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15 March 2006

Mr. Todd Gmitro
United States Environmental Protection Agency – Region V
Waste, Pesticides and Toxics Branch
Enforcement and Compliance Assurance Branch, DRE-9J
77 West Jackson Blvd
Chicago, IL 60604

Work Order Nos.: 00709.033.041
00709.033.043

Re: Remedial Measures Design Report – 30% Submittal
The Sherwin-Williams Company
Chicago, Illinois

Dear Mr. Gmitro:

Weston Solutions, Inc. (WESTON®) is pleased to present, on behalf of The Sherwin-Williams Company (Sherwin-Williams), three copies of the Remedial Measures Design Report – 30% Submittal, as required by the Consent Decree between Sherwin-Williams and the United States Environmental Protection Agency. One copy of the report has also been submitted to the Illinois Environmental Protection Agency as required by paragraph 84b of the Consent Decree.

The following aspects of the Remedial Measures Design Report either contain information that has been revised from the Remedial Measures Study (RMS) Report or new information.

- The extent of engineered barriers within Areas 1 and 2 West have been enlarged from the extents proposed in the RMS Report (WESTON, 2003). The engineered barrier extents were enlarged based on the results of the Predesign Investigation.

- The type of hydraulic containment barrier proposed in the remedial measure for Area 2 East has been specified to be hot-rolled interlocking steel sheet piling sealed with a water-swelling joint filler as opposed to a Waterloo Barrier®, which was proposed in the RMS Report (WESTON, 2003). Justification for this modification is included within Section 5 of the attached Remedial Measures Design Report.

- The engineered barrier proposed for containment of potential source material in Area 2 East has been modified from six inches of asphalt underlain by a High-Density Polyethylene (HDPE) membrane to a six-inch layer of Modified Asphalt Technology for Waste Control (MatCon™). MatCon is a proprietary modified asphalt concrete that has a hydraulic conductivity of less than 1.0 x 10^{-7} centimeters per second which is technically equivalent to the asphalt and HDPE membrane combination.

- The duration of the groundwater collection system proposed as part of the remedial measure for Area 2 East has been modified. In the RMS Report (WESTON, 2003), it was assumed that the dewatering system will be operated as necessary with an unknown duration following installation of the vertical and horizontal containment in Area 2 East, and the storage tanks were to remain at the site indefinitely. This has been modified with the assumption that the dewatering system will be used continuously to dewater the contained area after installation of the sheet piles and MatCon barrier, and the temporary storage tanks will then be removed. Justification for this modification is included within Section 5 of the attached Remedial Measures Design Report.

- One of the areas within Area 3 West where an engineered barrier was proposed in the RMS Report (WESTON, 2003) will now be excavated and consolidated on-site within the on-site 25-Acre Fill Area, under the engineered cap. The proposed excavation boundaries and confirmation sampling procedures are detailed Section 5 of the attached Remedial Measures Design Report.

- The *ex-situ* bioremediation of soils from Area 3 East will be conducted in the 25-Acre Fill Area, not within Area 3 East, as specified in the RMS Report (WESTON, 2003). In addition, the treated soil will be consolidated within the 25-Acre Fill Area under the engineered cap, and will not be re-placed in the open excavation, as specified previously. Clean soil from off-site will be used to backfill the excavation following confirmation sampling. In addition, the verification sampling criteria and treatment objectives have been modified. Detailed discussions of these modifications are included in Section 5 of the attached Remedial Measures Design Report.

- The proposed end-use of the 5-Acre Fill Area is a truck parking lot for the Chicago Emulsion Plant. The parking lot will include both asphalt and concrete pavement, will have a truck scale at a convenient location within the parking lot, and a building located within the 5-Acre Fill Area. Also, the results of the Predesign Investigation indicated that the fill material within the 5-Acre Fill Area will have significant settlement under the anticipated loading conditions and therefore will require deep dynamic compaction prior to construction at the site. The proposed layout of the remedial measures for the 5-Acre Fill Area is detailed in Section 5 of the attached Remedial Measures Design Report.

I certify that the information contained in or accompanying the above referenced documents is true, accurate, and complete. As to those portions of the above referenced documents for which I cannot personally verify their truth and accuracy, I certify as the Supervising Contractor having supervisory responsibility for the person(s) who, acting under my direct instructions, made the verification, that this information is true, accurate, and complete.

If you have any questions or comments regarding these documents, please feel free to contact Dr. Gordon Kuntz at (216) 566-2889 of myself at (847) 918-4045.

Very truly yours,

WESTON SOLUTIONS, INC.

Stephen R. Clough, P.G.
Project Director
Supervising Contractor

cc: Jonathan Adenuga (without enclosure)
James Moore, IEPA (1 copy)
John Gerulis, Sherwin-Williams (without enclosure)
Gordon Kuntz, Sherwin-Williams (2 copies)
Alan Danzig (without enclosure)

30% DESIGN REPORT
REMEDIAL MEASURE IMPLEMENTATION
CHICAGO, ILLINOIS

Prepared for

THE SHERWIN-WILLIAMS COMPANY
Cleveland, Ohio

Prepared by

WESTON SOLUTIONS, INC.
750 East Bunker Court, Suite 500
Vernon Hills, Illinois 60061

March 2006

Work Order Nos.: 00709.033.041
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30% DESIGN REPORT
REMEDIAL MEASURE IMPLEMENTATION
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March 2006

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APPENDIX

ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
%	Percent
μg/kg	microgram per kilogram
ASTM	American Society for Testing and Materials
Beacon	Beacon Environmental Services, Inc.
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
C	Carbon
CAMU	Corrective Actions Management Unit
CEP	Chicago Emulsion Plant
CFR	Code of Federal Regulations
CFU/g	Colony Forming Units per Gram
CL	low plasticity silty clay
cm/day	centimeters per day
cm/sec	centimeters per second
COPC	Contaminant of potential concern
COPEC	Contaminant of potential environmental concern
CQA	Construction Quality Assurance
CQAP	Construction Quality Assurance Plan
CSF	cancer slope factors
CTL	Corrosion Testing Laboratories, Inc.
DDC	Deep Dynamic Compaction
DTM	Digital Terrain Modeling
FI	Facility Investigation
FID	Flame Ionization Detector
FML	Flexible Membrane Liner
ft_2	square foot
feet per day	ft/day
ft/year	Feet per Year
GC/MS	Gas Chromatograph/Mass Spectrometer
GPS	Global Positioning System
g	gram
GPR	Ground Penetrating Radar
GRT	Global Remediation Technologies, Inc.
HASP	Health and Safety Plan
HDPE	High-Density Polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
HSA	Hollow-stem Auger
I-94	Interstate 94, the Bishop Ford Freeway
IAC	Illinois Administrative Code
IDOT	Illinois Department of Transportation

ACRONYMS AND ABBREVIATIONS

Illinois EPA	Illinois Environmental Protection Agency
in^3/ft	cubic inches per foot
IRIS	Integrated Risk Information System
IWBZ	intermediate water-bearing zone
lb/yd^3	pounds per cubic yard
LDPE	Low-density Polyethylene
LDR	Land Disposal Restrictions
LF	linear feet
LOAEL	lowest-observed-asverse-exposure-level
MatCon™	Modified Asphalt Technology for Waste Control
MCS	Media Cleanup Standards
meq	Milliequivelent
ML	low plasticity clayey silt
MTR	Minimum Technology Requirements
N	Nitrogen
ng	Nanogram
$ng/m^2/min$	Nanograms per Square Meter per Minute
NPDES	National Pollutant Discharge Elimination System
N_{reqd}	standard penetration resistance value
P	Phospahte
PAH	Polyaromatic Hydrocarbons
PCB	Poly-chlorinated Biphenyl
pcf	pounds per cubic foot
PI	plasticity index
PID	Photoionization Detector
PNA	polynuclear aromatic hydrocarbon
PPE	Personal Protective Equipment
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RMI	Remedial Measures Implementation
RMS	Remedial Messages Study
S_{act}	actual section modulus
SC	clayey sand
SCS	Soil Conservation Services
Sherwin-Williams	The Sherwin-Williams company
SITE	Superfund Innovative Technology Evaluation
SLERA	Screening-level Environmental Risk Assessment
SM	silty sand
SMP	Soil Management Plan
S_{reqd}	minimum requires section modulus
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristic Leaching Procedure

ACRONYMS AND ABBREVIATIONS

USCS	Unified Soil Classification System
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WESTON	Weston Solutions, Inc.

SECTION 1
INTRODUCTION

This Preliminary (30%) Design Report has been prepared by The Sherwin-Williams Company (Sherwin-Williams) in accordance with the requirements specified in Attachment 3 of the Consent Decree. Weston Solutions, Inc. (WESTON®) was retained to complete the Remedial Measures Design required in the Consent Decree. This submittal, consisting of the 30% Design Report and the accompanying design drawings, presents the design of remedial measures that will be implemented at the Sherwin-Williams Facility, located in Chicago, Illinois. Pursuant to the Consent Decree, Sherwin-Williams has also been performing closure activities at 26 former hazardous waste management units (10 container storage areas, 15 tanks, and one waste pile) under the oversight of the Illinois Environmental Protection Agency (IEPA) in accordance with 35 Illinois Administrative Code (IAC) Part 725. IEPA has determined that Resource Conservation and Recovery Act (RCRA) closure activities have been completed at 14 of the tanks (IEPA letter dated 23 June, 2000). Sherwin-Williams has requested, and the IEPA has approved, to incorporate the closure of the remaining units into the Remedial Measures. The closure of the following hazardous waste management units (10 container storage areas, one tank, and one waste pile) are incorporated into the Remedial Measures:

- Suspected Chromium Soil Pile
- Aboveground Caustic Dip Tank Inside Building 440
- Hazardous Waste Container Storage Area – Yard P Pumping Pad
- Former Container Storage Areas Inside Building 28 (5 individual units)
- Former Container Storage Area Outside Building 28
- Paint Plant and A.W. Stuedel Center Container Storage Areas
- Container Storage Area at the Resin Plant
- Paint Overstock Container Storage Area

1.1 <u>PURPOSE</u>

The purpose of the 30% Design Report is to outline important design components, determine the criteria on which the design will be based, and identify potential problems which could influence the final design.

1.2 REPORT ORGANIZATION

The 30% Design Report includes the following sections:

- Introduction – The purpose of the 30% Design Report and how this report is organized.
- Site Background – The location, operational history, and a summary of the previous work performed at the Sherwin-Williams site.
- Site-Specific Information – Specific information regarding the site setting, geology, hydrogeology, groundwater flow properties, hydraulic conductivity, and the Sherwin-Williams site's Media Cleanup Standards (MCS).
- Predesign Investigation Results – Results of the predesign investigation conducted in 2005.
- Remedial Measures Design – Preliminary design for each of the remedial measures, including the design criteria and basis of design.
- Groundwater Monitoring Plan – The Groundwater Monitoring Plan, which describes the short- and long-term monitoring that will be implemented as part of the remedial measures at the facility.
- Specifications – The specifications that support the design and construction of the remedial measures.
- Institutional Controls – Deed restrictions that will be utilized as institutional controls, and will be established as part of the remedial measures.
- Permits – Information about the permits required for the Remedial Measures Implementation.
- Project Schedule – A comprehensive project schedule, which details the critical steps in the Remedial Measures Implementation.
- Cost Estimate – A detailed cost estimate for the implementation of the remedial measures.
- Supporting Plans – The supporting plans that will be required for the Remedial Measures Implementation, including Pre- and Post-Construction Plans. Pre-Construction plans include the following: Construction Work Plan and Health and Safety Plan (HASP). Post-Construction Plans include the following: Remedial Measures Implementation Report, Operation and Maintenance Plan, Soil Management Plan, and Contingency Plan.
- References – References used during the preparation of this report.

SECTION 2
SITE BACKGROUND

2.1 SITE LOCATION

The Sherwin-Williams facility is located in Chicago, Illinois. The facility comprises approximately 81 acres and is bounded on the north by 115th Street, on the south by 119th Street, on the west by Cottage Grove Avenue, and on the east by Doty Avenue (also called Frontage Road). The Calumet Expressway (Interstate 94), also called the Bishop Ford Freeway (I-94), runs parallel to Doty Avenue along the east side of the property. Entry to the facility is south on Champlain Avenue off of 115th Street. Figure 2-1, the Site Location Map, shows the location of the Sherwin-Williams Chicago facility. Figure 2-2, the Detailed Site Map, details the important features of the site.

2.2 SITE HISTORY

Sherwin-Williams has maintained operations at the subject property since the late 1800s. The exact dates of initial ownership and affected parcels are not known. However, Sherwin-Williams has not owned the entire site since the late 1800s. As Sanborn maps, site diagrams, and aerial photographs indicate, the Sherwin-Williams Chicago facility grew by acquiring adjacent property parcels and expanding operations. Additionally, the Lake Calumet shoreline once extended west of its current configuration by at least 1,000 feet.

The Sherwin-Williams Chicago facility currently contains two active operations. The Chicago Emulsions Plant (CEP) manufactures water-based latex coatings, and the Steudel Center is a coatings research and development facility. The former Paint Plant (deactivated in May 1997) produced organic solvent-based paints and special-purpose coatings. The former Resin Plant operations (deactivated in 1992) manufactured resins to be used as raw materials in the paint manufacturing process.

The CEP plant manufactures water-based latex paints and has been in operation since 1979. The Steudel Center is a research and development laboratory, which conducts development work on organic solvent-based paints and resins. Four general categories of organic, solvent-based coatings were historically produced at the former Paint Plant. These include reactive coatings, general metal market paints, water-reducible paints, and wood product coatings. Principal raw materials in each of these coatings categories include resin, pigments, solvents, and additives. Resins used in the paint manufacturing process that were made at the former Resin Plant were of two major types, alkyd and acrylic resin.

2.3 SUMMARY OF PREVIOUS WORK

2.3.1 Facility Investigation

Between 1998 and 2001, WESTON, on behalf of Sherwin-Williams, performed Phases I, II, and III of the Facility Investigation (FI).

Phase I

The Phase I Investigation was performed at the Sherwin-Williams Chicago site, beginning in November of 1998. The purpose of the investigation was to determine if any environmental impacts had occurred during historical operations at the site.

WESTON completed a geophysical (EM-1) survey was completed within both the 5-Acre Fill Area and 25-Acre Fill Area. Additionally, WESTON completed a ground penetrating radar (GPR) survey was completed within the 25-Acre Fill Area.

Following completion of the geophysical survey, soil borings were advanced in the 5-Acre and 25-Acre Fill Areas to investigate subsurface magnetic anomalies detected during the geophysical survey. Four soil borings were advanced in the 5-Acre Fill Area, with one sample collected from each location; and 12 soil borings were advanced in the 25-Acre Fill, with 21 samples collected. Samples were analyzed for Target Appendix IX constituents, specifically VOCs, SVOCs, organochlorine pesticides, organophosphorous pesticides, PCBs, and inorganics, as well as corrosivity, ignitablility and reactivity. In addition, groundwater samples were collected from two temporary monitoring well locations in the 5-Acre Fill Area and from three temporary monitoring well locations in the 25-Acre Fill Area. Groundwater samples were analyzed for Target Appendix IX constituents, including volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), organochlorine pesticides, organophosphorus pesticides, polychlorinated biphenyls (PCB), dioxins, furans and total and soluble metals.

Soil samples were collected from three perimeter borings and analyzed for geotechnical parameters, including moisture content, specific gravity, porosity, hydraulic conductivity, dry density, and cation exchange capacity. Upon completion of drilling, nested monitoring wells were also installed at each of the perimeter boring locations. Two monitoring wells screened in the intermediate and deep aquifers were installed at Monitoring Well (MW) 001 and three monitoring wells, screened within the shallow, intermediate, and deep aquifers, respectively, were installed at MW002 and MW003. Following development, rising and falling head slug tests were completed at each monitoring well. One groundwater sample was collected from each monitoring well, and the samples were analyzed for Target Appendix IX constituents.

The Phase I Investigation also included advancing 35 soil borings throughout Areas 1, 2, 3, and 4. A total of 74 soil samples were collected. Soil samples were analyzed for Target Appendix IX VOCs, SVOCs, organochlorine pesticides, organophosphorous pesticides, PCBs, and inorganics. Soil samples from Yard M were also analyzed for Target Appendix IX dioxins/furans.

Phase II

In 2000, WESTON conducted a Phase II Investigation at the Sherwin-Williams Chicago facility to collect information to fill in data gaps from the previous investigation.

Activities conducted during the Phase II Investigation included advancing 13 soil borings along the north and west perimeters of the site to determine background levels and aid in the development of groundwater screening levels. Soil samples were collected and analyzed for Target Appendix IX VOCs, SVOCs and metals. Three groundwater samples were collected from three off-site temporary monitoring wells to determine background levels and groundwater screening levels. Groundwater samples were analyzed for Target Appendix IX VOCs, SVOCs and metals.

Sixteen additional soil borings were advanced within Areas 2 and 3. The soil samples were analyzed for Target Appendix IX constituents, specifically VOCs, SVOCs and inorganics.

Seven permanent monitoring wells were installed during the Phase II investigation. Six of the wells were screened within the shallow water-bearing zone and one well was screened within the intermediate water-bearing zone. Following development of the monitoring wells, rising and falling head slug tests were performed to determine the hydraulic conductivity of the geologic formations.

Groundwater samples were collected from two temporary monitoring wells in the 5-Acre Fill area and all permanent shallow monitoring wells. Groundwater samples were analyzed for Target Appendix IX SVOCs and inorganics.

Phase III

In 2001, WESTON conducted a Phase III Investigation at the Sherwin-Williams Chicago facility to fill in data gaps from previous investigations.

Activities conducted during the Phase III investigation included the installation and development of four permanent shallow monitoring wells. Following development, rising and falling head slug tests were performed on the four newest wells. Groundwater samples were then collected from all shallow monitoring wells at the facility and analyzed for Target Appendix IX VOCs, SVOCs, pesticides and metals. One round of water levels was collected from all existing permanent monitoring wells.

Nine soil samples were collected from three soil boring locations in Area 2. Ten soil samples were collected from eight soil boring locations in Area 3. All soil samples collected from Area 2 and four soil samples collected from Area 3 were analyzed for Target Appendix IX SVOCs and metals. Five soil samples from Area 3 were analyzed for Target Appendix IX metals and hexavalent chromium. One soil sample from Area 3 was analyzed for Target Appendix IX SVOCs.

2.3.2 Human Health and Screening-Level Ecological Risk Assessments

For the FI, the property was split into investigational units based on historical activities conducted within certain sub-areas at the facility (Area 1, Area 2, Area 3, Area 4, 5-Acre Fill, and 25-Acre Fill). These investigational areas were used as exposure units within the risk assessment to determine exposure point concentrations. Area 3, however, was further subdivided in two exposure areas – Areas 3A and 3B. The chemicals present and their respective concentrations vary by investigational area. The risk assessment evaluated each area separately not only to follow methods used in the FI Report but also to aid in determining which area(s) of the site should be considered for remediation. In addition, the areas are physically separated by buildings or roadways that limit movement among areas.

Media investigated during the FI at the Sherwin-Williams site included soil and groundwater. The 5-Acre Fill and 25-Acre Fill Areas were targeted for a landfill presumptive remedy since these areas are currently capped landfills and only subsurface fill material is present. Both areas are currently covered with a soil cap and vegetation. Subsurface fill material and native soil samples were collected to characterize the source material and potential extent of vertical migration within the 5-Acre Fill Area and 25-Acre Fill Area. Surface and subsurface soil samples were collected from Areas 1, 2, 3, and 4. Each sample was analyzed for VOCs, SVOCs, organochlorine pesticides, PCBs, organophosphorous pesticides, and inorganics. Additionally, samples collected from Yard M, the 5-Acre Fill Area, and the 25-Acre Fill Area were analyzed for dioxins/furans. Contaminants of potential concern (COPC) identified for the Human Health risk Assessment (HHRA) included both organic and inorganic compounds detected at levels above risk-based screening levels and/or background. In order to provide a more conservative screening and to account for similar cancer and non-cancer endpoints, a risk level of 1E-07 and a Hazard Quotient (HQ) of 0.1 were used in the screening.

Based on current site conditions and site ownership, the HHRA evaluated commercial/industrial users and trespassers/site visitors as current/future receptor groups at this site. Future residential use of the site was not evaluated because the property is zoned industrial and is not intended for residential redevelopment. Workers employed in current and future construction or utility repair may also be exposed to subsurface soil. Therefore, the human health risk to commercial/industrial users, construction workers, and trespassers/site visitors from exposure to COPCs in soil was quantitatively evaluated for Areas 1, 2, 3A, 3B, and 4.

The HHRA quantitatively evaluated the risk to construction workers for the 5-Acre Fill and 25-Acre Fill areas. Both areas are currently covered with a soil cap and vegetated, though the cap is not a RCRA (Subtitle C) cap. Current receptor groups are not exposed to source material. In addition, both the areas were targeted for the landfill presumptive remedy. Therefore, future exposure of commercial/industrial users and trespassers/site visitors in the 5-Acre Fill and 25-Acre Fill areas was assumed to be an incomplete exposure pathway at the time the HHRA was completed. As part of the risk assessment, future exposure to commercial/industrial users was considered a potential pathway at the 5-Acre Fill area based on potential redevelopment plans. In addition, as discussed in Section 3, a recreational end use for the 25-Acre Fill area is considered a viable option, and thus MCSs for children have been developed.

