N00210.AR.000214
5090.3a
NTC Great Lakes

Draft
Remedial Investigation and Risk Assessment Report
for
Site 1 - Golf Course Landfill
Volume I of II
Text

Naval Station Great Lakes
Great Lakes, Illinois

NAVFAC
Naval Facilities Engineering Command
Midwest

Naval Facilities Engineering Command Midwest
Contract Number N62467-04-D-0055
Contract Task Order 13

July 2007

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220
Tel 412.921.7090 • Fax 412.921.4040 • www.tetratech.com

PITT-08-7-004

August 03, 2007

Project 00295

Dept of the Navy
Naval Station Great Lakes
NAVFAC MW Code EV
Attn: Howard Hickey
201 Decatur Ave.
Building 1A
Great Lakes, IL 60088

Reference: CLEAN Contract No. N62467-04-D-0055
Contract Task Order 0013

Subject: Draft Remedial Investigation and Risk Assessment Report
Site 1 –Golf Course Landfill (aka Willow Glen Golf Course)
Naval Station Great Lakes
Great Lakes, Illinois

Dear Mr. Hickey:

Please find attached four copies of the subject report for review and comment. Copies have also been distributed as indicated below.

If you have any questions, please call Chris Pike at 412-921-8861 or me at 412-921-7251.

Sincerely,

Robert F. Davis, P.E.
Task Order Manager

RFD/kf

Enclosure

cc: M. Singletary, NAVFAC SE (1 copy)
B. Conrath, Illinois EPA (3 copies)
D. Humbert, TtNUS (cover letter only)
Mark Perry/File 00295, TtNUS (1 copy)
C. Pike, TtNUS (1 copy)
A. Bernhardt, TtNUS (cover letter only)
T. Jackman, TtNUS (cover letter only)

DRAFT REMEDIAL INVESTIGATION AND RISK ASSESSMENT REPORT

SITE 1- GOLF COURSE LANDFILL

NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command
201 Decatur Avenue, Building 1A Midwest
Great Lakes, Illinois 60088

Submitted by:
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406

CONTRACT NUMBER N62467-04-D-0055
CONTRACT TASK ORDER 0013

JULY 2007

PREPARED UNDER THE SUPERVISION OF:

ROBERT DAVIS, PE
PROJECT MANAGER
TETRA TECH NUS, INC.

BLAYNE KIRSCH, PE, PG
BUSINESS LINE COORDINATOR
NAVFAC MIDWEST

HOWARD HICKEY
IR PROJECT MANAGER
NAVFAC MIDWEST

MICHAEL SINGLETARY
TECHNICAL SERVICES BRANCH
NAVFAC SOUTHEAST

APPROVED FOR SUBMITTAL BY:

JOHN TREPANOWSKI, PE
PROGRAM MANAGER
TETRA TECH NUS, INC.

BRIAN A. CONRATH
PROJECT MANAGER
ILLINOIS EPA

LESLIE MORROW
RISK ASSESSOR
ILLINOIS EPA

TABLE OF CONTENTS

SECTION **PAGE NO.**

EXECUTIVE SUMMARY **ES-1**

ACRONYMS **7**

1.0 INTRODUCTION **1-1**
1.1 RI/RA APPROACH AND OBJECTIVES 1-2
1.2 REPORT SCOPE AND ORGANIZATION 1-2
1.3 NAVAL STATION GREAT LAKES LOCATION AND DESCRIPTION 1-3
1.4 ENVIRONMENTAL SETTING 1-3
1.4.1 Geography, Demographics, and Land Use 1-3
1.4.2 Physiography and Topography 1-4
1.4.3 Climate 1-5
1.4.4 Soil 1-5
1.4.5 Regional Geology 1-5
1.4.6 Regional Hydrology 1-6

2.0 SITE BACKGROUND **2-1**
2.1 SITE CHARACTERIZATION 2-1
2.1.1 Location and Description 2-1
2.1.2 History 2-2
2.2 ENVIRONMENTAL SETTING 2-2
2.2.1 Geography and Land Use 2-2
2.2.2 Physiography and Topography 2-2
2.2.3 Soil and Geology 2-2
2.2.4 Ecology 2-3
2.3 PREVIOUS SAMPLING EVENTS 2-3
2.3.1 Previously Documented Groundwater and Surface Water Contamination 2-4
2.3.2 Previously Documented Soil Contamination 2-5

3.0 SITE INVESTIGATION ACTIVITIES **3-1**
3.1 DEVIATIONS FROM THE WORK PLAN 3-1
3.2 FIELD INVESTIGATION 3-2
3.2.1 Direct Push Technology Drilling/Sampling 3-2
3.2.2 Subsurface Soil Sample Handling/Analysis 3-3
3.2.3 Well Drilling and Installation 3-3
3.2.4 Monitoring Well Development 3-4
3.2.5 Groundwater Level Measurements 3-5
3.2.6 Groundwater Sampling 3-6
3.2.7 Aquifer Testing 3-7
3.2.8 Surface Water Sampling 3-8
3.2.9 Sediment Sampling 3-9
3.2.10 Sample Handling, Packaging, and Shipping 3-9
3.2.11 Surveying 3-11
3.2.12 Investigation-Derived Waste 3-12
3.2.13 Well Abandonment 3-12

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

3.3 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES 3-12
3.4 SITE-SPECIFIC GEOLOGY 3-12
3.5 SITE-SPECIFIC HYDROGEOLOGY 3-13
3.5.1 Hydrogeologic Framework 3-13
3.5.2 Groundwater Flow Directions 3-13
3.5.3 Aquifer Tests 3-14
3.5.4 Groundwater Migration Velocities 3-14

4.0 NATURE AND EXTENT OF CONTAMINATION 4-1
4.1 SOURCES OF CONTAMINATION 4-2
4.2 SUBSURFACE SOIL CONTAMINATION ASSESSMENT 4-2
4.3 GROUNDWATER SOIL CONTAMINATION ASSESSMENT 4-5
4.4 SURFACE WATER CONTAMINATION ASSESSMENT 4-8
4.5 SURFACE SEDIMENT CONTAMINATION ASSESSMENT 4-10
4.6 SUBURFACE SEDIMENT CONTAMINATION ASSESSMENT 4-12
4.7 SUMMARY AND CONCLUSIONS 4-14

5.0 CHEMICAL FATE AND TRANSPORT ANALYSIS 5-1
5.1 CHEMICAL AND PHYSICAL PROPERTIES IMPACTING FATE AND TRANSPORT 5-1
5.1.1 Specific Gravity 5-2
5.1.2 Vapor Pressure 5-2
5.1.3 Water Solubility 5-2
5.1.4 Octanol/Water Partition Coefficient 5-3
5.1.5 Organic Carbon Partition Coefficient 5-3
5.1.6 Henry's Law Constant 5-3
5.1.7 Bioconcentration Factor 5-4
5.1.8 Distribution Coefficient 5-4
5.1.9 Mobility Index 5-4
5.2 CONTAMINANT TRANSPORT PATHWAYS 5-5
5.2.1 Leaching of Soil Contaminants to Groundwater 5-5
5.2.2 Migration of Groundwater Contaminants 5-5
5.2.3 Leaching of Sediment Contaminants to Surface Water 5-5
5.2.4 Migration of Contaminants in Surface Water 5-5
5.2.5 Erosion and Runoff of Contaminated Soil and Deposition in Surface Water Bodies .. 5-7
5.3 CHEMICAL PERSISTENCE 5-7
5.3.1 Ketones 5-7
5.3.2 Monocyclic Aromatics 5-8
5.3.3 Halogenated Aliphatics 5-8
5.3.4 PAHs 5-9
5.3.5 Phthalate Esters 5-10
5.3.6 Pesticides 5-10
5.3.7 PCBs 5-11
5.3.8 Dioxins as 2,3,7,8-TCDD 5-12
5.3.9 Inorganics 5-12

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

5.4 CONTAMINANT FATE AND TRANSPORT 5-13
5.4.1 VOCs 5-13
5.4.2 PAHs 5-13
5.4.3 Pesticides 5-14
5.4.4 PCBs 5-14
5.4.5 Inorganics 5-14

6.0 HUMAN HEALTH RISK ASSESSMENT 6-1
6.1 DATA EVALUATION 6-3
6.1.1 Data Usability 6-4
6.1.2 Methodology for Selection of COPCs 6-4
6.1.3 Selection of COPCs 6-12
6.2 EXPOSURE ASSESSMENT 6-17
6.2.1 Conceptual Site Model 6-17
6.2.2 Central Tendency Exposure versus. Reasonable Maximum Exposure 6-21
6.2.3 Exposure Point Concentrations 6-22
6.2.4 Chemical Intake Estimation 6-23
6.2.5 Exposure to Lead 6-34
6.3 TOXICITY ASSESSMENT 6-35
6.3.1 Toxicity Criteria 6-36
6.3.2 Toxicity Criteria for Dermal Exposure 6-36
6.3.3 Toxicity Criteria for Carcinogenic Effects of PAHs 6-37
6.3.4 Calculation of Risks for Carcinogens that Act by a Mutagenic Mode of Action (PAHs) 6-37
6.3.5 Toxicity of Dioxins/Furans 6-38
6.3.6 Toxicity Criteria for Chromium 6-39
6.4 RISK CHARACTERIZATION 6-39
6.4.1 Quantitative Analysis 6-39
6.4.2 Comparison of Quantitative Risk Estimates to Benchmarks 6-40
6.4.3 Qualitative Analysis 6-40
6.4.4 Risk Characterization 6-41
6.5 UNCERTAINTY ANALYSIS 6-47
6.5.1 Uncertainty in Selection of COPCs 6-48
6.5.2 Uncertainty in the Exposure Assessment 6-51
6.5.3 Uncertainty in the Toxicological Evaluation 6-54
6.5.4 Uncertainty in the Risk Characterization 6-59
6.6 SUMMARY AND CONCLUSIONS 6-59
6.6.1 Exposure to Subsurface Soil 6-60
6.6.2 Exposure to Surface Water in Skokie Ditch 6-61
6.6.3 Exposure to Sediment in Skokie Ditch 6-61
6.6.4 Exposure to Groundwater 6-61

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

7.0 ECOLOGICAL RISK ASSESSMENT 7-1
7.1 SCREENING-LEVEL PROBLEM FORMULATION 7-1
7.1.1 Environmental Setting 7-2
7.1.2 Chemical Fate and Transport 7-3
7.1.3 Potential Exposure Pathways 7-4
7.1.4 Endpoints 7-4
7.2 ECOLOGICAL EFFECTS VALUES 7-6
7.2.1 Sediment Screening Values 7-6
7.2.2 Surface Water Screening Values 7-7
7.2.3 Toxicity Reference Values 7-10
7.3 EXPOSURE ESTIMATE 7-11
7.4 ECOLOGICAL RISK CHARACTERIZATION 7-13
7.5 SELECTION OF CHEMICALS OF POTENTIAL CONCERN 7-14
7.5.1 Risks to Aquatic Organisms 7-16
7.5.2 Risks to Terrestrial Wildlife 7-17
7.6 STEP 3A – REFINEMENT OF COPCS 7-17
7.6.1 Risks to Aquatic Receptors 7-18
7.6.2 Risks to Terrestrial Wildlife 7-23
7.7 ECOLOGICAL RISK UNCERTAINTY ANALYSIS 7-24
7.7.1 Measurement and Assessment Endpoints 7-24
7.7.2 Exposure Characterization 7-24
7.7.3 Ecological Effects Data 7-26
7.7.4 Risk Characterization 7-25
7.8 SUMMARY AND CONCLUSIONS 7-26

8.0 CONCLUSIONS AND RECOMMENDATIONS 8-1
8.1 CONCLUSIONS 8-1
8.2 RECOMMENDATIONS 8-2

REFERENCES R-1

TABLE OF CONTENTS (Continued)

APPENDICES

A FIELD FORMS
- A.1 SOIL SAMPLE LOG SHEETS
- A.2 BORING LOGS
- A.3 MONITORING WELL CONSTRUCTION SHEETS
- A.4 LAKE COUNTY DEPARTMENT OF PUBLIC HEALTH WELL AND BORING RECORDS
- A.5 MONITORING WELL DEVELOPMENT SHEETS
- A.6 SYNOPTIC WATER LEVEL MEASUREMENTS
- A.7 LOW FLOW PURGE DATA SHEETS AND GROUNDWATER SAMPLE LOG SHEETS
- A.8 SURFACE WATER SAMPLE LOG SHEETS
- A.9 SEDIMENT SAMPLE LOG SHEETS
- A.10 CHAIN OF CUSTODY SHEETS
- A.11 WATER WELL SEALING FORMS
- A.12 SAMPLE LOG SHEETS FOR QUALITY ASSURANCE / QUALITY CONTROL

B AQUIFER CHARACTERISTICS, CALCULATIONS, AND RECORDS
- B.1 SLUG TESTS DATA SHEETS
- B.2 SLUG TEST CALCULATIONS, HYDRAULIC GRADIENT, AND GROUNDWATER VELOCITY CALCULATIONS

C DATA VALIDATION PACKAGES AND ASSESSMENT

D LABORATORY ANALYTICAL SUMMARY SHEETS

E IDW WASTE PROFILES
- E.1 LIQUID IDW
- E.2 SOLID IDW

F HUMAN HEALTH RISK ASSESSMENT SUPPORT
- F.1 RISK ASSESSMENT CALCULATIONS AND RAGS PART D TABLES
- F.2 PROUCL STATISTICAL CALCULATIONS
- F.3 CHILD (IEUBK) AND LEAD MODEL RESULTS
- F.4 EXAMPLE RISK ASSESSMENT CALCULATIONS

G ECOLOGICAL RISK ASSESSMENT SUPPORT
- G.1 CHEMICAL CLASS INFORMATION
- G.2 RECEPTOR PROFILES
- G.3 FOOD-CHAIN MODEL

TABLES

NUMBER

2-1 Groundwater Summary Statistics
2-2 Surface Water Summary Statistics
2-3 Soil Summary Statistics
3-1 Sampling Rationale
3-2 Sampling Summary
3-3 Summary of Monitoring Well Construction and Water Level Data
3-4 Summary of Sieve Analysis
3-5 Aquifer Test Summary
4-1 Summary of Analytical Results for Subsurface Soil Samples
4-2 Summary of Descriptive Statistics and Criteria Comparisons for RI Subsurface Soil Data
4-3 Summary of Analytical Results in Groundwater Samples
4-4 Summary of Descriptive Statistics and Criteria Comparisons for RI Groundwater Data
4-5 Summary of Analytical Results in Surface Water Samples
4-6 Summary of Descriptive Statistics and Criteria Comparisons for RI Surface Water Data
4-7 Summary of Analytical Results in Surface Sediment Samples
4-8 Summary of Descriptive Statistics and Criteria Comparisons for RI Surface Sediment Data
4-9 Summary of Analytical Results in Subsurface Sediment Samples
4-10 Summary of Descriptive Statistics and Criteria Comparisons for RI Subsurface Sediment Data
5-1 Environmental Fate and Transport Parameters for Organic Chemicals
5-2 Physical and Chemical Properties of Inorganic Site Chemicals
6-1 Occurrence, Distribution, and Selection of Chemicals of Potential Concern - Subsurface Soil – Direct Contact and Inhalation
6-2 Occurrence, Distribution, and Selection of Chemicals of Potential Concern - Subsurface Soil – Migration from Soil to Groundwater
6-3 Occurrence, Distribution, and Selection of Chemicals of Potential Concern - Groundwater
6-4 Occurrence, Distribution, and Selection of Chemicals of Potential Concern - Groundwater – Vapor Intrusion
6-5 Occurrence, Distribution, and Selection of Chemicals of Potential Concern - Sediment
6-6 Occurrence, Distribution, and Selection of Chemicals of Potential Concern – Surface Water
6-7 Chemicals Retained As COPCs
6-8 Exposure Routes for Possible Quantitative Evaluation
6-9 Exposure Point Concentrations (EPCs) for COPCs
6-10 Summary of Exposure Input Parameters – Reasonable Maximum Exposure (RME)
6-11 Summary of Exposure Input Parameters – Central Tendency Exposure (CTE)
6-12 Non-Cancer Toxicity Data - Oral/Dermal
6-13 Non-Cancer Toxicity Data - Inhalation
6-14 Cancer Toxicity Data - Oral/Dermal
6-15 Cancer Toxicity Data - Inhalation
6-16 Summary of Cancer Risks and Hazard Indices - Reasonable Maximum Exposures (RME)
6-17 Summary of Cancer Risks and Hazard Indices - Central Tendency Exposures (CTE)
7-1 Sediment Ecological Screening Levels
7-2 Surface Water Ecological Screening Levels
7-3 Exposure Parameters for Test Species and Surrogate Wildlife Species
7-4 Ecological COPC Selection Table – Surface Sediment
7-5 Ecological COPC Selection Table – Surface Water

TABLES (CONT.)

7-6 Terrestrial Wildlife Model NOAEL and LOAEL EEQS – Average Exposure Factors
7-7 Illinois EPA Tier 2 Sediment Screening Concentrations
7-8 Surface Water PAH Final Chronic Values
7-9 Terrestrial Wildlife Model NOAEL and LOAEL EEQS – Average Concentrations

FIGURES

NUMBER

1-1 Site Location Map
1-2 Site Map
2-1 Historical Groundwater Exceedances
2-2 Historical Surface Water Exceedances
2-3 Historical Residential Soil Exceedances
2-4 Historical Commercial/Industrial Soil Exceedances
3-1 Soil Boring Locations
3-2 Monitoring Well Locations
3-3 Surface Water and Sediment Sample Locations
3-4 Geologic Cross-Section Location Map
3-5 Generalized Geologic Cross Section A-A'
3-6 Generalized Geologic Cross Section B-B'
3-7 Generalized Geologic Cross Section C-C'
3-8 Generalized Geologic Cross Section D-D'
3-9 Potentiometric Surface Map March 13, 2007
4-1 Subsurface Soil Exceedances
4-2 Groundwater Exceedances
4-3 Surface Water Exceedances
4-4 SVOC and PAH Surface Sediment Exceedances
4-5 Pesticide and Dioxin Surface Sediment Exceedances
4-6 Inorganic Surface Sediment Exceedances
4-7 SVOC and PAH Subsurface Sediment Exceedances
6-1 Human Health Conceptual Site Model
7-1 Navy Ecological Risk Assessment Tiered Approach
7-2 Ecological Conceptual Site Model

ACRONYMS

ARCS	Assessment and Remediation of Contaminated Sediments
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeters
COPCs	Chemicals of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTE	Central Tendency Exposure
DA_{event}	Absorbed does per event
°C	Degrees Centigrade
DAF	Dilution/Attenuation Factor
EEQ	Ecological Effects Quotient
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
EU	Exposure Unit
GRO	Groundwater Remediation Objective
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IDW	Investigation-Derived Waste
Illinois EPA	Illinois Environmental Protection Agency
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
K_i	mass transfer coefficient
K_{OC}	organic carbon partition coefficient
K_{OW}	octanol/water partition coefficient
LOAEL	Lowest observed adverse effects level
MCL	Maximum Concentration Level
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MI	Mobility Index

ng/kg	Nanograms per Kilogram
NOAEL	No observed adverse effects level
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyls
pg/L	picograms per Liter
PRGs	Preliminary Remediation Goals
QA/QC	Quality Assurance/ Quality Control
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
SDG	Sample Delivery Group
SERA	Screening-level Ecological Risk Assessment
SOP	Standard Operating Procedure
SRO	Soil Remediation Objective
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compounds
TACO	Tiered Approach to Corrective Action Objectives
TAL	Target Analyte List
T_C	Time of Concentration
TCDD	Tetrachlorodibenzodioxin
TCL	Target Compounds List
TEQ	Toxic Equivalent Quotient
TOC	Total Organic Carbon
TRV	Toxic reference value
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper 95 Percent Confidence Limit
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
USEPA	U. S. Environmental Protection Agency
VDEQ	Virginia Department of Environmental Quality
VOCs	Volatile Organic Compounds
WQC	Water Quality Criteria
WQS	Water Quality Standard

1.0 INTRODUCTION

This Remedial Investigation (RI) and Risk Assessment (RA) Report was prepared for Site 1, Golf Course Landfill (aka Willow Glen Golf Course), at the Department of the Navy's Naval Station Great Lakes, Great Lakes, Illinois, under Contract Task Order 0013. The RI/RA Report was prepared in accordance with the Comprehensive Long-Term Environmental Action Navy IV Contract Number N62467-04-D-0055 and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance for conducting RIs and feasibility studies [United States Environmental Protection Agency (USEPA), October 1988]. This investigation will provide data on select organic and inorganic chemical concentrations in soil, sediment, surface water, and groundwater at Site 1.

The Navy implemented the investigation of this site with a team of representatives from the Illinois Environmental Protection Agency (Illinois EPA), Naval Facilities Engineering Command Midwest and Southeast and its consultant Tetra Tech NUS, Inc. (TtNUS), and the Naval Station Great Lakes Environmental Department. This RI/RA Report summarizes the environmental investigations of Site 1.

Figure 1-1 is an aerial view of Site 1 and Figure 1-2 is a site map. The site operated as a landfill from 1942 to 1967 on approximately 50 acres that is now covered by the Willow Glen Golf Course. The landfill was operated as a trenching/burning operation and received an estimated 1.5 million tons of material total during its years of operation. The landfill was closed in 1969, and at that time, a layer of ash from coal-fired power plants at Naval Station Great Lakes was placed over the landfill, and topsoil was placed over the ash. Based on aerial photography, it appears that the front nine-hole portion of the golf course was constructed between 1953 and 1955; the remainder of the golf course was constructed in 1968 when the landfill closed. A fire fighting training unit located in the center of the site was built in 1942 and operated until it was taken out of service in 1989. Environmental investigations were conducted to determine the nature and extent of contamination at the fire fighting training unit, and environmental remediation of the old fire fighting training unit site was conducted to remove underground and above-ground storage tanks and petroleum-contaminated soil (TtNUS, February 2007).

The Initial Assessment Study conducted in 1986 for Naval Station Great Lakes concluded that both surface water and shallow groundwater were potential contaminant migration pathways at Site 1. The Initial Assessment Study recommended that a Confirmation Study be completed at Site 1 because of the variety of toxic materials that may have been disposed in the landfill and the close proximity of human receptors (Rogers, Golden & Halpern, March 1986).

1.1 RI/RA APPROACH AND OBJECTIVES

The overall goal of the environmental investigative work at Naval Station Great Lakes is to characterize environmental contamination and to determine whether there is a risk to human health and the environment and to therefore determine whether further action is required, and if so, to develop appropriate remedial actions.

The overall goals of this environmental investigation were to delineate the nature and extent of contamination and to identify potential risks associated with Site 1. The chemical data for Site 1 (groundwater, subsurface soil, surface water, and sediment) were used to delineate the nature and extent of contamination. The chemical data were also used to conduct a baseline Human Health Risk Assessment (HHRA) (see Section 6.0) and to complete Steps 1, 2, and 3A of an ecological risk assessment (ERA) (see Section 7.0).

Naval Station Great Lakes is a Navy installation located within USEPA Region 5 and the State of Illinois. TtNUS has prepared this report on behalf of Naval Facilities Engineering Command Midwest and Naval Station Great Lakes to comply with USEPA Region 5 and Illinois EPA requirements and guidance governing the performance of RIs and RAs. In accordance with those requirements, project planning followed the USEPA Data Quality Objectives process (USEPA, August 2000). This process requires

- explicit statements of the problem to be solved,
- identification of the spatial and temporal boundaries related to the problem and the measurements to be made in solving the problem, and, if applicable,
- quantitative specifications of the error tolerances for making decisions.

The process culminates in the specification of decision rules designed to solve the stated problem that are documented in the Quality Assurance Project Plan (TtNUS, February 2007).

1.2 REPORT SCOPE AND ORGANIZATION

This report documents the results from the current field RI program and also presents data from and summarizes findings and conclusions of previous investigations at Site 1. Further, it incorporates the reports associated with these previous investigations by reference to provide a comprehensive record of the investigative activities at Site 1.

This report contains the following sections:

1.0 Introduction
2.0 Site Background
3.0 Site Investigation Activities
4.0 Nature and Extent of Contamination
5.0 Chemical Fate and Transport Analysis
6.0 Human Health Risk Assessment
7.0 Ecological Risk Assessment
8.0 Conclusions and Recommendations

1.3 NAVAL STATION GREAT LAKES LOCATION AND DESCRIPTION

Naval Station Great Lakes is located in Lake County, Illinois, along the shore of Lake Michigan. It is bounded on the north by the City of North Chicago, on the south by the Veterans Administration Hospital and Shore Acres Golf Course and Country Club, on the east by Lake Michigan, and on the west by U.S. Route 41 (Skokie Highway).

Naval Station Great Lakes is located within both the North Branch Chicago River Drainage Basin and the Lake Michigan North Drainage Basin. The divide between the basins is along Green Bay Road. Overland flow from precipitation that does not infiltrate into the ground flows into the Skokie River or Pettibone Creek. The areas east of Green Bay Road drain into Lake Michigan through Pettibone Creek and areas west of Green Bay Road drain into the Skokie River.

1.4 ENVIRONMENTAL SETTING

1.4.1 Geography, Demographics, and Land Use

Naval Station Great Lakes covers 1,632 acres of Lake County, Illinois. Lake County is located in northeastern Illinois, north of the City of Chicago, and comprises 24 miles of Lake Michigan shoreline. Lake County extends from the Wisconsin border south to Cook County and from Lake Michigan west to McHenry County. Lake County is divided into 18 townships, 52 incorporated cities and villages, and 18 unincorporated cities and villages.

There are numerous lakeside communities in Lake County. The most recent 2000 United States Census Bureau data estimate the county's population at 617,975. During the 1950s and 1960s, population growth occurred primarily in the lakefront communities but, by the 1980s and 1990s, population growth

moved north and west. Currently, most of Lake County's population lives in the 52 incorporated cities and villages.

Current land uses in Lake County include agricultural, industrial, and residential. Farmland and lake resorts characterize the western portions of the county, and industrial, urban, and suburban areas follow the 24 miles of Lake Michigan shoreline on the east. There are also three state parks in Lake County.

Naval Station Great Lakes administers base operations and provides facilities and related support to training activities (including the Navy's only boot camp) and a variety of other military commands located on base. A variety of land uses currently surround Naval Station Great Lakes. Along the northern boundary of the base are the most highly urbanized and industrial areas. Much of the land beyond the northwestern site boundary comprises unincorporated lands of Lake County and is vacant except for scattered retail and residential properties. Adjacent to the western boundary are primarily industrial properties, and along the southern boundary is a mixture of public open space and residential land (TtNUS, February 2007).

1.4.2 Physiography and Topography

The gently rolling topography of Lake County, Illinois, is the result of glaciation. The most prominent topographic features are glacial moraines and other unconsolidated glacial deposits that cover most of Naval Station Great Lakes. The terrain of Naval Station Great Lakes consists of relatively flat glacial drift deposits bordered by steep lake-facing bluffs cut with vertical sloping ravines. The unconsolidated glacial material that comprises the bluff faces and ravine walls is under continual erosion.

The topography of Lake County creates poorly defined drainage patterns consisting of swales that enter depressions and marshes. Most of Naval Station Great Lakes is located on a plateau with elevations of 640 to 660 feet above mean sea level. Pettibone Creek and the eastern portion of Naval Station Great Lakes and the Lake Michigan shoreline are at an elevation of approximately 600 feet above sea level.

Intensive development has replaced most of the oak, hickory, maple, and other hardwood forests that originally covered the area. Native woodlands occur primarily on the vertical sloped ravine of Pettibone Creek and on the bluffs facing Lake Michigan. The forested areas of Naval Station Great Lakes are includewith white and red oak, maple, European larch, and white and scotch pine trees and there are shrubs including raspberry and blackberry bushes. The principal mammals in the Naval Station Great Lakes area include groundhogs, raccoons, squirrels, opossum, rabbits, chipmunks, and deer (TtNUS, June 2003).

1.4.3 Climate

The climate of Lake County, Illinois, is considered continental. Changes in temperature, humidity, cloudiness, and wind direction occur frequently. The summer season is warm with few prolonged hot periods. Although major droughts are infrequent, there are commonly long periods of dry weather during the growing season. The area receives approximately 34 inches of rain per year, with 63 percent occurring between April and September. The average seasonal snowfall range is 37.2 to 41.1 inches. The average temperature is 58 degrees Fahrenheit; the winter months normally have temperatures below freezing.

1.4.4 Soil

The soil of Lake County, Illinois, is classified into two groups, Morley-Beecher-Hennepin and Made Land soil. Morley-Beecher-Hennepin soil consists primarily of loams and silt loams and is located on level to very steep ravines. This soil is characterized as well to poorly drained and has low to moderate permeability. Made Land soil include areas of manmade cuts and fills covered by roads and buildings. This fill material includes a variety of soil and non-soil materials that have not been characterized. The soil types that form the plateau where Naval Station Great Lakes is located include Morley, Aptakisic, Wauconda, Beecher, and silt loams (TtNUS, February 2007).

