to groundwater via injection, or infiltration basin/gallery;

- Surface-water discharge (on-Site ditch or Springstead Creek); and
- POTW discharge.

2.6.6 Ex-Situ Soil/Solids Treatment and Disposal

Potential technologies for on-Site treatment of excavated soil and wastewater treatment residue include: S/S, ChemOx, thermal treatment (desorption and/or incineration), and bioremediation (land-farming or biopile treatment). The treated soil from the above on-Site processes would be reused on Site as fill and/or cover material. Alternatively, untreated soil could be shipped to:

- Off-Site incinerator;
- Off-Site recycling center: recycled soil could potentially be used in asphalt mixes and could be used as an energy source; or
- Off-Site landfill (for some Site soil, this option may not be feasible in this country due to land disposal restrictions).

2.6.7 DNAPL Disposal

Any recovered DNAPL could potentially be recycled and used at a creosote wood-treating facility or at a coal tar processing facility. Otherwise it would be shipped for off-Site treatment (by incineration) and disposal. Currently, recovered DNAPL is shipped for off-Site treatment and disposal.

2.6.8 Upper Floridan Aquifer Groundwater

The remediation technologies identified through the screening process for UFA groundwater with impacts greater than GCTLs include: groundwater extraction, in-situ chemical oxidation, and MNA.

2.6.9 Off-Site Surface Soil

The remediation technologies identified through the screening process for impacted off-Site surface soil include excavation and surface caps/covers. The current residential land use limits the number of technologies that can be safely and efficiently implemented in that area.

3.0 Development of Alternatives

Various RTPOs identified and screened in Sections 2.4 through 2.6 are assembled into remedies for each of the three environmental media units (i.e., on-Site media [excluding UFA groundwater], UFA groundwater, and off-Site surface soil). Media-specific and zone-specific RTPOs are assembled so that RAOs for source material, and for non-source media impacted by constituents associated with Site operations are addressed or achieved. The final Site remedial alternative will consist of a set of three remedies: one for the on-Site media, one for the UFA, and one for the off-Site surface soil unit.

The remedies for impacted on-Site media are evaluated in Section 3.1. Remedies for UFA groundwater and off-Site surface soil are evaluated in Sections 3.2 and 3.3, respectively, separate from the remedies for on-Site media. Each is described in terms of the basic components, implementation details, viable design options, and various effectiveness assumptions. Additional information may be needed to supplement available information in order to complete a detailed design of the comprehensive remedial alternative that is ultimately selected. The actual design of any of the remedies may require slight variations from the concepts discussed below to accommodate Site-specific conditions or updated Site information.

3.1 On-Site Remedies

The list of on-Site media remedies (OnR) includes the obligatory No Action remedy (remedy OnR-1) and a remedy representing continuation of ongoing remedial actions (remedy OnR-2) with addition of surface-soil grading/covers. Also considered are two on-Site alternatives including removal of source areas (OnR-3A and OnR-3B), two alternatives for in-situ treatment of source areas (OnR-4A and OnR-4B), and seven containment alternatives that involve different levels of source-area treatment (OnR-5A through OnR-5G). Table 3-1 summarizes the thirteen on-Site media remedies; each is discussed in Sections 3.1.2 through 3.1.14 below. Remedial components that are common to multiple alternatives are described in more detail in Section 3.1.15.

3.1.1 Remedial Strategy

The remedies developed for this Site are based on the supportable assumption that the original source areas were lagoons, surface soils and shallow subsurface soils at four delineated areas on Site: the Former North Lagoon, the Former South Lagoon, the

Former Drip Track area and the Former Process Area (at the southeast quadrant of the Site property). Subsequent constituent migration through the subsurface is assumed to have originated from these four primary source areas. The vertical connections between the various layers or depths of geologic zones under, and downgradient of, the Site were considered as the remedies were developed.

The assembly of remedial technologies also acknowledges synergism and complementation among and between the various technologies. Most OnRs address or achieve RAOs by one of three primary mechanisms: (1) removing COC mass, primarily via excavation (removal response), (2) treating the COC mass in place (treatment response), or (3) containing COCs in place with, in some cases, treatment of primary source areas (containment/treatment response). However, no single technology is expected, or designed, to provide complete clean-up of any single medium or constituent.

3.1.2 On-Site Remedy OnR-1: No Action

The No Action remedy is presented as a baseline for comparison only, as required by the NCP. Under the No Action remedy, all active and passive Site activities, including groundwater extraction, DNAPL collection and groundwater monitoring, would cease. Furthermore, there would be no deed restrictions or Site security controls to prevent use of Site groundwater, limit exposures to Site soil, or restrict certain kinds of future development.

3.1.2.1 Remedy Components. This remedy would involve discontinuation of the following ongoing actions:

- The existing Surficial Aquifer groundwater extraction system;
- The on-going groundwater monitoring; and
- The on-going passive DNAPL recovery actions.

3.1.2.2 Implementation Details. The No Action remedy can be readily implemented. Shutting down the existing groundwater extraction system, groundwater monitoring, and DNAPL collection can be easily coordinated. The No Action remedy does not require any institutional controls, monitoring, construction or maintenance.

3.1.2.3 Effectiveness Assumptions. There are no effectiveness assumptions associated with the No Action remedy. While natural attenuation processes will occur, this remedy does not include any monitoring to evaluate the degree of concentration reductions that will occur.

3.1.3 On-Site Remedy OnR-2: Continue Current Actions with Surface Regrading/Covers

This remedial alternative represents a minimal action potentially sufficient to meet RAOs. It includes continuing the current interim remedial measures: Surficial Aquifer groundwater extraction/treatment, groundwater monitoring, and passive DNAPL recovery. Additionally, most of the Site would be regraded and surface covers placed to prevent direct exposure to soil with elevated levels of constituents. MNA and institutional controls are also part of this remedy. Remedy OnR-2 is depicted in Figure 3-1a in cross-section and in Figure 3-1b in plan view.

3.1.3.1 Remedy Components. This remedy includes the following primary components:

- Grading of Site soil and installation of soil covers and stormwater controls;
- Continued operation of the Surficial Aquifer extraction and treatment system;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures;
- Continuation of Passive DNAPL recovery in the Upper Hawthorn; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water, or groundwater.

3.1.3.2 Implementation Details. All of the components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-1b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.

- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. Eventually, once concentrations exceeding GCTLs are confined to the capture zones of the source-area horizontal drains, some or all of the perimeter wells of this system may be shut down. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.9 describes continuation of the passive DNAPL recovery program using five Upper Hawthorn wells in source areas.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.3.3 Effectiveness Assumptions. This remedy provides protection from potential soil exposure through the use of covers over areas that have constituent concentrations that result in the estimated potential risks that exceed applicable risk limits. The final grading and cover design will be evaluated in the context of expected future land use.

Collection of DNAPL in five Upper Hawthorn source area wells will continue to remove source mass at a slow rate. By operating the Surficial Aquifer source area containment system, it is assumed that COC migration away from source areas, both horizontally and vertically, will be controlled. This will allow for the remaining COC mass dissolved in groundwater or in residual DNAPL form in the HG, to be naturally attenuated.

For some period of time, it will be necessary to operate the perimeter extraction wells in the Surficial Aquifer to prevent off-Site migration of COCs exceeding GCTLs. Monitoring may also trigger contingent actions in the HG, such as chemical oxidation.

3.1.4 On-Site Remedy OnR-3A: Removal – Surficial Aquifer Excavation

This remedy includes excavating soil in the four source areas to the base of the Surficial Aquifer, approximately 25 feet below surface, treating the excavated soil by ex-situ S/S and returning most of this material to the excavations. Alternate material management options are discussed in Section 3.1.4.2.3, below. Some of the solidified material will be incorporated into covers over the excavated areas and much of the Site. Vertical retaining/barrier walls will be installed to the top of the middle clay unit of the HG to provide: (1) shoring for the excavations and (2) physical barriers to horizontal migration in the Upper Hawthorn. Remedy OnR-3A is depicted in Figure 3-2a in cross-section and in Figure 3-2b in plan view.

3.1.4.1 Remedy Components. This remedy includes the following components:

- ChemOx or ISBS treatment applied at existing Upper and Lower Hawthorn wells in source areas;
- Excavation of source areas to the HG upper clay;
- Installation of an encircling vertical retaining/barrier wall around each source area to the HG middle clay;
- On-Site treatment of excavated soil (S/S or alternate material management options as discussed in Section 3.1.4.2.3 below);
- Return of treated soil to the excavated areas with use of excess treated soil as a base layer in cover design;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of this system;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.4.2 Implementation Details

3.1.4.2.1 Excavation and barrier walls. A vertical retaining/barrier wall will be installed to encircle each source area and to extend vertically to the top of the HG middle clay, approximately 65 feet deep. Conceptually, these walls will be cement/bentonite slurry walls, though other types of retaining/barrier walls could be used. The total length of the barrier walls will be approximately 4,800 feet and the total vertical square footage will be 314,000 feet^2.

Within the retaining walls, soil will be excavated to the bottom of the Surficial Aquifer (HG upper clay), approximately 25 feet. This will be done one source area at a time and will require dewatering of the Surficial Aquifer. The total volume of soils removed from source areas will be approximately 280,000 cubic yards (some over-excavation of the delineated source areas is expected). Removed soils will be staged for treatment north of the Former Drip Track. A 500 gpm portable water treatment plant will be operated in preparation for and during excavation activities.

The excavation will require demolition/dismantling of foundations and below-grade utilities/structures in the Former Process Area and at the Former Drip Tracks. The excavation will also necessitate abandonment of some existing monitoring wells.

Excavated material will be treated on Site (Section 3.1.15.4) and returned to the excavation. Alternatively, another materials management option may be employed as described in Section 3.1.4.2.3.

3.1.4.2.2 Other remedial components. The remaining components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-2b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.

- Section 3.1.15.4 describes ex-situ soil treatment (unless material is transported off-Site, see Section 3.1.4.2.3).
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The horizontal drain near the former South Lagoon is abandoned in this alternative. Parts of the system would be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, both Upper Hawthorn and Lower Hawthorn wells in source areas would be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.4.2.3 Design Options. If this remedy is selected as the final remedy, design options that do not change the overall nature of the remedial response will be considered. These design options include, but are not limited to:

- Use of one or more alternative soil treatment processes such as chemical oxidation, thermal treatment, or biological treatment; or
- Transport of untreated excavated soils to an off-Site disposal/recycling center with imported clean fill used in excavations (which would obviate the need for covers over the excavated areas).

While off-Site treatment and/or disposal is an option for this remedy, it should be noted that the analysis of TRC (2005) indicated that off-Site treatment and/or disposal of excavated source-area soil would be, at a minimum, extremely challenging to implement, and would likely be infeasible. This option would also increase costs substantially.

3.1.4.3 Effectiveness Assumptions. Excavation and treatment of the source material will reduce the potential for ongoing groundwater impacts. It is assumed that the material returned to the excavation will have a reduced mass of COCs and/or that the mobility of COCs in this material will be significantly reduced relative to the current source area soil.

Barrier walls that extend to the HG middle clay will prevent lateral migration of DNAPL or groundwater from source areas. Downward migration will be limited by the excavation and replacement actions in the Surficial Aquifer and by the relatively low permeability of the HG middle clay (and lower clay).

This remedy provides protection from potential soil exposure through the use of covers over areas that have constituent concentrations that result in the estimated potential risks that exceed applicable risk limits. The final grading and cover design will be evaluated in the context of expected future land use.

Continued operation of the Surficial Aquifer containment system will control COC migration both horizontally and vertically. After some period of pumping, and depending on monitoring data, this system may be shut down.

3.1.5 On-Site Remedy OnR-3B: Removal – Excavation to Middle Clay

This remedy includes excavating soil in the four source areas to the middle clay of the HG, approximately 65 feet below surface, treating the excavated soil by ex-situ S/S, and returning most of this material to the excavations. Alternate material management options are discussed in Section 3.1.5.2.3, below. Some of the solidified material will be incorporated into covers for the excavated areas and for much of the Site. Remedy OnR-3B is depicted in Figure 3-3a in cross-section and in Figure 3-3b in plan view.

3.1.5.1 Remedy Components. This remedy includes the following components:

- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;

- Excavation of source areas to the HG middle clay with 2:1 side-slopes and vertical shoring where necessary;
- On-Site treatment of excavated soil (S/S or alternate material management options as discussed in Section 3.1.4.2.3 below);
- Return of treated soil to the excavated areas with use of excess treated soil as a base layer in cover design;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of this system (source area horizontal collection drains are abandoned);
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.5.2 Implementation Details

3.1.5.2.1 Excavation. Soil will be excavated to the bottom of the Upper Hawthorn (to the HG middle clay), approximately 65 feet. This will be done one source area at a time and will require dewatering of the Surficial Aquifer and Upper Hawthorn. The total volume of soils removed from source areas will be approximately 1,800,000 cubic yards. Removed soils will be staged for treatment north of the Former Drip Track. A 700 gpm portable water treatment plant will be operated in preparation for and during excavation activities.

The excavation will require demolition/dismantling of foundations and below-grade utilities/structures in the Former Process Area and at the Former Drip Tracks. The excavation will also necessitate abandonment of some existing monitoring wells.

Excavated material will be treated on Site (Section 3.1.15.4) and returned to the excavation. Alternatively, another materials management option may be employed as described in Section 3.1.5.2.3.

3.1.4.2.2 Other remedial components. The remaining components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-3b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.4 describes ex-situ soil treatment (unless material is transported off-Site, see Section 3.1.5.2.3).
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The horizontal drains near the source areas would be abandoned in this alternative. Parts of the system would be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas would be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.4.2.3 Design Options. If this remedy is selected as the final remedy, design options that do not change the overall nature of the remedial response will be considered. These design options include, but are not limited to:

- Use of one or more alternative soil treatment processes such as chemical oxidation, thermal treatment, or biological treatment; and

- Transport of untreated excavated soils to an off-Site disposal/recycling center with imported clean fill used in excavations (which would obviate the need for covers over the excavated areas).

While off-Site treatment and/or disposal is an option for this remedy, it should be noted that the analysis of TRC (2005) indicated that off-Site treatment and/or disposal of excavated source area soil would be, at a minimum, extremely challenging to implement, and would likely be infeasible. This option would also increase costs substantially.

3.1.5.3 Effectiveness Assumptions. The effectiveness assumptions for this alternative are similar to those of OnR-3A discussed in Section 3.1.4.3 except that the area and volume of soil treated is greatly increased.

3.1.6 On-Site Remedy OnR-4A: In-Situ Treatment – Solidification/ Stabilization to Middle Clay

This remedy includes ISS/S of impacted soil from the ground surface to the top of the middle clay unit of the HG (approximately 65 feet bgs) in the four source areas. Excess soil will be treated by ex-situ S/S and used as a base layer for surface covers. Remedy OnR-4A is depicted in Figure 3-4a in cross-section and in Figure 3-4b in plan view.

3.1.6.1 Remedy Components. This remedy includes the following components:

- ISS/S to the middle clay unit of the HG in the four source areas;
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;
- Ex-situ S/S of excess soil for use as a base layer in cover design;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of this system;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.6.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-4b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.4 describes ex-situ soil treatment that will be applied to excess soil resulting from ISS/S. The treated soil will be used as a base material for surface covers.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. Parts of the system would be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.7 describes the implementation of ISS/S in source areas. For this alternative ISS/S will be applied from the surface to the HG middle clay, approximately 65 feet deep.
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas would be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.6.3 Effectiveness Assumptions. ISS/S treatment of the source material in the Surficial Aquifer and Upper Hawthorn will reduce the potential for ongoing groundwater impacts. It is assumed that the COCs in the treated material will become effectively immobile.

This remedy provides protection from potential soil exposure through the use of covers over areas that have constituent concentrations that result in estimated potential risks that exceed applicable risk limits. The final grading and cover design will be evaluated in the context of expected future land use.

Continued operation of the Surficial Aquifer containment system will control COC migration both horizontally and vertically. After some period of pumping, and depending on monitoring data, this system may be shut down.

3.1.7 On-Site Remedy OnR-4B: In-Situ Treatment – Solidification/ Stabilization and Biogeochemical Stabilization

This remedy includes ISS/S of source area impacted soil from the ground surface to the top of the upper clay unit of the HG (approximately 25 feet below ground surface), with ISBS in the Upper Hawthorn below the ISS/S areas. Excess soil will be treated by ex-situ solidification/stabilization and used as a base layer for surface covers. This remedy is similar to remedy OnR-4A except that ISBS replaces ISS/S in the Upper Hawthorn. Remedy OnR-4B is depicted in Figure 3-5a in cross-section and in Figure 3-5b in plan view.

3.1.7.1 Remedy Components. This remedy includes the following components:

- ISS/S to the upper clay unit of the HG in the four source areas;
- ISBS in the Upper Hawthorn below the ISS/S treatment zones;
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;
- Ex-situ S/S of excess soil for use as a base layer in cover design;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of this system;

- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.7.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-5b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.4 describes ex-situ soil treatment that will be applied to excess soil resulting from ISS/S. The treated soil will be used as a base material for surface covers.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. Parts of the system would be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.7 describes the implementation of ISS/S in source areas. For this alternative ISS/S will be applied from the surface to the HG upper clay, approximately 25 feet deep.
- Section 3.1.15.8 describes the implementation of ISBS in source areas. For this alternative, ISBS would be applied in the Upper Hawthorn (from approximately 30 feet to 65 feet below surface).
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas would be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.

- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.7.3 Effectiveness Assumptions. ISS/S treatment of the source material in the Surficial Aquifer and ISBS treatment in the Upper Hawthorn will reduce the potential for ongoing groundwater impacts. It is assumed that some COC mass will be removed and COCs in the treated material will become effectively immobile. There will also be some benefit realized in the Lower Hawthorn because the ISBS solution would likely migrate downward along pathways that DNAPL had migrated. Other effectiveness assumptions are similar to those of alternative OnR-4A (Section 3.1.6.3).

3.1.8 On-Site Remedy OnR-5A: Containment/Treatment – Barrier Wall

This remedy is primarily a containment action that includes installing a vertical barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. The barrier wall will limit groundwater inflow to (and outflow from) DNAPL-impacted areas. A capped soil-consolidation area will be established inside the barrier-wall for soil excavated during on- or off-Site remedy construction and/or regrading. Outside the barrier wall, surface regrading and covers will eliminate potential exposure to soil with constituent concentrations that result in estimated potential risks that exceed applicable risk limits. Passive DNAPL recovery will continue at five source area wells in the Upper Hawthorn and operation of a modified version of the Surficial Aquifer groundwater extraction system will continue until it is no longer needed. Remedy OnR-5A is depicted in Figure 3-6a in cross-section and in Figure 3-6b in plan view.

3.1.8.1 Remedy Components. This remedy includes the following components:

- A single encircling vertical barrier wall around all four source areas to the HG middle clay;
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas; Establishment of a capped soil-consolidation area;
- Surface grading and covering for most of the Site with installation of stormwater controls;

- Continued operation of the northern perimeter wells of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of these wells;
- Continued operation of the horizontal collection drains of the Surficial Aquifer extraction and treatment system as needed for hydraulic control;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures;
- Continued passive DNAPL recovery at wells HG-16S, HG-10S, HG-12S, HG-15S, and HG-11S; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.8.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-6b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.3 describes the establishment of a soil consolidation area within the extents of the subsurface barrier wall. Soil placed in this area will be capped to prevent infiltration into source areas and reduce leaching.
- Section 3.1.15.5 describes the installation of the subsurface barrier wall encircling all source areas.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The barrier wall will eliminate the need for the southernmost set of perimeter wells. The horizontal drains within the slurry wall will be used as needed for hydraulic control. Other parts of the system will be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.

- Section 3.1.15.9 describes continuation of the passive DNAPL recovery program using five Upper Hawthorn wells in source areas.
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas will be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.8.3 Effectiveness Assumptions. A vertical barrier wall that extends to the HG middle clay will prevent lateral migration of groundwater from source areas. Other effectiveness assumptions are similar to those discussed in previous sections, particularly Section 3.1.3.3.

3.1.9 On-Site Remedy OnR-5B: Containment/Treatment – Barrier Wall plus In Situ Biogeochemical Stabilization in the Upper Hawthorn

This remedy is a combination of containment and treatment remedies that adds ISBS in the Upper Hawthorn to the prior remedy, OnR-5A. This remedy includes installing a vertical barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. The barrier wall will limit groundwater inflow to (and outflow from) DNAPL-impacted areas. A capped soil-consolidation area will be established inside the barrier-wall extents for excavated soil. Outside the barrier wall, surface regrading and covers will eliminate potential exposure to soil with constituent concentrations that result in estimated potential risks that exceed applicable risk limits. ISBS injections will take place in the Upper Hawthorn to treat DNAPL and reduce COC mobility. Operation of a modified version of the Surficial Aquifer groundwater extraction system will continue until it is no longer needed. Remedy OnR-5B is depicted in Figure 3-7a in cross-section and in Figure 3-7b in plan view.

3.1.9.1 Remedy Components. This remedy includes the following components:

- A single encircling vertical barrier wall around all four source areas to the HG middle clay;
- Establishment of a capped soil-consolidation area;
- ISBS in the Upper Hawthorn at each source area;
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the northern perimeter wells of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of these wells;
- Continued operation of the horizontal collection drains of the Surficial Aquifer extraction and treatment system as needed for hydraulic control;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.9.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-7b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.3 describes the establishment of a soil consolidation area within the extents of the subsurface barrier wall. Soil placed in this area will be capped to prevent infiltration into source areas and reduce leaching.
- Section 3.1.15.5 describes the installation of the subsurface barrier wall encircling all source areas.

- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The barrier wall will eliminate the need for the southernmost set of perimeter wells. The horizontal drains within the slurry wall will be used as needed for hydraulic control. Other parts of the system will be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.8 describes the implementation of ISBS in source areas. For this alternative, ISBS would be applied in the Upper Hawthorn (from approximately 30 feet to 65 feet below surface).
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas will be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.9.3 Effectiveness Assumptions. Many of the effectiveness assumptions for this alternative are the same as those of OnR-5A. Additionally, the ISBS treatment in the source areas of the Upper Hawthorn will limit COC mobility and will reduce downward groundwater flow through DNAPL zones.

3.1.10 On-Site Remedy OnR-5C: Containment/Treatment – Barrier Wall plus In Situ Biogeochemical Stabilization in the Surficial Aquifer

This remedy is a combination of containment and treatment remedies that is similar to the prior remedy (OnR-5B), but it has ISBS in the Surficial Aquifer rather than the Upper Hawthorn. This remedy includes installing a vertical barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. The barrier wall will limit groundwater inflow to (and outflow from) DNAPL-impacted areas. A capped soil-consolidation area will be established inside the barrier-wall extents for excavated soil.

Outside the barrier wall, surface regrading and covers will eliminate potential exposure to soil with constituent concentrations that result in estimated potential risks that exceed applicable risk limits. ISBS injections will take place in the Surficial Aquifer to treat DNAPL and reduce COC mobility. Operation of a modified version of the Surficial Aquifer groundwater extraction system will continue until it is no longer needed. Remedy OnR-5C is depicted in Figure 3-8a in cross-section and in Figure 3-7b in plan view. Note that the only difference between OnR-5B and OnR-5C is the depth of the ISBS treatment; thus, the plan view for these two remedies is shown on the same figure.

3.1.10.1 Remedy Components. This remedy includes the following components:

- A single encircling vertical barrier wall around all four source areas to the HG middle clay;
- Establishment of a capped soil-consolidation area;
- ISBS in the Surficial Aquifer at each source area;
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the northern perimeter wells of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of these wells;
- Continued operation of the horizontal collection drains of the Surficial Aquifer extraction and treatment system as needed for hydraulic control;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures;
- Continued passive DNAPL recovery at wells HG-16S, HG-10S, HG-12S, HG-15S, and HG-11S; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.10.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-7b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.3 describes the establishment of a soil consolidation area within the extents of the subsurface barrier wall. Soil placed in this area will be capped to prevent infiltration into source areas and reduce leaching.
- Section 3.1.15.5 describes the installation of the subsurface barrier wall encircling all source areas.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The barrier wall will eliminate the need for the southernmost set of perimeter wells. The horizontal drains within the slurry wall will be used as needed for hydraulic control. Other parts of the system will be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.8 describes the implementation of ISBS in source areas. For this alternative, ISBS would be applied in the Surficial Aquifer (from surface to an approximate depth of 25 feet).
- Section 3.1.15.9 describes continuation of the passive DNAPL recovery program using five Upper Hawthorn wells in source areas.
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas will be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.

- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.10.3 Effectiveness Assumptions. Effectiveness assumptions for this remedy are similar to those of alternative OnR-5B. In this Alternative the ISBS treatment is designed to treat the majority of the source area mass in the Surficial Aquifer rather than treating a smaller mass and creating a DNAPL barrier in the HG.

3.1.11 On-Site Remedy OnR-5D: Containment/Treatment – Barrier Wall plus In Situ Solidification/Stabilization in the Surficial Aquifer

This remedy is a combination of containment and treatment remedies that is similar to the prior remedy (OnR-5C), but it has ISS/S in the Surficial Aquifer rather than ISBS. This remedy includes installing a vertical barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. The barrier wall will limit groundwater inflow to (and outflow from) DNAPL-impacted areas. A capped soil-consolidation area will be established inside the barrier-wall extents for excavated soil and excess soil from ISS/S implementation. Outside the barrier wall, surface regrading and covers will eliminate potential exposure to soil with constituent concentrations that result in estimated potential risks that exceed applicable risk limits. ISS/S mixing will take place in the Surficial Aquifer to treat DNAPL and reduce COC mobility. Operation of a modified version of the Surficial Aquifer groundwater extraction system will continue until it is no longer needed. Remedy OnR-5D is depicted in Figure 3-9a in cross-section and in Figure 3-9b in plan view.

3.1.11.1 Remedy Components. This remedy includes the following components:

- A single encircling vertical barrier wall around all four source areas to the HG middle clay;
- ISS/S to the upper clay unit of the HG in the four source areas;
- ChemOx or ISBS treatment applied at existing Upper and Lower Hawthorn wells in source areas;
- Establishment of a capped soil-consolidation area;
- Surface grading and covering for most of the Site with installation of stormwater controls;

- Continued operation of the northern perimeter wells of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of these wells;
- Continued operation of the horizontal collection drains of the Surficial Aquifer extraction and treatment system as needed for hydraulic control;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.11.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-9b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.3 describes the establishment of a soil consolidation area within the extents of the subsurface barrier wall. Soil placed in this area will be capped to prevent infiltration into source areas and reduce leaching.
- Section 3.1.15.5 describes the installation of the subsurface barrier wall encircling all source areas.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The barrier wall will eliminate the need for the southernmost set of perimeter wells. The horizontal drains within the slurry wall will be used as needed for hydraulic control. Other parts of the system will be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.7 describes the implementation of ISS/S in source areas. For this alternative, ISS/S would be applied in the Surficial Aquifer (from surface to an approximate depth of 25 feet).

- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Upper Hawthorn and Lower Hawthorn wells in source areas will be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.11.3 Effectiveness Assumptions. The effectiveness assumptions for this alternative are similar to those of alternative OnR-5C. The only difference is the use of ISS/S as the treatment mechanism instead of ISBS.

3.1.12 On-Site Remedy OnR-5E: Containment/Treatment – Barrier Wall plus In Situ Biogeochemical Stabilization in the Surficial Aquifer and Upper Hawthorn

This remedy is a combination of containment and treatment remedies that includes ISBS treatment of source areas from the surface to the HG middle clay, in effect combining alternatives OnR-5B and OnR-5C. This remedy includes installing a vertical barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. The barrier wall will limit groundwater inflow to (and outflow from) DNAPL-impacted areas. A capped soil-consolidation area will be established inside the barrier-wall extents for excavated soil. Outside the barrier wall, surface regrading and covers will eliminate potential exposure to soil with constituent concentrations that result in estimated potential risks that exceed applicable risk limits. ISBS injections will take place in the Surficial Aquifer and Upper Hawthorn to treat DNAPL and reduce COC mobility. Operation of a modified version of the Surficial Aquifer groundwater extraction system will continue until it is no longer needed. Remedy OnR-5C is depicted in Figure 3-10a in cross-section and in Figure 3-7b in plan view. Note that the only difference between OnR-5E and remedies OnR-5B and OnR-5C is the depth of the ISBS treatment; thus, the plan view for these three remedies is shown on the same figure.

3.1.12.1 Remedy Components. This remedy includes the following components:

- A single encircling vertical barrier wall around all four source areas to the HG middle clay;
- Establishment of a capped soil-consolidation area;
- ISBS in the Surficial Aquifer and Upper Hawthorn at each source area;
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the northern perimeter wells of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of these wells;
- Continued operation of the horizontal collection drains of the Surficial Aquifer extraction and treatment system as needed for hydraulic control;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures;
- Continued passive DNAPL recovery at wells HG-16S, HG-10S, HG-12S, HG-15S, and HG-11S; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.12.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-7b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.3 describes the establishment of a soil consolidation area within the extents of the subsurface barrier wall. Soil placed in this area will be capped to prevent infiltration into source areas and reduce leaching.

- Section 3.1.15.5 describes the installation of the subsurface barrier wall encircling all source areas.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The barrier wall will eliminate the need for the southernmost set of perimeter wells. The horizontal drains within the slurry wall will be used as needed for hydraulic control. Other parts of the system will be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.8 describes the implementation of ISBS in source areas. For this alternative, ISBS would be applied in the Surficial Aquifer and Upper Hawthorn (from surface to an approximate depth of 65 feet).
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas will be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.12.3 Effectiveness Assumptions. Effectiveness assumptions for this remedy are similar to those of alternatives OnR-5B and OnR-5C. In this Alternative the ISBS treatment is designed to: (a) treat the majority of the source area mass in the Surficial Aquifer, (b) treat the smaller mass in the Upper Hawthorn, and (c) create a barrier to DNAPL movement in the Upper Hawthorn.

3.1.13 On-Site Remedy OnR-5F: Containment/Treatment – Barrier Wall plus In Situ Solidification/Stabilization in the Surficial Aquifer and Upper Hawthorn

This remedy is a combination of containment and treatment remedies that is similar to the prior remedy (OnR-5E), but it has ISS/S in the Surficial Aquifer and Upper Hawthorn rather than ISBS. This remedy includes installing a vertical barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. The barrier wall will limit groundwater inflow to (and outflow from) DNAPL-impacted areas. A capped soil-consolidation area will be established inside the barrier-wall extents for excavated soil and excess soil from ISS/S implementation. Outside the barrier wall, surface regrading and covers will eliminate potential exposure to soil with constituent concentrations that result in estimated potential risks that exceed applicable risk limits. ISS/S mixing will take place in the Surficial Aquifer and Upper Hawthorn to treat DNAPL and reduce COC mobility. Operation of a modified version of the Surficial Aquifer groundwater extraction system will continue until it is no longer needed. Remedy OnR-5F is depicted in Figure 3-11a in cross-section and in Figure 3-9b in plan view (the plan view is the same as for OnR-5D; only the depth of ISS/S treatment is changed).

3.1.13.1 Remedy Components. This remedy includes the following components:

- A single encircling vertical barrier wall around all four source areas to the HG middle clay;
- ISS/S to the middle clay unit of the HG in the four source areas;
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;
- Establishment of a capped soil-consolidation area;
- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the northern perimeter wells of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of these wells;
- Continued operation of the horizontal collection drains of the Surficial Aquifer extraction and treatment system as needed for hydraulic control;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.13.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-9b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.3 describes the establishment of a soil consolidation area within the extents of the subsurface barrier wall. Soil placed in this area will be capped to prevent infiltration into source areas and reduce leaching.
- Section 3.1.15.5 describes the installation of the subsurface barrier wall encircling all source areas.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The barrier wall will eliminate the need for the southernmost set of perimeter wells. The horizontal drains within the slurry wall will be used as needed for hydraulic control. Other parts of the system will be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.
- Section 3.1.15.7 describes the implementation of ISS/S in source areas. For this alternative, ISS/S would be applied in the Surficial Aquifer and Upper Hawthorn (from surface to an approximate depth of 65 feet).
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas will be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.13.3 Effectiveness Assumptions. The effectiveness assumptions for this alternative are similar to those of alternative OnR-5E. The only difference is the use of ISS/S as the treatment mechanism instead of ISBS.

3.1.14 On-Site Remedy OnR-5G: Containment/Treatment – Barrier Wall plus In Situ Solidification/Stabilization in the Surficial Aquifer and In Situ Biogeochemical Stabilization in the Upper Hawthorn

This remedy is a combination of containment and treatment remedies that is similar to the alternatives OnR-5E and OnR-5F, but it has a combination of ISS/S and ISBS treatment for the source areas. This remedy includes installing a vertical barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. The barrier wall will limit groundwater inflow to (and outflow from) DNAPL-impacted areas. A capped soil-consolidation area will be established inside the barrier-wall extents for excavated soil and excess soil from ISS/S implementation. Outside the barrier wall, surface regrading and covers will eliminate potential exposure to soil with constituent concentrations that result in estimated potential risks that exceed applicable risk limits. ISS/S mixing will take place in the Surficial Aquifer to treat DNAPL and reduce COC mobility. ISBS will be applied to the Upper Hawthorn in source areas to treat mass in that unit and create a barrier to vertical flow. The combination of ISS/S and ISBS is similar to alternative OnR-4B. Operation of a modified version of the Surficial Aquifer groundwater extraction system will continue until it is no longer needed. Remedy OnR-5F is depicted in Figure 3-12a in cross-section and in Figure 3-12b in plan view.

3.1.14.1 Remedy Components. This remedy includes the following components:

- A single encircling vertical barrier wall around all four source areas to the HG middle clay;
- ISS/S to the upper clay unit of the HG in the four source areas;
- ISBS in the Upper Hawthorn in the four source areas (below the treated ISS/S soil);
- ChemOx or ISBS treatment applied at existing Lower Hawthorn wells in source areas;
- Establishment of a capped soil-consolidation area;

- Surface grading and covering for most of the Site with installation of stormwater controls;
- Continued operation of the northern perimeter wells of the Surficial Aquifer extraction and treatment system for a period of time, then shutdown of these wells;
- Continued operation of the horizontal collection drains of the Surficial Aquifer extraction and treatment system as needed for hydraulic control;
- Expansion of the Surficial Aquifer and HG monitoring network for (1) establishment of TPOCs and POCs, (2) MNA demonstration, and (3) establishment of trigger locations for contingency measures; and
- Institutional controls to mitigate risks from exposure to Site soil, sediment, surface water or groundwater.

3.1.14.2 Implementation Details. The components of this remedy are also components of at least one other remedial alternative. Implementation details of the relevant components are described in the following subsections:

- Section 3.1.15.1 describes implementation of surface grading and covers. Most of the Site (approximately 83 acres, Figure 3-9b) would either be under the final soil cover, or have surface excavation sufficient to remove surface soil with constituent concentrations that result in the exceedance of applicable risk limits.
- Section 3.1.15.2 describes stormwater controls that will be implemented in concert with surface grading and covers.
- Section 3.1.15.3 describes the establishment of a soil consolidation area within the extents of the subsurface barrier wall. Soil placed in this area will be capped to prevent infiltration into source areas and reduce leaching.
- Section 3.1.15.5 describes the installation of the subsurface barrier wall encircling all source areas.
- Section 3.1.15.6 describes the operation of the on-Site Surficial Aquifer hydraulic containment system. The barrier wall will eliminate the need for the southernmost set of perimeter wells. The horizontal drains within the slurry wall will be used as needed for hydraulic control. Other parts of the system will be shut down when no longer needed for groundwater remediation. Section 3.1.15.6 also describes groundwater monitoring, including installation of new wells, for the Surficial Aquifer.

- Section 3.1.15.7 describes the implementation of ISS/S in source areas. For this alternative, ISS/S would be applied in the Surficial Aquifer (from surface to an approximate depth of 25 feet).
- Section 3.1.15.8 describes the implementation of ISBS in source areas. For this alternative, ISBS would be applied in the Upper Hawthorn (from approximately 30 feet to 65 feet below surface).
- Section 3.1.15.10 describes the use of existing HG wells as ChemOx/ISBS treatment points. For this alternative, Lower Hawthorn wells in source areas will be used as treatment points prior to their abandonment.
- Section 3.1.15.11 describes HG groundwater monitoring, including installation of new wells.
- Section 3.1.15.12 describes contingent actions that may be taken in the HG if warranted by monitoring that is conducted after remedy implementation.
- Section 3.1.15.13 describes the implementation of MNA.
- Section 3.1.15.14 describes the implementation of institutional controls.
- Section 3.1.15.15 describes the five-year review process.
- Section 3.1.15.16 describes post-remedy restoration activities.

3.1.14.3 Effectiveness Assumptions. The effectiveness assumptions for this alternative are similar to those of alternatives OnR-5E and OnR-5F. The only difference is the use of both ISS/S and ISBS in the treatment of sources instead of one of these technologies.

3.1.15 Remedy Components Common to Multiple On-Site Remedial Alternatives

Many of the on-Site remedial alternatives defined in the preceding subsections contained remedy components that are common to multiple alternatives. Each of these remedy components are described in more detail below. Note that none of the alternatives employ all of the components listed below. Rather, the alternatives use different combinations of the components below, perhaps with additional alternative-specific components described in prior subsections. Also note that the specific layout/implementation of the components listed below will be, in most cases, dependent on the other components of the overall alternative, as explained below and in the preceding subsections.

3.1.15.1 Surface grading and covers. This remedial component consists of re-grading much of the Site and using one or more types of surface covers to prevent potential direct exposure to surface soils. The covers will be designed to be impermeable where leachability and/or infiltration is a concern. The final surface cover design will be consistent with the expected future use of the Site.

The Site grading activity will involve removal of some surface soils, with placement elsewhere on Site. In some areas, such as in western portions of the Site, removal of surface soil (upper one or two feet) may result in removing all soil with constituent concentrations associated with estimated potential risks that exceed allowable risk limits. In such areas, if fill is not required to achieve the final design grade, confirmation sampling may be conducted and surface conditions will be restored.

In all other areas, surface covers will be constructed to prevent potential exposure to constituents in surface soils (including soil used as structural fill material). The type of surface covers applied will be determined during final design and will be consistent with the expected future use of the Site property. Surface covers may consist of two feet of clean soil or a lesser thickness of a hard wearing surface such as concrete or asphalt with appropriate supporting base material. As appropriate for the final land use, the covers will be vegetated.

In areas where left-in-place vadose-zone soil (or structural fill material) poses a leachability concern, an impermeable cap will be employed beneath the designed surface cover (e.g., soil or wearing surface with base material). The cap will be constructed using a drainage layer (such as sand or geosynthetic drainage material) with an underlying impermeable layer (such as a geosynthetic clay liner). Capped areas will be designed with sufficient slope to promote runoff. The exact footprint of any impermeable cap(s) will be determined during remedial design.

In summary, the potential components of the final grading and covering plan may include (but will not be limited to) one or more of the following:

- Excavation only (leaving low-concentration surface soil behind);
- Excavation with a two-foot soil cover;
- Placement of a two-foot soil cover without excavation;
- Placement of a two-foot thick impermeable cover/cap;

- Covering with a road and or paved parking area;
- Covering with structures (e.g., buildings) that prevent soil exposure; and
- Placement of a lined treatment pond over exposed soil.

This remedy component will likely result in the removal of trees on Site. It will be desirable to keep existing trees as a buffer along the western and northern property boundaries near existing residences. It will also be desirable to keep many of the existing on-Site monitoring wells (especially in the HG and UFA) intact during this activity; this may require modification of the wells and care during remedy construction.

This remedy component will include implementing dust controls in the form of dust suppression through continuous water application. During the remedial design of the Site remedy, Beazer East will design and implement an ambient air monitoring network at the fenceline.

The effectiveness of the final cover design in preventing potential direct exposure to impacted soil will be evaluated through risk (exposure) assessment. The risk assessment will use potential exposure scenarios (receptor types and assumptions) and potential exposure areas (sub-areas of the Site property) appropriate for the expected future land use(s). Exposure-point concentrations will be determined with the assumption that covered areas have very low (background, or measured from known fill source) concentrations of constituents. Deterministic and probabilistic approaches (AMEC, 2009e) will be employed to demonstrate that, after implementation of the final cover: (a) the non-cancer hazard index is below 1.0 and (b) the lifetime excess cancer risk is below 1×10^{-6}, for all applicable exposure scenarios.

3.1.15.2 Stormwater rerouting and detention. This remedy component consists of stormwater management controls which: (a) mitigate flash runoff events from the Site, (b) prevent surface water from contacting media with elevated constituent concentrations, and (c) reduce potential soil/sediment transport from the Site. This remedy component will be implemented in concert with the designed surface covers and grading (Section 3.1.15.1). Stormwater controls will consist of: (a) grading and contouring the Site to direct runoff toward collection points, (b) installation of one or more detention/retention ponds, and (c) possible replacement of the existing Site stormwater ditch with another ditch or with an engineered conveyance such as an underground concrete pipe (culvert).

The locations and design of stormwater controls will be consistent with the expected future use of the Site property.

Stormwater runoff will be managed by controlling the direction and location of its flow within the Site. This will consist of grading and contouring the Site topography to divert stormwater toward collection points, away from constituent sources, and into pathways that carry it off-Site before it can infiltrate through subsurface media that may contain elevated constituent concentrations. Both natural and/or engineered water pathways (e.g., drainage ditches, drainage trenches, culverts, etc.) may be used for this purpose.

High-volume stormwater flows will be addressed with one or more constructed detention ponds. These ponds will be constructed by excavating shallow soil in the pond area(s). The ponds detain water in low-lying areas and collect water during peak storm events to slow and reduce the rate of surface water discharge from the Site. The ponds collect sediment and would require some ongoing maintenance to inspect the ponds and clean out the sediment as appropriate. A detention pond with a permeable bottom allows collected water to infiltrate into the subsurface; such a pond would be appropriate where subsurface soil (after excavation of the pond) does not have elevated, leachable concentrations of Site constituents. A pond that is constructed with a bottom liner to prevent infiltration would be appropriate where elevated, leachable concentrations remain in the subsurface.

Depending on the remedial alternative and on the future use of the Site, it may be advantageous to eliminate the existing on-Site drainage ditch. The ditch would be replaced by another water conveyance to convey urban stormwater runoff from the existing ditch inlet (south edge of Site) to the existing ditch outfall (north edge of Site). This conveyance may be an underground pipe (culvert) that runs in the present ditch alignment or in a new alignment. Use of a pipe to replace the ditch would result in better separation of off-Site urban runoff from Site runoff. The existing ditch would be filled and the final grading/cover would be consistent with the Site final grading/cover design (Section 3.1.15.1).

3.1.15.3 Soil consolidation area with impermeable cap. This remedy component consists of placing soil in a designated on-Site consolidation area. The soil placed within the consolidation area includes surface soil that is removed during Site grading and soil that is derived from construction of other on-Site (or off-Site) remedy components (e.g., detention/retention pond, slurry wall, ISS/S, soil/sediment removal). For the remedial alternatives that include the consolidation area (OnR-5A through OnR-5G), it is located in the area encircled by a subsurface vertical barrier wall (see Section 3.1.15.5), and covers approximately 32 acres.

An impermeable cap will be constructed over the consolidation area using a drainage layer (such as sand or geosynthetic drainage material) with an underlying impermeable layer (such as a geosynthetic clay liner). These layers will lie beneath the designed final surface cover (e.g., soil or wearing surface with base material, see Section 3.1.15.1). Capped areas will be designed with sufficient slope to promote runoff. Soil compaction will be used, as necessary, to support the cap and to facilitate expected land uses. The final cover design will be consistent with the expected future use of the Site.

3.1.15.4 On-Site ex-situ soil treatment. This remedy component includes on-Site treatment of soils from source area excavation and/or resulting from ex-situ S/S implementation. The default assumption is that soils will be treated through (ex-situ) soil S/S though other treatment options (e.g., chemical oxidation, thermal treatment, biological treatment) could be considered during final design.

The ex-situ S/S process will use additive(s) such as cement, lime, fly ash, bentonite, or polymers in a mix percentage that is optimized through treatability tests. Based on a pilot test of S/S using Site soils, it is anticipated that an additive such as bentonite will be necessary (in addition to cement) to achieve a low hydraulic conductivity matrix. An on-Site pug mill or other equipment will be used for homogenization. Depending on the remedial alternative, the treated soil will be returned to the excavation (OnR-3A and OnR-3B) and/or used as a base material in construction of surface covers (see Section 3.1.15.1).

3.1.15.5 Barrier wall. This remedy component consists of installing a cement/bentonite slurry wall to encircle all four primary source areas. The slurry wall will be approximately 5,000 feet in length and will extend vertically from land surface to the top of the HG middle clay, approximately 65 feet deep. Other types of vertical barriers (e.g., sheet pile, in-situ solidified soil columns, or injected grout) may be considered in place of a slurry wall during final design.

3.1.15.6 Surficial Aquifer hydraulic containment and groundwater monitoring. This remedy component consists of operating the existing hydraulic containment system including the perimeter wells and the horizontal groundwater collection drains at the base of the Surficial Aquifer near the four source areas. Periodic adjustments to operations will be made as necessary to optimize containment and treatment reliability. This remedy component also includes Surficial Aquifer groundwater monitoring to demonstrate: (a) containment, (b) compliance at POCs, and (c) MNA (see Section 3.1.15.13).

Depending on the remedial alternative, the configuration of the perimeter extraction-well system may change. For alternatives including the slurry wall (OnR-5A through OnR-5G), the southernmost extraction wells (EW-13 through EW-17) will be abandoned and containment in this area will be achieved by the slurry wall. Also, extraction at the perimeter wells will eventually become unnecessary for most alternatives due to source area treatment or containment, though the length of time for operation depends on the alternative and depends on the results of future monitoring of remedy effectiveness. Triggers for shutting down perimeter extraction wells will be established during remedial design. After shutdown, frequent monitoring will be conducted at the well to determine whether concentrations rebound back to a determined action level, requiring re-initiation of the extraction. Existing and new monitoring wells between source areas and the perimeter extraction wells may also be used to define action levels for perimeter-well withdrawals.

Surficial Aquifer POC wells will be located at the eastern property boundary (or limit of institutional control) and at the northern edge of the existing plume where the plume meets GCTLs within the property boundary. Locations of permanent POC (PPOC) wells (existing and new wells) will be identified during remedy design and new wells will be installed during remedy implementation. Where necessary, groundwater constituent impacts will be delineated beyond the PPOC (where GCTLs are currently not met) during design; TPOC wells will be installed at the approximate leading edge of the plume for remedy performance monitoring.

Approximately ten new Surficial Aquifer monitoring wells are likely to be needed (2-inch diameter, 25 feet deep) to adequately define TPOCs, POCs, and action levels.

There are design options for the groundwater treatment and discharge systems that can be considered during final design, including:

- Modification of the groundwater treatment train for the most reliable and cost-effective COC removal (e.g., ion exchange may be more cost-effective than coagulation/precipitation/filtering for arsenic removal); and
- Discharge of treated groundwater to surface water feeding Springstead Creek. The discharge flow would be approximately 0.1 cubic feet per second (cfs). Surface water discharge concentration criteria would need to be achieved by the groundwater treatment system.

3.1.15.7 In-situ solidification/stabilization (ISS/S) of source areas. This remedy component consists of using a cement-based additive mixture to solidify and stabilize source area soils in place. Based on a pilot test of S/S using Site soils, it is anticipated that an additive such as bentonite will be necessary (in addition to cement) to achieve a low hydraulic conductivity matrix. A large diameter auger (6 feet to 12 feet in diameter) will be used to mix source area soil with the solidification agent. The precise mixing formula and rate of addition will be determined by a treatability study. Auger-mixed ISS/S columns will overlap to provide complete treatment of the delineated source areas to the target depth. For some Alternatives (OnR-4B, OnR-5D, and OnR-5G), the ISS/S will be conducted to the top of the HG upper clay, approximately 25 feet deep. For other alternatives (OnR-4A and OnR-5F), the ISS/S will extend to the HG middle clay, approximately 65 feet deep. Excess material will be removed and either transported to a staging area for treatment (OnR-4A and OnR-4B) or transported to the soil consolidation area (OnR-5D, OnR-5F, and OnR-5G).

Full treatment of source areas by ISS/S will require demolition/dismantling of foundations, subsurface utilities, and structures in the Former Process Area and at the Former Drip Tracks. The unknown location, condition, and contents of underground pipes, structures, and foundations significantly complicates application of ISS/S, particularly in the Former Process Area. This action will also necessitate abandonment of existing monitoring wells within the treatment zones.

The ISS/S treatment area would be determined through field sampling of material within and near delineated source areas. DNAPL source areas would be identified using a combination of indicators potentially including (but not limited to): visual observation of DNAPL in soil cores, photoionization detector readings, odors, and comparison of groundwater concentrations with effective solubility. However, only visual observation of DNAPL is definitive; some professional judgment will be required in many cases when identifying DNAPL source areas.

The effectiveness of ISS/S would be monitored by (1) comparing soil samples with and without treatment, and (2) comparing groundwater concentrations taken before and after treatment at wells located near/downgradient of treatment areas.

3.1.15.8 In-situ biogeochemical stabilization (ISBS) of source areas. This remedy component consists of injecting a catalyzed sodium permanganate solution within each source area using a series of borings spaced approximately 25 feet apart. The ISBS treatment solution specifications and delivery amounts will be based on the results of the Site ISBS Pilot Test (Adventus, 2009a and 2009b).

In one alternative (OnR-5C), the ISBS is applied in the Surficial Aquifer only, from surface to an approximate depth of 25 feet. In other alternatives (OnR-4B, OnR-5B, and OnR-5G) it is applied only in the Upper Hawthorn, from a depth of approximately 30 feet to a depth of approximately 65 feet. In alternative OnR-5E, ISBS is applied from the surface to the HG middle clay, approximately 65 feet below surface.

The ISBS treatment area would be determined through field sampling of material within and near delineated source areas. DNAPL source areas would be identified using a combination of indicators potentially including (but not limited to): visual observation of DNAPL in soil cores, photoionization detector readings, odors, and comparison of groundwater concentrations with effective solubility. However, only visual observation of DNAPL is definitive; some professional judgment will be required in many cases when identifying DNAPL source areas.

The effectiveness of ISBS would be monitored by (1) comparing soil cores taken before and after treatment, and (2) comparing groundwater concentrations taken before and after treatment at wells located near/downgradient of treatment areas.

UIC requirements are relevant to ISBS treatment. It is expected that the existing Site-specific UIC variance for injection of sodium permanganate will need to be modified and additional monitoring will be required.

3.1.15.9 Passive DNAPL recovery. This remedy component involves continuation of the current program of bi-weekly DNAPL bailing from Upper Hawthorn monitoring wells HG-11S, HG-15S, HG-12S, HG-10S, and HG-16S. This activity will continue as long as DNAPL is recoverable in these wells. Removed DNAPL will be temporarily stored on Site for eventual shipment to an appropriate off-Site disposal/recycling facility (e.g., currently off-Site incineration).

3.1.15.10 ChemOx/ISBS Using Existing Hawthorn Group Wells. This remedy component involves use of existing HG monitoring wells as treatment-injection points. Where groundwater concentrations are elevated but local DNAPL presence is not indicated, the injectate would be a ChemOx solution (e.g., peroxide, permanganate, or ozone). If DNAPL is indicated (e.g., where DNAPL has been recovered), the injectate could be the ISBS (catalyzed sodium permanganate) solution or a ChemOx solution. The injected volume will be determined during implementation based on the capacity of the well to receive injectate and based on monitoring of the injection well and nearby wells (if/as feasible) for presence of the injectate and Site constituents.

In most alternatives (all but the no-Action and OnR-2 alternatives), the three Lower Hawthorn wells in source areas (HG-10D, HG-16D, and HG-12D) will be used for ChemOx or ISBS delivery. In two alternatives (OnR-3A and OnR-5D), source area Upper Hawthorn wells will also be used as treatment injection points prior to their abandonment.