While chemical constituents have been detected in groundwater, this exposure pathway is incomplete since the City of Chicago has an ordinance prohibiting installation and use of private wells for drinking water purposes.

Applicable human toxicity values from United States Environmental Protection Agency (U.S. EPA) sources (primarily Integrated Risk Information System [IRIS]) were identified for each COPC for the relevant exposure routes. These toxicity values include reference doses (RfDs) for evaluating potential noncarcinogenic health effects and cancer slope factors (CSFs) for evaluating carcinogenic risks. In a risk characterization, the results of the exposure assessment and the toxicity assessment are integrated to quantitatively evaluate the potential current and future risk to human health. Carcinogenic risks and noncarcinogenic hazard quotients were estimated for each COPC through each exposure route of concern and for all COPCs through all exposure routes combined. In general, carcinogenic polyaromatic hydrocarbons (PAHs) and arsenic pose the greatest risk to on-site workers and trespassers/site visitors via ingestion and inhalation; however, other VOCs, SVOCs, and inorganics were identified at elevated concentrations in isolated locations. No individual cancer risks for the current/future construction worker greater than 1E-06 or noncancer HQs greater than one were estimated for the 25-Acre Fill Area.

A screening-level environmental risk assessment (SLERA) was conducted at this site to quantitatively evaluate which chemical constituents pose a potential to adversely impact ecological receptors inhabiting the site. An insectivorous bird (robin), an insectivorous mammal (shrew), and an herbivorous mammal (vole), which represent several trophic levels, were selected as target receptors. Direct ingestion of contaminants of potential ecological concern (COPECs) in soil and indirect ingestion through the food chain (i.e., ingestion of plants and earthworms) were considered in this assessment. The conservative SLERA found that there is a potential for adverse effects on higher-level organisms from site-related chemicals (including several VOCs, phthalate esters, PAHs, and heavy metals) in on-site surface soil.

A refinement of the preliminary COPEC was performed and included a recalculation of HQs using an average exposure point concentration and an evaluation to determine background levels and aid in the development of groundwater screening levels (LOAEL)-based TRVs. Refinement of the preliminary COPECs found that there continues to be a potential for adverse effects from PAHs and metals. While 2,6-dinitrotoluene, acetone, benzene, toluene, xylene, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate had recalculated HQs greater than unity after refinement of COPEC, there is considerable uncertainty associated with the plant and earthworm uptake factors applied for these constituents. Biomagnification of these chemicals is not expected because these chemicals are readily metabolized. In addition, 2,6-dinitrotoluene was only detected in one sample. Affects on ecological receptors were not evaluated in the 5-Acre Fill Area and the 25-Acre Fill Area since fill material is present in these areas at depths ecological receptors would not typically reach. In addition, both these landfilled areas were assumed to employ the landfill presumptive remedy as the remedial measure thereby eliminating potential risks to ecological receptors.

While the chemical constituents in soil pose a potential for adverse impacts to ecological receptors, land use at the Areas 1, 2, 3A, 3B, and 4 is industrial and is located in a highly industrialized area. The habitat provided by Areas 1, 2, 3A, 3B, and 4 is limited to mowed lawn and scattered pockets of old field grasses and shrubs of low quality. Since these areas provide little habitat and are anticipated to remain industrial, implementation of remedial measures to protect human health is anticipated to be adequate to manage potential ecological risks.

2.3.3 Remedial Measures Study

WESTON, on behalf of Sherwin-Williams, performed a RMS for the purposes of developing and evaluating remedial measure alternatives and to recommend the remedial measures that should be implemented at the facility. The first step in the RMS process was to prepare a RMS Work Plan (WESTON, 2003b), which documented the overall management strategy for the RMS and included the following: a discussion of the technical approach for the RMS, the personnel performing the RMS, the qualifications of personnel, and a schedule for completing the RMS-related activities. In addition, the RMS Work Plan summarized the development of the soil and groundwater MCSs. The RMS Work Plan also included a scope-of-work for additional data collection activities that were necessary to resolve the data gaps remaining after completion of the FI.

Following completion and approval of the RMS Work Plan, WESTON prepared the RMS Report (WESTON, 2003a). The RMS Report included the following: a description of the current conditions of the site, the MCS for soil and groundwater, a screening of remedial measure technologies and assembly of remedial measure alternatives, a detailed description of the identified remedial measure alternatives, a detailed evaluation and comparison of remedial measure alternatives, and a recommendation of the remedial measure alternatives that should be implemented at the site. The RMS evaluated the remedial measure alternatives based on the four general standards specified in the RCRA Corrective Action Plan Guidance (May 1994): protection of human health and the environment, attainment of MCSs, control of the source of releases, and compliance with applicable standards for the management of wastes. U.S. EPA approved the remedial measures recommended in the RMS Report, which are detailed below in subsection 2.3.3.2.

2.3.3.1 Remedial Measures Objectives

The remedial measures objectives for the Sherwin-Williams Chicago Facility are based on information gathered during the FI and developed in the HHRA, SLERA, and RMS. The remedial measures objectives are as follows:

- Attain MCSs – This involves establishing MCSs for soil and groundwater. Tables 2-1 and 2-2 present the MCSs for commercial/industrial and recreational/commercial/industrial land use, respectively.

- Control sources of releases – This addresses how the remedial measures reduce or eliminate, to the maximum extent possible, further releases.

- Comply with applicable standards for the management of waste – This requires that the remedial measures assure that wastes generated during the implementation of the remedial measures are managed in a protective manner and in accordance with applicable regulations.

2.3.3.2 U.S. EPA Proposed Remedy

The selected remedial measures, as detailed in the Final Decision/Response to Comments Document (U.S. EPA, 2005a) for each of the areas are detailed below:

- Areas 1, 2 West, 3 West, and 4 Remedial Measures:
  - Soil – Institutional controls and an engineered barrier
  - Groundwater – Short-term groundwater monitoring (5 years) and development of a contingency plan

- Area 2 East Remedial Measures:
  - Soil – Institutional controls and an engineered barrier
  - Groundwater – Hydraulic containment barrier, groundwater collection system, long-term groundwater monitoring (30 years), and development of a contingency plan

- Area 3 East Remedial Measures:
  - Soil – Institutional controls, excavation, *ex-situ* biological treatment, backfilling of treated soil, and an engineered barrier
  - Groundwater – Short-term groundwater monitoring (5 years) and development of a contingency plan

- 5-Acre Fill Area Remedial Measures:
  - Soil – Institutional controls and an engineered barrier

- Groundwater – Short-term groundwater monitoring (5 years) and development of a contingency plan

- 25-Acre Fill Area Remedial Measures:
  - Soil – Institutional controls, vehicular restrictions, and an engineered, multi-layered cap
  - Groundwater – Long-term groundwater monitoring (30 years) and development of a contingency plan

Institutional controls will consist of a deed restriction that limits the future uses of the property to industrial or recreational (25-Acre Fill Area only) use, and requires all future excavations to be conducted in accordance with a Soil Management Plan (SMP). The SMP will be developed following implementation of the remedial measures, and will ensure that future workers are protected and excavated soils are handled, classified, transported, and disposed of properly. The deed restriction will also prevent all future excavation within the 25-Acre Fill Area, and will require the use of vapor barriers beneath floor slabs or subsurface walls in areas within Area 3 East where VOCs are present above an inhalation risk.

The engineered barrier for Areas 1, 2 West, 3 West, and 4 will consist of either asphalt, concrete, soil, or buildings. The engineered barrier in Area 2 East will consist of an HDPE membrane beneath six inches of asphalt. The engineered barrier in Area 3 East will consist of either asphalt, concrete, or buildings, and will not include any soil engineered barriers. The engineered barrier in the 5-Acre Fill Area will consist of six inches of asphalt, underlain with a 12-inch sub-grade layer. The engineered, multi-layer cap in the 25-Acre Fill Area will consist of (from top to bottom): a top vegetative layer, a protective layer, a drainage layer, a low-permeability membrane, and a grading layer.

The soil in Area 3 East will be treated using *ex-situ* biological treatment, which is a controlled biological process by which organic constituents are converted by microorganisms into innocuous, stabilized byproducts. The *ex-situ* biological treatment will consist of excavation, removing large debris, forming soil into windrows, mechanical turning of the windrows, addition of soil amendments, off-gas treatment (if necessary), and verification sampling.

The contingency plans that will be developed as part of all of the areas' remedial measures will document the procedures that will be followed in the event that monitoring results from the short- or long-term monitoring indicate any of the following:

- The natural attenuation process is ineffective
- The hydraulic containment wall is ineffective (Area 2 East only)
- Groundwater is migrating in an unexpected direction

A hydraulic containment barrier will be installed around the perimeter of Area 2 East to prevent migration of groundwater constituents. A groundwater collection system will be installed within the hydraulic containment barrier in order to maintain an inward gradient and ensure that migration of the constituents via groundwater has been mitigated. This collection system used to withdraw the groundwater will be utilized to first create an inward gradient, and second, manage any water that infiltrates through the cap.

The groundwater monitoring program, either short- or long-term, will consist of utilizing existing and additional wells at the site to monitor the progress of the natural attenuation process. Short-term monitoring will consist of a minimum of five years of monitoring and long-term monitoring will consist of 30 years of monitoring. The groundwater monitoring programs will be utilized to evaluate if any contingency remedial measures are required in any of the areas.

SECTION 3
SITE-SPECIFIC INFORMATION

3.1 GENERAL SITE SETTING

The Sherwin-Williams facility is located in the southern portion of Cook County. In this area, winters are cold and snowy with average temperatures of 25 degrees Fahrenheit (º F), and summers are warm with average temperatures of 71º F. From late fall through winter, snow squalls are frequent, and total snowfall is normally heavy. Average seasonal snowfall is 39 inches. Total annual precipitation averages 33 inches with 67% of precipitation typically occurring from April through September. Thunderstorms occur on about 37 days of the year, and most occur in summer (Mapes, 1976).

3.2 GEOLOGY

This section describes the geologic setting in the vicinity of the Sherwin-Williams facility. Geologic conditions at the site have been characterized through the compilation of data from the FI, historical geotechnical borings, and from information contained in published reports.

3.2.1 Description of Fill Material

Prior to construction of I-94 and expansion of industrial operations in the area, Lake Calumet was much larger in areal extent. Historical aerial photos and evidence from boring logs indicate that Lake Calumet once extended approximately to the center of the Sherwin-Williams facility. Due to historical backfilling of the area, the western portion of the lake no longer exists. Lake Calumet is now located entirely east of I-94. The location of the former shoreline was identified through a review of all soil borings associated within this area, and historical Sanborn fire insurance maps from 1897 and 1911 (Figures 2-4 and 2-5 of the Description of Current Conditions Report, WESTON, 1998).

The geology of the Sherwin-Williams facility was characterized through the review of numerous historical geotechnical borings (presented in the Description of Current Conditions Report, WESTON, 1998) and the completion of soil borings (some over 91 feet in depth) during the RCRA closure and FI activities. Based on the observations made during these activities, the entire site appears to be underlain by fill material. The average fill thickness ranges from approximately 5 to 10 feet. However, thicknesses ranging up to approximately 26 feet were noted during the drilling of soil boring CHSPL-SB048 in the south parking lot area. The fill material consists predominantly of silty clay fill with sandy fill located east of Champlain Avenue within the former lake bed of Lake Calumet; however, numerous references to cinders, ash, stone, tile, glass, metal fragments, masonry fill, bricks, slag, and foundry sand were also noted on historical geotechnical boring logs.

3.2.2 Description of Glacial Till

Silty clay/clayey silt was encountered underlying the fill at nearly all locations. The silty clay/clayey silt commonly contained pebbles and interbedded lenses of silt or sand and gravel (generally less than five feet thick). The silty clay/clayey silt unit ranged in thickness from 44 feet to 67.5 feet in the deep borings at the facility. Bedrock was encountered underlying the silty clay/clayey silt unit. A more permeable layer of sand and/or silt with weathered bedrock was also encountered directly above the bedrock in all of the deep borings.

Geotechnical analysis of samples from the silty clay/clayey silt unit indicates that soil in this glacial unit exhibits similar characteristics at all three deep boring locations. The results of the geotechnical analyses from the silty clay/clayey silt unit are summarized as follows:

- Classification of the samples ranged from silty clay with trace sand and gravel to silt with clay and some fine gravel and fine-to-coarse sand.
- Moisture content in the samples ranged from 12.5 to 13.17% (average – 12.81).
- Specific gravity ranged from 2.70 to 2.72 (average – 2.71).
- Porosity ranged from 0.26 to 0.33 (average – 0.29).
- Vertical hydraulic conductivity ranged from 7.7×10^{-9} to 3.9×10^{-8} centimeters per second (cm/sec) (average – 1.9×10^{-8} cm/sec).
- Dry density ranged from 113.6 to 122 pounds per cubic foot (pcf) (average – 120.3 pcf).

- Cation exchange capacity ranged from 5.5 to 7.1 milliequivalents (meq)/100 grams (g) (average – 6.2 meq/100g).

Hydraulic conductivity in the upper portion of the glacial till is sufficiently low that vertical groundwater flow is expected to be minimal. Due to its thickness and low hydraulic conductivity, the silty clay/clayey silt unit acts as a confining layer across the entire facility.

3.2.3 Description of Bedrock

In the Chicago area, approximately 5,000 feet of consolidated sedimentary bedrock formations of Paleozoic age underlie the glacial deposits. The bedrock formations are exposed at the surface only in the southwestern portion of the Chicago area where bedrock highs are present, where modern streams have eroded the glacial deposits, or where overburden has been removed for quarries and mines. The uppermost bedrock formation in much of the Chicago area is Silurian dolomite of the Joliet formation. The Joliet formation is discontinuous on a regional scale due to erosion prior to the Wisconsinan glaciation, which occurred at several locations in the western portion of the Chicago area. During the FI, the Joliet formation was encountered at all of the monitoring well nest locations and, therefore, appears to be continuous across the Sherwin-Williams facility.

Along the eastern edge of the facility, bedrock was encountered at 62 feet and 61 feet below ground surface (bgs) at wells MW002B and MW003B, respectively. At well MW001B, located at the western edge of the property, bedrock was encountered at 72.5 feet bgs. Although not a bedrock well, centrally located well MW008I encountered refusal (interpreted as bedrock) at 61 feet bgs. Based on ground surface elevations at the monitoring wells and the above depths to bedrock, the bedrock surface appears to be irregular across the site. The highest bedrock elevation was encountered at MW008I, which was almost 10 feet higher than at MW001B and about 4 feet higher than at MW002B and MW003B.

In general, rock cores from wells MW001B and MW002B were characterized as thinly laminated dolomite with interbedded lenses of shale and occasional fractures with some solution cavities. The rock core sample collected from well MW003B was composed completely of thinly laminated dolomite. Shale lenses, fractures, and solution cavities were not observed in this sample.

3.3 HYDROGEOLOGY

This section describes the regional and local hydrogeologic setting in the vicinity of the Sherwin-Williams facility. Based on the hydrogeologic characteristics of the geologic units underlying the facility, subsurface soils and rock formations are then divided into hydrostratigraphic units. A hydrostratigraphic unit is one or more water-bearing geologic units grouped together based on similarities in hydraulic conductivity and other groundwater flow characteristics. For example, several geologic units may comprise one hydrostratigraphic unit if groundwater behaves similarly throughout the units. Hydrogeologic conditions at the site have been characterized through the compilation of data from the FI and from information contained in published reports.

3.3.1 Groundwater Occurrence

In northeastern Illinois, groundwater has been historically obtained from three major sources: glacial drift aquifers, shallow bedrock (limestone/dolomite) aquifers, and deep bedrock (sandstone) aquifers. The Ordovician-age St. Peter Sandstone and the Cambrian-age Mt. Simon sandstone have historically been major sources of potable groundwater in the Chicago area. Sherwin-Williams historically operated three on-site production wells, which were constructed at depths of 420; 1,634; and 1,648 feet bgs. The shallow well was constructed in Silurian dolomite while the deeper wells were constructed in Cambrian sandstone. Groundwater withdrawal within the Lake Calumet area decreased during the 1980s, and many of the production wells completed within the Silurian dolomite aquifer have been abandoned or taken out of service. Currently, the water supply source for all of the City of Chicago and much of the Chicago area is Lake Michigan.

During the Phase I FI activities, a hydrogeologic investigation consisting of the installation of three monitoring well nests was conducted. Shallow, intermediate, and bedrock wells were installed (where water-bearing units were identified) to investigate the characteristics of the hydrostratigraphic units underlying the facility. During the Phase II FI activities, four shallow wells and one intermediate well were installed (MW004S through MW008S and MW008I). During the Phase III FI activities, four additional shallow wells were installed (MW009S through MW012S).

Perched water within the shallow zone was continuous within the 25-Acre fill area; however, it was discontinuous or absent throughout the majority of the eastern portion of the site. Based on these findings, saturated conditions in the shallow zone are discontinuous across the facility with the exception of the 25-Acre fill area. Saturated soil conditions were not encountered during the RCRA closure activities (completed during the summer of 1998) except at the Paint Overstock/Resin Plant container storage areas. Temporary monitoring wells were installed during the FI at select locations where saturated conditions were encountered in the investigative borings.

During Phase I of the FI hydrogeologic investigation, shallow, intermediate, and bedrock water-bearing zones were encountered at each of the three well nest areas with the exception of area MW001, where perched water was not encountered in the shallow water-bearing zone. To investigate the characteristics of these hydrostratigraphic units, two wells were installed at well cluster MW001 (MW001I and MW001B), and three wells were installed at well clusters MW002 and MW003 (MW002S, I, B; and MW003S, I, B).

Based on U.S. EPA comments and recommendations presented in the Phase I FI Report, six shallow monitoring wells were installed during the Phase II activities. During the Phase II activities, a shallow water-bearing zone was encountered in the area of well nest MW001, and well MW001S was installed. Perched water was also encountered in the shallow water-bearing zone at locations MW004 through MW007, and wells MW004S through MW007S were installed during Phase II of the FI. Both shallow and intermediate water-bearing zones were encountered in the area of well nest MW008, and wells MW008S and MW008I were installed during Phase II of the FI.

In Phase III of the FI, four additional shallow monitoring wells were installed. A shallow water-bearing zone was encountered in all four of the monitoring wells (MW009S through MW012S).

These four wells were installed to further investigate the extent of elevated constituents and hydrostratigraphic characteristics of the shallow water-bearing unit.

3.3.2 Perched Shallow Water-Bearing Zone

The shallow hydrostratigraphic unit was encountered across most of the entire facility and typically occurred within the fill material. However, in three borings in the Building 440 and Yard P areas (temporary wells CH440-TW035, CH440-TW036, and CHYPP-TW041), the shallow zone consisted of a variety of geologic units, which included fill material, thin seams of sand and gravel, and thin seams of silt and clay. Collectively, these units are interpreted as one hydrostratigraphic unit.

Perched water is discontinuous within the shallow hydrostratigraphic unit. The fill material is generally more granular and more capable of storing water than the underlying glacial deposits. Therefore, water has a tendency to remain at the bottom of the fill material perched on the fine-grained (clay and silt) glacial deposits. The discontinuous nature of perched water is attributed to the absence of widespread coarse-grained fill material underlying the facility. As such, perched water is retained within localized pockets minimizing horizontal flow. Silty clay/clayey silt thicker than 30 feet separates the perched shallow water-bearing zone from the intermediate water-bearing zone.

Due to the shallow nature of perched groundwater at the site, water is expected to seep into Doty Avenue ditch located east of the facility. However, due to the shallow nature of the ditch, groundwater is expected to continue flowing down gradient of the ditch.

3.3.3 Intermediate Water-Bearing Zone

Water-bearing zones were encountered at separate intervals in the silty clay/clayey silt unit. Wells MW002I and MW003I were screened at the bottom of the glacial till unit at approximately five to ten feet above bedrock where the soil was more granular and groundwater yield was expected to be higher than in the upper portion of the unit. Well MW001I and MW008I were screened at higher intervals where granular zones were encountered within the glacial till unit.

Granular water-bearing zones were not encountered immediately above bedrock at well clusters MW001 and MW008. The water-bearing zones encountered in wells MW002I and MW003I are separated from the water-bearing zone encountered at wells MW001I and MW008I by at least ten vertical feet of silty clay/clayey silt. It appears that the intermediate water-bearing zones (granular zones within the glacial till) are discontinuous across the facility site and are encountered where lenses of higher permeable material are present within the silty clay/clayey silt or mantling the bedrock surface.

3.3.4 Bedrock Water-Bearing Zone

Bedrock at the MW001B and MW002B locations consisted of thinly laminated dolomite with solution cavities and fractures with interbedded lenses of shale. The rock core from well MW003B was made up entirely of thinly laminated dolomite. In all three cases, the bedrock zone was saturated.

3.4 GROUNDWATER FLOW

The migration of groundwater is determined by the direction and velocity of groundwater flow and is dictated by the hydraulic properties of the hydrostratigraphic units and by the hydraulic gradient of either the water table (unconfined units) or the potentiometric surface (confined units). The velocity of groundwater flow was calculated using the water-bearing zones' hydraulic properties, which were obtained from water elevation data and hydraulic conductivity testing WESTON conducted in May and June 1999, May 2000, and September 2001. The following subsections provide a detailed description of the information obtained and the resulting conclusions concerning groundwater migration.