1.4.5 Regional Geology

The geologic units encountered at Naval Station Great Lakes include aeolian and lacustrine deposits, glacial till, and bedrock. Bedrock consists of Silurian Niagran and Alexandrian dolomite, the lowermost geologic unit encountered at Naval Station Great Lakes. The bedding is nearly horizontal to gently eastward dipping in the vicinity of Naval Station Great Lakes. The interface between the bedrock surface and overlying till consists of 1 to 15 feet of broken bedrock (dolomite), gravel, sand, and coarser material. This material appears to be debris ground from the bedrock by the advancing glaciers of the Wisconsin Stage of glaciation during the Late Pleistocene epoch.

Unconsolidated glacial tills blanket Lake County. Several glacial moraine systems are present within the county including the Valparaiso, Tinley, Zion City, and Lake Border systems. Naval Station Great Lakes falls within both the Lake Border and Zion City moraine systems. In the northern portions of Naval Station Great Lakes, the Zion City moraine is exposed at the ground surface and extends from North Chicago to Waukegan, Illinois. These glacial moraine systems are composed of Wadsworth till, which constitutes the largest volume of surficial deposits overlying the bedrock. The Wadsworth till ranges from approximately

170 to 210 feet in thickness overlying the Silurian bedrock. This till is an unsorted mixture of sand, silt, and clay imbedded with pebbles, cobbles, and boulders. Interstices between the coarser-grained sediments are typically filled with fine, clay-sized particles resulting in low permeability. Generally, the Wadsworth till is clayey, with thin and irregular lenses of sand or silty sand occurring over limited areas. The till has been further subdivided into clayey and sandy phases according to the size of the dominant particles. Because clay comprises up to 70 percent of the till at Naval Station Great Lakes, the clayey phase dominates in the local area.

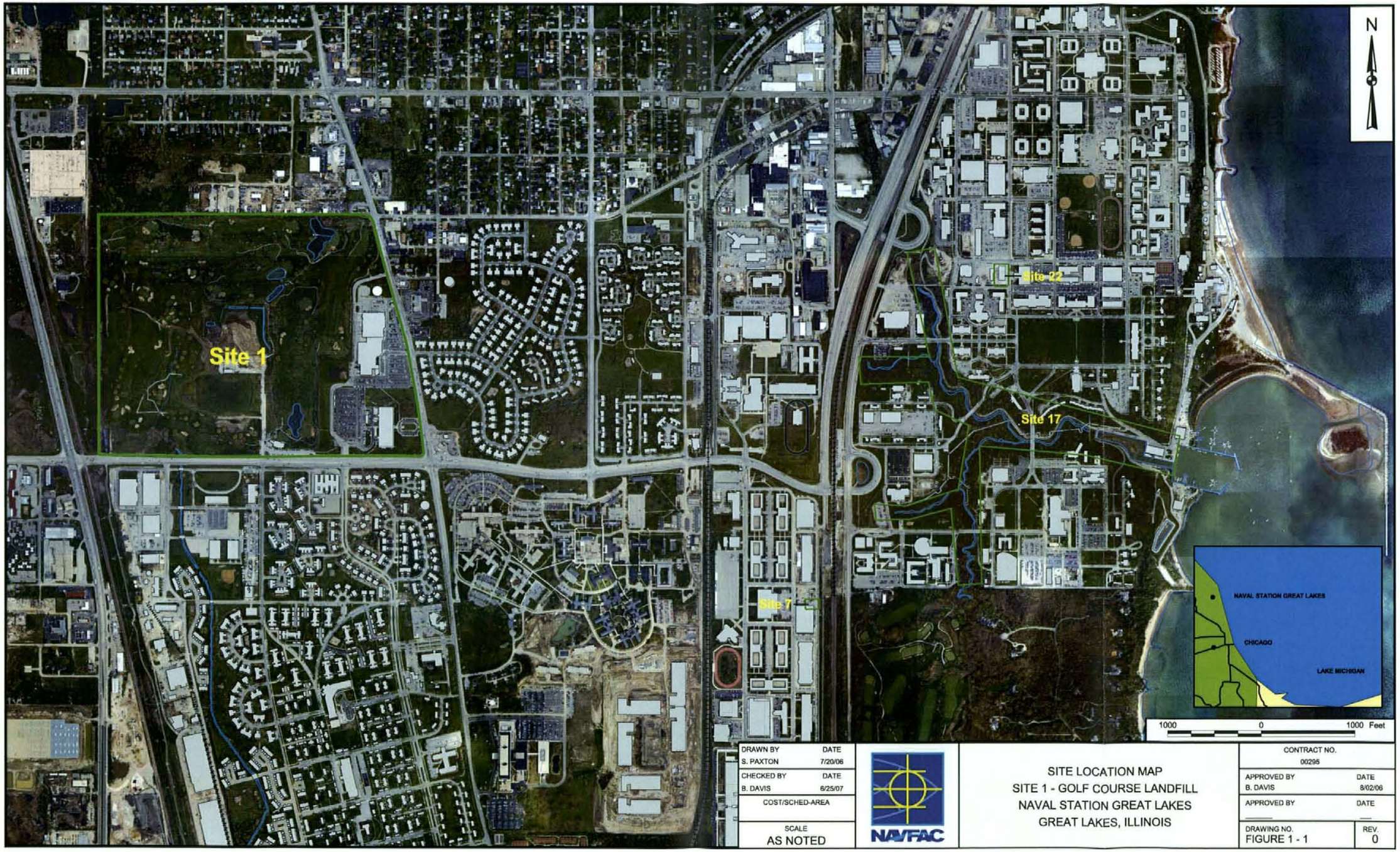
An aeolian material, the Richland loess, covers the Wadsworth till and ranges from 16 to 20 inches in thickness. This aeolian material is much finer grained than the underlying Wadsworth till. These wind-blown materials of the Richland Loess make up the current soil profile of Naval Station Great Lakes. Deposits of silt, clay, and sand of the Equality Formation characterize the central and southern portions of Naval Station Great Lakes (TtNUS, February 2007).

1.4.6 Regional Hydrology

The shallow subsurface at Naval Station Great Lakes is composed of glacial till that has few, if any, continuous sand stringers that could carry groundwater over long distances. The Skokie Ditch is a perennial stream on the golf course. The Skokie Ditch originates northwest of Site 1 and travels via an underground storm sewer until it surfaces in the middle of Site 1. The Skokie Ditch flows in a southerly direction from the site, passing the Supply Side section of Naval Station Great Lakes and exiting Navy property after passing the Green Bay Sewage Treatment Plant in Forrestal Village. From there, the Skokie Ditch becomes the Skokie River, which eventually discharges into the Chicago River. The Skokie Ditch is a sluggish, almost stagnant stream in this area, except immediately after a storm. No fishing has been reported in close proximity to the activity (Rogers, Golden & Halpern, March 1986).

The Skokie Ditch south of Buckley Road in the Supply Side and Forrestal Village section of Naval Station Great Lakes is steeply cut and the normal water level is approximately 10 feet below the top of the bank. The banks are mowed, with dominant vegetation species being turf grasses including Kentucky bluegrass and fescue. Scattered trees such as weeping willows and eastern cotton woods are also present. Representative test pits and general observations did not reveal any primary or secondary indicators of wetland hydrology, so the area does not qualify as a wetland. However, the channel of the Skokie Ditch does qualify as a jurisdictional "waters of the United States" below the ordinary high water mark, which includes the area below the top of the bank of the Skokie Ditch.

P:\GIS\GREATLAKES_NS\MAPDOCS\APR\SITE1.APR SITE LOCATION MAP LAYOUT 6/25/07 SS



DRAWN BY	DATE
S. PAXTON	7/20/06
CHECKED BY	DATE
B. DAVIS	6/25/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

SITE LOCATION MAP
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	8/02/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 1 - 1	0

000214HB01Y

P:\GIS\GREATLAKES_NS\MAPDOCS\APR\SITE1.APR SITE MAP LAYOUT 7/16/07 SS

DRAWN BY	DATE
S. PAXTON	7/20/06
CHECKED BY	DATE
B. DAVIS	7/16/07
COST/SCHED-AREA	
SCALE AS NOTED	

NAVFAC

SITE MAP
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO. 00078	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 1 - 2	REV. 0

2.0 SITE BACKGROUND

In 1986, an Initial Assessment Study conducted at Naval Station Great Lakes identified waste management areas, disposal sites, and contaminated areas caused by past hazardous substance storage, handling, or disposal practices from Naval activities. Each site was evaluated with respect to contamination characteristics, migration pathways, pollutant receptors, and potential threats to human health or the environment. As part of the Initial Assessment Study, the Navy identified 14 potential areas where hazardous materials may have been released to the environment at Naval Station Great Lakes. Of these 14 sites, seven sites were recommended for further investigation, one of which was Site 1 (Rogers, Golden, & Halpern, March 1986). The following sections provide a historical overview and background for Site 1.

2.1 SITE CHARACTERIZATION

2.1.1 Location and Description

Site 1 offers recreational activities for Naval Station Great Lakes and the surrounding area and is located north of Buckley Road and east of Route 41 in the northwestern corner of the naval station. The 18-hole golf course covers approximately 125 acres. Based on historical aerial photographs, a landfill was operated at this site between 1942 and 1967 on approximately 50 acres that is now covered by the western part (back nine) of the golf course.

2.1.2 History

Site 1 was a landfill that operated between 1942 and 1967 as a trench/burn facility. It received an estimated 1.5 million tons of material total during its years of operation. Types of waste reportedly disposed at the landfill included domestic refuse, sewage sludge, petroleum, oil, and lubricants, solvents, coal ash, and materials contaminated by polychlorinated biphenyls (PCBs) (C.H. Guernsey, November 2002).

A dragline was used for excavation of the trenches. Each trench was approximately 8 feet wide and was dug to at least the top of the water table (6 to 8 feet in this area). Occasionally, the trenches had several feet of standing water in the bottom. General refuse and trash were disposed directly into these trenches. Free liquid oil, such as waste engine oil from activity shops, was also disposed in this manner. After a significant volume of material was placed in a trench, the pile was ignited and allowed to burn.

Proceeding in this manner, the trenches were progressively filled and covered from west to east and north to south (Rogers, Golden & Halpern, March 1986).

When the landfill was closed in 1969, a layer of ash from coal-fired power plants at Naval Station Great Lakes was placed over the landfill and topsoil was placed over the ash. Based on aerial photography, it appears that the front nine-hole portion of the golf course was constructed between 1953 and 1955. The Golf Course Clubhouse, Building 3312, and the parking lot associated with the building were constructed in 1963. The back nine-hole portion of the golf course was initially constructed in 1968 and was reconstructed in 2003 (C.H. Guernsey, November 2002).

A fire fighting training unit was built in 1942 and operated until it was taken out of service in 1989. The fire fighting training unit was located on 10 acres that are now at the center of the golf course. Consequently, the fire fighting training unit was active during the operation of the landfill and during the operation of the golf course. Environmental investigations were conducted to determine the nature and extent of contamination at the fire fighting training unit, and environmental remediation of the old fire fighting training unit site was conducted to remove underground and above-ground storage tanks.

2.2 ENVIRONMENTAL SETTING

2.2.1 Geography and Land Use

The portion of Site 1 targeted in this investigation is a former landfill that occupied approximately 50 acres. The landfill is now covered by an 18-hole golf course that covers approximately 125 acres.

2.2.2 Physiography and Topography

Site 1 is located within the Skokie Drainage basin, which is part of the Mississippi River Watershed. The site is at an elevation of 690 feet above mean sea level, and the slopes in the site area range from 1.0 to 1.5 percent (C.H. Guernsey, November 2002).

2.2.3 Soil and Geology

The soils at Site 1 include of Pella silty clay loam, Morley silt loam, Ashkum silty clay loam, Grays and Markham silt loams, Zurich and Morley silt loams, and Made Land. The majority of soils at the golf course have been mapped as Made Land soils that consist of areas of manmade cuts and fills and areas associated with the landfill, as mapped by the Natural Resources Conservation Service.

In general, geologic materials in descending order include 100 to 150 feet of fine-grained till, 10 to 50 feet of sand and gravel, 10 to 50 feet of fine-grained till, and Silurian-age dolomitic bedrock. The geology of the county is described as unconsolidated glacial till overlying Silurian-age dolomite.

2.2.4 Ecology

General discussions of threatened and endangered plants and animals that occur or could potentially occur at Naval Station Great Lakes can be found in the Environmental Assessment for Implementation of an Integrated Natural Resources Management Plan at Naval Station Great Lakes, Illinois (Navy, February 2001).

Site 1 is located inland from the Lake Michigan shoreline of Naval Station Great Lakes. In the Pettibone Ravine and along the bluffs and beach areas where human impacts are least, there are a variety of breeding and migratory birds, as well as several species of mammals. Within the Main Installation, recent bird surveys documented 34 species of breeding birds and 100 species of migratory birds, including the downy woodpecker and cooper's hawk (Navy, October 1995 and August 2000). Mammals likely or known to occur on the Main Installation include the woodchuck, white-tailed deer, and raccoon. Ecological receptors that occur at Site 1 consist of those typically found in urban areas, such as terrestrial invertebrates and various songbirds.

Site 1 contains both surface water and groundwater. The Initial Assessment Study concluded that there are potential contamination migration pathways at Site 1 and that the downward migration of contaminants into deeper aquifers used for drinking water is unlikely due to aquitards formed by the glacial till of the area. It was determined that runoff from the Supply Side section of Naval Station Great Lakes may enter the Skokie Ditch, which eventually drains into the Chicago River. Groundwater migration should be monitored because of the variety of toxic materials that may have been disposed in the landfill and the close proximity of human receptors.

2.3 PREVIOUS SAMPLING EVENTS

The data from prior sampling events are shown in Tables 2-1 to 2-3. These summary tables show ranges of concentration, maximum and average concentrations, and frequencies of detection for groundwater, surface water, and soil sampling at Site 1. Tag maps showing exceedances of Illinois EPA Tiered Approach to Corrective Action Objectives (TACO; Illinois EPA, June 2007) and USEPA Region 9 Preliminary Remediation Goals (PRGs) for groundwater, surface water, residential soil, and industrial soil (USEPA. July 2006) are provided as Figures 2-1 to 2-4.

2.3.1 Previously Documented Groundwater and Surface Water Contamination

In 1991, Dames & Moore, Inc. completed an investigation at Naval Station Great Lakes. Nine groundwater monitoring wells were installed, and two rounds of groundwater samples were collected from these nine wells for chemical analysis (December 1988 and March 1989). As part of the investigation, surface water samples were collected at two locations (Dames & Moore, November 1991). Figure 2-1 shows all of the previous groundwater sampling locations, and Figure 2-2 shows all of the previous surface water sampling locations for Site 1.

The groundwater levels measured during this investigation indicated that the monitoring wells installed at Site 1 penetrated two different water-bearing zones, one with a potentiometric surface less than 10 feet below ground surface (bgs), and one with a potentiometric surface from approximately 15 to 30 feet bgs. There was no indication, however, that the two zones were connected, nor was there evidence that wells with similar water levels were in zones that are connected (Dames & Moore, November 1991).

Several inorganics were detected at very low concentrations in the shallow groundwater samples collected during the investigation. A single exceedance of Illinois EPA TACO criteria was detected for cadmium and selenium and may not be statistically significant. Beryllium was detected at concentrations in exceedance of Illinois EPA TACO criteria in two samples; however it was also detected at similar concentrations in background wells and downgradient wells, indicating that the observed beryllium concentrations may reflect naturally occurring beryllium and not contamination from the landfill. Figure 2-1 shows exceedances of Illinois EPA TACO values and USEPA Region 9 PRGs, and Table 2-1 provides a summary of the historical groundwater data collected at Site 1. This table provides the frequency at which each parameter was detected, provides the range of concentrations for each parameter, identifies the sample with the maximum concentration of each parameter, and provides a comparison of the data to regulatory criteria.

In March 2004, TolTest, Inc. was contracted by the Navy to collect three groundwater samples along a 250-yard section of the Skokie storm sewer located at Site 1. These samples were collected to support the investigation of several sinkholes that appeared on the golf course in the vicinity of the Skokie Ditch. The groundwater samples were analyzed for semivolatile organic compounds (SVOCs) and Resource Conservation and Recovery Act (RCRA) metals. The data obtained from the groundwater samples were compared to the TACO Class I and Class II groundwater screening objectives (see Table 2-1 and Figure 2-1). SVOCs were not detected in the groundwater samples at concentrations that exceeded method detection limits. However, two RCRA metals (barium and selenium) were detected at concentrations that

exceeded method detection limits. Selenium concentrations slightly exceeded its groundwater screening objectives (TolTest, March 2004).

Copper, lead, mercury, and silver were detected in the surface water samples collected from Skokie Ditch in 1991. Some of the concentrations exceeded surface water quality criteria. Oil and grease was also detected in the surface water samples (Dames & Moore, November 1991). Figure 2-2 shows exceedances of Illinois EPA TACO values and USEPA Region 9 PRGs, and Table 2-2 provides a summary of the historical surface water data collected at Site 1. This table provides the frequency at which each parameter was detected, provides the range of concentrations for each parameter, identifies the sample with the maximum concentration of each parameter, and provides a comparison of the data to regulatory criteria.

2.3.2 Previously Documented Soil Contamination

In December 1995, Brown & Root Environmental, as part of a Relative Risk Evaluation at Various Activities, collected one soil sample and a duplicate from Site 1 at Naval Station Great Lakes. The samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), SVOCs, pesticides, and PCBs, Target Analyte List (TAL) metals, and cyanide (Brown & Root Environmental, March 1996). Table 2-3 provides a summary of the historical soil data collected at Site 1. This table provides the frequency at which each parameter was detected, provides the range of concentrations for each parameter, identifies the sample with the maximum concentration of each parameter, and provides a comparison of the data to regulatory criteria. Figures 2-3 and 2-4 show the locations of exceedances of Illinois EPA TACO residential and commercial/industrial screening values, respectively, and exceedances of USEPA Region 9 PRGs.

In August 1998, TtNUS collected shallow subsurface soil samples at Site 1 as part of an Addendum to the Technical Memorandum Site Sampling in Support of Relative Risk Evaluation at Various Activities. Four samples were collected and analyzed for the full suite of TCL/TAL parameters and cyanide (TtNUS, August 1998). Table 2-3 provides a summary of the analytical results, and Figures 2-3 and 2-4 show the locations of exceedances of Illinois EPA TACO residential and commercial/industrial screening values, respectively, and exceedances of U.S. EPA Region 9 PRGs.

In January 2003, C.H. Guernsey & Company was tasked by the Engineering Field Activity Midwest to perform a subsurface environmental investigation at Site 1 in support of the reconstruction of the back nine holes of the golf course. Between January 14 and 15, 2003, C.H. Guernsey & Company installed 42 soil borings. Landfill material consisting of black cinders, black powder, broken glass, wood, plastic, fabric, paper, wire, nails, metal, brick, concrete, gravel and clay was encountered in 30 of the 42 soil

borings installed. Six soil samples were collected for headspace analysis, and five soil samples were collected for laboratory analysis (C.H. Guernsey, February 2003). Two of the samples were collected from an area near Hole No. 4, and one sample was collected from each of three areas where excavations were proposed. The samples were analyzed for VOCs, SVOCs, and eight RCRA metals. VOCs were not detected in the samples. SVOCs [anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, di-n-butylphthalate, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene] were detected in one soil sample, and metals were detected in the five soil samples (C.H. Guernsey, February 2003). Soil analytical results are summarized in Table 2-3. Figures 2-3 and 2-4 show the locations of exceedances of Illinois EPA TACO residential and commercial/industrial screening values, respectively, and exceedances of USEPA Region 9 PRGs.

C.H. Guernsey & Company performed a second investigation in February 2003 in which 22 soil borings were installed. Eight of the 22 soil borings encountered landfill material. Per Navy instructions, soil samples were not obtained for headspace or laboratory analysis.

TolTest, Inc., also collected 10 subsurface soil samples along a 250-yard section of the Skokie storm sewer located at Site 1 in March 2004. The 10 subsurface soil samples collected were analyzed for VOCs, SVOCs, and RCRA metals. The data obtained from the soil samples were compared to the Illinois EPA TACO screening objectives for residential and commercial properties (see Table 2-3). No VOCs, SVOCs, or RCRA metals were detected in the soil samples at concentrations that exceeded their respective screening objectives. The purpose of collecting these soil samples was to evaluate subsurface environmental conditions and not to obtain closure under TACO or the Illinois EPA Site Remediation Program (TolTest, March 2004).

TABLE 2-1

GROUNDWATER SUMMARY STATISTICS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Parameter	Fequency of Detection	Range of Detections	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Average of All Results	Region 9 Tap Water PRG	Region 9 Tap Water PRG Exceedances	IL TACO Groundwater Ingestion Tier 1	IL TACO Groundwater Ingestion Tier 1 Exceedances	Federal MCL	Federal MCL Exceedances
Volatile Organics (µg/L)												
ACETONE	3/20	12 - 26	10	GLDM-01MW09	14.8	6.5	5500	0	700	0	NC	0
CHLOROBENZENE	1/20	2	5	GLDM-01MW09	2	2.5	110	0	100	0	100	0
METHYLENE CHLORIDE	18/20	3 - 18	5	GLDM-01MW03; GLDM-01MW04A	9	9	4.3	14	5	13	5	13
Semivolatile Organics (µg/L)												
BIS(2-ETHYLHEXYL) PHTHALATE	7/23	2 - 14	5 - 10	GLDM-01MW05	7	5	4.8	5	6	3	6	3
DI-N-OCTYL PHTHALATE	1/23	3	1.36 - 10	GLDM-01MW05	3	4.35	1500	0	140	0	NC	0
Petroleum Hydrocarbons (µg/L)												
OIL & GREASE	1/20	49700	20 - 5000	GLDM-04MW01	49700	3615	NC	0	NC	0	NC	0
Inorganics (µg/L)												
ARSENIC	1/23	4.9	3 - 20	GLDM-01MW05	4.9	3.2	0.045	1	50	0	10	0
BARIUM	3/3	28 - 99.9	0	GLTO-01PZ007	53.3	53.3	2600	0	2000	0	2000	0
BERYLLIUM	9/20	4 - 5	2 - 5	GLDM-01MW08; GLDM-01MW09	4.2	3.2	73	0	4	2	4	2
CADMIUM	1/23	5.5	3 - 5	GLDM-01MW02	5.5	2.5	18	0	5	1	5	1
CHROMIUM	2/23	11 - 25.6	8 - 10	GLDM-01MW01	18.3	5.8	110	0	100	0	100	0
COPPER	8/20	7.5 - 65.4	3 - 8	GLDM-01MW09	12	6.7	1500	0	650	0	1300	0
LEAD	2/23	2.5 - 3	2 - 3	GLDM-01MW07B	2.8	1.4	NC	0	7.5	0	15	0
MERCURY	10/23	0.25 - 0.51	0.2	GLDM-01MW05	0.3	0.19	11	0	2	0	2	0
NICKEL	3/20	27.2 - 56.3	21 - 26	GLDM-01MW09	44.9	16.5	730	0	100	0	NC	0
SELENIUM	4/23	2.06 - 60	2 - 5	GLTO-01PZ005	37.8	8	180	0	50	1	50	1
SILVER	1/23	48.3	3 - 7	GLDM-01MW07B	48.3	4.3	180	0	50	0	NC	0
ZINC	18/20	6.6 - 66.4	3 - 4	GLDM-01MW09	19	17.3	11000	0	5000	0	NC	0
Miscellaneous Parameters (µg/L)												
CHLORIDE	20/20	900 - 768000	0	GLDM-01MW09	82500	82500	NC	0	200000	2	NC	0
TOTAL ORGANIC CARBON	20/20	870 - 8000	0	GLDM-04MW01	3080	3080	NC	0	NC	0	NC	0

Associated Samples:

1991 DAMES & MOORE RI STEP

Round 1 - December 1988	**Round 2 - March 1989**	**2004 TOLTEST INVESTIGATION**
GLDM-01MW01-1988	GLDM-01MW01-1989	GLTO-01PZ003-2004
GLDM-01MW02-1988	GLDM-01MW02-1989	GLTO-01PZ005-2004
GLDM-01MW03-1988	GLDM-01MW03-1989	GLTO-01PZ007-2004
GLDM-04MW01-1988	GLDM-04MW01-1989	
GLDM-01MW04A-1988	GLDM-01MW04A-1989	
GLDM-01MW05-1988	GLDM-01MW05-1989	
GLDM-01MW06A-1988	GLDM-01MW06A-1989	
GLDM-01MW07B-1988	GLDM-01MW07B-1989	
GLDM-01MW08-1988	GLDM-01MW08-1989	
GLDM-01MW09-1988	GLDM-01MW09-1989	

NC = No criterion.
PRG = Preliminary Remediation Goal
IL TACO = Illinois Tiered Approach to Corrective Action Objectives
MCL = Maximum Containment Level

TABLE 2-2

SURFACE WATER SUMMARY STATISTICS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Parameter	Fequency of Detection	Range of Detections	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Average of All Results	Region 9 Tap Water PRG	Region 9 Tap Water PRG Exceedances	IL TACO Groundwater Ingestion Tier 1	IL TACO Groundwater Ingestion Tier 1 Exceedances	Federal MCL	Federal MCL Exceedances	Federal Ambient Water Quality HH/Consumption Water and Organisms	Federal Water Quality Exceedances	Ecological Surface Water Criterion (1)	Ecological Surface Water Criterion Exceedances
Volatile Organics (µg/L)																
ACETONE	1/4	16	10	GLDM-01SW01	10.5	6.4	5500	0	700	0	NC	0	NC	0	120000	0
METHYLENE CHLORIDE	3/4	5 - 9	5	GLDM-01SW01	5.3	4.6	4.3	3	5	1	5	1	4.7	3	1400	0
Semivolatile Organics (µg/L)																
BIS(2-ETHYLHEXYL) PHTHALATE	1/4	2	10	GLDM-01SW02	2	4.3	4.8	0	6	0	6	0	1.8	1	380	0
Petroleum Hydrocarbons (µg/L)																
OIL & GREASE	2/4	7000 - 15600	2	GLDM-01SW02	12750	6375.5	NC	0	NC	0	NC	0	0	1	NC	0
Inorganics (µg/L)																
ARSENIC	1/4	7.39	3 - 10	GLDM-01SW02	7.39	4.7	0.045	1	50	0	10	0	0.018	1	190	0
COPPER	1/4	55.6	9 - 25	GLDM-01SW01	34.1	13.9	1500	0	650	0	1300	0	1000	0	11.4	1
LEAD	2/4	4.79 - 9.06	3	GLDM-01SW01	5.97	3.7	NC	0	7.5	0	15	0	NC	0	15.9	0
MERCURY	1/4	0.5 - 0.52	0.2	GLDM-01SW01	0.51	0.2	11	0	2	0	2	0	0.05	1	1.1	0
SELENIUM	1/4	2.41	2 - 5	GLDM-01SW02	2.41	2.1	180	0	50	0	50	0	170	0	1000	0
SILVER	1/4	43.6	7 - 10	GLDM-01SW01	43.6	14.3	180	0	50	0	NC	0	NC	0	5	1
ZINC	4/4	22.4 - 43.9	0	GLDM-01SW01	32.8	32.8	11000	0	5000	0	NC	0	5000	0	21.6	4
Miscellaneous Parameters (µg/L)																
CHLORIDE	4/4	247000 - 646000	0	GLDM-01SW02	420125	420125	NC	0	200000	4	NC	0	0	0	NC	0
TOTAL ORGANIC CARBON	4/4	7000 - 8930	0	GLDM-01SW02	8127.5	8127.5	NC	0	NC	0	NC	0	NC	0	NC	0

1 The sources of the ecological surface water criteria are provided in Table 1 in Appendix II of the Quality Assurance Project Plan.