3.1.15.11 Hawthorn Group groundwater monitoring. This remedy component includes monitoring of Upper Hawthorn and Lower Hawthorn groundwater using existing and new wells. The monitoring will be used to demonstrate MNA (see Section 3.1.15.13) and compliance at POCs.

In the Upper Hawthorn, POC wells will be established on Site along the eastern property boundary (or the limit of institutional control) and at the northern edge of the groundwater plume (but no further than the limit of institutional control). For this purpose, additional wells may be installed to complement existing wells.

For the Lower Hawthorn, POC wells will be established on Site along the eastern property boundary, along the western property boundary, and at the northern edge of the groundwater plume (but no further than the limit of institutional control). Additional wells may be required. Due to the potential for cross-contamination, no new Lower Hawthorn wells will be installed along the eastern property boundary where indications of the presence of Upper Hawthorn DNAPL have been found.

Off-Site TPOCs also will be designated in the Upper Hawthorn and Lower Hawthorn east of the Site, beyond the edge of the current groundwater plume.

The actual number and locations for POC and TPOC wells will be determined during remedial design. It is assumed in this FS that approximately eight new Upper Hawthorn monitoring wells will be required, and approximately four new Lower Hawthorn wells will be required. These wells will have diameters of 2 inches. The Upper Hawthorn wells will be approximately 65 feet deep and may be double cased to limit the potential for downward flow from the Surficial Aquifer. The Lower Hawthorn wells will be approximately 100 feet deep and will be double or triple cased to limit the potential for downward flow from the Surficial Aquifer or Upper Hawthorn.

3.1.15.12 Contingent Actions in the Hawthorn Group. This remedy component includes contingent remedial actions for groundwater in the HG. If monitoring results indicate that constituent concentrations are either above GCTLs and increasing (at POC wells where Site constituents have been detected) or begin to be detected above GCTLs at previously clean POC wells (i.e., where elevated concentrations of constituents have not been found up to that time), then an active remedy may be implemented in the HG where feasible and necessary to meet remedial objectives, as determined through monitoring during the remedial action. Increasing concentrations in the UFA could trigger contingent action in the HG.

The expected contingent action for organic constituents is ChemOx using a permanganate solution. The permanganate solution would be delivered to the target treatment zone via low-volume well injection. Existing monitoring wells and/or new delivery wells would be used for this purpose. In order to avoid potential cross contamination, new Lower Hawthorn wells will not be installed where concentrations in the Upper Hawthorn or Surficial Aquifer exceed (or are expected to exceed) certain thresholds (e.g., Florida Natural Attenuation Default Concentrations [NADCs]).

ChemOx is most appropriate action for targeted treatment of concentration hot spots; it may not be suitable for widespread application, particularly in the relatively low-permeability units of the HG.

3.1.15.13 Monitored Natural Attenuation. This remedy component includes using monitoring results to evaluate/demonstrate natural attenuation of constituents in groundwater. Results from monitoring for MNA in the Surficial Aquifer, Upper Hawthorn, and Lower Hawthorn will be used to demonstrate plume stability and decreasing constituent concentrations in groundwater. MNA implementation will include ongoing monitoring of constituents and other appropriate geochemical parameters, analysis of geochemical and biological conditions to determine the conduciveness for attenuation mechanisms, and analysis of concentration data trends.

3.1.15.14 Institutional controls. This on-Site remedy component consists of deed restrictions and other policy/programmatic actions to limit potential exposure to media with elevated constituent concentrations and to ensure the effectiveness of engineering controls.

A Site property deed restriction will specify or limit the types of permissible future Site development and will place health, safety, and materials-management requirements on any future construction activities. Commercial/industrial land use will be permitted on the property and certain types of commercial development will be acceptable. The deed restriction language will specify certain activities and property uses that are not permitted (e.g., daycare facilities). Certain construction activities or material land-use changes may trigger installation of additional engineering controls to eliminate or reduce potential exposures to levels that are consistent with applicable risk limits.

Groundwater use will be restricted permanently by a Site-wide property deed restriction (such a restriction does not currently exist). The only permitted withdrawals will be for remediation and sampling. Use of Surficial Aquifer or HG groundwater from the Site for potable use will be explicitly forbidden.

During any period of time when GCTLs are exceeded in off-Site areas, it is also assumed that regulatory groundwater use restrictions and development requirements will remain in place for the Site vicinity via (a) the FDEP/St. Johns River Water Management District (SJRWMD) regulation of the "Delineated Area" of contamination, (b) the local Murphree Well Field Wellhead Protection Area regulations, and (c) the Gainesville regulations that apply to the "Special Area of Environmental Concern."

3.1.15.15 Five-Year Reviews. This remedy component consists of remedy-performance reviews to be conducted every five years in compliance with CERCLA and EPA policy. Each review report documents the evaluation of remedy implementation and performance in order to determine if the remedy is or will be protective of human health and the environment. Evaluation of the remedy and the determination of protectiveness will be based on, and sufficiently supported by, data and observations. The five-year reviews will include an assessment of whether MNA (see Section 3.1.15.13) is effective.

3.1.15.16 Post-Remedy Site Restoration. This remedy component consists of actions taken after a remedy has been implemented, after active remedial operations have ceased, after remedial goals have been met, and when the only remaining activity associated with the remedy is limited monitoring to ensure long-term effectiveness. This action may include a final round of comprehensive groundwater sampling, analysis, and reporting followed by abandonment of certain groundwater wells and removal of any surface facilities no longer required for remediation. Final Site grading and surface finishing of areas previously used for remediation/monitoring components would also be part of post-remedy Site restoration. Site restoration activities may be implemented in a step-wise manner wherein certain wells/facilities are abandoned/removed once they are no longer needed for remedy implementation or effectiveness demonstration.

3.2 Upper Floridan Aquifer Remedies

Remedies for UFA groundwater are evaluated separately from those assembled to address impacted on-Site media and off-Site surface soil. Two remedies considered for the UFA include No Action (UFA-1) and MNA with hydraulic containment (UFA-2) (Table 3-2).

3.2.1 Remedial Strategy

The potential risk associated with impacted UFA groundwater is managed by addressing the linkage between constituent, transport pathway, and receptor. Removing any one of the three components disrupts the potential exposure pathway and achieves the goal of mitigating the environmental hazard.

- Constituents in UFA groundwater can be treated in place, or the impacted groundwater can be removed from its location and addressed ex-situ. Either approach will achieve the goal of reducing or eliminating constituent mass from the Site.

- The potential exposure pathway between constituent and receptor has two components, a migration pathway for constituents from a source to a potable water supply and an exposure pathway from the potable water to the point of exposure. Currently, the potential migration pathways from the Surficial Aquifer to the UFA are not known definitively. Unfortunately, the depth to the UFA and the presence of the (at least partially) protective lower clay unit of the HG limits the amount of direct investigation of potential migration pathways that can be performed in the UFA. If the primary migration mechanism is advective flow through leaky well casings, the leaky wells should be abandoned. If the primary migration is flux through the clay units (e.g., through the interstitial pore spaces of the Upper Clay, Middle Clay and Lower Clay of the HG), ideal technologies would seal the interface between aquifer sediment and underlying clay (e.g., between the Lower Hawthorn and the underlying lower clay unit).

- Alternatively, the exposure pathway from potable water in the ground to the point of exposure can be prevented. Groundwater containing constituents can be ingested or touched; either exposure route can be disrupted by preventing the groundwater from being used. Another exposure pathway disruption method is to pre-treat the collected groundwater prior to use by the consumer.

Of the three, the most viable strategy for addressing the UFA groundwater impacts is the first approach: in-situ treatment (including MNA) or removal of groundwater with elevated levels of constituents and addressing it ex-situ. This approach likely is not a short-duration strategy and may be relatively intrusive over the long-term as repeat actions may be required to ensure long-term protectiveness.

3.2.2 Points of Compliance – Upper Floridan Aquifer

The POCs for the UFA will include monitoring wells near the downgradient Site boundary, in accordance with Florida regulations. Currently, GCTLs are met at 47 of 50 Upper Floridan Aquifer monitoring ports near the Site boundary (including FW-2, FW-3, FW-4, FW-5, FW-7 and all ports of FW-4C, FW-10B, FW-11B, FW-15B, FW-17B, FW-22C, FW-23B, FW-23C, FW-24B, and FW-24C). Groundwater monitoring in the UFA indicates that the concentrations of organic Site-related constituents near the property boundaries are consistently below the GCTLs, with the following exceptions (FTS, 2009b):

- FW-22B, near the northwestern corner of the Site, had naphthalene and acenaphthene concentrations above their respective GCTLs in the third quarter of 2009. For naphthalene, the GCTL is 14 µg/L and the measured concentrations in ports two and three were 58 µg/L and 110 µg/L, respectively. For acenaphthene, the GCTL is 20 µg/L and the measured concentrations in ports two and three were both 23 µg/L. Measured concentrations at FW-22B were consistently below GCTLs until June 2008. Since then there have been measurements of naphthalene and acenaphthene concentrations slightly above GCTLs, primarily in Zone 3.
- FW-16B, along the eastern boundary of the Site northeast of the Former Drip Track, consistently has naphthalene and benzene concentrations above their respective GCTLs in the uppermost port (Zone 1). Since September 2006, naphthalene concentrations have been measured between 15 µg/L and 36 µg/L in this zone (GCTL 14 µg/L), and benzene concentrations have been measured between 2.5 µg/L and 4.4 µg/L (GCTL 1 µg/L, MCL 5 µg/L). There are also occasional slight exceedances for 2,4-dimethylphenol at this well in the upper port. There have been no exceedances of GCTLs in lower ports.

The concentrations at these three ports are below the Florida NADCs for source areas, as defined by 62-777 FAC. The NADCs are defined to be 10 times GCTLs for non-carcinogens (e.g., naphthalene, acenaphthene) and 100 times GCTLs for potential carcinogens (e.g., benzene, carbazole).

POCs to specifically address the benzene drinking-water standard ARAR (and any other drinking-water MCL) will be established at monitoring locations outside the footprint of the composite source area management zone. This would, at a minimum, establish that groundwater concentrations above the Federal MCLs for constituents such as benzene would not be acceptable at any points within the Koppers property that are outside of the containment zone or waste immobilization zone (e.g. outside the vertical barrier). This will be done to insure that groundwater concentrations do not exceed Federal drinking-water standards at points outside of areas where waste is managed in place, as a relevant and appropriate requirement (referencing 40 CFR Part 264, Subpart F, Section 264.95).

The Site-boundary POC wells are likely to include FW-24B/C, FW-22C, FW-23B/C, FW-4/4C, FW-15B, and a recently-installed well (FW-28B) located north-northwest of FW-22B and west of FW-23B. Also, because there are wells near Site boundaries (i.e. FW-22B and FW-16B) that currently have one or more concentrations exceeding GCTLs, it will be necessary to establish off-Site TPOCs (i.e. off-Site sentinel wells FW-25B/C, FW-26B/C, and a soon-to-be-installed well pair FW-29B/C). Additional POCs in the UFA will include wells FW-19B, FW-18B, and FW-13B (12 ports/POCs total). These wells historically and currently show no impacts and will be monitored in the future to ensure that Site-related constituents do not migrate downward from the HG or spread within the UFA to these areas.

3.2.3 Upper Floridan Aquifer Remedy UFA-1: No Action

The No Action remedy provides a baseline for comparison, and is required by the NCP. Under the No Action remedy, the existing groundwater monitoring in the UFA would cease. There would be no restrictions on groundwater use, and no monitoring would be performed to evaluate whether Site concentrations above the GCTLs were migrating beyond the points of compliance.

3.2.3.1 Implementation Details. From a technical standpoint, the No Action remedy can be readily implemented. There are no implementation details to present for this remedy.

3.2.3.2 Effectiveness Assumptions. The No Action remedy does not entail any implementation activities; therefore, there are no effectiveness assumptions associated with this remedy. While natural attenuation processes will occur, this remedy does not include monitoring to evaluate the degree of concentration reductions.

3.2.4 Upper Floridan Aquifer Remedy UFA-2: Monitored Natural Attenuation with Hydraulic Containment

This remedy consists of a combination of two technologies: (1) natural attenuation (for relatively low and isolated concentrations exceeding GCTLs); and (2) targeted groundwater extraction for groundwater containing higher and more persistent constituent concentrations.

3.2.4.1 Remedy Description. The components of this remedy are listed below:

- Continuation of periodic collection of groundwater samples from monitoring wells, and analysis of samples for potentially Site-related organic constituents;
- Continuation/expansion of the UFA groundwater extraction/ex-situ treatment system, initially using existing wells FW-6 and FW-21B, along with the recently-installed extraction well FW-31BE (near FW-22B);
- As needed, installation of additional high capacity groundwater extraction wells for inclusion in the UFA groundwater extraction/ex-situ treatment system; and
- Institutional controls to prevent UFA groundwater extraction for potable use at the Site or anywhere GCTLs are exceeded.

The groundwater will be pumped at a rate that will eliminate migration of dissolved constituents off-Site (e.g., to the north toward the Murphree Well Field) at concentrations above GCTLs. Collection and (if necessary) ex-situ groundwater treatment will be designed to accept and handle this flow rate, at a minimum.

3.2.4.2 Implementation Details. Frequent monitoring of on-Site UFA wells will continue in order to demonstrate that: (1) groundwater GCTL exceedances remain limited to a few of the on-Site monitoring ports; and (2) there is an overall reduction in mass and concentration of Site-related constituents. The monitoring will also be used to determine if action levels are reached, triggering additional remedy actions, described below. Monitoring will be conducted at POC wells and at interior UFA wells. Additional details include:

- Monitoring will initially be quarterly at POCs.
- If concentrations effectively remain below GCTLs at PPOCs for 2 years, sampling frequency may be reduced to semi-annual.
- If concentrations effectively remain below GCTLs for 4 years, sampling frequency may be reduced to annual.
- If concentrations exceed GCTLs for any sampling event at a PPOC well, monthly confirmatory sampling will be performed for 2 months on that well.
- If monthly sampling demonstrates that concentrations are above GCTLs at PPOC well for two consecutive months, corrective action will be initiated (see below) and monitoring frequency will be quarterly until concentrations remain below GCTLs for four consecutive quarters.
- If corrective action is initiated, sampling frequency will be adjusted to monitor performance of corrective action to contain the plume.

Monitoring also will also continue at off-Site sentinel wells FW-25B/C, FW-26B/C, and (soon-to-be-installed) FW-29B/C. In addition to providing early warning for any potential groundwater plume spreading toward the Murphree Well Field, these wells will effectively be TPOCs until all on-Site boundary wells exhibit concentrations below GCTLs.

3.2.4.2.1 Trigger Criterion for Groundwater Extraction. Compliance with defined groundwater quality goals will be determined through groundwater monitoring results. Monitoring results also will be used to define when groundwater quality has fallen out of compliance, and subsequently when groundwater has been returned into compliance. Ideally, an objective trigger criterion for dictating appropriate UFA groundwater remedial action should consist of a pre-defined sequence of actions and events. If analytical data from any monitoring well indicates that constituents have reached that well at GCTLs (or near GCTLs and increasing), targeted groundwater extraction will be initiated near the well at that time, and groundwater extraction will continue until analytical data shows constituent concentrations have returned to an acceptable level.

As/where needed, new large-diameter wells will be installed for targeted extraction, and appropriate capacity pumps will be installed. The layout of the extraction system will depend on where action levels are exceeded, but it is expected that all or most of the extraction will be within the property boundary. The goal of such a system will be to contain groundwater exceeding GCTLs within the Site boundary and the Site-boundary POCs.

3.2.4.2.2 Groundwater Extraction. Existing monitoring wells FW-6 and FW-21B are currently being used as low-flow groundwater extraction points, as part of an IRM (GeoTrans, 2008c). A new extraction well, FW-31BE, has recently been installed for higher-flow extraction near FW-22B; extraction from this well is expected to commence soon as part of the IRM. The withdrawals at FW-6 and FW-21B are designed to capture downward migration along those boreholes or other localized pathways and to remove constituent mass in these two areas. Initial extraction rates are 1 to 2 gpm at each well, as suggested by an independent panel of experts (Hinchee, Foster, and Larson, 2008) who reviewed Site data and recommended this action. Concentrations of COCs are being measured in the extracted groundwater from each well. The withdrawal at FW-31BE will be designed to hydraulically capture groundwater above GCTLs near and upgradient of FW-22B.

Calculations and modeling analyses have been conducted to estimate the amount of UFA extraction that may necessary to contain groundwater exceeding GCTLs on Site. These preliminary calculations and model simulations indicate that a total withdrawal rate of approximately 80 to 225 gpm will be sufficient to provide adequate capture, depending on the width of the target capture zone (GeoTrans, 2009a).

Concentrations of COCs will be measured in the groundwater from each UFA extraction well. Initially, and after any significant change in the average extraction rate, measurements will be made monthly; the frequency will then decrease in conformance with the Site-wide comprehensive groundwater monitoring plan.

Since it is impractical to predict all possible combinations and sequences of events that may trigger action, the party responsible for operations, maintenance, and monitoring (OM&M) will exercise some degree of professional judgment in periodically adjusting withdrawal rates for optimal performance. Semiannual OM&M reports will be made to EPA and FDEP.

3.2.4.2.3 Disposition of Extracted Groundwater. Extracted groundwater will be collected in holding tanks located near the extraction well and pump system. From there, groundwater can be sent to an on-Site water treatment facility (if necessary) and processed through a treatment train designed to remove constituents and polish the effluent prior to discharge. Groundwater (treated or untreated) can be discharged to the local wastewater utility under permit. Acceptance criteria for the wastewater utility generally are based on protection of the treatment plant processes and operations and on protection of surface water quality (through criteria such as NPDES permit limits) from impacts by effluent discharge. Water samples will be analyzed to determine if the pertinent discharge criteria are met.

It is assumed in this FS that groundwater extracted from any UFA well would be discharged to the GRU POTW sewer system after any necessary treatment. The current on-Site treatment system, which includes GAC filtering for organic constituents, is effective at removing Site COCs from groundwater. Expansion of this system to handle higher flows may be required depending on the remedies selected for the other environmental units (on-Site media and off-Site surface soil) and the amount of UFA pumping that is ultimately required for containment. Reevaluation and optimization of the treatment train may also be beneficial. These details will be part of the remedial design process.

3.2.4.3 Institutional controls. Groundwater use will be restricted permanently by a Site-wide property deed restriction. The only permitted withdrawals will be for remediation and sampling. Use of UFA groundwater from the Site for potable use will be explicitly forbidden.

During remediation, it is also assumed that regulatory groundwater use restrictions will remain in place for the vicinity via (a) the FDEP/SJRWMD regulation of the “Delineated Area” of contamination, (b) the local Murphree Well Field Wellhead Protection Area regulations, and (c) the Gainesville regulations that apply to the “Special Area of Environmental Concern.”

3.2.4.4 Substantive permitting requirements. The SJRWMD consumptive use permit (CUP) requirements may become applicable if: (1) the total extracted flow exceeds 100,000 gallons per day (70 gpm), or (2) if wells with a diameter of 6 inches or greater are used. In either of these cases, the withdrawal plan would need to show that existing groundwater users and natural resources (e.g., wetlands) would not be adversely impacted by the proposed withdrawals.

Also, if additional water is to be discharged to the POTW, then a discharge permit modification may be required.

3.2.4.5 Effectiveness Assumptions. Implementing a groundwater extraction remedy in the UFA zone can present some challenges, particularly in relation to effectiveness documentation. Finding high constituent concentrations within the UFA is difficult because of the extreme depth of UFA wells and the serious concern over breaching the protective Lower Clay Unit above the UFA. An effective higher-flow pumping remedy will require use of new UFA extraction wells and (potentially) substantial upgrades to the water treatment facility currently used to treat groundwater extracted from the Surficial Aquifer.

Natural attenuation alone is not expected to sufficiently reduce concentrations along the groundwater flow path within the Site boundaries. Natural attenuation processes affecting the COCs in the UFA can include biodegradation, sorption, dispersion, and matrix diffusion. Current measured concentrations in the UFA, almost 100 years after wood-treating operations began, could be interpreted as evidence that some attenuation may be occurring. This remedy does not rely completely on MNA in the UFA. Hydraulic containment will be the primary remedy action (especially in the short-term) and will be expanded if/as necessary, in order to prevent groundwater with elevated concentrations from migrating beyond its current extent. The UFA is a confined, high-transmissivity, lateral-flow aquifer. Hydraulic containment is a proven technology that would be effective in the UFA.

3.3 Off-Site Surface Soil Remedies

Remedies for surface soil off-Site are evaluated separately from impacted on-Site media and UFA groundwater. Collection of off-Site surface-soil data is still ongoing and the process used to determine whether constituent concentrations may pose an unacceptable risk has not been finalized. In addition, off-Site data collected to date represent a diversity of property uses and analytical results.

Based on the data obtained to date, it is foreseeable that remedial action may be implemented in some areas off-Site to the west of the Site. Surface soil conditions to the north, east, and south of the Site will be determined during ongoing sample collection. The precise area of remedial action, if any, is yet to be determined; however, there is enough information to identify and evaluate potential remedial alternatives.

Four off-Site surface soil remedies (OfR) are considered: No Action (OfR-1), removal (OfR-2), institutional and/or engineering controls (OfR-3), and a hybrid remedy consisting of removal, institutional controls and/or engineered controls (OfR-4). The remedy candidates for off-Site surface soil are presented in Table 3-3.

3.3.1 Remedial Strategy

At many sampling locations investigated to date, constituent soil concentrations are below all applicable criteria. At other sampling locations, one or more constituents exceed FDEP default residential soil SCTLs and further delineation is being undertaken.

Once the areas with concentrations exceeding default SCTLs are delineated, the potential risks to present and future receptors may be determined using risk assessment methods such as those utilized for on-Site soils (AMEC, 2009e). This delineation and assessment process will define whether off-Site areas pose any unacceptable risk (i.e. a potential excess lifetime cancer risk greater than one in one million) and what areas will require remedial action. Another approach which may be utilized is to compare sample results to default SCTLs and to require remedial action where soil sampling results show exceedances of the default SCTLs.

For soils posing an unacceptable risk, managing the potential risk requires addressing potentially complete exposure pathways. Complete exposure pathways consists of a migration pathway from a source to a point of contact, the point of contact, a receptor at the point of contact, and an exposure route by which a receptor can potentially take up a constituent. Removing any one of these elements of the potential exposure pathway achieves the goal of mitigating the environmental hazard. It is most likely that surface soil in the off-Site areas contains Site-related constituents because of (1) air deposition carrying dust containing COCs and possibly though not likely, (2) stormwater runoff carrying soil from the Site onto some off-Site areas. These migration mechanisms, if they occurred, have already occurred and cannot be undone. Therefore, to achieve the remedial goals, any or all of the following may be done to disrupt the potential exposure pathway:

1. Constituents in surface soil can be treated in place, or the soil with elevated concentrations of constituents can be removed from its location and addressed ex-situ. Either approach will achieve the goal of reducing or eliminating constituent mass from the affected area.

2. Exposure pathways (inhalation, dermal contact and ingestion) can be disrupted by covering impacted soil in place with an engineered cover or by preventing activities that may result in exposure.

3. Current receptors could be removed from the area and future receptors could be prevented from becoming residents of this area. This would achieve the goal of disrupting the potential exposure pathway and eliminating the potential risk/hazard to public health and/or the environment.

All of these possible strategies are potentially practical approaches for certain off-Site areas, depending on land use, property-owner preferences, and estimated potential risks. Florida RBCA standards allow for a combination of approaches for eliminating potential exposures to constituents in off-Site soils.

The total area and volume of off-Site surface soil requiring remediation, if any, is unknown at present. The total volume to be remediated will depend on the measured concentrations and the criterion used to determine what areas pose unacceptable risks. The sampling program for off-Site surface soil has not been completed at this point in time, and the potentially affected soils needing remediation cannot be defined until delineation is complete and a process developed that allows for identification of soils potentially requiring remediation. Fundamental to that process will be a demonstration that allowable risk levels are met. Such a demonstration can range from comparison of soil concentrations to specific concentration-based clean up levels, comparison to applicable background concentrations, conducting a Site-specific risk assessment to identify soils that need remediation to achieve allowable risk levels, or implementing a deed restriction that limits or prevents potential contact with soils such that allowable risk levels are met. Therefore, the descriptions of off-Site remedies are conceptual in nature, allowing some flexibility in the actual application process.

If areas exceeding Florida's allowable risk limit and/or default SCTLs are identified by soil sampling, Beazer East, Inc., will contact each affected private property owner to discuss possible approaches to address the soil impacts on the private property. The private property owner may decline to allow Beazer to remediate soils. Neither the lead environmental agency (in this instance the EPA) nor Beazer is able require a private property owner to allow access or require remediation to take place if the property owner decides not to do so.

3.3.2 Off-Site Remedy OfR-1: No Action

The No Action remedy provides a baseline for comparison, and is required by the NCP. There would be no restrictions on land-use in the residential area west of the facility, and no actions would be implemented to mitigate constituent concentrations in the soil. The No Action remedy will be applicable to areas demonstrated to not pose unacceptable risks.

3.3.2.1 Implementation Details. From a technical standpoint, the No Action remedy can be readily implemented. There are no implementation details to present for this remedy.

3.3.2.2 Effectiveness Assumptions. The No Action remedy does not include any activities; therefore, there are no effectiveness assumptions associated with this remedy.

3.3.3 Off-Site Remedy OfR-2: Remove Impacted Soil

This approach, although disruptive of residential lives and privacy during implementation, is a one-time action that permanently eliminates the potential risk associated with potential off-Site exposure to the removed soil and does not require continual long-term maintenance.

3.3.3.1 Implementation Details. If it is determined through delineation and risk assessment that soils in an off-Site residential property should be remediated, and if the property owner is willing, then the surface soil requiring remediation would be permanently removed. Such an excavation from residential areas will require a high level of attention to detail and care to minimize spread of impacted soil and to mitigate risks associated with the presence of large trucks and heavy equipment in a residential neighborhood. In addition, dust control will be implemented. The exact soil area and depth to be excavated will depend on the results of the ongoing delineation activities and the estimated risks associated with potential exposures to constituents in off-Site surface soil.

Excavated soil will be transported to an on-Site staging area. Access between the facility property and the residential areas immediately west should be easy given the proximity. Once transported on Site, the soil will be addressed in one of three ways:

1. Excavated soil can be consolidated and transported off-Site to a permitted disposal facility capable of accepting the material. Acceptance criteria for the soil may be based on constituent type, concentrations and leaching mechanisms; leachability tests on subsamples of the excavated soil will be use to determined if those criteria are met. Treatment, storage, and disposal facilities (TSDF) for hazardous or non-hazardous soil will be identified prior to initiating the excavation action.

2. Excavated soil can be consolidated with on-Site soil and covered under an engineered cover within the facility property. Soil brought on-Site will need to be managed to minimize potential dust generation and to distribute the soil volume strategically throughout the area to be covered.

3. The excavated soil can be used as raw material (e.g., fill material) for constructing the engineered surface cap for on-Site containment of surface soil or for other on-Site uses.

All three of these approaches are viable and could be used to some extent for portions of the total residential soil volume. All three are included in this proposed off-Site surface soil remedy.

Residential yards (and any other properties) will be restored after soil is removed. Excavated areas in residential yards will be backfilled with clean borrow soil, graded for proper surface drainage patterns, and topped with clean top soil. Transporting clean fill soil back to the residential areas and restoring the excavation zones is likely to cause additional disruption and dust generation and will result in increased risks due to the presence of large trucks and heavy equipment in a residential setting. To the extent practicable, the restoration process will progress with minimal dust generation or disruption to local residents, and will end with reseeding and final grading, as necessary.

3.3.3.2 Effectiveness Assumptions. Excavating soil in a residential area can present some challenges, primarily in relation to short-term impacts on the resident population. Large excavation equipment and soil-transport truck traffic will intersect normal civilian activities and traffic. The movement of soil from yards will create temporary hazards such as falls, slips on loose soil, and lacerations on unearthed objects (e.g., rock). An effective excavation remedy will require (1) agreements from local residents for access to private property, (2) careful communication and coordination between remediation/construction personnel and local residents and the community at large, (3) careful site-specific protection (engineered and administrative) during the soil moving stages of the process, and (4) post-excavation coordination during the restoration stage.

Effective remediation of the residential soil can be accomplished with representative sampling and timely analysis of soil samples. Analytical results will determine the extent of excavation (e.g., depth or lateral extent), and by association will determine the level of intrusion the remedy will have on the local residents. Thus, a balance is needed between (1) the number of samples collected and analyzed (delineation accuracy versus analytical costs), (2) the amount of soil excavated (protectiveness versus excavation costs), and (3) the speed with which the excavation is completed (short-term inconvenience versus thoroughness and quality of the remedy implementation).

3.3.4 Off-Site Remedy OfR-3: Institutional and Engineering Controls

This remedy includes administrative and/or engineering actions intended to disrupt the potentially complete exposure pathways between constituents in soils and off-Site receptors and not to actively address constituent mass directly. Preventing a receptor from contacting constituents in environmental media is effectively the same as eliminating the potential exposure for that receptor. Both institutional and engineering controls would be applied in a way that reduces or eliminates exposure to surface soil in the affected area.

3.3.4.1 Remedy Description. The components of this remedy are (1) institutional controls designed to prevent people from using or disturbing soil posing potentially unacceptable risk and (2) engineering controls to prevent receptors from potentially contacting affected soil.

3.3.4.2 Implementation Details. Institutional controls would be implemented administratively through deed restrictions and other legal processes. Engineering controls envisioned for the affected residential soil would consist of simple technologies (e.g., soil cover, fencing, and/or other simple barriers to exposure). Engineering controls such as soil covers and fences would require ongoing maintenance. Institutional controls and engineering controls require agreement from the property owner.

3.3.4.3 Effectiveness Assumptions. Institutional controls and engineering controls will be effective if human receptors (1) respect the limitations imposed by the legal instruments and (2) do not destroy or circumvent engineering controls.

3.3.5 Off-Site Remedy OfR-4: Removal, Institutional Controls, and/or Engineering Controls (Hybrid)

This remedy consists of a combination of removal as described in Section 3.3.3 and institutional and engineering controls as described in Section 3.3.4. The distinction between soil to be excavated and soil to be addressed by institutional and engineering controls will be based on constituent concentration(s), parcel land use (present and future), and property-owner preferences.

3.3.5.1 Remedy Description. The components of this remedy are a combination of those described in Sections 3.3.3.1 and 3.3.4.1. They include (1) excavation surface soil,

(2) institutional controls on properties and areas not excavated, and/or (3) engineering controls that act as physical barriers to contacting impacted soil.

3.3.5.2 Implementation Details. Implementation details are described for excavation and administrative/engineering controls in Sections 3.3.3.2 and 3.3.4.2, respectively. The distinction between soil that is to be excavated and soil that is to be controlled administratively (through institutional or engineering controls) is based on several factors including: constituent concentrations in the soil, present and future land use, and/or owner preferences.

3.3.5.3 Effectiveness Assumptions. Effectiveness assumptions for this remedy consist of those described for excavation and administrative/engineering controls in Sections 3.3.3.3 and 3.3.4.3, respectively.

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4.0 Detailed Analysis of Alternatives

This section provides a detailed analysis of the remedies developed and described in Section 3. The detailed analysis of remedies includes a description of the evaluation criteria (Section 4.1) used in the analysis, followed by the evaluation of each set of remedies against those criteria. Section 4.2 presents the evaluation for on-Site media (excluding UFA groundwater), Section 4.3 presents the evaluation for UFA groundwater, and Section 4.4 presents the evaluation for off-Site surface soil. The evaluation results for each set of remedies tare then compared to identify key similarities and differences among the remedies (Sections 4.5 through 4.7). This analysis is performed to provide sufficient information to select a Site remedy that is likely to meet the federal and state criteria, as well as technical, cost, and other considerations. This detailed analysis process provides decision makers with sufficient information to objectively compare the remedies, select the most viable and cost effective remedy for the Site, and demonstrate in the ROD that the remedy satisfies the requirements of CERCLA.

4.1 Criteria for Analysis

Nine criteria are used to evaluate each remedy, in accordance with CERCLA RI/FS Guidance (EPA, 1988a). The CERCLA criteria are presented and discussed in great detail in CERCLA guidance documents (EPA, 1989; EPA, 1999). The nine CERCLA criteria used to evaluate remedies in the FS process are:

1. Overall protection of human health and the environment;
2. Compliance with ARARs;
3. Long-term effectiveness and permanence;
4. Reduction in mobility/toxicity/volume through treatment;
5. Short-term effectiveness;
6. Implementability;
7. Cost;
8. State Acceptance; and
9. Community Acceptance

The CERCLA criteria encompass statutory requirements and technical, cost, and institutional considerations, and are grouped into three categories (threshold, primary, and modifying criteria) based on their function in the remedy evaluation process.

Furthermore, these primary CERCLA criteria are expanded into sub-criteria that clarify the intent of the primary criterion and that provide additional discriminatory power to the remedy evaluation process.

4.1.1 Threshold Criteria

The first two criteria (the threshold criteria) evaluate how candidate remedies satisfy regulatory and administrative aspects of remediation.

Overall protection of human health and the environment is evaluated considering the degree to which potential risk or hazard is reduced by a remedy. This can be done quantitatively by comparing constituent concentrations before the remedial action to concentrations remaining after the remedial action; these correspond to pre- and post-remedy potential risk/hazard levels, under specific receptor/exposure scenarios. In this way, a remedy can be described as providing some quantitative level of protection to human or ecological receptors. A similar evaluation might be done on a qualitative basis if exposure scenarios are altered by the remedy in such a way that receptors are not exposed to the pre-remedy constituent concentrations (e.g., for containment/isolation remedies).

Compliance with ARARs is a complex criterion because there are three categories of ARARs to address in addition to TBCs (see Section 2.1). This criterion is evaluated by considering how the technology components in a remedy function within, or comply with, the regulatory and legal framework created by all applicable local, State and Federal regulations. ARARs that specify chemical-specific requirements are evaluated using quantitative characterization data to compare with remedial goals. Location-specific and action-specific requirements can be less clear in how (or how effectively) a remedy or technology would comply.

Although the threshold criteria should be satisfied by all remedies being considered, the degree to which the remedies satisfy these criteria can vary. As such, these criteria can be distinguishing factors among remedies being evaluated. Primarily, they provide criteria to evaluate how well each remedy protects against potential risk or hazard to receptors (protectiveness) and complies with administrative/regulatory requirements (compliance).

4.1.2 Primary Balancing Criteria

Criteria three through seven (the balancing criteria) evaluate the candidate remedies' (1) effectiveness within the constraints presented by engineering and administrative limitations, (2) efficiency at meeting clean-up goals, and (3) economic impact based on cost to implement. The five balancing criteria, and pertinent sub-criteria used to define each balancing criterion, are listed below.

Long-term effectiveness and permanence (at attaining long-term remedial goals) is evaluated by considering (1) the *magnitude(s) of potential residual risk* left after implementing the remedy, (2) the *adequacy and reliability of controls* implemented for managing hazards and risks, and (3) overall *environmental impacts* caused by the remedy (including both on-Site and off-Site impacts). The magnitude of potential residual risk can also be evaluated in terms of how stable the risk reduction is over time. Remedies that have no likelihood of reversing or losing effectiveness over time are better at attaining this criterion than remedies that leave conditions for a potential rebound of constituent concentrations in the formerly remediated media. Potential long-term environmental impacts evaluated by this criterion are related to the National Environmental Policy Act (NEPA) criteria discussed in Section 4.1.2, below.

Short-term effectiveness (at attaining short-term remedial goals) is evaluated by considering (1) the *protection of community during remedial actions* (e.g., on-Site employees, off-Site community residents, etc.), (2) the *protection of workers during remedial actions* (e.g., remediation contractors and remedy construction personnel), (3) the *amount of time until remedial objectives are achieved*, and (4) overall *environmental impacts* generated during implementation of the remedy (including both on-Site and off-Site impacts). Potential short-term environmental impacts evaluated by this criterion are related to the NEPA criteria discussed in Section 4.1.2, below.

Reduction of toxicity, mobility, or volume by treatment (T/M/V) is evaluated by considering (1) *the treatment process(es) used and materials tested*, (2) *the amount of hazardous materials destroyed or treated*, (3) *the degree of expected reduction in T/M/V* attained by implementing the treatment-based remedy, (4) *the degree to which treatment is irreversible* (e.g., can the treatment process be undone at some point in the future, resulting in a rebound in the hazard or risk associated with the treated material), and (5) *the type and quantity of residuals remaining after treatment* has been implemented.

Implementability is an important criterion with broad implications for remedy viability and appropriateness for a Site. It is evaluated by considering ten sub-criteria listed below:

- The ability to construct and operate the technology;
- The overall reliability of the technology;
- The ease of expanding or modifying the technology, if necessary;
- The ability to add other remedial technologies around the evaluated technology, if necessary;
- The ability to monitor remedial effectiveness of the technology;
- The ability to obtain approvals from other regulatory agencies for constructing or operating the technology;
- The ease of coordinating with other regulatory agencies during construction or operation of the technology;
- The availability of off-Site treatment, storage, and disposal services and capacity to support the effective construction or operation of the technology;
- The availability of necessary equipment and specialists to construct or operate the technology; and
- The availability of prospective technologies.

Cost is the fifth balancing criterion defined by EPA (EPA, 2000; Los Alamos National Laboratory [LANL], 1997). Its role in the CERCLA process is unique in that it can play a role not only in remedy evaluation and selection but also in the broader regulatory policy and Agency-level management of CERCLA sites. Cost as a remedy evaluation and selection criterion is evaluated by considering the four cost categories listed below:

- Capital costs (expenses associated with initial construction and start-up of a remedy);
- Operation and maintenance (O&M) costs (expenses [usually presented as an annual cost] associated with the normal, continuous operation of the remedy, and any maintenance activities required to maintain the remedy's efficiency and efficacy);

- Periodic costs (non-annual expenses associated with one-time actions not occurring at initial construction and start-up; e.g., 5-year reviews, equipment replacement costs, decommissioning and close out); and
- Present worth cost (an analysis of changes in the time-value of the total estimated remediation cost).

Due to its unique role in the CERCLA process, cost considerations are discussed apart from the other balancing criteria. Details and assumptions used in calculating cost estimates for the remedies are presented in Appendix D of this FS.

4.1.3 Modifying Criteria

The last two criteria (the modifying criteria) are reserved for stakeholders, affected public and regulatory/administrative agencies to give input to the remedy evaluation process. These criteria are addressed during the public comment period of the Proposed Plan (PP). An EPA responsiveness summary of public comments is part of the Site's ROD.

4.2 Evaluation of On-Site Media Remedies

This section reviews the thirteen on-Site remedies and assesses each against the CERCLA evaluation criteria. The modifying criteria are not assessed in this FS document.

4.2.1 On-Site Remedy OnR-1: No Action

The No Action remedy is presented as a baseline for comparison only, as required in the RI/FS Guidance. This remedy would involve discontinuation of the existing Surficial Aquifer groundwater extraction system, on-going groundwater monitoring and the ongoing passive DNAPL recovery actions. No remediation technology pilot tests would be conducted and no MNA remediation plan would be formulated.

4.2.1.1 Overall Protection of Human Health and the Environment. The No Action remedy would fail to meet the RAOs. Overall protection of human health and the environment would not be met for the Surficial Aquifer as the groundwater extraction system would be shut down resulting in no controls to the off-Site migration of impacted groundwater at concentrations above applicable groundwater protection standards (e.g. GCTLs). Discontinuation of the groundwater monitoring system would prevent detection of potential off-Site migration of impacted groundwater with concentrations above the standards. Without Site use controls, depending up the nature of that future use, surface and shallow soils could potentially present an unacceptable risk to potential future receptors. Therefore, the No Action remedy does not satisfy this threshold criterion.

4.2.1.2 Compliance with ARARs. The No Action remedy could, depending on future land use, fail to meet allowable risk limits. Groundwater impacts above groundwater protection standards in the Surficial Aquifer,HG, and Floridan Aquifer would not be addressed. Under such circumstances, the No Action remedy would not be in compliance with the state and federal ARARs, therefore, this remedy would not satisfy this threshold criterion.

4.2.1.3 Long-Term Effectiveness and Permanence. The No Action remedy has no long-term effectiveness toward addressing the RAOs. There would be no reduction in potential risk associated with potential future exposures to Site soil and sediment in the absence of Site use and/or engineering controls. Groundwater with concentrations exceeding GCTLs would remain at the Site, without any controls to address the potential for groundwater to migrate off-Site. No institutional controls would be implemented to prevent potential future exposures. Therefore, the No Action remedy would be ineffective in the long term, and does not meet this primary criterion.

4.2.1.4 Reduction of Toxicity, Mobility, or Volume by Treatment. The No Action remedy does not include any treatment technologies or remedy components. It would not reduce the T/M/V of constituents in soils or groundwater.

4.2.1.5 Short-Term Effectiveness. The No Action remedy does not include any implementation activities, and therefore, there are no additional short-term risks to the community or environment. This remedy is therefore considered to be effective in the short-term.

4.2.1.6 Implementability. There are no constructability, administrative, or availability impediments associated with implementing this remedy.

4.2.1.7 Cost. The costs for implementing this remedy would be minimal. Note that any cost associated with the No Action remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.2 On-Site Remedy OnR-2: Continue Current Actions with Surface Grading/Covers

Remedy OnR-2 includes continuing the current interim remedial measures: Surficial Aquifer extraction/treatment, groundwater monitoring and passive DNAPL recovery. The remedy also includes regrading and covering most of the Site. As a contingency action, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12. MNA and institutional controls are also part of this remedy. The evaluation of this on-Site remedy against CERCLA criteria is discussed in the following sections.

4.2.2.1 Overall Protection of Human Health and the Environment. The engineering and institutional controls of remedy OnR-2 would protect against potential exposures to surface soils.

Groundwater impacts would continue to be addressed by continuing extraction of groundwater from the Surficial Aquifer. Beyond the POCs, the primary remedy would be MNA with ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential on-Site receptors and mitigating potential migration of impacted groundwater. Remedy OnR-2 would satisfy this threshold criterion.

4.2.2.2 Compliance with ARARs. The current remedial actions result in meeting groundwater protection standards at TPOCs and would eventually result in meeting standards at POCs in the Surficial Aquifer and HG (though the time frame may be extended for the HG). The potential for future surface water impacts is low.

Current groundwater impacts in the Surficial Aquifer and the HG exist at locations that require remedial action, and this remedy does nothing to aggressively address source material (and therefore potential future migration of constituents in the Surficial Aquifer or the HG). Future compliance with chemical-specific ARARs is not certain for this remedy.

Treated groundwater is discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals are managed, transported, and disposed of in compliance with appropriate regulations. For ChemOx application, UIC requirements would be met.

This remedy might not comply with all chemical-specific ARARs, and therefore would potentially not satisfy this threshold criterion.

4.2.2.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-2 reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The engineering and institutional controls of remedy OnR-2 would protect against potential exposures to surface soils. Groundwater impacts are contained near the Site and will eventually be contained on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted groundwater. Potential future impacts to surface water are not expected.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-2.

4.2.2.4 Reduction of Toxicity, Mobility, or Volume by Treatment. Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals. Passive removal of DNAPL (and off-Site incineration) would also reduce the volume of COCs.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-2.

4.2.2.5 Short-Term Effectiveness. Implementing OnR-2 would likely result in minimal additional short-term risks. On-Site operations, including the extraction/treatment system, collection of DNAPL from monitoring wells, and groundwater monitoring, would have the potential to create worker safety, accidental releases, and on- and off-Site emission risks. However, overall health and safety risks are low. During on-Site operations an ambient air monitoring will be conducted at the fenceline.

Relatively little time would be required to implement this remedy. It may take a few months to complete installation of new monitoring wells, execute institutional controls, and prepare a report. Other components of the remedy are already operational.

Groundwater impacts will be largely contained by the existing Surficial Aquifer hydraulic containment system. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs would likely be many years.

This primary criterion is met by remedy OnR-2.

4.2.2.6 Implementability. This remedy includes continuing current remedial activities (interim measures), along with (a) grading and covering most of the Site, (b) installing new monitoring wells, (c) developing, implementing, and analyzing an MNA program and additional hydraulic containment as needed, (d) implementing contingency actions in the HG if necessary, and (e) attaching deed restrictions to the Site property. These activities can be readily implemented, thus this primary criterion is met by remedy OnR-2.

4.2.2.7 Cost. The estimated capital cost for remedy OnR-2 is $6.2M. It assumes that the groundwater treatment system will be operated for 30 years in this remedy. The OM&M costs will be approximately $300,000 annually. The net present value (NPV) cost estimate for this remedy is $11.1M and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.3 On-Site Remedy OnR-3A: Removal – Surficial Aquifer Excavation

Remedy OnR-3A includes excavating the Surficial Aquifer material in the four source areas (to approximately 25 feet below surface). The excavated soil will be treated ex-situ by S/S and returned to the excavations. Excess solidified material will be incorporated into covers for the excavated areas. Vertical barrier/retaining walls will be installed to the top of the middle clay of the HG to provide shoring for the excavations and to contain groundwater impacts in the Upper Hawthorn. ChemOx or ISBS treatment will be applied at existing Upper and Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate potential groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

Excavating the Surficial Aquifer material in the four source areas combined with surrounding the source areas with slurry walls is anticipated to stabilize the plume in the Surficial Aquifer. Once the plume has been documented to be stable or shrinking, the existing Surficial Aquifer groundwater extraction system (including source area horizontal collection drains and perimeter wells) will be phased out. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.3.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-3A would be protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

Ex-situ S/S of source area soil from the Surficial Aquifer would reduce, but not eliminate, mass flux of COCs to groundwater in the long term.

Groundwater impacts would be addressed through (1) continuation of extraction in the Surficial Aquifer (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-3A would satisfy this threshold criterion.

4.2.3.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from potential direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excavated soil would be managed and treated within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. If ChemOx application were implemented as a contingent action, UIC requirements would be met.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.3.3 Long-Term Effectiveness and Permanence. The remedial actions of remedy OnR-3A would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated to limit (but not eliminate) ongoing impacts to groundwater and to reduce or eventually eliminate the need for hydraulic containment in the Surficial Aquifer.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-3A.

4.2.3.4 Reduction of Toxicity, Mobility, or Volume by Treatment. Technically, removal (excavation) is not considered a treatment action; excavated soil can be treated ex-situ. There is some risk that excavation activities could lead to mobilization of DNAPL that is presently immobile at residual saturation. Such mobilized DNAPL should be captured by the dewatering operation, though this capture is uncertain.

Treatment of the excavated soil by S/S would significantly decrease the mobility of COCs by binding the constituents and DNAPL to the soil and reducing hydraulic conductivity of the mass. The source area treatment would also reduce the dissolved-phase plume volume over the long term. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Graded surface covers, although technically not a treatment action, would decrease the mobility of constituents by reducing water infiltration through impacted soils. Likewise, vertical barriers in the Upper Hawthorn would limit groundwater flow through source areas thereby reducing COC mobility.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals. Targeted ChemOx or ISBS in the HG in source areas would also reduce the volume of COCs.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-3A.

4.2.3.5 Short-Term Effectiveness. Implementing OnR-3A would create short-term risks requiring mitigation. Implementation of excavation, ex-situ solidification, and surface covers will involve substantial use of heavy equipment, large open excavations, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of surface water runoff impacts during construction. Many of the short-term risks are addressed quantitatively in the Source Removal Assessment Report (TRC, 2005). The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is excavation, treatment, and backfilling, which would take approximately 1.5 years to complete. The total time for construction is estimated to be 2 years.

After construction, potential groundwater impacts would be largely contained by the source treatment and hydraulic containment system. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-3A.

4.2.3.6 Implementability. Remedy OnR-3A presents serious implementation challenges. While the practicality of implementing this remedy is highly questionable, as described below, it is assumed here that implementation challenges can be overcome.

For this remedy, large excavations would be required and large quantities of soil would need to be processed above ground. The amount of space, equipment, and time needed would be large.

Large quantities of cement and other additives would need to be procured and managed. Large volumes of impacted water would need to be treated and discharged during pre-excavation dewatering.

There would be logistical challenges to stockpiling and treating soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.3.7 Cost. The estimated capital cost for remedy OnR-3A is $64.1M, with most of the cost being for excavation and treatment. It assumes that the groundwater treatment system will be operated for 10 years in this remedy. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $67.8M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.4 On-Site Remedy OnR-3B: Removal – Excavation to Middle Clay

This remedy includes excavating the Surficial Aquifer material in the four source areas and in the Upper Hawthorn above the middle clay unit. The excavated soil will be treated by ex-situ S/S and returned to the excavations. Excess solidified material will be incorporated into surface covers. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

Excavating the Surficial Aquifer and the Upper Hawthorn material in the four source areas is anticipated to stabilize the plumes in their respective units. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.4.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-3B would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

Ex-situ S/S of source area soil from the Surficial Aquifer and HG would limit potential mass flux of COCs to groundwater in the long term.

Groundwater impacts would be addressed by (1) continuing extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-3B would satisfy this threshold criterion.

4.2.4.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excavated soil would be managed and treated within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. For ChemOx application, UIC requirements would be met.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.4.3 Long-Term Effectiveness and Permanence. The remedial actions of remedy OnR-3B would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated to limit (but not eliminate) ongoing impacts to groundwater and to reduce or eventually eliminate the need for hydraulic containment.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-3B.

4.2.4.4 Reduction of Toxicity, Mobility, or Volume by Treatment. Technically, removal (excavation) is not considered a treatment action; excavated soil can be treated ex-situ. There is some risk that excavation activities could lead to mobilization of DNAPL that is presently immobile at residual saturation. Such mobilized DNAPL should be captured by the dewatering operation; however, such capture is not certain.

Treatment of the excavated soil by S/S would significantly decrease the mobility of COCs by binding the constituents and DNAPL to the soil and reducing hydraulic conductivity of the mass. The source area treatment would also reduce the dissolved-phase plume volume over the long term. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Graded surface covers, although technically not a treatment action, would also decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-3B.

4.2.4.5 Short-Term Effectiveness. Implementing OnR-3B would create short-term risks that would require mitigation. Implementation of excavation, ex-situ solidification, and surface covers will involve substantial use of heavy equipment, large open excavations, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. Many of the short-term risks are addressed quantitatively in the *Source Removal Assessment Report* (TRC, 2005). The short-term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is excavation, treatment, and backfilling, which would take approximately 3 years to complete. The total time for construction is estimated to be 3.5 years.

After construction, groundwater impacts would be largely contained by the source treatment and hydraulic containment system. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-3B.

4.2.4.6 Implementability. Remedy OnR-3B presents very serious implementation challenges. While the practicality of implementing this remedy is highly questionable, as described below, it is assumed here that implementation challenges can be overcome.

For this remedy, extremely large excavations would be required and extremely large quantities of soil would need to be processed. The amount of space, equipment, and time needed would be much larger than any other remedy considered and may be infeasible.

Very large quantities of cement and other additives would need to be procured and managed. Very large volumes of impacted water would need to be treated and discharged during pre-excavation dewatering.

There would be logistical challenges to stockpiling and treating soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.4.7 Cost. The estimated capital cost for remedy OnR-3B is $190M, with most of the cost being for soil excavation and treatment. It is assumed that the groundwater treatment system will be required for 10 years in this remedy. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $193M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.5 On-Site Remedy OnR-4A: In-Situ Treatment – Solidification/ Stabilization to Middle Clay

Remedy OnR-4A includes ISS/S of impacted soil from the ground surface to the top of the middle clay unit of the HG in the four source areas. Excess soil will be treated by ex-situ S/S and used as a base layer for surface covers. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The ISS/S of the Surficial Aquifer and the Upper Hawthorn is anticipated to stabilize the plumes in their respective units. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.5.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of OnR-4A would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

ISS/S treatment of source areas in the Surficial Aquifer and Upper Hawthorn would reduce potential mass flux of COCs to groundwater.

Groundwater impacts would be addressed by (1) continuing extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-4A would satisfy this threshold criterion.