3.5 HYDRAULIC CONDUCTIVITY

Hydraulic conductivity testing (slug tests) was conducted in all permanent monitoring wells to characterize the horizontal permeability of the water-bearing zone. The perched shallow water-bearing zone generally exhibited the highest hydraulic conductivity of the three zones with values ranging from 9.74×10^{-4} to 1.17×10^{-1} cm/sec. During Phases I, II, and III, hydraulic conductivity testing was conducted for intermediate and bedrock water-bearing zones to determine the flow properties of these water-bearing zones. The results of the slug tests showed that the hydraulic conductivity ranged from $7.52x10^{-7}$ to $4.98x10^{-4}$ cm/sec in the intermediate water-bearing zone and from $5.28x10^{-8}$ to $1.30x10^{-3}$ cm/sec in the bedrock water-bearing zone.

A geometric mean of all of the hydraulic conductivity values for each water-bearing zone was computed. A geometric mean was used because the values of hydraulic conductivity spanned several orders of magnitude, and a geometric mean reduces bias toward the highest of value. The geometric mean of the hydraulic conductivity values for the shallow water-bearing zone is $3.35x10^{-3}$ cm/sec. The geometric mean of the hydraulic conductivity values for the intermediate water-bearing zone is $2.96x10^{-5}$ cm/sec. The geometric mean of the hydraulic conductivity values for the bedrock water-bearing zone is $6.68x10^{-5}$ cm/sec.

Due to the discontinuity of groundwater occurrence in the perched shallow water-bearing zone and the low permeability and discontinuity of the intermediate water-bearing zone, the Silurian dolomite is considered the first significant water-bearing unit underlying the site. The dolomite yields water primarily from joints, fractures, solution cavities, and bedding planes. In northeastern Illinois, this unit is generally recharged from the downward vertical migration through the overlying glacial drift material. Due to the predominantly clay till composition of the Chicago Lake Plain overburden in the area, the upper portion of the dolomite aquifer is typically a poor source of groundwater due to its low hydraulic conductivity and slow rate of recharge from the overlying till.

Hydraulic conductivity was determined to be highly variable in the three bedrock wells installed during the FI. Permeability was thought to be controlled by fractures, joints, solution cavities, and bedding planes; however, the *in-situ* hydraulic conductivity results did not support this theory. Well MW002B was determined to have the lowest hydraulic conductivity with values ranging from $5.28x10^{-8}$ to $1.16x10^{-5}$ cm/sec. However, the bedrock core from this well exhibited several fractures and solution cavities, which are normally associated with higher hydraulic conductivities. Well MW003B, where no fractures or solution cavities were noted along the entire core, was determined to have a relatively high hydraulic conductivity with values ranging from $1.86x10^{-4}$ to $2.63x10^{-4}$ cm/sec. Well MW001B was the only bedrock well with an abundance of fractures and solution cavities and an associated high permeability. Hydraulic conductivity values for this well ranged from 1.13×10^{-3} to 2.55×10^{-3} cm/sec.

3.6 GROUNDWATER FLOW VELOCITY

Horizontal groundwater flow velocity was calculated for the shallow and bedrock water-bearing zones. The shallow horizontal groundwater flow was calculated in all three phases of the FI investigation, and the flow direction has not significantly changed throughout the phases. The potentiometric surface of the shallow aquifer still shows an easterly to northeasterly flow direction with a groundwater mound in the vicinity of MW003 on the PMC site. Based on the elevation of Doty Avenue ditch, the direction of groundwater flow, and the elevation of the water table, shallow groundwater appears to partially discharge to the ditch. However, flow is likely to continue beneath the ditches and continue towards Lake Calumet.

Sherwin-Williams' conclusion of groundwater flow direction from the site is based on eight rounds of groundwater elevation data collected between April 2000 and June 2002. This data was collected from both the Sherwin-Williams facility and the adjacent Chicago Specialties, LLC site (located downgradient of Sherwin-Williams). This data clearly indicates that groundwater flows from the Sherwin-Williams facility eastward towards Lake Calumet. The groundwater flow data does not show local mounding or a change in flow direction along the eastern property boundary indicative of a hydraulic barrier and thus I-94 does not appear to be impacting groundwater flow. Based on the proximity of the facility to Lake Calumet, the elevation of the piezometric surface within the shallow perched water-bearing zone, and the approximate depth of Lake Calumet, it is reasonable to assume that groundwater at the site will continue to flow eastward after leaving the facility and ultimately discharge to Lake Calumet. This hypothesis has been discussed with Mr. George Roadcap of the Illinois State Water Survey (personal communication, November 2002) who has been conducting hydrologic studies of the Lake Calumet area for over 8 years. Mr. Roadcap believes this hypothesis to be correct.

The groundwater velocity for the shallow water-bearing zone only applies to the eastern portion of the facility where perched water was continuously present. Due to the discontinuous nature of the intermediate water-bearing zone, horizontal groundwater flow direction and gradient cannot be calculated.

The shallow water-bearing zone has a potentiometric surface that changes by one vertical foot over a horizontal distance that ranges from 75 to 220 feet. This yields a horizontal flow gradient that ranges between 0.0045 and 0.014 feet/feet. The geometric mean of hydraulic conductivity of the shallow water-bearing zone is 3.35×10^{-3} cm/sec. Based on split-spoon samples, the fill material is frequently a granular material whose hydraulic properties can be compared to sand or gravel. Thus, it is reasonable to assume an effective porosity of 30% for the fill material. Based on these values, the lower and upper limits of horizontal flow velocity (linear seepage velocity) are 52 feet per year (ft/year) and 162 ft/year.

Based on water level measurements taken on 19 June 1999; 13 April, 24 May, 6 July, and 28 July 2000 for the bedrock water-bearing zone, the potentiometric surface has a slope that ranges across the site from one vertical foot per 900 horizontal feet to one vertical foot per 1,120 horizontal feet. This yields an average horizontal flow gradient of 0.0009 feet/feet. The geometric mean of hydraulic conductivity of the bedrock water-bearing unit is 6.68×10^{-5} cm/sec. A horizontal flow velocity range may be calculated using the upper and lower limits of the effective porosity of limestone as measured by Domenico and Schwartz (1990), where 1% effective porosity was measured for massive limestone, and 24% was measured for fractured limestone. Dolomite bedrock, which occurs below the Sherwin-Williams facility, and limestone have virtually identical hydraulic properties. Additionally, both fractured dolomite and massive dolomite were observed in bedrock cores at the site. Therefore, the values of Domenico and Schwartz (1990) are considered representative of site conditions. The upper and lower limit velocities are calculated using the effective porosity range of limestone. The values obtained for upper and lower limits of horizontal flow velocity (linear seepage velocity) for the bedrock water-bearing unit are 5.98 ft/year and 0.24 ft/year.

The vertical flow velocity can be used to determine groundwater seepage velocity from the perched shallow water-bearing zone through the glacial till to the bedrock water-bearing unit. For this calculation, hydraulic gradient is determined by taking the head difference between the shallow and bedrock wells in a well cluster and dividing by the vertical distance between the midpoint of the two well screens. The values of vertical gradient are the averages from multiple rounds of water level measurements. The vertical hydraulic conductivities were determined through laboratory testing of shelby-tube samples collected from the glacial till.

The vertical seepage velocity range obtained for well cluster MW001 is from 0.015 centimeters per day (cm/day) ($4.9x10^{-4}$ feet per day [ft/day]) to 0.051 cm/day ($1.67x10^{-3}$ ft/day). Groundwater traveling at this velocity will migrate from the shallow water-bearing unit to the bedrock water-bearing unit in a minimum of 361 years. For well cluster MW002, the vertical seepage velocity range is from 0.026 cm/day ($8.53x10^{-4}$ ft/day) to 0.075 cm/day ($2.46x10^{-3}$ ft/day). At this rate, groundwater will migrate from the shallow water-bearing unit to the bedrock water-bearing unit in a minimum of 60 years. For well cluster MW003, the vertical seepage velocity range is from 0.0089 cm/day ($2.92x10^{-4}$ ft/day) to 0.027 cm/day ($8.86x10^{-4}$ ft/day). At this rate, groundwater will migrate from the shallow water-bearing unit to the bedrock water-bearing unit in a minimum of 162 years.

3.7 JUSTIFICATION FOR GROUNDWATER CLASSIFICATION

As previously stated, three water-bearing zones have been identified at the Sherwin-Williams facility. These zones are the shallow perched water-bearing zone, the intermediate water-bearing zones, and the dolomite bedrock. In accordance with 35 IAC Section 620.201, all groundwater in the State of Illinois is designated as Class I (Potable Resource Groundwater), Class II (General Resource Groundwater), Class III (Special Resource Groundwater), or Class IV (Other Groundwater). For purposes of establishing a Tier I soil remediation objective for the soil component of the groundwater ingestion exposure route, only Class I and Class II groundwater are considered. Based on the information presented in Subsections 3.5 and 3.6, the three water-bearing zones identified at the facility should be designated as Class I or Class II.

As specified in 35 IAC Section 620.210, Class I (Potable Resource Groundwater) is:

a) Groundwater located 10 feet or more below the land surface and within:
   1) The minimum setback zone of a well which serves as a potable water supply and to the bottom of such well;

2) Unconsolidated sand, gravel or sand and gravel that is 5 feet or more in thickness and that contains 12 percent or less of fines (i.e. fines which pass through a No. 200 sieve tested according to ASTM [American Society for Testing and Materials] Standard Practice D2488-84, incorporated by reference at Section 620.125);

3) Sandstone which is 10 feet or more in thickness, or fractured carbonate which is 15 feet or more in thickness; or

4) Any geologic material which is capable of a:

A) Sustained groundwater yield, from up to a 12 inch borehole, of 150 gallons per day or more from a thickness of 15 feet or less; or

B) Hydraulic conductivity of 1 x 10(-4) cm/sec or greater using one of the following test methods or its equivalent:

i) Permeameter;
ii) Slug test; or
iii) Pump test.

b) Any groundwater which is determined by the Board pursuant to petition procedures set forth in Section 620.260, to be capable of potable use. (Board Note: Any portion of the thickness associated with the geologic materials as described in subsections 620.210(a)(2), (a)(3) or (a)(4) should be designated as Class I: Potable Resource Groundwater if located 10 feet or more below the land surface.)

The characteristics of each water-bearing zone will be applied to 35 IAC Section 620.210 to determine if the water-bearing zone should be designated as Class I (Potable Resource Groundwater). If the water-bearing zone does not meet the requirements of 35 IAC Section 620.210, the aquifer characteristics will be applied to 35 IAC Section 620.220 (General Resource Groundwater) to determine if the zone should be designated as Class II (General Resource Groundwater). 35 IAC Section 620.220 specifies that Class II (General Resource Groundwater) is:

a) Groundwater which does not meet the provisions of Section 620.210 (Class I), Section 620.230 (Class III), or Section 620.240 (Class IV).

b) Groundwater which is found by the Board, pursuant to the petition procedures set forth in Section 620.260, to be capable of agricultural, industrial, recreational or other beneficial uses.

Each water-bearing zone has been evaluated separately and is presented in the following subsections.

3.7.1 Shallow Perched Water-Bearing Zone

As previously described, the perched water-bearing zone is located within the upper ten feet of the subsurface (with the exception of the area of the 25-Acre Fill Area). This unit consists of fill material that ranges from sand and gravel to silty clay. In addition, varying percentages of cinders, ash, stone, tile, glass, bricks, slag, metal fragments, masonry fill, and foundry sand have been identified in areas at the facility. Water has been detected within this fill unit on a sporadic basis within the western portions of the facility (generally west of Champlain Avenue). The discontinuous nature of perched water is attributed to the absence of widespread coarse-grained fill material underlying the facility. As such, perched water is retained within localized pockets minimizing horizontal flow. A thickness of greater than 30 feet of silty clay/clayey silt separates the perched shallow water-bearing zone from the intermediate water-bearing zone.

Hydraulic conductivity testing from permanent wells installed in this unit indicates that the fill is relatively permeable, where water has been encountered. The hydraulic conductivity of the perched water-bearing zone ranges from 9.74×10^{-4} to 1.17×10^{-1} cm/sec. The geometric mean of the hydraulic conductivity values for the shallow water-bearing zone is 3.35×10^{-3} cm/sec. In general, permanent monitoring wells have only been installed within the eastern portions of the facility where the fill material is coarser in nature.

Based on the information contained in this document, Sherwin-Williams believes that this unit should be designated as Class II (General Resource Groundwater) for the following reasons:

- The unit is not located below 10 feet or more below the land surface and;

  1) The unit is not located within the minimum setback zone of a well which serves as a potable water supply and to the bottom of such well;

  2) The unit is not an unconsolidated sand, gravel or sand and gravel which is 5 feet or more in thickness and that contains 12 percent or less of fines (i.e. fines which pass through a No. 200 sieve tested according to ASTM Standard Practice D2488-84, incorporated by reference at Section 620.125);

3) The unit is not a sandstone which is 10 feet or more in thickness, or fractured carbonate which is 15 feet or more in thickness;

- The quality of groundwater within this unit has been degraded due to historical filling activities (late 1800s and early 1900s) conducted by parties (other than Sherwin-Williams) that supported the production of railroad cars.

- The fine grained nature of fill material west of the former Lake Calumet shoreline inhibits the horizontal migration of perched water to nearby surface water bodies.

The perched water-bearing zone is underlain by glacial till which consists of silty clay/clayey silt. The intermediate water-bearing zone is detected within this glacial till.

3.7.2 <u>Intermediate Water-Bearing Zone</u>

The intermediate water-bearing unit is located within the glacial till. This silty clay/clayey silt unit commonly contained pebbles and interbedded lenses of silt or sand and gravel (generally less than five feet thick). The silty clay/clayey silt unit ranged in thickness from 44 feet to 67.5 feet in the deep borings at the facility. Within the western portion of the facility (west of the former Lake Calumet shoreline) intermediate water-bearing zone (IWBZ) No. 1 was detected at approximately 42 feet bgs. This unit, consisting of saturated sandy silt up to one foot thick, and was observed at well locations MW001I and MW008I. Within the eastern portion of the facility, a separate intermediate zone (IWBZ No. 2) was detected immediately above bedrock at a depth of approximately 60 feet below grade. The thickness of this lower unit ranges from one to five feet. Based on the geologic information for the site, it appears that these two intermediate water-bearing zones are discontinuous in nature. With their horizontal extent limited and approximately 18 feet of silty clay/clayey silt separating them vertically, a hydraulic connection does not appear to exist.

Hydraulic conductivity testing from permanent wells installed in these units indicates that the two intermediate water-bearing units are less permeable than the shallow zone. The hydraulic conductivity of the intermediate water-bearing zone ranges from $7.52x10^{-7}$ to $4.98x10^{-4}$ cm/sec. Hydraulic conductivity data indicated that IWBZ No. 1 is less permeable than IWBZ No. 2. The geometric mean of the hydraulic conductivity values for both intermediate water-bearing zones is 2.96×10^{-5} cm/sec.

Based on the information contained in this document, Sherwin-Williams believes that IWBZ No. 1 should be designated as Class II (General Resource Groundwater) for the following reasons:

- The unit is not located within the minimum setback zone of a well which serves as a potable water supply and to the bottom of such well;
- The unit is not an unconsolidated sand, gravel or sand and gravel which is five feet or more thick and that contains 12 percent or less of fines (i.e. fines which pass through a No. 200 sieve tested according to ASTM Standard Practice D2488-84, incorporated by reference at Section 620.125);
- The unit is not a sandstone which is ten feet or more thick, or fractured carbonate which is 15 feet or more thick;
- The unit is not a geologic material which is capable of a sustained groundwater yield, from up to a 12-inch borehole, of 150 gallons per day or more from a thickness of 15 feet or less; or
- The unit is not a geologic material with a hydraulic conductivity of 1×10^{-4} cm/sec.

Based on the hydraulic conductivity data for IWBZ No. 2 and the fact that this unit rests directly on top of the dolomite bedrock, Sherwin-Williams believes that this unit should be designated as Class I (Potable Resource Groundwater).

3.7.3 Bedrock Water-Bearing Zone

The first bedrock unit encountered below the facility was a thinly laminated dolomite. This unit also contained interbedded lenses of shale and occasional fractures with some solution cavities. The bedrock surface is irregular with its highest elevation detected in the center of the facility (at well MW008I). The upper portion of the dolomite yielded water to the installed wells at a relatively low rate. The bedrock water-bearing zone hydraulic conductivity ranged from 5.28×10^{-8} to 1.30×10^{-3} cm/sec. The geometric mean of the hydraulic conductivity values for the bedrock water-bearing zone is 6.68×10^{-5} cm/sec. Based on the hydraulic conductivity data and the fact that this unit is a fractured carbonate which is 15 feet or more thick, Sherwin-Williams believes that this unit should be designated as Class I (Potable Resource Groundwater).

SECTION 4
PREDESIGN INVESTIGATION RESULTS

A Predesign Investigation was conducted at the Sherwin-Williams Chicago Facility to assist with the Remedial Measures Design. Information gathered and analytical results obtained during this investigation are included within this section of the 30% Remedial Measures Design Submittal. The Predesign Investigation included a site survey, chemical investigation, geotechnical investigation, steel sheet pile corrosion testing, bioremediation bench-scale study, and landfill gas generation investigation. The results of the individual elements of the Predesign Investigation are detailed in the following sections.

4.1 SITE SURVEY

A survey of the entire site was completed utilizing aerial photography and Digital Terrain Modeling (DTM) in conjunction with a control survey. The aerial photography control survey was conducted by a survey crew using standard survey equipment, and vertical and horizontal control points will be established at the site. A fly-over survey was then conducted to collect color aerial photographs at a scale of 1 inch equals 50 feet. Following collection of the aerial photographs, a digital mosaic of the color aerial photography was prepared in AutoCAD. The final drawing includes one-foot contours and planimetric features, and is included as Figure 4-1. In addition, a certified property boundary survey and title search for the Sherwin-Williams Chicago Facility is currently underway. The results of the certified property boundary survey and title search will be included with the 95% design submittal.

4.2 CHEMICAL INVESTIGATION

A chemical investigation was completed at the site during the Predesign Investigation to determine the extents of the proposed engineered barriers within Areas 1, 2 East, 2 West, 3 West, and 4. In addition, the chemical investigation attempted to define the extents of the engineered barriers required in landscaped areas along Cottage Grove Avenue and 115th Street. Soil borings advanced during the chemical investigation were advanced using a Geoprobe, in accordance with standard procedures detailed in the approved Quality Assurance Project Plan

(QAPP). A qualified geologist used the Unified Soil Classification System (USCS) to describe each soil boring in accordance with ASTM method D2488. Boring logs generated from the geotechnical investigation are included within Appendix A. The chemical investigation in each area is detailed below in the following subsections.

4.2.1 Landscape Area Investigation

Soil borings were advanced approximately every 200 feet along Cottage Grove Avenue and 115th Street, which resulted in 14 soil borings (Figure 4-2). These samples were collected to determine if soil within the landscaped areas exceeded MCSs and/or exhibited characteristics of hazardous waste. The original scope of work specified that 17 soil borings be advanced, but three were unable to be advanced because of existing landscaping. One soil sample was collected from each soil boring from 1 to 2 feet bgs. Samples were analyzed for flashpoint; mercury; metals; paint filter; pesticides/PCBs; pH; phenolics; reactive cyanide; reactive sulfide; SVOCs; VOCs; and toxicity characteristic leaching procedure (TCLP) herbicides, metals, pesticides/PCBs, SVOCs, VOCs. Table 4-1 presents analytical results.

Table 4-1 also provides a comparison of the analytical results to the MCS (for chemical constituents) and the RCRA Hazardous Waste Characteristics as defined by 40 Code of Federal Regulations (CFR) Part 261 (for disposal parameters). The constituents exceeding the comparison criteria in Table 4-1 are shown on Figure 4-3. As shown in Table 4-1 and Figure 4-3, multiple constituents (including SVOCs, VOCs, and metals) in multiple borings exceeded the MCS. However, no concentrations exceeded the RCRA Hazardous Waste Characteristics comparison criteria.

4.2.2 Area 1 Investigation

Two soil borings, SB083 and SB084 (Figure 4-2) were advanced in Area 1, with two soil samples (1 to 2 and 8 to 9 feet bgs) collected from each boring. The two samples from SB083 were analyzed for arsenic and lead to attempt to define the proposed eastern extent of the engineered barrier within Area 1. The only analytical result that exceeded the MCS was lead in the sample from 1 to 2 feet bgs.

The samples from soil boring SB084 were initially held pending the results for samples from SB083; and were only to be analyzed if the analytical results for the samples from SB083 exceeded the MCS. Based on the results of the samples from SB083, the sample from 1 to 2 feet bgs in SB084 was analyzed for lead, and the result of this analysis did not exceed the MCS for lead.

The analytical results are presented in Table 4-2, which also provides a comparison with the MCSs. The constituents exceeding the MCSs in Table 4-2 are shown on Figure 4-4. Figure 4-4 also illustrates the revised extent of engineered barrier required in Area 1, which is based on the analytical results shown in Table 4-2.

4.2.3 <u>Area 2 Investigation</u>

Six soil borings were advanced in Areas 2 West and 2 East. The two soil borings advanced in Area 2 West (SB085 and SB086) had two soil samples collected from each boring, from 1 to 2 and 4 to 5 feet bgs. The samples from SB085 were analyzed for acetophenone and arsenic in an attempt to define the proposed eastern extent of the engineered barrier in Area 2 West. None of the analytical results associated with the samples from SB085 exceeded the MCS. The samples from SB086 were initially held pending the results for samples from SB085, and were not analyzed because the analytical results for samples from SB085 did not exceed the MCS.