Associated Samples:

1991 DAMES & MOORE RI STEP

Round 1 - December 1988
GLDM-01SW01-1988
GLDM-01SW02-1988

Round 2 - March 1989
GLDM-01SW01-1989
GLDM-01SW02-1989

NC = No criterion.
PRG = Preliminary Remediation Goal
IL TACO = Illinois Tiered Approach to Corrective Action Objectives
MCL = Maximum Containment Level
HH = Human Health

TABLE 2-3

SOIL SUMMARY STATISTICS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Parameter	Fequency of Detection	Range of Detections	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Average of All Results	IL TACO SRO for Residential Properties - Ingestion	IL TACO SRO for Residential Properties - Ingestion Exceedances	IL TACO SRO for Residential Properties - Inhalation	IL TACO SRO for Residential Properties - Inhalation Exceedances
Volatile Organics (µg/kg)										
2-BUTANONE	5/20	1.8 - 8	0 - 16.8	GLTT-01MW04	4.1	3.5	NC	0	NC	0
ACETONE	13/20	5 - 30	12 - 42	GLTT-01MW02	15.0	14.3	7800000	0	100000000	0
CARBON DISULFIDE	4/19	0.71 - 1.1	0.451 - 12	GLTO-01SB003	0.86	2.34	7800000	0	720000	0
CHLOROFORM	1/20	1 - 2	0 - 12	GLTT-01MW01	1	2	100000	0	300	0
METHYLENE CHLORIDE	5/19	1 - 13	0.447 - 12	GLTT-01MW02	3.8	2.85	85000	0	13000	0
Semivolatile Organics (µg/kg)										
1,2,4-TRICHLOROBENZENE	1/19	1190 - 1190	96.7 - 400	GLTO-01SB004	1190.0	146.9	780000	0	3200000	0
1,4-DICHLOROBENZENE	1/19	1150 - 1150	83.6 - 400	GLTO-01SB004	1150.0	141.6	NC	0	11000000	0
2,4-DINITROTOLUENE	1/19	1150 - 1150	40.8 - 400	GLTO-01SB004	1150.0	131.1	900	1	NC	0
2-CHLOROPHENOL	1/19	2890 - 2890	112 - 400	GLTO-01SB004	2890	259	390000	0	53000000	0
2-METHYLNAPHTHALENE	4/20	21 - 430	71.4 - 400	GLTT-01MW03	139.0	73.8	NC	0	NC	0
4-CHLORO-3-METHYLPHENOL	1/19	2770 - 2770	105 - 400	GLTO-01SB004	2770	232	NC	0	NC	0
4-NITROPHENOL	1/19	2340 - 2340	40.8 - 1070	GLTO-01SB004	2340.0	330.5	NC	0	NC	0
ACENAPHTHENE	3/20	110 - 1500	45.4 - 400	GLTT-01MW03	590.0	137.7	4700000	0	NC	0
ACENAPHTHYLENE	1/19	90 - 90	45.4 - 400	GLTT-01MW03	90.0	67.1	NC	0	NC	0
ANTHRACENE	4/20	210 - 4500	45.4 - 400	GLTT-01MW03	1369.8	320.2	23000000	0	NC	0
BENZO(A)ANTHRACENE	6/20	22 - 27000	45.4 - 215	GLTT-01MW03	5114.2	1560.5	900	4	NC	0
BENZO(A)PYRENE	6/20	25 - 28000	45.4 - 125	GLTT-01MW03	5265.0	1599.6	90	4	NC	0
BENZO(B)FLUORANTHENE	6/20	33 - 37000	45.4 - 215	GLTT-01MW03	6850.7	2081.4	900	4	NC	0
BENZO(G,H,I)PERYLENE	6/20	61 - 15000	45.4 - 215	GLTT-01MW03	2908.3	898.7	NC	0	NC	0
BENZO(K)FLUORANTHENE	5/19	25 - 21000	45.4 - 215	GLTT-01MW03	4611.4	1241.1	9000	1	NC	0
BIS(2-ETHYLHEXYL) PHTHALATE	5/20	100 - 890	189 - 709	GLTT-01MW01	225	163	46000	0	31000000	0
BUTYL BENZYL PHTHALATE	1/20	37 - 54	81.3 - 400	GLTT-01MW01	45.5	80.9	16000000	0	930000	0
CARBAZOLE	3/15	140 - 3300	189 - 400	GLTT-01MW03	1227	337	32000	0	NC	0
CHRYSENE	6/20	40 - 30000	45.4 - 215	GLTT-01MW03	5688.8	1732.9	88000	0	NC	0
DIBENZO(A,H)ANTHRACENE	5/20	32 - 8300	45.4 - 400	GLTT-01MW03	1829.2	487.4	90	4	NC	0
DIBENZOFURAN	3/20	59 - 890	35.2 - 400	GLTT-01MW03	348.2	98.9	NC	0	NC	0
DI-N-BUTYL PHTHALATE	2/19	25 - 889	91.1 - 709	GLGN-01SB004	457.0	154.9	7800000	0	2300000	0
FLUORANTHENE	7/20	37 - 59000	45.4 - 215	GLTT-01MW03	9612.5	3389.4	3100000	0	NC	0
FLUORENE	3/20	89 - 1800	45.4 - 400	GLTT-01MW03	688.0	152.4	3100000	0	NC	0
INDENO(1,2,3-CD)PYRENE	6/20	46 - 15000	45.4 - 215	GLTT-01MW03	2897.8	895.6	900	1	NC	0
NAPHTHALENE	3/20	55 - 420	45.4 - 400	GLTT-01MW03	185.8	77.1	1600000	0	170000	0
N-NITROSO-DI-N-PROPYLAMINE	1/19	1320 - 1320	92.7 - 400	GLTO-01SB004	1320.0	152.8	90	1	NC	0
PENTACHLOROPHENOL	3/20	39 - 1800	0 - 1070	GLTO-01SB004	730	280	3000	0	NC	0
PHENANTHRENE	6/20	34 - 30000	45.4 - 215	GLTT-01MW03	5735.0	1746.7	NC	0	NC	0
PHENOL	2/20	29 - 2880	0 - 400	GLTO-01SB004	1455	203	47000000	0	NC	0
PYRENE	6/20	81 - 63000	45.4 - 215	GLTT-01MW03	11655.2	3522.8	2300000	0	NC	0
Pesticides/PCBs (µg/kg)										
4,4'-DDD	2/5	2.5 - 8.8	3.9 - 3.9	GLTT-01MW01	4.7	3.1	3000	0	NC	0
4,4'-DDE	4/5	3 - 94	0 - 3.9	GLTT-01MW03	32.7	26.6	2000	0	NC	0
4,4'-DDT	4/5	2.4 - 140	3.9 - 3.9	GLTT-01MW03	40.9	33.1	2000	0	NC	0
ALDRIN	1/4	2 - 2	2 - 2	GLTT-01MW02	2.0	1.3	40	0	3000	0
ALPHA-CHLORDANE	1/5	1.3 - 3.2	2 - 2	GLTT-01MW01	2.3	1.3	1800	0	72000	0
AROCLOR-1254	1/5	1500 - 1500	0 - 39	GLTT-01MW03	1500	308.18	1000	1	NC	0
AROCLOR-1260	1/4	26 - 26	39 - 39	GLTT-01MW05	26	21	1000	0	NC	0
ENDOSULFAN I	1/5	5.8 - 14	2 - 2	GLTT-01MW01	9.9	2.8	470000	0	NC	0
ENDRIN	1/5	2.45 - 4.9	0 - 3.9	GLTT-01MW01	2.45	2.04	23000	0	NC	0
ENDRIN ALDEHYDE	1/5	3.45 - 6.9	0 - 3.9	GLTT-01MW01	3.45	2.24	NC	0	NC	0
GAMMA-CHLORDANE	1/5	1.4 - 1.4	0 - 2	GLTT-01MW02	1.4	0.9	1800	0	72000	0

TABLE 2-3

SOIL SUMMARY STATISTICS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Parameter	Fequency of Detection	Range of Detections	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Average of All Results	IL TACO SRO for Residential Properties - Ingestion	IL TACO SRO for Residential Properties - Ingestion Exceedances	IL TACO SRO for Residential Properties - Inhalation	IL TACO SRO for Residential Properties - Inhalation Exceedances
Inorganics (mg/kg)										
ALUMINUM	5/5	3140 - 16000	-	GLTT-01MW02	11124	11124	NC	0	NC	0
ANTIMONY	3/5	0.39 - 1.7	0 - 0.4	GLTT-01MW03	0.84	0.55	31	0	NC	0
ARSENIC	10/20	2.7 - 9.9	1.9 - 4.3	GLTT-01MW03	6.5	3.9	NC	0	750	0
BARIUM	20/20	28.5 - 223	-	GLGN-01SB015	86.3	86.3	5500	0	690000	0
BERYLLIUM	5/5	0.49 - 1.2	-	GLTT-01MW03	0.8	0.8	160	0	1300	0
CADMIUM	3/20	0.5 - 1.7	0 - 1.07	GLTT-01MW03	1.1	0.34	78	0	1800	0
CALCIUM	5/5	8840 - 51000	-	GLTT-01MW01	32208	32208	NC	0	NC	0
CHROMIUM	20/20	7.5 - 42.8	-	GLTO-01SB010	24.6	24.6	230	0	270	0
COBALT	5/5	6.1 - 12.3	-	GLTT-01MW05	10.6	10.6	4700	0	NC	0
COPPER	5/5	20.4 - 497	-	GLTT-01MW01	97.4	97.4	2900	0	NC	0
IRON	5/5	13100 - 29400	-	GLTT-01MW03	22200	22200	NC	0	NC	0
LEAD	20/20	6.69 - 429	-	GLTT-01MW03	54.7	54.7	400	1	NC	0
MAGNESIUM	5/5	7390 - 28700	-	GLTT-01MW01	17438	17438	NC	0	NC	0
MANGANESE	5/5	419 - 1500	-	GLTT-01MW04	799	799	3700	0	69000	0
MERCURY	9/20	0.0539 - 2.4	0 - 0.024	GLTT-01MW03	0.4931	0.23	23	0	10	0
NICKEL	5/5	11.7 - 29.2	-	GLTT-01MW03	24.9	24.9	1600	0	13000	0
POTASSIUM	5/5	793.5 - 2780	-	GLTT-01MW02	1978.7	1978.7	NC	0	NC	0
SELENIUM	5/20	1.2 - 4.8	0.63 - 5.37	GLTO-01SB010	3.3	1.66	390	0	NC	0
SILVER	3/20	0.6 - 1.1	0 - 5.37	GLTT-01MW03	0.9	0.67	390	0	NC	0
SILVER	3/20	0.6 - 1.1	0 - 5.37	GLTT-01MW02	0.9	0.67	390	0	NC	0
SODIUM	5/5	66.7 - 246	-	GLTT-01MW01	130.6	130.6	NC	0	NC	0
THALLIUM	4/4	1 - 3	-	GLTT-01MW04	1.8	1.8	6.3	0	NC	0
VANADIUM	5/5	14.8 - 37.8	-	GLTT-01MW02	27.1	27.1	550	0	NC	0
ZINC	5/5	62.4 - 654	-	GLTT-01MW01	195.3	195.3	23000	0	NC	0
Miscellaneous Parameters (%)										
PERCENT MOISTURE	10/10	11.82 - 17.1	-	GLTO-01SB009	14.9	14.9	NC	0	NC	0
PERCENT SOLIDS	5/5	46.5 - 89.5	-	GLGN-01SB015	75.5	75.5	NC	0	NC	0

TABLE 2-3

SOIL SUMMARY STATISTICS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Parameter	IL TACO - SRO for Industrial Properties Inhalation - Industrial	IL TACO - SRO for Industrial Properties Inhalation - Industrial Exceedances	IL TACO - SSLs for Migration from Soil to Groundwater (DAF 20)	IL TACO - SSLs for Migration from Soil to Groundwater (DAF 20) Exceedances	USEPA Region 9 PRG - Residential Soil	USEPA Region 9 PRG Residential Soil Exceedances	USEPA Generic SSLs for Migration from Soil to Groundwater (DAF 1)	USEPA Generic SSLs for Migration from Soil to Groundwater (DAF 1) Excedances
Volatile Organics (µg/kg)								
2-BUTANONE	NC	0	NC	0	22000000	0	4400	0
ACETONE	100000000	0	16000	0	14000000	0	6600	0
CARBON DISULFIDE	720000	0	32000	0	360000	0	1500	0
CHLOROFORM	540	0	600	0	220	0	29	0
METHYLENE CHLORIDE	24000	0	20	0	9100	0	1.2	4
Semivolatile Organics (µg/kg)								
1,2,4-TRICHLOROBENZENE	3200000	0	5000	0	62000	0	260	1
1,4-DICHLOROBENZENE	17000000	0	2000	0	3400	0	110	1
2,4-DINITROTOLUENE	NC	0	0.8	1	120000	0	0.049	1
2-CHLOROPHENOL	53000000	0	4000	0	63000	0	180	1
2-METHYLNAPHTHALENE	NC	0	NC	0	56000	0	NC	0
4-CHLORO-3-METHYLPHENOL	NC	0	NC	0	NC	0	NC	0
4-NITROPHENOL	NC	0	NC	0	NC	0	NC	0
ACENAPHTHENE	NC	0	570000	0	3700000	0	31000	0
ACENAPHTHYLENE	NC	0	NC	0	3700000	0	NC	0
ANTHRACENE	NC	0	12000000	0	22000000	0	650000	0
BENZO(A)ANTHRACENE	NC	0	2000	1	620	4	160	4
BENZO(A)PYRENE	NC	0	8000	1	62	5	410	4
BENZO(B)FLUORANTHENE	NC	0	5000	1	620	4	490	4
BENZO(G,H,I)PERYLENE	NC	0	NC	0	2300000	0	NC	0
BENZO(K)FLUORANTHENE	NC	0	49000	0	6200	1	490	3
BIS(2-ETHYLHEXYL) PHTHALATE	31000000	0	3600000	0	35000	0	180000	0
BUTYL BENZYL PHTHALATE	930000	0	930000	0	12000000	0	840000	0
CARBAZOLE	NC	0	600	1	24000	0	30	3
CHRYSENE	NC	0	160000	0	62000	0	160	4
DIBENZO(A,H)ANTHRACENE	NC	0	2000	1	62	4	1500	1
DIBENZOFURAN	NC	0	NC	0	150000	0	2400	0
DI-N-BUTYL PHTHALATE	2300000	0	2300000	0	6100000	0	250000	0
FLUORANTHENE	NC	0	4300000	0	2300000	0	310000	0
FLUORENE	NC	0	560000	0	2700000	0	41000	0
INDENO(1,2,3-CD)PYRENE	NC	0	14000	1	620	4	1400	1
NAPHTHALENE	270000	0	12000	0	56000	0	3100	0
N-NITROSO-DI-N-PROPYLAMINE	NC	0	0.05	1	69	1	0.003	1
PENTACHLOROPHENOL	NC	0	30	3	3000	0	1.4	3
PHENANTHRENE	NC	0	NC	0	2300000	0	NC	0
PHENOL	NC	0	100000	0	18000000	0	2800	1
PYRENE	NC	0	4200000	0	2300000	0	230000	0
Pesticides/PCBs (µg/kg)								
4,4'-DDD	NC	0	16000	0	2400	0	710	0
4,4'-DDE	NC	0	54000	0	1700	0	2200	0
4,4'-DDT	1500000	0	32000	0	1700	0	1300	0
ALDRIN	6600	0	500	0	29	0	25	0
ALPHA-CHLORDANE	140000	0	10000	0	1600	0	480	0
AROCLOR-1254	NC	0	NC	0	220	1	NC	0
AROCLOR-1260	NC	0	NC	0	220	0	NC	0
ENDOSULFAN I	NC	0	18000	0	370000	0	980	0
ENDRIN	NC	0	1000	0	18000	0	50	0
ENDRIN ALDEHYDE	NC	0	NC	0	18000	0	NC	0
GAMMA-CHLORDANE	140000	0	10000	0	1600	0	480	0

TABLE 2-3

SOIL SUMMARY STATISTICS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Parameter	IL TACO - SRO for Industrial Properties Inhalation - Industrial	IL TACO - SRO for Industrial Properties Inhalation - Industrial Exceedances	IL TACO - SSLs for Migration from Soil to Groundwater (DAF 20)	IL TACO - SSLs for Migration from Soil to Groundwater (DAF 20) Exceedances	USEPA Region 9 PRG - Residential Soil	USEPA Region 9 PRG Residential Soil Exceedances	USEPA Generic SSLs for Migration from Soil to Groundwater (DAF 1)	USEPA Generic SSLs for Migration from Soil to Groundwater (DAF 1) Excedances
Inorganics (mg/kg)								
ALUMINUM	NC	0	NC		76000	0	8.3	5
ANTIMONY	NC	0	0.006	3	31	0	0.27	3
ARSENIC	1200	0	0.05	10	0.39	10	0.29	10
BARIUM	910000	0	2	20	5400	0	82	7
BERYLLIUM	2100	0	0.004	5	150	0	3.2	0
CADMIUM	2800	0	0.005	3	37	0	0.38	3
CALCIUM	NC	0	NC	0	NC	0	NC	0
CHROMIUM	420	0	0.1	20	30	6	2.1	20
COBALT	NC	0	1	5	900	0	0.17	5
COPPER	NC	0	0.65	5	3100	0	560	0
IRON	NC	0	5	5	23000	2	NC	0
LEAD	NC	0	0.0075	20	400	1	NC	0
MAGNESIUM	NC	0	NC	0	NC	0	NC	0
MANGANESE	91000	0	0.15	5	1800	0	110	5
MERCURY	540000	0	0.002	9	23	0	0.1	5
NICKEL	21000	0	0.1	5	1600	0	14	5
POTASSIUM	NC	0	NC	0	NC	0	NC	0
SELENIUM	NC	0	0.05	5	390	0	0.26	5
SILVER	NC	0	0.05	3	390	0	1.6	0
SILVER	NC	0	0.05	3	390	0	1.6	0
SODIUM	NC	0	NC	0	NC	0	NC	0
THALLIUM	NC	0	0.002	4	5.2	0	0.056	4
VANADIUM	NC	0	0.049	5	78	0	260	0
ZINC	NC	0	5	5	23000	0	680	0
Miscellaneous Parameters (%)								
PERCENT MOISTURE	NC	0	NC	0	NC	0	NC	0
PERCENT SOLIDS	NC	0	NC	0	NC	0	NC	0

Associated Samples:

1995 Relative Risk Evaluation
GLTT-01MW01-1995
GLTT-01MW01-1995-AVG
GLTT-01MW01-1995-D

1998 Relative Risk Evaluation
GLTT-01MW02-1998
GLTT-01MW03-1998
GLTT-01MW04-1998
GLTT-01MW05-1998

2003 Guersney Investigation
GLGN-01SB004-0004
GLGN-01SB015-0004
GLGN-01SB022-0004
GLGN-01SB028-0004
GLGN-01SB041-0004

2004 TolTest Subsurface Investigation
GLTO-01SB001-1517
GLTO-01SB002-1517
GLTO-01SB003-1517
GLTO-01SB004-1517
GLTO-01SB005-1517
GLTO-01SB006-1517
GLTO-01SB007-1517
GLTO-01SB008-1517
GLTO-01SB009-1517
GLTO-01SB010-1517

PRG = Preliminary Remediation Goal
IL TACO = Illinois Tiered Approach to Corrective Action Objec
SSL = Soil Screening Level
DAF = Dilution Attenuation Factor
SRO = Soil Remediation Objective

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SITE01_TAGMAPS.APR GROUNDWATER EXCEEDANCE LAYOUT 7/16/07 SS

DRAWN BY	DATE
C. SPEHAR	5/12/06
CHECKED BY	DATE
B. DAVIS	7/16/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

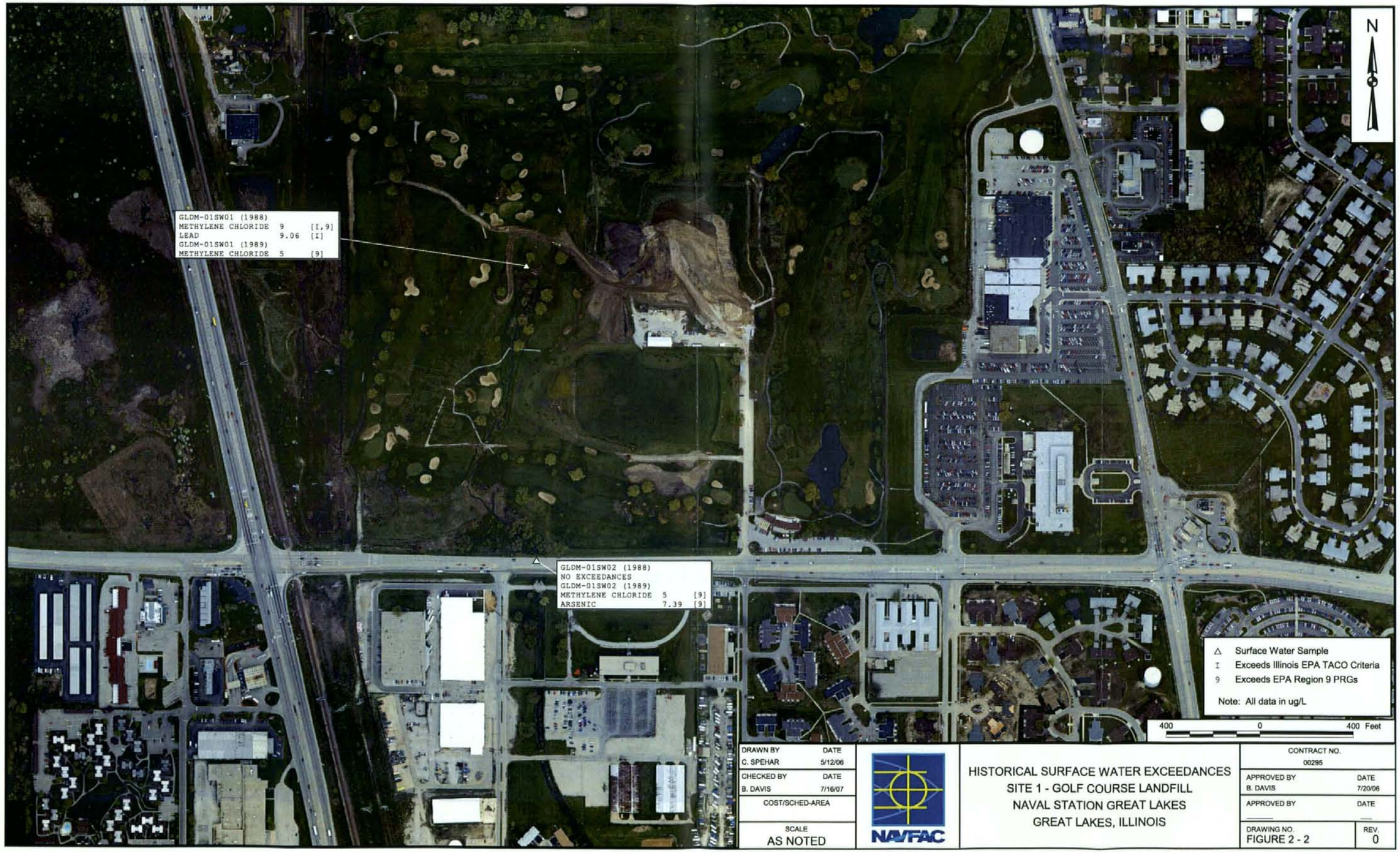
NAVFAC

HISTORICAL GROUNDWATER EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 2 - 1	0

000214H802Y

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SITE01_TAGMAPS.APR SURFACE WATER EXCEEDANCE LAYOUT 7/16/07 SS



DRAWN BY	DATE
C. SPEHAR	5/12/06
CHECKED BY	DATE
B. DAVIS	7/16/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

HISTORICAL SURFACE WATER EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 2 - 2	0

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SITE01_TAGMAPS.APR SOIL RESIDENTIAL EXCEEDANCE LAYOUT 7/16/07 SS

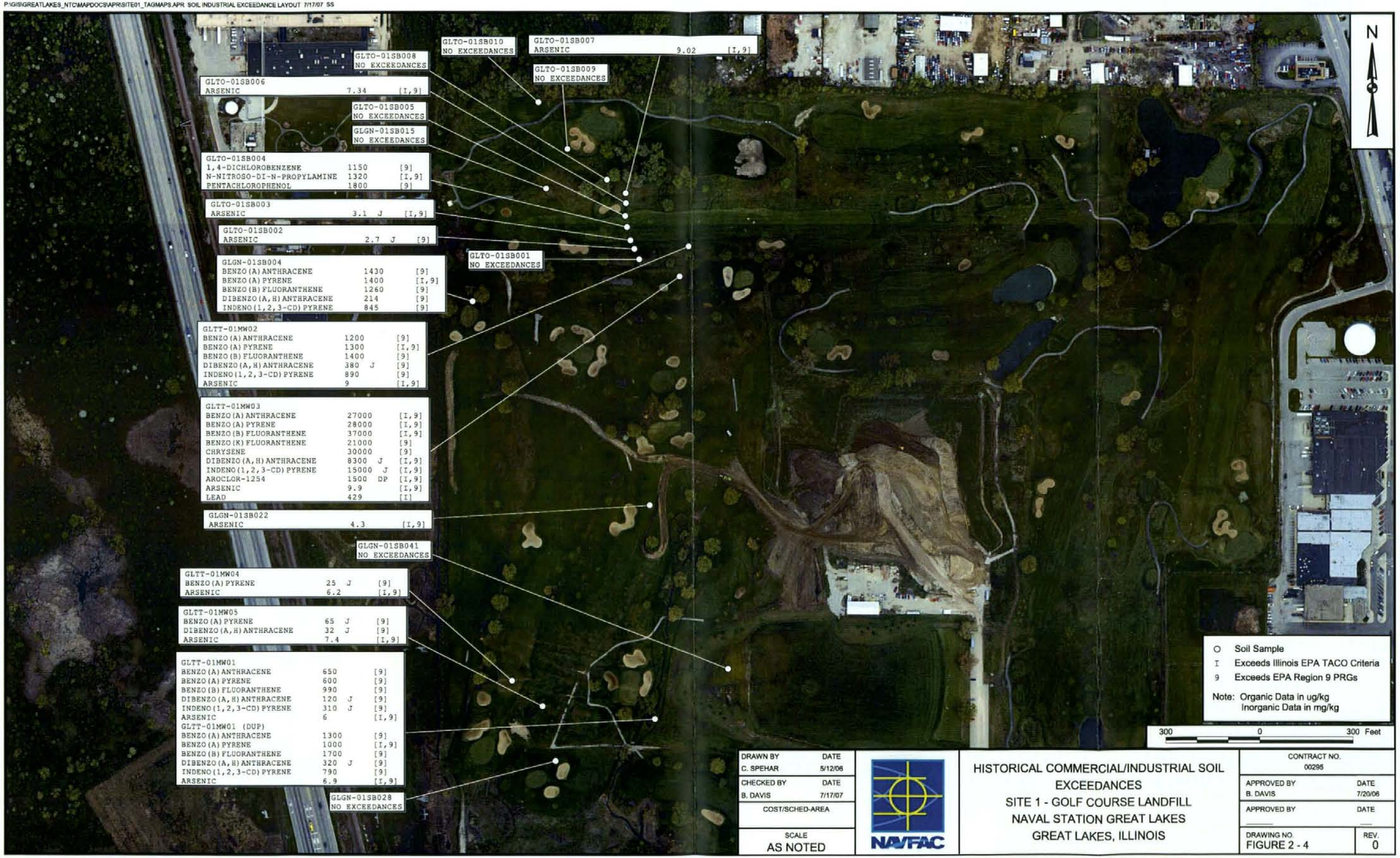
DRAWN BY	DATE
C. SPEHAR	5/12/06
CHECKED BY	DATE
B. DAVIS	7/16/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

HISTORICAL RESIDENTIAL SOIL EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 2 - 3	0

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SITE01_TAGMAPS.APR SOIL INDUSTRIAL EXCEEDANCE LAYOUT 7/17/07 SS



DRAWN BY	DATE
C. SPEHAR	5/12/06
CHECKED BY	DATE
B. DAVIS	7/17/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

HISTORICAL COMMERCIAL/INDUSTRIAL SOIL EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 2 - 4	0

3.0 SITE INVESTIGATION ACTIVITIES

RI field activities for Site 1 were performed from December 11 to December 20, 2006, and March 5 to March 14, 2007. The activities consisted of subsurface soil sampling, installation of temporary and permanent monitoring wells, groundwater sampling of these monitoring wells, aquifer testing on permanent monitoring wells, surface water sampling, and sediment sampling. These field activities supported the collection of data to meet the following objectives:

- To characterize the nature and extent of contamination at the site and to estimate human health risk for receptors exposed to subsurface soil, surface water, and sediment.

- To provide water level and hydraulic conductivity data useful for determining groundwater flow direction and velocity.

- To verify that the presumptive remedy (utilizing the golf course as cover and conducting groundwater monitoring at the landfill boundary) is protective of human health and environment.

A summary of the field investigation sampling rationale is presented in Table 3-1. The following sections discuss deviations from the work plan, field activities conducted, and site-specific geologic and hydrogeologic characteristics at Site 1. A summary of the environmental sampling (subsurface soil, groundwater, surface water and sediment) activities are provided in Table 3-2.

3.1 DEVIATIONS FROM THE WORK PLAN

There were several minor deviations from the project Quality Assurance Project Plan (TtNUS, February 2007) during the field investigation at Site 1 as follows:

- Bentonite seals for several shallow permanent monitoring wells were less than 2 feet thick due to the shallow depth of the screened interval and construction constraints of the flush-mount pads.