4.2.5.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed and treated within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations.

Storm water controls would result in compliance with ARARs during and after remedy construction. For ChemOx application, UIC requirements would be met.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.5.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-4A would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated to limit (but not eliminate) potential ongoing impacts to groundwater and to reduce or eventually eliminate the need for hydraulic containment.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-4A.

4.2.5.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISS/S of source area soils would significantly decrease the potential mobility of COCs by binding the constituents and DNAPL to the soil and reducing hydraulic conductivity of the mass. The source area treatment would also reduce the dissolved-phase plume volume. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Graded surface covers, although technically not a treatment action, would also decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-4A.

4.2.5.5 Short-Term Effectiveness. Implementing OnR-4A would create short-term risks that would require mitigation. Implementation of ISS/S and surface covers will involve substantial use of heavy equipment and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISS/S, which would take approximately 2.5 years to complete. The total time for construction is estimated to be 3 years.

After construction, groundwater impacts would be largely contained by the source treatment and hydraulic containment system. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-4A.

4.2.5.6 Implementability. Although OnR-4A presents implementation challenges, the remedy is constructible and this primary criterion is met.

This remedy requires mobilizing and operating large diameter ISS/S rigs. Approximately 5.5 acres of the Site would be subject to ISS/S. Very large quantities of cement and other additives would need to be procured and managed. The design depth of ISS/S treatment is near the practical limit of the technology.

Soil generated from ISS/S implementation would need to be managed and treated for use in the cover system. There may be logistical challenges to stockpiling and treating excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.5.7 Cost. The estimated capital cost for OnR-4A is $75.2M, with most of the cost being for ISS/S treatment. It assumes that the groundwater treatment system will be operated for 10 years. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $78.9M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.6 On-Site Remedy OnR-4B: In-Situ Treatment – Solidification/ Stabilization and Biogeochemical Stabilization

Remedy OnR-4B includes ISS/S of impacted soil from ground surface to the top of the upper clay unit of the HG in the four source areas. Excess soil will be treated by ex-situ S/S and used as a base layer for surface covers. ISBS (catalyzed sodium permanganate) will be injected in Upper Hawthorn in source areas. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The ISS/S of the Surficial Aquifer and the ISBS of the Upper Hawthorn is anticipated to stabilize the plumes in their respective units. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. Institutional controls will be implemented to mitigate the risks from impacted surface and shallow soils and from surface water and sediment.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.6.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-4B would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

ISS/S treatment of source areas in the Surficial Aquifer would limit the potential mass flux of COCs to groundwater. Similarly, ISBS treatment in the Upper Hawthorn would limit the potential mass flux of COCs to groundwater. ISBS would also remove some COC mass through oxidation.

Potential groundwater impacts would be addressed by (1) continuing extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-4B would satisfy this threshold criterion.

4.2.6.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed and treated within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. UIC requirements would be met for application of ISBS and ChemOx.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.6.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-4B would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated to limit (but not eliminate) ongoing potential impacts to groundwater and to reduce or eventually eliminate the need for hydraulic containment.

ISBS is an innovative technology that has been tested at this Site and has been successfully deployed at other sites. The ISBS Site study concluded that encrustation of DNAPL would be persistent and not subject to reversibility under likely future geochemical conditions (Adventus, 2009a). However, there would need to be further Site-specific testing to determine specific parameters (such as the radius of influence for effective implementation). In addition, an ongoing effectiveness demonstration along with reinjection criteria will need to be established as part of remedial design.

Many of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-4B.

4.2.6.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISS/S of Surficial Aquifer soils would significantly decrease the potential mobility of COCs by binding the constituents and DNAPL to the soil and reducing hydraulic conductivity of the mass. ISBS of Upper Hawthorn soils would decrease the potential mobility of COCs by encapsulating DNAPL in soil. ISBS would also reduce hydraulic conductivity and destroy some of the COC mass through oxidation. The source area treatment would also reduce the dissolved-phase plume volume. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Graded surface covers, although technically not a treatment action, would also decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-4B.

4.2.6.5 Short-Term Effectiveness. Implementing OnR-4B would create short-term risks that would require mitigation. Implementation of ISS/S, ISBS, and surface covers will involve substantial use of heavy equipment, handling of potentially harmful chemicals, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISS/S, which would take approximately 2 years to complete. The total time for construction is estimated to be 2.5 years.

After construction, potential impacts would be largely contained by the source treatment and hydraulic containment system. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-4B.

4.2.6.6 Implementability. Although OnR-4B presents implementation challenges, the remedy is constructible and this primary criterion is met.

This remedy requires mobilizing and operating large diameter ISS/S rigs. Approximately 5.5 acres of the Site would be subject to ISS/S. Demolition of structures would be required, especially in the former process area. Large quantities of cement and other additives would need to be procured and managed. The remedy also requires procurement and handling of large volumes of ISBS (catalyzed sodium permanganate) solution.

Soil generated from ISS/S implementation would need to be managed and treated for use in the cover system. There may be logistical challenges to stockpiling and treating excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.6.7 Cost. The estimated capital cost for remedy OnR-4B is \$38.1M. ISS/S and ISBS costs are the main contributors. It assumes that the groundwater treatment system will be operated for 10 years. After that, OM&M costs will be approximately \$165,000 annually. The NPV cost estimate for this remedy is \$48.1M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.7 On-Site Remedy OnR-5A: Containment/Treatment – Barrier Wall

Remedy OnR-5A is a combination of containment and treatment remedies and includes installing a barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG. Soil removed during the slurry wall installation will be used as fill in the soil consolidation area. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The barrier wall will be designed to contain groundwater impacts in the Surficial Aquifer and Upper Hawthorn, thus these plumes are anticipated to stabilize. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. It may be necessary, however, to extract groundwater from the Surficial Aquifer within the barrier wall for hydraulic control. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.7.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-5A would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

The barrier-wall system would limit groundwater flow through source areas. Potential groundwater impacts would largely be contained within the barrier wall. Potential groundwater impacts outside of the barrier wall would be addressed through (1) continuation of extraction in the Surficial Aquifer (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-5A would satisfy this threshold criterion.

4.2.7.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste.

Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. For ChemOx application, UIC requirements would be met.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.7.3 Long-Term Effectiveness and Permanence. The remedial actions of remedy OnR-5A would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil with elevated concentrations would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-5A.

4.2.7.4 Reduction of Toxicity, Mobility, or Volume by Treatment. Surrounding the source areas with slurry walls, although technically not a treatment action, would reduce the potential mobility of constituents in groundwater in both the Surficial Aquifer and Upper Hawthorn. Graded surface covers, also not a treatment action, would decrease the potential mobility of constituents by reducing water infiltration through impacted soils. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals. Passive removal of DNAPL (and off-Site incineration) would also reduce the volume of COCs.

This primary criterion would be met by remedy OnR-5A.

4.2.7.5 Short-Term Effectiveness. Implementing OnR-5A would create short-term risks that would require mitigation. Implementation of barrier walls and surface covers will involve substantial use of heavy equipment, open excavations, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The total time for construction is estimated to be 12 months.

After construction, the Surficial Aquifer plume and Upper Hawthorn impacts would be largely contained by the slurry walls. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-5A.

4.2.7.6 Implementability. Although OnR-5A presents implementation challenges, the remedy is constructible and this primary criterion is met.

Constructing the barrier wall would require mobilizing large equipment and materials at and around the Site, which may be logistically challenging. The design depth of the vertical barrier is near the practical limit of the technology.

Soil generated from slurry-wall construction would need to be managed. There may be logistical challenges to stockpiling excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.7.7 Cost. The estimated capital cost for remedy OnR-5A is $12.8M, with surface covers and barrier walls being main cost contributors. It assumes that the groundwater treatment system will be operated for 3 years. After that, OM&M costs will be approximately $181,000 annually. The NPV cost estimate for this remedy is $16.0M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.8 On-Site Remedy OnR-5B: Containment/Treatment – Barrier Wall plus In Situ Biogeochemical Stabilization in the Upper Hawthorn

This remedy is a combination of containment and treatment remedies and includes installing a barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG and ISBS treatment at the base of the Upper Hawthorn. Excess soil will be used as fill in the soil consolidation area. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The barrier wall will be designed to contain groundwater impacts in the Surficial Aquifer and Upper Hawthorn, thus, these plumes are anticipated to stabilize. Additionally, the ISBS treatment of the Upper Hawthorn will further stabilize the plume and the DNAPL source. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. It may be necessary, however, to extract groundwater from the Surficial Aquifer within the barrier wall for hydraulic control. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.8.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-5B would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

The barrier-wall system would limit groundwater flow through source areas and ISBS application in the Upper Hawthorn would limit migration in and through that unit. ISBS would also immobilize and remove (through oxidation) some COC mass.

Potential groundwater impacts would largely be contained within the barrier wall. Potential groundwater impacts outside of the barrier wall would be addressed by (1) continuing extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-5B would satisfy this threshold criterion.

4.2.8.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. UIC requirements would be met for application of ISBS and ChemOx.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.8.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-5B would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

Source areas in the Upper Hawthorn would also be treated by ISBS to limit (but not eliminate) ongoing impacts to groundwater. ISBS is an innovative technology that has been tested at this Site and has been successfully deployed at other sites. The ISBS study conducted at the Site concluded that encrustation of DNAPL would be persistent and not subject to reversibility under likely future geochemical conditions (Adventus, 2009a). However, there would need to be further Site-specific testing to determine specific parameters (such as the radius of influence for effective implementation). In addition, an ongoing effectiveness demonstration along with reinjection criteria will need to be established as part of remedial design.

The other technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-5B.

4.2.8.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISBS of Upper Hawthorn soils would decrease the mobility of COCs by encapsulating DNAPL in soil. ISBS would also reduce the soil hydraulic conductivity and destroy some of the COC mass through oxidation. The source area treatment would also reduce the dissolved-phase plume volume. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Surrounding the source areas with slurry walls, although technically not a treatment action, would reduce the potential mobility of constituents in groundwater in both the Surficial Aquifer and Upper Hawthorn. Graded surface covers, also not a treatment action, would decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-5B.

4.2.8.5 Short-Term Effectiveness. Implementing OnR-5B would create short-term risks that would require mitigation. Implementation of ISBS, barrier walls, and surface covers will involve substantial use of heavy equipment, open excavations, handling of potentially harmful chemicals, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISBS, which would take approximately 9 months to complete. The total time for construction is estimated to be 16 months.

After construction, the Surficial Aquifer plume and Upper Hawthorn impacts would be largely contained by the slurry walls. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-5B.

4.2.8.6 Implementability. Although OnR-5B presents implementation challenges, the remedy is constructible and this primary criterion is met. Constructing the barrier wall would require mobilizing large equipment and materials at and around the Site, which may be logistically challenging. The design depth of the vertical barrier is near the practical limit of the technology.

The remedy also requires procurement and handling of large volumes of ISBS (catalyzed sodium permanganate) solution.

Soil generated from slurry-wall construction would need to be managed. There may be logistical challenges to stockpiling excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.8.7 Cost. The estimated capital cost for OnR-5B is $18.0M, with over half of this cost for ISBS treatment. It assumes that the groundwater treatment system will be operated for 3 years. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $20.9M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.9 On-Site Remedy OnR-5C: Containment/Treatment – Barrier Wall plus In Situ Biogeochemical Stabilization in the Surficial Aquifer

This remedy is a combination of containment and treatment technologies and includes installing a barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG and ISBS treatment of the Surficial Aquifer in source areas. The excess soil will be used as fill in the soil consolidation area. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The barrier wall will be designed to contain groundwater impacts in the Surficial Aquifer and Upper Hawthorn, thus these plumes are anticipated to stabilize. Additionally, the ISBS treatment of the Surficial Aquifer will further stabilize this plume. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. It may be necessary, however, to extract groundwater from the Surficial Aquifer within the barrier wall for hydraulic control. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.9.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-5C would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

The primary source areas of the Surficial Aquifer would be treated by ISBS to significantly reduce potential future impacts to groundwater. ISBS would also remove some COC mass through oxidation. Additionally, the barrier-wall system would limit groundwater flow through source areas.

Potential groundwater impacts would largely be contained within the barrier wall. Potential groundwater impacts outside of the barrier wall would be addressed by (1) continuing extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-5C would satisfy this threshold criterion.

4.2.9.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. UIC requirements would be met for application of ISBS and ChemOx.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.9.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-5C would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated by ISBS to limit (but not eliminate) ongoing impacts to groundwater and to reduce or eliminate the need for hydraulic containment. ISBS is an innovative technology that has been tested at this Site and has been successfully deployed at other sites. The ISBS study conducted at the Site concluded that encrustation of DNAPL would be persistent and not subject to reversibility under likely future geochemical conditions (Adventus, 2009a). However, there would need to be further Site-specific testing to determine specific parameters (such as the radius of influence for effective implementation). In addition, an ongoing effectiveness demonstration along with reinjection criteria will need to be established as part of remedial design.

The other technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-5C.

4.2.9.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISBS of Surficial Aquifer soils would significantly decrease the potential mobility of COCs by encapsulating DNAPL in soil. ISBS would also reduce soil hydraulic conductivity and destroy some of the COC mass through oxidation. The source treatment would also reduce the dissolved-phase plume volume. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs. Passive removal of DNAPL (and off-Site incineration) would also reduce the volume of COCs.

Surrounding the source areas with slurry walls, although technically not a treatment action, would reduce the potential mobility of constituents in groundwater in both the Surficial Aquifer and Upper Hawthorn. Graded surface covers, also not a treatment action, would decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-5C.

4.2.9.5 Short-Term Effectiveness. Implementing remedy OnR-5C would create short-term risks that would require mitigation. Implementation of ISBS, barrier walls, and surface covers will involve substantial use of heavy equipment, open excavations, handling of potentially harmful chemicals, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISBS, which would take approximately 9 months to complete. The total time for construction is estimated to be 16 months.

After construction, the Surficial Aquifer plume and Upper Hawthorn impacts would be largely contained by the slurry walls. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-5C.

4.2.9.6 Implementability. Although OnR-5C presents implementation challenges, the remedy is constructible and this primary criterion is met. Constructing the barrier wall would require mobilizing large equipment and materials at and around the Site, which may be logistically challenging. The design depth of the vertical barrier is near the practical limit of the technology.

The remedy also requires procurement and handling of large volumes of ISBS (catalyzed sodium permanganate) solution.

Soil generated from slurry-wall construction would need to be managed. There may be logistical challenges to stockpiling excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.9.7 Cost. The estimated capital cost for remedy OnR-5C is $18.1M, with ISBS treatment and surface cover construction being the main contributors. It assumes that the groundwater treatment system will be operated for 3 years. After that, OM&M costs will be approximately $181,000 annually. The NPV cost estimate for this remedy is $21.3M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.10 On-Site Remedy OnR-5D: Containment/Treatment – Barrier Wall plus In Situ Solidification/Stabilization in the Surficial Aquifer

This remedy is a combination of containment and treatment technologies and includes installing a barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG and ISS/S treatment of the Surficial Aquifer. Excess soil will be used as fill in the soil consolidation area. ChemOx or ISBS treatment will be applied at existing Upper and Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The barrier wall will be designed to contain potential groundwater impacts in the Surficial Aquifer and Upper Hawthorn, thus these plumes are anticipated to stabilize. Additionally, the ISS/S treatment of the Surficial Aquifer will further stabilize this plume. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.10.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-5D would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

The primary source areas of the Surficial Aquifer would be solidified in place to significantly reduce potential future impacts to groundwater. Additionally, the barrier-wall system would limit groundwater flow through source areas.

Potential groundwater impacts would largely be contained within the barrier wall. Potential groundwater impacts outside of the barrier wall would be addressed by (1) continuing the extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the

POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-5D would satisfy this threshold criterion.

4.2.10.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. For ChemOx application, UIC requirements would be met.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.10.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-5D would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated to limit (but not eliminate) ongoing potential impacts to groundwater and to reduce or eliminate the need for hydraulic containment.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-5D.

4.2.10.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISS/S of Surficial Aquifer soils would significantly decrease the potential mobility of COCs by binding the constituents and DNAPL to the soil and reducing hydraulic conductivity of the mass. This stabilization would result in reducing or eliminating groundwater circulation through the impacted areas, thus reducing the dissolved-phase plume volume. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Surrounding the source areas with slurry walls, although technically not a treatment action, would reduce the mobility of constituents in groundwater in both the Surficial Aquifer and Upper Hawthorn. Graded surface covers, also not a treatment action, would decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-5D.

4.2.10.5 Short-Term Effectiveness. Implementing OnR-5D would create short-term risks that would require mitigation. Implementation of ISS/S, barrier walls, and surface covers will involve substantial use of heavy equipment, open excavations, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISS/S, which would take approximately 2 years to complete. The total time for construction is estimated to be 2.5 years.

After construction, the Surficial Aquifer plume and Upper Hawthorn impacts would be largely contained by the slurry walls. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-5D.

4.2.10.6 Implementability. While OnR-5D presents implementability challenges, the remedy is constructible, and this primary criterion is met. Constructing the barrier wall would require mobilizing large equipment and materials at and around the Site, which may be logistically challenging. The design depth of the vertical barrier is near the practical limit of the technology.

This remedy also requires mobilizing and operating large diameter ISS/S rigs. Approximately 5.5 acres of the Site would be subject to ISS/S. Demolition of structures would be required, especially in the former process area. Large quantities of cement and other additives would need to be procured and managed.

Excess soil that is generated during ISS/S would need to be managed. There may be logistical challenges to stockpiling excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.10.7 Cost. The estimated capital cost for remedy OnR-5D is $35.7M, over half of which is for ISS/S. It assumes that the groundwater treatment system will be operated for

3 years. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $38.7M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.11 On-Site Remedy OnR-5E: Containment/Treatment – Barrier Wall plus In Situ Biogeochemical Stabilization in the Surficial Aquifer and Upper Hawthorn

This remedy is a combination of containment and treatment technologies and includes installing a barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG and ISBS treatment of the Surficial Aquifer and HG in source areas. The excess soil will be used as fill in the soil consolidation area. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The barrier wall will be designed to contain potential groundwater impacts in the Surficial Aquifer and Upper Hawthorn, thus these plumes are anticipated to stabilize. Additionally, the ISBS treatment of the Surficial Aquifer and Upper Hawthorn will further stabilize this plume. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. It may be necessary, however, to extract groundwater from the Surficial Aquifer within the barrier wall for hydraulic control. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.11.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-5E would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

The primary source areas of the Surficial Aquifer and Upper Hawthorn would be treated by ISBS to significantly reduce potential future impacts to groundwater. ISBS would also remove some COC mass through oxidation. Additionally, the barrier-wall system would limit groundwater flow through source areas.

Potential groundwater impacts would largely be contained within the barrier wall. Potential groundwater impacts outside of the barrier wall would be addressed by (1) continuing extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-5E would satisfy this threshold criterion.

4.2.11.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. UIC requirements would be met for application of ISBS and ChemOx.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.11.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-5E would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated by ISBS to limit (but not eliminate) ongoing impacts to groundwater and to reduce or eliminate the need for hydraulic containment. ISBS is an innovative technology that has been tested at this Site and has been successfully deployed at other sites. The ISBS study conducted at the Site concluded that encrustation of DNAPL would be persistent and not subject to reversibility under likely future geochemical conditions (Adventus, 2009a). However, there would need to be further Site-specific testing to determine specific parameters (such as the radius of influence for effective implementation). In addition, an ongoing effectiveness demonstration along with reinjection criteria will need to be established as part of remedial design.

The other technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-5E.

4.2.11.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISBS of Surficial Aquifer and Upper Hawthorn soils would significantly decrease the potential mobility of COCs by encapsulating DNAPL in soil. ISBS would also reduce soil hydraulic conductivity and destroy some of the COC mass through oxidation. The source treatment would also reduce the dissolved-phase plume volume. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs. Passive removal of DNAPL (and off-Site incineration) would also reduce the volume of COCs.

Surrounding the source areas with slurry walls, although technically not a treatment action, would reduce the potential mobility of constituents in groundwater in both the Surficial Aquifer and Upper Hawthorn. Graded surface covers, also not a treatment action, would decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-5E.

4.2.11.5 Short-Term Effectiveness. Implementing remedy OnR-5E would create short-term risks that would require mitigation. Implementation of ISBS, barrier walls, and surface covers will involve substantial use of heavy equipment, open excavations, handling of potentially harmful chemicals, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISBS, which would take approximately 18 months to complete. The total time for construction is estimated to be 24 months.

After construction, the Surficial Aquifer plume and Upper Hawthorn impacts would be largely contained by the slurry walls. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-5E.

4.2.11.6 Implementability. Although OnR-5E presents implementation challenges, the remedy is constructible and this primary criterion is met. Constructing the barrier wall would require mobilizing large equipment and materials at and around the Site, which may be logistically challenging. The design depth of the vertical barrier is near the practical limit of the technology.

The remedy also requires procurement and handling of large volumes of ISBS (catalyzed sodium permanganate) solution.

Soil generated from slurry-wall construction would need to be managed. There may be logistical challenges to stockpiling excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.11.7 Cost. The estimated capital cost for remedy OnR-5E is $26.1M, with ISBS treatment and surface cover construction being the main contributors. It assumes that the groundwater treatment system will be operated for 3 years. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $29.1M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.12 On-Site Remedy OnR-5F: Containment/Treatment – Barrier Wall plus In Situ Solidification/Stabilization in the Surficial Aquifer and Upper Hawthorn

This remedy is a combination of containment and treatment technologies and includes installing a barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG and ISS/S treatment of the Surficial Aquifer and Upper Hawthorn. Excess soil will be used as fill in the soil consolidation area. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The barrier wall will be designed to contain potential groundwater impacts in the Surficial Aquifer and Upper Hawthorn, thus these plumes are anticipated to stabilize. Additionally, the ISS/S treatment of the Surficial Aquifer and Upper Hawthorn will further stabilize this plume. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.12.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-5F would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

The primary source areas of the Surficial Aquifer and Upper Hawthorn would be solidified in place to significantly reduce future impacts to groundwater. Additionally, the barrier-wall system would limit groundwater flow through source areas.

Potential groundwater impacts would largely be contained within the barrier wall. Potential groundwater impacts outside of the barrier wall would be addressed by (1) continuing the extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-5F would satisfy this threshold criterion.

4.2.12.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. For ChemOx application, UIC requirements would be met.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.12.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-5F would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated to limit (but not eliminate) ongoing potential impacts to groundwater and to reduce or eliminate the need for hydraulic containment.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-5F.

4.2.12.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISS/S of Surficial Aquifer and Upper Hawthorn soils would significantly decrease the potential mobility of COCs by binding the constituents and DNAPL to the soil and reducing hydraulic conductivity of the mass. This stabilization would result in reducing or eliminating groundwater circulation through the impacted areas, thus reducing the dissolved-phase plume volume. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Surrounding the source areas with slurry walls, although technically not a treatment action, would reduce the potential mobility of constituents in groundwater in both the Surficial Aquifer and Upper Hawthorn. Graded surface covers, also not a treatment action, would decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-5F.

4.2.12.5 Short-Term Effectiveness. Implementing OnR-5F would create short-term risks that would require mitigation. Implementation of ISS/S, barrier walls, and surface covers will involve substantial use of heavy equipment, open excavations, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISS/S, which would take approximately 2.5 years to complete. The total time for construction is estimated to be 3 years.

After construction, the Surficial Aquifer plume and Upper Hawthorn impacts would be largely contained by the slurry walls. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-5F.

4.2.12.6 Implementability. While OnR-5F presents implementability challenges, the remedy is constructible, and this primary criterion is met. Constructing the barrier wall would require mobilizing large equipment and materials at and around the Site, which may be logistically challenging. The design depth of the vertical barrier is near the practical limit of the technology.

This remedy also requires mobilizing and operating large diameter ISS/S rigs. Approximately 5.5 acres of the Site would be subject to ISS/S. Very large quantities of cement and other additives would need to be procured and managed. The design depth of ISS/S treatment is near the practical limit of the technology.

Excess soil that is generated during ISS/S would need to be managed. There may be logistical challenges to stockpiling excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.12.7 Cost. The estimated capital cost for remedy OnR-5F is $71.8M, over half of which is for ISS/S. It assumes that the groundwater treatment system will be operated for 3 years. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $74.8M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.2.13 On-Site Remedy OnR-5G: Containment/Treatment – Barrier Wall plus In Situ Solidification/Stabilization in the Surficial Aquifer and ISBS in the Upper Hawthorn

This remedy is a combination of containment and treatment technologies and includes installing a barrier wall around the DNAPL source areas to the top of the middle clay unit of the HG, ISS/S treatment of the Surficial Aquifer, and ISBS treatment of the Upper Hawthorn. Excess soil will be used as fill in the soil consolidation area. ChemOx or ISBS treatment will be applied at existing Lower Hawthorn wells in source areas. As a contingency, ChemOx will be injected if necessary to remediate groundwater impacts in the HG based on criteria outlined in Section 3.1.15.12.

The barrier wall will be designed to contain potential groundwater impacts in the Surficial Aquifer and Upper Hawthorn, thus these plumes are anticipated to stabilize. Additionally, the ISS/S treatment of the Surficial Aquifer and ISBS treatment of the HG will further stabilize this plume. Once the plume has been documented to be stable, the existing Surficial Aquifer groundwater extraction system will be phased out. MNA and institutional controls are also part of this remedy.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.2.13.1 Overall Protection of Human Health and the Environment. The combination of soil cover and institutional controls of remedy OnR-5G would be highly protective against potential exposures to Site-related constituents in surface soils and would protect surface water from potential impacted runoff.

The primary source areas of the Surficial Aquifer would be solidified in place to significantly reduce potential future impacts to groundwater. ISBS application in the Upper Hawthorn would limit potential migration in and through that unit. ISBS would also immobilize and remove (through oxidation) some COC mass. Additionally, the barrier-wall system would limit groundwater flow through source areas.

Potential groundwater impacts would largely be contained within the barrier wall. Potential groundwater impacts outside of the barrier wall would be addressed by (1) continuing the extraction of Surficial Aquifer groundwater (eventually to be phased out), (2) MNA, and (3) ChemOx application in the HG if necessary (contingent action). Monitoring would be used to demonstrate that groundwater concentrations beyond the POCs are decreasing to below applicable groundwater protection standards (e.g. GCTLs). Institutional controls would prevent potential exposure to impacted groundwater on Site.

These measures would achieve the RAOs of mitigating potentially unacceptable risks to potential receptors and mitigating potential migration of impacted groundwater. Remedy OnR-5G would satisfy this threshold criterion.

4.2.13.2 Compliance with ARARs. The remedial actions would result in meeting groundwater protection standards at TPOCs and eventually at POCs in the Surficial Aquifer and HG. After the soil cover is constructed, potential excess lifetime cancer risks from direct exposure to Site-related constituents in on-Site soil are expected to be well below the Florida allowable risk limit of $1x10^{-6}$ and the non-cancer Hazard Index would be well below 1. The potential for future surface water impacts would be very low.

All excess soil would be managed within the Site AOC, which would avoid certain conditions and restrictions on transportation and disposal of potentially hazardous waste. Treated groundwater would continue to be discharged under the conditions of a GRU sanitary-sewer discharge permit. Groundwater treatment residuals would continue to be managed, transported, and disposed of in compliance with appropriate regulations. Storm water controls would result in compliance with ARARs during and after remedy construction. For ChemOx application, UIC requirements would be met.

This remedy would comply with all ARARs, and therefore would satisfy this threshold criterion.

4.2.13.3 Long-Term Effectiveness and Permanence. The remedial actions of OnR-5G would substantially reduce the long-term likelihood of potential exposure to impacted soil, sediment, or groundwater. The highest-concentration areas of surface soil would be beneath an engineered cover. Potential groundwater impacts would be contained near the Site and eventually on Site (within POCs). Institutional controls would be effective at limiting potential contact with impacted soil or impacted groundwater. Potential future impacts to surface water would not be expected.

The primary source areas would also be treated to limit (but not eliminate) ongoing potential impacts to groundwater and to reduce or eliminate the need for hydraulic containment.

All of the technologies used in this remedy are proven and well tested in the field. Their long-term performance has been demonstrated. This primary criterion would be met for remedy OnR-5G.

4.2.13.4 Reduction of Toxicity, Mobility, or Volume by Treatment. ISS/S of Surficial Aquifer and ISBS of Upper Hawthorn soils would significantly decrease the potential mobility of COCs by binding the constituents and DNAPL to the soil and reducing hydraulic conductivity of the mass. This stabilization would result in reducing or eliminating potential groundwater circulation through the impacted areas, thus reducing the dissolved-phase plume volume. ISBS treatment would also eliminate some COC mass through oxidation. Targeted ChemOx/ISBS treatment at source area HG wells would also reduce the volume/mobility of COCs.

Surrounding the source areas with slurry walls, although technically not a treatment action, would reduce the potential mobility of constituents in groundwater in both the Surficial Aquifer and Upper Hawthorn. Graded surface covers, also not a treatment action, would decrease the potential mobility of constituents by reducing water infiltration through impacted soils.

Groundwater extraction and treatment would result in removal and immobilization of COCs via transfer of mass to treatment residuals.

If applied as a contingency, ChemOx injections into the HG would reduce the volume, mobility, and/or toxicity of COCs in groundwater. Natural attenuation also reduces the toxicity, mobility, and/or volume of Site constituents.

This primary criterion would be met by remedy OnR-5G.

4.2.13.5 Short-Term Effectiveness. Implementing OnR-5G would create short-term risks that would require mitigation. Implementation of ISS/S, ISBS, barrier walls, and surface covers will involve substantial use of heavy equipment, open excavations, handling of potentially harmful chemicals, and temporary above-ground stockpiling of impacted soil. There will be emissions from machinery, risks of injury to remediation workers, risks of exposure to on-Site personnel, and risks of storm water runoff impacts during construction. The short term risks can be managed through engineering controls, responsible construction management, and safe work practices.

It will take a substantial amount of time to implement this remedy. The most time-consuming component of the remedy is ISS/S, which would take approximately 2 years to complete. The total time for construction is estimated to be 3 years.

After construction, the Surficial Aquifer plume and Upper Hawthorn impacts would be largely contained by the slurry walls. MNA, with ChemOx if necessary, would be used to attain groundwater protection standards at and downgradient of POCs. The length of time required for groundwater to meet the groundwater protection standards at the POCs may be several years.

This primary criterion is met by remedy OnR-5G.

4.2.13.6 Implementability. While OnR-5G presents implementability challenges, the remedy is constructible, and this primary criterion is met. Constructing the barrier wall would require mobilizing large equipment and materials at and around the Site, which may be logistically challenging. The design depth of the vertical barrier is near the practical limit of the technology.

This remedy also requires mobilizing and operating large diameter ISS/S rigs. Approximately 5.5 acres of the Site would be subject to ISS/S. Large quantities of cement and other additives would need to be procured and managed. The remedy also requires procurement and handling of large volumes of ISBS (catalyzed sodium permanganate) solution.

Excess soil that is generated during ISS/S would need to be managed. There may be logistical challenges to stockpiling excess soil on-Site. Precautions would be taken to assure that all storm water was contained.

4.2.13.7 Cost. The estimated capital cost for remedy OnR-5G is $40.7M, over half of which is for ISS/S. It assumes that the groundwater treatment system will be operated for 3 years. After that, OM&M costs will be approximately $165,000 annually. The NPV cost estimate for this remedy is $43.6M, and is based on a 5 percent discount rate.

Contingent actions are not included in the cost estimate. Note that the cost of this remedy for on-Site media would be added to the costs of the selected UFA and off-Site surface soil remedies.

4.3 Evaluation of Upper Floridan Remedies

This section reviews the two UFA remedies and assesses each against the CERCLA evaluation criteria. These remedies are not assessed against the modifying criteria in this FS document.

4.3.1 Upper Floridan Remedy UFA-1: No Action

The No Action remedy is presented as a baseline for comparison only, as required in the RI/FS Guidance. It would have no restrictions on UFA groundwater use. No monitoring would be performed to evaluate the effectiveness of natural attenuation processes or whether concentrations of Site-related constituents above the applicable groundwater protection standards (e.g. GCTLs) were migrating beyond POCs. Additionally, the UFA IRM of extracting groundwater from Floridan Aquifer wells FW-6 and FW-21B would be shut down under this remedy.

4.3.1.1 Overall Protection of Human Health and the Environment. The No Action remedy for the UFA could fail to meet the RAOs and may, therefore, not protect human health or the environment. Groundwater extraction at FW-6 and FW-21B would be shut down resulting in no controls on the possible migration of potentially impacted UFA groundwater. Potential off-Site migration of impacted groundwater could not be detected if the groundwater monitoring system is decommissioned. Therefore, the UFA No Action remedy does not satisfy this threshold criterion.

4.3.1.2 Compliance with ARARs. UFA-1 would fail to meet chemical-specific ARARs, such as the GCTLs identified in Table 2-4. Constituent concentrations above the GCTLs in UFA groundwater would remain unaddressed under this remedy. The UFA No Action remedy would not be in compliance with local, state and federal ARARs and it would not satisfy this threshold criterion.

4.3.1.3 Long-Term Effectiveness and Permanence. The No Action remedy does not directly address constituent mass in the environment, and would have only indirect impact on constituent mass through incidental natural attenuation. However, without monitoring, the degree of such reductions would be unknown. Impacted UFA groundwater could potentially continue to migrate beyond the POCs. No institutional controls would be implemented to prevent future exposures. Therefore, the No Action remedy may not be effective in the long term.

4.3.1.4 Reduction of Toxicity, Mobility, or Volume by Treatment. The No Action remedy does not include any treatment technology components. It would have only indirect impact on T/M/V of UFA constituents through natural attenuation. However, without monitoring, the degree of such reductions would be unknown.

4.3.1.5 Short-Term Effectiveness. The UFA No Action remedy includes no implementation activities, and therefore, there are no additional short-term risks to the community or environment. Implementing this remedy creates no additional risk in the short-term.

4.3.1.6 Implementability. There are no impediments to construction, administration, or availability of equipment or services associated with this remedy.

4.3.1.7 Cost. The costs for implementing this remedy would be minimal. Note that any cost associated with the No Action remedy would be added to the base costs of the selected on-Site and off-Site surface soil remedies.

4.3.2 Upper Floridan Remedy UFA-2: Monitored Natural Attenuation with Hydraulic Containment

This remedy consists of MNA with groundwater extraction from on-Site wells as required. Remedy UFA-2 relies on groundwater withdrawals and MNA to achieve groundwater protection standards (e.g. GCTLs) at the POCs.

The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.3.2.1 Overall Protection of Human Health and the Environment. The UFA MNA and hydraulic containment remedy would meet the RAOs. Overall human health and the environment would be protected because groundwater extraction would (1) remove constituent mass from the UFA, and (2) prevent groundwater constituents from migrating off-Site. Monitoring would be used to document the stability of the UFA plume and ARAR compliance at POCs. The UFA MNA and hydraulic containment remedy satisfies this threshold criterion.

4.3.2.2 Compliance with ARARs. Remedy UFA-2 would meet ARARs identified for the UFA. Potential groundwater impacts in the UFA would be hydraulically contained through implementation of targeted withdrawals, and monitoring would verify plume stability and attenuation. This remedy would comply with ARARs and it would satisfy this threshold criterion.

4.3.2.3 Long-Term Effectiveness and Permanence. Remedy UFA-2 would meet the RAOs through continued extraction of impacted groundwater at selected, adaptable locations and the through aquifer's ability to naturally attenuate a decreasing constituent mass. MNA monitoring would document the effectiveness of UFA-2. Therefore, this remedy would meet this primary criterion.

4.3.2.4 Reduction of Toxicity, Mobility, or Volume by Treatment. The mass of Site-related COCs in the UFA is small. Natural attenuation mechanisms could reduce COC T/M/V. Groundwater withdrawals reduce COC mass in the aquifer. This primary criterion is met by remedy UFA-2.

4.3.2.5 Short-Term Effectiveness. There would be minimal health and safety risks associated with installing wells, pumps, and conveyance pipes from UFA wells to the groundwater treatment plant. This primary criterion is met by remedy UFA-2.

4.3.2.6 Implementability. The anticipated activities associated with this remedy (groundwater extraction from wells combined with a MNA program) can be readily implemented. This primary criterion is met by the remedy.

4.3.2.7 Cost. Installation of extraction wells in the UFA with telescoping casings would cost approximately $230,000 each. Assuming that groundwater treatment of the Surficial Aquifer continues, the additional OM&M costs for this remedy would likely be approximately $100,000 annually. Assuming a 5 percent discount rate and 30 years of withdrawal and monitoring, the NPV of this annual OM&M cost is $1.5M. Note that this cost would be added to the base costs of the selected on-Site and off-Site surface soil remedies.

4.4 Evaluation of Off-Site Surface Soil Remedies

This section reviews the four OfR and assesses each against the CERCLA evaluation criteria. These remedies are not assessed against the modifying criteria in this FS document.

Note that collection of off-Site soil data is still ongoing and the process used to determine what constituent concentrations may pose a potentially unacceptable risk has not been finalized. In addition, off-Site data collected to date represent a diversity of property uses and analytical results. Once the areas with concentrations exceeding default SCTLs are delineated, one approach is to address the potential risks to present and future receptors determined using risk assessment methods such as those utilized for on-Site soils (AMEC, 2009c). This delineation and assessment process would define whether off-Site areas pose any unacceptable risk (i.e. potential excess lifetime cancer risk greater than one in one million) and what areas would require remedial action. Another approach which may be utilized is to compare sample results to default SCTLs and to require remedial action where soil sampling results show exceedances of the default SCTLs.

4.4.1 Off-Site Remedy OfR-1: No Action

The No Action remedy is presented as a baseline for comparison, as required in the RI/FS Guidance. The No Action remedy for off-Site surface soil would have no restrictions on use and would only be appropriate in areas that are determined to pose no unacceptable risk.

4.4.1.1 Overall Protection of Human Health and the Environment. The No Action remedy would be protective of human health and the environment at properties that meet Florida’s allowable risk limits. The No Action remedy would fail to reduce any potentially unacceptable risks posed by constituents in surface soils at properties that did not meet Florida’s allowable risk limits. Human health and the environment would not be protected at such properties. Therefore, if Florida’s allowable risk limits are used to determine protection of human health and the environment, the No Action remedy may not satisfy this threshold criterion at some properties.

4.4.1.2 Compliance with ARARs. The No Action remedy would meet ARARs at properties that meet Florida's allowable risk limits. The No Action remedy for off-Site surface soil would fail to meet ARARs at properties for which potential risks exceed Florida's allowable risk limit or the default SCTLs. Any potentially unacceptable risk associated with dermal contact, inhalation, or ingestion of soil would remain unaddressed with the No Action remedy.

4.4.1.3 Long-Term Effectiveness and Permanence. At properties that do not meet Florida's allowable risk limits or the default SCTLs, surface soil posing potentially unacceptable risks would remain in place. No institutional controls would be implemented to prevent potential future exposures. Therefore, the No Action remedy would be ineffective in the long term at such properties.

4.4.1.4 Reduction of Toxicity, Mobility, or Volume by Treatment. The No Action remedy does not include any treatment technology component. There would be no decrease in toxicity, mobility, or volume of COCs.

4.4.1.5 Short-Term Effectiveness. The No Action remedy does not include any implementation activities, and therefore, there are no additional short-term risks to the community or environment. By default, this remedy would not create additional risks during implementation because there would be no actions to implement.

4.4.1.6 Implementability. There are no constructability, administrative, or availability impediments associated with implementing this remedy.

4.4.1.7 Cost. The costs for implementing this remedy would be minimal. Note that any cost associated with the No Action remedy would be added to the base costs of the selected on-Site and UFA remedies.

4.4.2 Off-Site Remedy OfR-2: Removal

This remedy consists of excavating the surface soil in areas surrounding the site determined to exceed Florida's allowable risk limit or the default SCTLs (subject to agreement of the property owner(s)) and, as necessary, replacement with clean fill. The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.4.2.1 Overall Protection of Human Health and the Environment. The removal of constituent mass provides protection of human health within the areas surrounding the site exceeding Florida's risk limit or the default SCTLs. After completion of the removal and replacement action, none of the surface soil would present potentially unacceptable risks.

4.4.2.2 Compliance with ARARs. The removal action would comply with chemical-specific ARARs. After completion of the removal action, none of the remaining surface soil would present potentially unacceptable risks. ARARs associated with excavation and soil transport would apply to this remedy. Location-specific ARARs also would be met by OfR-2.

4.4.2.3 Long-Term Effectiveness and Permanence. The removal action would be permanent and effective in the long-term.

4.4.2.4 Reduction of Toxicity, Mobility, or Volume by Treatment. The removal action is not a treatment action; however, it would reduce T/M/V of constituents associated with surface soil in off-Site areas to allowable levels. The soil would be transported to another location where constituents would be unavailable for exposure to residents. The soil would be managed with soil derived from on-Site remedial activities.

4.4.2.5 Short-Term Effectiveness. The process of excavating off-Site soil and transporting it onto the Site property (if selected as the disposal option) likely will create substantial amounts of dust and other risks associated with operation of large trucks and heavy equipment. The exposure to constituents in soil may increase while the remedy is implemented. This potential increase in exposure will require short term safety controls, such as dust control and air monitoring, for the residential population.

4.4.2.6 Implementability. The removal action consists of well-developed excavation equipment and technologies. Contractors and vendors for this remedy exist and are readily available for this type of project. Access between the residential areas and the western portion of the Site can be created. Access to and availability of sufficient volumes of clean fill material are likely.

4.4.2.7 Cost. Capital and construction costs are based heavily on soil volume addressed. The total volume of soil that may need to be remediated is unknown at present (see Section 3.3.1). For this reason, the remediation cost for this remedy cannot be calculated at this time. Note that the cost for this remedy will be added to the base costs of the selected on-Site and UFA remedies.

4.4.3 Off-Site Remedy OfR-3: Institutional and Engineering Controls

This remedy includes engineering and administrative actions (subject to property-owner approval) designed to disrupt the exposure pathways from constituents in soil to off-Site receptors, as described in Section 3.3.4. The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.4.3.1 Overall Protection of Human Health and the Environment. Overall protection of the off-Site human receptors is accomplished through institutional and/or engineering controls. These actions disrupt exposure to constituents in off-Site soils; they do not eliminate or move constituent mass. Overall protection of human health and the environment can be accomplished through appropriate controls that are maintained for the long term.

4.4.3.2 Compliance with ARARs. ARARs are met when off-Site residential receptors are prevented from contacting surface soil that poses a potentially unacceptable risk.

4.4.3.3 Long-Term Effectiveness and Permanence. Soils containing constituents will remain in place. Therefore, the controls must be made effective and long lasting. Institutional controls require long-term compliance with land-use restrictions. Engineering controls require long-term maintenance.

4.4.3.4 Reduction of Toxicity, Mobility, or Volume by Treatment. This remedy does not include any treatment technology component. A soil cover would render any COCs in soil posing a potentially unacceptable risk unavailable for potential exposure, but engineering controls would not reduce the inherent toxicity or volume of the constituents in soils.

4.4.3.5 Short-Term Effectiveness. This remedy is less disruptive of the physical environment than excavation, though some disruption would be required for soil covers. Implementing the administrative actions would not create additional risk to receptors.

4.4.3.6 Implementability. This remedy poses some implementability challenges for installation of soil covers, but the challenges are less than soil removal. Implementing the engineering and institutional controls will require the consent of the property owners affected.

4.4.3.7 Cost. The sampling and assessment program for off-Site surface soil has not been completed at this time. For this reason, the remediation cost for this remedy cannot be calculated at this time. Note that the cost for this remedy will be added to the base costs of the selected on-Site and UFA remedies.

4.4.4 Off-Site Remedy OfR-4: Removal, Institutional Controls, and/or Engineering Controls (Hybrid)

This remedy consists of a combination of targeted soil excavation and application of engineering and administrative controls. This strategy allows maximum flexibility in applying excavation or controls to soils that do not meet Florida's allowable risk limit or default SCTLs, as other limitations or criteria dictate during remedial design and implementation. The evaluation of this remedy against CERCLA criteria is discussed in the following sections.

4.4.4.1 Overall Protection of Human Health and the Environment. Overall protection of the off-Site human receptors is accomplished through a combination of soil removal and controls to prevent potential exposure. See Sections 4.4.2.1 and 4.4.3.1.

4.4.4.2 Compliance with ARARs. ARARs are met through a combination of soil removal and controls to prevent potential exposure. See Sections 4.4.2.2 and 4.4.3.2.

4.4.4.3 Long-Term Effectiveness and Permanence. This remedy would be effective in the long term through a combination of soil removal and permanent controls to prevent potential exposure. See Sections 4.4.2.3 and 4.4.3.3.

4.4.4.4 Reduction of Toxicity, Mobility, or Volume by Treatment. See Sections 4.4.2.4 and 4.4.3.4.

4.4.4.5 Short-Term Effectiveness. There would be disruptions and short-term risks in the off-Site areas that would need to be mitigated with this remedy. See Sections 4.4.2.5 and 4.4.3.5.

4.4.4.6 Implementability. This remedy provides maximum flexibility in implementability by allowing different approaches, as warranted, for different areas.

4.4.4.7 Cost. The sampling and assessment program for off-Site surface soil has not been completed at this time. For this reason, the cost for this remedy cannot be calculated at this time. Note that the cost for this remedy will be added to the base costs of the selected on-Site and UFA remedies.

4.5 Comparative Analysis – On-Site Remedies

This section presents the analysis of how on-Site remedies address or meet CERCLA criteria relative to each other. Rather than simply indicating whether the criteria are met, this section presents evaluations regarding the degree and certainty to which the criteria are met. The thirteen on-Site remedies are compared in a qualitative manner using four of the five primary balancing criteria: (1) long-term effectiveness; (2) implementability; (3) reduction of toxicity, mobility, or volume; and (4) short-term effectiveness. The fifth primary balancing criterion, cost, is also considered, based on cost estimates presented throughout Section 4.2.

In performing this evaluation, specific objectives (or sub-criteria) are defined for each of the first four balancing criteria. Then, the degree to which each remedial alternative meets each objective is estimated. Tables 4-1 through 4-13 provide, for each remedial alternative, the results of the qualitative ratings. The sections below describe the objectives/sub-criteria in more detail.

4.5.1 Long-Term Effectiveness

A remedial action will be effective in the long term if it results in permanent reductions of potential risk to acceptable levels. With this in mind, four specific risk-reduction objectives help define the long-term effectiveness criterion:

- Reduction of potential risk by eliminating potential exposure to impacted soil, sediment, and/or surface water;
- Reduction of potential risk by preventing potential migration of COCs in Surficial Aquifer groundwater to potential exposure locations;
- Reduction of potential risk by preventing potential migration of COCs in Upper Hawthorn groundwater to potential exposure locations;
- Reduction of potential risk by preventing potential migration of COCs in Lower Hawthorn groundwater to potential exposure locations; and
- Reduction of potential risk by eliminating DNAPL downward movement.

4.5.1.1 On-Site Soil, Sediment, and Surface Water. All of the on-Site remedies except OnR-1 include a surface cover for added protection. Surface covers also prevent possible impacts to surface water from COC migration in runoff.

4.5.1.2 Surficial Aquifer Groundwater. For Surficial Aquifer groundwater, the most effective remedies will be those that include a physical barrier to downgradient migration near POCs. A physical barrier is assumed to be more reliably effective in preventing migration than hydraulic containment. Credit is also given for Surficial Aquifer source removal/treatment which will result in long-term mitigation of Surficial Aquifer risks.

While source treatment will provide reduction in constituent mobility and long-term reduction in Surficial Aquifer impacts, source treatment alone will not limit migration of already impacted groundwater. Reliance on hydraulic containment is judged to be effective, but less reliably effective than a physical barrier.

4.5.1.3 Upper Hawthorn Groundwater. Similarly, with respect to Upper Hawthorn groundwater migration, the most effective remedies will include a physical barrier near the downgradient POCs and, of secondary importance, will address sources in the Upper Hawthorn and/or the Surficial Aquifer.

ISBS application in the Surficial Aquifer has the potential for benefit in the HG because the injected ISBS matrix/reagent may migrate downward to impacted portions of the Upper Hawthorn. While Surficial Aquifer ISS/S application does not have this advantage, it more directly and reliably treats the mass in the Surficial Aquifer, which is a source of COCs to the Upper Hawthorn.

4.5.1.4 Lower Hawthorn Groundwater. Due to constructability issues and relatively low observed Lower Hawthorn impacts, none of the on-Site remedies includes a containment barrier to lateral migration in the Lower Hawthorn. In all remedies (except OnR-1 and OnR-2), existing Lower Hawthorn wells are used for ChemOx/ISBS treatment.

The remedies that are most protective of the Lower Hawthorn (and UFA) are those that prevent potential downward migration at the middle clay of the HG. Additionally, ISBS reagent/material injected in the Upper Hawthorn may migrate downward via any potential migration pathways that exist to treat residual DNAPL areas within the Lower Hawthorn.

Source area excavation could mobilize some DNAPL that is presently at residual saturation. Surficial Aquifer source treatment will have a long-term positive effect on the Lower Hawthorn.

4.5.1.5 Upper Floridan Aquifer Groundwater. The comparative analysis for protection of the UFA is similar to the analysis for the Lower Hawthorn. The most protective remedies are those that prevent potential downward migration at the middle clay, and credit is given for Surficial Aquifer source treatment.

4.5.1.6 Vertical DNAPL Mobility. Some of the remedies address the potential for downward migration of DNAPL through source treatment. This is noted in the alternatives analysis tables.

4.5.2 Implementability

A remedy is judged to be implementable if it ranks highly for the following seven functions:

- Constructability;
- Ease of operation and maintenance;
- Reliability of technologies;

- Ease of undertaking additional remedial actions if necessary;
- Ability to monitor remediation effectiveness;
- Ability to obtain technology-implementation approvals (e.g., confirmation that substantive permit requirements have been met) from regulatory agencies as necessary; and
- Availability of services and materials.

4.5.2.1 Ability to Construct. The constructability objective relates to the complexity of a remedy and the probability of encountering a major issue that leads to a deviation from the construction plan.

Though none of the various major technologies contemplated for the other remedies are simple to construct, installation of a slurry wall to the middle clay is easier than large-scale ISS/S primarily because a slurry wall does not require as much volume of soil to be physically displaced. Excavation is the least straightforward technology to implement for many reasons as discussed in TRC (2005). ISBS is more easily implemented than ISS/S primarily because it is accomplished with traditional drilling equipment and does not require physical disturbance of the entire soil volume being treated. Directional drilling can be used with ISBS to avoid existing underground pipes and structures.

4.5.2.2 Ability to Operate and Maintain. All of the remedies meeting the threshold criteria are likely to require operation of a Surficial Aquifer groundwater extraction system for some period of time. Also, all will require maintenance of surface covers.

The biggest differentiator for this objective is the expected length of time that the Surficial Aquifer extraction and treatment system will need to be operated. Though there may be some ongoing need for hydraulic head control inside the slurry wall, it is possible that the extraction/treatment system can be shut down or at least scaled back significantly after installation many of the remedies.

4.5.2.3 Reliability. The on-Site remedies offer varying degrees of reliability in implementation (which is a different criterion than effectiveness reliability). Most of the major technologies being considered (surface covers, groundwater withdrawal and treatment, barrier walls, excavation, ex-situ S/S, and ISS/S), have demonstrated reliability in the field at many sites. ISBS is an innovative technology that has been thoroughly tested in bench and pilot tests at this Site and that has been successfully applied at the field and pilot/demonstration scale for several other wood-treatment sites. All of the technologies, therefore, are reliable.

In order to differentiate between remedies, it is recognized that ISBS is the least tested of the subsurface technologies, while slurry walls and pump-and-treat systems are most common and reliable. S/S (whether in-situ or ex-situ) ranks between slurry walls and ISBS in reliability.