The four soil borings advanced in Area 2 East, SB087 through SB090, had one soil sample collected from each boring from 1 to 2 feet bgs. The samples from Area 2 East were analyzed for the following:

- SB087 was analyzed for arsenic, lead, and chromium;
- SB088 was analyzed for arsenic;
- SB089 was analyzed for arsenic;
- SB090 was held for later analysis pending the results for the sample from SB089.

All of the analytical results of samples from SB087, SB088, and SB089 exceeded the MCS for all analysis. Therefore, analysis of the sample from SB090 was performed for arsenic. The analytical results of SB090 also exceeded the MCS. The analytical results are presented in Table 4-2, which also provides a comparison with the MCSs. The constituents exceeding the MCSs in Table 4-2 are shown on Figure 4-5.

Based on the analytical results in Table 4-2, the extent of the engineered barrier proposed in the RMS Report (WESTON, 2003a) is accurate for Area 2 West; however, the extent of engineered barrier in Area 2 East as presented in the RMS Report (WESTON, 2003a) requires revision. Figure 4-5 illustrates the extent of the engineered barrier in Area 2 West, which is the same as the extent proposed in the RMS Report (WESTON, 2003a). In addition, Figure 4-5 illustrates the revised extent of the engineered barrier required in Area 2 East, which is based on the analytical results shown in Table 4-2.

4.2.4 Area 3 Investigation

Eight total soil borings (SB091 through SB098) were advanced in Area 3 West. Soil boring SB091 was advanced at location YPP-SB040 with two samples collected, from 1 to 2 and 2 to 3 feet bgs. The sample from 1 to 2 feet bgs in SB091 was analyzed for chromium, and did not exceed the MCS. The deeper sample from SB091 was held for later analysis pending the results of the shallow sample. The deeper sample was not analyzed because the shallow sample from SB091 did not exceed the MCS.

Soil borings SB092 through SB095 were advanced 20 feet to the north, east, south, and west of SB091, respectively. One soil sample was collected from 0 to 1 foot bgs in each of these borings and analyzed for chromium. The only sample with a chromium concentration that exceeded the MCS was the sample from SB094.

In addition, SB096 (1 to 2 feet bgs), SB097 (0 to 1 foot bgs), and SB098 (0 to 1 foot bgs) were also advanced in Area 3. The soil samples from these three borings were analyzed for the following:

- SB096 was analyzed for chromium and benzo(a)pyrene;
- SB097 analyzed for chromium, benzo(a)pyrene, and dibenzo(a,h)anthracene;
- SB098 was held for later analysis pending the results for the sample from SB097.

The analytical results of the samples from SB096 and SB097 did not exceed the MCSs. The analysis was never performed on SB098 because the analytical results of the sample from SB097 did not exceed the MCS. The analytical results are presented in Table 4-2, which also provides a comparison with the MCSs. The constituents exceeding the MCSs in Table 4-2 are shown on Figure 4-6. In addition, the approximated extent of contamination within this area is illustrated on Figure 4-6. The northern engineered barrier proposed for use in the RMS Report (WESTON, 2003a) has been replaced with excavation and on-site consolidation beneath the engineered cap in the 25-Acre Fill Area. Additional detail regarding this removal and relocation of the Area 3 West soil is discussed further in Section 5.

In addition, Figure 4-6 shows the revised extent of engineered barrier in Area 3 East. This area was added because the extent of excavation for the benzene-impacted soils was refined since the RMS. The extent of excavation of benzene-impacted soils is discussed further in Section 5.7. Based on the revised extent of excavation in Area 2 East, the extent of engineered barrier was extended to include soil borings where arsenic, benzo(a)pyrene, chromium, or lead concentrations exceeded MCSs.

4.2.5 Area 4 Investigation

Two soil borings, SB099 and SB100 (Figure 4-2) were advanced in Area 4, with one soil sample (1 to 2 feet bgs) collected from each boring. The soil sample from SB099 was analyzed for arsenic and was collected to define the extent of the engineered barrier in Area 4. The analytical results of the soil sample from SB099 did not exceed MCS. Analysis of the soil sample from SB100 was held pending the results of the sample from SB099. The analysis was never performed on SB100 because the analytical results from SB099 did not exceed the MCS. The analytical results are presented in Table 4-2, which also provides a comparison with the MCSs. In addition, based on the results of the sampling, the extent of the engineered barrier in Area 4 (Figure 4-7) is the same as the extent proposed in the RMS Report (WESTON, 2003a).

4.3 GEOTECHNICAL INVESTIGATION

A geotechnical investigation was completed at the site during the Predesign Investigation to determine important aspects of the subsurface conditions in Area 2 East, the 5-Acre Fill Area, and the 25-Acre Fill Area. The following subsections describe the geotechnical investigation that was conducted during the Predesign Investigation within each area. The majority of soil borings advanced during the geotechnical investigation were advanced using a hollow-stem auger (HSA). The cross-sections' locations that were generated based on the results of this investigation are shown in Figure 4-8. Some soil borings in Area 2 East were advanced using a Geoprobe®. A full description of the procedures is included in the Predesign Work Plan (WESTON, 2005a) included in Appendix A. In addition to the soil sampling described below, multiple rounds of water level measurements were collected from the shallow wells on the site. Table 4-3 summarizes the water level measurements.

All HSA borings were split-spoon sampled through the fill material and at least ten feet (three consecutive split-spoon samples) into the underlying clay using a 24-inch spoon at five-foot depth intervals. The split spoon sampling was completed using the procedures of ASTM D1586, the Standard Penetration Test, so that the Standard Penetration Resistance (i.e., "N") values of the fill material and underlying clay soil could be determined. A qualified geologist used the USCS to describe each soil boring in accordance with ASTM method D2488. Boring logs generated from the geotechnical investigation are included within Appendix A.

4.3.1 Area 2 East Sheet Pile Wall Investigation

Prior to initiating this investigation, the vertical barrier horizontal alignment was established by Global Positioning System (GPS). A Geoprobe was then used to determine if historical building foundations and/or slabs are present along the proposed alignment of the sheet pile barrier wall. Each Geoprobe boring was advanced no more than eight feet bgs to locate historical foundations. The locations where subsurface obstructions were encountered, and the depth at which these obstructions were encountered, are summarized in Table 4-4 and illustrated in Figure 4-9. The results of the subsurface obstruction investigation are discussed further in Section 5.5.2.1.

Following the exploratory Geoprobe borings, geotechnical soil borings along the sheet pile barrier wall alignment were completed in the locations shown on Figure 4-2. Geotechnical laboratory tests were completed on selected samples of the fill material and the clay as part of this geotechnical investigation. The soil samples selected for analysis and the analytical parameters are summarized in Table 4-5. Results of the geotechnical analysis are included within Appendix A. In addition, geologic cross-section A-A' (Figure 4-10) was created based on the information obtained during the geotechnical investigation of the sheet pile wall in Area 2 East. The results of the geotechnical investigation were necessary for the driving stress analysis, which is discussed further in Section 5.5.2.1.

4.3.2 <u>Area 2 East Cap Investigation</u>

Additional geotechnical soil borings were completed within the area encompassed by the vertical barrier to assist with the design of the proposed cap within Area 2 East. These soil borings were advanced within this area using an HSA and were split-spoon sampled through the fill material and at least ten feet (three consecutive split-spoon samples) into the underlying clay using a 24-inch spoon at five-foot depth intervals to an approximate depth of 45 feet bgs.

Geotechnical laboratory tests were completed on selected samples of the fill material and the clay as part of this geotechnical investigation. The soil samples selected for analysis and the analytical parameters are summarized in Table 4-5. Results of the geotechnical analysis are included within Appendix A. In addition, geologic cross-sections B-B', C-C', and D-D' (Figures 4-11 through 4-13, respectively) were created based on the information obtained during the geotechnical investigation of the cap in Area 2 East. The results of the geotechnical investigation were necessary to analyze the potential for settlement, which will be discussed for Area 2 East in the 95% design.

4.3.3 <u>5-Acre Fill Area Cap Investigation</u>

Geotechnical soil borings were completed within the 5-Acre Fill Area to assist with the design of the proposed cap. The subsurface conditions within the 5-Acre Fill Area are an important parameter in determining the amount of soil settlement that will occur following installation of the cap and during loading that occurs following completion of the Remedial Measures. Four temporary peizometers were installed in the abandoned soil borings to determine shallow water levels in this area. These borings were extended to 30 feet bgs in order to adequately characterize the fill material and the clay layer under the proposed cap.

Geotechnical laboratory tests were completed on selected samples of the fill material and the clay as part of this geotechnical investigation. The soil samples selected for analysis and the analytical parameters are summarized in Table 4-5. Results of the geotechnical analysis are included within Appendix A. In addition, geologic cross-sections E-E' and F-F' (Figures 4-14 and 4-15, respectively) were created based on the information obtained during the geotechnical investigation of the cap in the 5-Acre Fill Area. The results of this geotechnical investigation and water level measurements were necessary to analyze the potential for and effective management of settlement, which is discussed further in Section 5.3.2.5.

4.3.4 25-Acre Fill Area Cap Investigation

Geotechnical soil borings were completed within the 25-Acre Fill Area to assist with the design of the proposed cap. The subsurface conditions within the 25-Acre Fill Area are an important parameter in determining the amount of soil settlement to occur following installation of the cap. A total of six borings were advanced within this area using an HSA and were split-spoon sampled through the fill material and at least ten feet (three consecutive split-spoon samples) into the underlying clay using a 24-inch spoon at five-foot depth intervals to refusal on bedrock.

Cased borings were advanced in the 25-Acre Fill Area to prevent hydraulic communication between the shallow and intermediate aquifers. These borings extended to bedrock in order to adequately characterize the fill material and the clay layer under the proposed cap. Immediately following completion of the drilling at each boring, the hole was sealed with a cement-bentonite slurry.

Geotechnical laboratory tests were completed on selected samples of the fill material and the clay as part of this geotechnical investigation. The soil samples selected for analysis and the analytical parameters are summarized in Table 4-5. Results of the geotechnical analysis are included within Appendix A. In addition, geologic cross-sections G-G' and H-H' (Figures 4-16 and 4-17, respectively) were created based on the information obtained during the geotechnical investigation of the cap in the 25-Acre Fill Area. The results of the geotechnical investigation were necessary to analyze the settlement and veneer stability of the engineered cap, which is discussed further in Section 5.4.2.6.

4.4 STEEL SHEET PILE CORROSION TESTING

Corrosion testing of the steel proposed for use as the sheet pile barrier was conducted to ensure an adequate design life of the steel sheet pile wall in Area 2 East. Corrosion Testing Laboratories, Inc. (CTL) conducted the tests in accordance with ASTM Method G31 – Standard Practice for Laboatory Immersion Corrosion Testing of Materials using a sample of the sheet pile, one gallon of impacted soil, and one gallon of impacted groundwater collected from Area 2 East during the Predesign Investigation. Soil was collected from the drill cuttings of the geotechnical soil borings conducted around the perimeter of the proposed sheet pile wall location. Groundwater was collected from the shallow wells located within Area 2 East.

Eight corrosion tests were conducted on the ASTM 572 Grade 50 alloy steel samples, four with natural moisture conditions and four with soil saturated with groundwater. The steel samples were given a 120-grit finish, cleaned, dimensioned, and weighted prior to beginning the corrosion testing. The soil was blended to obtain a representative mixture and placed into two test vessels, one with natural moisture content and one with saturated conditions. Two of the steel specimens were buried in the soil in each vessel and two were suspended so that they were partly exposed to the vapor phase in the headspace and partially buried in the soil. The test vessels were sealed and held at room temperature (approximately 22 degrees Celsius [° C])for 30 days.

At the end of the test period, the steel specimens were removed, cleaned, and reweighed. Corrosion rates were calculated based on the measured mass loss. The full report prepared by CTL summarizing the results of the corrosion testing is included in Appendix A. The average corrosion rates and type of corrosion are as follows:

- Sample 1 – Natural Moisture Content, Partially Buried: average corrosion of 2.5 mils (0.001 inches) per year with non-uniform corrosion, up to 2 mils deep.

- Sample 2 – Natural Moisture Content, Buried: average corrosion of 5.1 mils per year with non-uniform corrosion, up to 1 mil deep.

- Sample 3 – Saturated Moisture Content, Partially Buried: average corrosion of 3.2 mils per year with non-uniform corrosion, less than 1 mil deep.

- Sample 4 – Saturated Moisture Content, Buried: average corrosion of 3.3 mils per year with uniform corrosion.

The results of the corrosion testing will be examined further in Section 5.

4.5 BIOREMEDIATION BENCH-SCALE STUDY

During the Predesign Investigation, a bench-scale study was conducted to determine the design parameters for *ex-situ* bioremediation. This study examined the rate of *ex-situ* bioremediation to reduce concentrations of organics within the soil and also attempted to determine the optimum treatment parameters to be used while implementing the full-scale bioremediation. Further discussion of the objectives of the full-scale bioremediation process is included within Section 5. A representative sample of soil with elevated organic constituent concentrations was collected using an HSA and shipped to Global Remediation Technologies, Inc. (GRT). The conclusions related to the bioremediation bench-scale study will be examined further in Section 5.

4.5.1 Bioremediation Treatment

Eight individual treatment samples were produced from the overall composite sample. The eight samples included:

- Standard Control Sample (Control)

- Sterile Control Sample

- Sample T1, which includes tilling of the soil, moisture addition, and nutrient addition

- Sample T2, which includes tilling of the soil, moisture addition, nutrient addition, and addition of Alken Murray’s Alken Clear-Flo 7037 microbe mixture

- Sample T3, which includes tilling of the soil, moisture addition, nutrient addition, and addition of Alken Murray's Alken Clear-Flo 7038 microbe mixture

- Sample T4, which includes tilling of the soil, moisture addition, nutrient addition, and aeration of the soil

- Sample T5, which includes tilling of the soil, moisture addition, nutrient addition, addition of Alken Murray's Alken Clear-Flo 7037 microbe mixture, and aeration of the soil

- Sample T6, which includes tilling of the soil, moisture addition, nutrient addition, addition of Alken Murray's Alken Clear-Flo 7038 microbe mixture, and aeration of the soil

The microbe addition rate used was recommended by the manufacturer as 0.5 pounds per cubic yard (lb/yd3). Soil nutrient levels (carbon [C], nitrogen [N], and phosphate [P]) levels were maintained at a level of C:N:P = 100:10:1 to ensure microbial growth. A detailed discussion of each of these sample types and the methods used during the study was included in the Predesign Work Plan (WESTON, 2005a), which is included in Appendix A. In addition, the methods used during the study are detailed within the *Ex-situ* Bioremediation Potential Bench Study Report (GRT, 2005) in Appendix A. The laboratory results for each of the test types are discussed in the following subsections.

4.5.2 Laboratory Analysis Results

Analytical samples were collected prior to initiating the study (time = 0), after two days, and weekly for two months (10 times). The initial analysis included Benzene, Toluene, Ethylbenzene, and Xylene (BTEX), ammonia-N, nitrate-N, ortho-phosphate, percent water, arsenic, chromium, and lead. The remainder of the samples were analyzed for BTEX, PNAs, ammonia-N, nitrate-N, ortho-phosphate, and percent water. Analytical results are presented in Tables 4-6 through 4-8. The following subsections will discuss each important factor (VOCs, inorganics, and microbes) and the associated analytical results.

4.5.2.1 VOCs

VOC analytical data is presented in Table 4-6. Initial concentrations of BTEX ranged from 800,000 to 3,500,000 micrograms per kilogram (µg/kg). Ethylbenzene concentrations did not exceeded its MCS (42,000 µg/kg), so ethylbenzene will not be discussed further. Figure 4-18 illustrates the percent reduction of total BTEX over time. Also, Figures 4-19, 4-20, and 4-21 show benzene, toluene, and xylene concentrations over time, respectively.

As shown in Figure 4-20, all toluene concentrations were eventually reduced to below the MCS (11,400 µg/kg), excluding the final sample of the Control sample. The final toluene sample of the Control, appears to be an anomaly because the two samples collected prior to the final sample (21 July 2005) were below the MCS. The amount of time required to reduce the toluene varied, but was generally five weeks or longer.

As shown in Figure 4-21, all xylene concentrations were eventually reduced to below the MCS (165,000 µg/kg). Generally, xylene concentrations were reduced to below the MCS in the first one or two weeks of bioremediation.

As shown in Figure 4-19, none of the benzene concentrations were reduced to below the MCS (63.5 µg/kg) during the 57-day study. However, the estimated duration of treatment required to reduce the benzene concentrations below the MCS can be estimated by determining the first-order linear reduction rate of benzene concentrations (from day 28 to day 56) and interpolating forward. Based on this linear reduction rate, it is estimated that the benzene concentration could be reduced to below the MCS after an additional ten to 12 weeks of treatment (total treatment duration of 18 to 20 weeks).

Laboratory results indicate that the amount of VOC mass reduction due to volatilization is approximately 15%. Therefore, any loss of VOC mass is approximately 85% due to microbial degradation and 15% due to volatilization.

4.5.2.2 Inorganics

Inorganic analytical data is presented in Table 4-7. Inorganic concentrations were not compared to the MCSs because the analysis performed was only to determine if the elevated inorganic constituents would have inhibitory effects on the bioremediation. If any of the treatment samples would have been ineffective, the amount of inorganic constituents in the sample would have been examined to determine if the inorganic concentrations had inhibitory effects on the bioremediation process. Based on the inorganic concentrations shown in Table 4-8, the inorganic constituents should not inhibit *ex-situ* bioremediation.

4.5.2.3 Microbes

Microbial analytical data is presented in Table 4-8, and includes a detection limit of 100 colony forming units per gram (CFU/g). Figure 4-22 illustrates the microbial hydrocarbon concentrations over time.

4.6 LANDFILL GAS GENERATION INVESTIGATION

A landfill gas generation investigation was conducted to determine the gas generation capacity of the fill material within the 25-Acre Fill Area. Determination of the gas generation rate (if any) is essential for the proper design of the cap system proposed as part of the Remedial Measures for the 25-Acre Fill Area. If the fill material within the 25-Acre Fill Area were to generate gas during organic degradation, the design of the cap would have to incorporate a gas collection system. This landfill gas investigation included collection of 10 soil-gas samples using both passive surface flux chamber samplers to sample soil-gas at the ground surface, and subsurface soil-gas sampling ports to sample soil-gas at shallow depths. Passive soil-gas samples were collected following the protocols of the EMFLUX® Passive Soil-Gas Method, as described in U.S. EPA Report EPA/600/R-98/096. Laboratory analysis was performed on the samples to determine the concentrations (reported as nanograms [ng]) and emission flux rates (reported as ng per square centimeter per second) of methane and selected VOCs.

4.6.1 Sampling Procedures

Soil-gas sampling ports at each of the ten sample locations shown in Figure 4-2 were installed and developed to measure the percent methane present. Soil-gas sampling ports were intended to be placed adjacent to the passive soil-gas samplers, but due to debris encountered while hand-augering the holes, some locations were offset, sometime substantially. To create a sampling port, a one-inch diameter hole was advanced to a two-foot depth. Tubing was then lowered into the hole and the lower 12 inches of the hole around the tube was filled with clean dry sand. The upper 12 inches of the hole was filled to grade with grout to effectively seal the tube in the ground. A sampling valve was then attached to the end of the tubing, the tubing was purged of air, and the sampling valve was set to the closed position. Following installation of the sampling ports, the soil-gas was allowed to reach equilibrium over 12 to 24 hours. After the soil-gas had reached equilibrium, an infrared gas analyzer was used to measure the percent methane present in each sampling port. The lower reporting limit of the infrared gas analyzer instrument is 0.1% methane and the upper reporting limit is 100% methane. Each sampling port was measured with the infrared gas analyzer three times with three hours between sampling events. All measurements were recorded in a field log.

In addition, an EMFLUX® Surface Flux Chamber (Flux Chamber) was installed at each of the 10 sample locations following established protocols. A Flux Chamber was installed by first clearing each sample location of vegetation and debris to expose a flat surface. Two laboratory-prepared adsorbent cartridges containing standardized adsorbent were then affixed to a support stake, and the sampler assembly was secured to the ground at the specified sampling point. The Flux Chamber was then immediately placed on the ground, with the open end on the ground surface, over the sampler assembly and was surrounded with a collar of sand. The Flux Chamber was then covered with camouflage cloth, which was secured with additional sand. The adsorbent cartridges were exposed to subsurface gasses for approximately 72 hours, which was the predetermined time period predicted by the EMFLUX® Timing Model to maximize the collection of soil gas. The cartridges were then retrieved and shipped to Beacon Environmental Services, Inc. (Beacon) for analysis. A trip blank, which remained with the other EMFLUX samples during preparation, shipment, and storage, was included with the field samples during shipment.

4.6.2 Analytical Procedures

Soil gas samples were analyzed by Beacon using a gas chromatography/mass spectrometer (GC/MS), following modified U.S. EPA Method 8260B procedures. Samples were analyzed for the compounds listed in Table 4-10. Additional detail regarding the analytical procedures is included within the Soil-Gas Survey Report included within Appendix A.

4.6.3 Analytical Results

A total of 30 methane readings were collected during the three rounds of sampling. Only two of the methane gas readings collected on 25 May 2005 had methane present, both from the first sampling round (7:20 to 7:56 AM). Sample location MP-2 and MP-9 both had readings of 0.1% methane detected during the first sample round, but no further readings were recorded during the next two rounds of sampling.