- Temporary wells were developed with a high-rate submersible pump until visually clean because weather conditions (low temperature) made use of water quality instruments unreliable.

- An extra sediment sample was collected because the lithology was unique compared to other sediment sampling locations.

No task modification forms were deemed necessary for the minor variances that occurred because the actions taken are consistent with approved SOPs or had minimal effect on the quality of data collected.

3.2 FIELD INVESTIGATION

The following sections discuss the activities performed during the field investigation at Site 1, including subsurface soil, groundwater, surface water, and sediment sampling; monitoring well installation; groundwater level measurements; aquifer testing; and investigation-derived waste (IDW) management. The activities were conducted to meet requirements of the Quality Assurance Project Plan for Site 1 – Willow Glen Golf Course Remedial Investigation and Risk Assessment at Naval Station Great Lakes, Illinois (TtNUS, February 2007). A TtNUS geologist supervised the drilling and well installation activities and reviewed the field documentation. A TtNUS licensed Professional Geologist reviewed the drilling logs, well completion logs, and field documentation. The field activities followed TtNUS SOPs provided in the Quality Assurance Project Plan Appendix V (TtNUS, February 2007).

3.2.1 Direct Push Technology Drilling/Sampling

Subsurface soil samples were collected to provide information on the location of the landfill boundaries and to provide chemical data for soil along the proposed storm sewer routes. A total of 103 soil borings (Table 3-1 and Figure 3-1) were advanced. Boring depths ranged from 12 to 40 feet bgs.

Direct-push technology (DPT) methods were used to drill the borings. This technique involves pushing tools hydraulically or mechanically into the ground to the desired depth. This method was used to collect subsurface soil samples at various locations throughout Site 1. The soil samples were collected in 1.5-inch inside diameter (ID), 4-foot-long acetate liners. Soil cuttings from below the ash layer were placed in 55-gallon drums and labeled as IDW. A composite sample was prepared by the laboratory from submitted soil samples to characterize this waste for appropriate disposal.

3.2.2 Subsurface Soil Sample Handling/Analysis

A summary of the soil samples collected and analyses performed is presented in Table 3-2. Upon sample retrieval, each soil core was screened for the presence of volatile organics with a photoionization detector (PID) (calibrated to 100 part per million isobutylene), and visually classified for lithology and presence of ash and/or waste materials, soil moisture, and other pertinent observations. In addition, the soil borings were screened with Ludlum detectors for radiological contamination (a summary of these results are included in Appendix A.2) consistent with methodologies outlined in the approved Quality Assurance

Project Plan (TtNUS, February 2007). The soil fractions to be analyzed for VOCs were collected first using EnCore samplers and placed in a cooler of ice maintained at 4 degrees Centigrade (°C). The soil fractions to be analyzed for other parameters (SVOCs, PAHs, pesticides, PCBs, herbicides, dioxins/furans, metals) was mixed, placed into the required containers, immediately sealed, and placed in a cooler at 4°C. The 4-foot-long clear acetate sleeves were cleaned of soil and were decontaminated in accordance with Section B2.A.12 of the Quality Assurance Project Plan (TtNUS, February 2007), and disposed as non-hazardous, municipal trash. Copies of the soil sample log sheets are provided in Appendix A.

The soil samples were shipped to Severn Trent Laboratory in Pittsburgh, Pennsylvania, for chemical analysis (see Section 3.2.10 for additional information on sample handling, packaging, and shipping procedures). Validated laboratory data memoranda are provided in Appendix C, and the laboratory analytical summary sheets are provided in Appendix D.

3.2.3 Well Drilling and Installation

Fourteen monitoring wells (ten permanent, four temporary) were installed at Site 1 during this investigation as shown on Figure 3-2. Table 3-3 provides a summary of monitoring well construction information. The hollow-stem auger drilling technique was used for monitoring well drilling operations. The depths of the monitoring wells ranged from 18.7 to 39 feet bgs. The nominal diameter of the well borings was approximately 8 inches. With the exception of monitoring wells NTC01TW02 and NTC01TW03, each monitoring well was constructed of 2-inch inside diameter, Schedule 40 polyvinyl chloride, flush-joint, riser pipe and 10-foot-long flush-joint, factory-slotted, polyvinyl chloride well screen and with end cap. Well screens were 15 feet long at NTC01TW02 and NTC01TW03 to correlate to depths of waste observed. Each section of casing and screen was National Sanitation Foundation approved and met American Society for Testing and Materials Standard A312-86a. The well screens had a slot size of 0.01 inch (10 slot) and were supplied with a flush-joint bottom cap.

After the riser pipe and screens were in place, the annulus of the boring was backfilled with U.S. Standard Sieve size of No. 10-20 clean silica sand from the bottom of the boring to a minimum of 2 feet above the top of the well screen. Four and a quarter inch ID hollow stem augers were used to hold the borehole open as the clean silica sand was placed around the well screen. As the sand pack was installed, the augers were slowly retrieved to provide an adequate sand pack around the well. A bentonite seal consisting of bentonite chips (minimum 2-foot thickness at the wells except for NTC01TW02, NTC01MW01, NTC01MW05 and NTC01MW06 due to shallow screen placement) was then installed above the sand pack and allowed to hydrate in accordance with the manufacturer's recommendations.

The depths of construction materials were constantly monitored during the installation of the monitoring wells by using a weighted, stainless steel or plastic tape to make sure that no bridging of the sand pack or bentonite seal occurred during the installation process. Grout was then poured into the remaining borehole annulus to approximately 2 feet bgs, except for the four temporary wells in which bentonite chips were poured into the borehole to the ground surface.

After the grout had hardened, a flush-mounted protective steel casing equipped with a sealed, bolted down, and appropriately labeled cap was installed at the 10 permanent wells located at Site 1. Each flush-mount riser was secured with a locking J-plug. Flush-mounted covers were installed in accordance with the Illinois Department of Public Health Water Well Construction Code requirements. Each monitoring well was fitted with a 6-inch-diameter by 10 inch long steel protective casing. The annulus between the flush-mounted cover and the ground was filled with concrete. The 8-inch-diameter auger hole served as the outer form for the concrete. The soil cuttings from each monitoring well were collected in 55-gallon drums and labeled as IDW. The composite sample collected from the direct-push technique borings was used to characterize this waste for appropriate disposal.

Environmental Field Services, a licensed Illinois driller, installed the 14 monitoring wells at the site. A TtNUS geologist supervised the drilling and well installation activities, prepared the drilling logs and well completion logs, and reviewed the field documentation. A TtNUS licensed Professional Geologist reviewed the drilling logs, well completion logs, and field documentation. Boring logs and well construction diagrams are provided in Appendix A.2 and A.3, respectively. Well permit records are provided in Appendix A.4.

3.2.4 Monitoring Well Development

After the 14 monitoring wells were installed, they were developed to remove fine materials (i.e., sands, silts, and clays) from the sand pack and the immediate area around the screened interval of the wells. The monitoring wells were developed no sooner than 24 hours after well completion to allow for settling/curing of the grout. Wells were developed by pumping using a whale pump (a high-rate submersible pump). During pumping, the well screens were periodically surged and the saturated screen interval was swept to remove the fine materials. For the permanent wells, the pH, temperature, turbidity, and specific conductance of the purged water were measured every 5 to 10 minutes during pumping or at the discretion of the field geologist. The purge water was containerized in 55-gallon drums and labeled as IDW.

The wells were considered developed after the readings stabilized based on the following criteria:

- pH ±0.1 standard unit
- Temperature ±3°C
- Turbidity less than 10 nephelometric turbidity units
- Specific conductivity ±3 percent

Well development continued until the parameters stabilized or a minimum of five well volumes were removed. Wells that ran dry were allowed to recharge while the rate of recovery was monitored. After the well had substantial recovery, the well was again pumped until it ran dry. This process was repeated until the purge water became visually clean. Measurements from monitoring well development were recorded and are included in Appendix A.5

3.2.5 Groundwater Level Measurements

Three rounds of synoptic water level measurement were collected at the site to determine static potentiometric water surface elevations for shallow groundwater. One round of synoptic water-level measurement was collected from the four temporary monitoring wells at Site 1 on December 19, 2006, before groundwater sampling occurred. The second round was collected on March 8, 2007, during installation of permanent monitoring wells and before abandonment of temporary wells. The third round was collected on March 13, 2007, after the abandonment of the temporary wells. A summary of water level measurements is provided in Table 3-3.

The synoptic measurements were collected within a 1-hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Measurements were collected with an electrical water level indicator (M-scope or equivalent) using the top of the well casing (i.e., riser pipe) as the reference point for determining the depth to water. Water level measurements were collected from a notch made at the top of each casing to make sure that rounds of synoptic measurements are collected from a consistent point. Water level measurements were recorded to the nearest 0.01 foot on a groundwater level measurement form included in Appendix A.6.

3.2.6 Groundwater Sampling

Groundwater sampling of temporary wells at Site 1 occurred on December 19, 2006 to determine which constituents may be present in landfill leachate. Groundwater sampling of permanent wells at Site 1

occurred on March 11 and 12, 2007 to determine if contaminants are migrating off site. Table 3-2 provides a summary of the groundwater samples collected.

The monitoring wells were purged and sampled using standard purging techniques (low flow) in accordance with the Quality Assurance Project Plan Appendix V, SOP CTO 154-6 (TtNUS, February 2007). Using a peristaltic pump and disposable polyethylene tubing, one to three screen casing volumes were purged from the well. Prior to purging, the intake of the sampling pump was placed at the approximate midpoint of the well screen or at least 3 feet up from the bottom of the well. If the water table was below the top of the well screen, the pump intake was placed at the middle of the water column and at least 2 feet from the bottom of the well.

At the start of purging, pumping was conducted at a low rate to minimize drawdown. The pumping rate was adjusted so the drawdown did not exceed 0.3 foot during purging. Water quality parameters (pH, temperature, specific conductance, turbidity, and dissolved oxygen) were measured and recorded at 5- to 10-minute intervals (Appendix A.7). Measurements were collected until the parameters stabilized for at least three consecutive readings and the minimum purge volume (one screen volume) was removed. Stabilization of the above parameters was defined as follows:

- pH ±0.1 standard unit
- Temperature ±3 °C
- Turbidity less than 10 nephelometric turbidity units
- Specific conductance ±3 percent
- Dissolved oxygen ±10%

If the turbidity remained greater than 10 nephelometric turbidity units but the other field parameters stabilized, a filtered metal sample was collected in addition to the unfiltered metal sample. This occurred at NTC01MW03 and NTC01MW06. Purge water was containerized in 55-gallon drums and labeled as IDW.

After the parameters stabilized and immediately prior to sampling, the temperature, pH, specific conductance, turbidity, and dissolved oxygen of the groundwater sample were measured and recorded on a Groundwater Sample Log Sheet. The sample containers were filled by allowing the pump discharge to flow with minimal turbulence down the inside of the container. For the collection of filtered samples, an in-line 0.45-micron, disposable particulate filter was used. Groundwater Sample Log Sheets are provided in Appendix A.7. The results of the groundwater sample analysis are presented in Section 4.

3.2.7 Aquifer Testing

Thirteen slug tests were performed in seven permanent monitoring wells to determine the hydraulic characteristics of the formation in the immediate vicinity of these monitoring wells. Prior to performing each slug test, the static water level was recorded along with the well construction details on a Hydraulic Conductivity Testing Data Sheet (see Appendix B.1). Both rising-head and falling-head tests were performed by inserting a solid plastic slug into the well to raise the water level and then recording the rate of decline in water level (falling-head test) in wells where the static water-level was above the top of screen. Water level and time data were collected until the static water level returned to equilibrium. The solid slug was then removed and the rate of rise in the water level back to equilibrium (rising-head test) was measured. The changes in water levels were induced as quickly as possible because slug test data analysis methods assume an instantaneous change in head. Falling-head tests were not performed for wells where the water level was within the screened interval (i.e., below the top of the well screen). Wells that were slug tested were developed prior to slug testing to obtain accurate results.

Slug test data [water levels (in feet of head) and time] were collected using a Mini Troll data logger with a pressure transducer and manually checked using an electronic water level indicator (M-scope). The Mini Troll was programmed to record measurements on a logarithmic time scale to facilitate data graphing and presentation.

Slug test data were used to calculate values of horizontal hydraulic conductivity for the aquifer in the immediate vicinity of the well. The data were analyzed using the Bouwer-Rice Method (Bouwer and Rice, 1976) in the Windows-based program AQTESOLV. Slug test calculations are provided in Appendix B.2. Slug test results are discussed in Section 3.5.3.

3.2.8 Surface Water Sampling

Surface water sampling was performed at Site 1 from December 17 to 19, 2006, to define the nature and extent of surface water contamination in Skokie Ditch, to determine if contaminants are migrating off site, and to evaluate risk. Surface water samples were collected from five locations and analyzed for the parameters listed in Table 3-2. Figure 3-3 shows the surface water sample locations.

The surface water samples were collected in accordance with the Quality Assurance Project Plan (TtNUS, February 2007). Sampling started downstream and proceeded to the farthest upstream location. Before collecting each water sample, water quality parameter data were collected using a Horiba U-22. The following parameters were recorded and documented on Surface Water Sample Log Sheets:

- pH (standard unit)
- Temperature (°C)
- Turbidity (nephelometric turbidity units)
- Specific Conductivity (percent)
- Dissolved Oxygen [milligrams per liter (mg/L)]
- Salinity (%)
- Oxidation-reduction potential (millivolts)

Surface water samples were analyzed for VOCs, PAHs, metals, cyanide, TOC and pH. Samples for VOC analysis were collected first by filling the bottles directly from the stream. Bottles for the remaining parameters were then collected. The information collected during sampling was recorded on Surface Water Sample Log Sheets provided in Appendix A.8.

The surface water samples were placed on ice in coolers immediately after collection and shipped to Severn Trent Laboratory in Pittsburgh, Pennsylvania, for chemical analysis (see Section 3.2.10 for additional information on sample handling, packaging, and shipping procedures). The results of the surface water sample analysis are presented in Section 4.

3.2.9 Sediment Sampling

Sediment samples for Site 1 were collected from locations along Skokie Ditch (Figure 3-3). The samples were collected using clean 2-inch-diameter sampling tubes and analyzed for the parameters outlined in Table 3-2. Surface sediment samples (0 to 4 centimeters bgs) were collected at each location for the HHRA and ERA and subsurface sediment samples (at 1 foot bgs) were collected at each location for the HHRA.

Upon retrieval, each sediment sample was screened for the presence of VOCs with a photo-ionization detector and then visually classified for lithology, soil moisture, and other pertinent observations. Copies of Sediment Sample Log Sheets are provided in Appendix A.9.

Immediately after collection, the sediment samples were placed in sample jars then placed on ice in coolers and shipped to Severn Trent Laboratory in Pittsburgh, Pennsylvania, for chemical analysis (see Section 3.2.10 for additional information on sample handling, packaging, and shipping procedures). The results of the sediment sample analysis are presented in Section 4.

3.2.10 Sample Handling, Packaging, and Shipping

This section of the RI identifies the general procedures for storing and transferring collected samples.

3.2.10.1 Sampling Handling

The following subsections describe the precautions taken to make sure that sample integrity was maintained throughout the sample collection and shipping processes. Each sample was divided among several containers. Each container of a particular sample was specific to the analysis of one or more analyte groups (fractions). Sample collection followed a logical sequence to make sure that the more volatile components of samples were not lost or that losses were minimized during sample handling. For example, samples for VOCs were collected first and containerized immediately after collection to prevent or minimize losses from volatilization. Samples for VOC analyses were also handled in a way that minimized agitation or disturbance, again to prevent loss of VOCs. Aqueous VOC samples did not have air bubbles in them after containerization (no head space). In general, sample fractions were containerized in the following sequence:

- VOCs
- SVOCs, polynuclear aromatic hydrocarbons (PAHs), pesticides/PCBs, herbicides, dioxins/furans, metals, etc.
- Other environmental parameters such as TOC, grain size, percent solids, etc.
- Field parameters

Sample nomenclature was governed by the Quality Assurance Project Plan (TtNUS, February 2007). Samples were shipped in coolers via air courier (e.g. Federal Express) to Severn Trent Laboratory in Pittsburgh, Pennsylvania. Samples were associated into sample delivery groups (SDGs) of up to 20 samples. An SDG is compiled in the chronological sequence in which the samples were received at the laboratory over a period of up to 14 days. Additional details concerning various aspects of sample handling are provided below.

3.2.10.2 Sample Preservation

Preservation requirements for samples for each of the analytes of interest were provided in Table B-11 of the Quality Assurance Project Plan (TtNUS, February 2007). Sample bottles for aqueous samples contained the proper amounts and types of preservatives prior to being shipped to Naval Station Great Lakes. The samples were promptly chilled with ice to 4 ± 2°C and packaged in an insulated cooler. Each

cooler included a temperature blank. The samples and ice were sealed in heavy-duty plastic bags to prevent water leakage.

3.2.10.3 Sample Labeling

Sample labels were printed in real time during sample collection. Before samples were packaged, the sample labels were checked to make sure that the information on the label was complete and correct. This information was also checked against the information on the sample collection log sheet and the chain-of-custody form.

3.2.10.4 Sample Packaging

Each sample container was placed in a zip-lock bag to prevent cross-contamination or leakage. The zip-lock bag was then placed in a bubble-wrap sleeve to protect it from breakage. Only shipping containers that met minimum packaging requirements of 49 Code of Federal Regulations 174 for safe shipment were used. Ice was then placed around and between the samples in sufficient quantity to chill the samples to 4 ± 2 °C during transport to the analytical laboratory.

The completed field chain-of-custody form was signed, placed in a sealed plastic envelope, and taped to the top inside cover of the shipping container. Appendix A.10 includes copies of the completed chain-of-custody forms. The Field Operations Leader was responsible for completion of the following forms:

- Sample labels
- Chain-of-custody forms
- Custody seals for coolers
- Shipping labels for coolers
- Express mail air bills

3.2.10.5 Sample Shipping

Shipping containers (i.e., coolers) were sealed with nylon strapping tape, and custody seals were signed, dated, and affixed in a manner that would allow the receiver to identify tampering that may have occurred during transport to the laboratory.

Shipments were made by Federal Express following completion of sample collection. Copies of the air bills were retained by the Field Operations Leader for tracking purposes, if needed, and for communications with the laboratory.

3.2.11 Surveying

The soil boring locations at Site 1 were surveyed for horizontal control by TtNUS personal utilizing a sub-meter Global Positioning System (GPS) unit with real-time fixed-station corrections. Accuracies were approximately 6 inches or less. The monitoring wells at Site 1 were surveyed for horizontal and vertical control by James Anderson Company (Illinois licensed) in accordance with the Quality Assurance Project Plan (TtNUS, February 2007). Monitoring well locations were surveyed horizontally to the nearest 0.10 foot. The top of the riser (where notched) and the ground surface elevation adjacent to the protective cover at each monitoring well location were surveyed to within 0.01-foot vertical accuracy. The northing and easting coordinates are referenced to the Illinois State Plane Coordinate System, North American Datum 1988.

3.2.12 Investigation-Derived Waste

During the RI field activities, decontamination water, development water, purge water, and soil cuttings (below the observed ash layer) were containerized in 55-gallon drums and stored on site. Other IDW such as trowels, paper towels, etc. were double-bagged and placed in Naval Station Great Lakes trash receptacles (dumpsters). Following the investigation, composite soil and water samples were submitted for laboratory testing to characterize the waste for appropriate disposal via Toxicity Characteristic Leaching Procedure (TCLP) analysis. Completed Waste Profiles were signed and are provided in Appendix E. The IDW was handled in accordance with the Quality Assurance Project Plan (TtNUS, February 2007). The drums were picked up, transported, and disposed by American Waste Processing of Maywood, Illinois; a Naval Station Great Lakes approved transportation and disposal company.

3.2.13 Well Abandonment

Abandonment of temporary monitoring wells NTC01TW01 to NTC01TW03 occurred on March 10, 2007, and abandonment of NTC01TW04 occurred on March 13, 2007. Environmental Field Services, a licensed Illinois driller, performed the well abandonment according to Illinois State regulations and provided water well sealing forms, provided in Appendix A.11. Each polyvinyl chloride riser was cut at approximately 2 feet bgs, the wells were sanitized with bleach, then backfilled with bentonite chips and hydrated per the manufacturer's recommendations. Surface conditions were matched to the surrounding area.

3.3 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

TtNUS established a quality control (QC) program to monitor and assess the quality of field work and laboratory work performed during environmental investigation. This program included various types of QC samples as indicated below. The field quality control samples consisted of field duplicates, trip blanks, equipment rinsate blanks, and temperature blanks. Temperature blanks were included in each cooler submitted to the laboratory to monitor sample storage conditions prior to arrival at the laboratory. Each type of field QC sample had the same preservation, analysis, and reporting procedures as the related environmental samples with the exception of temperature blanks. The log sheets for the quality assurance/quality control (QA/QC) samples are included in Appendix A.12. Laboratory QC samples consisted of laboratory control samples, laboratory duplicates, internal standards, laboratory method blanks, matrix spikes, matrix spike duplicates, post digestion spikes, and surrogates. Severn Trent Laboratory conducted the laboratory QC in accordance with the Quality Assurance Project Plan (TtNUS, February 2007). TtNUS reviewed the laboratory quality control during the data validation and noncompliances were noted in the data validation memoranda in Appendix C.

3.4 SITE-SPECIFIC GEOLOGY

Geologic conditions at Site 1 were characterized as part of the RI. Surface and subsurface materials at Site 1 were characterized based on acetate liner samples collected during the drilling of soil and well borings during the TtNUS field investigation. The visual classifications were utilized to develop geologic cross-sections for the site. Figure 3-presents the locations of the geologic cross sections and based on select borings across Site 1. Figures 3-5 to 3-8 show cross-sectional transects A-A', B-B', C-C' and D-D', respectively, that were developed from the soil boring data collected.

The shallow subsurface lithology of Site 1 to a depth of 40 feet consists predominantly of brown silty clay grading to blue-gray clay with infrequent sand and gravel layers. Along the western portion of the site (nearly the entire north-south-trending western boundary and up to 400 feet along the northern boundary), a thin layer of ash/burn material was observed. The ash/burn material is composed of black sands, metal fragments, and coke-like by-products (cinders, manganese nodules ranging from 0.5 to 4 millimeters in diameter and low-density and highly porous rock fragments). The thickness of the ash/burn layer varied significantly from boring to boring but is generally less than 0.5 foot thick and interbedded with silty clay. A maximum ash/burn layer thickness of 10.7 feet was observed at NTC01SB004. Landfill waste was observed in the interior western portion of the site (soil borings NTC01SB088 to NTC01SB100). Landfill waste was markedly different than ash/burn material, being composed of black sands intermixed with significant metal, plastic, glass, and wood. No coke-like burned by-products were observed in the landfill

waste. At NTC01SB099 the observed lithology indicates that multiple filling activities followed by burning and subsequent covering occurred due to the presence of four distinct waste layers interbedded with silty clay.

Laboratory sieve analysis of composite samples from these deposits (Table 3-4) indicates that the Unified Soil Classification System description of these soils ranges from ML (sandy silt) to CL (silty clay).

3.5 SITE-SPECIFIC HYDROGEOLOGY

The hydrogeologic conditions at Site 1 were interpreted from data collected during the subsurface investigation activities at the site, including drilling, groundwater sampling, groundwater level measurements, and aquifer testing.

3.5.1 Hydrogeologic Framework

The shallow water table aquifer was characterized at Site 1. A deeper (confined) aquifer is most likely present (based on previous studies at this site and adjacent areas) but was not part of this investigation. The shallow aquifer ranges from 0.5 to 40 feet bgs and is composed primarily of unconsolidated silty clays to clays and minor silts with discontinuous sand and gravel lenses interspersed throughout (see Figures 3-5 to 3-8). In general, the water table within these heterogeneous deposits is shallow and was typically encountered at a depths ranging from 1 to 17 feet bgs at the site. Groundwater can be expected to migrate laterally through the more permeable materials present with the silty clays and clays. At many soil boring locations, even locations reaching 40 feet bgs, no water was encountered even when sand and gravel lenses were encountered. Additionally, many soil borings did not contain sand and gravel lenses and were subsequently dry. Therefore, the shallow water table aquifer is assumed to be discontinuous across the site. Groundwater is also expected to migrate vertically into the deep aquifer.

3.5.2 Groundwater Flow Directions

Groundwater flow directions for the shallow water table aquifer were determined based on the synoptic water level measurements collected on March 13, 2007 (see Table 3-3). Water elevations for the four temporary wells were based on water level measurements collected on March 8, 2007. Groundwater elevations were determined based on these depths to water measurements, then posted on site maps and evaluated. Figure 3-9 presents the groundwater potentiometric surface for the shallow water table aquifer at the site.

As seen in Figure 3-9, shallow groundwater flows towards Skokie Ditch, which trends north-south in the western portion of the site. Groundwater dominantly flows from the north, west, and east toward the Skokie Ditch.

3.5.3 Aquifer Tests

Rising-head and falling-head slug tests were conducted in seven monitoring wells across the site as described in Section 3.2.7. These slug tests were performed to generate estimates of horizontal hydraulic conductivity in the immediate vicinity of the wells. Slug tests were performed in monitoring wells screened in different lithologies and vertical zones representative of the unique site conditions encountered. The results of the test evaluations are presented in Table 3-5.

Slug tests were performed at NTC01MW01, NTC01MW02, NTC01MW04, NTC01MW05, NTC01MW07, NTC01MW08, and NTC01MW10. The falling-head test at NTC01MW04 did not yield usable data (due to well recovery occurring while the slug test was being performed).

Good agreement between the results of the falling- and rising-head tests was observed in wells exhibiting calculated hydraulic conductivity values greater than 1 foot per day. In wells where calculated hydraulic conductivities were less than 1 foot per day (NTC01MW05 and NTC01MW08), the results showed less agreement, especially in NTC01MW08. The reason for the larger discrepancies is unknown. Horizontal hydraulic conductivity values ranged from 0.05 foot per day (1.73×10^{-5} centimenters per second) in NTC01MW08 to 5.13 feet per day (1.81×10^{-3} centimenters per second) in NTC01MW10. The geometric mean of horizontal hydraulic conductivity was calculated to be 1.04 feet per day (3.68×10^{-4} centimenters per second). These values are within the typical range for silty clays, clays, and sand and gravel lenses within these formations (Fetter, 1980 and Freeze and Cherry, 1979).

3.5.4 Groundwater Migration Velocities

The hydraulic gradient for the shallow groundwater at the site was calculated graphically from groundwater elevations found on Figure 3-9, based on the groundwater flow paths presented.

The horizontal hydraulic gradient ranged from a high of approximately 0.0152 along flow path number 1; 0.021 along flow path number 2 and 0.0083 along flow path number 3. Using an average porosity of 0.35 for the gravelly clay/silty clay (Freeze and Cherry, 1979) and the site-wide geometric mean hydraulic conductivity of 1.04 feet per day, the groundwater velocity was approximated for each groundwater flow path at the site. The groundwater velocities determined were 0.045 feet per day (16.5 feet per year),

0.062 feet per day (22.8 feet per year), and 0.025 feet/day (9 feet per year) for flow paths 1, 2 and 3, respectively. Care must be taken when interpreting these results, however because significant groundwater flow potential is likely limited to the sand and gravel lenses. There is no evidence from the boring logs (and Figures 3-4 to 3-8) that any of these lenses are laterally extensive. Large-scale, site-wide transport of potential contaminants in the shallow aquifer is not likely to be occurring.

TABLE 3-1

SAMPLING RATIONALE
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Sample Location	Sampling Rationale
Subsurface Soil	
NTC01SB001 to NTC01SB087	Visual observations to determine the extent of landfill waste along the perimeter of the Willow Glen Golf Course.
NTC01SB088 to NTC01SB103	Visual observations and samples collected to determine the extent of landfill waste along proposed sewer routes and to support human health risk assessment.
NTC01SB059, NTC01SB068, NTC01SB076 and NTC01SB087	Visual observations and samples collected to determine the vertical extent of landfill waste along the western perimeter of the Willow Glen Golf Course.
Sediment	
NTC01SD0100, NTC01SD0101 to NTC01SD0500, NTC01SD0501	Samples collected from Skokie Ditch to determine potential impacts of landfill waste to surface water and sediment and to support human health and ecological risk assessments.
Surface Water	
NTC01SW0100 to NTC01SW0500	Samples collected from Skokie Ditch to determine potential impacts of landfill waste to surface water and to support human health and ecological risk assessments.
Groundwater (Leachate)	
NTC01TW01 to NTC01TW04	Samples collected from inside the landfill to determine potential impacts of landfill waste to shallow groundwater and to support human health risk assessment.
Groundwater (Perimeter Wells)	
NTC01MW01 to NTC01MW10	Samples collected to determine potential impacts of landfill waste to shallow groundwater on the landfill permieter and to support human health risk assessment.