4.5.2.4 Ease of Undertaking Additional Actions. It may be necessary to take additional remedial actions if all RAOs are not attained or if Site use changes in the future. Therefore, it would be better to implement technologies that do not significantly hinder these potential actions in the future. Such actions may include contingent remedial actions contemplated in this FS (e.g., ChemOx in the HG), installation of additional surface covers or caps (perhaps to support the load of new structures), grading for a new land use, or installation of wells for extraction, injection, and/or monitoring.

None of the actions contemplated here will result in major impediments to future actions. While solidification of soil may make it more difficult to work with, it will also make deep drilling less likely to cause cross contamination. It is difficult to compare the remedies on this objective without knowing what future actions are going to be taken.

Installation of a barrier wall and surface cover would most likely aid the undertaking of additional actions by confining impacted groundwater to a certain area for withdrawal or in-situ treatment.

4.5.2.5 Ability to Monitor Effectiveness. There are challenges (inherent to the Site) to effectiveness monitoring, especially given the cross-contamination risks of drilling to the Lower Hawthorn or UFA. Each remedy has its own set of monitoring challenges that are, on the whole, judged to be similar in magnitude.

4.5.2.6 Ability to Obtain Approvals. Local, state, and/or federal regulatory approvals (e.g., confirmation that substantive permit requirements have been met) will likely be required for implementation of the remedial technologies. For the most part, it is anticipated that these approvals will be relatively easily attained. Under CERCLA, it is necessary to meet all of the substantive requirements of various permit requirements, but the administrative requirements do not apply. Pilot tests for the technologies under consideration have been allowed to proceed and substantive requirements have been met (e.g., for UIC regulation in the case of ISBS injection). Significant excavation and on-Site materials handling would require the most effort to coordinate necessary regulatory approvals. That is because of the large quantity of waste soil that would need to be managed and the large amounts of water that would need to be treated and disposed of during excavation.

4.5.2.7 Availability of Services and Materials. It is expected that all necessary materials and services will be readily available for remediation. Large quantities of catalyzed sodium permanganate would be required for ISBS and very large quantities of cement and other additives (e.g. bentonite) would be required for ISS/S.

4.5.3 Reduction of Toxicity, Mobility, or Volume through Treatment

Three objectives are used to evaluate each remedy with respect to reduction of T/M/V through treatment:

- Volume of potential source material treated or destroyed (and degree of T/M/V reduction);
- Irreversibility of treatment; and
- Minimization of treatment residuals posing potential risks.

4.5.3.1 Volume Treated or Destroyed. This objective is used to rate how much of the principal-threat potential source material, in this case primarily DNAPL and DNAPL-impacted soil, is effectively treated.

None of the remedies will be successful in treating all DNAPL-impacted soil. OnR-3B, which is the larger excavation, would remove and treat the most (but not all) DNAPL-impacted soils. Several remedies include soil treatment in the Surficial Aquifer, where most of the impacted soil resides. ISBS treatment may not treat quite as much volume as S/S.

4.5.3.2 Irreversibility of Treatment. All treatment technologies contemplated in the on-Site remedies are likely to irreversibly treat DNAPL-impacted soils. However, there is a small chance that changing geochemical conditions could result in partial reversibility of ISBS and there is an even smaller chance that chemical/physical weathering could render cemented soil (S/S) a less effective binder material. ChemOx treatment (without catalysts) is less certain to be irreversible.

4.5.3.3 Minimization of Treatment Residuals. Treatment residuals include impacted soils that have been treated but that may pose a long-term risk. For the on-Site remedies considered here, the amount of residuals is generally proportional to the volume of amendment (e.g., cement) that is needed. Groundwater treatment also produces solid residuals in the form of clarifier sludge and used carbon canisters.

4.5.4 Short-Term Effectiveness

Short-term effectiveness is evaluated by considering the following four objectives:

- Protection of the community during remediation;
- Protection of remediation workers during remediation;
- Protection against short-term environmental impacts; and
- Minimization of time to complete remedy construction.

4.5.4.1 Protection of the Community. The community should not experience significant risks during construction of any of the on-Site remedies. The risks of a substantial release of constituents will be low if the remedy is engineered and constructed appropriately. Likewise, there is minimal risk to community infrastructure. The main risks during construction may be derived from dust and vehicle emissions. Dust exposure will be minimized through dust controls in the form of dust suppression through continuous water application. During the remedial design of the Site remedy, Beazer East will design and implement an ambient air monitoring network at the fenceline.

4.5.4.2 Protection of Remediation Workers. Higher risks are faced by remediation workers when large-scale excavations are involved. This involves operation of more large machinery, greater potential exposure to impacted soils, and potential for excavation collapse.

4.5.4.3 Protection against Short-Term Environmental Impacts. As with some of the above objectives, the risks of environmental impacts during construction increase with the overall size of the remediation. The potential for machinery emissions and impacted runoff increases as more soil is excavated. Remedies involving ISBS result in slightly increased short-term risks of environmental impacts due to the use of chemicals that carry some risks.

4.5.4.4 Time to Complete Construction. For this objective, the complexity of the remedy and the time to implement specific technologies is considered. Of the major technologies being considered, source area excavation would take the longest. ISS/S would also be a time-consuming venture, given the size of the treatment areas under consideration.

4.5.5 Comparative Analysis Summary

Using the evaluations provided in Tables 4-1 through 4-13, an overall summary table is developed for each remedy and each balancing criteria (Table 4-14) to summarize the comparative analysis.

As shown in Table 4-14, the alternatives are qualitatively categorized relative to the first four balancing criteria. For long-term effectiveness, the alternatives range from "not effective" (OnR-1, No Action) to "very protective" (all of the vertical barrier-wall alternatives). For implementability, many alternatives are "easily implemented," others are "implementable" (but not as easily), and the excavation alternatives are "challenging" or "extremely challenging." For reduction of T/M/V by treatment, the amount of DNAPL and DNAPL-impacted soil that is treated is summarized in qualitative terms. Finally, for the short-term effectiveness category, the time of implementation is summarized. The estimated remedy costs are also listed in Table 4-14. The total cost (including present-value of future OM&M cost) is provided, along with the capital (initial) cost.

In reviewing this table, it should be noted that all balancing criteria should not necessarily be given equal importance. In particular:

- Long-term effectiveness is the most critical criterion because it relates directly to the risk-reduction RAOs. A successful remedy must be effective in reducing unacceptable risks in the long term.

- Implementability is likely to be the next most important criterion. For instance, it is important to not mobilize DNAPL that is presently at residual saturation, and it is important to take great care when penetrating the natural low-permeability clay units of the HG. It is not possible to reduce T/M/V without first considering the remedy implementability.
- Reduction of T/M/V through treatment is more important than short-term effectiveness.
- While short-term effectiveness is an important issue, it is expected that short-term risks can be adequately managed
- Cost is an important factor; the added benefits of alternatives with higher costs should be weighed carefully to determine whether the benefits are worth the cost.

4.6 Comparative Analysis – Upper Floridan Aquifer Remedies

Only one of the two UFA remedies evaluated in this FS is expected to meet the two threshold CERCLA criteria. The No Action remedy (UFA-1) would fail to meet these mandatory criteria. Because there are no other remedies to which to compare UFA-2, a formal comparison is not necessary.

4.7 Comparative Analysis – Off-Site Surface Soil Remedies

Remedy OfR-1 is applicable only at locations where Florida's allowable risk limit or default SCTLs are met.

Alternatives OfR-2, OfR-3, and OfR-4 are all protective and would be effective at eliminating any potentially unacceptable risks from direct contact. The relative effectiveness, implementability, and cost of these alternatives will vary depending on estimated potential risk, the type or types of properties, and the preferences of the land owners. Therefore a detailed comparison of these alternatives cannot be completed at this time.

However, it is noted that alternative OfR-4 allows for a flexible approach that may include institutional and/or engineering controls on properties that (1) are suitable for such controls and (2) have owners that are amenable to such controls. Where institutional/engineering controls are not possible, surface-soil removal may be applied (subject to owner agreement). Because of its flexible approach, Alternative OfR-4 will be the most implementable remedy for soils that do not meet Florida's allowable risk limit or default SCTLs.

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5.0 Feasibility Study Findings and Conclusions

The CERCLA process has been implemented to identify a viable and appropriate remedial strategy for mitigating potential risk from exposure to constituents in environmental media. The culmination of environmental investigations, field sampling events, analytical data collection and pilot/interim actions for this Site is the evaluation of three sets of remedies, one for each of the three environmental units defined for this Site: (1) on-Site media (excluding UFA groundwater), (2) UFA groundwater, and (3) off-Site surface soil

5.1 Findings of the Feasibility Study

The following sections briefly summarize the major findings of the FS.

5.1.1 Regulatory and Technical Stipulations

Identified ARARs and remedial objectives are dictated in part by current and anticipated land-use conditions. Land-use and property ownership issues off-Site impose some limitations to any remedial strategy developed for off-Site environments.

Geologic conditions under the Site consist in part of various layers of low-permeability clays. These may have acted as partial barriers to broader migration of Site-related constituents. Remedial and investigative activities need to maintain the partial protectiveness function of these geologic features. For example, soil boring activities within source area footprints (i.e., locations suspected of having DNAPL source material or groundwater with elevated concentrations) should be prevented or at the very least minimized. Preventing potential migration of constituents to deeper aquifers (groundwater units) is one of the main objectives of the remedial work at this Site.

5.1.2 Screening Analysis of Remedial Technologies

Based on the Site conditions, impacted environmental media, and the identified Site constituents, a sub-set of RTPOs was selected from the universe of remedial technologies available to risk managers and remediation professionals. The identified RTPOs then were used to develop a suitable range of remedies to address all media with elevated constituent concentrations. The FS process applied to this Site resulted in a number of technologies for soil and solids media, groundwater and liquid media, source material (i.e. DNAPL), and supplemental support operations that are necessary for primary remedy operations to function effectively. These, in turn, were used as the basis for selecting specific technologies appropriate for all impacted environmental media: surface soil (on-Site and off-Site), subsurface soil (on-Site), shallow and deep groundwater (on-Site), and surface water and sediment (on-Site).

5.1.3 Development of Remedies

The sub-set of RTPOs identified for this Site was applied to the three environmental units (on-Site media [excluding UFA groundwater], UFA groundwater, and off-Site surface soil). The result was the development of three sets of remedies (one for each environmental unit): thirteen on-Site remedies (including the No Action remedy); two UFA remedies (one of which is the No Action remedy); and four off-Site remedies (including the No Action remedy). The remedies were developed and evaluated through a series of technical meetings and extensive discussion and consideration of the available Site data and information by stakeholders.

The on-Site remedies are specifically designed to include at least one representative of each of the major remediation processes: removal (excavation or extraction), isolation/containment, in-situ treatment, and ex-situ treatment. They focus primarily on addressing the majority of source material in the surface soil, Surficial Aquifer and Upper Hawthorn zones. In all remedies (except OnR-1), there is a provision for implementing an additional direct chemical oxidant injection remedy component if constituents migrate vertically or horizontally. The on-Site remedies also provide a wide range of remedial costs for evaluation. Each on-Site remedy is described in sufficient detail to allow evaluation and subsequent detailed engineering design if selected as part of the preferred alternative.

Remedies for the UFA and the off-Site surface soil environmental units are also considered. A more limited number of remedies are available for those two environmental units because of the inherent limitations associated with those units (e.g., extreme depth to UFA, preservation of the partially impervious nature of some of the geologic features under the Site, current residential land-use of off-Site areas to the west of the Site). Two remedies were evaluated for the UFA: no action (UFA-1) or a combination MNA/hydraulic containment remedy (UFA-2). Four remedies were evaluated for the off-Site surface soil environmental unit: no action (OfR-1), removal (OfR-2), institutional/engineering controls (OfR-3), and a combination of removal and institutional/engineering controls (OfR-4). Each UFA and off-Site remedy is described in sufficient detail to allow evaluation and engineering design if selected as part of the preferred alternative.

5.1.4 Comparative Evaluation of Remedies

Three sets of remedies were evaluated to determine which remedies are most suitable to be recommended to risk managers.

5.1.4.1 On-Site Remedies. Table 4-14 summarizes the comparative analysis of the on-Site remedies. The comparative analysis indicates some potential variation in protectiveness among the thirteen remedies. All twelve active remedies have significant protectiveness compared to the no-action alternative. Some alternatives are more thorough than others at treating principal source areas. All alternatives are judged to be implementable, though the excavation alternatives would pose significant challenges. When remedial cost is introduced into the evaluation, greater differentiation among the most protective remedies is evident.

5.1.4.2 Upper Floridan Aquifer Remedies. Only two remedies were evaluated for the UFA: no action (UFA-1) or a combination MNA/hydraulic containment remedy (UFA-2). Since the ultimate goal of the remedial actions at this Site is to protect the Floridan Aquifer water source, UFA-1 is not a realistic option. The comparative analysis process does not apply to the UFA remedies.

5.1.4.3 Off-Site Surface Soil Remedies. Collection of off-Site soil concentration data is still ongoing and the process used to determine what constituent concentrations may pose an unacceptable risk has not been finalized.

Alternative OfR-1 is applicable only at locations where Florida’s risk limits or default SCTLs are met.

Alternatives OfR-2, OfR-3, and OfR-4 are all protective and would be effective at eliminating any potentially unacceptable risks associated with direct contact. The relative effectiveness, implementability and cost of these alternatives will vary depending on potential risk, the type of property, and the preferences of the land owners. Therefore a detailed comparison of these alternatives cannot be completed at this time.

However, it is noted that alternative OfR-4 allows for a flexible approach that may include institutional and/or engineering controls on properties that (1) are suitable for such controls and (2) have owners that are amenable to such controls. Where institutional/engineering controls are not possible, surface-soil removal may be applied (subject to owner agreement). Because of its flexible approach, Alternative OfR-4 will be the most implementable remedy for soils containing COCs that pose unacceptable risks.

5.2 Anticipated Future Activities

As part of the remedial design process which follows remedy selection, additional characterization in Site aquifers will be conducted to fully characterize and address uncertainties related to DNAPL migration and, more importantly, identify vertical and horizontal boundaries for effective future remedy implementation. Further off-Site soil characterizations are under way to the north, south, east, and west of the Site and will continue after remedy selection through the remedial design phase of the project.

The on-Site human health risk assessment (AMEC, 2009c) is being updated at this time. Given that soil grading and cover will be implemented regardless of potential risk from on-Site surface soil, final approval of a human health risk assessment is not a critical issue impacting recommendation of a preferred on-Site remedy. The only impact that changes in the potential human health risk estimates could have on the overall on-Site remedial strategy is a change in the size of the surface cap/cover (i.e., the aerial extent of the cap/cover). This might impact remedial costs slightly; these types of contingencies may be captured by the conservative estimates provided in this FS. No other impacts to the remedy selection process are anticipated.

The detailed analysis presented in this FS evaluates individual remedies against the first seven of nine CERCLA evaluation criteria listed in the NCP. Generally, EPA conducts the detailed analysis with respect to the final two criteria, State acceptance and Community acceptance, after release of the Final FS and the remedy selection. The basis for selecting the preferred alternative generally follows the recommended remedial alternative (presented in this FS) modified or amended (if necessary) by other risk management decisions.

The preferred alternative (i.e., set of three remedies) will be presented to the public (for review and comment) via the PP document. The PP briefly summarizes the remedies evaluated in the FS and highlights the factors and rationale used to select the preferred set of three remedies. The information and rationale that led to the recommending these three remedies, along with risk manager decisions and information, will be included in the PP so that the public is informed about the process of arriving at a remedial alternative for this Site.

The EPA documents the remedy selection decision in the Site ROD after receiving public comments and any final comments from supporting agencies. The original ROD created in 1990 was based on a previous FS and on information available at that time. The remedy selection based on this FS will be documented in an amendment to the existing ROD.

Once the ROD is approved and signed, the conceptual designs for the set of three selected remedies presented in the FS will be converted into more detailed, construction-ready designs and plans. The components of the remedies will be evaluated for best method of implementation, and specific equipment types and sizes will be identified. Once these design documents are completed, reviewed and approved, subcontractor and vendor procurement can proceed. This is followed by commencement of remedy implementation at the Site. During construction/implementation of the selected remedies, institutional controls and other administrative support requirements will be obtained. Operation and maintenance of applicable components of the remedies (e.g., groundwater extraction and treatment) will commence and proceed until completion of the remedy.

5.3 Off-Site Sampling and Remediation Considerations

Chapter 62-780 FAC, RBCA provides multiple alternatives for a potentially responsible party (PRP), such as Beazer East, to prevent potential exposure of people to soils that have either: (a) constituent concentrations that could lead to a potential increased lifetime risk of cancer of greater than one-in-a-million or (b) constituent concentrations that could potentially result in unacceptable non-cancer effects, as measured by a health index ratio of greater than one. One alternative allowed for addressing off-Site soil impacts is to remove soils that do not meet Florida's risk limit or the default SCTLs and replace them, as warranted, with clean soil. Another approach allowed is for implementation of an engineering control that uses existing Site features or modifies existing Site features to eliminate/mitigate potential exposure to soils. One example of an engineering control is the installation of an asphalt driveway over an area to prevent potential exposure to soils in excess of the health-based limits. Another approach allowed is establishment of institutional controls such as land-use restrictions, restrictive covenants, and deed restrictions to eliminate/mitigate potential exposure to soils. One example of an institutional control is a deed restriction that prohibits using a specific piece of property as a residential area. Often, engineering and institutional controls are combined to maximize protectiveness. For instance, a PRP may install an asphalt parking lot over soil (an engineering control) and an institutional control (a restrictive covenant) may require that the asphalt be maintained in its current use without change. A final approach allowed is the use of a Site-specific risk assessment to show that current conditions are not associated with unacceptable risks to human health and the environment. This regulation also allows a mixture of these approaches to be utilized.

The application of this regulation in off-Site areas requires seeking written permission to enter upon private property to sample soils to assess current conditions. A private property owner may decline to grant access to a property for any reason. However, it is unlikely that soils can be assessed or remedial action implemented without obtaining access. It is not uncommon for private property owners to decline to grant access and, under those circumstances, a PRP is discharged from remediating private properties when owners will not allow access for soil characterization or remediation purposes.

Once soil sampling results are completed and assuming those are associated with an exceedance of Florida's risk or default SCTLs, the PRP (Beazer East, Inc.) and each affected private property owner will have a discussion about possible approaches to address the constituent concentrations in soil on the private property. The private property owner has the right to work with the PRP to customize the remedial action for that land parcel. The private property owner may also decline to allow the PRP to remediate soils. The critical aspect to keep in mind with respect to remediation is that neither the lead environmental agency (in this instance the EPA) nor the PRP will require a private property owner to allow access or require remediation to take place if the property owner determines that it is in his or her best interest not to do so.

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Tables

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Table 1-1: Estimated Volume of Soil Potentially Impacted by DNAPL

	Former South Lagoon	Former North Lagoon	Former Process Area	Former Drip Track	Total
Area (acres)	1.4	1.4	2.1	0.5	5.4
Thickness of Surficial Aquifer (vadose + saturated)	21	22	23	23	
Total soil volume in Surficial Aquifer (cubic yards)	48,200	49,900	78,900	19,900	196,900
Percentage of soil in Surficial Aquifer that is DNAPL impacted	45%	65%	45%	50%	
DNAPL impacted soil volume in Surficial Aquifer (cubic yards)	21,700	32,500	35,500	10,000	99,700
Thickness of Upper Hawthorn (including upper clay unit) (ft)	43	37	47	35	
Total soil volume in Upper Hawthorn (cubic yards)	98,700	85,500	162,000	30,400	376,600
Thickness of Lower Hawthorn (including middle clay unit) (ft)	53	55	47	57	
Total soil volume in Lower Hawthorn (cubic yards)	121,600	127,100	162,000	49,600	460,300

Source for quantities above Hawthorn Group: GeoTrans, 2004b.

Sorce for Hawthorn Group thicknesses: Beazer 2006.

Note: Areas and volumes listed above are uncertain estimates.

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Table 2-1: Chemical-Specific ARARs
Cabot Carbon/Koppers Superfund Site, Gainesville, Alachua County, Florida

Requirement	Citation	ARAR Type	Description	Comment
Soil and Groundwater Cleanup Levels/Criteria				
Federal				
Safe Drinking Water Act-National Primary Drinking Water Standards, Maximum Contaminant Level (MCLs)	40 CFR Part 141.61 (organics) and 141.62 (inorganics)	Relevant and Appropriate	Legally enforceable federal drinking water standards that establish maximum contaminant levels (MCLs) for specific contaminants that have been determined to adversely affect human health.	These standards are relevant and appropriate to the restoration of groundwater, a potential drinking water source.
State				
Florida Surface Water Criteria Rule	Chapter 62-302.530 Florida Administrative Code (FAC)	Relevant and Appropriate	Provides surface water classifications and water quality criteria (numeric and narrative) for protection of State surface water bodies. Numeric ambient water quality criteria (AWQC) are relevant during remedial action of the site soils that are impacting surface water.	Remedial Action Objectives (RAOs) require protection of surface water by monitoring surface water for some contaminants of concern (COCs) against AWQC.
Florida Groundwater Classes, Standards, and Exemptions	Chapter 62-520.410 and 62-520.420, FAC	Applicable	Designates the groundwater of the State into five classes and establishes minimum criteria. This rule also specifies that Class I and Class II groundwater must meet primary drinking water standards listed in Chapter 62-550.310, FAC.	This rule was used to classify groundwater and establish cleanup goals for groundwater. Groundwater at this Site is considered a potential source of drinking water (Class G-II).
Florida Drinking Water Standards, Monitoring and Reporting	Chapter 62-550.310, FAC	Relevant and Appropriate	Provides primary drinking water quality standards and maximum contaminant levels (MCLs) for public water supply systems that are applicable at the tap and are relevant and appropriate to the restoration of a Class G-II aquifer. Remedial objectives require restoration of the surficial aquifer to drinking water quality standards.	Cleanup goals for some of the COCs in groundwater are based upon MCLs listed in this rule. RAOs require restoration of surficial aquifer to drinking water quality standards.

Requirement	Citation	ARAR Type	Description	Comment
Florida Contaminant Cleanup Target Levels Rule	Chapter 62-777.170, FAC Tables I & II	Relevant and Appropriate	This rule provides default cleanup criteria, namely cleanup target levels (CTLs) in Tables I and II and an explanation for deriving CTLs for soil, groundwater and surface water that can be used for site rehabilitation (i.e., cleanup).	CTLs for groundwater in Table I of this rule were used to establish cleanup goals for some of the COCs in groundwater at this Site. Soil CTLs in Table II of this rule were used to establish cleanup goals for some of the soil COCs.
Florida Contaminant Site Cleanup Criteria Rule – Risk Assessment	Chapter 62-780.650(1)(d), FAC	Relevant and Appropriate	This section of the rule generally provides elements to be addressed when performing a risk assessment. Requires that a lifetime excess cancer risk level of 1.0E-6 and a hazard index of 1 or less shall be used in establishing alternative CTLs for groundwater or soil.	The 1.0E-6 and a hazard index of 1 or less requirement considered in developing site-specific or alternative CTLs for certain COCs.

Requirement	Citation	ARAR Type	Description	Comment
Waste Characterization, Storage, Treatment and Disposal – Primary and Secondary Wastes				
Federal				
Resource Conservation & Recovery Act (RCRA) Regulations – Identification, Characterization and Listing of Solid and Hazardous Wastes	40 Code of Federal Regulations (CFR) Part 262.11(a)-(d) (*Solid waste*) and 264.13(a)(1) (*Hazardous waste*)	Applicable	Requires characterization of solid waste and additional characterization of waste determined to be hazardous. Part 261.11(a)-(d) requires determination of whether solid waste is hazardous. Part 263.13(a)(1) requires a detailed chemical and physical analysis of a representative sample of the waste to determine treatment, storage, and disposal requirements.	Response action is expected to generate non-hazardous solid waste (contaminated soil determined not to be hazardous) and RCRA hazardous waste.
RCRA – Land Disposal Restrictions (LDRs) Treatment Standards for Contaminated Soil	40 CFR Part 268.7(a)	Applicable	40 CFR Part 268.7 requires determination of whether waste is restricted from land disposal under 40 CFR 268.40, 268.45, or 268.49 by testing in accordance with prescribed methods or by use of generator knowledge of the waste. 40 CFR 268.49 prohibits land disposal of untreated hazardous wastes and provides treatment standards for contaminated soil considered hazardous waste. *Note:* This determination can be made concurrently with the hazardous waste determination required by 40 CFR 262.11.	Excavated soil determined to be hazardous waste will be sent off-site for treatment and disposal at an appropriate facility.
RCRA -Temporary on-site storage of hazardous waste *in containers*	40 CFR 262.34(a); 40 CFR 262.34(a)(1)(i);	Applicable	A generator may accumulate hazardous waste at the facility provided that: waste is placed in containers that comply with 40 CFR 265.171-173; and	Applies to accumulation of RCRA hazardous waste on-site as defined in 40 CFR 260.10
	40 CFR 262.34(a)(2);		the date upon which accumulation begins is clearly marked and visible for inspection on each container;	
	40 CFR 264.34(a)(3)		container is marked with the words "hazardous waste"; or	
	40 CFR 262.34(c)(1)		container may be marked with other words that identify the contents.	Applies to accumulation of 55 gal. or less of RCRA hazardous waste <u>or</u> one quart of acutely hazardous waste listed in 261.33(e) at or near any

Requirement	Citation	ARAR Type	Description	Comment
				point of generation
Use and Management of Hazardous Waste in *Containers*	40 CFR Part 265.171 to 173	Applicable	Establish requirements for use and management of hazardous waste in containers on-Site.	Containers that may be used for temporary storage of hazardous waste (i.e., precipitate, GAC, contaminated soil) on-site prior to off-site treatment and disposal will comply with these requirements.
Storage of hazardous waste in container area	40 CFR 264.175(a)	Applicable	Area must have a containment system designed and operated in accordance with 40 CFR 264.175(b)	Applies to storage of RCRA hazardous waste in containers ***with free liquids***
	40 CFR 264.175(c)	Applicable	Area must be sloped or otherwise designed and operated to drain liquid from precipitation, or Containers must be elevated or otherwise protected from contact with accumulated liquid.	Applies to storage of RCRA-hazardous waste in containers that *do not contain free liquids* (other than F020, F021, F022, F023,F026 and F027)
Closure performance standard for RCRA container storage unit	40 CFR 264.111	Applicable	Must close the facility (e.g., container storage unit) in a manner that: • Minimizes the need for further maintenance; • Controls minimizes or eliminates to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or the atmosphere; and Complies with the closure requirements of subpart, but not limited to, the requirements of 40 CFR 264.178 for containers.	Applies to storage of RCRA hazardous waste in containers
Closure of RCRA container storage unit	40 CFR 264.178	Applicable	At closure, all hazardous waste and hazardous waste residues must be removed from the containment system. Remaining containers, liners, bases, and soils containing or contaminated with hazardous waste and hazardous waste residues must be decontaminated or removed. [Comment: At closure, as throughout the operating period, unless the owner or operator can demonstrate in accordance with40 CFR 261.3(d) of this chapter that the solid waste removed from the containment system is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with all applicable requirements of parts 262 through 266 of this chapter].	Applies to storage of RCRA hazardous waste in containers in a unit with a containment system

Requirement	Citation	ARAR Type	Description	Comment
RCRA Regulations – Temporary Storage and Closure of remediation Hazardous Waste in *Staging Piles*	40 CFR Part 264.554(a)(1)(i)-(iii), 264.554(d)(1)(i)-(iii), 264.554(d)(2)(i)-(vi), 264.554(e)(1)-(2), 264.554(f)(1)-(3) 264.554(h), 264.554(i)(1)(i)-(ii), 264.554(j)(1)-(2), 264.554(k)	Applicable	Provides requirements for temporary storage and closure of *non-flowing hazardous remediation waste* in a staging pile to prevent or minimize releases of hazardous substances or constituents into the environment.	Storage area for contaminated soil/remediation waste temporarily staged on-site will consider these requirements.
Disposal of RCRA Hazardous waste in a land-based unit	40 CFR 268.40(a)	Applicable	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 CFR 268.40 before land disposal.	Applies to land disposal (40 CFR 268.2) of restricted RCRA waste
	40 CFR 268.40(a)	Applicable	All underlying hazardous constituents [as defined in 40 CFR 268.2(i)] must meet the Universal Treatment Standards, found in 40 CFR 268.48 Table UTS prior to land disposal	Applies to land disposal of restricted RCRA characteristic wastes (D001-D043) that are not managed in a wastewater treatment system that is regulated under the CWA, that is CWA equivalent, or that is injected into a Class I non-hazardous injection well.
Treatment of hazardous waste in Miscellaneous Treatment Unit with air emissions	40 CFR 264.601	Relevant and Appropriate	Unit must be located, designed, constructed, operated, maintained and closed in a manner that will ensure protection of human health and the environment.	Applies to treatment of RCRA hazardous waste in miscellaneous units, except as provided in 40 CFR 264.1.
	40 CFR 264.601(c)	Relevant and Appropriate	Protection of human health and the environment includes, but is not limited to prevention of any release that may have adverse effects on human health or the environment due to migration of waste constituents in the air, considering the factors listed in 40 CFR 264.601(c)(1) thru (7).	
	40 CFR 264.1080(a)(5)	Relevant and Appropriate	The requirements of RCRA Subpart CC – Air Emission Standards for Tanks, Surface Impoundments, and Containers do not apply to a waste management unit that is solely used for on-site treatment or storage of hazardous waste that is placed in the unit as a result of implementing remedial activities required under	Applies to air pollutant emissions with volatile organics from a hazardous waste tank, surface impoundment or container.

Requirement	Citation	ARAR Type	Description	Comment
			RCRA 3004(u) and (v), RCRA 3008(h), or CERCLA authorities.	
RCRA Regulations – Disposal of RCRA characteristic wastewaters in a POTW	40 CFR 268.1(c)(4)(ii)	Applicable	Permits the disposal of such wastewaters if treated pursuant to the pretreatment requirements of Section 307 of the CWA, unless the wastes are subject to a specified method of treatment other than DEACT in 40 CFR 268.40, or are D003 reactive cyanide.	Applies to the land disposal of RCRA hazardous wastewaters that are hazardous only because they exhibit a characteristic and are not otherwise prohibited under 40 CFR 268
RCRA Regulations – Treatment standards for hazardous debris l	40 CFR 268.45(a), (c), (d)(1), and 40 CFR 268.49(c)(1)-(2)	Applicable	Hazardous debris remaining on-Site must comply with 40 CFR 268.45 prior to off-Site disposal as a solid waste. All off-Site disposal must also comply with LDR certification requirements (40 CFR 268.49), which apply to these wastes. If the debris does not fully comply with 40 CFR 268.45, it must be disposed off-site at a regulated subtitle C facility.	Applies to debris, including treatment residuals, used or generated during remedial activities.
		Waste Transportation – Primary and Secondary Wastes		
RCRA Regulations – Transportation of Hazardous Waste *off-site*	40 CFR Part 262.10(h)	Applicable	An owner or operator who initiates a shipment of hazardous waste from a treatment, storage, or disposal facility must comply with the generator standards established in this part, including the requirements of 40 CFR 262.20-23 for manifesting; Section 262.30 for packaging; Section 262.31 for labeling; Section 262.32 for marking; Section 262.33 for placarding; Section 262.41(a) for record-keeping; and Section 262.12 to obtain EPA ID number.	Hazardous waste requiring off-site disposal will meet these transportation requirements.
Federal Hazardous Materials Transportation Act (49 U.S.C. §§ 5101 et seq.) Regulations	49 CFR Part 171.1(c)	Applicable	This regulation applies to a person, including a person under contract with a department or agency of the federal government, that transports, or causes to be transported or shipped "in commerce", a hazardous material.	Hazardous material requiring off-site disposal will meet this transportation requirement.
RCRA Regulations, Transportation of Hazardous Wastes *on-site*	40 CFR 263.10 through 263.31	Applicable	These regulations establish standards which apply to persons transporting hazardous waste within the United States if the transportation requires a manifest under 40 CFR Part 262	Hazardous material requiring on-site disposal will meet this transportation requirement.
		Capping Waste in Place – Landfill Closure and Post Closure		
		State		

Requirement	Citation	ARAR Type	Description	Comment
Florida Solid Waste Management Facilities Regulations	Chapter 62-701.300, Florida Administrative Code (FAC)	Relevant and Appropriate	Prohibits storage, processing, or disposal except at a permitted solid waste management facility.	Waste generated on-site and deemed nonhazardous solid waste will be stored, transported, or disposed of properly.
Florida Solid Waste Management Facilities – Landfill Final Closure Rule	Chapter 62-701.600(5)(e),(f),(g), and (h), FAC	Relevant and Appropriate	Provides requirements for final cover design and construction for a solid waste landfill, including control of stormwater occurring on the landfill property in order to meet the general performance standard in Chapter 62-701.340(1), FAC.	Capping and closure of the on-site landfill will meet the relevant provisions of this rule.
Federal				
RCRA Subtitle C Landfill Cover Standards	40 C.F.R. § 264.310(a)(1)-(5)	Relevant and Appropriate	Defines the design requirements for a Subtitle C Landfill Cap. Must cover the landfill or cell with a final cover designed and constructed to: -provide long-term minimization of migration of liquids through the closed landfill: -function with minimum maintenance; -promote drainage and minimize erosion or abrasion of the cover; -accommodate settling and subsidence so that the cover's integrity is maintained; and -have a permeability less than or equal to the permeability of any bottom liner system or natural subsurface soils present	Construction of a RCRA hazardous waste landfill cover, with the construction of an impermeable cap designed to prevent the migration of hazardous constituents, using a hydraulic conductivity of no more than 1 x 10-7 cm/sec.
RCRA run-on/run-off control systems for landfill cover	40 CFR § 264.301(g)-(h)	Relevant and Appropriate	Run-on control system must be capable of preventing flow onto the active portion of the landfill during peak discharge from a 25-year storm event. Run-off management system must be able to collect and control the water volume from a runoff resulting from a 24-hour, 25 year storm event.	Construction of a RCRA landfill cover
RCRA Closure Performance	40 CFR §§ 264.111, 264.111(a)-(c)	Relevant and Appropriate	Must close the unit in a manner that : Minimizes the need for further maintenance; controls or	Closure of a RCRA hazardous waste management facility

Requirement	Citation	ARAR Type	Description	Comment
			eliminates releases of hazardous materials to the environment and protects human health; and complies with the closure requirements of 40 C.F.R. § 264.310.	
RCRA - General Post Closure Care/Notices for Closed Landfills	40 CFR 264.310(b)(1), (5), and (6) 40 CFR 264.117(c) 40 CFR 264.119(a) 40 CFR 264.119 (b)(1)(i)-(iii)	Relevant and Appropriate	Must maintain the effectiveness and integrity of the final cover, make necessary repairs and prevent erosion. Post closure property uses must not be allowed to impact the integrity of the cover, the liner or the containment/monitoring system. Must provide proper notices to the local zoning authority and record deed notices/ICs regarding the contamination that will run with the land.	Closure of a RCRA landfill
General Construction Standards – Land Disturbance Activities – Water Wells -- Monitoring				
Construction of Groundwater Monitoring Wells	40 CFR 264.97(c)	Relevant and Appropriate	All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole, this casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples, the annular space above the sampling depth must be sealed to prevent contamination of groundwater and samples.	Construction of a RCRA groundwater monitoring well
Florida General Pollutant Emission Limitation Standards	Chapter 62-296.320(4)(c), FAC	Applicable	Requires reasonable precautions, such as application of water or other dust suppressants, to control emission of particulate matter from any activity including but not limited to, vehicular movement and construction..	Precautions will be undertaken to prevent fugitive dust emissions from any land disturbing activities.
Florida Regulation of Stormwater Discharge – Facility Performance Standards	Chapter 62-25.025(7), FAC	Relevant and Appropriate	Establishes requirements for discharges of untreated stormwater from the facility to ensure protection of the surface waters of the state.	Erosion and stormwater control best management practices will be implemented during construction to retain sediment on site.
Florida Generic Permit For Stormwater Discharge from Construction Activities	Chapter 62-621.300(4)(a), FAC	Applicable	Requires development and implementation of best management practices (BMPs) and erosion and sedimentation controls for stormwater discharges to ensure protection of the surface waters of the state.	Erosion and stormwater control BMPs will be implemented during construction activity such as well installation and slurry

Requirement	Citation	ARAR Type	Description	Comment
				wall construction to retain sediment on site.
Florida Hazardous Waste Requirements for Remedial Action	Chapter 62-730.225(3) FAC	Applicable	Requires warning signs at sites suspected or confirmed to be contaminated with hazardous wastes.	This requirement will be met.
Florida Water Well Construction Standards Rule	Chapter 62-532.500, FAC	Applicable	Establishes minimum standards for the location, construction, repair and abandonment of water wells.	The requirements for the construction, repair and abandonment of monitoring, extraction and injection wells will be met.
Florida Underground Injection Control Regulations	Chapter 62-528.600 through 528.645, FAC	Applicable	Establishes standards and criteria for construction, operation, monitoring, plugging, and abandonment for Class V wells Group 4 injection wells associated with aquifer remediation projects.	Requirements pertaining to Class V Group 4 injection wells will be followed.
Florida Groundwater Permitting and Monitoring Requirements	Chapter 62-522.300 and 522.300(2)(e), FAC	Applicable	Establishes permitting and monitoring requirements for installations discharging to groundwater to prevent contaminants from causing a violation of water quality standards and criteria of the receiving groundwater	A zone of discharge is allowed for primary standards for groundwater for closed-loop reinjection systems and for the prime constituents of the reagents used to remediate the contaminants.
Florida Natural Attenuation with Monitoring Regulation	Chapter 62-780.690(8)(a) through (c), FAC	Relevant and Appropriate	Specifies the minimum number of wells and sampling frequency for conducting groundwater monitoring as part of a natural attenuation remedy.	The requirements associated with implementation of groundwater monitoring as part of the natural attenuation remedy will be met. (1)
	Chapter 62-780.690(8)(e), FAC	Relevant and Appropriate	Specifies that if analyses of groundwater samples indicate that concentrations of contaminants of concern exceed action levels, then the wells shall be resampled no later than 30 days after the initial positive result is known.	The monitoring during implementation of the groundwater MNA remedy will consider the relevant

Requirement	Citation	ARAR Type	Description	Comment
				requirements of this rule (1)
	Chapter 62-780.700(12)(a), FAC	Relevant and Appropriate	Specifies that water-level data should be collected from designated wells, piezometers, and staff gauge locations at the time monitoring wells are sampled.	The monitoring during implementation of the groundwater MNA remedy will consider the relevant requirements of this rule (1)
MNA of Inorganic Contaminants in Ground Water (Volumes 1 and 2) issued in October 2007	EPA/600/R-07/139	TBC	Provides a framework for evaluation of monitored natural attenuation as an effective remedy for inorganics in groundwater.	Groundwater performance monitoring criteria will be considered in the development of the MNA Performance Work Plan
Florida Active Remediation Regulation for Groundwater In-situ Systems	Chapter 62-780.700(12)(g), FAC	Relevant and Appropriate	Specifies that operations parameters for in-situ systems should include measurements of biological, chemical, or physical indicators that will verify the radius of influence at representative monitoring locations, on a predetermined schedule.	In-situ groundwater remediation will meet the relevant requirements of this rule.(1)
Florida Active Remediation Regulation for Groundwater Bioremediation Systems.	Chapter 62-780.700(12)(h), FAC	Relevant and Appropriate	Specifies that operational parameters for bioremediation systems should include measurements of dissolved oxygen at representative monitoring locations; rates of biological, chemical, or nutrient enhancement additions, on a predetermined schedule.	Groundwater remediation will meet relevant requirements of this rule.(1)
Florida Post Active Remediation Monitoring Regulation	Chapter 62-780.750(4)(a) through (c), FAC	Relevant and Appropriate	Specifies minimum number of wells and sampling frequency for conducting groundwater monitoring as part of post active remediation monitoring.	Post active remediation monitoring will meet the relevant requirements of this rule.(1)
	Chapter 62-780-750(4)(f), FAC	Relevant and Appropriate	Specifies in part, that a minimum of four sampling events is required when conducting post active remediation monitoring	Post active remediation monitoring will meet the relevant requirements of this rule.(1)

(1) The designated number of wells, sampling time frames/frequency, and specific parameters for analyses will be provided in a Monitoring Plan that is included in a post-ROD document prepared as part of the Remedial Design or Remedial Action which is approved by the EPA and FDEP.

Table 2-3: Location-Specific ARARs and To Be Considered (TBC)
Cabot Carbon/Koppers Superfund Site, Gainesville, Alachua County, Florida

Requirement	Citation	ARAR Type	Description	Comment
Federal				
Clean Water Act Regulations – Section 404(b) Guidelines	40 Code of Federal Regulations (CFR) Part 230.10(a)	Applicable	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact.	Remedial work involves location encompassing aquatic ecosystem as defined in 40 CFR 230.3(c).
Clean Water Act Regulations – Section 404(b) Guidelines	40 CFR Part 230.10(d)	Applicable	No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps in accordance with 40 CFR 230.70 et seq. have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem.	Remedial work involves location encompassing aquatic ecosystem as defined in 40 CFR 230.3(c)
Clean Water Act – Nation Wide Permit (38) <u>Cleanup of Hazardous and Toxic Waste</u>	33 CFR Part 323.3(b)	Applicable	Must comply with the substantive requirements of the NWP 38 General Conditions, as appropriate, and any regional or case-specific conditions recommended by the USACE District Engineer, after consultation.	Remedial work involves location encompassing aquatic ecosystem as defined in 40 CFR 230.3(c)
Fish and Wildlife Coordination Act – Impounding, diverting or controlling of waters	16 United States Code §662(a)	Relevant and Appropriate	Requires that the U.S. Fish and Wildlife Service and the related state agency be consulted prior to structural modification of any body of water, including wetlands with a view to the conservation of wildlife resources by preventing loss of and damage to such resources.	The local agencies would be consulted to determine protective measures to prevent loss of wildlife resources.
Executive Order 11990 – Protection of Wetlands	Exec. Order 11990 Section 1.(a)	TBC	Requires Federal agencies to evaluate action to minimize the destruction, loss or degradation of wetlands and to preserve and enhance beneficial values of wetlands.	Sediment excavation in the Peace River Floodplain Area and Oak Creek Area involves probable disturbance of jurisdictional wetlands.
Executive Order 11988 – Floodplain Management	Exec. Order 11988 Section 2(a)(2)	TBC	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the maximum extent possible, the adverse impacts associated with direct and indirect development of a floodplain.	Oak Creek Area floodplain may need to be restricted from residential development at completion of the excavation and restoration portion of the remedy.

State				
Florida Environmental Resources Permit Procedures	Chapter 62-343.050 and 070, FAC	Applicable	This rule requires an environmental resource permit when action requires dredging or filling in, on or over wetlands.	FDEP will be consulted to determine the substantive aspects of an environmental resource permit for restoring wetlands.

Table 2-4
Federal MCLs and Florida GCTLs for Constituents of Interest in Groundwater
Cabot Carbon/Koppers Superfund Site
Gainesville, Alachua County, Florida

Constituent of Interest		Federal MCL (µg/L)	Florida Default GCTL (µg/L)
Arsenic		10	10
Pentachlorophenol		1	1
Phenol			10
Benzene		5	1
PAHs	2,4-Dimethylphenol		140
PAHs	2-Methylnaphthalene		28
PAHs	2-Methylphenol		35
PAHs	3- and 4-Methylphenol (Note 3)		3.5
PAHs	Acenaphthene		20
PAHs	Acenaphthylene		210
PAHs	Anthracene		2,100
PAHs	Carbazole		1.8
PAHs	Dibenzofuran		28
PAHs	Fluoranthene		280
PAHs	Fluorene		280
PAHs	Naphthalene		14
PAHs	Phenanthrene		210
PAHs	Pyrene		210

Notes:

1. Of the groundwater COCs, federal MCLs are set for only arsenic, pentachlorophenol, and benzene.
2. Florida default GCTLs are 10 times higher than listed in groundwater of low yield or poor quality.
3. 3- and 4-methylphenol are not quantified separately using standard EPA methods. The lower GCTL for 4-methylphenol is provided.

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Table 3-1. Summary of Site-Wide Remedial Alternatives

		Alternative OnR-1	Alternative OnR-2	Alternative OnR-3A	Alternative OnR-3B	Alternative OnR-4A	Alternative OnR-4B	Alternative OnR-5A	Alternative OnR-5B	Alternative OnR-5C	Alternative OnR-5D	Alternative OnR-5E	Alternative OnR-5F	Alternative OnR-5G
		No Action	**Continue Current Actions + Grading/Cover**	**Removal: Surficial Aquifer Excavation**	**Removal: Excavation to Middle Clay**	**Treatment: ISS/S to Middle Clay**	**Treatment: Surficial Aquifer ISS/S + UHG ISBS**	**Containment/Treatment: Barrier Walls**	**Containment/Treatment: Barrier Walls + ISBS (UHG)**	**Containment/Treatment: Barrier Walls + ISBS (SA)**	**Containment/Treatment: Barrier Walls + ISS/S (SA)**	**Containment/Treatment: Barrier Walls + ISBS (SA & UHG)**	**Containment/Treatment: Barrier Walls + ISS/S (SA & UHG)**	**Containment/Treatment: Barrier Walls + ISS/S (SA) + ISBS (UHG)**
Surface and Shallow Soil		No Action	Grading/Cover	**Excavate** + Grading/Cover	**Excavate** + Grading/Cover	**ISS/S** + Grading/Cover	**ISS/S** + Grading/Cover	Grading/Cover	Grading/Cover	Grading/Cover	**ISS/S** + Grading/Cover	Grading/Cover	**ISS/S** + Grading/Cover	**ISS/S** + Grading/Cover
DNAPL Source Areas	**Surficial Aquifer**	No Action	Hydraulic Contain	**Excavate** + **Barrier Walls**	**Excavate**	**ISS/S**	**ISS/S**	**Barrier Wall**	**Barrier Wall**	**Barrier Wall** + **ISBS**	**Barrier Wall** + **ISS/S**	**Barrier Wall** + **ISBS**	**Barrier Wall** + **ISS/S**	**Barrier Wall** + **ISS/S**
	Upper Hawthorn	No Action	Passive Recovery	**Barrier Walls** + **ChemOx/ISBS**	**Excavate**	**ISS/S**	**ISBS**	**Barrier Wall** + Passive Recovery	**Barrier Wall** + **ISBS**	**Barrier Wall** + Passive Recovery	**Barrier Wall** + **ChemOx/ISBS**	**Barrier Wall** + **ISBS**	**Barrier Wall** + **ISS/S**	**Barrier Wall** + **ISBS**
	Lower Hawthorn	No Action	No Action	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**	**ChemOx/ISBS**
Groundwater	**Surficial Aquifer**	No Action	Hydraulic Contain + MNA	Phase-out Hydraulic Contain + MNA	Phase-out Hydraulic Contain + MNA	Phase-out Hydraulic Contain + MNA	Phase-out Hydraulic Contain + MNA	**Barrier Wall** + Hydraulic Contain + MNA	**Barrier Wall** + Phase-out Hydraulic Contain + MNA	**Barrier Wall** + Phase-out Hydraulic Contain + MNA	**Barrier Wall** + Phase-out Hydraulic Contain + MNA	**Barrier Wall** + Phase-out Hydraulic Contain + MNA	**Barrier Wall** + Phase-out Hydraulic Contain + MNA	**Barrier Wall** + Phase-out Hydraulic Contain + MNA
	Upper Hawthorn	No Action	MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency	**Barrier Wall** + MNA w/ Contingency
	Lower Hawthorn	No Action	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency	MNA w/ Contingency
	Floridan Aquifer	Hydraulic Containment + MNA (assuming selection of remedial alternative UFA-2)												

Note: colored text is used to identify primary technology components that differ between alternatives.

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Table 3-2
Summary of Components in Upper Floridan Aquifer Remedies
Cabot Carbon/Koppers Superfund Site
Gainesville, Alachua County, Florida

Remedy Components		Alternative UFA-1	Alternative UFA-2
		No Action [Required by Statute]	Monitored Natural Attenuation and Hydraulic Containment
Primary Remedy Options			
Upper Floridan Aquifer		No Action	Monitored Natural Attenuation + Hydraulic Containment
Remedy Support Activities			
Final Disposition	**Solid Waste**	Not Applicable	Not Applicable
Final Disposition	**Liquid Waste**	No Action	Optimize existing GW Treatment; Post-treatment POTW disposal
Final Disposition	**Collected DNAPL**	Not Applicable	Not Applicable
Generic Support Operations		Five-Year Reviews	Five-Year Reviews Periodic Monitoring
Institutional Controls	**Government Controls**	No Action	Site zoned industrial; continue existing groundwater controls
Institutional Controls	**Proprietary Instruments**	No Action	No Action
Institutional Controls	**Enforcement & Permits**	No Action	Construction and disposal activities require permit compliance
Institutional Controls	**Public Information**	No Action	Regular communications with community stakeholders

Notes: MNA = monitored natural attenuation; GW = groundwater; POTW = publicly owned treatment works

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Table 3-3
Summary of Components in Offsite Surface Soil Remedies (OfR)
Cabot Carbon/Koppers Superfund Site
Gainesville, Alachua County, Florida

Remedy Components		Remedy OfR-1	Remedy OfR-2	Remedy OfR-3	Remedy OfR-4
		No Action [Required by Statute]	Excavation and Disposal	Administrative Action (Institutional and Engineering Controls)	Hybrid: Excavation plus Administrative Action
Primary Remedy Options					
Offsite (Residential) Surface Soil		No Action	Excavation	Property Acquisition, Administrative Controls, Legal Instruments + Engineered Barriers	Excavation Property Acquisition, Administrative Controls, Legal Instruments + Engineered Barriers
Remedy Support Activities					
Final Disposition	Solid Waste	Not Applicable	Transport to Facility for Handling and Disposition	Not Applicable	Not Applicable
Final Disposition	Liquid Waste	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Final Disposition	Collected DNAPL	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Generic Support Operations		Five-Year Reviews	Storm Water Management Decommission / Demobilize Site Restoration Five-Year Reviews (if needed)	Storm Water Management Decommission / Demobilize Site Restoration Five-Year Reviews (if needed)	Storm Water Management Decommission / Demobilize Site Restoration Five-Year Reviews (if needed)
Institutional Controls	Government Controls	No Action	Alter Zoning Ordinances	Alter Zoning Ordinances	Alter Zoning Ordinances
Institutional Controls	Proprietary Instruments	No Action	Property Use / Deed Restrictions	Property Use / Deed Restrictions	Property Use / Deed Restrictions
Institutional Controls	Enforcement & Permits	No Action	Construction and disposal activities require permit compliance	Construction and disposal activities require permit compliance	Construction and disposal activities require permit compliance
Institutional Controls	Public Information	No Action	Regular communications with community stakeholders	Regular communications with community stakeholders	Regular communications with community stakeholders

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Table 4-1
Evaluation Summary for Alternative OnR-1:
No Action

LONG-TERM EFFECTIVENESS

- Soil, Sediment & Surface Water: **No protection against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Eliminating Surficial-Aquifer hydraulic containment provides **no protection against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: **No protection against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: **No protection against Lower Hawthorn groundwater exposure**..
- Floridan Aquifer Groundwater: **No protection against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is not addressed**.

IMPLEMENTABILITY

- Constructability: **No construction**.
- Operation & Maintenance: **No O&M effort**.
- Reliability: **Not applicable** – no technologies deployed.
- Additional Remedial Actions: **Additional actions can be easily undertaken**.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this alternative, especially near source areas.
- Ability to Obtain Approvals: **No approvals/permits needed**.
- Availability of Services and Materials: **No materials or services required**.

REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

- Volume Treated or Destroyed: **None**.
- Irreversibility: **Not Applicable**.
- Treatment Residuals: **None**.

SHORT-TERM EFFECTIVENESS

- Community: **Community is not protected** due to removal of current controls.
- Remediation Workers: **No remediation workers**; therefore, no risk.
- Environmental Impacts: Removing hydraulic capture system creates a **likelihood of short-term environmental impacts** in the Surficial Aquifer – expanding area of constituents in groundwater.
- Time to complete construction: No construction, so completion is **immediate**.