The results of the laboratory analysis of the sample cartridges is included in Table 4-10. Only 1,2-dichlorobenzene was detected above laboratory reporting limits, at a concentration of 75 ng per sample cartridge. This result translates to an estimated emission rate of 2.85 ng per square meter per minute (ng/m2/min). The results of the landfill gas sampling will be examined further in Section 5.

SECTION 5
REMEDIAL MEASURES DESIGN

This section presents the 30% design of the Remedial Measures planned for the Sherwin-Williams Chicago Facility. Each of the remedial measures are presented in a section below, with the design criteria and design basis detailed for each component. All of the designs presented below will be modified, as necessary based on comments received from the U.S. EPA and the finalized redevelopment plans. Design modifications will be presented as part of the 95% design submittal. In addition, all of the designs presented below are based on sound engineering principals and comply with all applicable local, state, and federal regulations.

5.1 TYPICAL ENGINEERED BARRIER DESIGN – AREAS 1, 2 WEST, 3 EAST, 3 WEST, AND 4

5.1.1 Design Criteria

The design criteria for the engineered barriers in Areas 1, 2 West, 3 East, 3 West, and 4 are as follows:

- Install one of three types of engineered barriers over the soil in each of the areas specified in Figures 4-4 through 4-7 to prevent ingestion and direct contact with the soil exceeding MCSs.
- Install HDPE membranes in areas where soil presents an inhalation risk to eliminate the inhalation exposure pathway.
- Select the type of engineered barrier for each area based on the facility redevelopment plans.

5.1.2 Design Basis

As per the Final Decision Document (U.S. EPA, 2005a), one of three types of engineered barriers will be placed over the areas of impacted soil within Areas 1, 2 West, 3 East, 3 West, and 4. The three types of engineered barriers consist of the following:

- Asphalt or concrete pavement

- Buildings
- Soil/Geotextile (12 inches of soil with an underlying geotextile)

A detailed discussion of each of the three types of engineered barriers is presented in the following subsections.

5.1.2.1 Asphalt or Concrete Pavement

The asphalt and concrete engineered barriers will generally be composed of either asphalt or concrete underlain with a compacted sub-grade layer. The exact features that will be included as part of the engineered barrier in Areas 1, 2 West, 3 East, 3 West, and 4 will be specified in the 95% design, and will be determined based on the redevelopment plans for the facility. Details of all types of pavement, e.g., parking lots, driveways, sidewalks, curbs, gutters, and loading dock ramps will be included within the Design Drawings, which will be included in the 95% design.

5.1.2.2 Buildings

The foundations and floor slabs of the buildings anticipated during redevelopment will act as the required engineered barriers. The exact features of the buildings are not yet determined, but will be specified in the 95% design, and will be determined based on the redevelopment plans for the facility. Details of all types and features of the buildings slabs and foundations will be included within the Design Drawings, which will be included within the 95% design.

5.1.2.3 Soil/Geotextile

Soil/geotextile engineered barriers will be composed of 12-inches of soil underlain by a geotextile. Soil/geotextile engineered barriers will not be installed in areas where soil concentrations exceed inhalation standards. The soil/geotextile engineered barrier is designed to prevent direct contact and ingestion of impacted soils.

Soil

The 12-inch engineered barrier will generally be composed of 6 inches of general fill material beneath 6 inches of topsoil rich in organic content and nutrients necessary to support plant growth. All fill material will be obtained from off-site sources. Some potential sources of off-site fill (general and topsoil) are listed in Appendix B. The specifications that will be included in the 95% design will specify the required properties of general fill and topsoil, and will detail installation procedures.

Geotextile

The geotextile used at the site will be selected based on effectiveness, cost, availability, and ease of installation. The following criteria will be examined during the 95% design to determine the effectiveness of different geotextiles:

- Puncture strength – the ability of the geotextile to withstand punctures from a handheld digging or probing instrument (as determined by testing method ASTM D4833-88).
- Tensile strength – the overall strength of the geotextile under horizontal strain, which will be encountered during the installation process (as determined by testing method ASTM D4595-86).
- Tearing strength – the ability of the geotextile to not tear during horizontal strains, which will be encountered during the installation process (as determined by testing method ASTM D4533-91).
- Deterioration rate from exposure to ultraviolet light and water – the effective design life of the geotextile (as determined by testing method ASTM D4595-86).
- Apparent opening size – the overall ground coverage of the geotextile, which relates to its ability to act as an adequate barrier between the impacted soil and the clean soil (as determined by testing method ASTM D4751-87).
- Water permeability – the vertical hydraulic conductivity of the geotextile, which needs to allow adequate vertical migration of precipitation to not produce standing water (as determined by testing method ASTM 4491-92).

In addition, the visibility of the geotextile will be taken into account. The visibility of the geotextile is an important aspect that is not accounted for in any of the standard testing methods listed above. Visibility will be important to illustrate to anyone performing unauthorized digging at the site with hand tools that an engineered barrier exists.

The specification for the geotextile to be used as part of the soil/geotextile engineered barrier in Areas 1, 2 West, 3 East, 3 West, and 4 will include one or more acceptable options that will be selected by the construction contractor based on cost, availability, and ease of installation.

5.2 ENGINEERED BARRIER DESIGN – AREA 2 EAST

5.2.1 Design Criteria

The design criteria for the engineered barrier in Area 2 East are as follows:

- Install an impermeable cap over the soil in Area 2 East to accomplish the following:
    - Prevent infiltration of precipitation into the soil,
    - Prevent ingestion and direct contact with soil that exceeds MCSs,
    - Eliminate the inhalation exposure pathway.
- Install asphalt paving in the area as part of the impermeable cap.

5.2.2 Design Basis

As per the Final Decision Document (U.S. EPA, 2005a), an impermeable engineered barrier will be installed Area 2 East. The area where this barrier will be installed is shown in Figure 4-5. The basis of this design is to determine the most effective type of barrier that will accomplish the design criteria listed above, based on cost, availability, and ease of construction. The two alternatives that will be examined are standard asphalt underlain with a geomembrane and impermeable asphalt. Each of the two alternatives are discussed in the following subsections. A comparative analysis and selection of the preferred alternative is also presented. In addition, an analysis of the potential settlement at the site will be performed during the 95% design.

5.2.2.1 Asphalt and Geomembrane Alternative

The first impermeable engineered barrier option for Area 2 East is standard asphalt overlaying a flexible membrane liner (FML). Additional detail related to the FML is included in Section 5.4.2.3. Components of the asphalt paving incorporating an FML, from bottom to top, will consist of the following:

- Bedding Layer
- Flexible Membrane Liner
- Bedding Layer
- Crushed Aggregate Layer
- Asphalt Paving Layer

The exact specifications for each of these layers will be developed during the 95% design if this engineered barrier is selected. Details that will be determined include: thickness of each layer, type and thickness of FML, necessity of bedding layer (to protect membrane), construction material of bedding layer (typically sand), construction of crushed aggregate layer (typically CA-6 crushed stone), need for and type of drainage system used between the pavement and the FML, and the exact thickness of the asphalt paving layer.

5.2.2.2 Impermeable Asphalt Alternative

MatCon is the impermeable asphalt selected for analysis. MatCon consists of a proprietary binder with very specific aggregates. MatCon was specifically designed for situations where a permeability of $1x10^{-7}$ cm/sec is required. The performance of this technology was tested by U.S. EPA during a Superfund Innovative Technology Evaluation (SITE) using both field and laboratory testing. MatCon is installed using standard asphalt installation equipment, and will be certified to have an in-place hydraulic conductivity less than $1x10^{-7}$ cm/sec, based on laboratory testing. If this engineered barrier is selected for use, specifications and further detail will be provided in the 95% design.

5.2.2.3 Feasibility Analysis and Selection of Alternative

The major disadvantage to the asphalt/geomembrane engineered barrier is the difficulty of ensuring that the FML is acting as an effective impermeable layer after installation. Another disadvantage of this alternative is that two additional layers of bedding material will be required, therefore increasing the overall thickness of the engineered barrier, and increasing costs over standard installation of asphalt paving. The major advantage associated with the asphalt/geomembrane engineered barrier is that installation is very standard and could be performed by a large number of firms, which would lead to a competitive bidding process on the overall scope of work.

The major disadvantage to the impermeable asphalt is that only one manufacturer can provide the proprietary binding agent, preventing competitive bidding on the overall scope of work. However, a large number of firms could bid on the installation process because of the standard equipment used. Another disadvantage of the impermeable asphalt is the increased cost over an asphalt/geomembrane engineered barrier. The major advantage of the impermeable asphalt is the ability to determine if the engineered barrier is performing properly and obstructing water from entering the soil. Since the asphalt is essentially impermeable, if the surface of the pavement does not show any cracking, then the technology is properly working. This is in contrast to the asphalt/geomembrane engineered barrier, in which it will be very difficult to ensure that the membrane under the pavement, aggregate, and bedding layer has retained its effectiveness following installation of all layers. Two final advantages of the impermeable asphalt is the reduced thickness of the barrier and the superior wearing characteristics.

Based on the advantages and disadvantages of the asphalt/geomembrane and impermeable asphalt, it has been decided that the impermeable asphalt will be utilized as the engineered barrier in Area 2 East. The 95% design will include further detail regarding the impermeable asphalt, and will include a specification and drawing detailing the construction techniques. The cost estimate included in Section 11 includes MatCon as the engineered barrier for Area 2 East.

5.3 5-ACRE FILL AREA CAP DESIGN

5.3.1 Design Criteria

The design criteria for the cap in the 5-Acre Fill Area are as follows:

- Install an asphalt, concrete, or structure cap over the impacted soil in the 5-Acre Fill Area to prevent ingestion and direct contact with soil exceeding MCSs.
- Select the type of cap (asphalt, concrete, soil, or structure) throughout the 5-Acre Fill Area based on the redevelopment plans for the facility.

5.3.2 Design Basis

As per the Final Decision Document (U.S. EPA, 2005a), an asphalt cap will be installed in the 5-Acre Fill Area. Based on the proposed redevelopment plans for the facility, the uses of three types of caps (asphalt, concrete, structures, or soil) are proposed for the 5-Acre Fill Area. The basis of this design is to determine the effectiveness of the four types of caps that will accomplish the design criteria listed above. The construction of the four types of caps is discussed in the following subsections. In addition, an analysis of the potential settlement at the site and the planned surface water management system will also be presented in subsections below.

5.3.2.1 Asphalt

The exact design of the asphalt pavement that will be used in the 5-Acre Fill Area cap will be based on the final redevelopment plans. The preliminary site layout illustrated in Figure 5-1 details the proposed location of the asphalt, concrete, and structures within the 5-Acre Fill Area. Design details and specifications will be included within the 95% design submittal.

5.3.2.2 Concrete

The exact design of the concrete pavement that will be used in the 5-Acre Fill Area cap will be based on the final redevelopment plans. The preliminary site layout illustrated in Figure 5-1 details the proposed location of the asphalt, concrete, and structures within the 5-Acre Fill Area. Design details and specifications will be included within the 95% design submittal.

5.3.2.3 Structures

The exact design of the structures (building and truck-scale) that will be included as part of the cap used in the 5-Acre Fill Area will be based on the final redevelopment plans. The preliminary site layout illustrated in Figure 5-1 details the proposed location of the asphalt, concrete, and structures within the 5-Acre Fill Area. Design details and specifications will be included within the 95% design submittal.

5.3.2.4 Soil

Soil engineered barriers will be required on the side slopes of the 5-Acre Fill Area. The exact dimensions of the soil barriers will be determined based on the final redevelopment plans. The soil engineered barrier used on the side slopes of the 5-Acre Fill Area will be composed of 12 inches of soil underlain by a geotextile. The geotextile used as part of the soil cap on the side slopes of the 5-Acre Fill Area will be similar to the geotextile described in Subsection 5.1.2.3. The specification for the geotextile, which will be included in the 95% design submittal, will include one or more acceptable options that will be selected by the construction contractor based on cost, availability, and ease of installation.

5.3.2.5 Settlement Analysis

Based on the proposed redevelopment use of the 5-Acre Fill Area as a truck parking lot, settlement of the fill was examined. Although the amount of soil and asphalt will not create a significant bearing load on the fill material, the loads generated by the trucks are significant enough to warrant analysis.

A total of 8 soil borings (SB135 through SB142) were completed within the 5-Acre Fill Area as shown on Figure 4-2. Subsurface profiles (i.e., cross-sections) developed from the soil borings are presented as Figures 4-14 and 4-15. The locations of these cross-sections are shown on

Figure 4-8. As shown on the cross-sections, the site is underlain by a surficial layer of fill soils (Stratum 1) and natural clay soils (Stratum 2). The Standard Penetration Resistance values (i.e., "N") based on split spoon sampling of soil using the ASTM D1586 sampling procedures are highly variable within Stratum 1, ranging from 7 to greater than 100 blows per foot (i.e., the 52/6" N value in boring SB-140). The average N value is 21.4, neglecting the value in SB-140 and directly averaging the remaining 23 N values within Stratum 1. In addition, groundwater was encountered within the Stratum 1 fill soils in five of the eight completed borings at an approximate depth of 10 feet bgs.

The soils within Stratum 1 are also highly variable as evidenced by a total of 13 gradation tests (included within the Geotechnical Analytical Results included in Appendix A) completed within the stratum. Stratum 1 soil types include low placiticity silty clay (CL), low plasticity clayey silt (ML), silty sand (SM), clayey sand (SC), and poorly graded sand with silt fines (5 to 12%) (SP-SM). Table 5-1 summarizes data from these 13 tests including the boring and depth interval relevant to the tested sample, the USCS classification symbol, the percentage of fines, and the plasticity index (PI) of plastic soils if measured. The geotechnical variability of the Stratum 1 fill soils is evident in Table 5-1, and, therefore, soil stabilization should be completed prior to redevelopment and paving.

Proposed Soil Stabilization

The soil stabilization technique proposed for use at the 5-Acre Fill Area is deep dynamic compaction (DDC). DDC consists of the repeated dropping of heavy weights (tampers) on the ground requiring stabilization. DDC is generally performed in a square grid pattern and is completed in multiple passes. The following subsections include the basis of designing the DDC program proposed for the 5-Acre Fill Area.

Applicability of DDC to the Stratum 1 soils of the 5-Acre Fill Area

The applicability of a given soil type to stabilization (i.e., densification) by DDC is generally assessed via correlation to soil physical properties (i.e., gradation and plasticity). This assessment is generally quantified consistent with the three-zone plot system shown on Figure 5-2. As is evident from this plot, the three classifications of soil can be completed using the gradation requirement of percentage fines (i.e., soil fraction by weight which passes a number 200 sieve) and the plasticity property of PI. As shown on Figure 5-2, there are three zones of soils that have the following properties:

- Zone 1 – has less than 29% fines and a PI equal to 0, and is the most suitable for DDC.
- Zone 2 – has less than 90% fines and a PI greater than 0 but less than 8, and is less suitable than Zone 1 but acceptable for DDC.
- Zone 3 – has greater than or equal to 90% fines and a PI greater than 8, and is least suitable for DDC.

The previously listed criteria have been used to assign a zone number (1, 2, or 3) to the data summary of the gradation tests presented in Table 5-1. As evident from this data, seven of the 13 samples classify as Zone 1, three of the 13 samples classify as Zone 2, one of 13 samples classifies as Zone 3, and two of 13 samples classify as Zones 2 or 3 (i.e., conflicting classification based on gradation results and PI value).

Based on the above discussion in which a total of 77% (10 of 13 samples) of the tested soil samples classify as either Zone 1 or Zone 2 soil types, DDC should represent a technically viable and efficient stabilization technique for densifying the loose soils of Stratum 1 at the 5-Acre Fill Area.

5.3.2.6 Surface Water Management

After installation of the cap in the 5-Acre Fill Area, the stormwater runoff generated from the impermeable surfaces (asphalt, concrete, and structures) will require management. The 95% design submittal will include design calculations related to the management of stormwater, and will be designed using the Soil Conservation Service (SCS) Runoff Curve Number method. Discussions are currently ongoing with the City of Chicago Department of Water Management regarding discharge of surface water from the site.

5.4 25-ACRE FILL AREA ENGINEERED CAP DESIGN

5.4.1 Design Criteria

The design criteria for the engineered cap in the 25-Acre Fill Area are as follows:

- Install a multilayered engineered cap over the impacted soil in the 25-Acre Fill Area to accomplish the following:
  - Prevent infiltration of precipitation into the soil,
  - Prevent ingestion and direct contact with soil that exceeds MCSs,
  - Eliminate the inhalation exposure pathway.
- Comply with all applicable regulations and guidance ARARs regarding construction of an engineered cap.

5.4.2 Design Basis

As per the Final Decision Document (U.S. EPA, 2005a), an engineered cap will be placed over the 25-Acre Fill Area. Components of the engineered cap, from bottom to top, will consist of the following:

- Grading Layer
- Flexible Membrane Liner
- Drainage Layer
- Fill Layer
- Vegetative Layer

A detailed discussion of each component of the engineered cap and geotechnical analysis based on the results of the Predesign Investigation are presented in the following subsections.

5.4.2.1 Borrow Source Analysis

The engineered cap system requires various types of soil materials not available on site. Therefore, a borrow source search was initiated to identify locations capable of supplying the necessary materials in the required quantities. The borrow source analysis can be found in Appendix B.

5.4.2.2 Grading Layer

The purpose of the grading layer is to prepare a suitable base on which to construct the cover and to create the necessary grades required for effective drainage prior to construction of the engineered cap system. Two grading plans were developed for this 30% design, the first grading plan (preliminary), shown in Figure 5-3, was developed as a “worst-case scenario”. This grading plan assumed that interior slopes were 5% and swale slopes were 0.5%, and was used in the design calculations discussed below in Subsection 5.4.2.6. The second grading plan (second iteration), shown in Figure 5-4 was developed after the design calculations were completed and assumed interior slopes were 4% and swale slopes were 1%.

The interior slopes were decreased in the grading plan in Figure 5-4 based on the results of the design calculations, which illustrated that an initial designed slope of less than 5% could be used to still meet the slope requirements following settlement. Also, the slopes of the swales were increased to ensure that ponding within the swales did not occur. Based on the grading plan shown in Figure 5-4, some excavation will be required within the limits of the 25-Acre Fill Area. The excavation is necessary to minimize the amount of fill required for the grading layer and to minimize the overall height of the final layers of the engineered cap.

Prior to undertaking any excavation deeper than 2 ft bgs within the 25-Acre Fill Area, an exploratory soil boring program will be undertaken. Excavations that do not extend beneath 2 ft bgs will not be investigated because they will not extend beneath the existing soil cap. In areas where excavation will extend deeper than 2 ft bgs, a Geoprobe will be used to advance a stainless steel sampling core to an approximate depth of 4 ft bgs in the areas where excavation into the existing material are planned. Descriptions of the soil samples recovered from the Geoprobe investigation will be recorded on field logs. It is estimated that one soil probe will be completed every 25 ft^2. The probe will be advanced to determine if any obstructions exist in the area, and to determine the thickness of the existing soil cap in the areas where excavation will occur.

The grading layer will be comprised of clean off-site fill. Some potential sources of off-site fill are listed in Appendix B. It is very likely that soil used for the grading layer may be obtained from the Illinois Department of Transportation (IDOT) from the Dan Ryan Expressway Reconstruction Project. It is anticipated that this soil will be obtained prior to full-scale implementation of the remedial measures, and very likely that the soil will be in-place prior to submittal of the 95% design. The acceptance of IDOT soil will be addressed in a separate work plan that will be submitted to U.S. EPA for approval. If the IDOT soil is placed prior to submittal of the 95% design, the results of this soil acceptance, including analytical data and survey results.

5.4.2.3 Flexible Membrane Liner

Applicable regulations require that the FML have a minimum thickness of 30-mils, and have a minimum thickness of 60-mils when HDPE is used as the FML. On slopes steeper than 10%, a textured FML will be used, and a smooth FML will be used in all other areas. During the 95% design, the material used and required thickness of the FML will be specified. The specification regarding the FML that will be included in the 95% design will for the material type and thickness of FML that will be used, such as 60-mil HDPE or 40-mil low-density polyethylene (LDPE).

5.4.2.4 Drainage Layer

The drainage layer included as part of the engineered cap will either consist of granular material or a geocomposite drainage net. Either alternative will incorporate a geotextile between the drainage layer and the FML, either as a separate entity, or as part of the geocomposite drainage net. The choice between these two alternatives will be based on cost, availability, and ease of construction. An analysis will be performed during the 95% design phase to determine whether granular material or a geocomposite drainage net will be used as the drainage layer. For the purposes of this 30% design, it is assumed that a geocomposite drainage net will be used as the drainage layer.

5.4.2.5 Fill Layer and Vegetative Layer

The final portions of the cover system, an 18-inch thick fill layer and a 6-inch vegetative layer, will be placed using standard construction equipment and methods. Low-ground-pressure construction equipment will be used so as not to damage the geosynthetic components during placement. Temporary haul roads about three feet thick will be constructed to support trucks. The specifications, which will be prepared for the 95% design, will require periodic compaction testing and/or proof rolling to verify cover stability. Appropriate compaction will increase soil strength and essentially eliminate any post-construction settlement of the fill material.

Following the construction of the soil cover, the 25-Acre Fill Area will be vegetated. The vegetative layer will consist of pre-selected topsoil rich in organic content and nutrients necessary to support vigorous plant growth. The soil may be augmented with additional nutrients or fertilizer to enhance plant propagation. The vegetative layer will use area-appropriate seed mixtures, which will be specified in the 95% design.