TABLE 3-2

SAMPLING SUMMARY
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Sample Name	Depth (feet bgs)	Visual (and PID)	TCL VOCs	TCL PAHs	TAL Metals and Cyanide	Secondary Parameters[1]	TOC and pH	Grain Size	Radiological Screening[2]	Field Parameters[3]
SURFACE/SUBSURFACE SOIL										
NTC01SB001 to NTC01SB087	0 - 40	X							X	
SUBSURFACE SOIL										
NTC01SB0880708	7.0 - 8.0	X	X	X	X				X	
NTC01SB0891112	11.0 - 12.0	X	X	X	X				X	
NTC01SB0900812	8.0 - 12.0	X	X	X	X	X	X	X	X	
NTC01SB0910812	8.0 - 12	X	X	X	X				X	
NTC01SB0921516	15.0 - 16.0	X	X	X	X				X	
NTC01SB0930810	8.0 - 10.0	X	X	X	X				X	
NTC01SB0941416	14.0 - 16.0	X	X	X	X				X	
NTC01SB0950810	8.0 - 10.0	X	X	X	X	X	X	X	X	
NTC01SB0961012	10.0 - 12.0	X	X	X	X				X	
NTC01SB0970304	3.0 - 4.0	X	X	X	X				X	
NTC01SB0981516	15.0 - 16.0	X	X	X	X				X	
NTC01SB0991012	10.0 - 12.0	X	X	X	X	X	X	X	X	
NTC01SB1001012	10.0 - 12.0	X	X	X	X				X	
NTC01SB1010406	4.0 - 6.0	X	X	X	X				X	
NTC01SB1020408	4.0 - 8.0	X	X	X	X	X	X	X	X	
NTC01SB1031919	19.0	X	X	X	X				X	
NTC01SB2050414	4.0 - 14.0	X			X		X	X		
NTC01SB2072838	28.0 - 38.0	X			X		X	X		
NTC01SB2090717	7.0 - 17.0	X			X		X	X		
SEDIMENT										
NTC01SD0100	0.0		X	X	X	X	X	X		
NTC01SD0101	1.0		X	X	X	X	X			
NTC01SD0200	0.0		X	X	X	X	X			
NTC01SD0201	1.0		X	X	X	X	X	X		
NTC01SD0300	0.0		X	X	X	X	X			
NTC01SD0301	1.0		X	X	X	X	X			
NTC01SD0400	0.0		X	X	X	X	X			
NTC01SD0401	1.0		X	X	X	X	X			
NTC01SD0500	0.0		X	X	X	X	X	X		
NTC01SD0501	1.0		X	X	X	X	X			
SURFACE WATER										
NTC01SW0100	NA		X	X	X	X	X			
NTC01SW0200	NA		X	X	X	X	X			
NTC01SW0300	NA		X	X	X	X	X			
NTC01SW0400	NA		X	X	X	X	X			
NTC01SW0500	NA		X	X	X	X	X			

TABLE 3-2

SAMPLING SUMMARY
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Sample Name	Depth (feet bgs)	Visual (and PID)	TCL VOCs	TCL PAHs	TAL Metals and Cyanide	Secondary Parameters[1]	TOC and pH	Grain Size	Radiological Screening[2]	Field Parameters[3]
GROUNDWATER										
NTC01GWTW0101	shallow/first water		X	X	X	X				X
NTC01GWTW0201	shallow/first water		X	X	X	X				X
NTC01GWTW0301	shallow/first water		X	X	X	X				X
NTC01GWTW0401	shallow/first water		X							X
NTC01GW0101	shallow/first water		X	X	X					X
NTC01GW0201	shallow/first water		X	X	X					X
NTC01GW0301	shallow/first water		X	X	X					X
NTC01GW0401	shallow/first water		X	X	X					X
NTC01GW0501	shallow/first water		X	X	X		X			X
NTC01GW0601	shallow/first water		X	X	X					X
NTC01GW0701	shallow/first water		X	X	X		X			X
NTC01GW0801	shallow/first water		X	X	X					X
NTC01GW0901	shallow/first water		X	X	X		X			X
NTC01GW1001	shallow/first water		X	X	X					X

1 Secondary parameters include dioxins/furans, TCL semivolatile organic compounds, polychlorinated biphenyls, organochlorine pesticides, and herbicides.
2 Screening conducted with a Ludlum Model 2241 with a 44-10 (2X2) NaI detector, Ludlum Model 12 with a 44-9 probe and Ludlum 2929 with 43-10-1.
3 Field parameters include temperature, pH, specific conductance, turbidity, oxidation-reduction potential, and dissolved oxygen.

Notes:
bgs - below ground surface
TCL - Target Compound List
VOCs - Volatile organic compounds
PAHs - Polynuclear aromatic hydrocarbons
TAL - Target Analyte List
TOC - Total organic carbon

SB - Soil boring
SD - Sediment sample
SW - Surface water sample
TW - Groundwater sample collected from temporary well
MW - Groundwater sample collected from permanent monitoring well
NA - Not applicable

TABLE 3-3

SUMMARY OF MONITORING WELL CONSTRUCTION AND WATER LEVEL DATA
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Well ID	Ground Surface Elevation (feet above msl)	Top of Well Casing Elevation (feet above msl)	Bottom of Boring (feet bgs)	Screened Interval		12/19/2006		3/8/2007		3/13/2007	
				Top (feet bgs)	Bottom (feet bgs)	Depth to Water (feet)	Water Level (feet above msl)	Depth to Water (feet)	Water Level (feet above msl)	Depth to Water (feet)	Water Level (feet above msl)
NTC01TW01	694.63	696.05	22.5	11.0	21.0	16.96	679.09	16.96	679.09	NA	NA
NTC01TW02	692.98	696.09	20.6	4.0	19.0	16.07	680.02	15.98	680.11	NA	NA
NTC01TW03	693.82	696.25	24.4	7.0	22.0	16.90	679.35	16.93	679.32	NA	NA
NTC01TW04	696.40	698.19	18.7	7.0	17.0	Dry	< 679.54	17.93	680.26	NA	NA
NTC01MW01	693.60	693.05	24.0	5.0	15.0	NA	NA	8.32	684.68	8.07	684.98
NTC01MW02	710.70	710.52	39.0	29.0	39.0	NA	NA	16.15	695.95	13.45	697.07
NTC01MW03	718.41	718.13	23.0	13.0	23.0	NA	NA	5.05	715.76	1.32	716.81
NTC01MW04	696.27	695.98	27.0	17.0	27.0	NA	NA	NA	NA	4.47	691.51
NTC01MW05	689.67	689.37	20.0	4.0	14.0	NA	NA	4.61	686.81	2.42	686.95
NTC01MW06	683.91	683.72	24.0	4.5	14.5	NA	NA	NA	NA	7.94	675.78
NTC01MW07	681.96	681.82	38.0	28.0	38.0	NA	NA	20.08	664.43	17.19	664.63
NTC01MW08	689.35	689.20	20.0	7.0	17.0	NA	NA	NA	NA	3.54	685.66
NTC01MW09	692.17	692.11	20.0	7.0	17.0	NA	NA	NA	NA	7.56	684.55
NTC01MW10	691.67	691.44	21.0	11.0	21.0	NA	NA	7.50	688.27	2.41	689.03

bgs: Below ground surface.
msl: Mean sea level.
Prior to installation of monitoring wells, exploratory direct push technology boring performed to determine well depth and screen position.
1 Ground surface used to estimate water level elevation for monitoring wells.
NA - Not available.

TABLE 3-4

SUMMARY OF SIEVE ANALYSIS RESULTS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Fraction	NTC01SB0900812	NTC01SB0950810	NTC01SB0991012	NTC01SB1020408	NTC01SB2050414	NTC01SB2072838	NTC01SB2090717	NTC01SD0100	NTC01SD0201	NTC01SD0500
CLAY	49.6	49.7	14.2	50.8	12.2	14	14.2	50.8	12.2	14
GRAVEL	4	2.1	19.1	0.4	17.2	6.9	19.1	0.4	17.2	6.9
SAND	10.3	16.7	52.5	11.6	58.3	65.8	52.5	11.6	58.3	65.8
SILT	36	31.5	14.1	37.2	12.3	13.4	14.1	37.2	12.3	13.4
SIEVE 1"	100	100	100	100	100	100	100	100	100	100
SIEVE 1-1/2"	100	100	100	100	100	100	100	100	100	100
SIEVE 2"	100	100	100	100	100	100	100	100	100	100
SIEVE 3"	100	100	100	100	100	100	100	100	100	100
SIEVE 3/4"	100	100	100	100	100	100	100	100	100	100
SIEVE 3/8"	100	100	90.2	100	94.5	95.6	90.2	100	94.5	95.6
NO. 4 SIEVE	96	97.9	80.9	99.6	82.8	93.1	80.9	99.6	82.8	93.1
NO. 10 SIEVE	94	95.7	73.5	97.7	69.7	91.5	73.5	97.7	69.7	91.5
NO. 20 SIEVE	91.9	93.5	64.7	95.3	58.8	88	64.7	95.3	58.8	88
NO. 40 SIEVE	90.1	91.6	54.6	93.3	49.6	77.2	54.6	93.3	49.6	77.2
NO. 60 SIEVE	87.8	88.5	43.1	90.5	38.6	54.5	43.1	90.5	38.6	54.5
NO. 80 SIEVE	85.9	85.8	36.3	88.4	31.8	40.2	36.3	88.4	31.8	40.2
NO. 100 SIEVE	85.6	85.1	35.5	87.9	31.2	36.6	35.5	87.9	31.2	36.6
NO. 200 SIEVE	85.6	81.2	28.4	87.9	24.5	27.3	28.4	87.9	24.5	27.3
USCS SYMBOL	CL	CL	SC	CL	SM/SC	SM	SC	CL	SM/SC	SM
USCS CLASSIFICATION	Silty clay	Silty clay	Clayey sand	Silty clay	Silty/clayey sand	Silty sand	Clayey sand	Silty clay	Silty/clayey sand	Silty sand

TABLE 3-5

SUMMARY OF AQUIFER TEST RESULTS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Well	Test	Screen Length (ft)	Saturated Thickness (ft)	K (ft/day)	K (ft/min)	K (cm/sec)	Average K (cm/sec)
NTC01MW01	Falling-head	10	7.13	1.265	8.8E-4	4.5E-4	4.8E-4
	Rising-head			1.479	1.0E-3	5.2E-4	
NTC01MW02	Falling-head	10	24.99	2.66	1.8E-3	9.4E-4	8.9E-4
	Rising-head			2.398	1.7E-3	8.5E-4	
NTC01MW04	Rising-head	10	6.98	0.197	1.4E-4	6.9E-5	6.9E-5
NTC01MW05	Falling-head	10	12.15	0.4772	3.3E-4	1.7E-4	1.0E-4
	Rising-head			0.1156	8.0E-5	4.1E-5	
NTC01MW07	Falling-head	10	20.77	3.331	2.3E-3	1.2E-3	1.5E-3
	Rising-head			4.94	3.4E-3	1.7E-3	
NTC01MW08	Falling-head	10	12.78	0.6729	4.7E-4	2.4E-4	1.3E-4
	Rising-head			0.04903	3.4E-5	1.7E-5	
NTC01MW10	Falling-head	10	17.53	5.127	3.6E-3	1.8E-3	1.7E-3
	Rising-head			4.723	3.3E-3	1.7E-3	

Site Wells	K (cm/sec)	K (ft/day)
Geometric Mean	3.7E-4	1.0E+0
Arithmetic Mean	7.4E-4	2.1E+0

Well diameter was 2 inches (0.1667 foot) and wellbore diameter was 8 inches (0.667 foot) for all wells.
Data analyzed using AQTESOLV for Windows using Bouwer-Rice solution.
K = Horizontal hydraulic conductivity.

P:\GIS\GREATLAKES_NS\MAPDOCS\APR\SITE1.APR SOIL BORING LOCATIONS LAYOUT 7/17/07 SS

DRAWN BY	DATE
S. STROZ	6/25/07
CHECKED BY	DATE
B. DAVIS	7/17/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

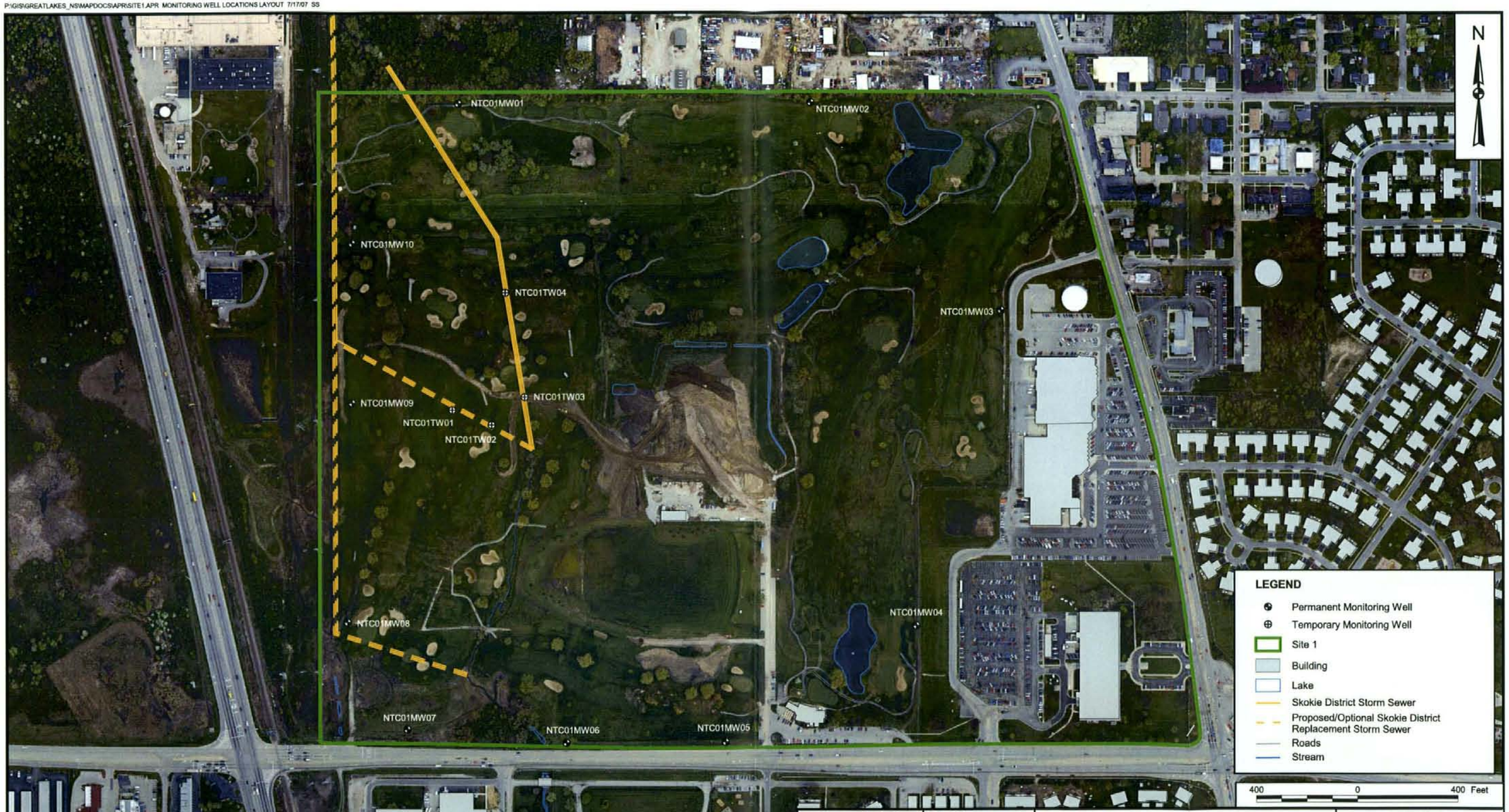
NAVFAC

SOIL BORING LOCATIONS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/25/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 3 - 1	0

0002144B03Y

P:\GIS\GREATLAKES_NS\MAPDOCS\APR\SITE1.APR MONITORING WELL LOCATIONS LAYOUT 7/17/07 SS



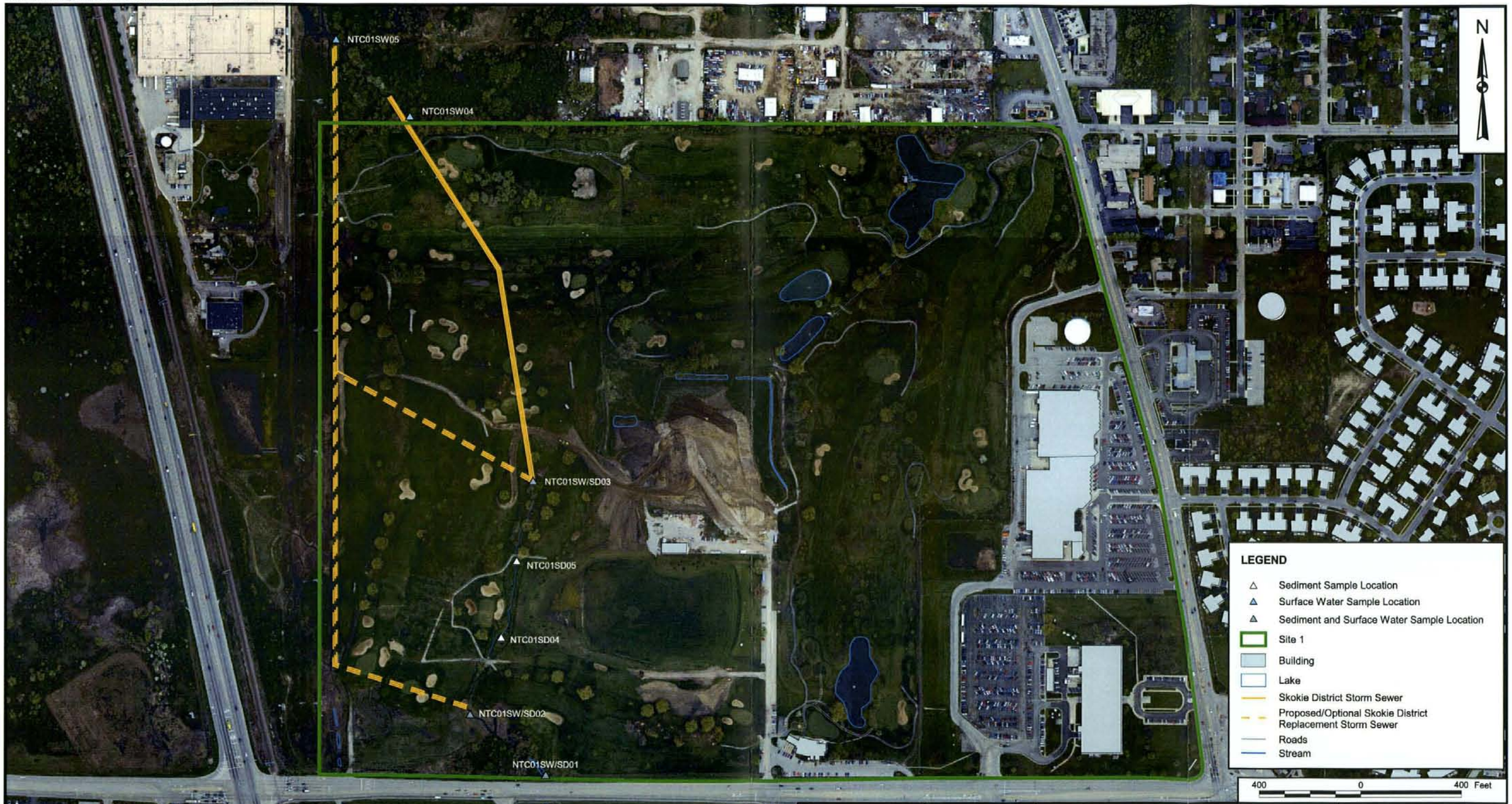
DRAWN BY	DATE
S. STROZ	6/25/07
CHECKED BY	DATE
B. DAVIS	7/17/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

MONITORING WELL LOCATIONS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	8/02/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 3 - 2	0

P:\GIS\GREATLAKES_NS\MAPDOCS\APR\SITE1.APR SW AND SD LOCATION LAYOUT 7/18/07 SS



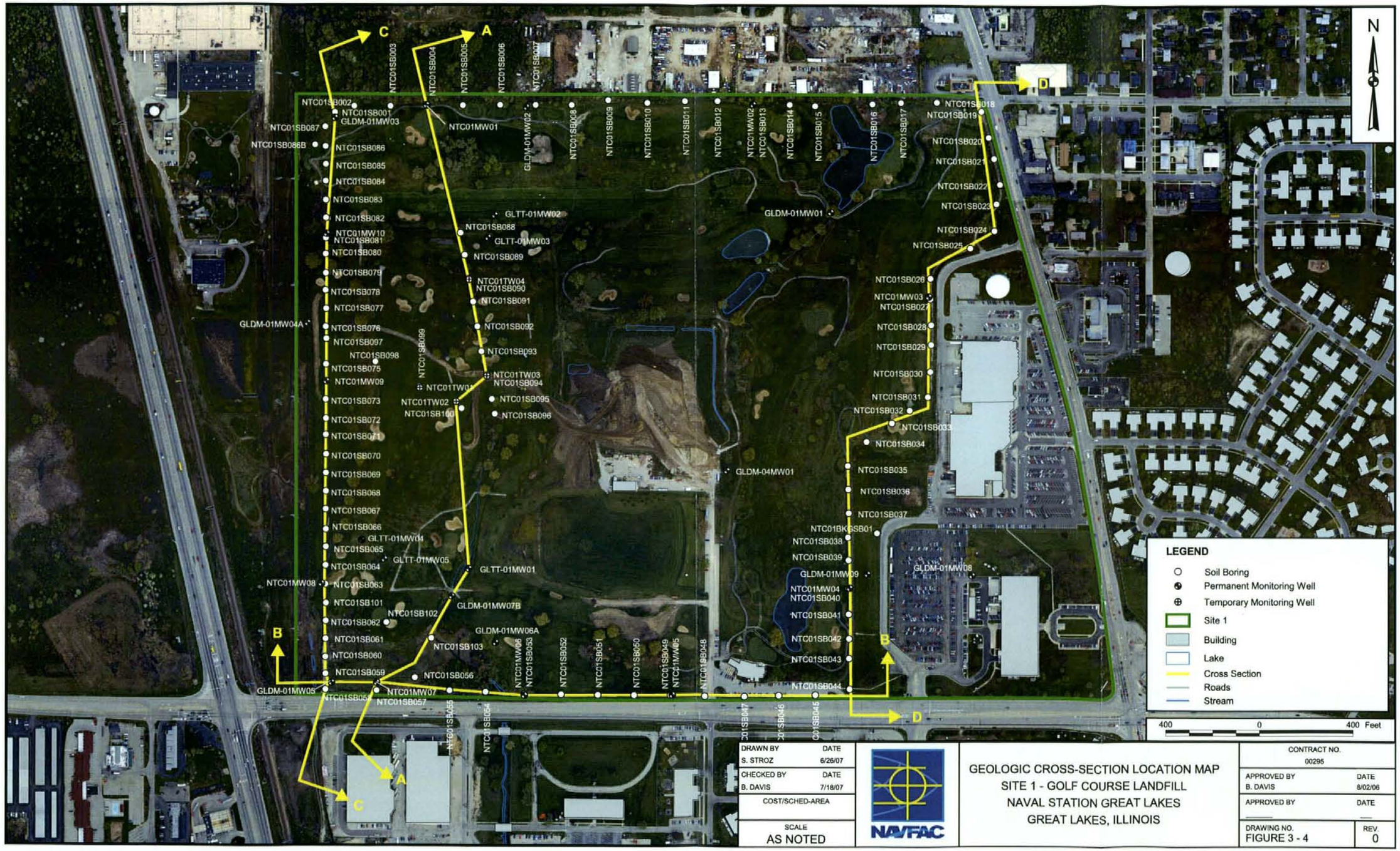
DRAWN BY	DATE
S. STROZ	6/25/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

SURFACE WATER AND SEDIMENT
SAMPLING LOCATIONS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	8/02/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 3 - 3	0

P:\GIS\GREATLAKES_NS\MAPDOCS\APR\SITE1.APR GEOLOGIC CROSS-SECTION LOCATION LAYOUT 2 7/18/07 SS



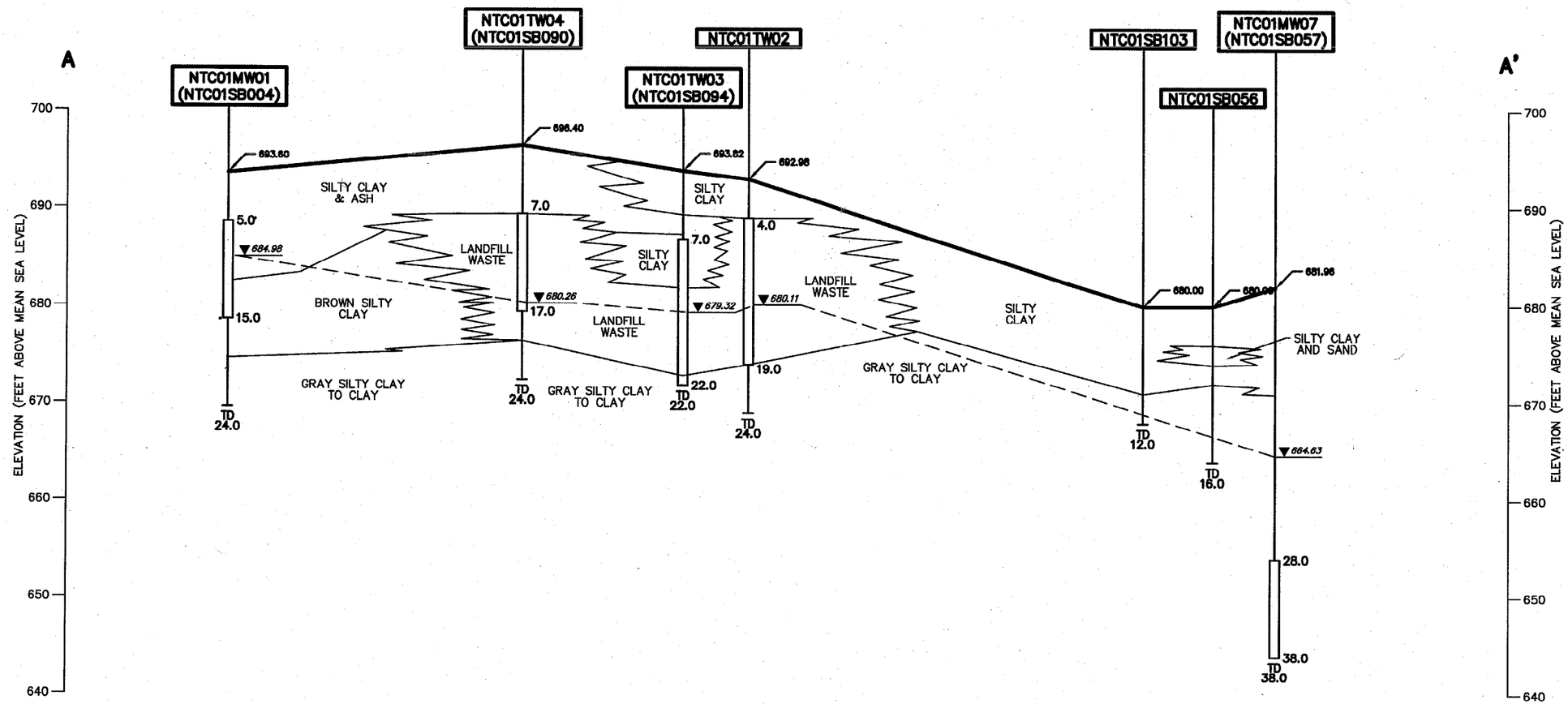
DRAWN BY	DATE
S. STROZ	6/26/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

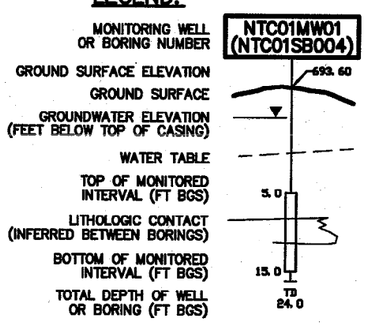
GEOLOGIC CROSS-SECTION LOCATION MAP
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	8/02/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 3 - 4	0

ACAD: 02956X04.dwg 07/19/07 MF PIT



LEGEND:



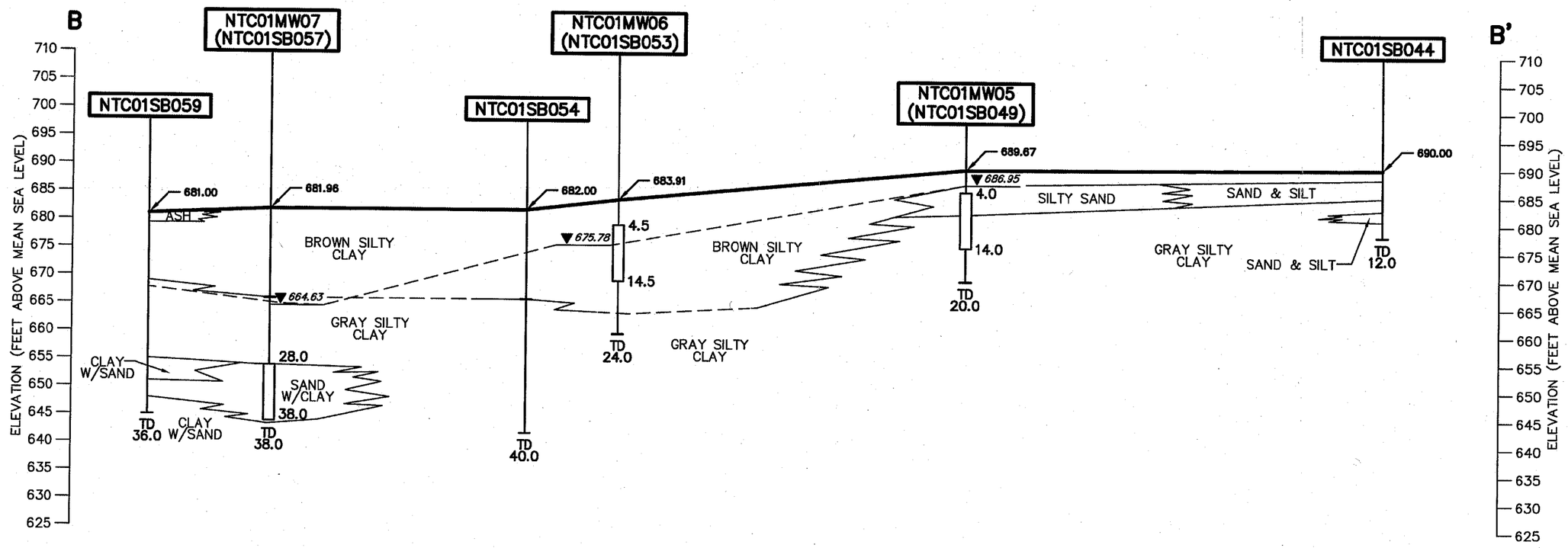
0 250 500
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

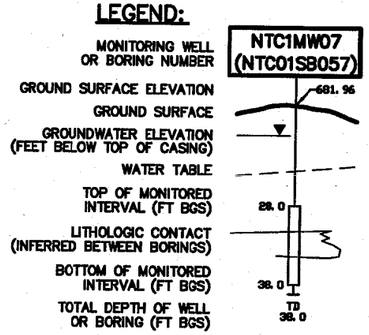
DRAWN BY MF	DATE 4/19/07	GEOLOGICAL CROSS SECTION A - A' SITE 1 - GOLF COURSE LANDFILL NAVAL STATION GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NO. 0295
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 3-5 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 2 - 6/19/06

ACAD: 0295GX01.dwg 07/13/07 MF PIT



LEGEND:



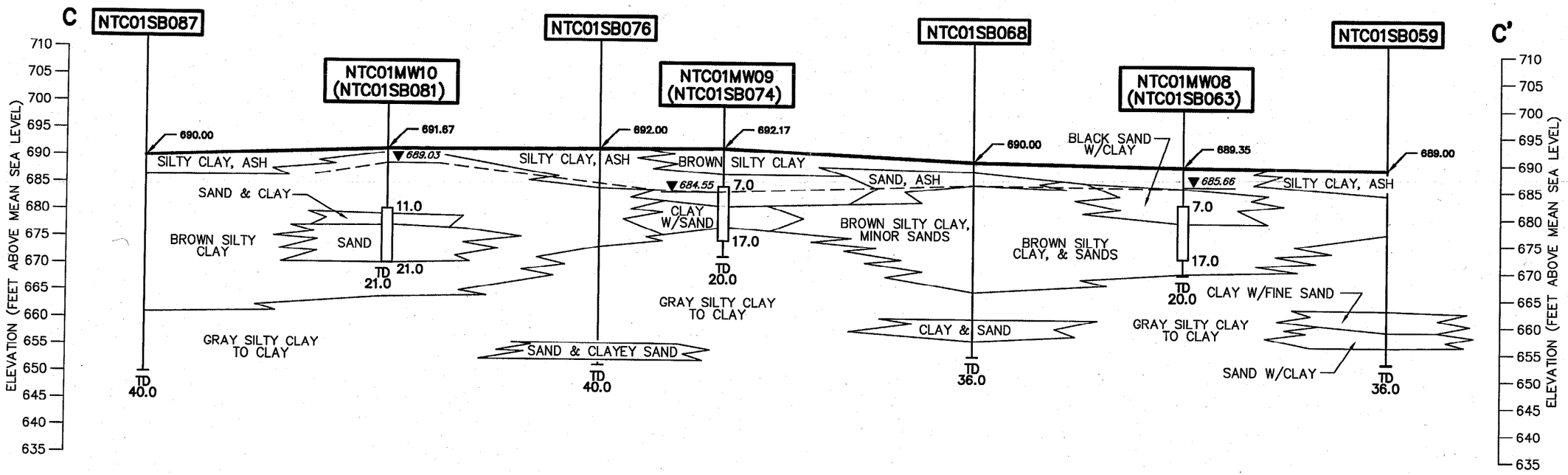
0 200 400
HORIZONTAL SCALE IN FEET

0 20 40
VERTICAL SCALE IN FEET

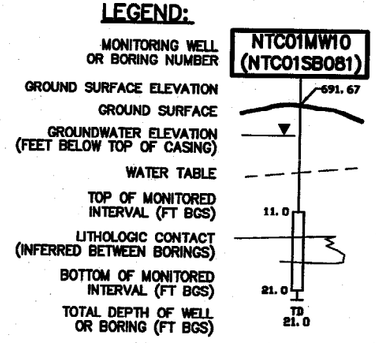
DRAWN BY MF	DATE 4/19/07	GEOLOGICAL CROSS SECTION B - B' SITE 1 - GOLF COURSE LANDFILL NAVAL STATION GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NO. 0295
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 3-6 / REV. 0

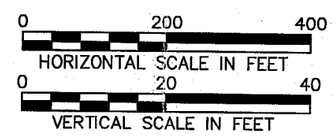
FORM CADD NO. SDIV-BH.DWG - REV 2 - 6/19/05

ACAD: 0295GX03.dwg 07/13/07 MF PIT



LEGEND:



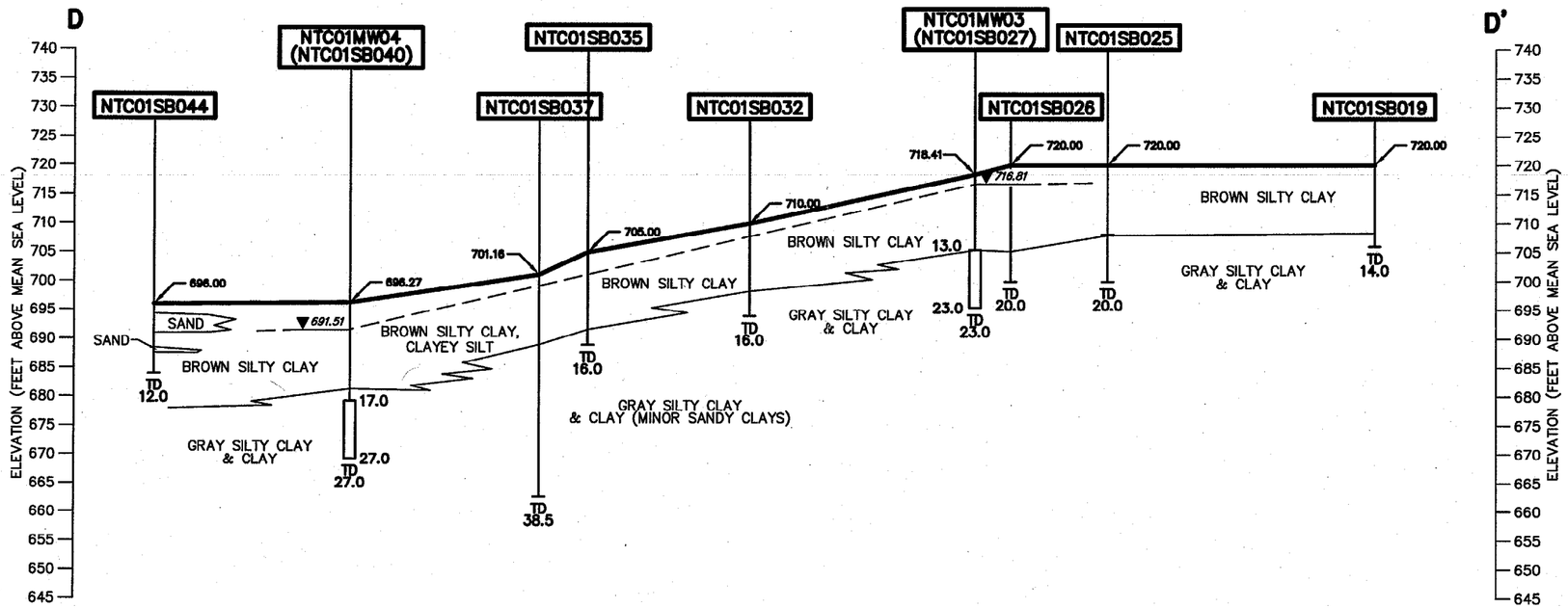


DRAWN BY MF	DATE 4/19/07	GEOLOGICAL CROSS SECTION C - C' SITE 1 - GOLF COURSE LANDFILL NAVAL STATION GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NO. 0295
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 3-7 / REV. 0

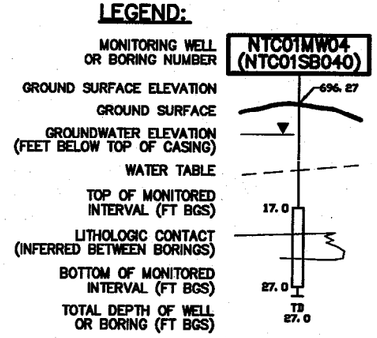
NAVFAC

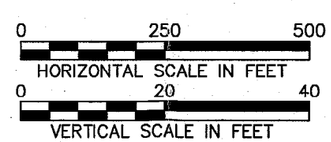
FORM CADD NO. SDIV-BH.DWG - REV 2 - 6/19/06

ACAD: 0295GX02.dwg 07/19/07 MF PIT



LEGEND:

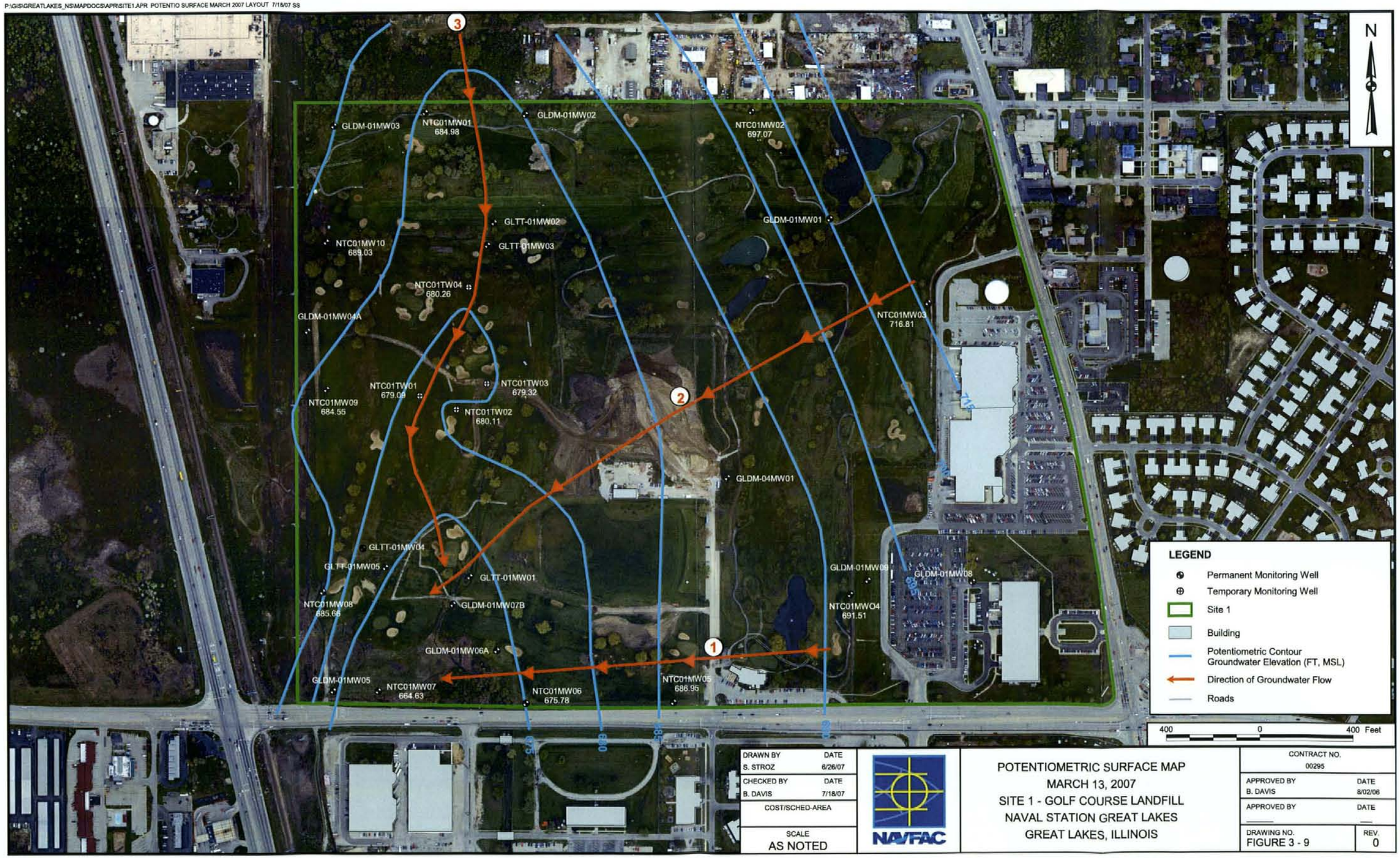




DRAWN BY MF	DATE 4/19/07	GEOLOGICAL CROSS SECTION D - D' SITE 1 - GOLF COURSE LANDFILL NAVAL STATION GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NO. 0295
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 3-8 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 2 - 6/19/06

P:\GIS\GREATLAKES_NS\MAPDOCS\APR\SITE1.APR POTENTIO SURFACE MARCH 2007 LAYOUT 7/18/07 SS



DRAWN BY	DATE
S. STROZ	6/26/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

POTENTIOMETRIC SURFACE MAP
MARCH 13, 2007
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	8/02/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 3 - 9	0

C00214H04Y

4.0 NATURE AND EXTENT OF CONTAMINATION

This section summarizes and evaluates the results of RI sampling and analysis activities as described in Sections 3.0. Specifically, this section summarizes the nature and extent of contamination in subsurface soil, groundwater, surface water, and sediment samples collected at the locations presented on Figures 3-1, 3-2, and 3-3. The data quality assessment summary and analytical summary sheets from the subcontract laboratory are presented in Appendices C and D, respectively. Ten percent of the data packages received from the analytical laboratory were validated; the results of the data validation are summarized in the data validation memoranda presented in Appendix C.

The quality of the chemical analytical data collected during the Site 1 investigation has been documented in the data validation memoranda. The analytical data validation process was completed for selected laboratory data packages in accordance with the USEPA Region 5 Guidelines for Organic Data Validation (USEPA, August 1993) and the USEPA Region 5 Guidelines for Inorganic Data Validation (USEPA, September 1993), with consideration given to the USEPA National Functional Guidelines for Organic Data Validation (USEPA, October 1999) and the USEPA National Functional Guidelines for Inorganic Data Validation (USEPA, February 2004). The parameters were reviewed using applicable sections of the aforementioned guidelines and the laboratory SOPs. The data set compiled using these guidelines is considered acceptable for use in this RI.

Contaminant sources at Site 1 are discussed in Section 4.1. The nature and extent of contamination in environmental media (subsurface soil, groundwater, surface water, surface sediment, and subsurface sediment) are discussed and compared to regulatory criteria (Illinois EPA TACO, etc.), where available, in Sections 4.2, 4.3, 4.4, 4.5, and 4.6, respectively. The tables referenced in Sections 4.2 to 4.6 include calculation of benzo(a)pyrene (BaP) Equilvalent, BaP Equivalent Zerond, total PAHs ECO, TEQ Bird, TEQ Fish, TEQ Mammal, Total HPCDD, Total HPCDF, Total HXCDD, Total PECDD, Total PECDF, Total TCDD, and Total TCDF. These parameters are used as part of the HHRA and ERA but are not discussed in this section. A summary and conclusions of the nature and extent of contamination at Site 1 are presented in Section 4.7.

The discussion of the nature and extent of contamination at Site 1 is structured according to the RI and feasibility study guidance (USEPA, October 1988). Sources of contamination are discussed first and then environmental media sampled during the investigation are discussed in the following order: subsurface soil, groundwater, surface water, surface sediment, and subsurface sediment. Within each of these

media, analytical fractions are discussed as follows: VOCs, SVOCs (if applicable), PAHs, pesticides/PCBs, herbicides (if applicable), dioxins/furans (if applicable), and inorganics.

4.1 SOURCES OF CONTAMINATION

The following presents a brief description of each identified source of potential contamination and reported historical releases to the environment at Site 1. Additional details regarding the source areas and releases are provided in Section 2.1.2.

- A landfill was operated between 1942 and 1967 on approximately 50 acres that is now covered by Willow Glen Golf Course. The landfill was operated as a trench/burn operation and received an estimated 1.5 million tons of material total during its years of operation. Types of waste reportedly disposed at the landfill included domestic refuse, sewage sludge, petroleum, oil, and lubricants, solvents, coal ash, and materials contaminated by PCBs.

- When the landfill was closed in 1969, a layer of ash from coal-fired power plants at Naval Station Great Lakes was placed over the landfill and topsoil was placed over the ash.

- The front nine-hole portion of the golf course was constructed between 1953 and 1955. The Golf Course Clubhouse, Building 3312, and the associated parking lot were constructed in 1963. The back nine-hole portion of the golf course was initially constructed in 1968 and was reconstructed in 2003.

- A fire fighting training unit was built next to the landfill (in the middle of the golf course) in 1942 and operated until it was taken out of service in 1989. Environmental investigations were conducted to determine the nature and extent of contamination at the fire fighting training unit, and environmental remediation of the old fire fighting training unit site was conducted to remove underground and above-ground storage tanks.

- As discussed in Section 2, previous investigations at Site 1 detected SVOCs and metals in soil and metals in groundwater and surface water.

4.2 SUBSURFACE SOIL CONTAMINATION ASSESSMENT

This section discusses the Site 1 subsurface soil data collected for the RI. Sixteen subsurface soil samples (plus two duplicate samples) were collected from 16 soil borings, NTC01SB088 through NTC01SB103 (see Figure 3-1), from depths ranging from 3 to 19 feet bgs. Samples were collected from

nine locations along proposed sewer route 1 (NTC01SB088 through NTC01SB096), from four locations along proposed sewer route 2 (NTC01SB097 through NTC01SB100), and from three locations along proposed sewer route 3 (NTC01SB101 through NTC01SB103). The subsurface soil samples were analyzed for TCL VOCs, PAHs, TAL metals, and cyanide in accordance with the Quality Assurance Project Plan (TtNUS, February 2007). In addition, samples were collected from four locations and also analyzed for TCL SVOCs, PCBs, and organochlorine pesticides, herbicides, and dioxins/furans.

Soil analytical results are grouped by fraction and discussed below. The analytical results were used to delineate the nature and extent of contamination and to support the HHRA. Table 4-1 presents the analytical results for the 16 subsurface soil samples collected during the RI. Descriptive statistics (e.g., frequencies of detection, ranges detected, locations of maximum detections, etc.) are presented in Table 4-2. Additionally, the analytical results were compared to the following standards and criteria, and the results of these comparisons are shown in Table 4-2 and on Figure 4-1:

- **State of Illinois, TACO Tier 1 Soil Remediation Objectives (SROs) for Residential Receptors (Ingestion and Inhalation) and Industrial Receptors (Inhalation) -** The TACO Tier 1 SROs are risk-based criteria for evaluating chemical concentrations in soil. TACO Tier 1 SROs are available for a human receptor hypothetically exposed to chemicals in soil assuming a residential land use scenario and assuming that the receptor is exposed as a result of the daily ingestion of a small amount of soil. In addition, TACO Tier 1 SROs are available for a human receptor hypothetically exposed to chemicals in soil assuming residential and industrial land use scenarios and assuming that the receptor was exposed as a result of the daily inhalation of volatile organic vapors.

- **State of Illinois, TACO Tier 1 Soil-to-Groundwater Soil Screening Levels (SSLs) for the Migration of Chemicals from Soil to Groundwater Assuming a Dilution Attenuation Factor (DAF) of 20 -** Illinois EPA SSLs for the migration of chemicals from soil to groundwater are used to identify chemicals detected in soil at concentrations that may impact groundwater quality. The migration-to-groundwater SSLs are calculated using default, residential land use exposure factors, infinite source models, and conservative default assumptions for source delineation. Therefore, these values are conservative and are designed to be protective of potential exposure at most sites. SSLs assuming a DAF of 20 are used as conservative screening values in Section 4 text, tables, and figures.

- **USEPA Region 9 PRGs for Residential Receptors -** Region 9 PRGs are risk-based concentrations derived by USEPA Region 9 for evaluating chemical concentrations in soil. The PRGs were calculated for residential receptors that may be hypothetically exposed to and ingest soil containing

the chemicals. A PRG for a carcinogenic chemical is set at the one-in-one-million cancer risk level ($1x10^{-06}$); a PRG for a non-carcinogenic chemical corresponds to an exposure concentration that will not result in adverse, non-carcinogenic health effects [i.e., a hazard index (HI) equal to or less than 1]. The current and anticipated future use of Site 1 is as a golf course. PRGs assuming a residential land use are used as conservative screening values in the Section 4 text and tables.

- **USEPA SSLs for the Migration of Chemicals from Soils to Groundwater Assuming a Dilution/Attenuation Factor of 1** - USEPA Generic SSLs for the migration of chemicals from soil to groundwater are used to identify chemicals detected in soils at concentrations that may impact groundwater quality. The migration to groundwater SSLs are calculated using default, residential land use exposure factors, infinite source models, and conservative default assumptions for source delineation. Therefore, these values are conservative and are designed to be protective of potential exposure at most sites. SSLs assuming a dilution and attenuation factor of 1 are used as conservative-screening values in the Section 4 text, tables, and figures.

4.2.1 VOCs

The following three VOCs were detected in the subsurface soil samples collected from Site 1 during the RI:

- 2-Butanone – 3.2 to 12 micrograms per kilogram (µg/kg) in 3 of 16 samples
- Acetone – 6.4 to 59 µg/kg in 2 of 16 samples
- Methylene chloride – 2.1 to 2.3 µg/kg in 2 of 16 samples

None of the VOCs were detected at concentrations exceeding Illinois TACO residential criteria or Region 9 residential PRGs.

4.2.2 SVOCs

27 SVOCs were detected in the four subsurface soil samples analyzed for these parameters including PAHs that will be discussed further in Section 4.2.3. None of the non-PAH SVOCs (2-methylphenol, 4-methylphenol, dibenzofuran, diethyl phthalate, di-n-butyl phthalate, and phenol) were detected at concentrations greater than Illinois TACO residential criteria or Region 9 residential PRGs.

4.2.3 PAHs

Twenty PAHs were detected in subsurface soil samples. Five of the 20 PAHs detected had concentrations that were greater than Illinois TACO residential criteria and/or Region 9 residential PRGs. These five contaminants, which include benzo(a)anthracene, BaP, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and naphthalene, were found at the same sample location (NTC01SB102). The maximum concentrations of the other PAHs were also found primarily at this location, with the exception of acenaphthene and acenaphthalene (maximum concentration at NTC01SB99) and dibenzo(a,h)anthracene (maximum concentration at NTC01SB088).

4.2.4 Pesticides/PCBs/Herbicides

Four subsurface soil samples were analyzed for pesticides, PCBs, and herbicides during the Site 1 investigation, and although low concentrations of these parameters were detected, none were found at concentrations in exceedance of Illinois TACO residential criteria or USEPA Region 9 Residential PRGs. 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected in the four samples collected.

Other pesticides and PCBs present in at least one sample included aldrin, alpha-BHC, alpha-chlordane, Aroclor-1248, Aroclor-1254, Aroclor-1260, delta-BHC, endosulfan I, endosulfan II, endosulfan sulfate, endrin ketone, endrin, gamma-BHC, gamma-chlordane, heptachlor epoxide, heptachlor, and methoxychlor.

One herbicide, pentachlorophenol, was also detected in one sample at a concentration of 4.2 µg/kg. This concentration is less than the TACO residential criteria and USEPA Region 9 Residential PRG.

4.2.5 Dioxins/Furans

Various dioxins and furans were detected in the four samples analyzed. Several of the samples had concentrations greater than Region 9 residential PRGs and USEPA Generic SSLs. Sample NTC01SB090 had the maximum concentration of dioxins/furans at a depth of 8 to 12 feet bgs. This sample contained the burned waste materials.

4.2.6 Inorganics

Two inorganics, lead and silver, were detected at concentrations that exceeded Illinois TACO Tier 1 residential criteria. Lead was detected in 16 soil samples, with a maximum concentration of 1,410 milligrams per kilogram (mg/kg) and silver was detected in 11 of 16 soil samples, with a maximum of 709

mg/kg. Several inorganics were detected at concentrations that exceeded Region 9 residential PRGs, including aluminum, antimony, arsenic, chromium, copper, iron, lead, manganese, thallium, and vanadium.

4.3 GROUNDWATER CONTAMINATION ASSESSMENT

This section discusses the Site 1 groundwater data collected for the RI. Groundwater samples were collected from four temporary monitoring wells along the existing and/or one of the proposed sewer routes within the landfill and from 10 permanent monitoring wells installed at the landfill perimeter. The Quality Assurance Project Plan (TtNUS, February 2007) specified that the samples be analyzed for TCL VOCs, PAHs, TAL metals, and cyanide. In addition, the samples collected from the temporary wells were analyzed for the secondary parameters TCL SVOCs, PCBs (at three locations), and organochlorine pesticides, and herbicides. The results for SVOCs, PCBs, organochlorine pesticides, and herbicides were less than detection limits and the groundwater from the permanent monitoring wells were not analyzed for these secondary parameters. Groundwater samples were not analyzed for dioxins or furans, as described in the Quality Assurance Project Plan.

Groundwater analytical results are grouped by fraction and discussed below. The analytical results were used to delineate the nature and extent of contamination and to support the HHRA. Table 4-3 presents the analytical results for the 14 groundwater samples (plus two duplicate samples) collected during the RI. Permanent and temporary monitoring well locations are shown on Figure 3-2. Descriptive statistics (e.g., frequencies of detection, ranges detected, locations of maximum detections, etc.) are presented in Table 4-4. Additionally, the analytical results were compared to the following standards and criteria, and the results of these comparisons are shown in Table 4-4 and on Figure 4-2:

- **State of Illinois, Class I TACO Tier 1 Groundwater Remediation Objectives (GROs) – Ingestion -** Class I TACO Tier 1 GROs are used to evaluate chemical concentrations in groundwater or surface water that may be used as a domestic water supply.

- **USEPA Safe Drinking Water Act Primary Maximum Contaminant Levels (MCLs) -** Primary MCLs are enforceable standards promulgated under the federal Safe Drinking Water Act and are designed for the protection of human health. Primary MCLs are based on laboratory or epidemiological studies and apply to public water systems. A public water supply is defined as a system that provides water to the public for human consumption and that has at least 15 service connections or regularly serves an average of 25 individuals daily at least 60 days per year. Primary MCLs are designed for the prevention of human health effects but also reflect the technical feasibility of removing a contaminant.

Primary (i.e., health-based) and secondary (i.e., aesthetic-based) MCLs are promulgated under the Safe Drinking Water Act. Primary MCLs are referenced in this section.

- **USEPA Region 9 PRGs for Tap water -** Region 9 Tap water PRGs are risk-based concentrations derived by USEPA Region 9 for evaluating chemicals in groundwater or surface water sources that may used as a domestic water supply. A PRG for a carcinogenic chemical is set at the one-in-one-million cancer risk level ($1x10^{-06}$); a PRG for a non-carcinogenic chemical corresponds to an exposure concentration that will not result in adverse, non-carcinogenic health effects (i.e., a HI equal to or less than 1).