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Table 4-2
Evaluation Summary for Alternative OnR-2:
Continue Current Actions, Soil Regrading/Cover

LONG-TERM EFFECTIVENESS

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Surficial-Aquifer hydraulic containment is **protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Exposure already limited; institutional controls plus ChemOx as necessary provide **some protection against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Exposure already limited; institutional controls plus ChemOx at hot spots as necessary provide **some protection against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Small reduction in downward migration due to ChemOx in units above provide **minimal additional protection against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is not addressed** in any significant way.

IMPLEMENTABILITY

- Constructability: **Very easily constructed**; soil regrading and cover are the main components.
- Operation & Maintenance: Surficial Aquifer perimeter extraction system likely to be needed for an extremely long period of time, resulting in **high O&M effort**.
- Reliability: Technologies are well-tested at many sites; overall alternative is **extremely reliable**.
- Additional Remedial Actions: If necessary, **additional actions can be easily undertaken**.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this alternative, especially near source areas.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals can be very easily obtained** for all work.
- Availability of Services and Materials: The main material needed is clean soil which is readily available; **materials are certain to be available** in the necessary quantities.

REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

- Volume Treated or Destroyed: Some mass treated through groundwater treatment; **minor amount of principal-treat material treated**.
- Irreversibility: The treatment, while minor, is considered **irreversible**.
- Treatment Residuals: **Negligible soil residuals** are generated; groundwater-treatment residuals will continue to be generated in small quantities.

SHORT-TERM EFFECTIVENESS

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Regrading and soil-cover installation will take weeks to months to complete; it will take a **short time to complete construction** of this alternative.

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Table 4-3
Evaluation Summary for Alternative OnR-3A: Removal – Surficial Aquifer Excavation

<u>LONG-TERM EFFECTIVENESS</u>

- Soil, Sediment & Surface Water: Excavation, soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Surficial-Aquifer hydraulic containment with ex-situ source treatment is **protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Ex-situ source treatment and source-area barrier walls are **protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ex-situ treatment in Surficial Aquifer plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ex-situ treatment and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is addressed** through the implementation of ex-situ treatment in the Surficial Aquifer. However, the process of excavation creates **vertical-mobility risks during construction**.

<u>IMPLEMENTABILITY</u>

- Constructability: **Constructible but very challenging** due to logistics of excavation.
- Operation & Maintenance: Surficial Aquifer perimeter extraction system likely to be needed for a long period of time, resulting in **moderately high O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; overall alternative is **extremely reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**; ex-situ treatment may limit additional options for Surficial Aquifer, but makes drilling into the Upper Hawthorn less problematic.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this alternative, especially near source areas.
- Ability to Obtain Approvals: Materials kept on Site; significant approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals can be obtained** for all work.
- Availability of Services and Materials: Large quantities of cement and bentonite will be needed for ex-situ S/S treatment and slurry-wall implementation; the **materials are likely to be available** in the necessary quantities.

<u>REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ex-situ treatment, reducing mobility; minor amount of mass destroyed through ChemOx; **majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through S/S treatment, which is expected to be resistant to chemical/physical weathering; overall, the alternative is judged **irreversible**.
- Treatment Residuals: ISS/S implementation generates a **very large amount of soil residuals** to be consolidated on Site; groundwater-treatment residuals will also continue to be generated.

<u>SHORT-TERM EFFECTIVENESS</u>

- Community: Construction/excavation activity will generate significant dust and vehicle emissions, but these can be managed; overall, **community is protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; significant open excavations results in greater potential accidents; overall, **remediation workers are protected** through proper health and safety planning/procedures.
- Environmental Impacts: Emissions from large machines; significant staging of soils before/during/after treatment; significant temporary erosion prevention measures will be required; overall, there is a **low to moderate threat of short-term environmental impacts**.
- Time to complete construction: excavation, treatment, and backfill will take multiple years to complete; it will take a **very long time to complete construction** of this alternative.

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Table 4-4
Evaluation Summary for Alternative OnR-3B: Removal – Excavation to Middle Clay

<u>LONG-TERM EFFECTIVENESS</u>

- Soil, Sediment & Surface Water: Excavation, soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Surficial-Aquifer hydraulic containment with ex-situ source treatment is **protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Ex-situ source treatment is **protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ex-situ treatment in units above plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ex-situ treatment and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is addressed** through the implementation of ex-situ treatment above the middle clay. However, the process of excavation creates **vertical-mobility risks during construction**.

<u>IMPLEMENTABILITY</u>

- Constructability: **Extremely challenging to construct** due to logistics of excavation and space limitations.
- Operation & Maintenance: Surficial Aquifer perimeter extraction system likely to be needed for a long period of time, resulting in **moderately high O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; overall alternative is **extremely reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**; ex-situ treatment may limit additional options for Surficial Aquifer and Upper Hawthorn, but makes drilling into the Lower Hawthorn less problematic.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site lowered through S/S treatment making it **possible to monitor (with some difficulty)** the effectiveness of this alternative.
- Ability to Obtain Approvals: Materials kept on Site; significant approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals can be obtained** for all work.
- Availability of Services and Materials: Extremely large quantities of cement and bentonite will be needed for ex-situ S/S treatment; the **materials are likely to be available** in the necessary quantities.

<u>REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ex-situ treatment, reducing mobility; minor amount of mass destroyed through ChemOx; **nearly all principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through S/S treatment, which is expected to be resistant to chemical/physical weathering; overall, the alternative is judged **irreversible**.
- Treatment Residuals: Implementation generates a **extreme amount of soil residuals** to be consolidated on Site; groundwater-treatment residuals will also continue to be generated.

<u>SHORT-TERM EFFECTIVENESS</u>

- Community: Construction/excavation activity will generate very significant dust and vehicle emissions, but these can be managed; overall, **community is protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; significant open excavations results in greater potential accidents; overall, **remediation workers are protected** through proper health and safety planning/procedures.
- Environmental Impacts: Emissions from large machines; significant staging of soils before/during/after treatment; significant temporary erosion prevention measures will be required; overall, there is a **moderate threat of short-term environmental impacts**.
- Time to complete construction: excavation, treatment, and backfill will take many years to complete; it will take an **extremely long time to complete construction** of this alternative.

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Table 4-5
Evaluation Summary for Alternative OnR-4A: In-Situ Treatment – ISS/S in Surficial Aquifer and Upper Hawthorn

<u>LONG-TERM EFFECTIVENESS</u>

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Surficial-Aquifer hydraulic containment with source treatment through ISS/S is **protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Source treatment through ISS/S provides **some protection against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISS/S in units above, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISS/S and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is very effectively addressed** through the implementation of ISS/S in the Surficial Aquifer and Upper Hawthorn.

<u>IMPLEMENTABILITY</u>

- Constructability: **Constructible**, though multiple technologies involved, much soil displaced for ISS/S.
- Operation & Maintenance: Surficial Aquifer perimeter extraction system likely to be needed for a long period of time, resulting in **moderately high O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; overall alternative is **extremely reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**; ISS/S limits additional options for Surficial Aquifer and Upper Hawthorn, but makes drilling into the Lower Hawthorn less problematic.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site lowered through ISS/S making it **possible to monitor (with some difficulty)** the effectiveness of this Alternative.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Very large quantities of cement and bentonite will be needed for ISS/S implementation; the **materials are likely to be available** in the necessary quantities.

<u>REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ISS/S, reducing mobility; minor amount of mass destroyed through ChemOx; **great majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through ISS/S, which is expected to be resistant to chemical/physical weathering; overall, the alternative is judged **irreversible**.
- Treatment Residuals: ISS/S implementation generates a **very large amount of soil residuals** to be consolidated on Site; groundwater-treatment residuals will also continue to be generated.

<u>SHORT-TERM EFFECTIVENESS</u>

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: ISS/S will take months to years to complete; it will take a **extremely long time to complete construction** of this alternative.

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Table 4-6
Evaluation Summary for Alternative OnR-4B: In-Situ Treatment –
ISS/S in Surficial Aquifer, ISBS in Upper Hawthorn

LONG-TERM EFFECTIVENESS

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Surficial-Aquifer hydraulic containment with source treatment through ISS/S is **protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Source treatment through ISS/S provides **some protection against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISS/S and ISBS in units above, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISS/S, ISBS and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is very effectively addressed** through the combination of ISS/S in the Surficial Aquifer and ISBS in the Upper Hawthorn.

IMPLEMENTABILITY

- Constructability: **Constructible**, though multiple technologies involved, much soil displaced for ISS/S.
- Operation & Maintenance: Surficial Aquifer perimeter extraction system likely to be needed for a long period of time, resulting in **moderately high O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; ISBS technology less tested but promising in Site pilot study; overall alternative is **very reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**; ISS/S limits additional options for Surficial Aquifer, but makes drilling into the Upper Hawthorn less problematic.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this Alternative, especially the source-treatment components.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Large quantities of catalyzed sodium permanganate, cement, and bentonite will be needed for ISS/S and ISBS implementation; the **materials are likely to be available** in the necessary quantities.

REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ISS/S, reducing mobility; ISBS reduces mobility in Upper Hawthorn; some mass destroyed through ISBS and ChemOx; **great majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through ISS/S, which is expected to be resistant to chemical/physical weathering; ISBS is also expected to be irreversible, though there is a chance that changing geochemical conditions could result in partial reversibility (requiring retreatment); overall, the alternative is judged **likely to be irreversible**.
- Treatment Residuals: ISS/S implementation generates a **significant amount of soil residuals** to be consolidated on Site; groundwater-treatment residuals will also continue to be generated.

SHORT-TERM EFFECTIVENESS

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines and low risk of chemical release during ISBS implementation; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Several remedy components (ISBS, ISS/S) will take months to years to complete, with ISS/S likely taking the longest; it will take a **very long time to complete construction** of this alternative.

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Table 4-7
Evaluation Summary for Alternative OnR-5A: Containment/Treatment – Barrier Wall

LONG-TERM EFFECTIVENESS

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Physical barrier to migration from source areas is **very protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Physical barrier to migration from source areas is **very protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: ChemOx at hot spots provides **some protection against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: ChemOx in Lower Hawthorn provides **some protection against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is somewhat addressed** through the use of a low-permeability cover over source areas.

IMPLEMENTABILITY

- Constructability: **Very easily constructed**; significant soil displaced for barrier wall.
- Operation & Maintenance: Barrier wall reduces and eventually eliminates need for Surficial Aquifer perimeter extraction system, resulting in **low ongoing O&M effort**.
- Reliability: Component technologies are well-tested at many sites; overall alternative is **extremely reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be easy to implement**.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this Alternative, especially near source areas.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Moderate quantities of cement and bentonite will be needed for slurry wall; the **materials are very likely to be available** in the necessary quantities.

REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

- Volume Treated or Destroyed: Some mass destroyed through ChemOx; **minor amount of principal-treat material treated**.
- Irreversibility: The ChemOx treatment has **uncertain irreversibility**.
- Treatment Residuals: Slurry-wall construction generates **some soil residuals** to be consolidated on Site; groundwater-treatment residuals will be reduced and eventually eliminated.

SHORT-TERM EFFECTIVENESS

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Barrier wall will take months to complete; it will take a **reasonably short time to complete construction** of this alternative.

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Table 4-8
Evaluation Summary for Alternative OnR-5B: Containment/Treatment – Barrier Wall, ISBS in Upper Hawthorn

<u>LONG-TERM EFFECTIVENESS</u>

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Physical barrier to migration from source areas is **very protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Physical barrier to migration from source areas plus source treatment through ISBS are **very protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISBS in Upper Hawthorn, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISBS and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is addressed effectively** through the implementation of ISBS in the Surficial Aquifer and use of a low-permeability cover over source areas.

<u>IMPLEMENTABILITY</u>

- Constructability: **Easily constructed**, though multiple technologies involved, significant soil displaced for barrier wall.
- Operation & Maintenance: Barrier wall reduces and eventually eliminates need for Surficial Aquifer perimeter extraction system, resulting in **low ongoing O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; ISBS technology less tested but promising in Site pilot study; overall alternative is **very reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this Alternative, especially source treatment.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Large quantities of catalyzed sodium permanganate will be needed for ISBS, and moderate quantities of cement and bentonite will be needed for slurry wall; the **materials are very likely to be available** in the necessary quantities.

<u>REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>

- Volume Treated or Destroyed: Some DNAPL and DNAPL-impacted soil treated through ISBS, reducing mobility; some mass destroyed through ISBS and ChemOx; **some principal-treat material treated**.
- Irreversibility: Some DNAPL volume treated through ISBS which is expected to be irreversible, though there is a chance that changing geochemical conditions could result in partial reversibility (requiring retreatment); overall, the alternative is judged **likely to be irreversible**.
- Treatment Residuals: Slurry-wall construction generates **some soil residuals** to be consolidated on Site; groundwater-treatment residuals will be reduced and eventually eliminated.

<u>SHORT-TERM EFFECTIVENESS</u>

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines and low risk of chemical release during ISBS implementation; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Some remedy components (ISBS, barrier wall) will take months to complete, with ISBS likely taking the longest; it will take a **moderate time to complete construction** of this alternative.

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Table 4-9
Evaluation Summary for Alternative OnR-5C: Containment/Treatment – Barrier Wall, ISBS in Surficial Aquifer

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LONG-TERM EFFECTIVENESS

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Physical barrier to migration from source areas plus source treatment through ISBS are **very protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Physical barrier to migration from source areas plus source treatment through ISBS in unit above are **very protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISBS in units above, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISBS and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is addressed effectively** through the implementation of ISBS in the Surficial Aquifer and use of a low-permeability cover over source areas.

IMPLEMENTABILITY

- Constructability: **Easily constructed**, though multiple technologies involved, significant soil displaced for barrier wall.
- Operation & Maintenance: Barrier wall reduces and eventually eliminates need for Surficial Aquifer perimeter extraction system, resulting in **low ongoing O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; ISBS technology less tested but promising in Site pilot study; overall alternative is **very reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this Alternative, especially source treatment.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Large quantities of catalyzed sodium permanganate will be needed for ISBS, and moderate quantities of cement and bentonite will be needed for slurry wall; the **materials are very likely to be available** in the necessary quantities.

REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ISBS, reducing mobility; some mass destroyed through ISBS and ChemOx; **majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through ISBS which is expected to be irreversible, though there is a chance that changing geochemical conditions could result in partial reversibility (requiring retreatment); overall, the alternative is judged **likely to be irreversible**.
- Treatment Residuals: Slurry-wall construction generates **some soil residuals** to be consolidated on Site; groundwater-treatment residuals will be reduced and eventually eliminated.

SHORT-TERM EFFECTIVENESS

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines and low risk of chemical release during ISBS implementation; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Some remedy components (ISBS, barrier wall) will take months to complete, with ISBS likely taking the longest; it will take a **moderate time to complete construction** of this alternative.

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Table 4-10
Evaluation Summary for Alternative OnR-5D: Containment/Treatment – Barrier Wall, ISS/S in Surficial Aquifer

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<u>LONG-TERM EFFECTIVENESS</u>

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Physical barrier to migration from source areas plus source treatment through ISS/S are **very protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Physical barrier to migration from source areas plus source treatment through ISS/S in unit above are **very protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISS/S in Surficial Aquifer, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISS/S and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is very effectively addressed** through the application of ISS/S in the Surficial Aquifer and use of a low-permeability cover over source areas.

<u>IMPLEMENTABILITY</u>

- Constructability: **Constructible**, though multiple technologies involved, much soil displaced for barrier wall and ISS/S.
- Operation & Maintenance: Barrier wall reduces and eventually eliminates need for Surficial Aquifer perimeter extraction system, resulting in **low ongoing O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; overall alternative is **extremely reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**; ISS/S limits additional options for Surficial Aquifer, but makes drilling into the Upper Hawthorn less problematic.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this Alternative, especially source treatment.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Large quantities of cement and bentonite will be needed for ISS/S and slurry-wall implementation; the **materials are likely to be available** in the necessary quantities.

<u>REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ISS/S, reducing mobility; minor amount of mass destroyed through ChemOx; **majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through ISS/S, which is expected to be resistant to chemical/physical weathering; overall, the alternative is judged **irreversible**.
- Treatment Residuals: Slurry-wall construction and (especially) ISS/S implementation generate a **significant amount of soil residuals** to be consolidated on Site; groundwater-treatment residuals will be reduced and eventually eliminated.

<u>SHORT-TERM EFFECTIVENESS</u>

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Some remedy components (barrier wall, ISS/S) will take months to years to complete, with ISS/S taking the longest; it will take a **very long time to complete construction** of this alternative.

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Table 4-11
Evaluation Summary for Alternative OnR-5E: Containment/Treatment – Barrier Wall, ISBS in Surficial Aquifer and Upper Hawthorn

<u>LONG-TERM EFFECTIVENESS</u>

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Physical barrier to migration from source areas plus source treatment through ISBS are **very protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Physical barrier to migration from source areas plus source treatment through ISBS are **very protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISBS in units above, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISBS and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is addressed effectively** through the implementation of ISBS in the Surficial Aquifer and Upper Hawthorn and use of a low-permeability cover over source areas.

<u>IMPLEMENTABILITY</u>

- Constructability: **Easily constructed**, though multiple technologies involved, significant soil displaced for barrier wall.
- Operation & Maintenance: Barrier wall reduces and eventually eliminates need for Surficial Aquifer perimeter extraction system, resulting in **low ongoing O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; ISBS technology less tested but promising in Site pilot study; overall alternative is **very reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this Alternative, especially source treatment.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Large quantities of catalyzed sodium permanganate will be needed for ISBS, and moderate quantities of cement and bentonite will be needed for slurry wall; the **materials are very likely to be available** in the necessary quantities.

<u>REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ISBS, reducing mobility; some mass destroyed through ISBS and ChemOx; **great majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through ISBS which is expected to be irreversible, though there is a chance that changing geochemical conditions could result in partial reversibility (requiring retreatment); overall, the alternative is judged **likely to be irreversible**.
- Treatment Residuals: Slurry-wall construction generates **some soil residuals** to be consolidated on Site; groundwater-treatment residuals will be reduced and eventually eliminated.

<u>SHORT-TERM EFFECTIVENESS</u>

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines and low risk of chemical release during ISBS implementation; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Some remedy components (ISBS, barrier wall) will take months to complete, with ISBS likely taking the longest; it will take a **long time to complete construction** of this alternative.

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Table 4-12
Evaluation Summary for Alternative OnR-5F: Containment/Treatment – Barrier Wall, ISS/S in Surficial Aquifer and Upper Hawthorn

LONG-TERM EFFECTIVENESS

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Physical barrier to migration from source areas plus source treatment through ISS/S are **very protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Physical barrier to migration from source areas plus source treatment through ISS/S are **very protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISS/S in units above, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISS/S and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is very effectively addressed** through the application of ISS/S in the Surficial Aquifer and Upper Hawthorn and use of a low-permeability cover over source areas.

IMPLEMENTABILITY

- Constructability: **Constructible**, though multiple technologies involved, much soil displaced for barrier wall and ISS/S.
- Operation & Maintenance: Barrier wall reduces and eventually eliminates need for Surficial Aquifer perimeter extraction system, resulting in **low ongoing O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; overall alternative is **extremely reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**; ISS/S limits additional options for Surficial Aquifer and Upper Hawthorn, but makes drilling into the Lower Hawthorn less problematic.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site lowered through ISS/S making it **possible to monitor (with some difficulty)** the effectiveness of this Alternative.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Very large quantities of cement and bentonite will be needed for ISS/S and slurry-wall implementation; the **materials are likely to be available** in the necessary quantities.

REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ISS/S, reducing mobility; minor amount of mass destroyed through ChemOx; **great majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through ISS/S, which is expected to be resistant to chemical/physical weathering; overall, the alternative is judged **irreversible**.
- Treatment Residuals: Slurry-wall construction and (especially) ISS/S implementation generate a **very large amount of soil residuals** to be consolidated on Site; groundwater-treatment residuals will be reduced and eventually eliminated.

SHORT-TERM EFFECTIVENESS

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Some remedy components (barrier wall, ISS/S) will take months to years to complete, with ISS/S taking the longest; it will take a **extremely long time to complete construction** of this alternative.

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Table 4-13
Evaluation Summary for Alternative OnR-5G: Containment/Treatment – Barrier Wall, ISS/S in Surficial Aquifer, ISBS in Upper Hawthorn

<u>LONG-TERM EFFECTIVENESS</u>

- Soil, Sediment & Surface Water: Soil covers, rerouting/management of stormwater are **very protective against soil, sediment, and surface-water exposure**.
- Surficial Aquifer Groundwater: Physical barrier to migration from source areas plus source treatment through ISS/S are **very protective against Surficial Aquifer groundwater exposure**.
- Upper Hawthorn Groundwater: Physical barrier to migration from source areas plus source treatment through ISBS are **very protective against Upper Hawthorn groundwater exposure**.
- Lower Hawthorn Groundwater: Reduction in downward migration due to ISS/S and ISBS in units above, plus ChemOx at hot spots as available/necessary are **protective against Lower Hawthorn groundwater exposure**.
- Floridan Aquifer Groundwater: Reduction in downward migration due to ISS/S, ISBS and ChemOx in units above are **protective against Floridan Aquifer groundwater exposure**.
- Vertical DNAPL Mobility: The potential for **vertical mobility is very effectively addressed** through the combination of ISS/S in the Surficial Aquifer and ISBS in the Upper Hawthorn and use of a low-permeability cover over source areas.

<u>IMPLEMENTABILITY</u>

- Constructability: **Constructible**, though many technologies involved, much soil displaced for barrier wall and ISS/S.
- Operation & Maintenance: Barrier wall reduces and eventually eliminates need for Surficial Aquifer perimeter extraction system, resulting in **low ongoing O&M effort**.
- Reliability: Component technologies are generally well-tested at many sites; ISBS technology less tested but promising in Site pilot study; overall alternative is **very reliable**.
- Additional Remedial Actions: If necessary, **additional actions will be possible**; ISS/S limits additional options for Surficial Aquifer, but makes drilling into the Upper Hawthorn less problematic.
- Ability to Monitor Effectiveness: Risks of cross-contamination at the Site make it **somewhat difficult to monitor** the effectiveness of this Alternative, especially the source-treatment components.
- Ability to Obtain Approvals: Materials kept on Site; approvals will be required and substantive requirements of permits will need to be met, but based on experience at this Site and others, **approvals will be easily obtained** for all work.
- Availability of Services and Materials: Large quantities of catalyzed sodium permanganate, cement, and bentonite will be needed for ISS/S, ISBS, and slurry-wall implementation; the **materials are likely to be available** in the necessary quantities.

<u>REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>

- Volume Treated or Destroyed: Majority of DNAPL and DNAPL-impacted soil treated through ISS/S, reducing mobility; ISBS reduces mobility in Upper Hawthorn; some mass destroyed through ISBS and ChemOx; **great majority of principal-treat material treated**.
- Irreversibility: Most of DNAPL volume treated through ISS/S, which is expected to be resistant to chemical/physical weathering; ISBS is also expected to be irreversible, though there is a chance that changing geochemical conditions could result in partial reversibility (requiring retreatment); overall, the alternative is judged **likely to be irreversible**.
- Treatment Residuals: Slurry-wall construction and (especially) ISS/S implementation generate a **significant amount of soil residuals** to be consolidated on Site; groundwater-treatment residuals will be reduced and eventually eliminated.

<u>SHORT-TERM EFFECTIVENESS</u>

- Community: Construction activity will generate some dust and vehicle emissions, but these can be managed; overall, **community is very protected** during construction.
- Remediation Workers: Manageable risks are faced by those working with machinery in a construction area; overall, **remediation workers are very protected** through proper health and safety planning/procedures.
- Environmental Impacts: Some emissions from large machines and low risk of chemical release during ISBS implementation; temporary erosion prevention measures will be required; overall, there is a **low threat of short-term environmental impacts**.
- Time to complete construction: Several remedy components (ISBS, barrier wall, ISS/S) will take months to years to complete, with ISS/S likely taking the longest; it will take a **very long time to complete construction** of this alternative.

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Table 4-14 Comparative Evaluation Summary for On-Site Alternatives

Alternative	Long-Term Effectiveness	Implementability	TMV Reduction by Treatment	Short-Term Effectiveness	Total PV Cost (Capital)
OnR-1: No Action	Not Effective	Nothing to Implement	None	Not Effective	Negligible
OnR-2: Continue Current Actions, Soil Regrading/Cover	Protective with Limitations	Easily Implemented	Minor	Effective Very Quickly	\$11.1M (\$6.2M capital)
OnR-3A: Removal – Surficial Aquifer Excavation	Protective	Challenging	Majority Treated	Lengthy Implementation	\$67.8M (\$64.1M capital)
OnR-3B: Removal – Excavation to Middle Clay	Protective	Extremely Challenging	Nearly All Treated	Very Lengthy Implementation	\$193.7M (\$190.0M capital)
OnR-4A: Treatment – ISS/S to Middle Clay	Protective	Implementable	Great Majority Treated	Very Lengthy Implementation	\$78.9M (\$75.2M capital)
OnR-4B: Treatment – ISS/S in Surficial Aquifer, ISBS in Upper Hawthorn	Protective	Implementable	Great Majority Treated	Lengthy Implementation	\$41.8M (\$38.1M capital)
OnR-5A: Containment/ Treatment – Barrier Wall	Protective	Easily Implemented	Minor	Effective Quickly	\$16.0M (\$12.8M capital)
OnR-5B: Containment/ Treatment – Barrier Wall, ISBS in Upper Hawthorn	Very Protective	Easily Implemented	Some Treated	Effective within Months	\$20.9M (\$18.0M capital)
OnR-5C: Containment/ Treatment – Barrier Wall, ISBS in Surficial Aquifer	Very Protective	Easily Implemented	Majority Treated	Effective within Months	\$21.3M (\$18.1M capital)
OnR-5D: Containment/ Treatment – Barrier Wall, ISS/S in Surficial Aquifer	Very Protective	Implementable	Majority Treated	Lengthy Implementation	\$38.7M (\$35.7M capital)
OnR-5E: Containment/ Treatment – Barrier Wall, ISBS to Middle Clay	Very Protective	Easily Implemented	Great Majority Treated	Moderate/ Lengthy Implementation	\$29.1M (\$26.1M capital)
OnR-5F: Containment/ Treatment – Barrier Wall, ISS/S to Middle Clay	Very Protective	Implementable	Great Majority Treated	Very Lengthy Implementation	\$74.8M (\$71.8M capital)
OnR-5G: Containment/ Treatment – Barrier Wall, Surficial Aquifer ISS/S, Upper Hawthorn ISBS	Very Protective	Implementable	Great Majority Treated	Lengthy Implementation	\$43.6M (\$40.6M capital)

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Figures

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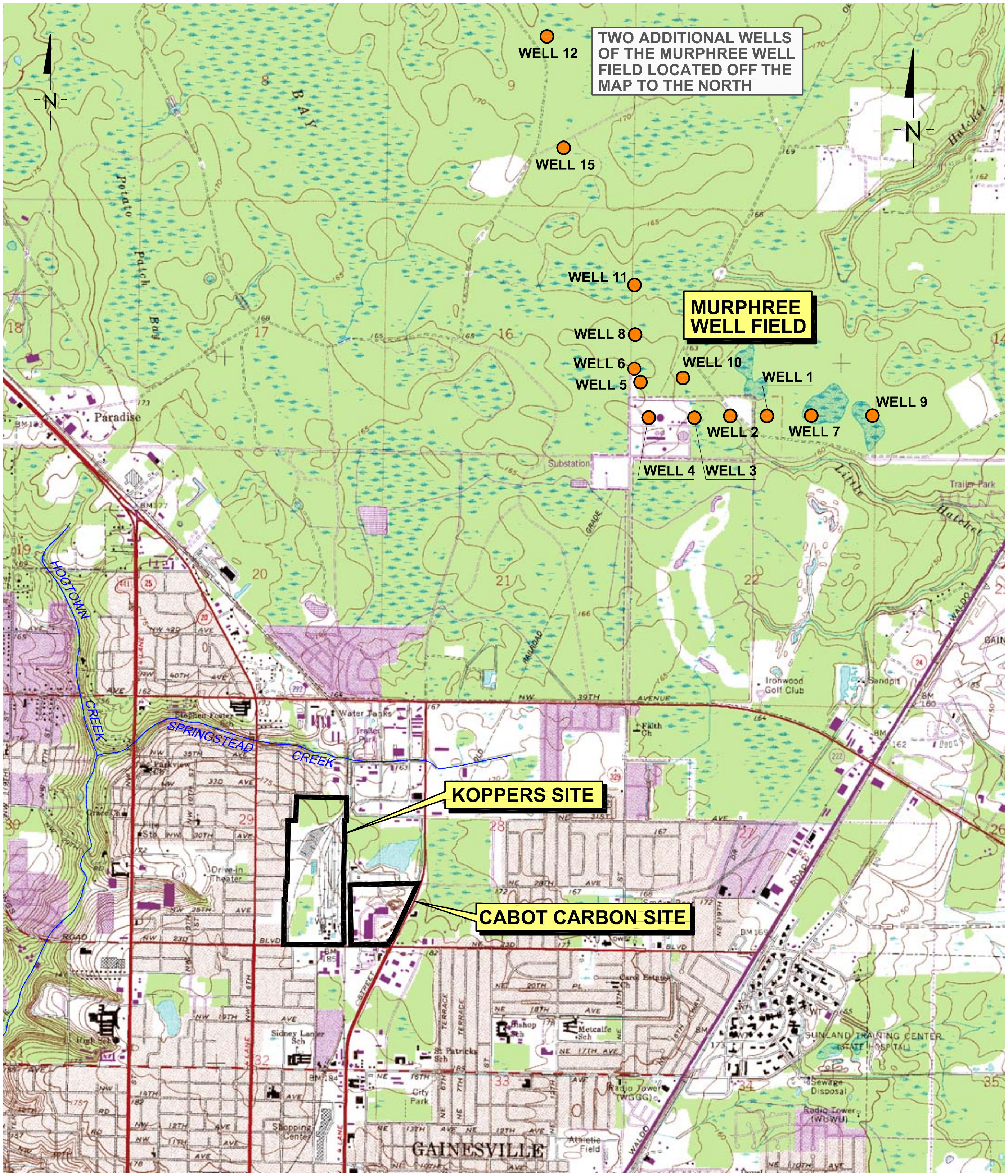

SOURCE: U.S.G.S. QUADRANGLE GAINESVILLE
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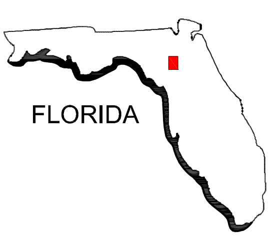

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Figure 1-1.
Site Location Map
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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Figure 1-2.
Site Map and Aerial Photograph
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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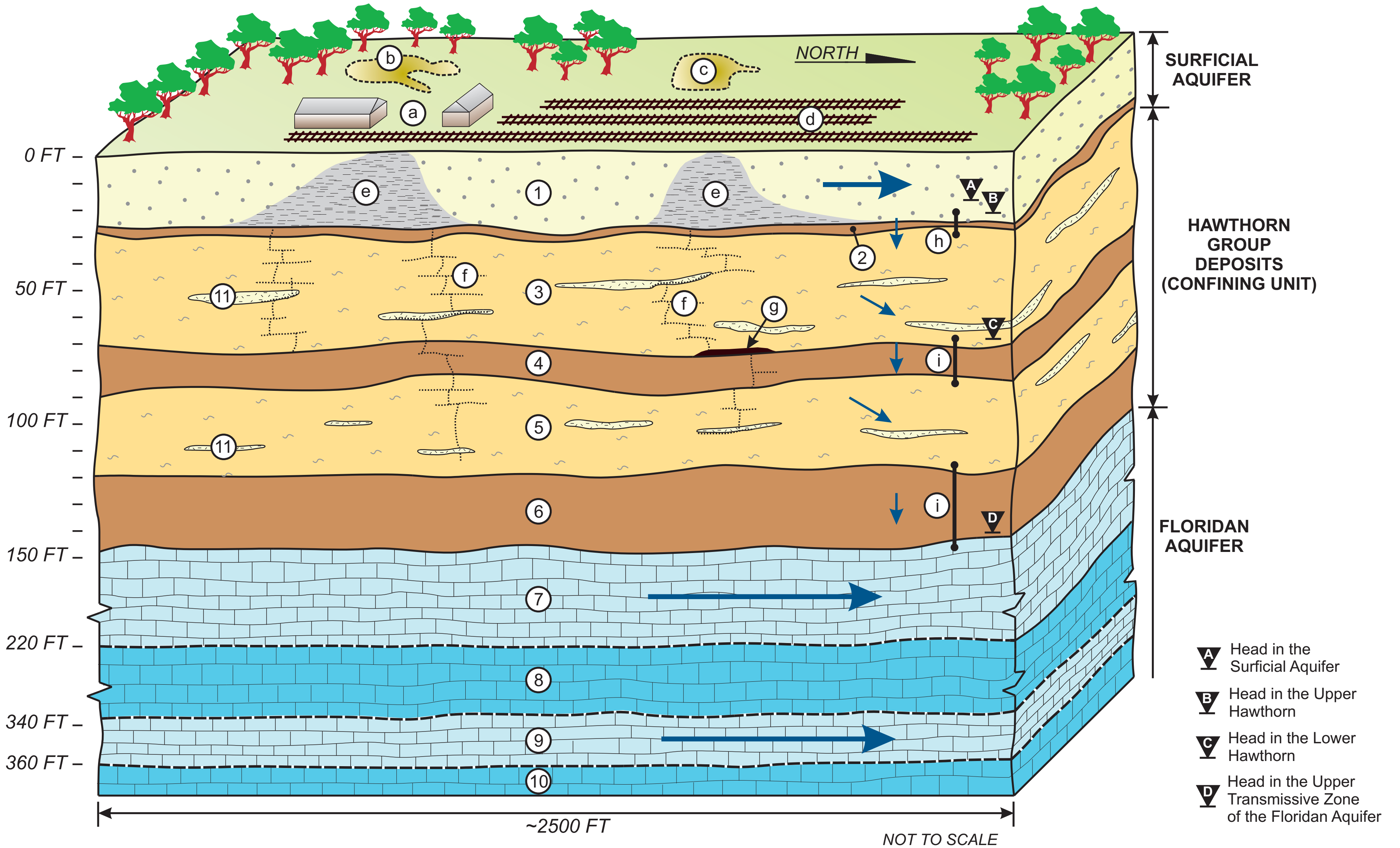

1) Surficial Aquifer
2) Hawthorn Group - Upper Clay
3) Hawthorn Group - Upper Hawthorn
4) Hawthorn Group - Middle Clay
5) Hawthorn Group - Lower Hawthorn
6) Hawthorn Group - Lower Clay
7) Floridan Aquifer - Upper Transmissive Zone
8) Floridan Aquifer - Semi-Confining Zone
9) Floridan Aquifer - Lower Transmissive Zone
10) Floridan Aquifer - Semi-Confining Zone
11) Discontinuous Sandy Interbeds

a) Former Process Area
b) Former South Lagoon
c) Former North Lagoon
d) Former Drip Track
e) Soils with Residual DNAPL
f) Sparse Seams of Residual DNAPL
g) Sparse Seams of Locally Continuous DNAPL
h) Moderate Vertical Hydraulic Gradient (~1 ft/ft)
i) Large Vertcial Hydraulic Gradient (~3 ft/ft)

Note:
There are uncertainties associated with the conceptual understanding presented in this figure.

Figure 1-3.
Conceptual Block Diagram
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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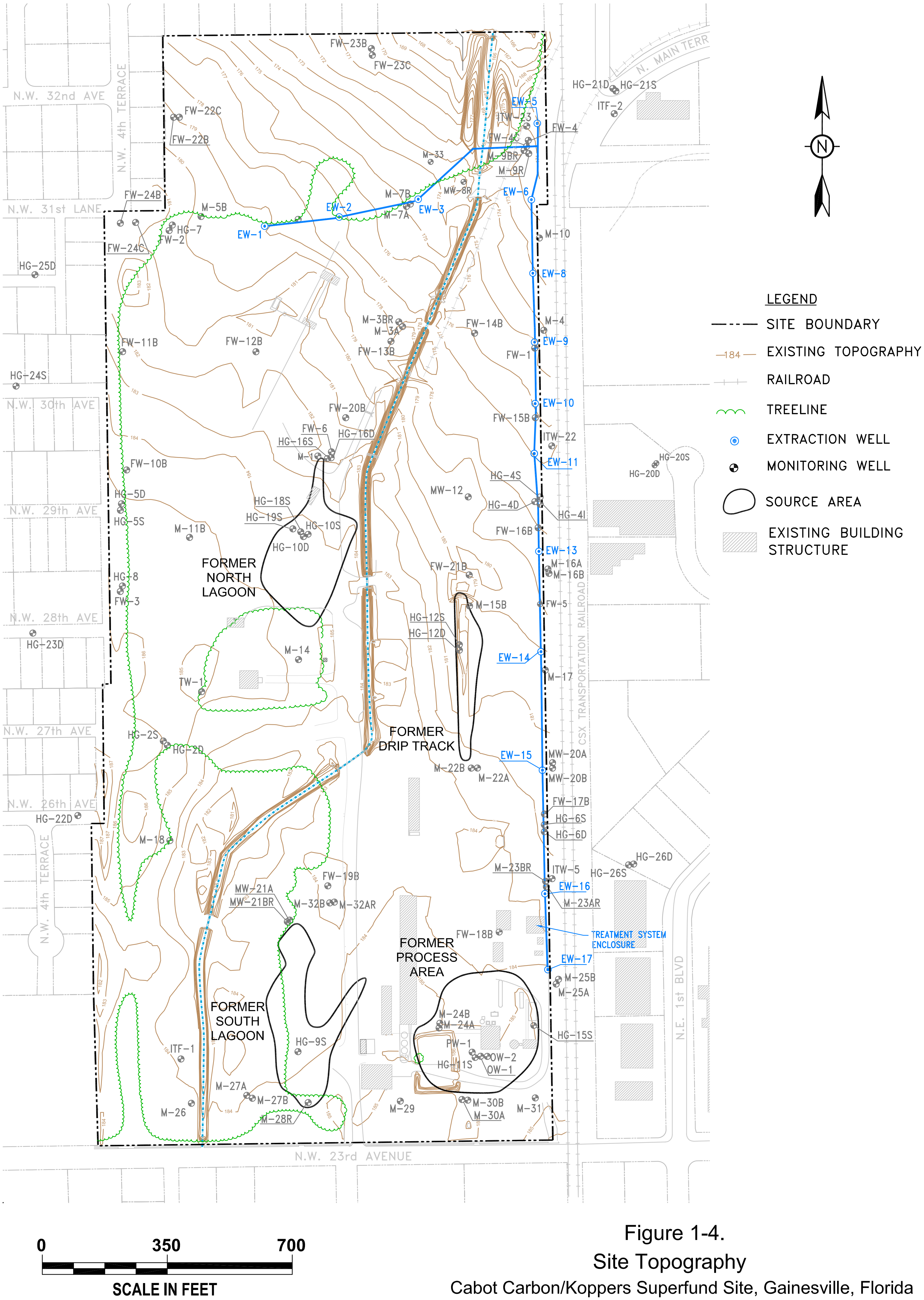

Figure 1-4.
Site Topography
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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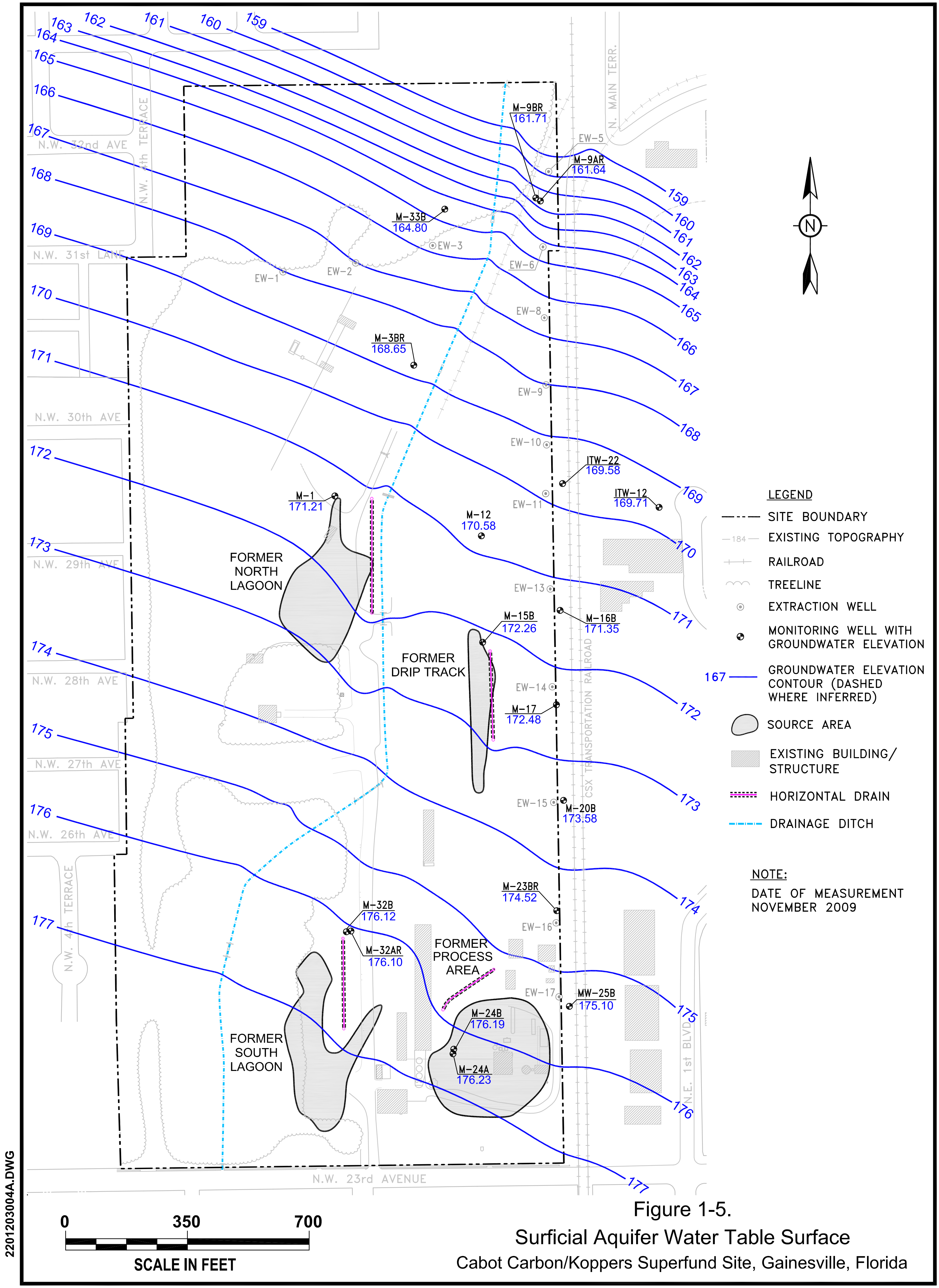

Figure 1-5.
Surficial Aquifer Water Table Surface
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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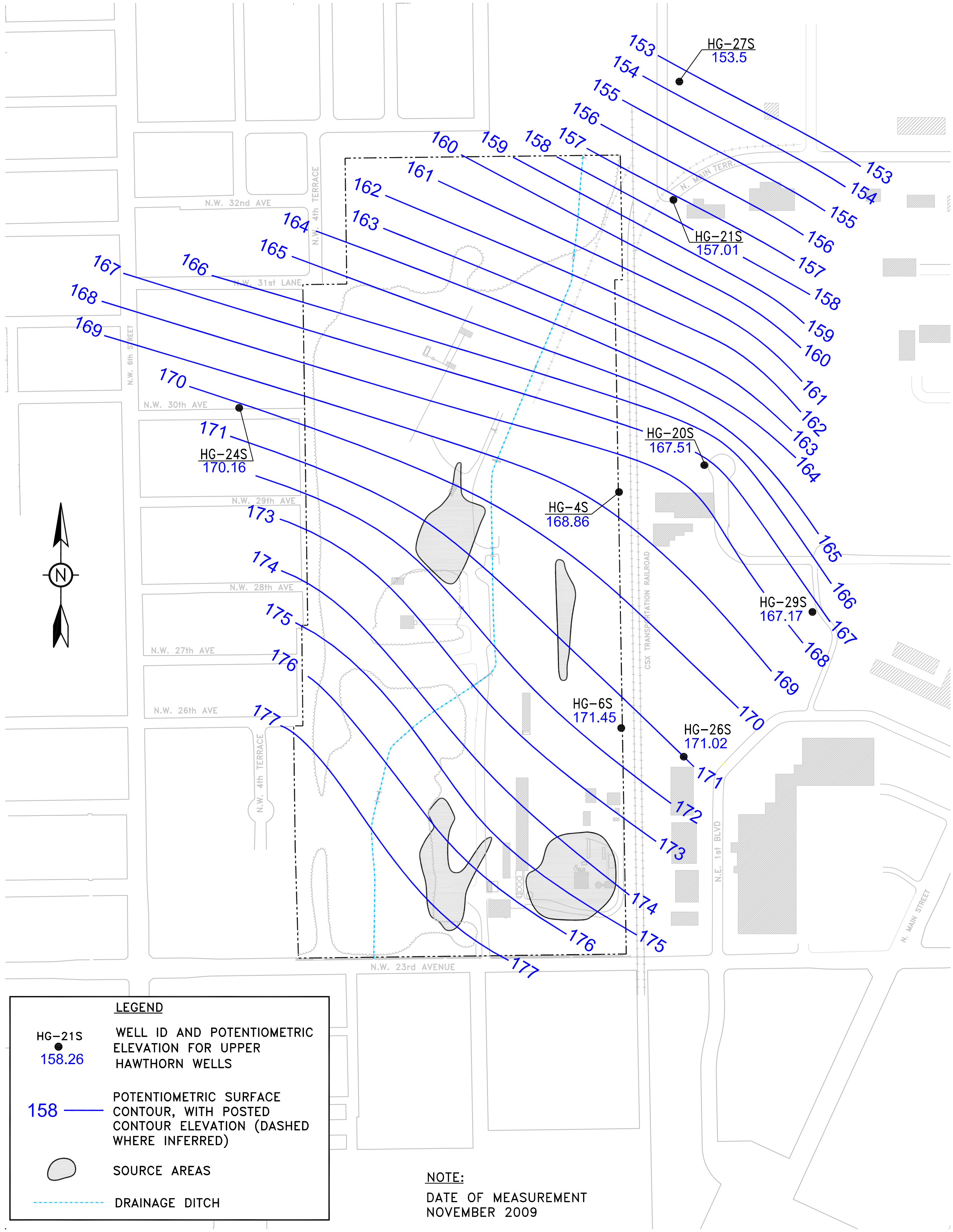

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Figure 1-6.