5.4.2.6 Engineered Cap Design Analysis

The following subsections detail the design analyses that were completed to ensure that the composite cap meets or exceeds applicable regulations.

Hydrologic Performance Analysis

The hydrologic performance of the cover alternatives will be evaluated in the 95% design using the U.S. EPA's Hydrologic Evaluation of Landfill Performance (HELP) model (Shroeder et al., 1994). The HELP model will be used to determine the performance of sand versus a geocomposite drainage net.

Geotechnical Analysis

Geotechnical analysis was completed based on the results of the Predesign Investigation geotechnical sampling and analysis. The following subsections detail the settlement analysis and the veneer stability analysis completed for the engineered cap that will be placed on the 25-Acre Fill Area. All calculations were based on the preliminary grading plan presented in Figure 5-3.

Settlement Analysis

An analysis was completed to assess the impacts of settlement on the drainage slopes of the 25-Acre Fill Area. The site is comprised of predominantly granular fill which overlies a stiff clay stratum of native soil. Placement of fill material will impose stress on the compressible soils at the site which will result in consolidation of those materials and settlement of the ground surface. Thickness of the fill material was based on recent soil borings are estimated on profiles G-G' and H-H' shown on Figures 4-16 and 4-17, respectively. The profiles illustrate the fine grained fill material as well as the lower stratum of stiff clay. The thickness of fill material ranges up to 21 feet, and the clay stratum to 50 feet.

The 25-Acre Fill Area was subdivided into a 200-foot grid comprised of 29 nodal points encompassing the site. The grid was superimposed on site grading and topographic survey plans. Contour lines showing the top and bottom of the clay layer (Appendix C) were developed using boring logs from historical investigations and the Predesign Investigation.

Primary Settlement was estimated using conventional engineering procedures and considered the thickness of future cover materials to be placed, thickness of fill and the thickness of the clay stratum. The subsurface stratigraphy was estimated at each nodal point using the clay contour plans discussed previously in combination with the topographic survey information and the preliminary grading plan (Figure 5-3). The maximum thickness of cover material that will be placed over the original grade elevation will be approximately 11.6 feet. Groundwater levels were based on an existing groundwater map obtained from the elevations reported in a number of monitoring wells from the site. Further analysis of the settlement, including design calculations are included in Appendix C. Figure 5-5 illustrates the anticipated settlement based on the preliminary grading plan, which ranged from 0 to 7.7 inches. Future revisions of the grading plan will require settlement calculations to be recalculated to ensure that, after settlement, the slope of the engineered cap will meet the minimum requirements.

Veneer Stability Analysis

The objectives of the veneer stability analysis are as follows:

- Determine the stability of the cover soil atop the geosynthetic components of the cover system.
- Determine the minimum required interface friction shear strength necessary to achieve a static factor of safety of 1.3 with seepage forces.
- Determine the minimum required interface friction shear strength necessary to achieve a long-term, static factor of safety of 1.5.
- Assess the availability of materials that can potentially satisfy the requirements based on published data.
- Estimate the amount of deformation the landfill side-slopes will experience as a result of a seismic event.

The specific components of the capping system for the 25-Acre Fill Area have not yet been identified. However, it is assumed that a typical geosynthetic cap will be installed with 2 feet of protective cover soil. Based on the preliminary grading plan, the steepest slopes were located around the perimeter of the site beyond the perimeter drainage ditch. The inclination of these slopes was no steeper than 3H:1V (33% or 18.4°). The maximum slope length was found to be 30 feet. The flat areas of the site are inclined at a slope of 5%. The maximum length was estimated to be about 180 feet. The preliminary grading plan is presented in Figure 5-3. Analyses have not yet been completed to determine the potential hydrostatic head build up within the cover soil. Therefore, the stability analyses will also be completed to determine the maximum allowable head build-up. Further analysis of the veneer stability, including design calculations are included in Appendix C.

The analysis of veneer stability included evaluation of three critical factors, internal stability (sloughing) of the cover soils, slippage between any two components of the cover system, and permanent deformation analysis. Each of the three analyses are discussed below.

Sloughing is evaluated to account for possible shallow failure within the final cover soil and is a function of the soil strength properties, density, and moisture conditions. Two conditions were evaluated, a dry condition and a condition considering hydrostatic seepage force. The results of these analysis based on the slopes of the preliminary grading plan resulted in factors of safety greater than 1.5, which indicates that the preliminary grading plan design is acceptable.

Slippage between any two components of the cover system was evaluated using a system developed by Koerner and Soong (1998), which evaluates the minimum interface shear strength required to achieve the minimum factor-of-safety. The calculations included in Appendix C detail the minimum required friction angle for steady state conditions (21°) and the maximum allowable head buildup of 5.1 inches, with respect to 3H:1V sideslopes.

Permanent deformation analysis was evaluated using a system developed by Matasovic (1991), Makdisi, and Seed (1978) to evaluate the stability of the cover system under a seismic event. The analysis was based on the minimum shear strength calculated to be required to provide an adequate static factor-of-safety (1.0) against instability on the 3H:1V sideslopes. The result of this analysis was an anticipated deformation of less than 3 inches following a seismic event, which should not pose a significant risk to the integrity and performance of the engineered cap.

Drainage Layer Transmissivity

The purpose of a drainage layer is to transmit precipitation that percolates downward through the cover soil layers to an outlet. This minimizes the time water is in contact with the FML and reduces the hydraulic head over the FML, thereby reducing the potential for sloughing and instability of the overlying soil layers. During the 95% design phase, the drainage layer will be analyzed to ensure that transmissivity of the layer will adequately drain percolated water from the cover system.

Vegetative Layer Erosion

The primary purpose of the vegetative cover soil layer is to sustain vegetative growth. A good stand of vegetation will reduce the potential for erosion, thus protecting the entire final cover system section. Excessive erosion creates maintenance problems. Erosion is also a factor in assessing the adequacy of the thickness of the surface soil, which protects the underlying layers.

The cover system will be evaluated on the basis of potential soil loss using the Universal Soil Loss Equation (USLE) in the 95% design submittal.

Landfill Gas

As shown in the Predesign Investigation results presented in Section 4, the landfill gas generation within the 25-Acre Fill Area is extremely minimal. However, because any accumulation of landfill gas under the FML can jeopardize the integrity of the cap, landfill gas vents will be installed at the points of highest elevation to ensure adequate long-term performance of the engineered cap. The exact construction and number of gas vents will be specified in the 95% design submittal. Based on the results of the Predesign Investigation, no monitoring of the gas vents will be required following installation.

5.4.2.7 Surface Water Management

After installation of the engineered cap, the stormwater runoff generated from the impermeable FML will require management. The 95% design submittal will include design calculations related to the management of stormwater, and will be designed using the SCS Runoff Curve Number method. Discussions are currently ongoing with the City of Chicago Department of Water Management regarding discharge of surface water from the site.

5.5 SHEET PILE DESIGN

5.5.1 Design Criteria

The design criteria for the steel sheet pile wall in Area 2 East are as follows:

- Install a steel sheet pile wall around Area 2 East to accomplish the following:
    - Prevent migration of constituents in soil that exceed MCSs, thereby eliminating the migration of groundwater pathway,
    - Minimize infiltration of perched water from other areas into Area 2 East,
    - Maintain adequate thickness and integrity of steel to ensure the proposed design life of 50 years is achieved.

- Comply with all applicable regulations and guidance ARARs regarding construction of a hydraulic containment barrier.

5.5.2 Design Basis

The design of the steel sheet pile wall will be based on the following parameters: driving stress, ability to withstand corrosion and obtain the effective design life of 50 years, and the amount of seepage that will occur through the sheet pile wall.

5.5.2.1 Driving Stress

The purposes of evaluating the required driving stress of the steel sheet piles is to determine an acceptable hot-rolled steel sheet piling section as well as driving hammer characteristics that will allow efficient and effective installation of the sheets without structurally damaging the sheets (e.g. bending, cracking) during their installation.

The minimum required structural characteristics of sheet pile, consistent with the subsurface environment the sheets are to be driven into, may be developed through correlating minimum required section modulus (S_{reqd}) versus a representative standard penetration resistance value (N_{reqd}) for the subsurface conditions. Boring logs and geotechnical data generated during the Predesign Investigation were used to determine the standard penetration resistance value. Also, the required sheet depth was determined by plotting standard-size sheets along the subsurface profile for Area 2 East generated previously (Figure 4-10). The approximated sheet lengths and the depth of driving to ensure a minimum of 3 feet penetration into the clay stratum soils are shown in Figure 5-6. Further analysis of the driving stress, including design calculations, are included in Appendix C.

Based on the design calculations listed in Appendix C, the minimum required section modulus is 28.3 cubic inches per foot (in^3/ft). Two common steel sheet piling sections have actual section moduli (S_{act}) that satisfy this criterion, AZ-18 (S_{act} = 33.5 in^3/ft) and PZ-27 (S_{act} = 31.0 in^3/ft). AZ-18 is manufactured by Arcelor S.A., and marketed by Skyline Steel, LLC. PZ-27 is manufactured and marketed by Chaparral Steel Company.

The Final Decision Document (U.S. EPA, 2005a) states that a Waterloo Barrier will be used as the hydraulic containment barrier in Area 2 East. Based on the above calculations, the Waterloo Barrier cannot be used as the hydraulic containment barrier because the steel sheets manufactured by Waterloo Barrier are only available with two section moduli, 15.9 and 24.9 in^3/ft, which are both below the S_{reqd} of 28.3 in^3/ft.

In the design calculations (Appendix C), a number of parameters are calculated that will be specified in the specifications that will be included in the 95% design. The parameter calculated for the two sections of steel include the maximum permissible rated hammer energy of an impact pile hammer, and the ability to drive steel sheets with a vibratory pile hammer and maximum permissible vibratory hammer energy. In addition, the specifications included in the 95% design will incorporate the results of the subsurface obstruction investigation summarized in Section 4.3.1. The results of this investigation will allow the sheet pile installation subcontractor to accurately determine the best method of sheet pile installation and subsurface obstruction removal. In addition, the sheet pile specification that will be included in the 95% design submittal will detail the procedures for either abandonment or relocation of the underground utilities in Area 2 East.

5.5.2.2 Corrosion Evaluation

The corrosion of the steel sheet piles in contact with site soil and groundwater is an important design consideration. The results of the corrosion testing analysis completed during the Predesign Investigation (Section 4.4) were used to ensure that the sections of steel sheet piling have an adequate design life of 50 years. The corrosion testing indicated a maximum corrosion rate of 5.1 mils per year, which equates to 0.0051 inches per year. The design calculations included in Appendix C examined both potential steel sections (AZ-18 and PZ-27) to calculate the estimated design life based on the thickness of steel (flange and web). The estimated design life of both AZ-18 and PZ-27 were calculated to be 73.5 years, which is acceptable, based on an anticipated design life of 50 years.

5.5.2.3 Seepage Analysis

The final design consideration for the steel sheet pile wall that will be installed in Area 2 East is the amount of seepage that will occur between the sheet pile joints, based on the assumption that the site will be dewatered by the groundwater collection system, which will create an inward hydraulic gradient. The amount of seepage will be used as a design consideration in the groundwater collection system (Section 5.6).

For this analysis, it is assumed that either AZ-17 or PZ-27 hot-rolled steel sheet piles with ball and socket interlocks will be used at the site. It is also assumed that the sheet piles will be driven into the clay stratum to a minimum depth of 3 feet and the area within the sheet pile wall will be capped with an impervious surface. The soil properties and groundwater elevations used for these calculations were obtained from the information generated during the Predesign Investigation. The groundwater elevation outside of the sheet pile wall was conservatively assumed to exist at a constant elevation equal to the highest elevation at which groundwater was encountered during the Predesign Investigation. The final assumption used when calculating seepage is that the steel sheet piles are impervious surfaces, and seepage will only occur through the sheet piling interlocks.

The seepage calculations were performed on the following six scenarios for the two types of steel:

- Standard interlocks, single sheets – all sheets will be driven individually and nothing will be added to the interlocks.
- Welding of interlock joint, double sheets – each pair of sheets will be welded together before installation (reducing the number of interlocks by half).
- Interlocks with bituminous filler material, single sheets – all sheets will be driven individually and all female sheet pile interlocks will be treated with a bituminous filler material before installation.
- Interlocks with bituminous filler material, double sheets – all sheets will be driven as a pair after welding of joints (reducing the number of interlocks by half) and every non-welded female sheet pile interlock will be treated with a bituminous filler material before installation.

- Interlocks with water-swelling filler, single sheets – all sheets will be driven individually and all female sheet pile interlocks will be treated with a water-swelling product before installation.

- Interlocks with bituminous filler material, double sheets – all sheets will be driven as a pair after welding of joints (reducing the number of interlocks by half) and every other female sheet pile interlock will be treated with a water-swelling material before installation.

The results of these calculations are summarized in Table 5-2. Total volume of inflow, which ranges from approximately 105,000 to 4.4×10^8 gallons, is illustrated in Table 5-2, along with the associated amount of groundwater elevation increase, which ranges from approximately 6 inches to 2,200 feet. These calculations assumed that the inflow rate listed was constant and the fill soils in Area 2 East have a porosity of 30%. Table 5-2 clearly illustrates that a one-time dewatering effort could not be undertaken unless the water-swelling joint filler is used (because the elevations listed for the other options exceed the depth of fill in Area 2 East). Also, the difference in seepage between the driving single and double sheets is minimal and the cost to weld the sheets together is significant. Therefore, the specifications that will be included in the 95% design will specify that either AZ-17 or PZ-27 hot-rolled steel sheet piles with ball and socket interlocks will be used, single sheets will be driven, and every other female sheet pile interlock will be treated with a water-swelling joint filler.

5.6 GROUNDWATER COLLECTION SYSTEM DESIGN

5.6.1 Design Criteria

The design criteria for the groundwater collection system in Area 2 East are as follows:

- Install a groundwater collection system inside of the sheet pile wall in Area 2 East to accomplish the following:
  - Collect groundwater that contains concentrations above MCSs,
  - Create an inward gradient to ensure that water inside the sheet pile wall does not migrate,
  - Effectively dewater the area within the sheet pile wall to eliminate the need for further water collection.

- Comply with all applicable regulations and guidance ARARs regarding collection, transportation, and disposal of groundwater.

5.6.2 Design Basis

The design of the groundwater collection system was based on the following parameters:

- Groundwater collection will not begin until the sheet pile wall and impermeable asphalt cap have been installed in Area 2 East.
- Groundwater collection will occur only once (unless monitoring indicates otherwise) to dewater as much of the area as possible and the extremely minimal seepage through the sheet pile wall and impermeable asphalt will ensure that further pumping will not be required.
- The groundwater collection system will utilize submersible pumps within newly installed wells.
- Groundwater collected will be pumped from the wells to temporary storage tanks located in close proximity to the pumps.
- Groundwater collection will be completed during warmer months and therefore will not require freeze protection of the above-ground piping system.
- The amount of seepage will be negligible.

Further detail regarding the pumps, wells (location and size), piping, and storage tanks will be provided in the 95% design.

5.7 BIOREMEDIATION SYSTEM DESIGN

5.7.1 Design Criteria

This subsection provides a summary of the state and federal regulations related to the design and operation of the *ex-situ* bioremediation system. The design constraints were based on the following regulations:

- 35 IAC Part 215: Emission Standards and Limitations for Stationary Sources – Organic Material Emissions Standards and Limitations

- 40 CFR Part 63: National Emission Standards for Hazardous Air Pollutants for Source Categories

Additional design criteria will be identified, as necessary, during the 95% Design phase.

5.7.2 <u>Design Basis</u>

The bench-scale study conducted during the Predesign Investigation forms the basis for the design for the bioremediation system planned for the benzene-impacted soils in Area 2 East. The design of the bioremediation system will be based on using the full-scale bioremediation treatment to reduce concentrations of benzene to acceptable levels. Further detail regarding treatment objectives is included in the consolidation discussion below. The results of the bench-scale study are discussed in detail in Section 4.5. The following elements will be examined during the design of the *ex-situ* bioremediation system:

- Treatment pad, location, and design
- Excavation
- Debris Removal and soil handling
- Moisture content
- Soil nutrients
- Microbes
- Soil tilling/aeration
- Sampling and analysis
- Off-gas controls and treatment

A detailed discussion of each component of the *ex-situ* bioremediation process based on the results of the Predesign Investigation is presented in the following subsections.

The remedial measures associated with soil allow for the use of the 25-Acre Fill Area as an on-site consolidation option for excavated soil, including the soil from Area 3 East that will undergo *ex-situ* bioremediation. The 25-Acre Fill Area where excavated soil could be consolidated would be designated as a Corrective Action Management Unit (CAMU), and therefore excavation of soil from other areas and consolidation within the 25-Acre Fill Area under the engineered cap would not trigger land disposal restrictions (LDRs) or minimum technology requirements (MTRs), in accordance with 40 CFR 264.552. The CAMU regulations state the following regarding CAMU eligible wastes: “All solid and hazardous wastes, and all media (including ground water, surface water, soils, and sediments) and debris, that are managed for implementing cleanup." Therefore, soil can be consolidated within the 25-Acre Fill Area under the CAMU rule since it is 'CAMU-eligible waste'.

In addition, 40 CFR 264.552 (e)(4)(iv)(A) states that the amount of reduction of organic constituents "must achieve 90 percent reduction in total principal hazardous constituent concentrations". Therefore, the bioremediation process will be designed to reduce the benzene concentrations within the impacted soil by 90%. The determination of the overall treatment standard is discussed further in the sampling and analysis subsection.

5.7.2.1 Treatment Pad, Location, and Design

The specifics regarding the treatment pad, location, and design features will not be discussed in detail in this 30% design, but will be included within the bioremediation specification that will be included within the 95% design. The treatment pad location will be determined following placement of the grading layer soil that will be obtained from the Dan Ryan Expressway Reconstruction project. In general, the treatment pad will have the following characteristics:

- Located within the extent of the 25-Acre Fill Area (prior to implementation of the remedial measure for the 25-Acre Fill Area)
- Constructed of an impermeable material, such as asphalt, concrete, or a FML
- Sufficient size for treatment
- Ability to contain excess treatment water runoff or stormwater that may have come in contact with the soil
- Ability to easily collect any contained water, such as a blind sump

5.7.2.2 Excavation and Backfill

The area that will be excavated is shown in Figure 5-7. The depth of excavation is anticipated to vary across the area. Soil will be direct-loaded into trucks for transportation to the treatment area within the 25-Acre Fill Area. Large sections of debris will not be loaded into trucks, but will be stockpiled for transportation and disposal at an appropriate off-site facility in accordance with all state and federal requirements. The horizontal and vertical limits of excavation are illustrated in Figure 5-7. The vertical extent of excavation varies throughout the excavation, and is based on the vertical delineation provided by the soil samples. When the limits of the excavation have extended to the limits shown in Figure 5-7, verification samples will be collected and analyzed for BTEX.

Analytical results of the verification samples will be compared against an "excavation criteria" to determine if excavation should continue. The excavation criteria is proposed as 10% of the soil saturation limits (C_{sat}) for the BTEX compounds, as specified in 35 IAC Part 724, Table A. The excavation criteria for this area are as follows:

- Benzene – 87 mg/kg (Csat = 870 mg/kg)
- Toluene – 65 mg/kg (Csat = 650 mg/kg)
- Ethylbenzene – 40 mg/kg (Csat = 400 mg/kg)
- Total Xylene – 32 mg/kg (Csat = 320 mg/kg)

If verification sampling results indicate that BTEX concentrations exceed the excavation criteria, then excavation will continue. After the continued excavation, additional verification samples will be collected. This cycle will continue until verification samples indicate that BTEX concentrations are below the excavation criteria.

Following completion of excavation activities and successful verification sampling, the excavation will be backfilled. If groundwater is present within the excavation, it will be pumped out by a vacuum truck and transported off-site for treatment and disposal in accordance with state and federal regulations. The open excavation will be backfilled with clean soil or aggregate obtained from an off-site source. Further detail on the backfilling and compaction process will be included within the specifications, which will be included in the 95% design.

5.7.2.3 Debris Removal and Soil Handling

After the soil is moved to the treatment area within the 25-Acre Fill Area, it will be placed from the trucks onto the treatment pad. The first step in the treatment process will be to remove the oversize debris from the soil that will be treated. The exact definition of "oversize debris" is dependent on the material handling equipment that will be used to turn the treatment piles or windrows. The anticipated equipment will be specified in the specifications, which will be included in the 95% design. Therefore, the 95% design will also include the definition of oversize debris, and will specify the anticipated removal methods (exact method will be determined by subcontractor). It is anticipated that a multi-step physical removal method, such as screening the soil with a grizzly screen or punch-plate (to remove the large debris), followed by the use of a vibratory screen or screen-mill (to remove smaller debris down to the optimal size). Debris removal is extremely important to allow for adequate mixing of the soil during the treatment process, which ensures uniform removal of organic constituents.

Following removal of oversize debris, the soil will be formed into windrows. The exact number and placement of the windrows will be determined in the 95% design. The bioremediation specification that will be included in the 95% design will specify the exact windrow forming procedures, including the maximum height and width of windrows.