4.3.1 VOCs

The following 10 VOCs were detected in groundwater samples collected from Site 1 during the RI:

- 1,2-Dichlorobenzene – 0.27 to 0.27 micrograms per liter (µg/L) in 2 of 14 samples
- Acetone – 2.7 to 5 µg/L in 2 of 14 samples
- Benzene – 0.26 to 0.44 µg/L in 2 of 14 samples
- Carbon disulfide – 0.33 to 0.42 µg/L in 2 of 14 samples
- Chlorobenzene – 0.71 to 0.76 µg/L in 2 of 14 samples
- Cyclohexane – 2.1 to 2.3 µg/L in 2 of 14 samples
- Isopropylbenzene – 0.19 to 0.26 µg/L in 2 of 14 samples
- Methyl cyclohexane – 1.7 to 2.3 µg/L in 2 of 14 samples
- Toluene – 0.2 µg/L in 1 of 14 samples
- Total xylenes – 2.7 to 5 µg/L in 2 of 14 samples

The VOC concentrations were less than Illinois TACO GROs and federal MCLs. VOCs were detected only at sampling locations NTC01TW01 or NTC01TW02, with the exception of acetone and total xylenes, which were detected at low concentrations at locations NTC01TW04 and NTC01MW02, respectively.

This nature and extent section focused on and includes comparisons to Illinois EPA TACO Tier 1 criteria. For comparison only, the following briefly compares chemicals of concern to Region 9 tap water PRGs. Benzene was the only VOC that exceeded the Region 9 tap water PRG in one sample (NTC01TW02). Benzene was detected at two locations (NTC01TW01 and NTC01TW02), with a maximum concentration of 0.44 µg/L. The Region 9 tap water PRG exceedance is presented in Table 4-4.

Based on the results of RI groundwater sampling, VOC impacted groundwater is confined to the area near temporary well locations NTC01TW01 and NTC01TW02.

4.3.2 SVOCs

Three SVOCs (benzaldehyde, diethyl phthalate, and naphthalene) were detected at one temporary well (NTC01TW01). The concentrations detected were less than the reporting limit, and consequently, the analytical results were qualified as estimated. SVOC concentrations were less than the criteria presented in Table 4-4, with the exception of naphthalene, which was detected in excess of its Region 9 tap water PRG. The concentrations of diethyl phthalate and naphthalene did not exceed the TACO groundwater criteria.

4.3.3 PAHs

Ten PAHs were detected in groundwater at Site 1, and none were detected at concentrations greater than the Illinois TACO GROs and federal MCLs. The ten PAHs were detected at location NTC01TW01. Several PAHs were detected in more than one sample. Phenanthrene was detected in 13 of the 13 samples collected, at a maximum concentration of 0.043 µg/L. Fluorene was detected in 5 of 13 samples, with a maximum concentration of 0.23 µg/L, and pyrene was detected in 3 of 13 samples, with a maximum concentration of 0.043 µg/L. 2-Methylnaphthalene was detected in one sample at a maximum concentration of 1.5 µg/L, which exceeds its Region 9 tap water PRG.

4.3.4 Pesticides/PCBs/Herbicides

No pesticides, PCBs, or herbicides were detected in Site 1 groundwater samples.

4.3.5 Inorganics

The following eight inorganic constituents were detected in RI groundwater samples at concentrations exceeding one or more of the screening criteria presented in Table 4-4.

Parameter	Range Detected (µg/L)	Region 9 PRG (µg/L)	TACO GRO (µg/L)	Federal MCL (µg/L)
Aluminum	68.3 – 8,650	3,600 (1)	NA	NA
Arsenic	2.4 - 3.3	0.045 (3)	50 (0)	10 (0)
Barium	29.3 - 566	260 (2)	2,000 (0)	2,000 (0)
Chromium	0.65 - 14.1	11 (1)	100 (0)	100 (0)

Parameter	Range Detected (µg/L)	Region 9 PRG (µg/L)	TACO GRO (µg/L)	Federal MCL (µg/L)
Iron	106-17,600	1,100 (6)	5,000 (2)	NA
Lead	1.2-8.4	NA	7.5 (1)	15 (0)
Manganese	9.4-5,070	88 (9)	150 (7)	NA
Vanadium	1.6 - 20.7	3.6 (8)	49 (0)	NA

NA – Not available.
The number of exceedances is presented in parentheses.

Iron and lead were both detected at concentrations greater than the Illinois TACO GRO at sample location NTC01TW01. Iron also exceeded the Illinois TACO criterion at location NTC01MW03. Several inorganics were detected at concentrations greater than the Region 9 PRGs, including aluminum, arsenic, barium, chromium, iron, manganese, and vanadium.

4.4 SURFACE WATER CONTAMINATION ASSESSMENT

This section discusses the Site 1 surface water data collected for the RI. Surface water samples were collected from five locations within Skokie Ditch and manholes to the culverts that contain Skokie Ditch. The sample locations are as follows: one from the point where Skokie Ditch flows off the site/under Buckley Road (NTC01SW01), one near the bend in Skokie Ditch (NTC01SW02), one from the origination point of Skokie Ditch (NTC01SW03), and two from manholes north of the golf course (NTC01SW04 and NTC01SW05), as shown on Figure 3-3. A duplicate sample was collected at location NTC01SW03. The samples were analyzed for TCL VOCs, SVOCs, PAHs, and organochlorine pesticides, PCBs, herbicides, dioxins/furans, TAL metals (filtered and unfiltered samples), and cyanide.

Surface water analytical results are grouped by fraction and discussed below. The analytical results were used to delineate the nature and extent of contamination and to support human health and ecological risk assessments. Table 4-5 presents the analytical results for the five surface water samples. Descriptive statistics (e.g., frequencies of detection, ranges detected, locations of maximum detections, etc.) are presented in Table 4-6. Additionally, the analytical results are compared to the following standards and criteria, and the results of these comparisons are shown in Table 4-6 and on Figure 4-3:

- **State of Illinois, Class I TACO Tier 1 GROs – Ingestion** - Class I TACO Tier 1 GROs are used to evaluate chemical concentrations in groundwater or surface water that may be used as a domestic water supply.

- **USEPA Safe Drinking Water Act Primary Maximum Contaminant Levels (MCLs) -** Primary MCLs are enforceable standards promulgated under the federal Safe Drinking Water Act and are designed for the protection of human health. Primary MCLs are based on laboratory or epidemiological studies and apply to public water systems. A public water supply is defined as a system that provides water to the public for human consumption and that has at least 15 service connections or regularly serves an average of 25 individuals daily at least 60 days per year. Primary MCLs are designed for the prevention of human health effects but also reflect the technical feasibility of removing a contaminant. Primary (i.e., health-based) and secondary (aesthetic-based) MCLs are promulgated under the Safe Drinking Water Act. Primary MCLs are referenced in this section.

- **USEPA Region 9 PRGs for Tap water -** Region 9 Tap water PRGs are risk-based concentrations derived by USEPA Region 9 for evaluating chemicals in groundwater or surface water sources that may used as a domestic water supply. A PRG for a carcinogenic chemical is set at the one-in-one-million cancer risk level (1E-06); a PRG for a non-carcinogenic chemical corresponds to an exposure concentration that will not result in adverse, non-carcinogenic health effects (i.e., a HI equal to or less than 1).

- **Ecological Screening Levels for Surface Water -** The ecological screening levels for surface water presented in Table 4-6 are default benchmarks suggested for use in the ERA presented in Section 7.0. These criteria are presented as points of reference only.

4.4.1 VOCs

The following three VOCs were detected in RI surface water samples collected from Site 1:

- 1,1-Dichloroethane – 0.21 to 0.39 µg/L in 3 of 5 samples
- cis-1,2-Dichloroethene – 0.99 to 1.7 µg/L in 5 of 5 samples
- Vinyl chloride – 0.25 to 0.34 µg/L in 2 of 5 samples

Concentrations of the three VOCs detected in Site 1 surface water samples did not exceed Illinois TACO Tier I GROs, MCLs, or ecological surface water screening criteria; however, concentrations of vinyl chloride detected in two samples slightly exceeded Region 9 tap water PRGs.

4.4.2 SVOCs

No SVOCs were detected in Site 1 surface water samples.

4.4.3 PAHs

Several PAHs were detected in surface water samples; however none exceeded Illinois TACO criteria or MCLs. Several PAHs exceeded their Region 9 tap water PRG. Most PAHs were detected at relatively low concentrations in three of the five samples collected.

BaP and pyrene were detected in the surface water samples at concentrations that exceeded the ecological screening levels.

4.4.4 Pesticides/PCBs/Herbicides

No pesticides, PCBs, or herbicides were detected in Site 1 surface water samples.

4.4.5 Dioxins/Furans

One dioxin/furan (1,2,3,4,6,7,8,9-OCDD) was detected in surface water samples collected at Site 1; however the concentration did not exceed the USEPA Region 9 tap water criteria.

4.4.6 Inorganics

Several metals were detected in Site 1 surface water; however, only thallium was detected at a concentration greater than Illinois TACO criteria. Thallium was detected in one sample (NTW01SW01) at a concentration of 5.1 µg/L, which exceeds the Illinois TACO GRO, MCL, and Region 9 tap water PRG. Antimony was also detected at a concentration greater than the Region 9 tap water PRG and the ecological screening level.

4.5 SURFACE SEDIMENT CONTAMINATION ASSESSMENT

This section discusses the Site 1 surface sediment (0 to 4 centimeters bgs) data collected for the RI. Sediment samples were collected from five locations within Skokie Ditch as it flows across the golf course. Samples were collected at the point where Skokie Ditch flows off the site under Buckley Road (NTC01SW01), at the bend in Skokie Ditch (NTC01SD02), at the origination point of Skokie Ditch (NTC01SD03), in the sediment trap located near the split in Skokie Ditch (NTC01SD04), and equidistant between the origination point and the split (NTC01SW05), as shown on Figure 3-3. At each location, one sediment sample was collected from 0 to 4 centimeters bgs. A duplicate sample was collected at location NTC01SD04. The samples were analyzed for TCL VOCs, PAHs, TAL metals, and cyanide. Select

samples were analyzed for TCL SVOCs, organochlorine pesticides, and PCBs, herbicides, and dioxins/furans.

The analytical results are grouped by fraction and discussed below. The analytical results were used to delineate the nature and extent of contamination and to support HHRA and ERA. Table 4-7 presents the analytical results for the five surface sediment samples. Descriptive statistics (e.g., frequencies of detection, ranges detected, locations of maximum detections, etc.) are presented in Table 4-8. Additionally, the analytical results are compared to the following standards and criteria, and the results of these comparisons are shown in Table 4-8 and on Figures 4-4, 4-5, and 4-6:

- **State of Illinois, TACO Tier 1 SRO for Residential Receptors (Ingestion and Inhalation) and Industrial Receptors (Inhalation)** - The TACO Tier 1 SROs are risk-based criteria for evaluating chemical concentrations in soil and sediment. TACO Tier 1 SROs are available for a human receptor hypothetically exposed to chemicals in soil or sediment assuming a residential land use scenario and assuming that the receptor was exposed as a result of the daily ingestion of small amount of soil or sediment. In addition, TACO Tier 1 SROs are available for a human receptor hypothetically exposed to chemicals in soil or sediment assuming residential and industrial land use scenarios and assuming that the receptor was exposed as a result of the daily inhalation of volatile organic vapors.

- **USEPA Region 9 PRGs for a Residential Receptor** - Region 9 PRGs are risk-based concentrations derived by USEPA Region 9 for evaluating chemical concentrations in soil and sediment. The PRGs were calculated for residential receptors that may be hypothetically exposed to and ingest soil or sediment containing the chemicals. A PRG for a carcinogenic chemical is set at the one-in-one-million cancer risk level (1E-06); a PRG for a non-carcinogenic chemical corresponds to an exposure concentration that will not result in adverse, non-carcinogenic health effects (i.e., a hazard index [HI] equal to or less than 1). It is noteworthy that the current and anticipated future use of Site 1 is a recreational golf course. PRGs assuming a residential land use are used as conservative-screening values in the Section 4 text and tables.

- **Ecological Screening Levels for Sediment** - The ecological screening levels for sediment presented in Table 4-8 are default benchmarks suggested for use in the ERA presented in Section 7.0. These criteria are presented as points of reference only.

4.5.1 VOCs

No VOCs were detected in Site 1 surface sediment samples.

4.5.2 SVOCs

Three samples and one duplicate sample were analyzed for SVOCs in Site 1 surface sediment. The SVOCs detected are also categorized as PAHs and are discussed in the following section.

4.5.3 PAHs

Five PAHs were detected in the five surface sediment samples collected from Site 1 at concentrations exceeding TACO residential criteria and USEPA Region 9 Residential PRGs. Concentrations of benzo(a)anthracene (maximum concentration of 1,700 µg/kg), BaP (maximum concentration of 2,000 µg/kg), benzo(b) fluoranthene (maximum concentration 6,400 of µg/kg), dibenzo(a,h)anthracene (maximum concentration 280 of µg/kg), and indeno(1,2,3-cd)pyrene (maximum concentration of 1,700 µg/kg) were detected in the five samples collected, and benzo(b)fluoranthene (maximum concentration of 2,400 µg/kg) was detected in four of the five samples collected.

Fifteen (15) PAHs were detected in the surface sediment samples collected at concentrations exceeding the ecological screening levels.

Also of note, the maximum concentration of each PAH detected was found at one of two sampling locations, NTC01SD02 or NTC01SD03.

4.5.4 Pesticides/PCBs/Herbicides

Three samples and one duplicate sample were analyzed for pesticides and PCBs in surface sediment at Site 1. Although no pesticides were detected at concentrations exceeding TACO residential criteria or USEPA Region 9 Residential PRGs, 4,4'-DDD (maximum concentration of 17 µg/kg), 4,4'-DDE (maximum concentration of 32 µg/kg), and 4,4'-DDT (maximum concentration of 7.4 µg/kg) were detected at concentrations that exceeded ecological screening levels at the three sample locations. Alpha-chlordane, endosulfan II, and gamma-chlordane were also detected at concentrations that exceeded ecological screening levels in at least one sample collected.

No PCBs or herbicides were detected in Site 1 surface sediment samples.

4.5.5 Dioxins/Furans

One dioxin/furan [2,3,7,8-Tetrachlorodibenzodioxin (TCDD)] was detected in surface sediment samples collected at Site 1 at a concentration that exceeded ecological screening level; however 2,3,7,8-TCDD only exceeded the ecological screening levels in one of three samples, with a concentration of 0.76 nanograms per kilogram (ng/kg). Several other dioxins/furans were detected in the three samples (plus one duplicate) collected from Site 1; however none had concentrations that exceeded the TACO residential criteria or USEPA Region 9 Residential PRGs.

4.5.6 Inorganics

The five samples collected at Site 1 were analyzed for inorganics, and although no inorganics were detected at concentrations in exceedance of TACO residential criteria, eight inorganics were detected at concentrations that exceeded ecological screening levels. Copper and zinc were detected at concentrations that exceeded ecological screening levels in all five samples, with maximum concentrations of 71.3 and 400 mg/kg, respectively. Antimony, arsenic, iron, lead, manganese, and mercury were also detected at concentrations greater than the ecological screening levels in at least one of the five samples collected.

Six inorganics were detected at concentrations exceeding USEPA Region 9 Residential PRGs. Arsenic, iron and manganese concentrations exceeded USEPA Region 9 Residential PRGs in the five samples collected, while aluminum, thallium, and vanadium were detected with concentrations in at least one sample greater than the USEPA Region 9 Residential PRGs.

4.6 SUBSURFACE SEDIMENT CONTAMINATION ASSESSMENT

This section discusses the Site 1 subsurface sediment (1 foot bgs) data collected for the RI. Subsurface sediment samples were collected from the five previously described sampling locations for surface sediment, as shown on Figure 3-3. At each location, a subsurface sediment sample was collected at 1 foot bgs. The samples were analyzed for TCL VOCs, PAHs, TAL metals, and cyanide. Select samples were analyzed for TCL SVOCs, organochlorine pesticides, and PCBs, herbicides, and dioxins/furans.

The analytical results are grouped by fraction and discussed below. The analytical results were used to delineate the nature and extent of contamination and to support the HHRA. Table 4-9 presents the analytical results for the five subsurface sediment samples. Descriptive statistics (e.g., frequencies of detection, ranges detected, locations of maximum detections, etc.) are presented in Table 4-10. Additionally, the analytical results are compared to previously defined standards and criteria, and the

results of these comparisons are shown in Table 4-10 and on Figure 4-7. The subsurface sediment results were not compared to ecological screening levels but were compared to the TACO SRO for Residential Ingestion and USEPA Region 9 Residential PRG criteria as described in the Surface Sediment Contamination Assessment (Section 4.5).

4.6.1 VOCs

No VOCs were detected in Site 1 subsurface sediment samples.

4.6.2 SVOCs

One sample was analyzed for SVOCs in Site 1 subsurface sediment. The SVOCs detected above the TACO SRO are also categorized as PAHs and are discussed in the following section.

4.6.3 PAHs

Five PAHs were detected in the five subsurface sediment samples collected from Site 1 at concentrations exceeding TACO residential criteria and USEPA Region 9 Residential PRGs. The maximum concentration of each PAH was detected at sampling location NTC01SD01, the sample where Skokie Ditch flows under Buckley Road.

4.6.4 Pesticides/PCBs/Herbicides

One subsurface sediment sample at Site 1, from location NTC01SD01, was collected and analyzed for pesticides and PCBs. The concentrations of the pesticides and PCBs were less than TACO residential criteria; however Aroclor-1248, at a concentration of 820 µg/kg, exceeded USEPA Region 9 Residential PRG.

No herbicides were detected in Site 1 subsurface sediment samples.

4.6.5 Dioxins/Furans

Several dioxins and furans were detected in the subsurface sediment sample collected from location NTC01SD01. The concentrations of the dioxin/furan 1,2,3,4,6,7,8-HPCDD exceeded USEPA Region 9 Residential PRG. Other dioxins/furans were detected at concentrations less than USEPA Region 9 Residential PRGs and TACO residential criteria.

4.6.6 Inorganics

The five subsurface sediment samples collected from Site 1 were analyzed for inorganics, and the concentrations of seven of the inorganics (aluminum, arsenic, chromium, iron, manganese, thallium, and vanadium) were greater than USEPA Region 9 Residential PRGs; however the concentrations of inorganics were less than TACO residential criteria.

4.7 SUMMARY AND CONCLUSIONS

The following briefly summarizes the nature and extent of the current contamination in subsurface soil, groundwater, surface water, surface sediment, and subsurface sediment at Site 1:

- **Very few VOCs were detected at Site 1.** Low concentrations of VOCs were detected in Site 1 subsurface soil, groundwater, and surface water, and none were detected at concentrations that exceeded TACO criteria. No VOCs were detected in sediment samples.

- **PAHs are the predominant SVOCs detected in subsurface soil, groundwater, surface water, and sediment samples collected at Site 1.** Many of the PAH results exceeded the referenced human health or ecological screening criteria. However, interpretation of PAH data must consider the fact that PAHs are common, anthropogenic contaminants frequently detected as a result of the wide spread use of petroleum products in our modern, industrialized society as well as potential byproducts of combustion that took place in the landfill.

- **Pesticides were detected in subsurface soil and sediment samples collected at Site 1 at concentrations that reflect the widespread and historical use of these chemicals for pesticide control.** DDT and its degradation by-products were the pesticides detected most frequently. The pesticide concentrations for the Site 1 soil and sediment samples do not exceed TACO screening levels for human health. In contrast, the pesticide results frequently exceed referenced screening levels for ecological receptors. **Pesticides were not detected in the Site 1 groundwater or surface water samples.**

- **PCBs were detected in less than 50 percent of the subsurface soil and sediment samples analyzed.** Low concentrations of PCBs, including Aroclor-1248, -1254, and -1260, were detected in several subsurface soil samples and one subsurface sediment sample. Detected concentrations of PCBs in subsurface soil and subsurface sediments were less than the TACO screening criteria and

EPA Region 9 PRGs. **No PCBs were detected in Site 1 groundwater, surface water, or surface sediment.**

- **Herbicides were detected in one subsurface soil sample collected at Site 1.** Pentachlorophenol was detected in one subsurface soil sample at a concentration that was less than the TACO screening level for human health. **Herbicides were not detected in the Site 1 groundwater, surface water, or sediment samples.**

- **Several metals were detected in the soil, groundwater, and sediment samples collected at Site 1 at concentrations greater than TACO screening levels for human health or ecological screening levels.** Lead and silver were detected in subsurface soil at concentrations greater than TACO criteria. Lead was also detected in one groundwater sample. Iron and manganese exceeded TACO criteria in groundwater as well. Thallium was the only metal detected in surface water, in one sample, at a concentration greater than TACO criterion. All inorganics in sediment samples were detected at concentrations less than TACO criteria; however several metals were detected at concentrations greater than USEPA Region 9 Residential PRGs or ecological screening levels.

TABLE 4-1

SUMMARY OF ANALYTICAL RESULTS FOR SUBSURFACE SOIL SAMPLES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	NTC01SB088	NTC01SB089	NTC01SB090[1]		NTC01SB091	NTC01SB092	NTC01SB093	NTC01SB094	NTC01SB095	NTC01SB096	NTC01SB097	NTC01SD098	NTC01SB099[1]		NTC01SB100	NTC01SB101	NTC01SB102	NTC01SB103
	7-8	11-12	8-12	8-12	8-12	15-16	8-10	14-16	8-10	10-12	3-4	15-16	10-12	10-12	10-12	4-6	4-8	19-19
Volatile Organics (µg/kg)																		
2-BUTANONE	5.6 U	7.5 U	8.7 UJ	10 U	6.6	12 U	6.6 U	8.8 U	16 U	5.8 U	8.1 U	3.2 J	6.1 U	6.1 U	12	7.3 U	13 U	4.5 U
ACETONE	22 U	30 U	35 UJ	41 UJ	6.4 J	49 U	26 U	35 U	62 U	23 U	33 U	32 U	25 U	24 U	59 J	29 U	51 U	18 U
METHYLENE CHLORIDE	5.6 U	7.5 U	8.7 UJ	10 U	5.6 U	12 U	6.6 U	8.8 U	16 U	5.8 U	8.1 U	2.3 J	6.1 U	6.1 U	2.1 J	7.3 U	13 U	4.5 U
Semivolatile Organics (µg/kg)																		
2-METHYLNAPHTHALENE			58 J	96 J					40 J				250 J	160 J			41 J	
2-METHYLPHENOL			420 U	2100 U					890 U				400 U	39 J			660 U	
4-METHYLPHENOL			13 J	160 J					890 U				60 J	170 J			660 U	
ACENAPHTHENE			11 J	2100 U					890 U				160 J	180 J			290 J	
ACENAPHTHYLENE			11 J	100 J					890 U				400 U	18 J			660 U	
ANTHRACENE			420 U	2100 U					890 U				13 J	160 J			260 J	
BENZALDEHYDE			150 J	2100 U					890 U				400 U	110 J			660 U	
BENZO(A)ANTHRACENE			420 U	2100 U					890 U				400 U	520			320 J	
BENZO(A)PYRENE			14 J	2100 U					890 U				400 U	500			250 J	
BENZO(B)FLUORANTHENE			24 J	2100 U					890 U				400 U	870			370 J	
BENZO(G,H,I)PERYLENE			20 J	2100 U					890 U				400 UR	500			200 J	
BENZO(K)FLUORANTHENE			420 U	2100 U					890 U				400 U	230 J			130 J	
BIS(2-ETHYLHEXYL)PHTHALATE			160 J	660 J					890 U				150 J	400 U			660 U	
BUTYL BENZYL PHTHALATE			13 J	2100 U					74 J				9.8 J	400 U			46 J	
CARBAZOLE			420 U	2100 U					890 U				400 U	100 J			250 J	
CHRYSENE			420 U	2100 U					890 U				400 U	680			400 J	
DIBENZO(A,H)ANTHRACENE			420 U	2100 U					890 U				400 UR	130 J			59 J	
DIBENZOFURAN			19 J	2100 U					890 U				62 J	96 J			100 J	
DIETHYL PHTHALATE			26 J	430 J					890 U				400 U	18 J			660 U	
DI-N-BUTYL PHTHALATE			56 J	340 J					890 U				400 U	400 U			660 U	
FLUORANTHENE			61 J	2100 U					890 U				45 J	1400 J			1100	
FLUORENE			11 J	92 J					890 U				400 U	140 J			320 J	
INDENO(1,2,3-CD)PYRENE			12 J	2100 U					890 U				400 UR	400			200 J	
NAPHTHALENE			110 J	250 J					52 J				150 J	200 J			210 J	
PHENANTHRENE			99 J	140 J					58 J				120 J	920 J			1700	
PHENOL			420 U	93 J					890 U				400 U	400 U			22 J	
PYRENE			56 J	55 J					890 U				41 J	1100 J			1300	
Polynuclear Aromatic Hydrocarbons (µg/kg)																		
2-METHYLNAPHTHALENE	1300 J	710	130 J	120 J	24 J	25 J	150 J	94	58 J	400 U	290 J	7.7 J	260 J	1200 J	27 J	490	3500 J	7.5 J
ACENAPHTHENE	4100 U	210 U	14 J	43 UJ	40 UR	57 U	200 U	24 J	89 U	400 U	890 U	46 U	400 U	260 J	42 U	190 U	13000 U	38 U
ACENAPHTHYLENE	4100 U	670	300 J	280 J	37 J	57 U	1400	52 U	25 J	78 J	890 U	30 J	250 J	3100 J	300	2600	13000 U	38 U
ANTHRACENE	2200	130	25 J	8.8 J	4.1 J	11 J	31 J	19	1.8 J	27 J	470	4 J	120 J	360 J	7.4 J	72	5200	2.7 J
BAP EQUIVALENT	8800	450	32	17	4	58	92	61	20	380	1800	7	150	740	35	350	13000	10
BAP EQUIVALENT ZEROND	8800	450	27	12	4	58	68	56	0.3	380	1700	2	110	740	30	330	13000	1
BENZO(A)ANTHRACENE	6200	280	8.5 UJ	8.6 UJ	8.2 UR	47	40 U	41	18 U	250	1400	9.4 U	120 J	580 J	8.5 U	150	11000	7.8 U
BENZO(A)PYRENE	6200	300	20 J	8.6 UJ	2.9 J	41	58	39	18 U	270	1300	1.5 J	71 J	480 J	23	250	9300	7.8 U
BENZO(B)FLUORANTHENE	6100	290	52 J	26 J	11 J	47	40 U	76	18 U	290	1700	4.9 J	120 J	620 J	35	420	14000	5 J
BENZO(G,H,I)PERYLENE	5100	280	17 J	2.9 J	2.6 J	46	87	54	1.6 J	300	900	0.96 J	98 J	490 J	44	250	7300	18
BENZO(K)FLUORANTHENE	3100	120	10 J	8.6 UJ	1.8 J	18	40 U	24	18 U	130	800	9.4 U	38 J	190 J	9.7	39 U	4600	1.8 J
CARBAZOLE	830 J	57 J	12 J	43 UJ	40 UR	57 U	200 U	52 U	89 U	400 U	160 J	46 U	56 J	300 J	42 U	190 U	4300 J	38 U
CHRYSENE	6200	370	42 J	1.6 J	6.9 J	46	78	43	18 U	300	1600	3.5 J	120 J	690 J	23	360	12000	19
DIBENZO(A,H)ANTHRACENE	850	60	8.5 UJ	8.9 J	8.2 UR	4.4 J	40 U	10 U	18 U	34 J	180 U	9.4 U	82 U	83 J	8.5 U	39 U	580 J	7.8 U
FLUORANTHENE	14000	620	160 J	21 J	36 J	90	200	120	4.8 J	470	3700	15	540 J	1800 J	46	270	49000	11
FLUORENE	1200	48	19 J	23 J	8.2 UR	12 U	40 U	14	18 U	82 U	110 J	9.4 U	230	220	8.5 U	39 U	3300	7.8 U
INDENO(1,2,3-CD)PYRENE	4600	290	16 J	3.1 J	2.2 J	32	99	46	2.5 J	230	1100	1 J	99 J	550 J	38	220	6300	9
NAPHTHALENE	4100 U	460	150 J	160 J	21 J	20 J	66 J	110	72 J	400 U	280 J	20 J	110 J	770 J	25 J	110 J	3100 J	38 U
PHENANTHRENE	6500	440	140 J	55 J	24 J	52	130	110	14 J	140	2100	26	920 J	1600 J	34	350	26000	7 J
PYRENE	13000	420	120 J	9.9 J	27 J	74	87	81	4 J	420	2500	12	370 J	1000 J	34	350	31000	14
Organochlorine Pesticides/PCBs (µg/kg)																		
4,4'-DDE			12 J	0.6 J					8.3				45 J	82 J			16	
4,4'-DDD			6.9	4.8					56				83 J	280 J			45	
4,4'-DDT			1.4 J	2.2 U					11				15 J	27 J			3.6	
ALDRIN			2.2 U	2.2 U					4.6 U				10 U	1.5 J			3.4 U	
ALPHA-BHC			2.2 U	2.2 U					4.6 U				1.7 J	10 U			3.4 U	
ALPHA-CHLORDANE			2.8 J	2.2 U					2.2 J				10 U	10 U			3.4 U	
AROCLOR-1248			42 U	43 UJ					89 U				130 J	40 UJ			66 U	
AROCLOR-1254			33 J	43 UJ					89 U				40 U	40 U			66 U	
AROCLOR-1260			42 U	43 UJ					89 U				100 J	40 UJ			66 U	
DELTA-BHC			2.2 U	2.2 U					4.6 U				1.2 J	10 U			3.4 U	
DIELDRIN			2.2 U	0.32 R					4.6 U				1.2 J	10 U			0.55 J	
ENDOSULFAN I			2.2 U	2.2 U					4.6 U				3.1 J	10 U			3.4 U	
ENDOSULFAN II			0.65 R	2.2 U					4.6 U				6.1 J	3.7 J			3.4 U	
ENDOSULFAN SULFATE			2.2 U	2.2 U					4.6 U				10 U	2 J			3.4 U	
ENDRIN			1.6 J	2.2 U					4.6 U				10 U	9.6 J			3.4 U	
ENDRIN KETONE			0.73 J	2.2 U					4.6 U				2.2 J	10 U			3.4 U	
GAMMA-BHC (LINDANE)			2.2 U	2.2 U					4.6 U				1.2 J	7.7 J			3.4 U	
GAMMA-CHLORDANE			3.2	2.2 U					2 J				6.9 J	10 U			3.4 U	
HEPTACHLOR			2.2 U	2.2 U					4.6 U				10 U	2.4 J			3.4 U	
HEPTACHLOR EPOXIDE			2.2 U	2.2 U					4.6 U				4.4 J	2 J			3.4 U	
METHOXYCHLOR			4.2 U	4.3 U					8.9 U				2.4 J	2.5 J			6.6 U	