Upper Hawthorn Potentiometric Surface

Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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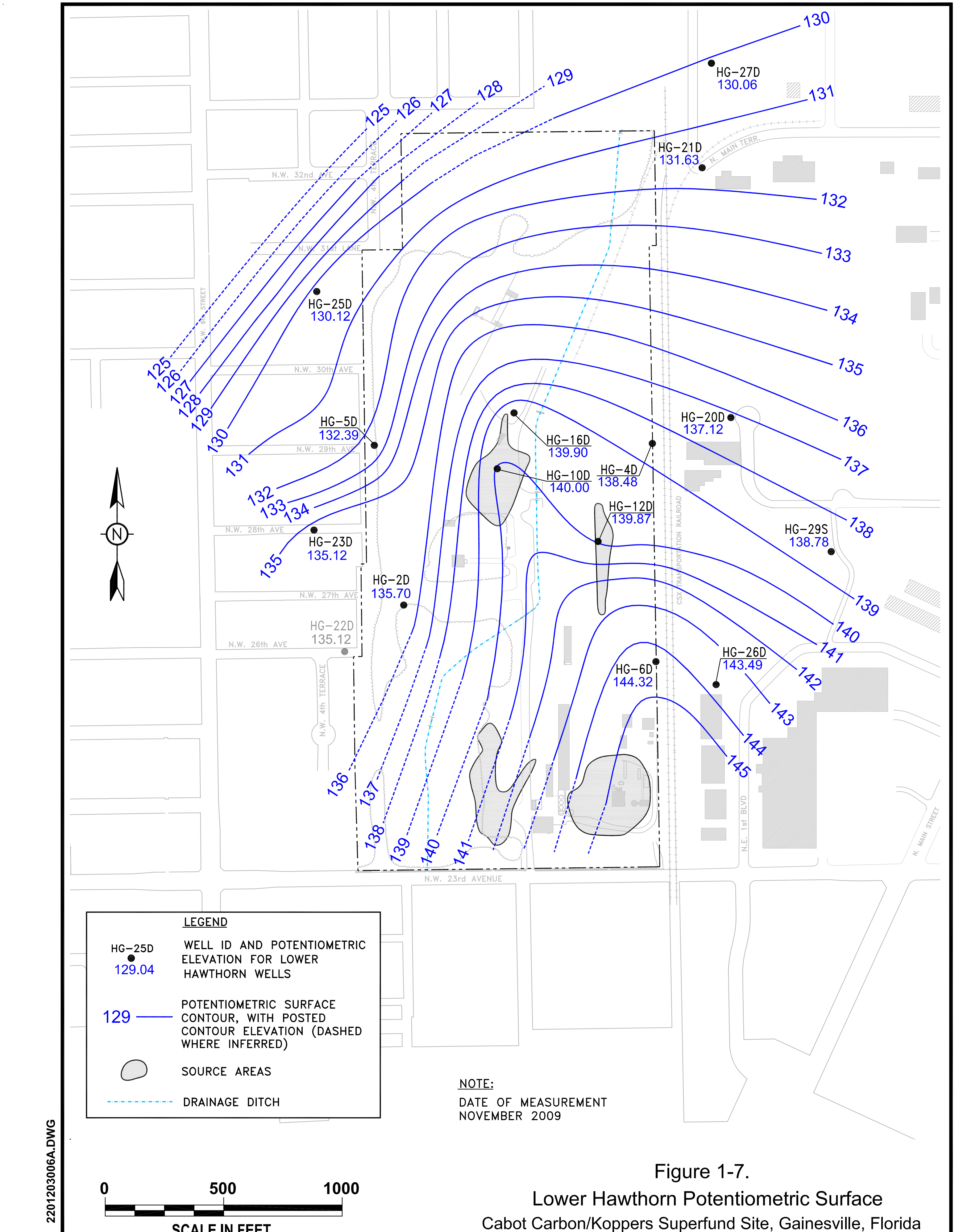

Figure 1-7.
Lower Hawthorn Potentiometric Surface
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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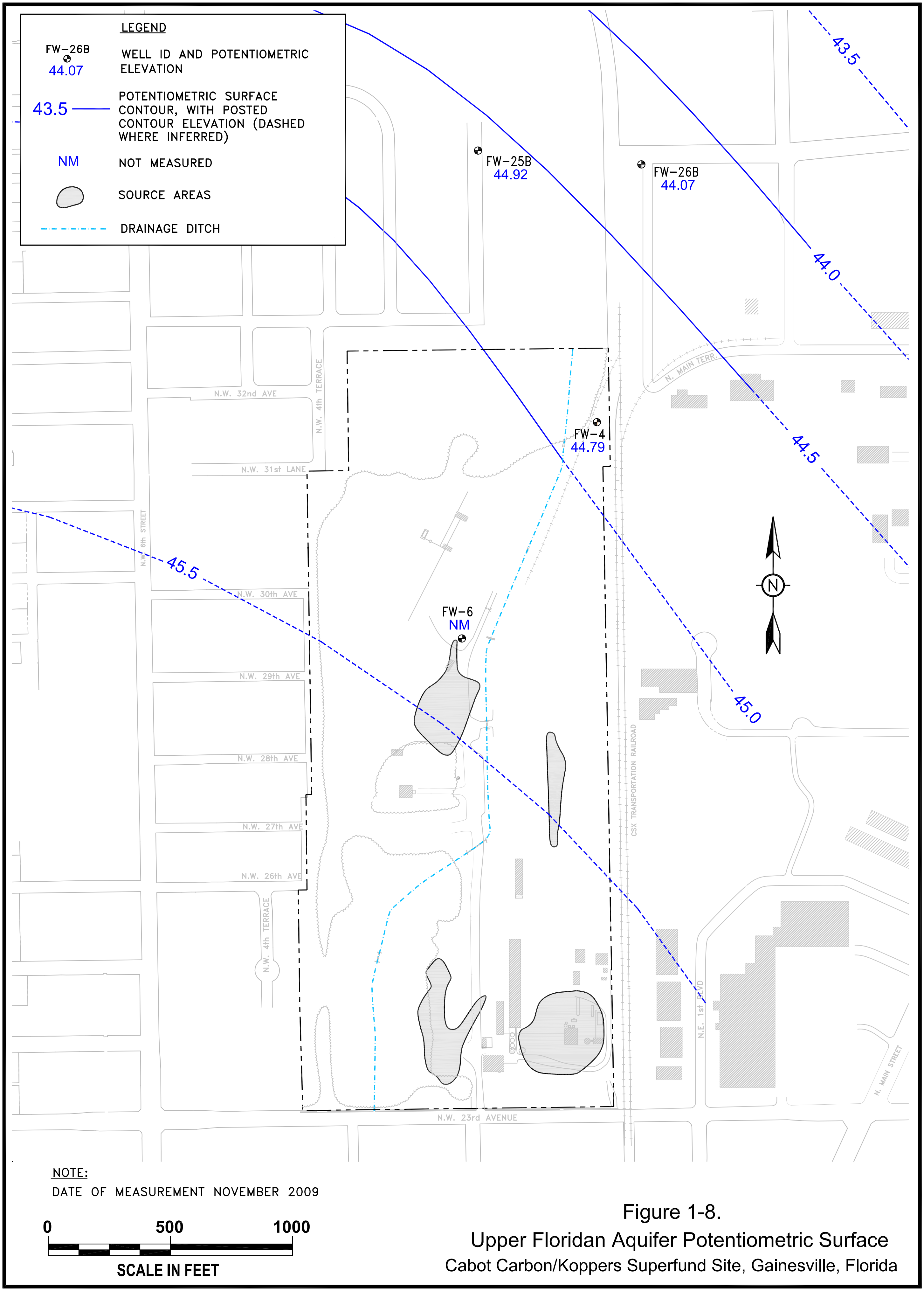

Figure 1-8.
Upper Floridan Aquifer Potentiometric Surface
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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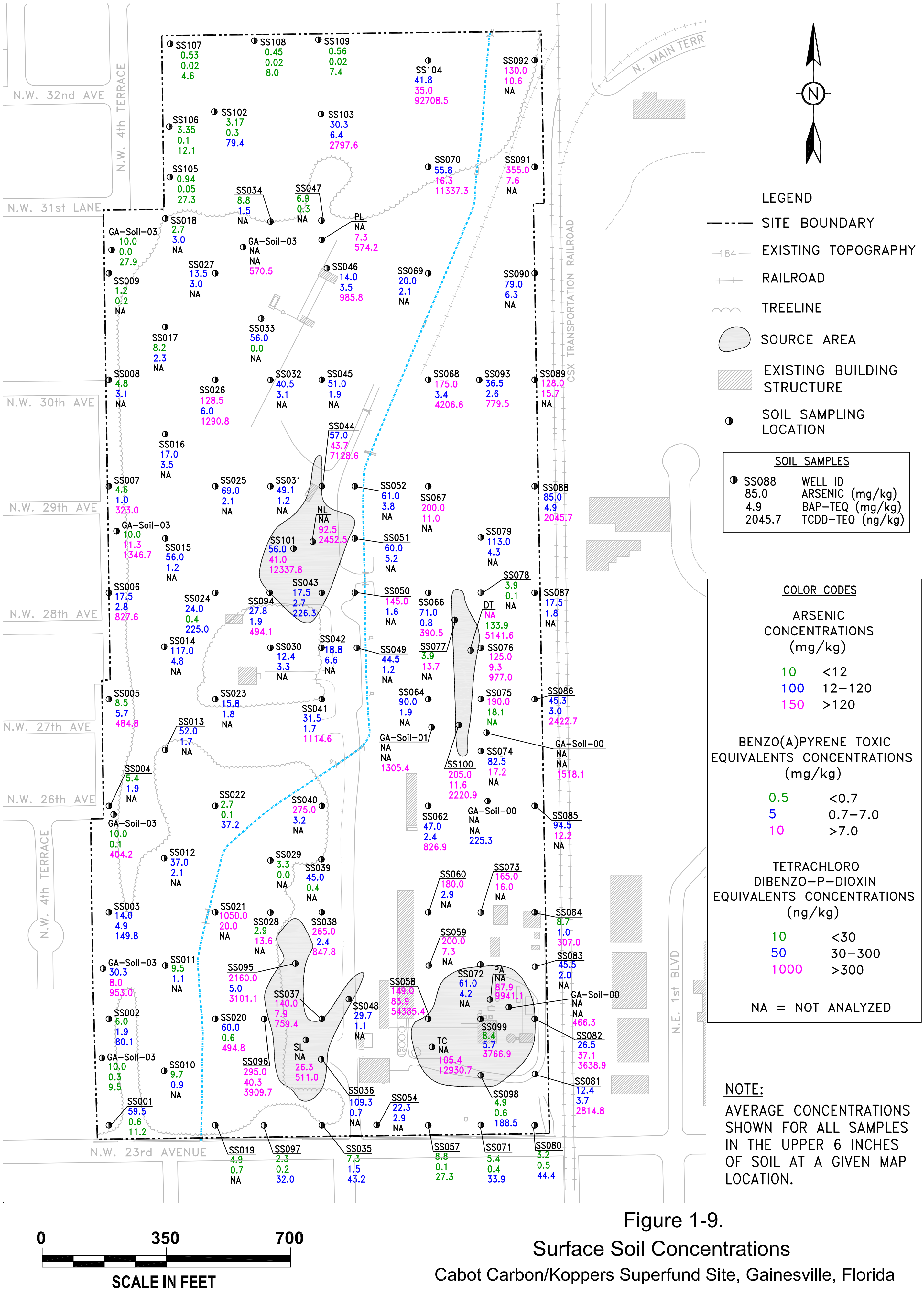

Figure 1-9.
Surface Soil Concentrations
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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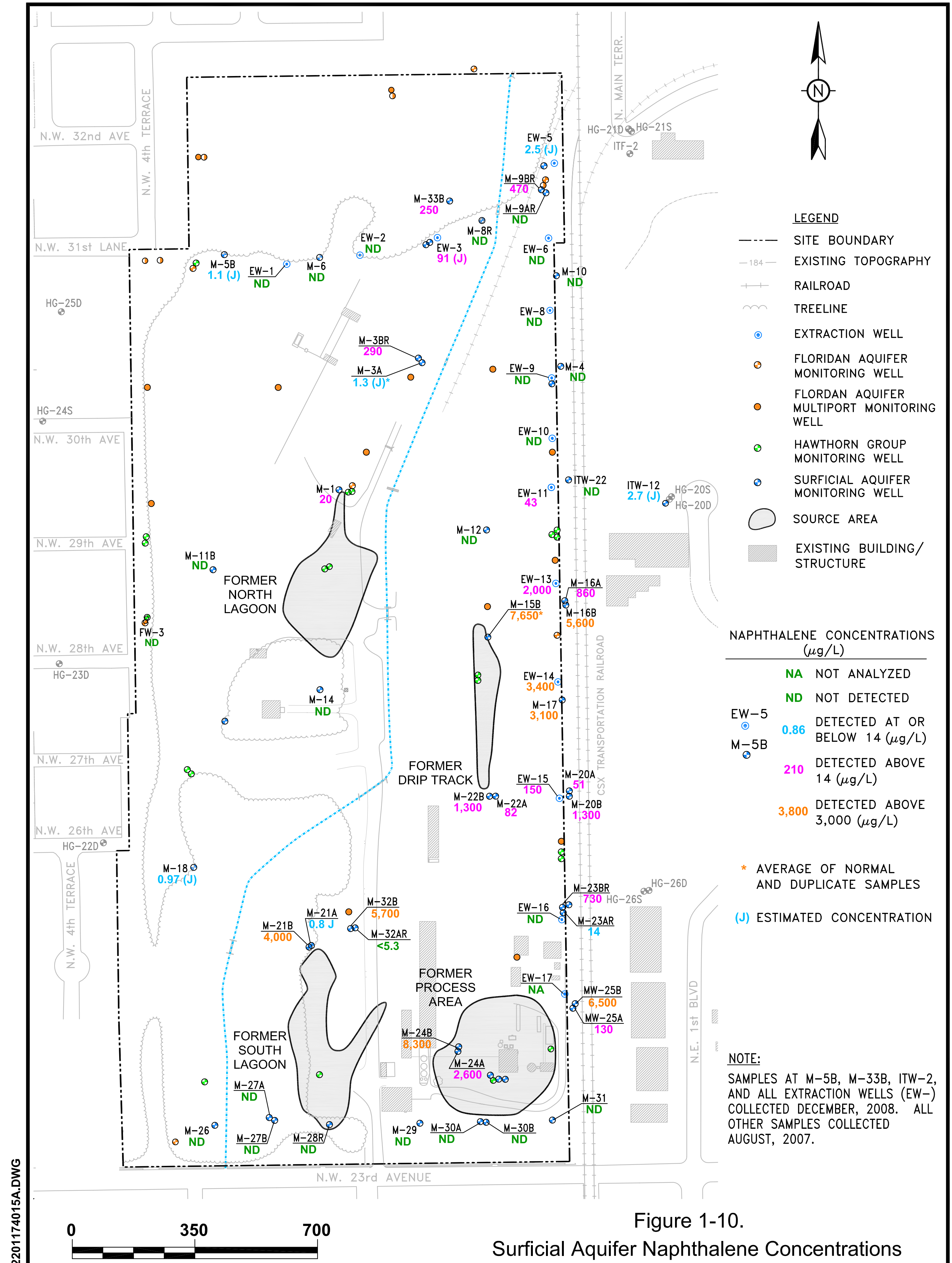

Figure 1-10.

Surficial Aquifer Naphthalene Concentrations

Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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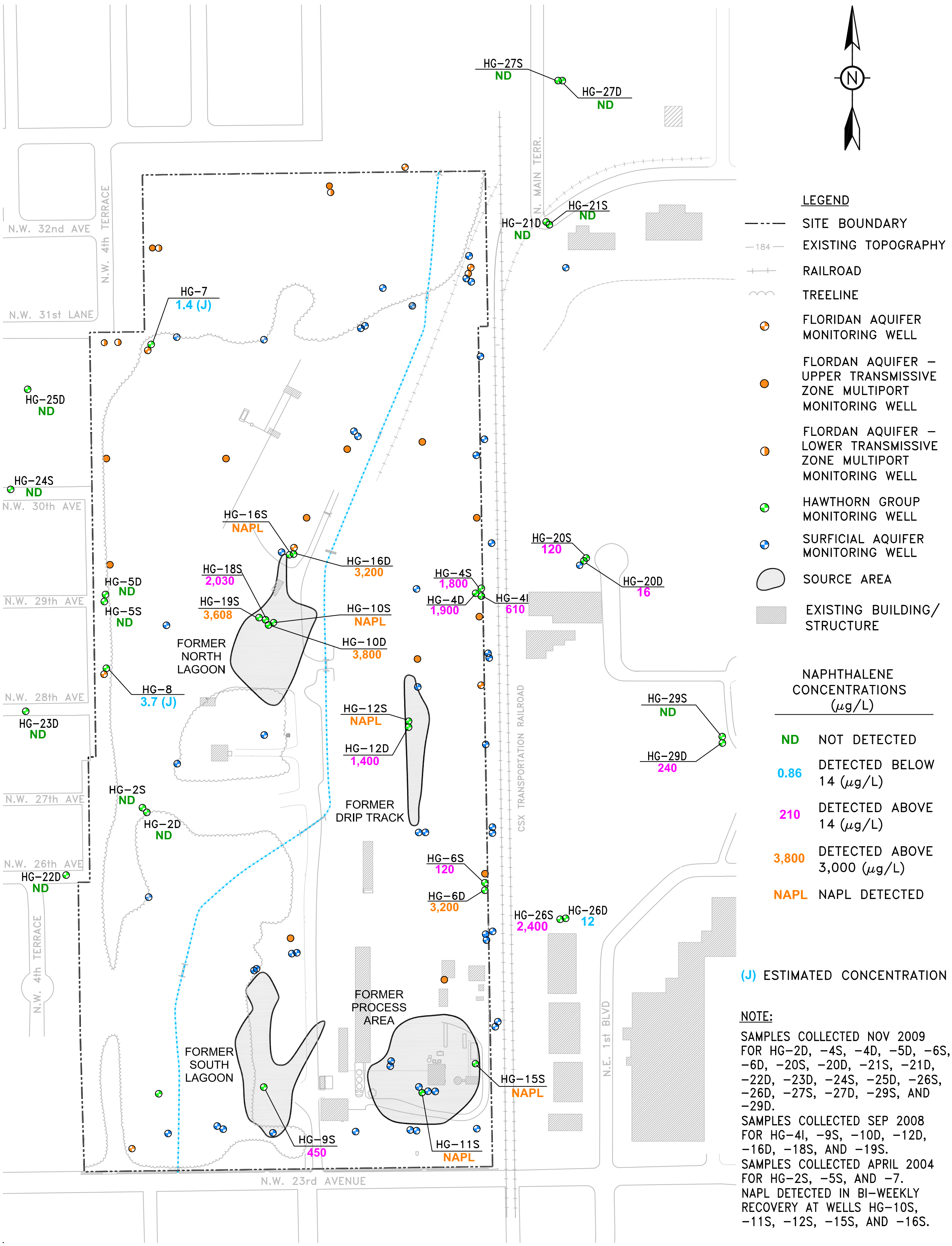

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Figure 1-11.
Hawthorn Group Naphthalene Concentrations
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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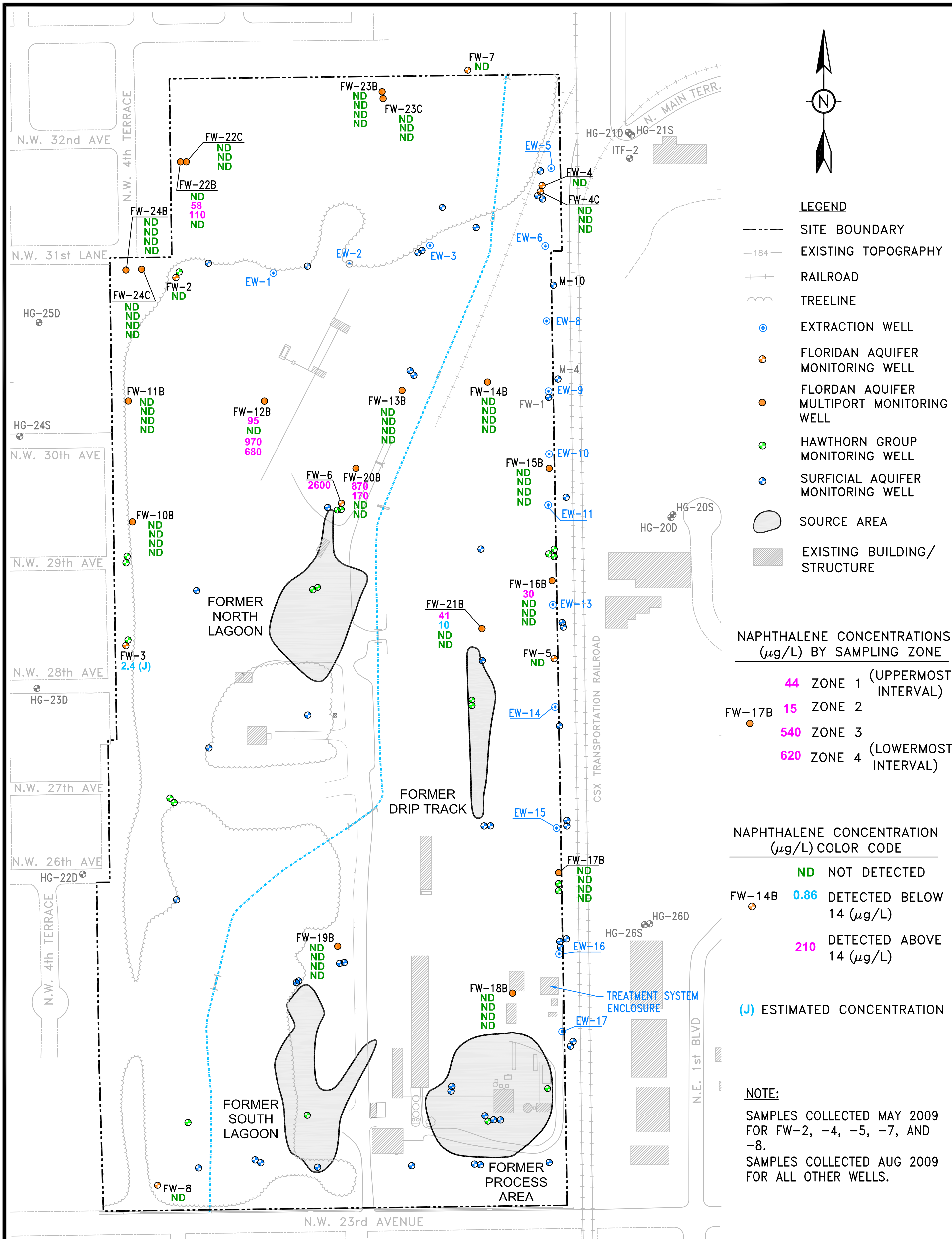

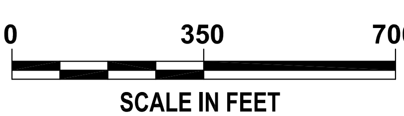

Figure 1-12.
Upper Floridan Aquifer Naphthalene Concentrations
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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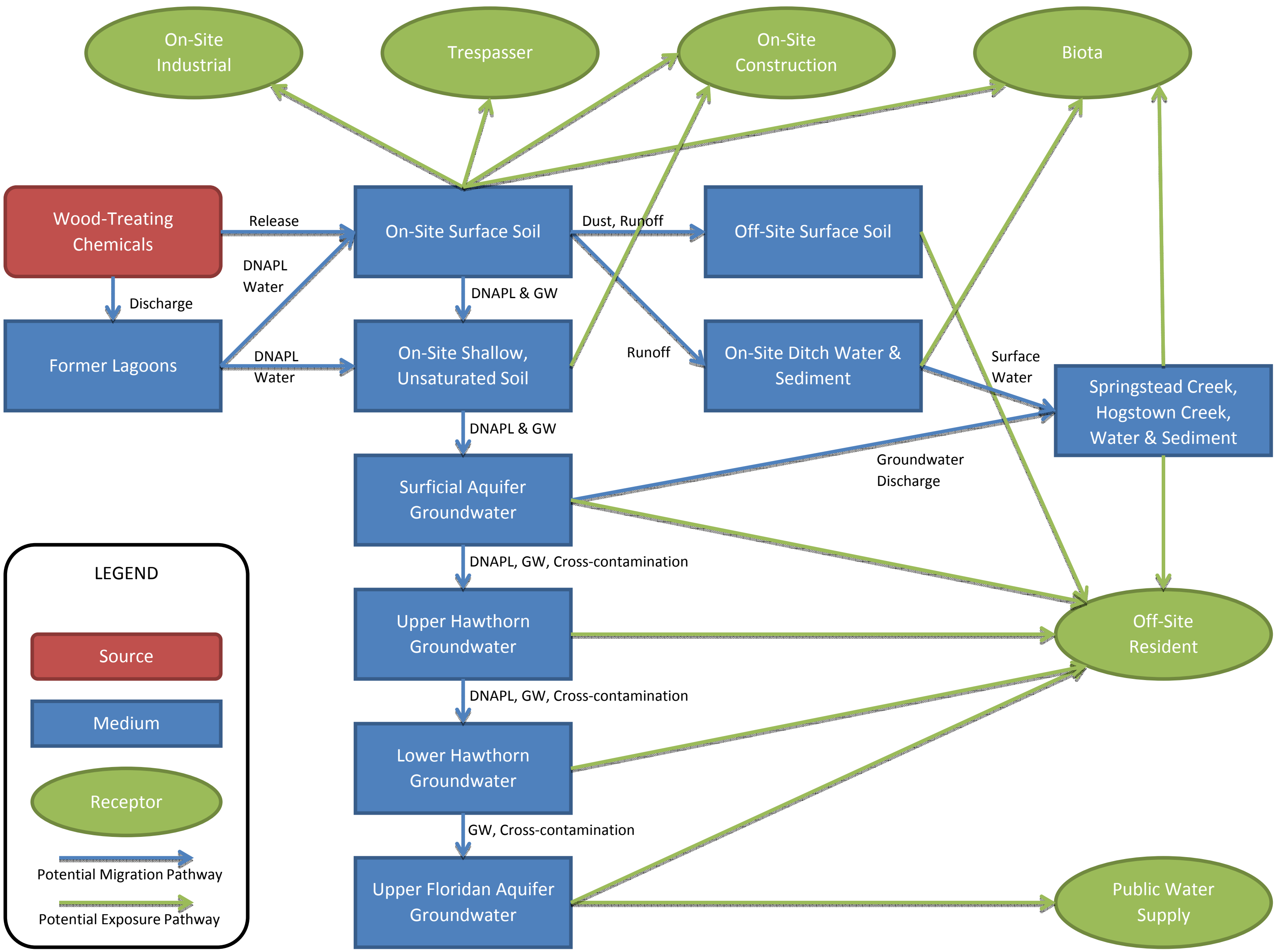
Figure 1-13
Conceptual Diagram of Potential Migration and Exposure Pathways
Cabot Carbon/Koppers Superfund Site
Gainesville, Alachua County, Florida



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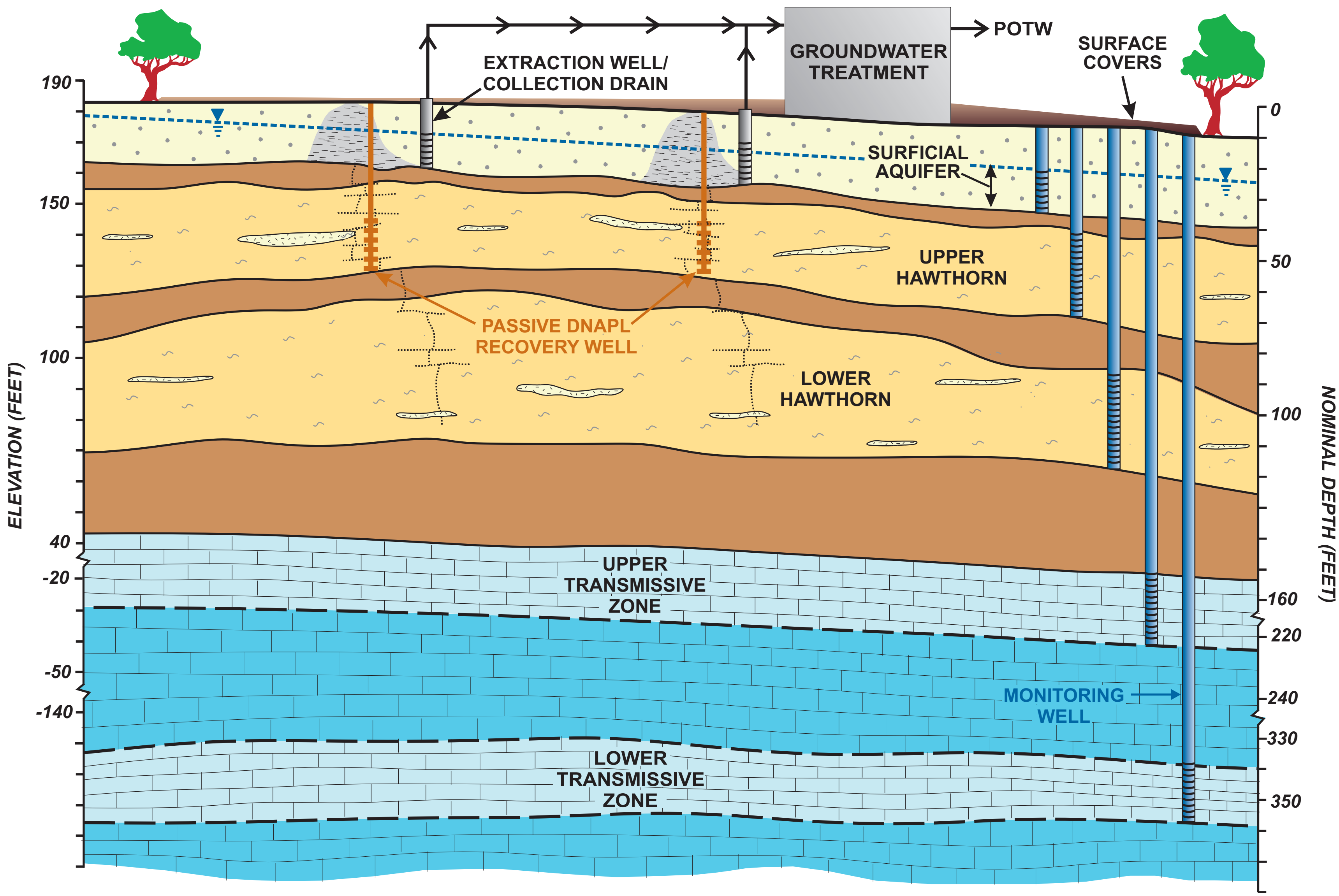

NOTE:
ELEVATIONS ARE APPROXIMATE.

Figure 3-1a.
Cross-Section Depiction of Alternative OnR-2
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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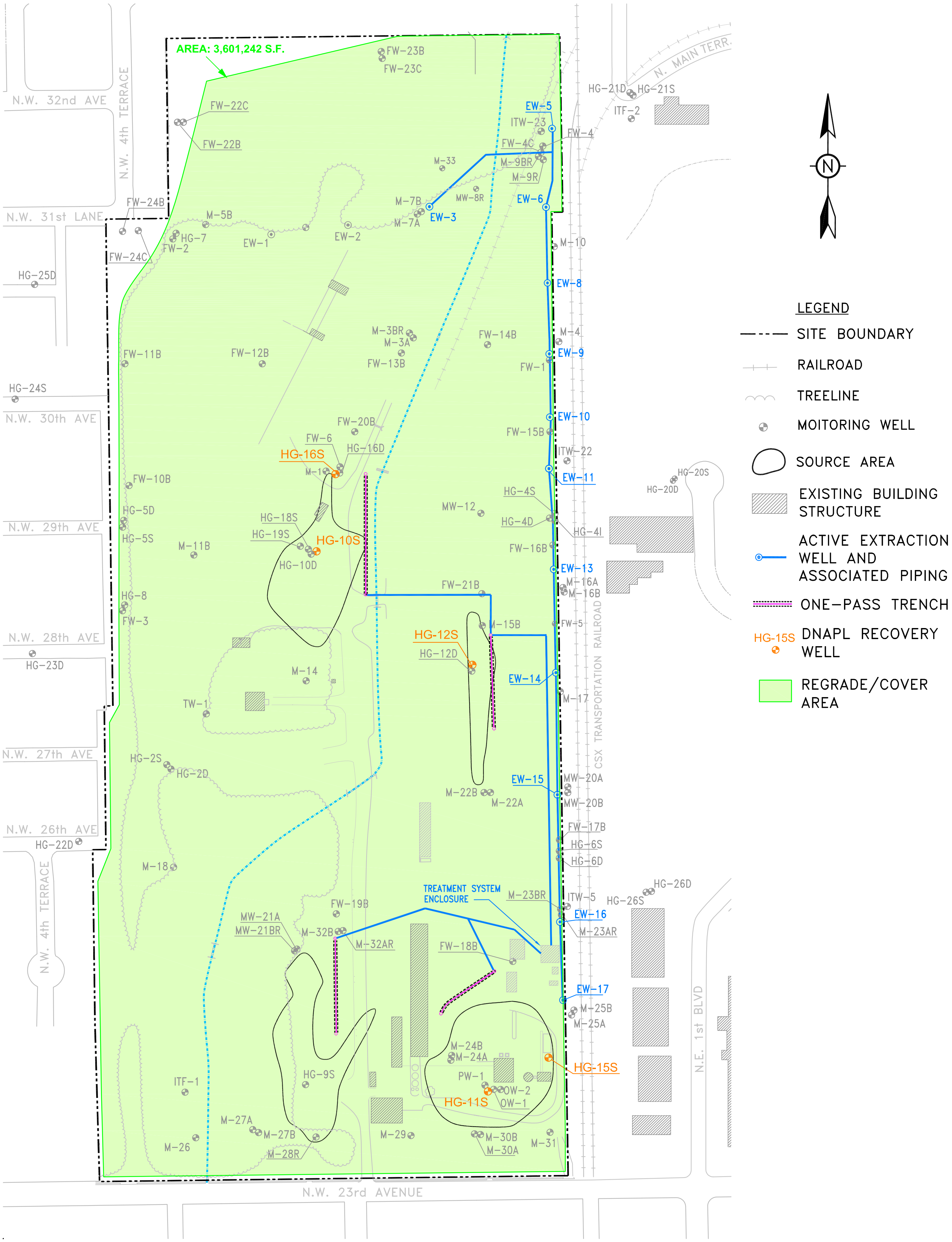

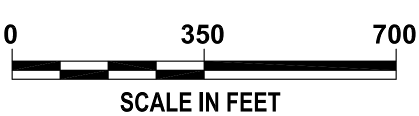

Figure 3-1b.
Plan View Depiction of Alternative OnR-2
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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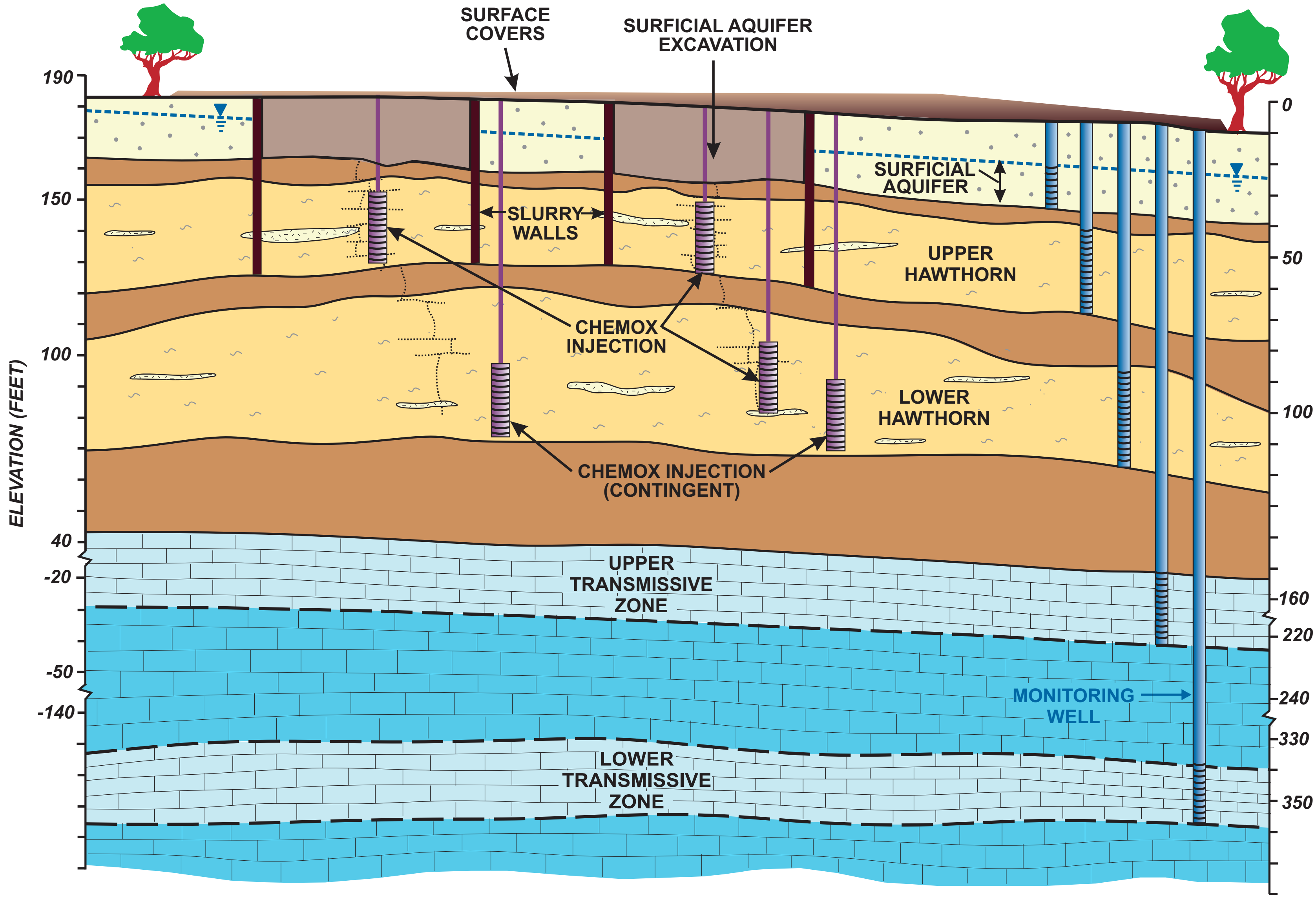

NOTE:
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Figure 3-2a.
Cross-Section Depiction of Alternative OnR-3A
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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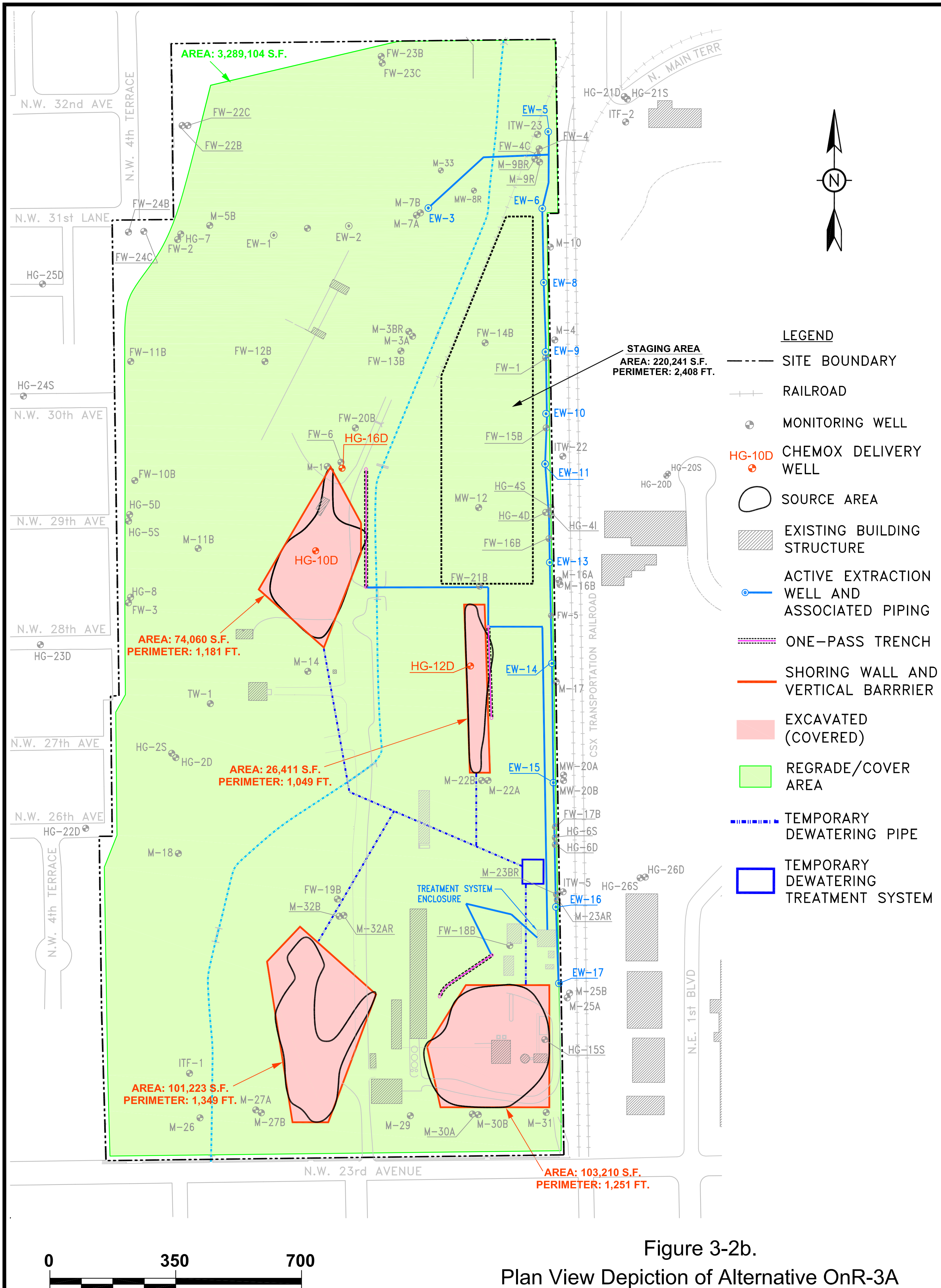

Figure 3-2b.
Plan View Depiction of Alternative OnR-3A
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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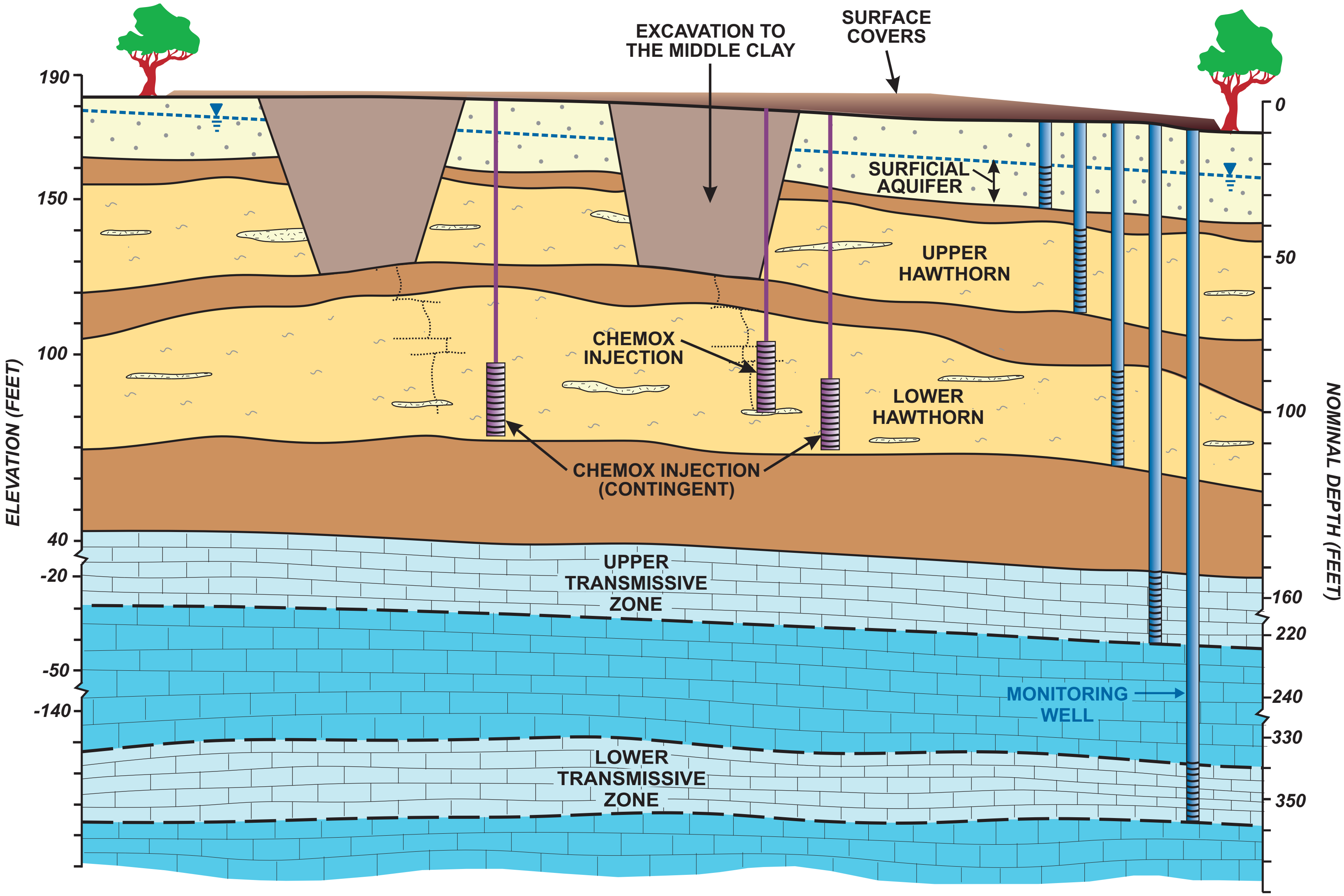

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Figure 3-3a.
Cross-Section Depiction of Alternative OnR-3B
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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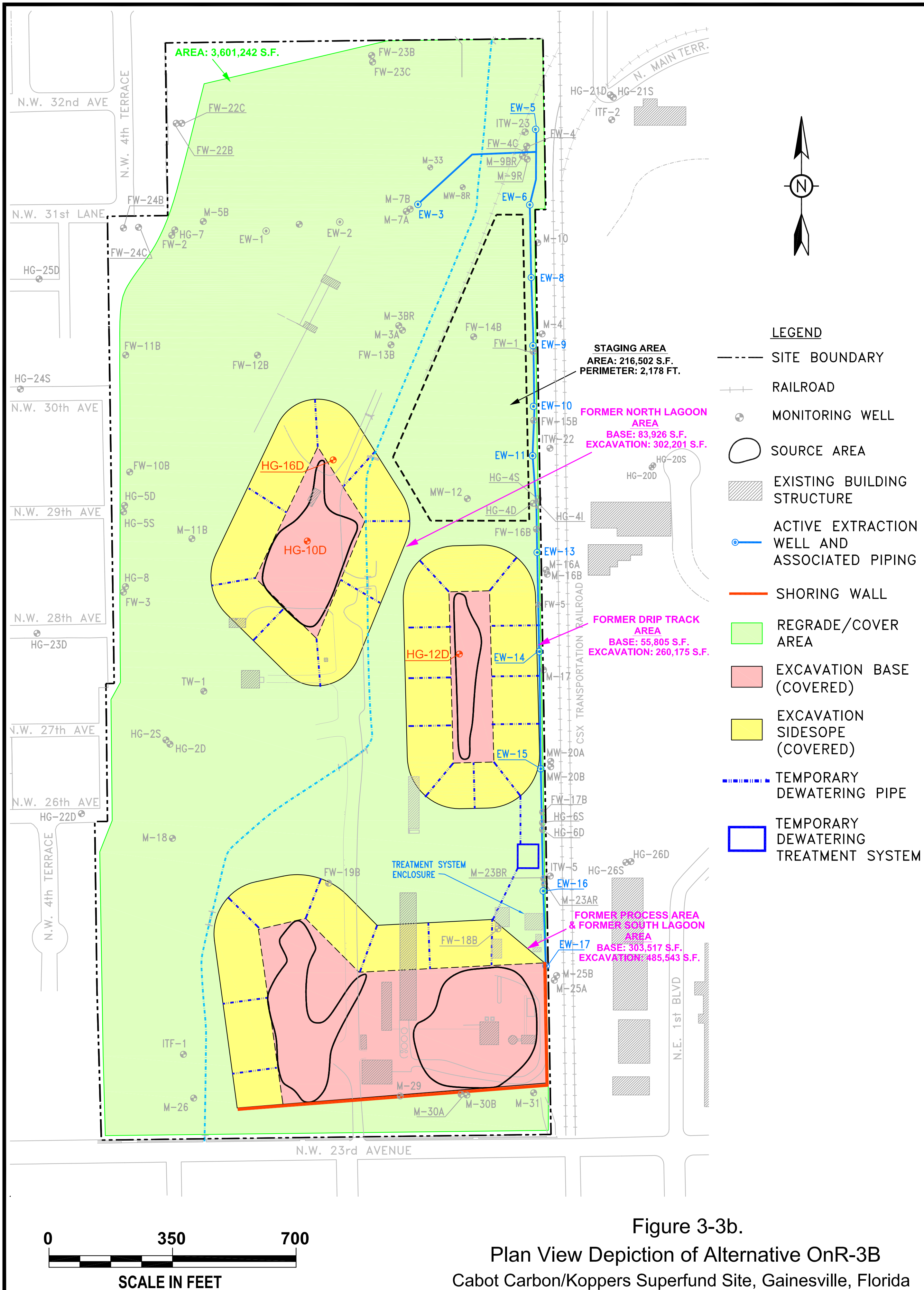

Figure 3-3b.
Plan View Depiction of Alternative OnR-3B
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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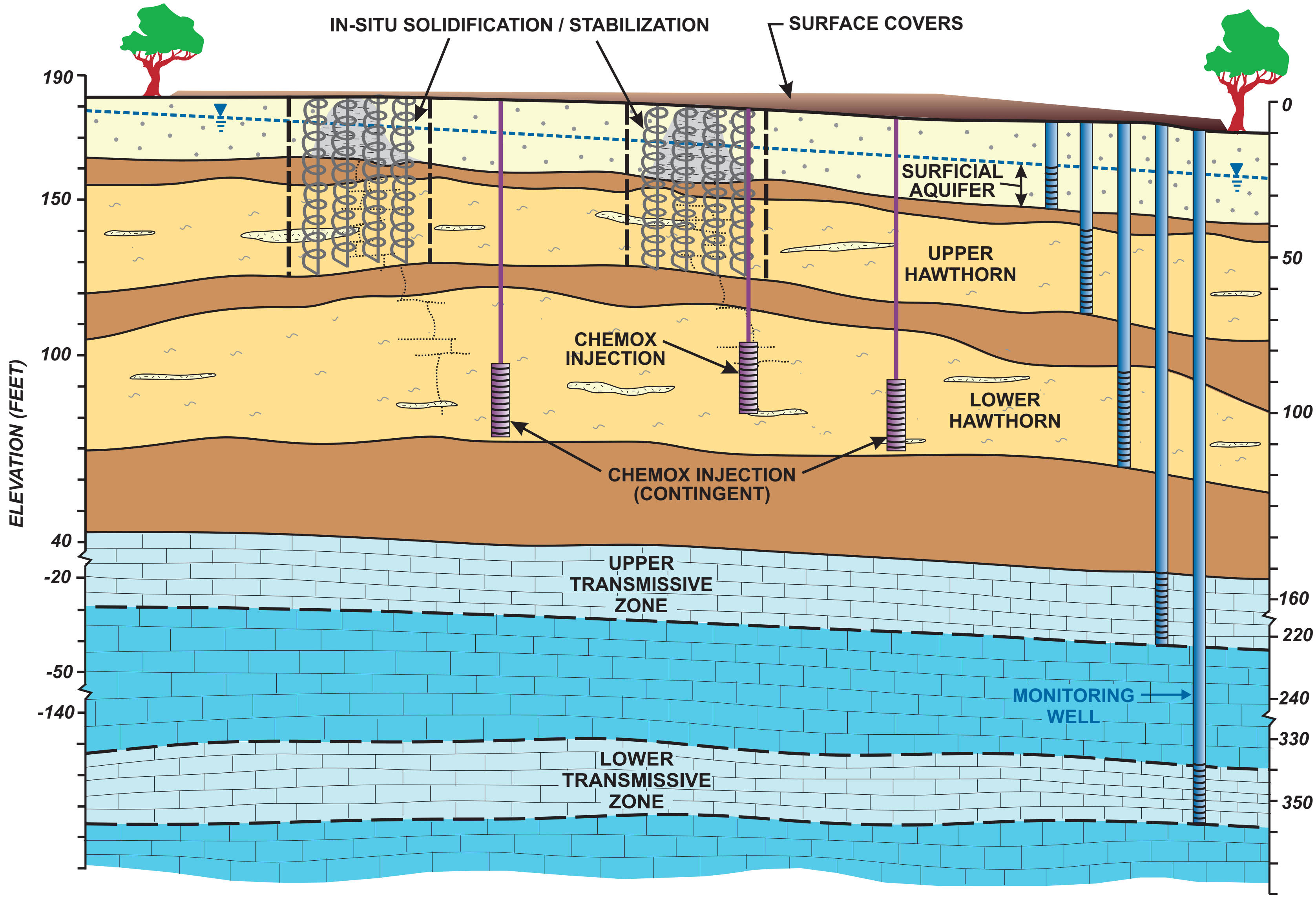

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Figure 3-4a.
Cross-Section Depiction of Alternative OnR-4A
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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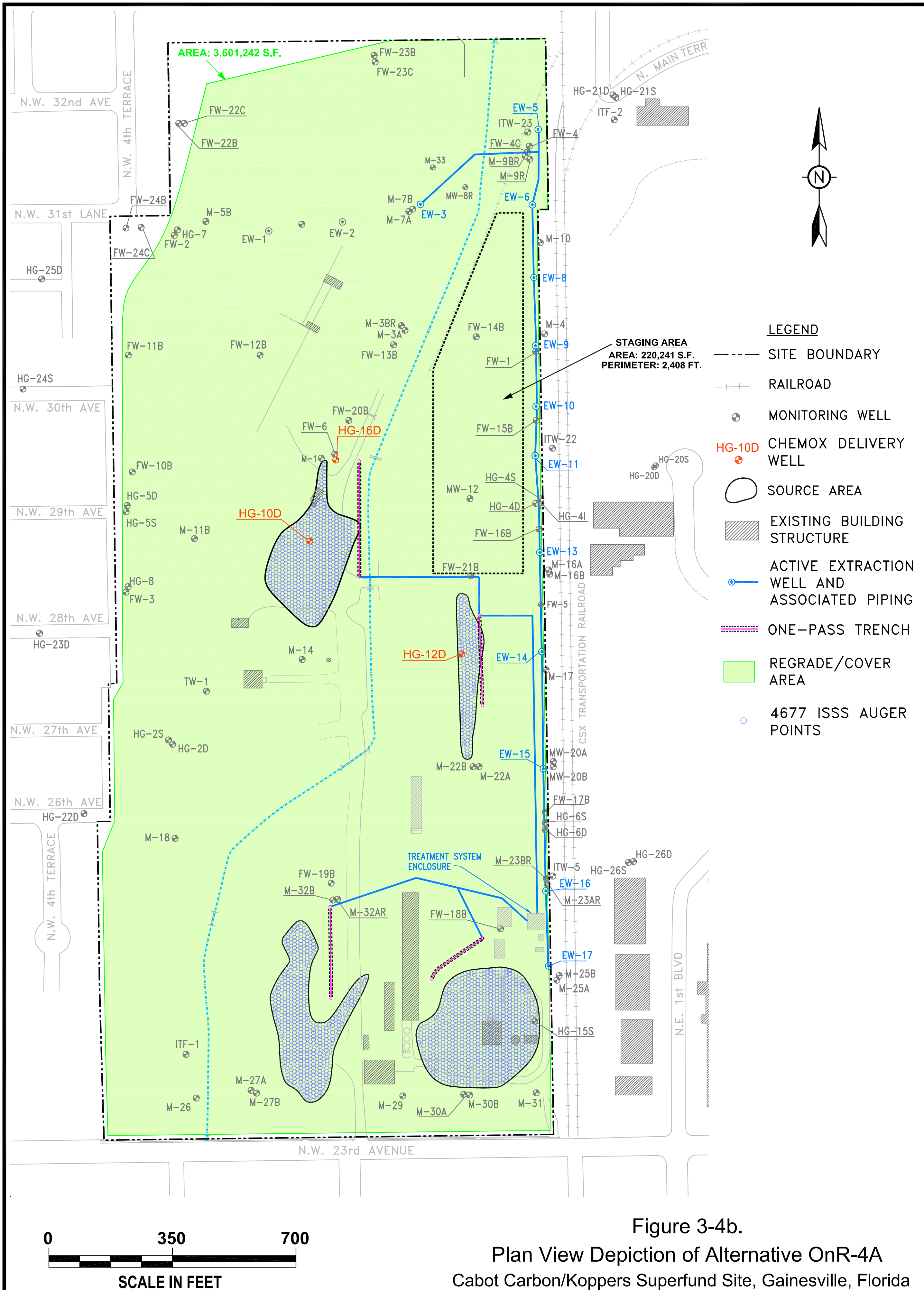