5.7.2.4 Moisture Content

As specified in the Bench-Scale Bioremediation Study, the ideal soil moisture level ranges from 30 to 40 percent (%) of the soil's water holding capacity, which equates to an approximate moisture content of 20%. Moisture content of the soil being bioremediated will be maintained at the optimal level (approximately 20%) during the duration of the study. Additional water will be added to the treatment windrows by the use of automatic sprinklers, or by hand-watering. All water added to the soil during the bioremediation will be potable, municipal water from the City of Chicago, and will be obtained from an on-site fire hydrant. Optimal moisture content will be monitored by periodic sampling, which is further discussed in Subsection 5.7.2.8.

5.7.2.5 Soil Nutrients

The microbes responsible for the biodegradation of organic constituents need nutrients, in addition to organic constituents, to effectively function. The macronutrients carbon, nitrogen, and phosphorus should ideally be present in the soil at a ratio of 100:10:1, respectively. The commercially-available nutrient used in the bench-scale study was Alken Murray's Bio-Nutrient 4.

5.7.2.6 Microbes

The commercially-available microbes used in the bench-scale study were Alken Murray's diesel degrader, Alken Clear-Flo® 7037 and gasoline degrader, Alken Clear-Flo® 7038. Both blends of microbes are highly concentrated, with a microbial concentration of $3x10^9$ CFU/g. The manufacturer suggests, and the study utilized, an inoculation rate of 0.5 lb/yd^3. Inoculations were performed initially, and after the second week of the study. Either of these microbes or an equivalent type of microbe will be used during the full-scale treatment. The final selection of microbes will be based on availability and cost.

As shown in Table 4-8 and Figure 4-22, the overall concentration of microbes was below detection limits or extremely low within all of the test samples during the first 5 to 6 weeks of the study. Based on these low levels, it is anticipated that one additional inoculation will be performed. During full-scale treatment, an inoculation will be performed initially, after the first week, and after the third week of treatment. The additional microbes induced into the treatment process will accelerate the treatment process. In addition, based on the sampling and analysis discussed below, if the microbe concentration begins to decrease significantly during the later phases of the study, another inoculation will be performed.

5.7.2.7 Soil Tilling/Aeration

The specifics regarding the tilling/aeration will not be discussed in detail in this 30% design, but will be included within the bioremediation specification that will be included within the 95% design. In general, it is assumed that soil tilling and/or aeration will be used to ensure that aerobic conditions are maintained within the treatment piles. The soil tilling will be completed mechanically by a material handling machine that will be specified in the specifications included in the 95% design. The aeration system can either be a positive pressure air system (blowing air into the soil), or a negative pressure air system (drawing air into and through the soil). The design of the aeration system will depend on the calculations performed in the 95% design relating to the off-gas treatment or lack thereof (Subsection 5.7.2.9).

5.7.2.8 Sampling and Analysis

The sampling and analysis program will be composed of the following components:

- Initial sampling
- Verification sampling
- Baseline sampling
- Weekly sampling
- Final sampling

Each of the sampling portions will be discussed in further detail in the subsections below.

Initial Sampling

Initial sampling will be completed during the excavation process to establish the treatment objectives, which is a reduction in concentration by 90%. A total of 10 grab samples will be collected from the excavation and/or the excavated soil for analysis of BTEX. The treatment objectives will be determined by first calculating the arithmetic average of all of the concentrations. Any samples where BTEX compounds are below the laboratory detection limits will not be included in this arithmetic average. The treatment objectives for each of the BTEX compounds would then be determined by calculating 10% of the initial concentration arithmetic average.

Verification Sampling

Verification sampling will be completed following the planned excavation. All verification samples will be collected as grab samples. No compositing of samples will be completed during verification sampling. Samples will be collected from the following locations in the excavation:

- Vertical verification samples will not be required in the majority of the excavation because the benzene-impacted soil has been previously delineated. As shown in Figure

5-7, there are nine sections of excavation that will be excavated to varying depths. Only the southern section (around CDT-SB006) will require vertical verification sampling.

- One verification sample from the floor of the excavation around CDT-SB006 will be collected for every 500 square feet (ft^2) of floor area, with a minimum of two samples collected, and the number of samples will be rounded up when the area exceeds a multiple of 500 ft^2. For example, if the excavation floor has an area of 1,800 ft^2, then 4 samples will be collected.

- Two verification samples from each wall of the excavation will be collected for every 20 linear feet (LF) of wall length, with a minimum of two samples collected per wall, and the number of samples will be rounded up when the length exceeds a multiple of 20 LF. For example, if one of the excavation walls has a length of 42 LF, then 6 samples will be collected from this wall.

All samples will be collected from areas where signs of organic constituents are present, such as odors, staining, or indication by field screening methods (FID/PID). If signs of organic constituents are not present, then the Field Engineer will determine logical points where samples will be collected. Verification samples will be collected in accordance with the QAPP, which is further discussed in Subsection 12.1.1.4.

Baseline Sampling

Prior to initiating treatment, samples will be collected to adequately characterize the baseline concentrations in the soil that will be undergoing bioremediation. The number of samples required will be specified in the bioremediation specification, which will be included in the 95% design. The following analysis will be performed on the initial samples:

- BTEX
- Ammonia-N
- Nitrate-N
- Orthophosphate
- Moisture content

Weekly Sampling

Weekly sampling of all of the treatment piles will be conducted in order to monitor the progress of the treatment process, determine if treatment parameters are sufficient (nutrient levels, moisture content, and microbial count), and to determine if treatment has adequately reduced the concentrations below the treatment objectives.

The exact number of samples and sample collection methods will be detailed in the QAPP, which is further discussed in Subsection 12.1.1.4. Weekly samples will be analyzed for the following:

- BTEX
- Ammonia-N
- Nitrate-N
- Orthophosphate
- Moisture content
- Microbial count

The Field Engineer will be able to adjust the sample collection frequency during the study duration if necessary. For example, if weekly sampling indicates that BTEX concentrations are approaching the treatment objectives, the next round of samples may be collected before the scheduled weekly sampling. Also, during the initial phase of the study, it may be determined that weekly sampling may be more than is necessary, and the sample duration may be extended.

Final Sampling

When the weekly sampling indicates that the BTEX concentrations within a treatment pile or a section of a treatment pile have been reduced to meet the treatment objectives, final sampling of that pile or section of pile will be conducted. Final sampling will consist of collection of two verification samples per 100 yd^3, or a minimum of one sample per treatment pile (regardless of size) that will be analyzed for BTEX.

5.7.2.9 Off-Gas Controls and Treatment

During the 95% design, the state, local, and federal regulations will be reviewed to determine if off-gases from the treatment process will need to be captured and treated. This determination will be made by comparing the allowable emission rates (pounds per hour or pounds per year) with the anticipated emissions from the treatment process. The anticipated emission rates from the treatment process will be estimated by determining the total emissions, which is the total concentration in the soil being treated (average concentration of VOC multiplied by total mass of soil) multiplied by a factor of 0.15 (factor generated from bench-scale study stating that 15% of organic constituent reduction is due to volatilization) and dividing by the estimated treatment duration. If off-gas controls and treatment is required, the specific treatment elements will be detailed in the bioremediation specification that will be included in the 95% design. In addition, if off-gas controls and treatment are required, sampling of the off-gasses (to determine if controls and treatment are still necessary as treatment progresses) and the treatment process (to determine that the treatment process is effective) will be detailed in the QAPP.

5.7.2.10 Completion of Study

After the final sampling (discussed above) indicates that BTEX concentrations have met the treatment objectives, the soil will be removed from the treatment pad and graded in the 25-Acre Fill Area as part of the grading layer.

Grading and compaction of this treated soil will be completed according to the specifications detailing grading and compaction of general fill at the site. In addition, after treatment of all soil has been completed, the treatment pad will be removed and recycled or disposed of at an off-site facility in accordance with state and federal regulations.

5.8 EXCAVATION AND ON-SITE CONSOLIDATION

This section presents the 30% design of the proposed excavation within Area 3 West and on-site consolidation within the 25-Acre Fill Area. This planned excavation and on-site consolidation will only be possible if the remedial measure for Area 3 West is completed prior to completion of the remedial measure for the 25-Acre Fill Area.

5.8.1 Excavation

The area shown on Figure 5-8 will be excavated to remove the soil with chromium concentrations exceeding the MCS. The area of excavation is anticipated to extend approximately 15 feet south of soil boring YPP-SB094. The northern, eastern, and western extents of the excavation are defined by YPP-SB092, YPP-SB093, and YPP-SB095, respectively. In addition, the northern extent of the excavation is, and extending to YPP-SB091 and YPP-SB095 to the north. The excavation will extend to a depth of 2 feet bgs, as the soil samples with chromium concentrations exceeding the MCS were collected from a depth of 0 to 1 foot bgs, and therefore the vertical extent of contamination has been defined. Following excavation, verification samples will be collected and analyzed for chromium to determine if the excavation removed the impacted soil. Further information regarding verification sampling is detailed in Subsection 5.8.2. If the verification sampling analytical results show that concentrations of organic constituents above the MCS still remains, excavation will continue and additional verification samples will be collected. This process of verification sampling and further excavation would continue until verification sampling indicates that all soil with elevated concentrations of organic constituents has been excavated.

5.8.2 <u>Verification Sampling</u>

Verification sampling will be completed following the planned excavation. All verification samples will be collected as grab samples. No compositing of samples will be completed during verification sampling. Verification samples from the floor of the excavation will not be necessary, as the vertical extent of contamination (2 feet bgs) has been determined from previous soil samples. Samples will be collected from the following locations in the excavation:

- Two verification samples will be collected from the southern wall of the excavation. Each of the four walls of the excavation (assuming that all wall lengths are equal to or less than 20 LF; if any wall length exceeds 20 LF, then one additional sample will be collected for every 20 LF of wall exceeding 20 LF).

Excavation wall samples will be collected from the mid-point of the wall height (i.e., if the excavation is 2 feet deep, samples will be collected from 1 foot bgs) and length (i.e., if an excavation wall is 45 LF, the samples will be collected 15 feet from the edges of excavation walls). Verification samples will be collected in accordance with the QAPP, which is further discussed in Subsection 12.1.1.4.

5.8.3 Consolidation

Soil will be excavated and direct-loaded into trucks for relocation to the 25-Acre Fill Area. The excavated soil will only be consolidated on the 25-Acre Fill area if it is determined by the Field Engineer that no large debris is present and the excavated soil is of sufficient geotechnical quality to be acceptable for use as the grading layer under the engineered cap in the 25-Acre Fill Area. Following transportation to the 25-Acre Fill Area, the soil will be deposited in lifts (where space is available) as part of the grading layer, which is located beneath the protective layers of the engineered cap. Field notes will be collected, and a rough as-built drawing will be prepared showing the areas where on-site soils were consolidated. Consolidated soil will be placed in lifts and compacted in a similar manner to the other soils being used for the grading layer.

SECTION 6
GROUNDWATER MONITORING PLAN

This groundwater monitoring plan has been prepared in accordance with Attachment A, Task II of the Consent Decree, which outlines the remedial measures to be implemented based on the Final RMS Report Approval and Final Decision and Response to Comments (U.S. EPA, 2005). This plan outlines the groundwater sampling of the shallow groundwater at the site. Plan modifications, if any, will be submitted as part of the 95% design report.

Short-term and long-term groundwater monitoring have been identified as the remedial measures as outlined in the Final RMS Report Approval and Final Decision and Response to Comments (U.S. EPA, 2005). This document identifies the monitoring wells to be sampled and describes the scheduled frequency of sampling and analysis over the course of the short- or long-term monitoring period. The objectives of establishing the groundwater monitoring program include:

- Ensure constituents in groundwater do not migrate from the site at concentrations that would present an unacceptable risk to human health and the environment;
- Confirm the reduction in constituent levels in groundwater beneath the site over time; and
- Determine whether MCSs for shallow groundwater are achieved.

This groundwater monitoring plan outlines the procedures for effectively accomplishing these objectives.

The first step in both the short- and long-term groundwater monitoring is to establish a baseline. The baseline for the Facility will be established by performing one year of quarterly sampling (four rounds). The quarterly baseline sampling for all areas, excluding Area 2 East (which will begin after installation of the sheet pile wall and impermeable asphalt), will begin prior to completion of the remedial measures design process. A work plan for this baseline sampling, Work Plan for Baseline Quarterly Groundwater Monitoring (WESTON, 2006) was submitted to U.S. EPA for review, and the approval letter was issued on 3 March 2006. Additional detail regarding the four quarters of baseline monitoring are included within the approved Work Plan, which has been included as Appendix E. Therefore, additional detail regarding the baseline sampling will only be discussed below for Area 2 East, which was not included in the approved work plan included in Appendix E.

6.1 SHORT-TERM MONITORING

A short-term groundwater monitoring program focusing on shallow groundwater will be implemented for Areas 1, 2 West, 3 East, 3 West, 4, and the 5-Acre Fill Area. It is assumed that short-term shallow groundwater monitoring will be used to evaluate if any contingency remedial measures are required. The baseline sampling for these areas is detailed in the approved Work Plan, which is included in Appendix E.

6.1.1 Short-Term Sampling and Analysis

All shallow groundwater monitoring wells shown in Figure 6-1 will be sampled and analyzed for total and dissolved metals using SW-846 methods 6010, 6020 and 7470; VOCs using method 8260B; and SVOCs using method 8270C. The project-specific laboratory reporting limits for the analysis list will be included in the QAPP that will be submitted during the 95% design phase. In addition, the sampling procedures will also be detailed in the QAPP that will be included within the 95% design.

6.1.2 Sampling Frequency

Shallow groundwater samples will be collected on an annual basis for the estimated five-year duration of the short-term monitoring program. However, if analytical data indicates that contamination is migrating or has greatly increased since the previous sampling event, the sampling frequency may be increased. An increase in sampling frequency may be recommended for one or more of the areas undergoing short-term monitoring. Recommendations regarding any increase of sampling frequency would be included within the annual groundwater monitoring report, which is discussed in further detail in the following subsection.

6.1.3 Reporting

Following each annual sampling, an annual short-term groundwater report will be prepared and submitted to U.S. EPA for review. This report will be comprehensive for all areas undergoing short-term groundwater monitoring, including Areas 1, 2 West, 3 East, 3 West, 4, and the 5-Acre Fill Area. The annual report will include the following: a summary of the groundwater elevations from the previous sampling rounds, potentiometric surface maps showing seasonal variations in groundwater flow direction, a comprehensive summary of the analytical results, and a statistical evaluation of the analytical data. This report will also contain recommendations for each area regarding further courses of action regarding sampling (i.e., if annual monitoring should continue beyond the initial 5-year program or if the monitoring program should be switched to quarterly or semi-annual sampling).

6.2 LONG-TERM MONITORING

A long-term groundwater monitoring program focusing on shallow groundwater will be implemented for Area 2 East and the 25-Acre Fill Area. It is assumed that long-term shallow groundwater monitoring in Area 2 East and the 25-Acre Fill Area will be used to evaluate if any contingency remedial measures are required.

6.2.1 Area 2 East

A long-term groundwater monitoring program focusing on shallow groundwater will be implemented for Area 2 East. It is assumed that long-term shallow groundwater monitoring will be used to evaluate the effectiveness of the soil and groundwater remedial measures and to determine if any contingency remedial measures are required. During all sampling events (baseline and long-term), water level measurements will be collected from inside and outside of the sheet pile wall to ensure that an inward gradient exists.

6.2.1.1 Baseline Sampling

The baseline sampling of the long-term monitoring program for Area 2 East will consist of well installation, four rounds of quarterly sampling and reporting, and the preparation of an annual report. The following subsections provide additional detail on each of the components of the baseline sampling portion of long-term groundwater monitoring program.

Monitoring Well Installation

A total of five monitoring wells will be installed in Area 2 East prior to initiating the baseline quarterly sampling. The locations of these proposed wells are shown in Figure 6-2, and will be installed and constructed similar to the existing monitoring wells at the site, which were installed and constructed in accordance with Section 4 and the standard operating procedures included in the Facility Investigation Work Plan (WESTON, 1998). The exact installation and construction procedures will be detailed in the specifications that will be included in the 95% design.

Quarterly Sampling and Analysis

The quarterly groundwater sampling at the site will be performed by collecting groundwater samples from the proposed shallow monitoring wells (Figure 6-2). In addition, groundwater elevation measurements will be collected from all of the wells during each sampling event. All groundwater samples will be collected in accordance with the procedures outlined in the QAPP, which will be included in the 95% design submittal. All shallow groundwater monitoring wells shown in Figure 6-1 will be sampled and analyzed for total and dissolved metals using SW-846 methods 6010, 6020 and 7470; VOCs using method 8260B; and SVOCs using method 8270C.

Quarterly Reporting

Following completion of each of the four rounds of sampling, a Quarterly Groundwater Sampling Report will be prepared and submitted to U.S. EPA for approval. This report will include the following: a summary of the groundwater elevation measurements, a potentiometric surface map showing the direction of groundwater flow, a summary of the analytical results, a comparison of the analytical results with the MCSs, and a comparison of the results of the current round of sampling to the previous results.

Annual Reporting

Following completion of the four rounds of baseline sampling, an Annual Groundwater Sampling Report will be prepared and submitted to U.S. EPA for approval. This report will include the following: a summary of the groundwater elevations from the four sampling rounds, potentiometric surface maps showing seasonal variations in groundwater flow direction, a comprehensive summary of the analytical results, and a statistical evaluation of the analytical data. This report will also contain recommendations regarding further courses of action regarding sampling (i.e., if quarterly monitoring should continue or if the monitoring program should be switched to semiannual or annual sampling).

6.2.1.2 Long-Term Sampling and Analysis

All shallow groundwater monitoring wells shown in Figure 6-2 will be sampled and analyzed for total and dissolved metals using SW-846 methods 6010, 6020 and 7470; VOCs using method 8260B; and SVOCs using method 8270C. The project specific laboratory reporting limits for the analysis list will be included in the QAPP that will be submitted during the 95% design phase. In addition, the sampling procedures will also be detailed in the QAPP that will be included within the 95% design.

6.2.1.3 Sampling Frequency

Shallow groundwater samples will be collected on an annual basis for the estimated 20-year duration of the long-term monitoring program. However, if analytical data indicates that contamination is migrating unexpectedly or has greatly increased since the previous sampling event, the sampling frequency may be increased. Recommendations regarding any increase of sampling frequency would be included within the annual groundwater monitoring report, which is discussed in further detail in the following subsection.

6.2.1.4 Reporting

Following each annual sampling, an annual long-term groundwater report will be prepared and submitted to U.S. EPA for review. The annual report will include the following: a summary of the groundwater elevations from the previous sampling rounds, potentiometric surface maps showing seasonal variations in groundwater flow direction, a comprehensive summary of the analytical results, and a statistical evaluation of the analytical data. This report will also contain recommendations regarding further courses of action regarding sampling (i.e., if annual monitoring should continue or if the monitoring program should be switched to quarterly or semi-annual sampling).

6.2.2 <u>25-Acre Fill Area</u>

A long-term groundwater monitoring program focusing on shallow groundwater will be implemented for the 25-Acre Fill Area. It is assumed that long-term shallow groundwater monitoring will be used to evaluate if any contingency remedial measures are required. The baseline sampling for this area is detailed in the approved Work Plan, which is included in Appendix E.

6.2.2.1 Long-Term Sampling and Analysis

All shallow groundwater monitoring wells shown in Figure 6-3 will be sampled and analyzed for total and dissolved metals using SW-846 methods 6010, 6020 and 7470; VOCs using method 8260B; SVOCs using method 8270C; pesticides by method 8081A; and PCBs using method 8082. The project specific laboratory reporting limits for the analysis list will be included in the QAPP that will be submitted during the 95% design phase. In addition, the sampling procedures will also be detailed in the QAPP that will be included within the 95% design.

6.2.2.2 Sampling Frequency

Shallow groundwater samples will be collected on an annual basis for the estimated 20-year duration of the long-term monitoring program. However, if analytical data indicates that contamination is migrating unexpectedly or has greatly increased since the previous sampling event, the sampling frequency may be increased. Recommendations regarding any increase of sampling frequency would be included within the annual groundwater monitoring report, which is discussed in further detail in the following subsection.

6.2.2.3 Reporting

Following each annual sampling, an annual long-term groundwater report will be prepared and submitted to U.S. EPA for review. The annual report will include the following: a summary of the groundwater elevations from the previous sampling rounds, potentiometric surface maps showing seasonal variations in groundwater flow direction, a comprehensive summary of the analytical results, and a statistical evaluation of the analytical data. This report will also contain recommendations regarding further courses of action regarding sampling (i.e., if annual monitoring should continue or if the monitoring program should be switched to quarterly or semiannual sampling).

SECTION 7
SPECIFICATIONS

Design specifications will be provided as part of the 95% Submittal. Table 7-1 lists the specifications anticipated to be included as part of the 95% Submittal.

SECTION 8
INSTITUTIONAL CONTROLS

The institutional controls included within the remedial measures consist of a deed restriction that limits the future uses of the property to industrial or recreational (25-Acre Fill Area only) use, and requires all future excavations to be conducted in accordance with a SMP, which is discussed in greater detail in Section 12. The SMP will ensure that future workers are protected and excavated soils are handled, classified, transported, and disposed of properly. The deed restriction will also prevent all future excavation within the 25-Acre Fill Area, and will require the use of vapor barriers beneath floor slabs or subsurface walls in areas within Area 3 East where VOCs are present above an inhalation risk. Figure 8-1 details the areas within Area 3 East where vapor barriers will be required during any future redevelopment. The process of implementing the deed restrictions will begin following U.S. EPA approval of the 100% Design Report, and will be completed prior to initiation of the Remedial Measures Implementation.