Figure 3-4b.
Plan View Depiction of Alternative OnR-4A
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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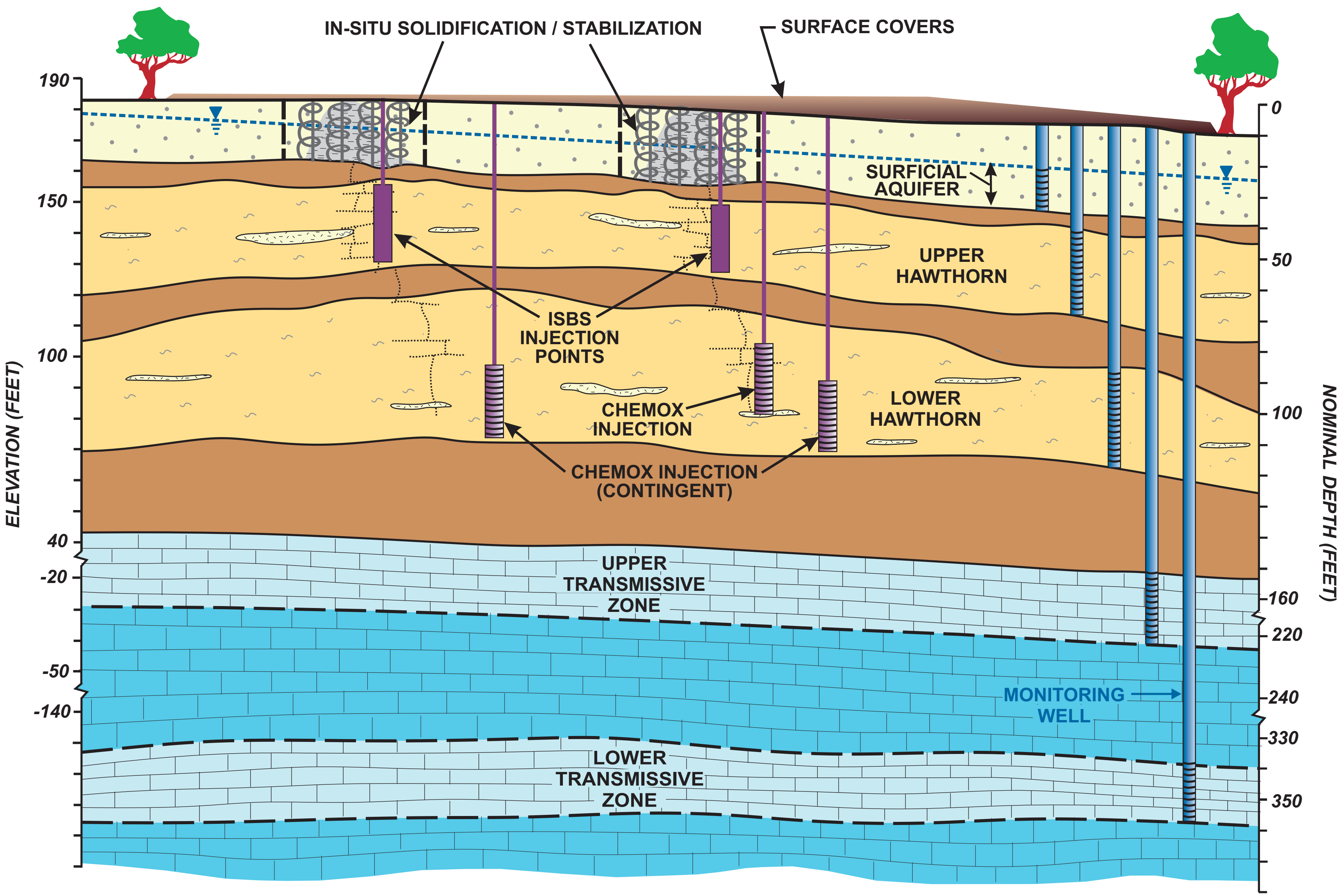

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Figure 3-5a.
Cross-Section Depiction of Alternative OnR-4B
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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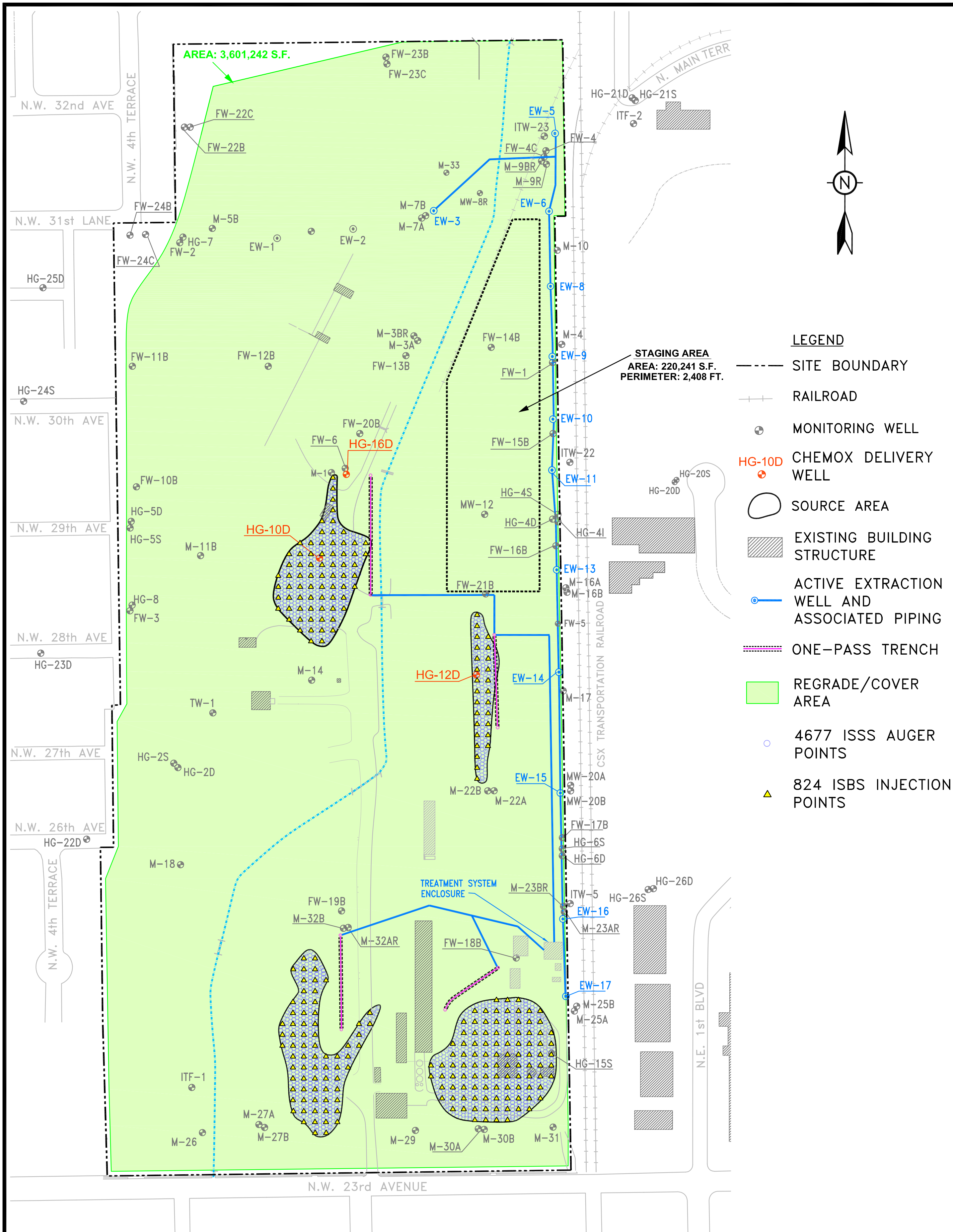

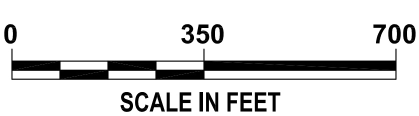

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Figure 3-5b.
Plan View Depiction of Alternative OnR-4A
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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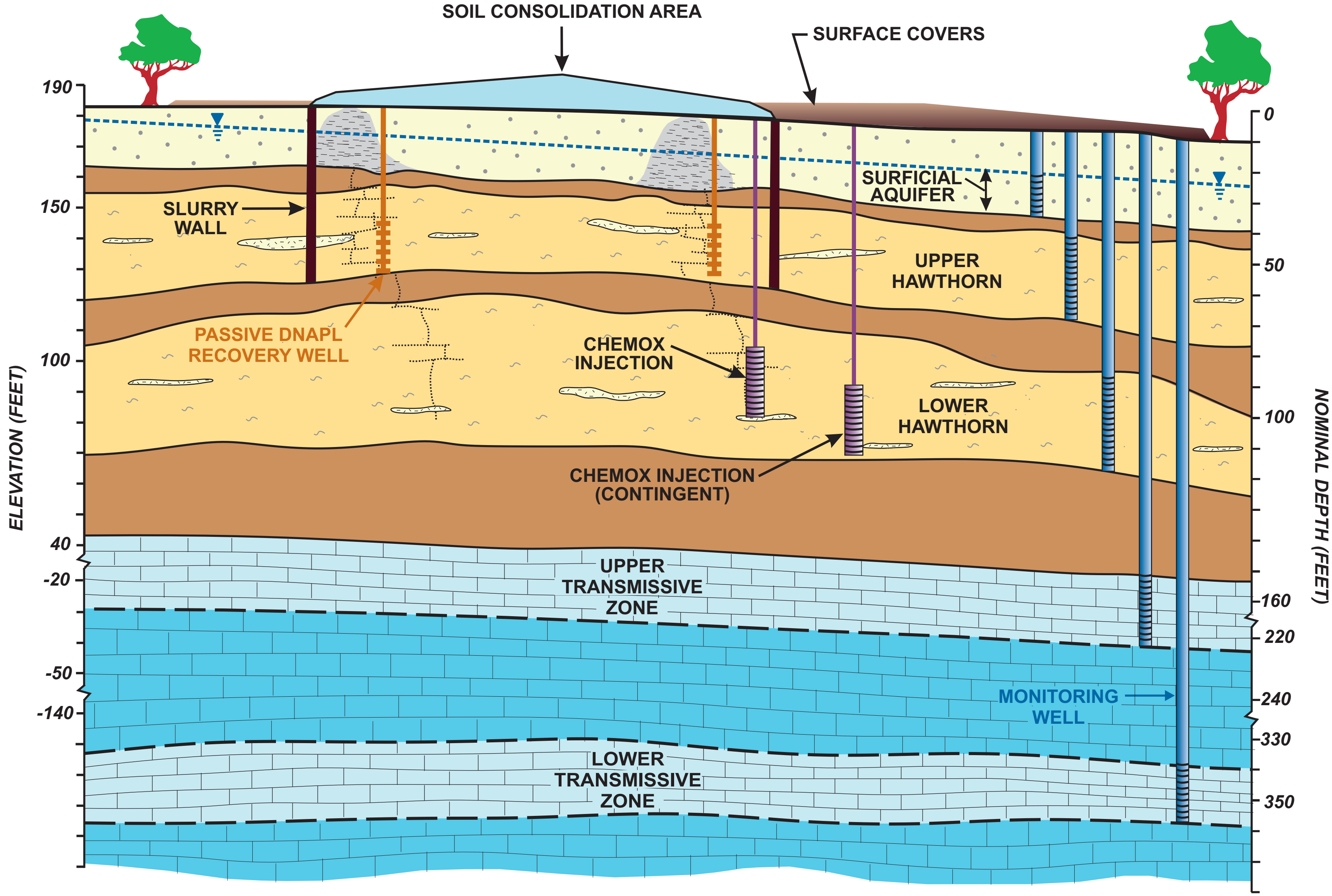

Figure 3-6a.
Cross-Section Depiction of Alternative OnR-5A
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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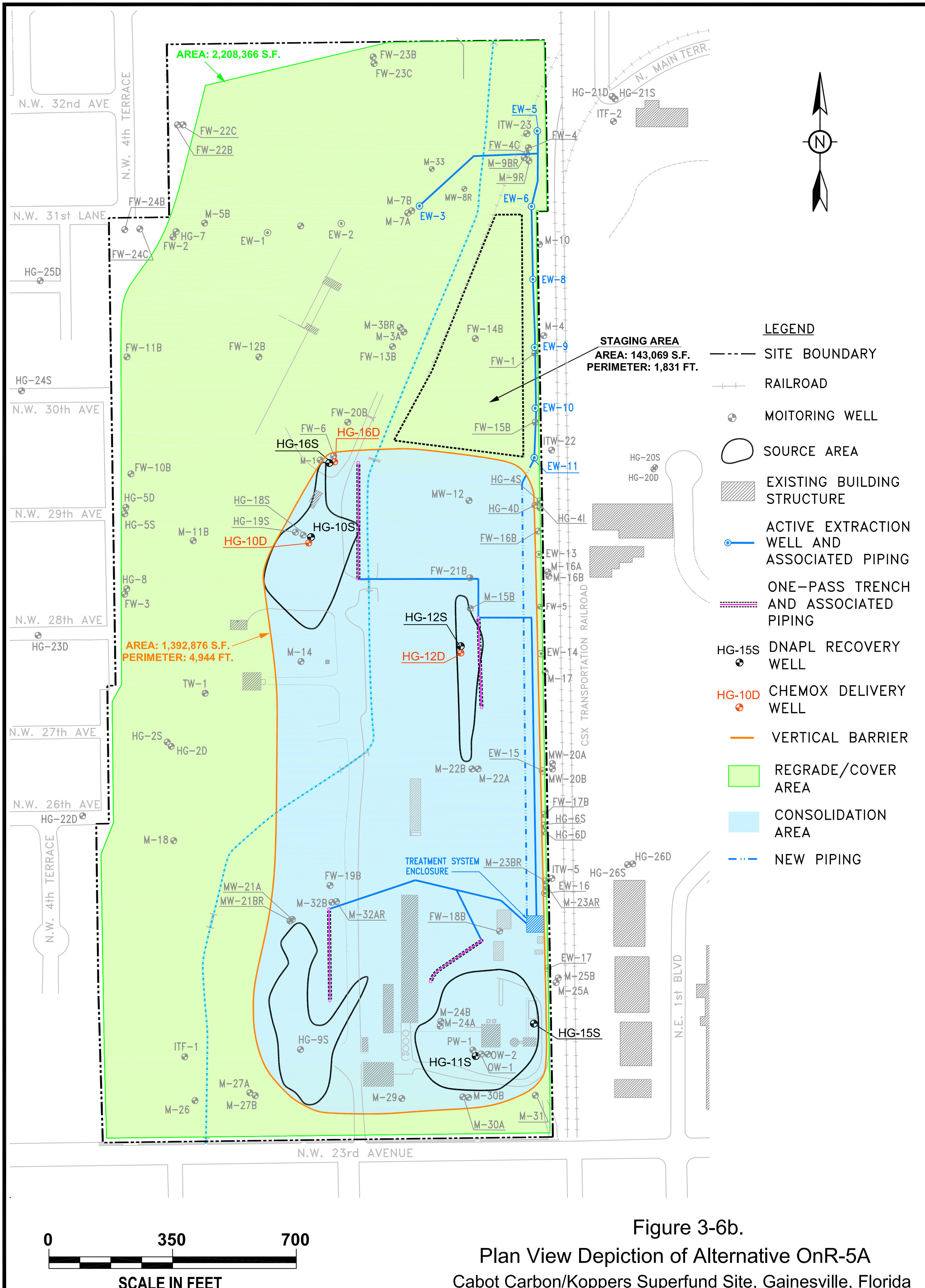

Figure 3-6b.
Plan View Depiction of Alternative OnR-5A
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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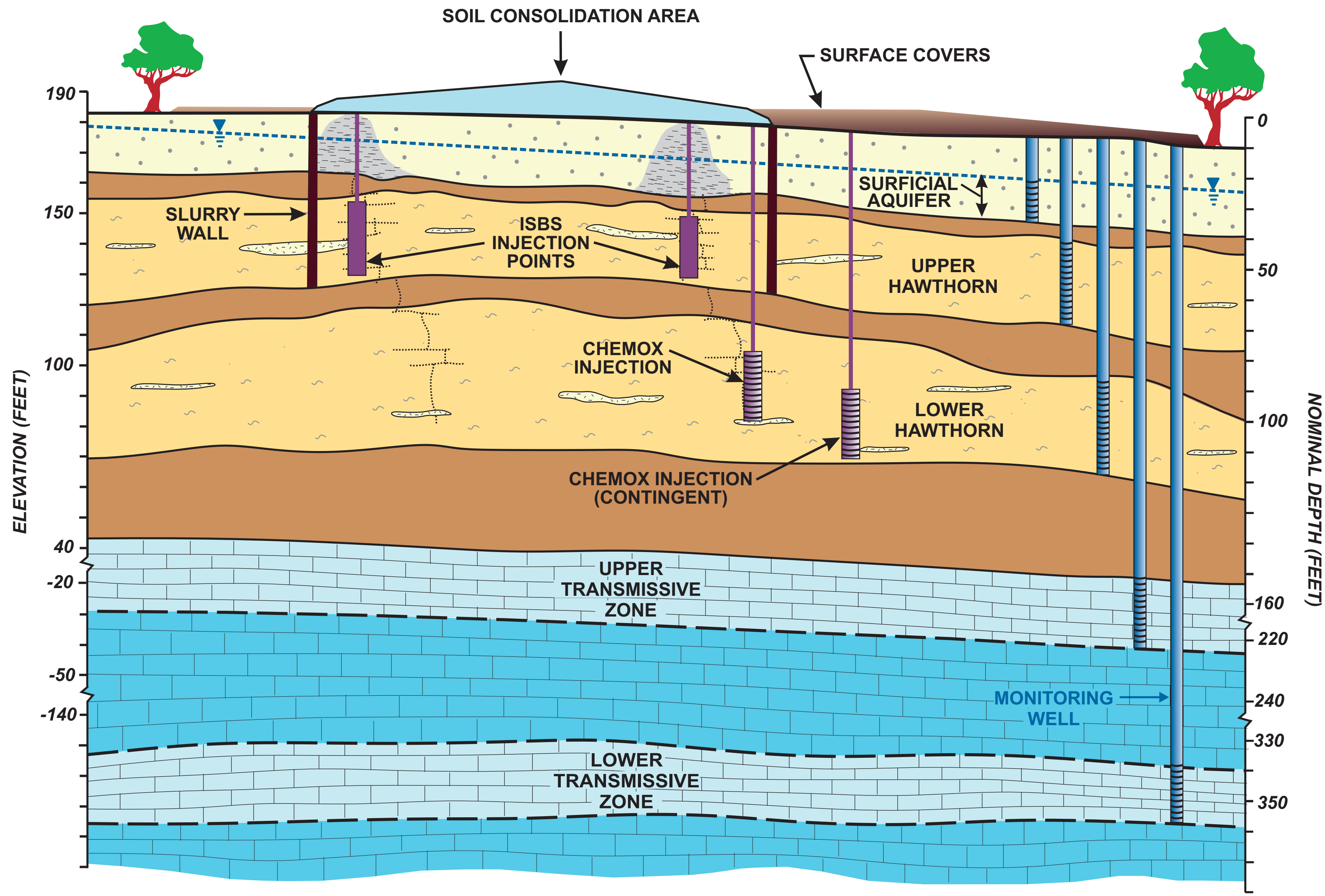

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Figure 3-7a.
Cross-Section Depiction of Alternative OnR-5B
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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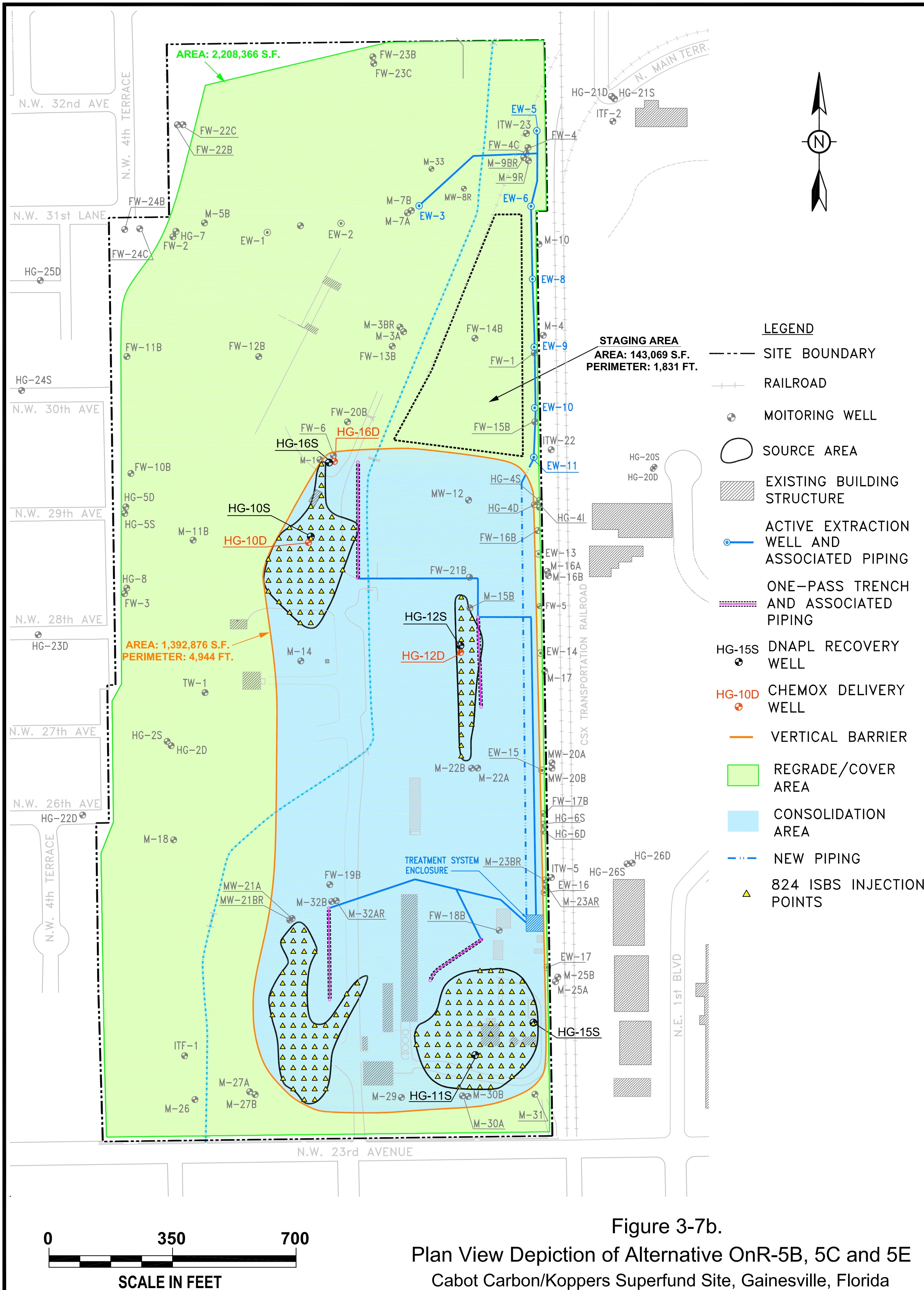

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Figure 3-7b.
Plan View Depiction of Alternative OnR-5B, 5C and 5E
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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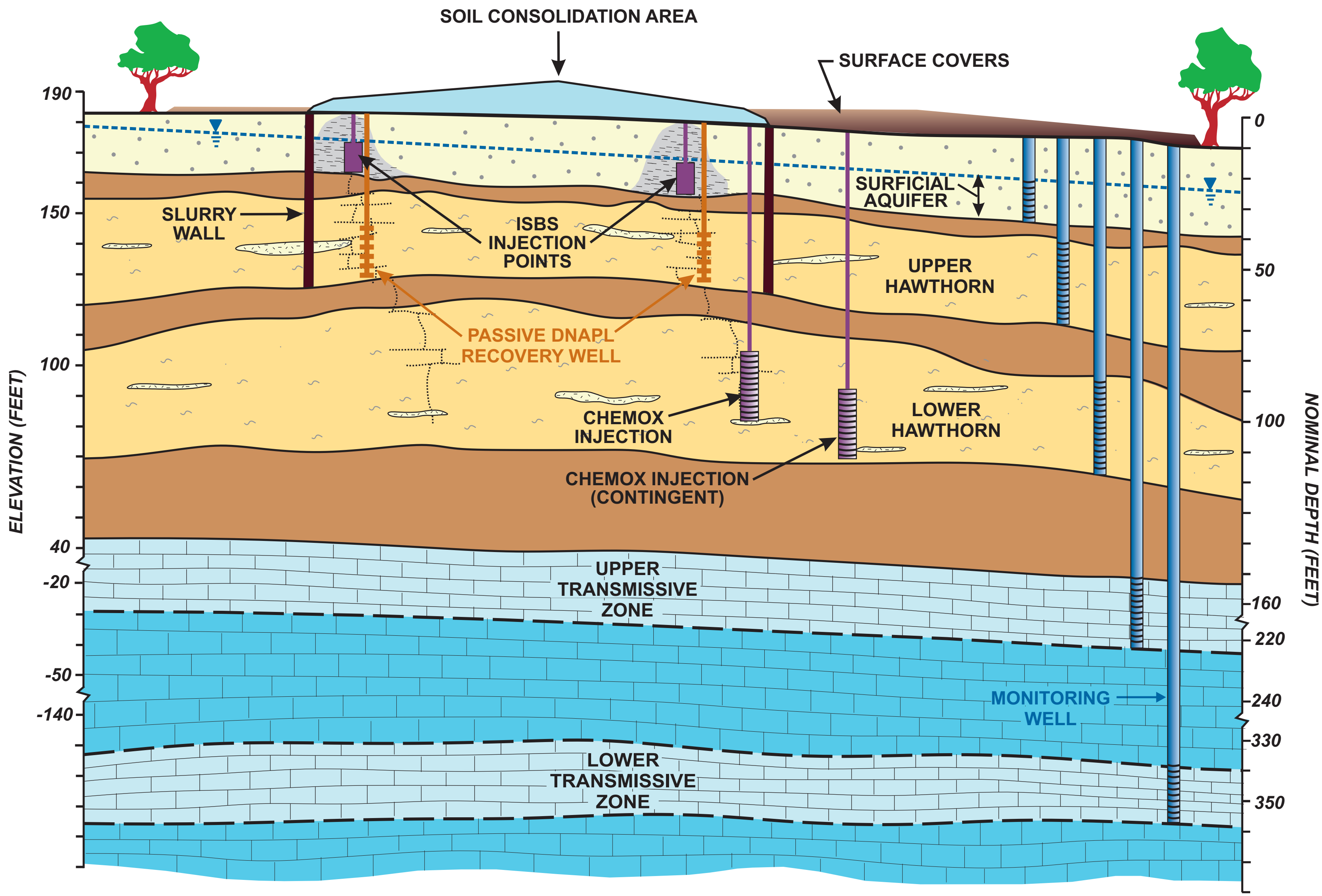

Figure 3-8a.
Cross-Section Depiction of Alternative OnR-5C
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

NOTE:
ELEVATIONS ARE APPROXIMATE.

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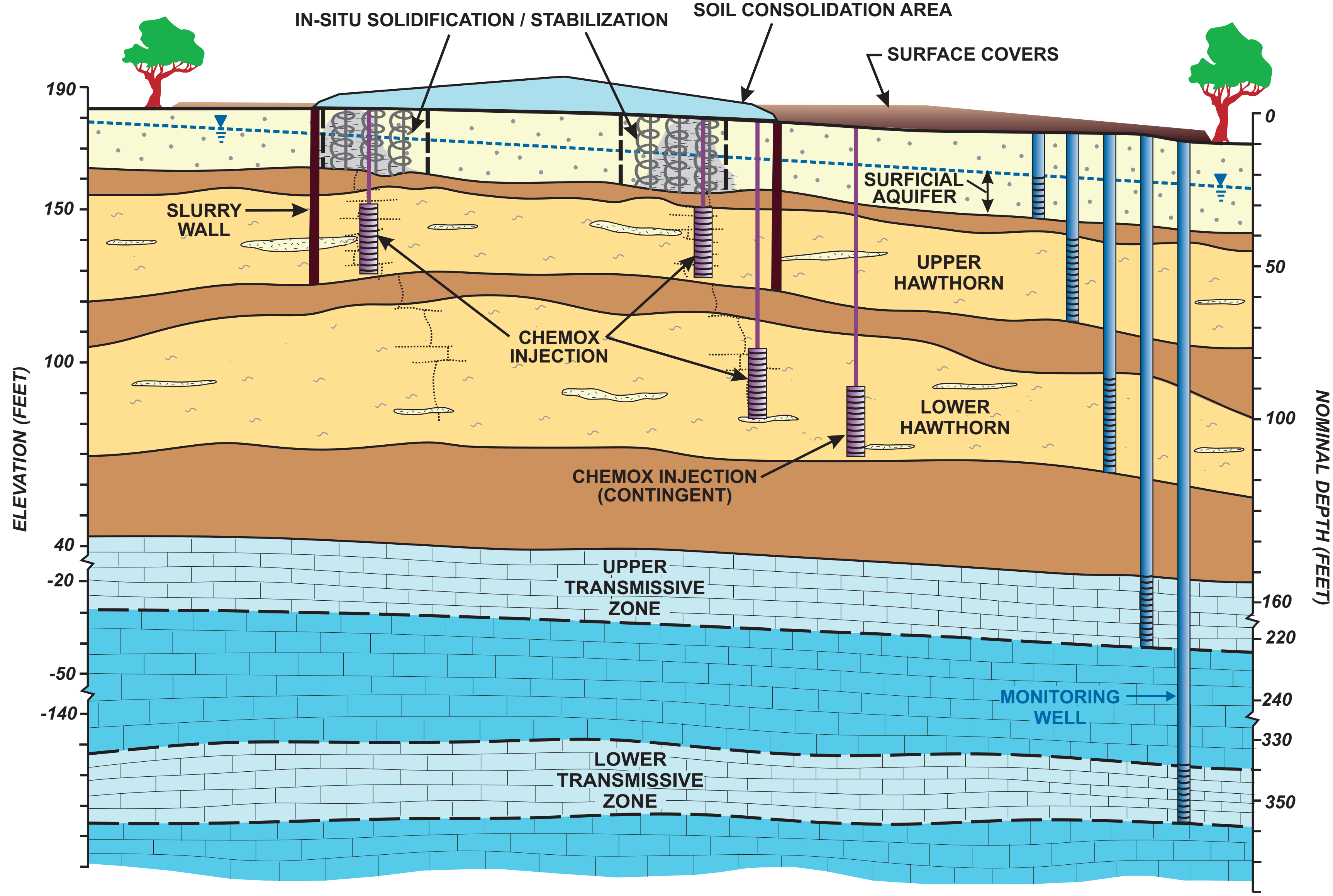

Figure 3-9a.
Cross-Section Depiction of Alternative OnR-5D
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

NOTE:
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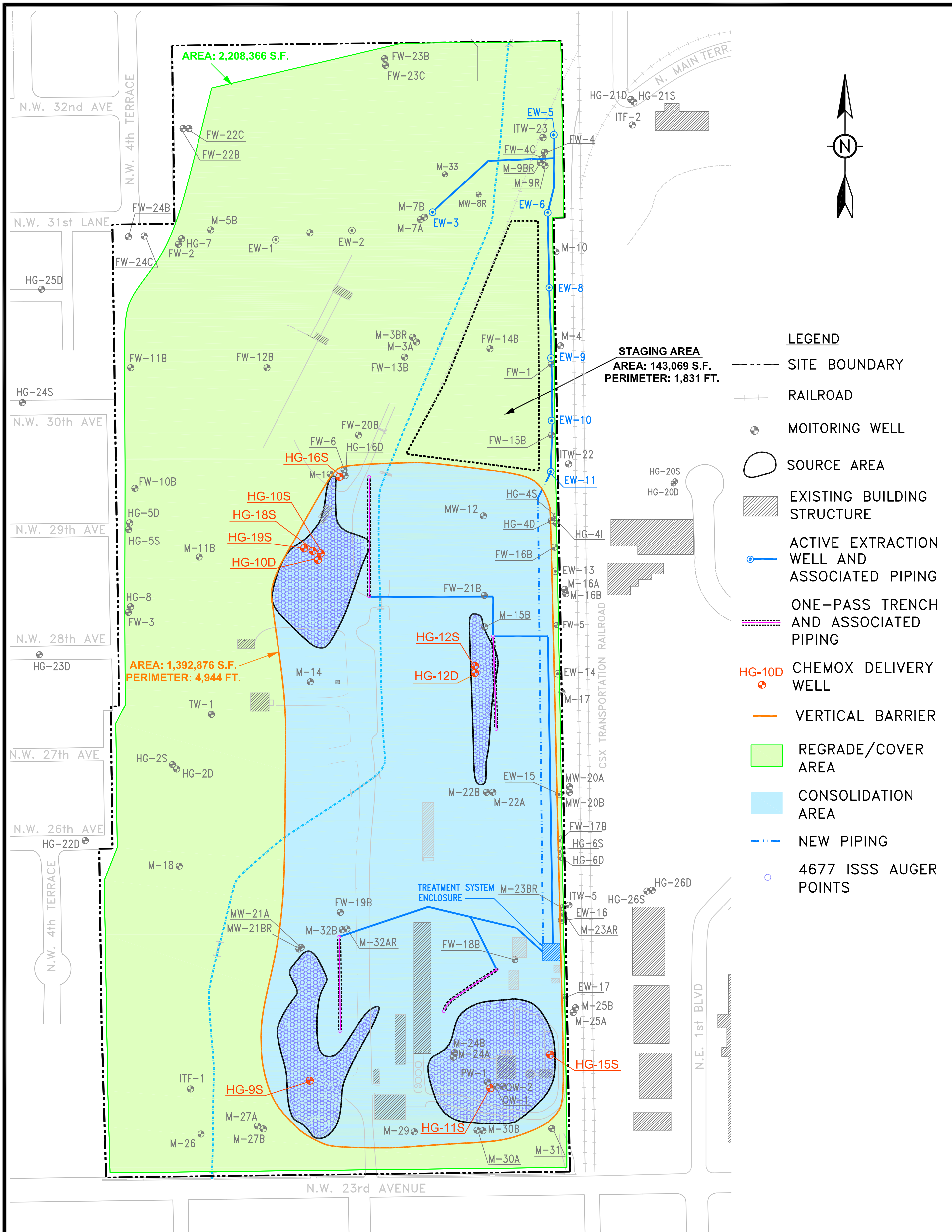

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Figure 3-9b.

Plan View Depiction of Alternative OnR-5D and 5F

Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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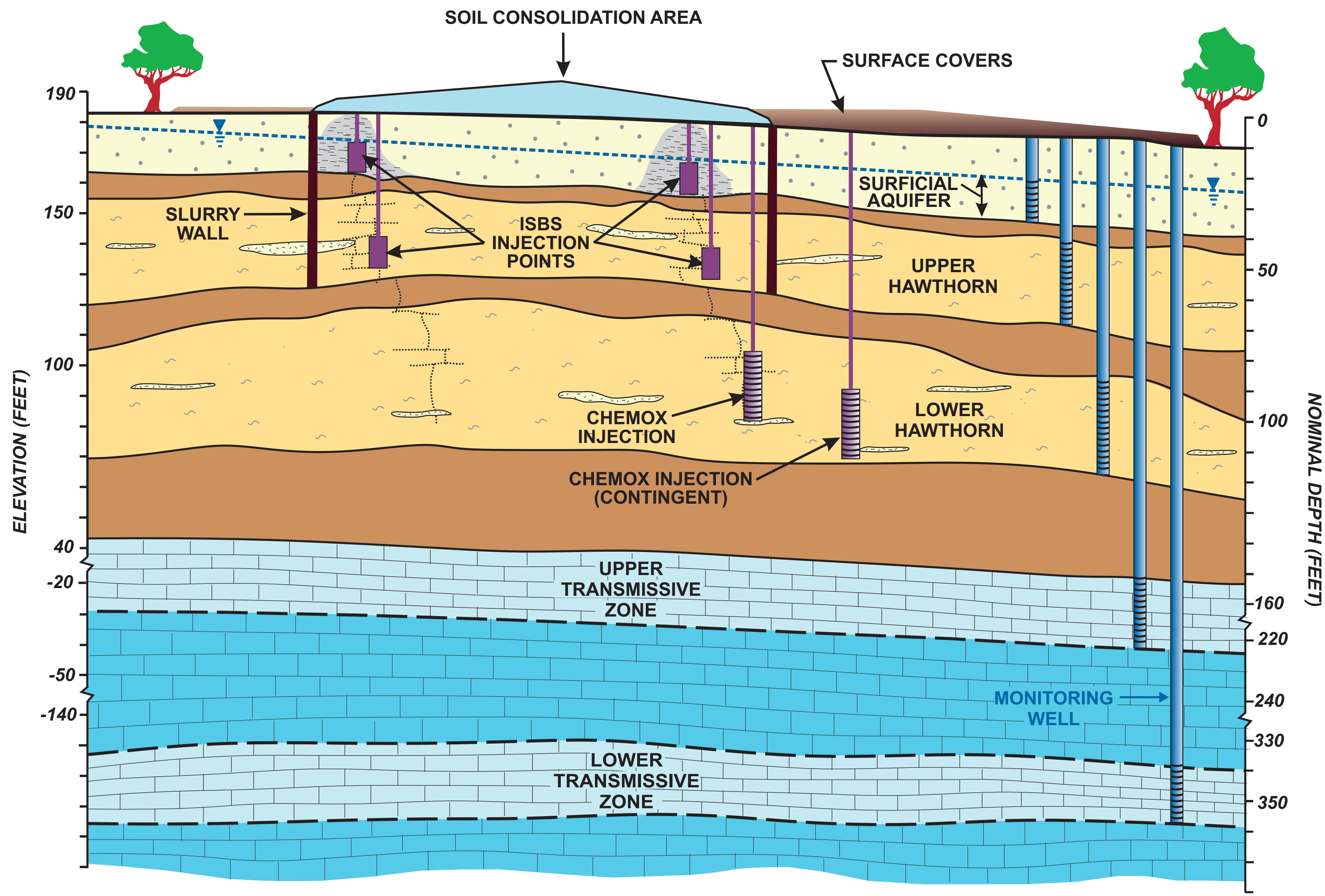

Figure 3-10a.
Cross-Section Depiction of Alternative OnR-5E
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

NOTE:
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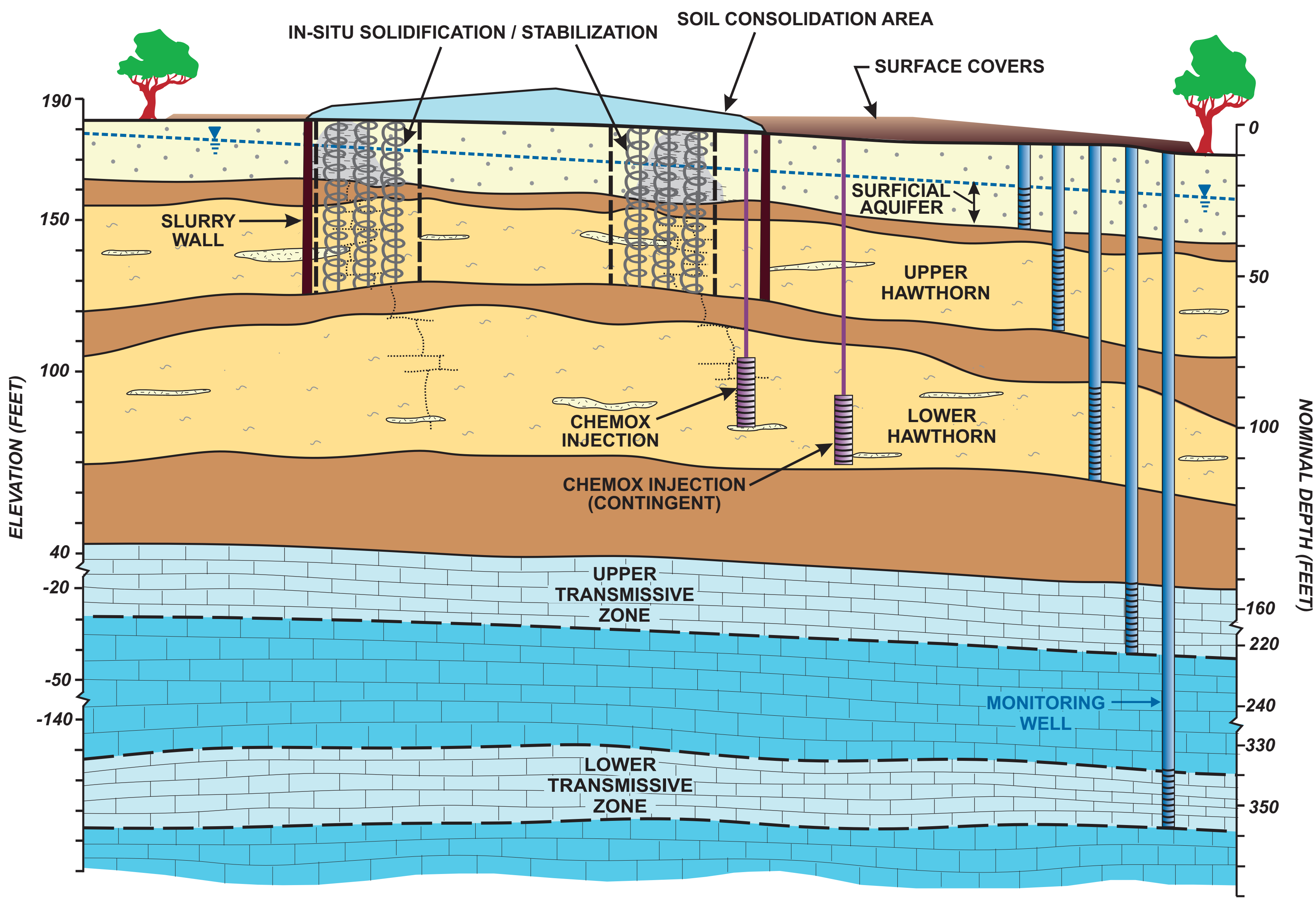

NOTE:
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Figure 3-11a.
Cross-Section Depiction of Alternative OnR-5F
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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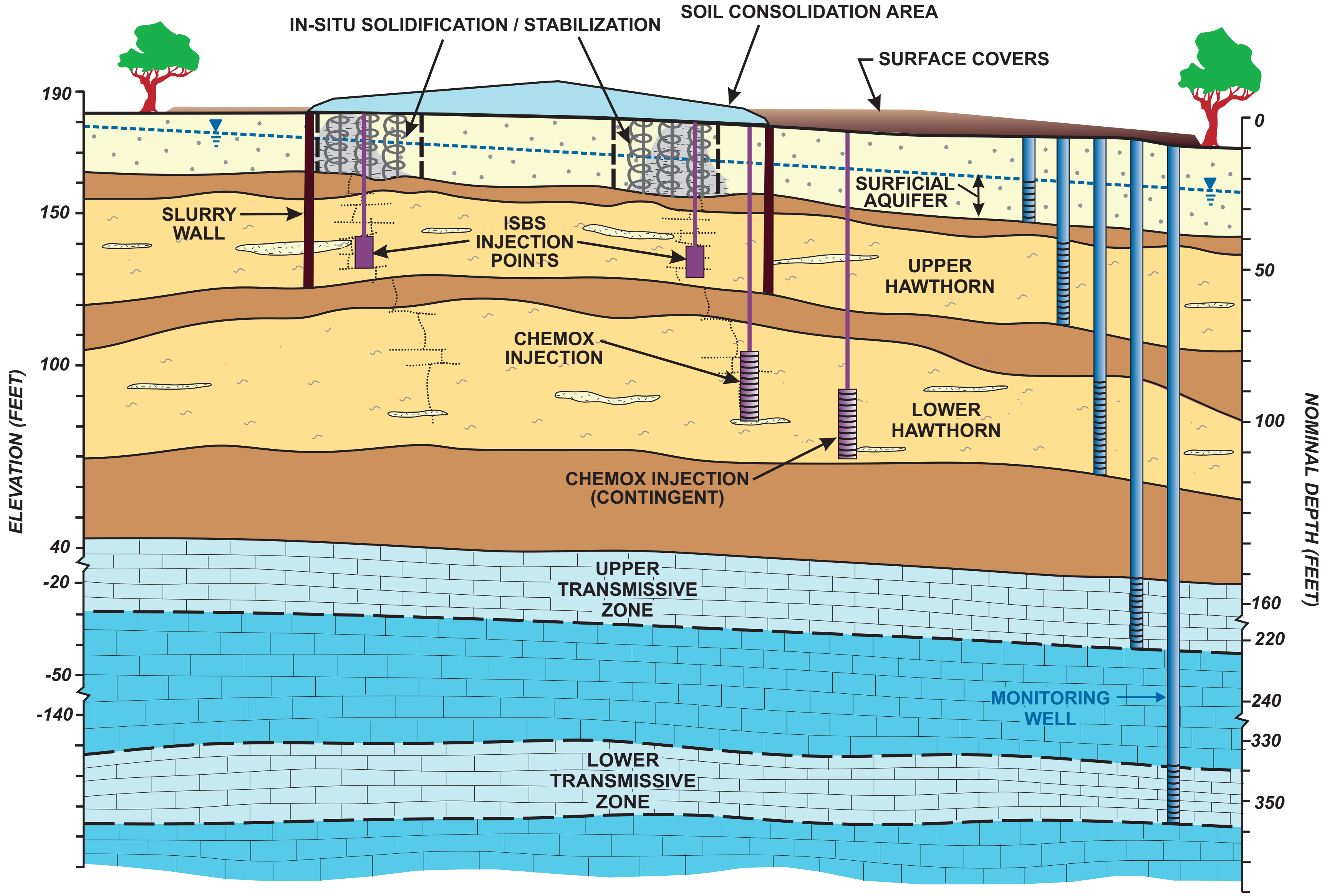

NOTE:
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Figure 3-12a.
Cross-Section Depiction of Alternative OnR-5G
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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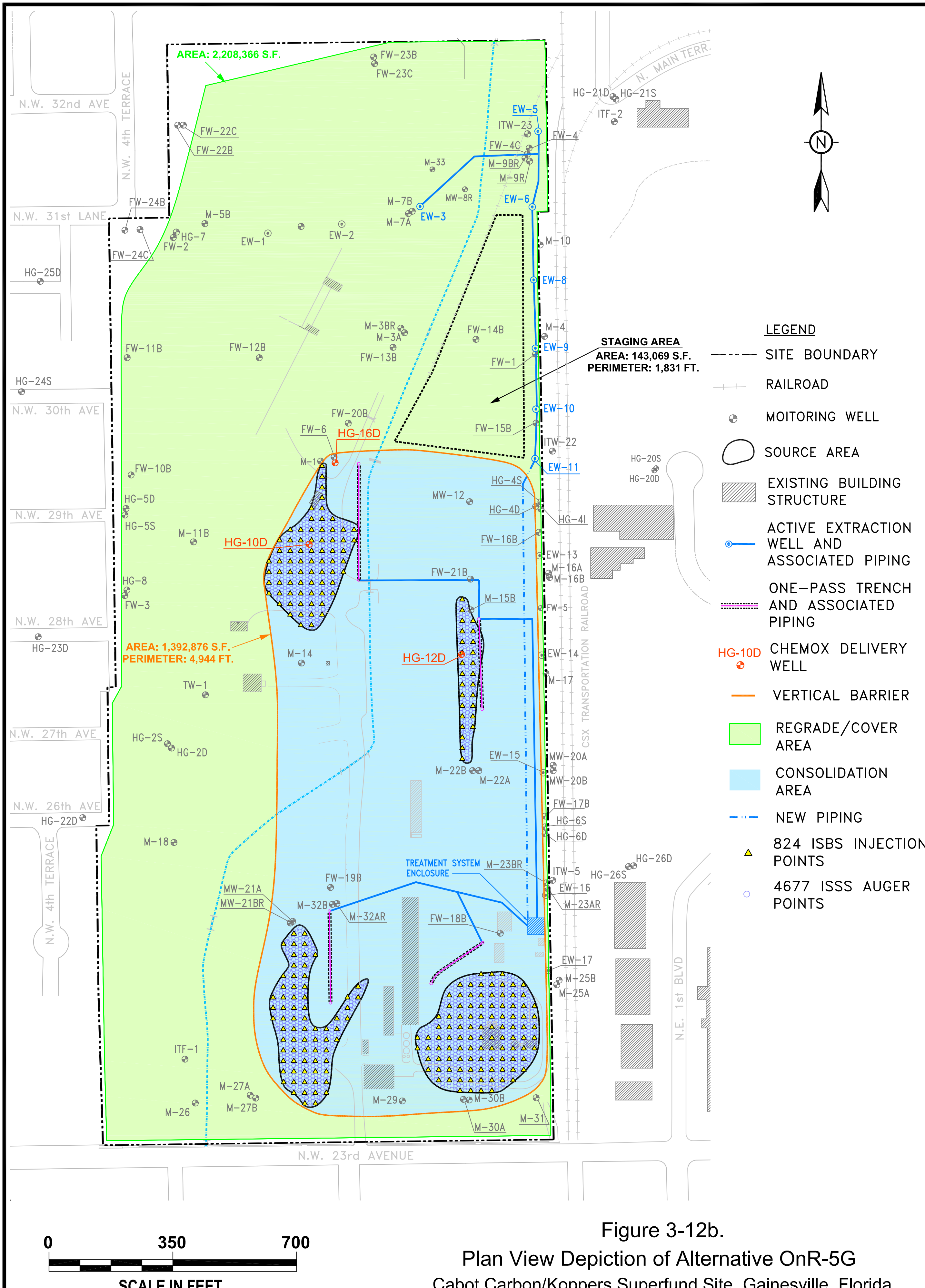

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Figure 3-12b.
Plan View Depiction of Alternative OnR-5G
Cabot Carbon/Koppers Superfund Site, Gainesville, Florida

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Appendix A

Annotated List of Supporting Documents and Technology Study Reports

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Partial List of Investigation and Remedy-Analysis Reports for the Koppers portion of the Cabot Carbon/Koppers Superfund Site

Report Date	Author/Firm	Title or Subject
April 1983	FDER	Summary of Data Collection Efforts
March 1985	Koppers Company, Inc.	Hydrogeologic Investigation
January 1987	IT Corp	Remedial Investigation Report
April 1989	Florida Department of Health and Rehabilitative Services	Health Assessment
September 1989	Hunter/ESE	Remedial Investigation/Risk Assessment
May 1990	ESE	Remedial Investigation/Feasibility Study
June 1991	Keystone Environmental Resources	Soil and Groundwater Remedial Design Work Plans
April 1993	McLaren/Hart	Site Characterization Data Report for the Initial Soil and Groundwater Remedies
April 1993	McLaren/Hart	Soil Washing Pilot Scale Design and In Situ Bioremediation Design
September 1993	McLaren/Hart	Groundwater Treatability Studies and Initial Groundwater Remedial System Design
December 1993	McLaren/Hart	Technical Specifications: Groundwater Treatment System
December 1994	McLaren/Hart	Groundwater Remedial Action Report: Interim Groundwater Remedial Action
September 1995	McLaren/Hart	Operation and Maintenance Plan for the Initial Groundwater Remedial Action
August 1997	TRC	Proposed Stage 2 Ground Water Monitoring Program
July 1998	TRC	Revised Supplemental Sampling and Analysis Plan
September 1999	TRC	Revised Supplemental Feasibility Study
March 2001	USACE	Five-Year Review
September 2002	TRC	Field Investigation Activities Report
February 2003	RETEC	Operations and Maintenance Manual
August 2003	TRC	Addendum Hawthorn Group Field Investigation Report
November 2003	TRC	Second Addendum to the Workplan for Additional Characterization of the Hawthorn Group
January 2004	TRC	Data Report: November (2003) Sampling Event, Investigation of the Hawthorn Group
May 2004	TRC	Data Report: Investigation of Private Wells
June 2004	TRC	Revised Floridan Aquifer Monitoring Report
September 2004	GeoTrans	Data Report for Additional Investigation of Hawthorn Group: DNAPL Source Evaluation
October 2004	GeoTrans	Groundwater Flow and Transport Model (Draft)
November 2004	Adventus	Engineering Optimization Tests for ISBS Technology
December 2004	TRC	Draft Remediation Grouting Work Plan

Partial List of Investigation and Remedy-Analysis Reports for the Koppers portion of the Cabot Carbon/Koppers Superfund Site

Report Date	Author/Firm	Title or Subject
January 2005	TRC	Source Removal Assessment Report
May 2005	Pilcher, Thomas	Arsenic Concentrations in Groundwater
May 2005	RETEC, GeoTrans, and Key	Surficial Aquifer DNAPL Removal Interim Measures/Remedy Pilot Test Report
June 2005	Waterloo Hydrogeologic	Technical Memorandum: A Critique of the GeoTrans Flow and Transport Model
October 2005	GeoTrans	Upper Floridan Monitoring Well Alternative Design
November 2005	Waterloo Hydrogeologic	Technical Memorandum 2: Evaluation of the Capture Effectiveness of the Ground Water Extraction System
February 2006	Jones Edmunds	Review and Recommendations Report
April 2006	USACE	Second Five-Year Review Report
July 2006	GeoTrans	Supplemental Upper Floridan Aquifer Monitoring Well Installation - Addendum to the Floridan Aquifer Monitoring Plan: Final Report
August 2006	GeoTrans	Addendum to the Floridan Aquifer Monitoring Plan
September 2006	AMEC	Revised Supplemental Sampling Plan - Additional Data for Risk Assessment
October 2006	GeoTrans	Letter regarding Five-Year Review Report - April 2006; Recommendation #9 – Redevelopment/Sampling of Surficial Aquifer Wells
November 2006	GeoTrans	Letter regarding Five-Year Review Report - April 2006; Recommendation #6 – Reevaluation of Site Stratigraphy
December 2006	ACEPD	Screening of Sediment and Water Quality within Springstead creek and Ditched Tributaries
December 2006	Haley & Aldrich	Evaluation of Thermal Remediation Technologies
December 2006	Sale, Tom	Screening Analysis of Surfactant Flushing Technologies
December 2006	GeoTrans	Recommendation #1 – Surficial Aquifer Hydraulic Containment System Evaluation
March 2007	GeoTrans	Hydraulic Testing and Geophysical Logging of UTZ, LTZ and Semi-Confining Unit
March 2007	GeoTrans	Evaluation of Arsenic Detections in Groundwater in the Floridan Aquifer
March 2007	GeoTrans	Supplemental Hawthorn Group Investigation and Monitoring Well Installation Workplan
April 2007	GeoTrans	Response to EPA Comment Letter dated December 7, 2006; Five-Year Review Report-April 2006; Recommendation #9 – Redevelopment/Sampling of Surficial Aquifer Wells
May 2007	Key and GeoTrans	Upper Hawthorn Group DNAPL Recovery Pilot Study Work Plan
July 2007	GeoTrans	Supplemental Hawthorn Group Investigation and Monitoring Well Installation Workplan: Revision #2
September 2007	FTS	Supplemental Groundwater Monitoring Report
October 2007	Key	Petition for Variance (UIC): Adventus Americas Inc. RemOx EC Stabilization Reagent
October 2007	AMEC	Revised Data Summary Report – Results of the Revised Supplemental Sampling Plan – Additional Data for Risk Assessment
October 2007	GeoTrans	Supplemental Upper Floridan Aquifer Monitoring Well Installation - Addendum III to the Floridan Aquifer Monitoring Plan”
December 2007	GeoTrans	Surficial Aquifer Well Redevelopment and Sampling Report

Partial List of Investigation and Remedy-Analysis Reports for the Koppers portion of the Cabot Carbon/Koppers Superfund Site

Report Date	Author/Firm	Title or Subject
January 2008	Beazer Expert Panel (Hinchee, Foster, and Larson)	Evaluation of Groundwater Issues
February 2008	Adventus	Final Field Activity Plan – Revision 3: Field-Scale Testing of *In Situ* Biogeochemical Stabilization
March 2008	GeoTrans	Supplemental Hawthorn Group Investigation and Monitoring Well Installation Report
March 2008	Adventus	Phase I ISBS – Field Pilot Study Report
June 2008	GeoTrans	Upper Floridan Aquifer Sentinel Monitoring Well Installation Work Plan: Revision 1
June 2008	AMEC	Proposed Approach to Estimating Potential On-Site Human Health Risks Associated with Soils and Sediments
June 2008	GeoTrans	Addendum to Supplemental Hawthorn Group Investigation and Monitoring Well Installation Report
October 2008	AMEC	Off-Site Sampling Plan
October 2008	FTS and GeoTrans	Comprehensive Groundwater Monitoring and Sample Analysis Plan
November 2008	GeoTrans	Supplemental Hawthorn Group Investigation and Monitoring Well Installation Workplan: Revision #3
December 2008	GeoTrans	Completion of Actions Recommended in the 2006 Five-Year Review
December 2008	GeoTrans	Upper Floridan Aquifer Interim Remedial Measure Work Plan
January 2009	GeoTrans	Surficial Aquifer Interim Remedial Measure and Soil Solidification/Stabilization Pilot Test Work Plan (Revision 1)
February 2009	GeoTrans	Groundwater Sampling Results for the September 2008 Sampling Event of Hawthorn Monitoring Wells
March 2009	Adventus	ISBS Pilot Study Report: Field Performance Assessment
May 2009	ACEPD	Sediment Quality in Springstead and Hogtown Creeks
May 2009	AMEC	Additional Off-Site Sampling
August 2009	GeoTrans	Upper Floridan Aquifer Monitoring Well Installation Workplan: Investigation of Northwestern Area
August 2009	GeoTrans	Supplemental 2009 Hawthorn Group Investigation and Monitoring Well Installation Report
August 2009	AMEC	Evaluation of Potential Ecological Risks
August 2009	AMEC	Potential Fugitive Dust Impacts Predicted from Air Dispersion Modeling
August 2009	GeoTrans	Proposed Addition to the Upper Floridan Aquifer Interim Remedial Measure
August 2009	AMEC	Evaluation of Potential On-Site Human Health Risks
August 2009	Adventus	Variance Monitoring Report, ISBS Pilot Study

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Appendix B

Cost Estimate Worksheets

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APPENDIX B

Alternative OnR-2

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$6,226,000**	
1.0	**Indirect capital costs**					**$1,038,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 518,800	$ 518,800		10% of direct capital cost
1.2	Contingency	1	LS	$ 518,800	$ 518,800		10% of direct capital cost
2.0	**Direct capital costs**					**$5,188,000**	
2.1	Mobilization/demobilization	1	LS	$ 140,000	$ 140,000	$140,000	
Soil Excavation						$1,108,000	
2.10	Excavate Soil (Assume 45 Acres with 2' avg. deep) & Transport	145,200	CY	$ 7.25	$ 1,052,700		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
Surface Covers						$1,770,000	
2.13	Import Soil Cover (51-Acre with 2.5' avg thickness)	205,700	CY	$ 8	$ 1,645,600		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
Detention Pond						$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
Storm Water Conveyance (Non-Site Water)						$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
Monitoring Wells						$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
Construction Oversight, Survey, and Reporting						$380,000	
2.41	Oversight Labor	5.0%	LS	$ 4,808,000	$ 240,400		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$307,000**	
Surface Cover						$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
Monitoring						$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
Passive DNAPL Recovery						$16,000	
3.3	Passive DNAPL Recovery in UHG	1	LS	$ 15,000	$ 15,000		
3.4	Waste management	5	Drums	$ 275	$ 1,375		
Surficial Aquifer Hydraulic Containment						$126,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	21,550	Kgal	$ 2	$ 43,100		Calculation based on 41 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	68,340	Kw-hr	$ 0.12	$ 8,201		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 17,100	$ 17,100		
4.6	Pumping system maintenance	1	LS	$ 22,300	$ 22,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 570,000**	
Confirmation Sampling						$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
Site Closing						$420,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,600	FT	$ 26.91	$ 312,156		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		

PRESENT VALUE ANALYSIS				
Item	**Cost**	**Rate**	**Year(s)**	**Net Present Value**
Total Capital Cost	$ 6,226,000		0	$ 6,226,000
Total Annual O&M Cost (for 30 years)	$ 307,000	5%	30	$ 4,719,000
Future Costs (Last Year of 30 Years of Remediation)	$ 570,000	5%	30	$ 132,000
GRAND TOTAL				**$ 11,100,000**

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APPENDIX B

Alternative OnR-3A

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$64,109,000**	
1.0	**Indirect capital costs**					**$10,685,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 5,342,400	$ 5,342,400		10% of direct capital cost
1.2	Contingency	1	LS	$ 5,342,400	$ 5,342,400		10% of direct capital cost
2.0	**Direct capital costs**					**$53,424,000**	
2.1	Mobilization/demobilization	1	LS	$ 400,000	$ 400,000	$400,000	
Soil Excavation, Treatment, & Barrier Walls						$46,526,000	
2.10	Excavate Shallow Soil (Assume 40 Acres with 2' avg. deep) & Transport	130,000	CY	$ 7.25	$ 942,500		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
	Excavate Source Areas to Upper Clay (25')	280,000	CY	$ 4.50	$ 1,260,000		TRC Unit Cost
	Transport to Treatment Area & Back (2 trips)	468,080	CY	$ 5.50	$ 2,574,440		$2.75 each way, include surface soil & pond excavations
	Ex-situ solidification and placement	468,080	CY	$ 60	$ 28,084,800		Contractor Estimate
	Install Dewatering Trench	128,900	SF	$ 15.50	$ 1,997,950		TRC
	Install Dewatering Piping System	8,101	FT	$ 26.75	$ 216,702		TRC
	Install Dewatering Sumps & Pumps (every 200 ft)	41	EA	$ 7,500	$ 307,500		TRC
	Install Dewatering Treatment System	1	LS	$ 1,200,000	$ 1,200,000		TRC
	Operate Dewatering Treatment System	22,500,000	gal	$ 0.015	$ 337,500		TRC
	Slurry Wall to 65 ft	314,000	vsf	$ 15	$ 4,710,000		Contractor Estimate
	Reinforcement for Shoring (25')	120,000	vsf	$ 40	$ 4,800,000		Contractor Estimate
	Install and Remove Silt Fence	8,000	FT	$ 5	$ 40,000		Includes ISS/S excess (25%) and pond-excavation; contractor estimate for unit cost
Surface Covers						$1,931,000	
2.13	Import Soil Cover (56-Acre with 2.5' avg thickness)	225,867	CY	$ 8	$ 1,806,933		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
Detention Pond						$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
Storm Water Conveyance (Non-Site Water)						$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
ChemOX in Existing UHG/LHG Wells						$100,000	
2.36	Injection and all associated costs	10	PT	$ 10,000	$ 100,000		Engineer's estimate
Monitoring Wells						$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
Construction Oversight, Survey, and Reporting						$2,677,000	
2.41	Oversight Labor	5.0%	LS	$ 50,747,000	$ 2,537,350		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
Surface Cover						$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
Monitoring						$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 10 yr**					**$126,000**	The existing treatment system will be phased out in three years
Surficial Aquifer Hydraulic Containment						$126,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	21,550	Kgal	$ 2	$ 43,100		Calculation based on 41 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	68,340	Kw-hr	$ 0.12	$ 8,201		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 17,100	$ 17,100		
4.6	Pumping system maintenance	1	LS	$ 22,300	$ 22,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
Confirmation Sampling						$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
Site Closing						$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 10 yr**					**$ 38,000**	
Well Abandonment and Site Restoration						$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 64,109,000		0	$ 64,109,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 10 years)	$ 126,000	5%	10	$ 973,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 10 Years)	$ 38,000	5%	10	$ 23,000
GRAND TOTAL				**$ 67,800,000**

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APPENDIX B

Alternative OnR-3B

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$190,033,000**	
1.0	**Indirect capital costs**					**$31,672,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 15,836,100	$ 15,836,100		10% of direct capital cost
1.2	Contingency	1	LS	$ 15,836,100	$ 15,836,100		10% of direct capital cost
2.0	**Direct capital costs**					**$158,361,000**	
2.1	Mobilization/demobilization	1	LS	$ 600,000	$ 600,000	$600,000	
	Soil Excavation and Treatment					$146,336,000	
2.10	Excavate Shallow Soil (Assume 30 Acres with 2' avg. deep) & Transport	96,800	CY	$ 7.25	$ 701,800		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
	Excavate Source Areas to Middle Clay (65')	1,800,000	CY	$ 4.50	$ 8,100,000		TRC Unit Cost
	Transport to Treatment Area & Back (2 trips)	1,954,880	CY	$ 5.50	$ 10,751,840		$2.75 each way, include surface soil & pond excavations
	Ex-situ solidification and placement	1,954,880	CY	$ 60	$ 117,292,800		Contractor Estimate
	Install Dewatering Trench	128,900	SF	$ 15.50	$ 1,997,950		TRC
	Install Dewatering Piping System	10,560	FT	$ 26.75	$ 282,480		TRC
	Install Dewatering Sumps & Pumps (every 200 ft)	53	EA	$ 7,500	$ 397,500		TRC
	Install Dewatering Treatment System	1	LS	$ 1,200,000	$ 1,200,000		TRC
	Operate Dewatering Treatment System	67,500,000	gal	$ 0.015	$ 1,012,500		3x volume of 25' excavation
	Shoring for Southern Excavation	81,900	vsf	$ 55	$ 4,504,500		Contractor Estimate
	Install and Remove Silt Fence	8,025	FT	$ 5	$ 40,125		Includes ISS/S excess (25%) and pond-excavation; contractor estimate for unit cost
	Surface Covers					$1,931,000	
2.13	Import Soil Cover (56-Acre with 2.5' avg thickness)	225,867	CY	$ 8	$ 1,806,933		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
	Detention Pond					$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
	Storm Water Conveyance (Non-Site Water)					$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
	ChemOX in Existing LHG Wells					$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
	Monitoring Wells					$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
	Construction Oversight, Survey, and Reporting					$7,674,000	
2.41	Oversight Labor	5.0%	LS	$ 150,687,000	$ 7,534,350		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
	Surface Cover					$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
	Monitoring					$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 10 yr**					**$126,000**	The existing treatment system will be phased out in three years
	Surficial Aquifer Hydraulic Containment					$126,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	21,550	Kgal	$ 2	$ 43,100		Calculation based on 41 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	68,340	Kw-hr	$ 0.12	$ 8,201		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 17,100	$ 17,100		
4.6	Pumping system maintenance	1	LS	$ 22,300	$ 22,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
	Confirmation Sampling					$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
	Site Closing					$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 10 yr**					**$ 38,000**	
	Well Abandonment and Site Restoration					$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 190,033,000		0	$ 190,033,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 10 years)	$ 126,000	5%	10	$ 973,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 10 Years)	$ 38,000	5%	10	$ 23,000
GRAND TOTAL				**$ 193,700,000**

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APPENDIX B

Alternative OnR-4A

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$75,222,000**	
1.0	**Indirect capital costs**					**$12,537,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 6,268,500	$ 6,268,500		10% of direct capital cost
1.2	Contingency	1	LS	$ 6,268,500	$ 6,268,500		10% of direct capital cost
2.0	**Direct capital costs**					**$62,685,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
Soil Excavation and Treatment						$8,974,000	
2.10	Excavate Soil (Assume 45 Acres with 2' avg. deep) & Transport	145,200	CY	$ 7.25	$ 1,052,700		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
	Ex-Situ Solidification and placement/compaction	131,100	CY	$ 60	$ 7,866,000		ISS/S excess (25%)
Surface Covers						$1,770,000	
2.13	Import Soil Cover (51-Acre with 2.5' avg thickness)	205,700	CY	$ 8	$ 1,645,600		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
In-Situ Solidification/Stabilization for Surficial Aquifer (~65', 5 acres)						$46,713,000	
2.15	ISSS Soil Mixing Only (construction, materials, and labor)	524,400	CY	$ 62	$ 32,512,800		Past experience
2.16	Cement (8%) and Freight Charge	63,000	Ton	$ 120	$ 7,560,000		Supplier estimate 8% by mass
2.17	Bentonite (3%)	23,600	Ton	$ 230	$ 5,428,000		Vendor quote: $572,200 for 2500 tons
2.18	Tax	1	LS	$ 811,750	$ 811,750		6.25%
2.19	Excess material from ISSS move to consolidation area	131,100	CY	$ 2.75	$ 360,525		25% soil volume
2.20	ISSS Bench Scale/Pilot Test	1	LS	$ 40,000	$ 40,000		
Detention Pond						$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
Storm Water Conveyance (Non-Site Water)						$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
ChemOX in Existing LHG Wells						$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
Monitoring Wells						$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
Construction Oversight, Survey, and Reporting						$3,118,000	
2.41	Oversight Labor	5.0%	LS	$ 59,567,000	$ 2,978,350		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
Surface Cover						$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
Monitoring						$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 10 yr**					**$126,000**	The existing treatment system will be phased out in three years
Surficial Aquifer Hydraulic Containment						$126,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	21,550	Kgal	$ 2	$ 43,100		Calculation based on 41 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	68,340	Kw-hr	$ 0.12	$ 8,201		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 17,100	$ 17,100		
4.6	Pumping system maintenance	1	LS	$ 22,300	$ 22,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
Confirmation Sampling						$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
Site Closing						$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 10 yr**					**$ 38,000**	
Well Abandonment and Site Restoration						$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 75,222,000		0	$ 75,222,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 10 years)	$ 126,000	5%	10	$ 973,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 10 Years)	$ 38,000	5%	10	$ 23,000
GRAND TOTAL				**$ 78,900,000**

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APPENDIX B

Alternative OnR-4B

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$38,069,000**	
1.0	**Indirect capital costs**					**$6,345,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 3,172,400	$ 3,172,400		10% of direct capital cost
1.2	Contingency	1	LS	$ 3,172,400	$ 3,172,400		10% of direct capital cost
2.0	**Direct capital costs**					**$31,724,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
	Soil Excavation and Treatment					$4,133,000	
2.10	Excavate Soil (Assume 45 Acres with 2' avg. deep) & Transport	145,200	CY	$ 7.25	$ 1,052,700		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Ex-Situ Solidification and placement/compaction	50,425	CY	$ 60	$ 3,025,500		ISSS Excess (25%)
	Surface Covers					$1,770,000	
2.13	Import Soil Cover (51-Acre with 2.5' avg thickness)	205,700	CY	$ 8	$ 1,645,600		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
	In-Situ Solidification/Stabilization for Surficial Aquifer (~25', 5 acres)					$18,006,000	
2.15	ISSS Soil Mixing Only (construction, materials, and labor)	201,700	CY	$ 62	$ 12,505,400		Past experience
2.16	Cement (8%) and Freight Charge	24,300	Ton	$ 120	$ 2,916,000		Supplier estimate 8% by mass
2.17	Bentonite (3%)	9,100	Ton	$ 230	$ 2,093,000		Vendor quote: $572,200 for 2500 tons
2.18	Tax	1	LS	$ 313,063	$ 313,063		6.25%
2.19	Excess material from ISSS move to consolidation area	50,425	CY	$ 2.75	$ 138,669		25% soil volume
2.20	ISSS Bench Scale/Pilot Test	1	LS	$ 40,000	$ 40,000		
	In-Situ Biogeochemical Stabilization (ISBS)					$3,991,000	
2.21	ISBS Materials 5 acres, 15 ft thickness within UHG	2,025,000	LBS	$ 0.80	$ 1,620,000		Quoted by Adventus Group, ~675,000 lbs material needed for one acre area (25' thickness)
2.26	Freight Costs	2,025,000	LS	$ 0.10	$ 202,500		Quoted by Adventus Group, ~$ 0.1/lb freight cost for material
2.27	Tax	6.25%		$ 1,822,500	$ 113,906		Quoted by Adventus Group, 6.25% tax rate for Gainesville, FL
2.28	Injection Costs (821 ISBS auger points + Exploratory Borings)	411	Day	$ 5,000	$ 2,055,000		Assumes 2 points/day
	Detention Pond					$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
	Storm Water Conveyance (Non-Site Water)					$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
	ChemOX in Existing UHG/LHG Wells					$100,000	
2.36	Injection and all associated costs	10	PT	$ 10,000	$ 100,000		Engineer's estimate
	Monitoring Wells					$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
	Construction Oversight, Survey, and Reporting					$1,644,000	
2.41	Oversight Labor	5.0%	LS	$ 30,080,000	$ 1,504,000		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
	Surface Cover					$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
	Monitoring					$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 10 yr**					**$126,000**	The existing treatment system will be phased out in three years
	Surficial Aquifer Hydraulic Containment					$126,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	21,550	Kgal	$ 2	$ 43,100		Calculation based on 41 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	68,340	Kw-hr	$ 0.12	$ 8,201		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 17,100	$ 17,100		
4.6	Pumping system maintenance	1	LS	$ 22,300	$ 22,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
	Confirmation Sampling					$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
	Site Closing					$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 10 yr**					**$ 38,000**	
	Well Abandonment and Site Restoration					$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 38,069,000		0	$ 38,069,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 10 years)	$ 126,000	5%	10	$ 973,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 10 Years)	$ 38,000	5%	10	$ 23,000
GRAND TOTAL				**$ 41,800,000**

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APPENDIX B

Alternative OnR-5B

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						$12,775,000	
1.0	**Indirect capital costs**					**$2,129,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 1,064,600	$ 1,064,600		10% of direct capital cost
1.2	Contingency	1	LS	$ 1,064,600	$ 1,064,600		10% of direct capital cost
2.0	**Direct capital costs**					**$10,646,000**	
2.1	Mobilization/demobilization	1	LS	$ 150,000	$ 150,000	$150,000	
	Slurry-Wall (extended to 65' bgs)					$2,320,000	
2.7	Slurry Trench Excavate/Backfill Overburden	325,000	vsf	$ 6.00	$ 1,950,000		Based on contractor quote
2.8	Clay Top on slurry Wall	5,000	LF	$ 60.00	$ 300,000		Contractror quote
2.9	QC Testing / Slurry Wall Report / Submittals	1	LS	$ 70,000	$ 70,000		Contractor quote
	Soil Excavation					$723,000	
2.10	Excavate Soil (Assume 24 Acres with 2' avg. deep)	77,440	CY	$ 4.50	$ 348,480		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Transport Soil to the consolidation area & compact	116,160	Ton	$ 2.75	$ 319,440		Assumed 1 CY is 1.5 ton, unit price was based on TRC's estimate
	Surface Covers					$4,993,000	32-acre GCL+soil cover, 12-acre pond, 20.5-acre no cover, and 22-acre soil cover (2.5' thick)
2.12	Within Slurry Wall Area: Site Prep/Install GCL/Soil Cover	32	ACRE	$ 125,000	$ 3,997,004		Based on a similar site experience
2.13	Import Soil Cover (27-Acre with 2.5' avg thickness)	108,900	CY	$ 8	$ 871,200		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
	Detention Pond					$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
	Storm Water Conveyance (Non-Site Water)					$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
	ChemOX in Existing LHG Wells					$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
	Monitoring Wells					$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
	Construction Oversight, Survey, and Reporting					$640,000	
2.41	Oversight Labor	5.0%	LS	$ 10,006,000	$ 500,300		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$181,000**	
	Surface Cover					$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
	Monitoring					$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
	Passive DNAPL Recovery					$16,000	
3.3	Passive DNAPL Recovery in UHG	1	LS	$ 15,000	$ 15,000		Includes labor and equipment
3.4	Waste management	5	Drums	$ 275	$ 1,375		
4.0	**Temporary Annual OM&M Costs - 3 yr**					**$77,000**	The existing treatment system will be phased out in three years
	Surficial Aquifer Hydraulic Containment					$77,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	9,990	Kgal	$ 2	$ 19,980		Calculation based on 19 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	31,670	Kw-hr	$ 0.12	$ 3,800		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 8,000	$ 8,000		
4.6	Pumping system maintenance	1	LS	$ 10,300	$ 10,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
	Confirmation Sampling					$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
	Site Closing					$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 3 yr**					**$ 38,000**	
	Well Abandonment and Site Restoration					$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 12,775,000		0	$ 12,775,000
Total Annual O&M Cost (for 30 years)	$ 181,000	5%	30	$ 2,782,000
Annual O&M Cost (existing system for 3 years)	$ 77,000	5%	3	$ 210,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 3 Years)	$ 38,000	5%	3	$ 33,000
GRAND TOTAL				**$ 16,000,000**

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APPENDIX B

Alternative OnR-5B

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						$17,981,000	
1.0	**Indirect capital costs**					**$2,997,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 1,498,400	$ 1,498,400		10% of direct capital cost
1.2	Contingency	1	LS	$ 1,498,400	$ 1,498,400		10% of direct capital cost
2.0	**Direct capital costs**					**$14,984,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
Slurry-Wall (extended to 65' bgs)						$2,320,000	
2.7	Slurry Trench Excavate/Backfill Overburden	325,000	vsf	$ 6.00	$ 1,950,000		Based on contractor quote
2.8	Clay Top on slurry Wall	5,000	LF	$ 60.00	$ 300,000		Contractror quote
2.9	QC Testing / Slurry Wall Report / Submittals	1	LS	$ 70,000	$ 70,000		Contractor quote
Soil Excavation						$723,000	
2.10	Excavate Soil (Assume 24 Acres with 2' avg. deep)	77,440	CY	$ 4.50	$ 348,480		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Transport Soil to the consolidation area & compact	116,160	Ton	$ 2.75	$ 319,440		Assumed 1 CY is 1.5 ton, unit price was based on TRC's estimate
Surface Covers						$4,993,000	32-acre GCL+soil cover, 12-acre pond, 20.5-acre no cover, and 22-acre soil cover (2.5' thick)
2.12	Within Slurry Wall Area: Site Prep/Install GCL/Soil Cover	32	ACRE	$ 125,000	$ 3,997,004		Based on a similar site experience
2.13	Import Soil Cover (27-Acre with 2.5' avg thickness)	108,900	CY	$ 8	$ 871,200		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
In-Situ Biogeochemical Stabilization (ISBS)						$3,991,000	
2.21	ISBS Materials 5 acres, 15 ft thickness within UHG	2,025,000	LBS	$ 0.80	$ 1,620,000		Quoted by Adventus Group, ~675,000 lbs material needed for one acre area (25' thickness)
2.26	Freight Costs	2,025,000	LS	$ 0.10	$ 202,500		Quoted by Adventus Group, ~$ 0.1/lb freight cost for material
2.27	Tax	6.25%		$ 1,822,500	$ 113,906		Quoted by Adventus Group, 6.25% tax rate for Gainesville, FL
2.28	Injection Costs (821 ISBS auger points + Exploratory Borings)	411	Day	$ 5,000	$ 2,055,000		Assumes 2 points/day
Detention Pond						$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
Storm Water Conveyance (Non-Site Water)						$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
ChemOX in Existing LHG Wells						$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
Monitoring Wells						$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
Construction Oversight, Survey, and Reporting						$847,000	
2.41	Oversight Labor	5.0%	LS	$ 14,137,000	$ 706,850		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
Surface Cover						$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
Monitoring						$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 3 yr**					**$77,000**	The existing treatment system will be phased out in three years
Surficial Aquifer Hydraulic Containment						$77,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	9,990	Kgal	$ 2	$ 19,980		Calculation based on 19 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	31,670	Kw-hr	$ 0.12	$ 3,800		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 8,000	$ 8,000		
4.6	Pumping system maintenance	1	LS	$ 10,300	$ 10,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
Confirmation Sampling						$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
Site Closing						$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 3 yr**					**$ 38,000**	
Well Abandonment and Site Restoration						$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 17,981,000		0	$ 17,981,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 3 years)	$ 77,000	5%	3	$ 210,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 3 Years)	$ 38,000	5%	3	$ 33,000
GRAND TOTAL				**$ 20,900,000**

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APPENDIX B

Alternative OnR-5C

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$18,058,000**	
1.0	**Indirect capital costs**					**$3,010,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 1,504,800	$ 1,504,800		10% of direct capital cost
1.2	Contingency	1	LS	$ 1,504,800	$ 1,504,800		10% of direct capital cost
2.0	**Direct capital costs**					**$15,048,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
	Slurry-Wall (extended to 65' bgs)					$2,320,000	
2.7	Slurry Trench Excavate/Backfill Overburden	325,000	vsf	$ 6.00	$ 1,950,000		Based on contractor quote
2.8	Clay Top on slurry Wall	5,000	LF	$ 60.00	$ 300,000		Contractror quote
2.9	QC Testing / Slurry Wall Report / Submittals	1	LS	$ 70,000	$ 70,000		Contractor quote
	Soil Excavation					$723,000	
2.10	Excavate Soil (Assume 24 Acres with 2' avg. deep)	77,440	CY	$ 4.50	$ 348,480		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Transport Soil to the consolidation area & compact	116,160	Ton	$ 2.75	$ 319,440		Assumed 1 CY is 1.5 ton, unit price was based on TRC's estimate
	Surface Covers					$4,993,000	32-acre GCL+soil cover, 12-acre pond, 20.5-acre no cover, and 22-acre soil cover (2.5' thick)
2.12	Within Slurry Wall Area: Site Prep/Install GCL/Soil Cover	32	ACRE	$ 125,000	$ 3,997,004		Based on a similar site experience
2.13	Import Soil Cover (27-Acre with 2.5' avg thickness)	108,900	CY	$ 8	$ 871,200		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
	In-Situ Biogeochemical Stabilization (ISBS)					$4,052,000	
2.21	ISBS Materials 5 acres, 25 ft	3,375,000	LBS	$ 0.80	$ 2,700,000		Quoted by Adventus Group, ~675,000 lbs material needed for one acre area (25' thickness)
2.26	Freight Costs	3,375,000	LS	$ 0.10	$ 337,500		Quoted by Adventus Group, ~$ 0.1/lb freight cost for material
2.27	Tax	6.25%		$ 3,037,500	$ 189,844		Quoted by Adventus Group, 6.25% tax rate for Gainesville, FL
2.28	Injection Costs (821 ISBS auger points + Exploratory Borings)	165	Day	$ 5,000	$ 825,000		Quoted by Adventus Group, Injection Trailer Rate, 5 points per day for shallow zone (25' deep)
	Detention Pond					$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
	Storm Water Conveyance (Non-Site Water)					$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
	ChemOX in Existing LHG Wells					$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
	Monitoring Wells					$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
	Construction Oversight, Survey, and Reporting					$850,000	
2.41	Oversight Labor	5.0%	LS	$ 14,198,000	$ 709,900		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$181,000**	
	Surface Cover					$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
	Monitoring					$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
	Passive DNAPL Recovery					$16,000	
3.3	Passive DNAPL Recovery in UHG	1	LS	$ 15,000	$ 15,000		Includes labor and equipment
3.4	Waste management	5	Drums	$ 275	$ 1,375		
4.0	**Temporary Annual OM&M Costs - 3 yr**					**$77,000**	The existing treatment system will be phased out in three years
	Surficial Aquifer Hydraulic Containment					$77,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	9,990	Kgal	$ 2	$ 19,980		Calculation based on 19 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	31,670	Kw-hr	$ 0.12	$ 3,800		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 8,000	$ 8,000		
4.6	Pumping system maintenance	1	LS	$ 10,300	$ 10,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
	Confirmation Sampling					$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
	Site Closing					$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 3 yr**					**$ 38,000**	
	Well Abandonment and Site Restoration					$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 18,058,000		0	$ 18,058,000
Total Annual O&M Cost (for 30 years)	$ 181,000	5%	30	$ 2,782,000
Annual O&M Cost (existing system for 3 years)	$ 77,000	5%	3	$ 210,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 3 Years)	$ 38,000	5%	3	$ 33,000
GRAND TOTAL				**$ 21,300,000**

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APPENDIX B

Alternative OnR-5D

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$35,728,000**	
1.0	**Indirect capital costs**					**$5,955,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 2,977,300	$ 2,977,300		10% of direct capital cost
1.2	Contingency	1	LS	$ 2,977,300	$ 2,977,300		10% of direct capital cost
2.0	**Direct capital costs**					**$29,773,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
	Slurry-Wall (extended to 65' bgs)					$2,320,000	
2.7	Slurry Trench Excavate/Backfill Overburden	325,000	vsf	$ 6.00	$ 1,950,000		Based on contractor quote
2.8	Clay Top on slurry Wall	5,000	LF	$ 60.00	$ 300,000		Contractror quote
2.9	QC Testing / Slurry Wall Report / Submittals	1	LS	$ 70,000	$ 70,000		Contractor quote
	Soil Excavation					$723,000	
2.10	Excavate Soil (Assume 24 Acres with 2' avg. deep)	77,440	CY	$ 4.50	$ 348,480		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Transport Soil to the consolidation area & compact	116,160	Ton	$ 2.75	$ 319,440		Assumed 1 CY is 1.5 ton, unit price was based on TRC's estimate
	Surface Covers					$4,993,000	32-acre GCL+soil cover, 12-acre pond, 20.5-acre no cover, and 22-acre soil cover (2.5' thick)
2.12	Within Slurry Wall Area: Site Prep/Install GCL/Soil Cover	32	ACRE	$ 125,000	$ 3,997,004		Based on a similar site experience
2.13	Import Soil Cover (27-Acre with 2.5' avg thickness)	108,900	CY	$ 8	$ 871,200		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
	In-Situ Solidification/Stabilization for Surficial Aquifer (~25') - Former North Lagoon					$18,006,000	
2.15	ISSS Soil Mixing Only (construction, materials, and labor)	201,700	CY	$ 62	$ 12,505,400		Past experience
2.16	Cement (8%) and Freight Charge	24,300	Ton	$ 120	$ 2,916,000		Supplier estimate 8% by mass
2.17	Bentonite (3%)	9,100	Ton	$ 230	$ 2,093,000		Vendor quote: $572,200 for 2500 tons
2.18	Tax	1	LS	$ 313,063	$ 313,063		6.25%
2.19	Excess material from ISSS move to consolidation area	50,425	CY	$ 2.75	$ 138,669		25% soil volume
2.20	ISSS Bench Scale/Pilot Test	1	LS	$ 40,000	$ 40,000		
	Detention Pond					$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
	Storm Water Conveyance (Non-Site Water)					$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
	ChemOX in Existing UHG/LHG Wells					$100,000	
2.36	Injection and all associated costs	10	PT	$ 10,000	$ 100,000		Engineer's estimate
	Monitoring Wells					$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
	Construction Oversight, Survey, and Reporting					$1,551,000	
2.41	Oversight Labor	5.0%	LS	$ 28,222,000	$ 1,411,100		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
	Surface Cover					$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
	Monitoring					$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 3 yr**					**$77,000**	The existing treatment system will be phased out in three years
	Surficial Aquifer Hydraulic Containment					$77,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	9,990	Kgal	$ 2	$ 19,980		Calculation based on 19 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	31,670	Kw-hr	$ 0.12	$ 3,800		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 8,000	$ 8,000		
4.6	Pumping system maintenance	1	LS	$ 10,300	$ 10,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
	Confirmation Sampling					$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
	Site Closing					$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 3 yr**					**$ 38,000**	
	Well Abandonment and Site Restoration					$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 35,728,000		0	$ 35,728,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 3 years)	$ 77,000	5%	3	$ 210,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 3 Years)	$ 38,000	5%	3	$ 33,000
GRAND TOTAL				**$ 38,700,000**

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APPENDIX B

Alternative OnR-5E

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$26,114,000**	
1.0	**Indirect capital costs**					**$4,352,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 2,176,200	$ 2,176,200		10% of direct capital cost
1.2	Contingency	1	LS	$ 2,176,200	$ 2,176,200		10% of direct capital cost
2.0	**Direct capital costs**					**$21,762,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
Slurry-Wall (extended to 65' bgs)						$2,320,000	
2.7	Slurry Trench Excavate/Backfill Overburden	325,000	vsf	$ 6.00	$ 1,950,000		Based on contractor quote
2.8	Clay Top on slurry Wall	5,000	LF	$ 60.00	$ 300,000		Contractror quote
2.9	QC Testing / Slurry Wall Report / Submittals	1	LS	$ 70,000	$ 70,000		Contractor quote
Soil Excavation						$723,000	
2.10	Excavate Soil (Assume 24 Acres with 2' avg. deep)	77,440	CY	$ 4.50	$ 348,480		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Transport Soil to the consolidation area & compact	116,160	Ton	$ 2.75	$ 319,440		Assumed 1 CY is 1.5 ton, unit price was based on TRC's estimate
Surface Covers						$4,993,000	32-acre GCL+soil cover, 12-acre pond, 20.5-acre no cover, and 22-acre soil cover (2.5' thick)
2.12	Within Slurry Wall Area: Site Prep/Install GCL/Soil Cover	32	ACRE	$ 125,000	$ 3,997,004		Based on a similar site experience
2.13	Import Soil Cover (27-Acre with 2.5' avg thickness)	108,900	CY	$ 8	$ 871,200		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
In-Situ Biogeochemical Stabilization (ISBS)						$10,446,000	
2.21	ISBS Materials 5 acres, 65 ft	8,775,000	LBS	$ 0.80	$ 7,020,000		Quoted by Adventus Group, ~675,000 lbs material needed for one acre area (25' thickness)
2.26	Freight Costs	8,775,000	LBS	$ 0.10	$ 877,500		Quoted by Adventus Group, ~$ 0.1/lb freight cost for material
2.27	Tax	6.25%		$ 7,897,500	$ 493,594		Quoted by Adventus Group, 6.25% tax rate for Gainesville, FL
2.28	Injection Costs (821 ISBS auger points + Exploratory Borings)	411	Day	$ 5,000	$ 2,055,000		Assumes 2 Points/day
Detention Pond						$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
Storm Water Conveyance (Non-Site Water)						$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
ChemOX in Existing LHG Wells						$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
Monitoring Wells						$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
Construction Oversight, Survey, and Reporting						$1,170,000	
2.41	Oversight Labor	5.0%	LS	$ 20,592,000	$ 1,029,600		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
Surface Cover						$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
Monitoring						$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 3 yr**					**$77,000**	The existing treatment system will be phased out in three years
Surficial Aquifer Hydraulic Containment						$77,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	9,990	Kgal	$ 2	$ 19,980		Calculation based on 19 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	31,670	Kw-hr	$ 0.12	$ 3,800		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 8,000	$ 8,000		
4.6	Pumping system maintenance	1	LS	$ 10,300	$ 10,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
Confirmation Sampling						$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
Site Closing						$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 3 yr**					**$ 38,000**	
Well Abandonment and Site Restoration						$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 26,114,000		0	$ 26,114,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 3 years)	$ 77,000	5%	3	$ 210,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 3 Years)	$ 38,000	5%	3	$ 33,000
GRAND TOTAL				**$ 29,100,000**

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APPENDIX B

Alternative OnR-5F

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$71,810,000**	
1.0	**Indirect capital costs**					**$11,968,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 5,984,200	$ 5,984,200		10% of direct capital cost
1.2	Contingency	1	LS	$ 5,984,200	$ 5,984,200		10% of direct capital cost
2.0	**Direct capital costs**					**$59,842,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
	Slurry-Wall (extended to 65' bgs)					$2,320,000	
2.7	Slurry Trench Excavate/Backfill Overburden	325,000	vsf	$ 6.00	$ 1,950,000		Based on contractor quote
2.8	Clay Top on slurry Wall	5,000	LF	$ 60.00	$ 300,000		Contractror quote
2.9	QC Testing / Slurry Wall Report / Submittals	1	LS	$ 70,000	$ 70,000		Contractor quote
	Soil Excavation					$723,000	
2.10	Excavate Soil (Assume 24 Acres with 2' avg. deep)	77,440	CY	$ 4.50	$ 348,480		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Transport Soil to the consolidation area & compact	116,160	Ton	$ 2.75	$ 319,440		Assumed 1 CY is 1.5 ton, unit price was based on TRC's estimate
	Surface Covers					$4,993,000	32-acre GCL+soil cover, 12-acre pond, 20.5-acre no cover, and 22-acre soil cover (2.5' thick)
2.12	Within Slurry Wall Area: Site Prep/Install GCL/Soil Cover	32	ACRE	$ 125,000	$ 3,997,004		Based on a similar site experience
2.13	Import Soil Cover (27-Acre with 2.5' avg thickness)	108,900	CY	$ 8	$ 871,200		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
	In-Situ Solidification/Stabilization for Surficial Aquifer (~65', 5 acres)					$46,713,000	
2.15	ISSS Soil Mixing Only (construction, materials, and labor)	524,400	CY	$ 62	$ 32,512,800		Past experience
2.16	Cement (8%) and Freight Charge	63,000	Ton	$ 120	$ 7,560,000		Supplier estimate 8% by mass
2.17	Bentonite (3%)	23,600	Ton	$ 230	$ 5,428,000		Vendor quote: $572,200 for 2500 tons
2.18	Tax	1	LS	$ 811,750	$ 811,750		6.25%
2.19	Excess material from ISSS move to consolidation area	131,100	CY	$ 2.75	$ 360,525		25% soil volume
2.20	ISSS Bench Scale/Pilot Test	1	LS	$ 40,000	$ 40,000		
	Detention Pond					$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
	Storm Water Conveyance (Non-Site Water)					$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
	ChemOX in Existing LHG Wells					$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
	Monitoring Wells					$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
	Construction Oversight, Survey, and Reporting					$2,983,000	
2.41	Oversight Labor	5.0%	LS	$ 56,859,000	$ 2,842,950		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
	Surface Cover					$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
	Monitoring					$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 3 yr**					**$77,000**	The existing treatment system will be phased out in three years
	Surficial Aquifer Hydraulic Containment					$77,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	9,990	Kgal	$ 2	$ 19,980		Calculation based on 19 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	31,670	Kw-hr	$ 0.12	$ 3,800		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 8,000	$ 8,000		
4.6	Pumping system maintenance	1	LS	$ 10,300	$ 10,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
	Confirmation Sampling					$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
	Site Closing					$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 3 yr**					**$ 38,000**	
	Well Abandonment and Site Restoration					$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS				
Item	**Cost**	**Rate**	**Year(s)**	**Net Present Value**
Total Capital Cost	$ 71,810,000		0	$ 71,810,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 3 years)	$ 77,000	5%	3	$ 210,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 3 Years)	$ 38,000	5%	3	$ 33,000
GRAND TOTAL				**$ 74,800,000**

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APPENDIX B

Alternative OnR-5G

ITEM	DESCRIPTION	QTY	UNITS	UNIT RATE	ITEM COST	TOTAL	NOTES
CAPITAL COSTS						**$40,668,000**	
1.0	**Indirect capital costs**					**$6,778,000**	
1.1	Engineering design and Permit/Approval	1	LS	$ 3,389,000	$ 3,389,000		10% of direct capital cost
1.2	Contingency	1	LS	$ 3,389,000	$ 3,389,000		10% of direct capital cost
2.0	**Direct capital costs**					**$33,890,000**	
2.1	Mobilization/demobilization	1	LS	$ 290,000	$ 290,000	$290,000	
	Slurry-Wall (extended to 65' bgs)					$2,320,000	
2.7	Slurry Trench Excavate/Backfill Overburden	325,000	vsf	$ 6.00	$ 1,950,000		Based on contractor quote
2.8	Clay Top on slurry Wall	5,000	LF	$ 60.00	$ 300,000		Contractror quote
2.9	QC Testing / Slurry Wall Report / Submittals	1	LS	$ 70,000	$ 70,000		Contractor quote
	Soil Excavation					$723,000	
2.10	Excavate Soil (Assume 24 Acres with 2' avg. deep)	77,440	CY	$ 4.50	$ 348,480		Unit price was based on TRC's Estimate
	Confirmation Sampling	50	EA	$ 1,100	$ 55,000		In area receiving no cover
2.11	Transport Soil to the consolidation area & compact	116,160	Ton	$ 2.75	$ 319,440		Assumed 1 CY is 1.5 ton, unit price was based on TRC's estimate
	Surface Covers					$4,993,000	32-acre GCL+soil cover, 12-acre pond, 20.5-acre no cover, and 22-acre soil cover (2.5' thick)
2.12	Within Slurry Wall Area: Site Prep/Install GCL/Soil Cover	32	ACRE	$ 125,000	$ 3,997,004		Based on a similar site experience
2.13	Import Soil Cover (27-Acre with 2.5' avg thickness)	108,900	CY	$ 8	$ 871,200		RS Means
2.14	Seed grass for excavation areas and cover areas	83	ACRE	$ 1,500	$ 124,500		
	In-Situ Solidification/Stabilization for Surficial Aquifer (~25', 5 acres)					$18,006,000	
2.15	ISSS Soil Mixing Only (construction, materials, and labor)	201,700	CY	$ 62	$ 12,505,400		Past experience
2.16	Cement (8%) and Freight Charge	24,300	Ton	$ 120	$ 2,916,000		Supplier estimate 8% by mass
2.17	Bentonite (3%)	9,100	Ton	$ 230	$ 2,093,000		Vendor quote: $572,200 for 2500 tons
2.18	Tax	1	LS	$ 313,063	$ 313,063		6.25%
2.19	Excess material from ISSS move to consolidation area	50,425	CY	$ 2.75	$ 138,669		25% soil volume
2.20	ISSS Bench Scale/Pilot Test	1	LS	$ 40,000	$ 40,000		
	In-Situ Biogeochemical Stabilization (ISBS)					$3,991,000	
2.21	ISBS Materials 5 acres, 15 ft thickness within UHG	2,025,000	LBS	$ 0.80	$ 1,620,000		Quoted by Adventus Group, ~675,000 lbs material needed for one acre area (25' thickness)
2.26	Freight Costs	2,025,000	LS	$ 0.10	$ 202,500		Quoted by Adventus Group, ~$ 0.1/lb freight cost for material
2.27	Tax	6.25%		$ 1,822,500	$ 113,906		Quoted by Adventus Group, 6.25% tax rate for Gainesville, FL
2.28	Injection Costs (821 ISBS auger points + Exploratory Borings)	411	Day	$ 5,000	$ 2,055,000		Assumes 2 points/day
	Detention Pond					$850,000	
2.29	Pond Excavation & Transport to Consolidation Area	58,080	CY	$ 7.50	$ 435,600		12-Acre pond 3' deep
2.30	Inlet and Outlet Structures	6	PC	$ 3,000	$ 18,000		
2.31	Liner for Detention Pond	522,720	SQFT	$ 0.50	$ 261,360		12 acres, Aqwaseal
2.32	Side Grading	1	LS	$ 60,000	$ 60,000		
2.33	Lanscaping/Bank Vegetation	1	LS	$ 75,000	$ 75,000		
	Storm Water Conveyance (Non-Site Water)					$750,000	
2.34	48" RCP Culvert	4000	LF	$ 150	$ 600,000		
2.35	Installation	1	LS	$ 150,000	$ 150,000		
	ChemOX in Existing LHG Wells					$30,000	
2.36	Injection and all associated costs	3	PT	$ 10,000	$ 30,000		Engineer's estimate
	Monitoring Wells					$190,000	
2.37	Install 10 monitoring wells (2-inch) in Surficial Aquifer (25' deep)	10	EA	$ 4,200	$ 42,000		Drilling 8" HSA, 2" well, 10ft screen, 15ft blank, 12 ft sand, 2 ft bentonite, 11 ft grout.
2.38	Install 8 monitoring wells (2-inch) in UHG (65' deep), double casings	8	EA	$ 9,500	$ 76,000		8" borehole, 6" casing, 4" borehole, and 2" wells
2.39	Install 4 monitoring wells (2-inch) in LHG (120' deep), triple casings	4	EA	$ 18,000	$ 72,000		12.25" borehole, 10" casing, 8"borehole, 6" casing, 4" borehole, and 2" wells
	Construction Oversight, Survey, and Reporting					$1,747,000	
2.41	Oversight Labor	5.0%	LS	$ 32,143,000	$ 1,607,150		5% of direct capital cost
2.42	Survey	3	LS	$ 20,000	$ 60,000		Multiple survey runs will be required
2.43	Construction Completion Report	1	LS	$ 80,000	$ 80,000		
ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS							
3.0	**Annual OM&M Costs - 30 Yr**					**$165,000**	
	Surface Cover					$15,000	
3.1	Soil Cover Maintenance	1	LS	$ 15,000	$ 15,000		
	Monitoring					$150,000	
3.2	Annual Monitoring Costs	1	LS	$ 150,000	$ 150,000		Assumes new monitoring plan
4.0	**Temporary Annual OM&M Costs - 3 yr**					**$77,000**	The existing treatment system will be phased out in three years
	Surficial Aquifer Hydraulic Containment					$77,000	
4.1	Labor	200	hr	$ 60	$ 12,000		
4.2	POTW Discharge Fees	9,990	Kgal	$ 2	$ 19,980		Calculation based on 19 gpm
4.3	Chemicals	1	LS	$ 4,750	$ 4,750		
4.4	Energy	31,670	Kw-hr	$ 0.12	$ 3,800		Energy for well pumps and treatment system
4.5	Treatment system repairs & maintenance	1	EA	$ 8,000	$ 8,000		
4.6	Pumping system maintenance	1	LS	$ 10,300	$ 10,300		
4.7	Effluent monitoring & reporting	1	EA	$ 1,700	$ 1,700		
4.8	Lab costs	1	EA	$ 6,000	$ 6,000		
4.9	Carbon replacement	0.5	EA	$ 4,700	$ 2,350		
4.10	Waste management	20	CY	$ 400	$ 8,000		
FUTURE COSTS							
5.0	**Full Close Out in 30 yr**					**$ 560,000**	
	Confirmation Sampling					$150,000	
5.1	Confirmation Sampling (include labor, materials, & lab costs)	1	LS	$ 150,000	$ 150,000		
	Site Closing					$410,000	
5.2	Abandon Monitoring Wells (Existing and New-Installed)	11,250	FT	$ 26.91	$ 302,738		2" monitoring wells, RS Means
5.3	Equipment Removal and Site Restoration	1	LS	$ 100,000	$ 100,000		
5.4	Final Close Out Report	1	LS	$ 7,500	$ 7,500		
6.0	**Close Out of Temporary Facilities - 3 yr**					**$ 38,000**	
	Well Abandonment and Site Restoration					$38,000	
6.1	Abandon Existing Recovery Wells	350	FT	$ 85.42	$ 29,897		6" recovery wells, RS Means
6.2	Equipment Removal and Site Restoration	1	LS	$ 5,000	$ 5,000		
6.3	Environmental Report	1	LS	$ 3,000	$ 3,000		

PRESENT VALUE ANALYSIS

Item	Cost	Rate	Year(s)	Net Present Value
Total Capital Cost	$ 40,668,000		0	$ 40,668,000
Total Annual O&M Cost (for 30 years)	$ 165,000	5%	30	$ 2,536,000
Annual O&M Cost (existing system for 3 years)	$ 77,000	5%	3	$ 210,000
Future Costs (Last Year of 30 Years of Remediation)	$ 560,000	5%	30	$ 130,000
Future Costs (End of 3 Years)	$ 38,000	5%	3	$ 33,000
GRAND TOTAL				**$ 43,600,000**

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