SECTION 9

PERMITS

A number of permits will be required during the remedial measures implementation. The tentative list of permits, subject to revisions and updates during the 95% design phase, are:

- City of Chicago:
  - Department of Underground – Will require notification and possible permits for all work regarding underground utility installation, relocation, or removal. In addition, the department will be notified and a permit may be required for the DDC.
  - Department of Water Management – Will require notification and will review and approve all stormwater management plans.
  - Department of Transportation – Will require notification regarding increased truck traffic during construction activities. Will also issue permit for any intrusive activities completed within the City of Chicago right-of-way. Will be notified of the DDC activities.
  - Department of Streets and Sanitation – Will be notified of construction activities and planned street-sweeping.
- Illinois EPA:
  - A National Pollutant Discharge Elimination System (NPDES) permit may be required to authorize stormwater discharges associated with construction activity during implementation of the remedial measures.
  - An air permit may be required for the off-gasses generated during the *ex-situ* bioremediation of soils from Area 3 East.
- Local Utility Companies: Existing above-ground or underground utilities, including underground utilities that cross the steel sheet pile wall, may require temporary or permanent relocation. In addition, if redevelopment of the site is performed simultaneously with the remedial measures, local utilities will be required to install utilities to the buildings included in the redevelopment.
- Local Railroads: The owner of the railroad located east of the 5-Acre Fill Area will be notified of construction activities, and a permit may be required for any temporary or permanent railroad crossings or any activities conducted within the railroad right-of-way.

SECTION 10
PROJECT SCHEDULE

The project schedule for the remedial measures design is included in Figure 10-1. This schedule assumes a U.S. EPA review period of 30 days for each submittal. The submittals will be as follows:

- Preliminary (30%) Remedial Measures Design Report
- Pre-Final (95%) Remedial Measures Design Report
- Final (100%) Remedial Measures Design Report

The Intermediate (60%) Remedial Measures Design Report that is stipulated in the Consent Decree will not be submitted during the remedial measures design phase. The exclusion of the 60% Design Report was approved by the U.S. EPA Project Manager, Todd Gmitro. U.S. EPA comments from the 30% Remedial Measures Design Report will be incorporated into the 95% Remedial Measures Design Report. U.S. EPA comments from the 95% Remedial Measures Design Report will be incorporated into the 100% Remedial Measures Design Report.

SECTION 11
COST

A cost estimate for design, construction, oversight, and operation and maintenance of the remedial measures implementation is provided in Table 11-1. Table 11-1 also lists the materials needed for construction of the remedial measures, estimated quantities, unit cost of materials, labor costs, and total construction costs. Included in the direct costs are the individual items composing the remedial measures, separated into general costs for the site, groundwater remedy costs, and soil remedy costs. Each of the remedy costs are further subdivided to examine the remedial measure for each area or group of areas (i.e., Areas 1, 2 West, 3 West, and 4). Indirect costs include construction management, health and safety, and construction quality assurance costs.

Also included is an estimate of costs for the operation and maintenance of the remedial measures. The estimate includes costs for annual repairs to the engineered barriers and engineered cap, fencing repairs, mowing, long-term and short-term monitoring of the shallow groundwater at the site, and preparation of annual reports.

The total estimated construction cost for the remedial measures implementation is approximately $16,359,000.

SECTION 12
SUPPORTING PLANS

12.1 PRE-CONSTRUCTION PLANS

Prior to implementation of the remedial measures, the following plans will be submitted to the U.S. EPA: community relations plan, data management plan, construction work plan, and HASP. Each of these plans are detailed further in the following sections.

12.1.1 Construction Work Plan

This subsection details the construction work plan, which will be followed during the implementation of the Remedial Measures. The tentative requirements of this work plan will ensure that the completed remedial measures will meet or exceed all design criteria, plans, and specifications. This section includes procedures associated with waste management, sampling and analysis, construction contingency, construction safety, and also includes documentation requirements for the RMS.

12.1.1.1 Project Management

The overall project organization and key personnel for the overall Remedial Measures Implementation (RMI) is detailed in the Remedial Measures Implementation Program Plan (WESTON, 2005b). Roles and responsibilities for key construction Quality Assurance (QA) and Quality Control (QC) personnel are described below. All QA/QC personnel have the authority to stop work if any work is found to be non-compliant with the approved plans and specifications. Non-compliant work will be corrected to the satisfaction of the QA staff. An attachment containing resumes and qualifications of key construction QA/QC personnel will be submitted prior to start of construction.

The team members who will likely be utilized during the construction phase of the RMI will be specified prior to start of construction. As long as a conflict of interest does not exist, on-site personnel may fill multiple positions to limit the number of personnel required on-site. A list of project personnel positions and responsibilities is included below (likely personnel that will be utilized are listed where applicable):

<u>WESTON Project Manager</u> – The WESTON Project Manager, Mr. Mark Kleiner, will be responsible for the overall project, including management of funds and schedule, staffing all field and technical staff, health and safety, and quality of the project. The WESTON Project Manager may delegate various responsibilities and tasks to qualified individuals. The WESTON Project Manager will be the point of contact with the regulatory agencies (U.S. EPA and Illinois EPA) and Sherwin-Williams.

<u>WESTON Site Manager</u> – The WESTON Site Manager will be responsible for oversight of all field activities, including coordination of field staff, equipment, and materials. The WESTON Site Manager will work closely with the construction contractors and the design engineers to ensure that the project is executed effectively and in compliance with applicable plans and specifications.

<u>WESTON Site Health and Safety Officer</u> – The WESTON Site Health and Safety Officer will be responsible for the implementation and enforcement of the WESTON health and safety program. The WESTON Site Health and Safety Officer will ensure that the health and safety of personnel are not jeopardized during field activities. Work will be conducted to meet the quality objectives, however, safety will not be compromised in any case. The WESTON Site Health and Safety Officer will work closely with the WESTON Site Manager, Subcontractors, and any other applicable personnel for all field activities.

<u>WESTON Design Team Manager</u> – The WESTON Design Team Manager, Mr. William Karlovitz, P.E., is responsible for designing and specifying the construction details for various components of the Remedial Measures. Mr. Karlovitz is registered in the states of Illinois, Iowa, and Wisconsin and is responsible for approving the design plans and specifications. QA/QC personnel will work closely with Mr. Karlovitz to ensure that the various site features are constructed as intended. In the event of a discrepancy, changed field conditions, or clarifications required, Mr. Karlovitz will be consulted for support and guidance.

WESTON Certifying Professional Engineer –Mr. William Karlovitz will be the Certifying Professional Engineer and provide QA/QC for this project.

Construction Quality Assurance Manager – The Construction Quality Assurance (CQA) Manager will be a professional engineer, licensed in the State of Illinois with previous experience in similar construction projects. The CQA Manager will be responsible for all CQA activities associated with the construction phase of the RMI.

WESTON Site QA/QC Representative – Specific responsibilities of the WESTON Site QA/QC Representative include, but are not limited to, the following:

- **Supervision of sampling.** The WESTON Site QA/QC Representative will ensure QC samples, measurements, and documentation are collected by the Subcontractors or WESTON with proper methods and at the proposed frequency. WESTON's Site QA/QC Representative will coordinate all sample management, including assigning sample identification numbers to each unique sample collected.

- **Oversight and documentation of all construction activities.** WESTON will maintain a written log, photographs, and videotape (if necessary) of all significant construction activities.

- **Oversight of Collection of QC samples.** WESTON will witness and/or perform collection and packaging of QC samples for all samples immediately after they are collected and containerized.

- **Site Health and Safety.** Provide overall direction to the development, implementation, and oversight of health and safety-related aspects of the project.

Specialty QA staff, such as engineers, chemists, and geologists, may be brought on during applicable phases of the project, as necessary.

Subcontractor QC Manager – All labor and materials needed for certain aspects of QC shall be supplied by the subcontractor. QC responsibilities of the subcontractor include the following:

- Subcontractor's QC personnel performing tests.
- Furnish and maintain QC and construction equipment.
- Collect QC samples and perform field tests as required.

WESTON Project Geologist – The WESTON Project Geologist will work with the WESTON Site QA/QC Representative to ensure the geologic work is performed in accordance with the applicable design documents and any other local, county, state, and federal regulations and requirements.

WESTON Project Engineer – The WESTON Project Engineer will work with the WESTON Site QA/QC Representative to ensure the engineering work is performed in accordance with the applicable design documents and any other local, county, state, and federal regulations and requirements.

12.1.1.2 Construction Quality Assurance/Quality Control Programs

A Construction QA/QC program for the RMI at the Sherwin-Williams facility will be implemented to ensure that completed remedial measures will meet or exceed all design criteria, plans, and specifications. The focal point of the Construction QA/QC program will be the Construction Quality Assurance Plan (CQAP), which will be included as an attachment to the 95% Design Submittal. The CQAP will be completed in accordance with U.S. EPA's Guidance on Quality Assurance for Environmental Technology, Design, Construction, and Operation (U.S. EPA, 2005b). The purpose of the CQAP is to outline the QA and QC measures to be implemented for construction of the remedial measures in accordance with the Final Remedial Measures Design. Specifically, the CQAP will provide the necessary procedures, controls, tests, records, and inspections to ensure that the project has been properly constructed in accordance with the intended design. The CQAP will list all of the regulations relevant to CQA and construction requirements, including City of Chicago, IEPA and U.S. EPA regulations.

12.1.1.3 Waste Management Procedures

Erosion Control

An erosion control plan will be detailed within the construction work plan. This section will detail erosion control techniques and devices that will be used to ensure that erosion does not transport any soil off-site during construction.

Personal Protective Equipment

It is anticipated that Personal Protective Equipment (PPE) generated during the RMI will be non-hazardous and may be disposed of as solid waste.

Well Development/Purge Water

Well development and purge water will be containerized and disposed of according to federal, state, and local regulations.

Drilling Cuttings

Drilling cuttings produced from the installation of new monitoring wells during the RMI will be drummed and disposed of at a permitted off-site facility in accordance with federal, state, and local regulations. The 95% Design Submittal will include a list of available facilities with the capability to receive drummed cuttings.

Excavated Soil

The remedial measures associated with soil allow for the use of the 25-Acre Fill Area as an on-site consolidation option for excavated soil, including the soil from Area 3 East that will undergo *ex-situ* bioremediation. The 25-Acre Fill Area where excavated soil could be consolidated would be designated as a CAMU, and therefore excavation of soil from other areas and consolidation within the 25-Acre Fill Area under the engineered cap would not trigger LDRs or MTRs, in accordance with 40 CFR 264.552. The Amendment to the Final CAMU Rule (67 CFR 2962, effective 22 April 2002) states the following regarding CAMU-eligible wastes: “All solid and hazardous wastes, and all media (including ground water, surface water, soils, and sediments) and debris, that are managed for implementing cleanup.” Therefore, soil can be consolidated within the 25-Acre Fill Area under the CAMU rule since it is ‘CAMU eligible waste’.

12.1.1.4 Sampling and Analysis

Sampling and monitoring activities will be used for construction QA/QC and for other construction-related purposes. In order to ensure that all information, data, and resulting decisions are technically sound, statistically valid, and properly documented, a QAPP will be prepared. The QAPP will document all monitoring procedures, sampling, field measurements, and sample analysis performed during all on-site activities. The QAPP will be prepared in accordance with EPA Requirements for QAPPs for Environmental Data Operations (U.S. EPA, 2001). A draft version of the QAPP will be prepared and submitted with the 95% Design Submittal.

12.1.1.5 Construction Contingency Procedures

The purpose of this subsection is to identify contingency procedures to be followed if unforeseen events occur.

<u>Changes in Design/Specifications</u>

During construction, unforeseen problems encountered at the facility may affect the original design of the remedial measures. A list of potential problems that might be encountered will be included with the 95% Design Submittal.

All major changes in the design/specifications will be brought to the attention of the Sherwin-Williams Project Director, WESTON Project Manager, and the U.S. EPA Corrective Action Project Manager. All parties involved will discuss possible solutions to the situation and determine the most appropriate course of action.

<u>Construction Emergency</u>

Sherwin-Williams will orally notify U.S. EPA within 24 hours of any construction emergency (e.g., fire or earthwork failure) and will notify U.S. EPA in writing within 72 hours of the event. The written notification will, at a minimum, specify what happened, what response action is being taken and/or is planned, and any potential impacts on human health and/or the environment.

Unforeseen Events

Although not anticipated, if it is determined in the field that the RMI construction cannot be completed, U.S. EPA will be notified orally within 24 hours of this determination and will be notified in writing within 72 hours. A conference call between all parties involved including U.S. EPA will be conducted to discuss the problem and possible solutions. The 95% Design Submittal will include likely scenarios in which unforeseen problems could be encountered. Each scenario of unforeseen problems will be presented with one or more proposed solutions.

Emergency Contacts

Table 12-1 lists all emergency contacts (Note: Table 12-1 is not included with this submittal). This list will be included in the HASP and 95% Design submittal

12.1.1.6 Construction Safety Procedures

Construction safety procedures will be specified within the site-specific HASP, which is discussed in detail in Subsection 12.1.2 of the this document.

12.1.1.7 Documentation Requirements

In order to document project progress throughout the life of the project, the WESTON Site QA/QC Representative will maintain accurate records of all work verifying proper construction of the remedial measures. Verbal communication during meetings, discussions with project staff and subcontractors, and telephone conversations will be summarized in writing. Copies of all communications, both written and verbal will be sent to the Site Manager, and will be distributed further if necessary. Additional record keeping and reporting is discussed in the following sections.

Photographic Record

A project photographic record will be made and kept as part of the CQA record. In addition to recording construction progress and "as-built" installation details, the photographic record will be used to document deviations from the design and nonconformance items or work. Each photograph will be marked with a sequence number, date, location, photographer, and description. Any on-site personnel may photograph work for record purposes. The Site Manager will maintain the photographic record file.

Daily Reporting

The WESTON and subcontractor's project staff will maintain daily inspection reports. At the end of each shift, copies of the daily report will be submitted to the Site Manager. Each daily report will be completed in ink with each workday consecutively numbered in a bound document. The content of the report will include, at minimum (where applicable): weather conditions, personnel on-site, list of major equipment on-site, substantive conversations held between project staff, a log of work in progress and new work started, location and description of work, summary of verification testing performed, summary of verification surveying, and signature of the report preparer with name, title, and date.

Logbooks

The Site Manager will maintain a field logbook. The field logbook will be a bound, hard cover logbook in which the Site Manager records specific field incidents as they occur. The logbook will also be used to document general site conditions, visitors, incidents or specific visual inspections for use at a later date in recreating events of the day. Each log entry will be dated, each event's time of occurrence logged, and the preparer of the logbook will sign the daily entry.

Monthly Inspections

The WESTON design engineer will conduct a series of site inspections. These site inspections will be conducted on a monthly basis. During the inspections, specific areas of the construction will be reviewed and documented. The specific areas that will require inspection will be specified in the 95% Design Submittal. The results of these monthly inspections will be included within the monthly reports that will be submitted to U.S. EPA during the Remedial Measures Construction.

The findings of the inspection will be documented in a written report and submitted to the U.S. EPA with the monthly progress reports that will be submitted during the Remedial Measures Construction. The inspection reports will form the basis for the RMI Report.

Monthly Progress Reporting

As directed by the Consent Decree, Sherwin-Williams will submit monthly progress reports to U.S. EPA. Monthly progress will contain the following:

- A description of the work performed during the reporting period and an estimate of the percentage of the RMI completed;
- Summaries of all findings;
- Summaries of all changes made in the RMI during the reporting period;
- Summaries of all contacts with representatives of the local community, public interest groups, or State government during the reporting period;
- Summaries of all problems or potential problems encountered during the reporting period;
- Actions being taken to rectify the problems;
- Changes in personnel during the reporting period;
- Projected work for the next reporting period; and
- Copies of daily reports, inspection records, laboratory/monitoring data, etc.

12.1.2 Health and Safety Program

This subsection provides an overview of the Health and Safety Program for the Sherwin-Williams facility during the RMI. The Health and Safety Program will be split into two main categories: the WESTON site-specific Health and Safety Program and the Contractor Health and Safety Program.

12.1.2.1 WESTON Health and Safety Program

WESTON will develop a site-specific HASP for use at the Sherwin-Williams facility during the upcoming RMI activities. The Draft HASP will be included in the 95% Design Report. The HASP will specify employee training, PPE, medical surveillance requirements, standard operating procedures, and a contingency plan in accordance with 29 CFR 1910.120.

12.1.2.2 Contractor Health and Safety Program

The remedial measures construction Contractor will be required to supply a site-specific HASP for the activities associated with the RMI construction, and will comply with 29 CFR 1926 Safety and Health Regulations for Construction, 29 CFR 1910 Occupation Safety and Health Standards, and 29 CFR 1910.120 Hazardous Operations and Emergency Response. The requirements for the construction Contractor's HASP will be contained within the specifications that will be submitted with the 95% Design Report.

12.2 POST-CONSTRUCTION PLANS

Following the implementation of the remedial measures, the following reports and plans will be submitted to the U.S. EPA: RMI Report, Operations and Maintenance (O&M) Plan, SMP, and Contingency Plan. Each of these plans are detailed further in the following sections.

12.2.1 Remedial Measures Implementation Report

The RMI Report will document that the construction project is consistent with the design specifications, and that the remedial measures are performing adequately. The RMI Report will include the following:

- A synopsis of the remedial measures and certification of the designs and construction;
- An explanation of any modifications to the plans and why these were necessary for the project;
- Listing of the criteria, established before the remedial action was initiated, for judging the functioning of the remedial action and also providing explanation of any modification to these criteria;
- Results of monitoring, indicating that the remedial action will meet or exceed the performance criteria;
- Explanation of the operation and maintenance, including monitoring, to be undertaken with respect to the remedial measures;
- Data demonstrating that the MCSs have been achieved.

The RMI Report will be submitted following completion of the remedial measures construction, and will document site conditions at the beginning of the O&M phase of the remediation.

12.2.2 Operation and Maintenance Plan

This preliminary O&M Plan includes an outline detailing the anticipated sections that will be included in the O&M Plan in more detail in the 95% Design Report. As required by the Consent Decree, the Final O&M Plan will be submitted concurrently with the Final (100%) Design Report. The plan will assume an O&M period of 20 years for Area 1, Area 2 West, Area 2 East, Area 3 West, Area 3 East, Area 4, 5-Acre Fill Area, and 25-Acre Fill Area. The following is an outline specifying the important sections of the O&M Plan:

1) Description of normal O&M
    a) Description of tasks for operation
    b) Description of tasks for maintenance

c) Description of prescribed treatment or operation conditions
d) Schedule showing frequency of each O&M task

2) Description of potential operating problems
   a) Description and analysis of potential operation problems
   b) Sources of information regarding problems
   c) Common and/or anticipated remedies

3) Description of routine monitoring and laboratory testing
   a) Description of monitoring tasks
   b) Description of required laboratory tasks and their interpretation
   c) Required data collection and QAPP
   d) Schedule of monitoring frequency
   e) Description of triggering mechanisms for groundwater monitoring results

4) Description of alternate O&M
   a) Should any system fail, alternate procedures to prevent release or threatened releases of hazardous substances, pollutants, or contaminants which may endanger public health and the environment or exceed MCSs
   b) Analysis of vulnerability and additional resource requirements should a failure occur

5) Corrective Steps
   a) Description of corrective steps to be implemented in the event that cleanup or performance standards are not met
   b) Schedule for implementing corrective steps

6) Safety Plan
   a) Description of precautions for site personnel
   b) Safety tasks required in the event of systems failure

7) Description of equipment
   a) Equipment identification
   b) Installation of monitoring components
   c) Maintenance of site equipment
   d) Replacement schedule for equipment and installed components

8) Records and reporting mechanisms required
   a) Daily operating logs
   b) Laboratory records
   c) Records for operating costs
   d) Mechanism for reporting emergencies
   e) Personnel and maintenance records
   f) Monthly/annual reporting to regulatory agencies

12.2.3 Soil Management Plan

This preliminary SMP includes an outline detailing the anticipated sections that will be included in the SMP in more detail in the 95% Design Report. The SMP will be established to deal with excavated soil during future development activities that will involve excavation of soil that will be located under an engineered barrier. The following is an outline specifying the important sections of the SMP:

1) Introduction
   a) Purpose
   b) Applicable Areas

2) Responsibilities

3) Health and Safety
   a) Personnel Requirements
   b) PPE Requirements
   c) Personnel Decontamination

4) Soil Management Procedures
   a) Staging of Excavated Soil
   b) Replacement of Engineered Barriers

5) Waste Disposal
   a) Waste Types
   b) Characterization Sampling
   c) Transportation
   d) Disposal

12.2.4 Contingency Plan

During construction, unforeseen problems encountered at the facility may affect the original design of the remedial measures. A contingency plan will be included in the Construction Work Plan. The Construction Work Plan developed for the 95% Design Submittal will include likely scenarios in which unforeseen problems could be encountered. Each scenario of unforeseen problems will be presented with one or more proposed solutions.

In addition, the O&M Plan outlines contingency procedures to follow in case of failure of any of the remedial measures. Detailed contingency plans included in the O&M Plan will be developed and included in the 95% Design Submittal.

SECTION 13

REFERENCES

United States Environmental Protection Agency (U.S. EPA), *Design and Construction of RCRA/CERCLA Final Covers*. May 1991.

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