TABLE 4-1

SUMMARY OF ANALYTICAL RESULTS FOR SUBSURFACE SOIL SAMPLES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	NTC01SB088	NTC01SB089	NTC01SD090[1]		NTC01SB091	NTC01SB092	NTC01SB093	NTC01SB094	NTC01SB095	NTC01SB096	NTC01SB097	NTC01SB098	NTC01SB099[1]		NTC01SB100	NTC01SB101	NTC01SB102	NTC01SB103
	7-8	11-12	8-12	8-12	8-12	15-16	8-10	14-16	8-10	10-12	3-4	15-16	10-12	10-12	10-12	4-6	4-8	19-19
Herbicides (µg/kg)																		
PENTACHLOROPHENOL			13 U	4.2 J					27 U				12 U	12 U			20 U	
Dioxins/Furans (ng/kg)																		
1,2,3,4,6,7,8,9-OCDD			4200 J	16000 J					57				850 J	2000 J			2200	
1,2,3,4,6,7,8,9-OCDF			340 J	20000 J					5.7 U				29	47			38 U	
1,2,3,4,6,7,8-HPCDD			920 J	11000 J					14				190 J	400 J			600	
1,2,3,4,6,7,8-HPCDF			310 J	34000 J					7.3 J				41 J	71 J			59	
1,2,3,4,7,8,9-HPCDF			28 J	3100 J					0.59 U				3.6 J	4.7 J			2.4 U	
1,2,3,4,7,8-HXCDD			18 J	1200 J					0.89 U				5.8 J	8.4			7.4 U	
1,2,3,4,7,8-HXCDF			62 J	8900 J					3.3 U				13 U	20			3 U	
1,2,3,6,7,8-HXCDD			56 J	2000 J					0.86 U				15	22			66	
1,2,3,6,7,8-HXCDF			33 J	6700 J					1.6 U				7.4 U	10			2 U	
1,2,3,7,8,9-HXCDD			47 J	1600 J					1.4 U				12	20			41 J	
1,2,3,7,8,9-HXCDF			3.3 J	290 J					0.57 U				0.75 U	0.5 U			1.2 U	
1,2,3,7,8-PECDD			22 J	1200 J					0.84 U				6.4 U	9.1			20 U	
1,2,3,7,8-PECDF			40 J	6400 J					1.2 U				8.4 U	12			5.5 U	
2,3,4,6,7,8-HXCDF			38 J	8000 J					1.5 U				10 U	12			1.2 U	
2,3,4,7,8-PECDF			48 J	12000 J					1.3 U				11 U	19			5.7 U	
2,3,7,8-TCDD			8 J	140 J					0.4 U				1.9 J	3.6 J			9 U	
2,3,7,8-TCDF			48 J	5500 J					1 U				10 J	18 J			11 U	
TEQ MAMMAL			90	9000					0.2				9	35			18	
TOTAL HPCDD			1700 J	21000 J					26				380 J	760 J			1100	
TOTAL HPCDF			470 J	47000 J					7.3				75 J	130 J			110	
TOTAL HXCDD			540 J	21000 J					3.8 U				180	250			550	
TOTAL HXCDF			350 J	61000 J					3.3 U				21 J	110 J			13 U	
TOTAL PECDD			270 J	16000 J					0.84 U				15 J	110 J			25 U	
TOTAL PECDF			480 J	110000 J					4.4 U				47 J	140 J			7.3 U	
TOTAL TCDD			250 J	8000 J					0.62 U				42 J	84 J			9 U	
TOTAL TCDF			800 J	100000 J					23				140 J	270 J			11 U	
Metals (mg/kg)																		
ALUMINUM	7660	6570	8470	5160	9840	10300	2750	6400	6970	8640	7680	7790	5110	6620	9120	3750	7300	7290
ANTIMONY	12.3	7.5	21.4	0.31 U	0.29 U	0.6	0.88	6.7	0.65 U	0.54	5.2	9.2	0.53	1.5	1.6	0.28 U	0.48 U	0.28 U
ARSENIC	8.4	19.6	11	6.6	6.4	16	4.4	8.1	6.4	14.5	6.2	8.3	9.7	9.5	8.6	8.1	18.9	8.1
BARIUM	55.3 J	355 J	386 J	54.1 J	116 J	165 J	46 J	209 J	63.6 J	106 J	146	222	101	131	63.7	50.8 J	58.6 J	35.9 J
BERYLLIUM	0.77 U	1.1 U	1.8	2.4	1.2 U	1.3 U	1.5	2.7	5.7	1.1 U	0.8	1.5	1.8	1.3	1.6	1.2 U	5.2	0.74 U
CADMIUM	0.054 U	0.11 U	1	0.057 U	0.054 U	0.076 U	0.14	0.39	0.52	0.054 U	1.2	0.12 U	0.054 U	0.053 U	2.3	0.051 U	1.1	0.051 U
CALCIUM	45300	23700	24600	22100	10200	50900	9620	10700	2840	39300	10700	16800	20400	28500	26000	8080	4870	66300
CHROMIUM	16.7 J	29.3 J	27.8 J	9.6 J	18.3 J	27.9 J	7.8 J	20.6 J	15.4 J	16.7 J	21.2 J	55.9 J	10.4 J	42.9 J	20.8 J	6 J	12.6 J	14.5 J
COBALT	9.3	11	10.1	5.9	10.8	10.6	4.2	7.5	9.8	9.8	3.7	13	5.5	8.2	9.2	4.3	5.5	8.7
COPPER	19.2 J	112 J	829 J	24.5 J	28.4 J	63.1 J	37.5 J	51.7 J	38.9 J	61 J	58.8 J	189 J	27.9 J	1530 J	55 J	22.9 J	25.8 J	22 J
IRON	19800 J	69100 J	53100 J	23500 J	19900 J	25600 J	13600 J	28600 J	20800 J	19200 J	14500 J	102000 J	19100 J	40600 J	27100 J	11400 J	16000 J	17700 J
LEAD	30.1 J	445 J	1410 J	54.9 J	32.9 J	188 J	42.6 J	160 J	68.1 J	212 J	355	766	185	117	102	30.1 J	11.9 J	19.7 J
MAGNESIUM	23400 J	7370 J	6730 J	3490 J	6650 J	22100 J	1420 J	3960 J	855 J	19100 J	3160 J	2480 J	6080 J	10900 J	11200 J	1790 J	1360 J	36600 J
MANGANESE	530 J	425 J	587 J	171 J	930 J	433 J	105 J	332 J	61.6 J	523 J	163 J	612 J	1000 J	512 J	747 J	93.5 J	59.1 J	499 J
MERCURY	0.43 J	0.72 J	0.59 J	0.14 J	0.075 J	0.19 J	0.21 J	0.75 J	0.13 J	0.17 J	0.23	0.056	0.51	0.48	0.23	0.21 J	0.11 J	0.014 U
NICKEL	20.1 J	45.1 J	37.7 J	22 J	19.4 J	27.1 J	11.6 J	26.7 J	45.9 J	23.3 J	13.3 J	52.7 J	13.8 J	26.2 J	44.7 J	13.3 J	21.1 J	24.1 J
POTASSIUM	1270	752	1240	810	1010	1880	420	1160	1390	1490	569	1130	996	911	958	421	1400	1610
SELENIUM	0.94	5.7	4.2	3.4	1.1	1.5	1.6	3	4.3	1.2	1.2 U	4.5 U	1.8 U	3	2.1 U	1.2	4.2	0.83
SILVER	0.12 U	17.3 J	16.1 J	0.23 U	0.61 J	0.54 J	0.79 J	4.4 J	0.37 U	0.3 U	4.6	4.5	709	3.7	0.47 U	0.34 J	0.093 UJ	0.063 U
SODIUM	128	464	871	170	250	441	202	359	304	268	229	1240	745	597	648	154	204	214
THALLIUM	0.32 U	0.73	0.33 U	0.34 U	0.32 U	0.45 U	0.31 U	0.41 U	1.5	0.32 U	0.35 U	0.73 U	0.32 U	0.55 U	0.33 U	0.3 U	1.2	0.3 U
VANADIUM	18.9	28.8	25.5	21.9	23	27.2	13.8	32.2	122	22.4	14.7	23.5	34.6	28.8	56.1	15.7	47.4	17.2
ZINC	124 J	426 J	1310 J	101 J	113 J	333 J	105 J	367 J	343 J	248 J	410 J	779 J	65 J	246 J	2170 J	103 J	50.1 J	44.9 J
Miscellaneous Parameters (mg/kg)																		
CYANIDE	0.62 U	0.63 U	0.64 U	0.64 U	0.61 U	0.86 U	0.6 U	2.9	1.3 U	0.61 U	0.67 U	0.7 U	0.61 U	0.61 U	0.64 U	0.58 U	0.99 U	0.58 U

1 - Duplicate samples.
J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
U = The value is not detected at the reported concentration and is considered not present in the sample.
UJ = The nonetected value is considered to be a quantitative estimate due to technical noncompliances.
Shaded chemical name / cell indicates that the concentration is greater than the TACO SRO Residential Ingestion criterion.
Blank cells indicate that the sample was not analyzed for those parameters.

TABLE 4-2

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI SUBSURFACE SOIL DATA
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	TACO - Soil Remediation Objectivefor Residential Properties - Ingestion	TACO - Soil Remediation Objective for Residential Properties - Ingestion Exceedances	TACO - Soil Remediation Objective for Residential Properties - Inhalation	TACO - Soil Remediation Objective for Residential Properties - Inhalation Exceedances	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Industrial	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Industrial Exceedances	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Construction Worker	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Construction Worker Exceedances	TACO - SSL for Migration from Soil to Groundwater (DAF 20)	TACO - SSL for Migration from Soil to Groundwater (DAF 20) Exceedances	USEPA Region 9 PRG - Residential Soil	USEPA Region 9 PRG - Residential Soil Exceedances	USEPA Generic SSL for Migration from Soil to Groundwater (DAF 1)	USEPA Generic SSL for Migration from Soil to Groundwater (DAF 1) Exceedances
Volatile Organics (µg/kg)																			
2-BUTANONE	3/16	3.2 J - 12	4.5 - 16	NTC01SB1001012	5	NA	0	NA	0	NA	0	NA	0	NA	0	2200000	0	4400	0
ACETONE	2/16	6.4 J - 59 J	18 - 62	NTC01SB1001012	19	7800000	0	100000000	0	100000000	0	100000000	0	16000	0	1400000	0	6600	0
METHYLENE CHLORIDE	2/16	2.1 J - 2.3 J	4.5 - 16	NTC01SB0981516	4	85000	0	13000	0	24000	0	34000	0	20	0	9100	0	1.2	2
Semivolatile Organics (µg/kg)																			
2-METHYLNAPHTHALENE	4/4	40 J - 250 J	--	NTC01SB0991012	91	1600000	0	NA	0	NA	0	NA	0	NA	0	5600	0	NA	0
2-METHYLPHENOL	1/4	39 J	400 - 2100	NTC01SB0991012-D	360	3900000	0	NA	0	NA	0	NA	0	15000	0	310000	0	700	0
4-METHYLPHENOL	2/4	13 J - 170 J	660 - 890	NTC01SB0991012-D	240	NA	0	NA	0	NA	0	NA	0	NA	0	31000	0	66	2
ACENAPHTHENE	3/4	11 J - 290 J	890 - 2100	NTC01SB1020408	230	4700000	0	NA	0	NA	0	NA	0	570000	0	370000	0	31000	0
ACENAPHTHYLENE	2/4	11 J - 100 J	400 - 890	NTC01SB0900812-D	210	4700000	0	NA	0	NA	0	NA	0	NA	0	370000	0	NA	0
ANTHRACENE	2/4	13 J - 260 J	420 - 2100	NTC01SB1020408	360	23000000	0	NA	0	NA	0	NA	0	12000000	0	2200000	0	650000	0
BENZALDEHYDE	2/4	110 J - 150 J	400 - 2100	NTC01SB0900812	260	NA	0	NA	0	NA	0	NA	0	NA	0	610000	0	860	0
BENZO(A)ANTHRACENE	2/4	320 J - 520	400 - 2100	NTC01SB0991012-D	440	900	0	NA	0	NA	0	NA	0	2000	0	620	0	160	2
BENZO(A)PYRENE	3/4	14 J - 500	400 - 2100	NTC01SB0991012-D	260	90	2	NA	0	NA	0	NA	0	8000	0	62	2	410	1
BENZO(B)FLUORANTHENE	3/4	24 J - 870	400 - 2100	NTC01SB0991012-D	340	900	0	NA	0	NA	0	NA	0	5000	0	620	1	490	1
BENZO(G,H,I)PERYLENE	3/4	20 J - 500	890 - 2100	NTC01SB0991012-D	290	2300000	0	NA	0	NA	0	NA	0	NA	0	230000	0	NA	0
BENZO(K)FLUORANTHENE	2/4	130 J - 230 J	400 - 2100	NTC01SB0991012-D	360	9000	0	NA	0	NA	0	NA	0	49000	0	6200	0	490	0
BIS(2-ETHYLHEXYL)PHTHALATE	2/4	150 J - 660 J	400 - 890	NTC01SB0900812-D	330	46000	0	31000000	0	31000000	0	31000000	0	3600000	0	35000	0	180000	0
BUTYL BENZYL PHTHALATE	4/4	9.8 J - 74 J	--	NTC01SB0950810	36	16000000	0	930000	0	930000	0	930000	0	930000	0	1200000	0	840000	0
CARBAZOLE	2/4	100 J - 250 J	400 - 2100	NTC01SB1020408	360	32000	0	NA	0	NA	0	NA	0	600	0	24000	0	30	2
CHRYSENE	2/4	400 J - 680	400 - 2100	NTC01SB0991012-D	480	88000	0	NA	0	NA	0	NA	0	160000	0	62000	0	160	2
DIBENZO(A,H)ANTHRACENE	2/4	59 J - 130 J	420 - 2100	NTC01SB0991012-D	320	90	1	NA	0	NA	0	NA	0	2000	0	62	1	1500	0
DIBENZOFURAN	3/4	19 J - 100 J	890 - 2100	NTC01SB1020408	160	NA	0	NA	0	NA	0	NA	0	NA	0	15000	0	2400	0
DIETHYL PHTHALATE	2/4	18 J - 430 J	400 - 890	NTC01SB0900812-D	260	63000000	0	2000000	0	2000000	0	2000000	0	470000	0	4900000	0	23000	0
DI-N-BUTYL PHTHALATE	1/4	198 J	400 - 890	NTC01SB0900812-D	290	7800000	0	2300000	0	2300000	0	2300000	0	2300000	0	610000	0	250000	0
FLUORANTHENE	3/4	45 J - 1400 J	890 - 2100	NTC01SB0991012-D	580	3100000	0	NA	0	NA	0	NA	0	4300000	0	230000	0	310000	0
FLUORENE	3/4	11 J - 320 J	400 - 890	NTC01SB1020408	240	3100000	0	NA	0	NA	0	NA	0	560000	0	270000	0	41000	0
INDENO(1,2,3-CD)PYRENE	3/4	12 J - 400	890 - 2100	NTC01SB0991012-D	260	900	0	NA	0	NA	0	NA	0	14000	0	620	0	1400	0
NAPHTHALENE	4/4	52 J - 250 J	--	NTC01SB0900812-D	150	1600000	0	170000	0	270000	0	1800	0	12000	0	5600	0	3100	0
PHENANTHRENE	4/4	58 J - 1700	--	NTC01SB1020408	600	2300000	0	NA	0	NA	0	NA	0	NA	0	230000	0	NA	0
PHENOL	2/4	22 J - 93 J	400 - 890	NTC01SB0900812-D	190	47000000	0	NA	0	NA	0	NA	0	100000	0	1800000	0	2800	0
PYRENE	3/4	41 J - 1300	890 - 890	NTC01SB1020408	590	2300000	0	NA	0	NA	0	NA	0	4200000	0	230000	0	230000	0
Polynuclear Aromatic Hydrocarbons (µg/kg)																			
2-METHYLNAPHTHALENE	15/16	7.5 J - 3500 J	400 - 400	NTC01SB1020408	480	1600000	0	NA	0	NA	0	NA	0	NA	0	5600	0	NA	0
ACENAPHTHENE	3/15	14 J - 260 J	38 - 13000	NTC01SB0991012-D	660	4700000	0	NA	0	NA	0	NA	0	570000	0	370000	0	31000	0
ACENAPHTHYLENE	10/16	25 J - 3100 J	38 - 13000	NTC01SB0991012-D	1000	4700000	0	NA	0	NA	0	NA	0	NA	0	370000	0	NA	0
ANTHRACENE	16/16	1.8 J - 5200	--	NTC01SB1020408	530	23000000	0	NA	0	NA	0	NA	0	12000000	0	2200000	0	650000	0
BAP EQUIVALENT ZEROND	16/16	0.25 - 13068	--	NTC01SB1020408	1600	90	8	NA	0	NA	0	NA	0	NA	0	62	9	410	5
BAP EQUIVALENT	16/16	4.2449 - 13068	--	NTC01SB1020408	1600	90	9	NA	0	NA	0	NA	0	NA	0	62	9	410	5
BENZO(A)ANTHRACENE	9/15	41 - 11000	7.8 - 40	NTC01SB1020408	1300	900	3	NA	0	NA	0	NA	0	2000	0	620	3	160	6
BENZO(A)PYRENE	14/16	1.5 J - 9300	7.8 - 18	NTC01SB1020408	1100	90	7	NA	0	NA	0	NA	0	8000	0	62	8	410	4
BENZO(B)FLUORANTHENE	14/16	4.9 J - 14000	18 - 40	NTC01SB1020408	1500	900	3	NA	0	NA	0	NA	0	5000	0	620	3	490	4
BENZO(G,H,I)PERYLENE	16/16	0.96 J - 7300	--	NTC01SB1020408	920	2300000	0	NA	0	NA	0	NA	0	NA	0	230000	0	NA	0
BENZO(K)FLUORANTHENE	12/16	1.8 J - 4600	8.6 - 40	NTC01SB1020408	560	9000	0	NA	0	NA	0	NA	0	49000	0	6200	0	490	3
CARBAZOLE	6/15	12 J - 4300 J	38 - 400	NTC01SB1020408	410	32000	0	NA	0	NA	0	NA	0	600	0	24000	0	30	6
CHRYSENE	15/16	1.6 J - 12000	18 - 18	NTC01SB1020408	1300	88000	0	NA	0	NA	0	NA	0	160000	0	62000	0	160	7
DIBENZO(A,H)ANTHRACENE	7/15	4.4 J - 850	7.8 - 180	NTC01SB0880708	120	90	2	NA	0	NA	0	NA	0	2000	0	62	3	1500	0
FLUORANTHENE	16/16	4.8 J - 49000	--	NTC01SB1020408	4400	3100000	0	NA	0	NA	0	NA	0	4300000	0	230000	0	310000	0
FLUORENE	7/15	14 - 3300	7.8 - 82	NTC01SB1020408	340	3100000	0	NA	0	NA	0	NA	0	560000	0	270000	0	41000	0
INDENO(1,2,3-CD)PYRENE	16/16	1 J - 6300		NTC01SB1020408	830	900	3	NA	0	NA	0	NA	0	14000	0	620	3	1400	2
NAPHTHALENE	13/16	20 J - 3100 J	38 - 4100	NTC01SB1020408	450	1600000	0	170000	0	270000	0	1800	1	12000	0	5600	0	3100	0
PHENANTHRENE	16/16	7 J - 26000	--	NTC01SB1020408	2300	2300000	0	NA	0	NA	0	NA	0	NA	0	230000	0	NA	0
PYRENE	16/16	4 J - 31000	--	NTC01SB1020408	3000	2300000	0	NA	0	NA	0	NA	0	4200000	0	230000	0	230000	0
Organochlorine Pesticides/PCBs (µg/kg)																			
4,4'-DDD	4/4	4.8 - 280 J	--	NTC01SB0991012-D	72	3000	0	NA	0	NA	0	NA	0	16000	0	2400	0	710	0
4,4'-DDE	4/4	0.6 J - 82 J	--	NTC01SB0991012-D	24	2000	0	NA	0	NA	0	NA	0	54000	0	1700	0	2200	0
4,4'-DDT	4/4	1.4 J - 27 J	--	NTC01SB0991012-D	9	2000	0	NA	0	NA	0	NA	0	32000	0	1700	0	1300	0
ALDRIN	1/4	1.5 J	2.2 - 10	NTC01SB0991012-D	2	40	0	3000	0	6600	0	9300	0	500	0	29	0	25	0
ALPHA-BHC	1/4	1.7 J	2.2 - 10	NTC01SB0991012	2	100	0	800	0	1500	0	2100	0	0.5	1	90	0	0.036	1
ALPHA-CHLORDANE	2/4	2.2 J - 2.8 J	2.2 - 10	NTC01SB0900812	3	1800	0	72000	0	140000	0	22000	0	10000	0	1600	0	480	0
AROCLOR-1248	1/4	130 J	40 - 89	NTC01SB0991012	43	1000	0	NA	0	NA	0	NA	0	NA	0	220	0	NA	0
AROCLOR-1254	1/4	33 J	40 - 89	NTC01SB0900812	33	1000	0	NA	0	NA	0	NA	0	NA	0	110	0	NA	0
AROCLOR-1260	1/4	100 J	40 - 89	NTC01SB0991012	40	1000	0	NA	0	NA	0	NA	0	NA	0	220	0	NA	0
DELTA-BHC	1/4	1.2 J	2.2 - 10	NTC01SB0991012	2	NA	0	NA	0	NA	0	NA	0	NA	0	90	0	NA	0
DIELDRIN	2/4	0.55 J - 1.2 J	2.2 - 10	NTC01SB0991012	1	40	0	1000	0	2200	0	3100	0	4	0	30	0	0.23	2
ENDOSULFAN II	1/4	4.9 J	2.2 - 4.6	NTC01SB0991012	3	470000	0	NA	0	NA	0	NA	0	18000	0	37000	0	980	0
ENDOSULFAN I	1/4	3.1 J	2.2 - 10	NTC01SB0991012	2	470000	0	NA	0	NA	0	NA	0	18000	0	37000	0	980	0
ENDOSULFAN SULFATE	1/4	2 J	2.2 - 10	NTC01SB0991012-D	2	470000	0	NA	0	NA	0	NA	0	NA	0	37000	0	980	0
ENDRIN KETONE	2/4	0.73 J - 2.2 J	2.2 - 10	NTC01SB0991012	2	23000	0	NA	0	NA	0	NA	0	NA	0	1800	0	NA	0
ENDRIN	2/4	1.6 J - 9.6 J	2.2 - 10	NTC01SB0991012-D	4	23000	0	NA	0	NA	0	NA	0	1000	0	1800	0	50	0
GAMMA-BHC (LINDANE)	1/4	4.4 J	2.2 - 4.6	NTC01SB0991012-D	2	500	0	NA	0	NA	0	NA	0	9	0	440	0	0.47	2
GAMMA-CHLORDANE	3/4	2 J - 6.9 J	2.2 - 10	NTC01SB0991012	3	1800	0	72000	0	140000	0	22000	0	10000	0	1600	0	480	0
HEPTACHLOR EPOXIDE	1/4	3.2 J	2.2 - 4.6	NTC01SB0991012	2	70	0	5000	0	9200	0	13000	0	700	0	53	0	33	0
HEPTACHLOR	1/4	2.4 J	2.2 - 10	NTC01SB0991012-D	2	100	0	100	0	11000	0	16000	0	23000	0	110	0	1100	0
METHOXYCHLOR	1/4	2.4 J	4.2 - 8.9	NTC01SB0991012-D	3	390000	0	NA	0	NA	0	NA	0	160000	0	31000	0	7800	0
Herbicides (µg/kg)																			
PENTACHLOROPHENOL	1/4	4.2 J	12 - 27	NTC01SB0900812-D	8	3000	0	NA	0	NA	0	NA	0	30	0	3000	0	1.4	1
Dioxins/Furans (ng/kg)																			

TABLE 4-2

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI SUBSURFACE SOIL DATA
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	TACO - Soil Remediation Objectivefor Residential Properties - Ingestion	TACO - Soil Remediation Objective for Residential Properties - Ingestion Exceedances	TACO - Soil Remediation Objective for Residential Properties - Inhalation	TACO - Soil Remediation Objective for Residential Properties - Inhalation Exceedances	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Industrial	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Industrial Exceedances	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Construction Worker	TACO - Soil Remediation Objective for Industrial Properties - Inhalation - Construction Worker Exceedances	TACO - SSL for Migration from Soil to Groundwater (DAF 20)	TACO - SSL for Migration from Soil to Groundwater (DAF 20) Exceedances	USEPA Region 9 PRG - Residential Soil	USEPA Region 9 PRG - Residential Soil Exceedances	USEPA Generic SSL for Migration from Soil to Groundwater (DAF 1)	USEPA Generic SSL for Migration from Soil to Groundwater (DAF 1) Exceedances
1,2,3,4,6,7,8,9-OCDD	4/4	57 - 16000 J	--	NTC01SB0900812-D	3400	NA	0	NA	0	NA	0	NA	0	NA	0	13000	1	933	4
1,2,3,4,6,7,8,9-OCDF	2/4	29 - 20000 J	5.7 - 38	NTC01SB0900812-D	2600	NA	0	NA	0	NA	0	NA	0	NA	0	13000	1	933	1
1,2,3,4,6,7,8-HPCDD	4/4	14 - 11000 J	--	NTC01SB0900812-D	1700	NA	0	NA	0	NA	0	NA	0	NA	0	390	4	28	5
1,2,3,4,6,7,8-HPCDF	4/4	7.3 J - 34000 J	--	NTC01SB0900812-D	4300	NA	0	NA	0	NA	0	NA	0	NA	0	390	1	28	5
1,2,3,4,7,8,9-HPCDF	2/4	3.6 J - 3100 J	0.59 - 2.4	NTC01SB0900812-D	390	NA	0	NA	0	NA	0	NA	0	NA	0	390	1	28	1
1,2,3,4,7,8-HXCDD	2/4	5.8 J - 1200 J	0.89 - 7.4	NTC01SB0900812-D	160	NA	0	NA	0	NA	0	NA	0	NA	0	39	1	2.8	4
1,2,3,4,7,8-HXCDF	2/4	20 - 8900 J	3 - 13	NTC01SB0900812-D	1100	NA	0	NA	0	NA	0	NA	0	NA	0	39	2	2.8	3
1,2,3,6,7,8-HXCDD	3/4	15 - 2000 J	0.86 - 0.86	NTC01SB0900812-D	280	NA	0	NA	0	NA	0	NA	0	NA	0	39	3	2.8	5
1,2,3,6,7,8-HXCDF	2/4	10 - 6700 J	1.6 - 7.4	NTC01SB0900812-D	840	NA	0	NA	0	NA	0	NA	0	NA	0	39	1	2.8	3
1,2,3,7,8,9-HXCDD	3/4	12 - 1600 J	1.4 - 1.4	NTC01SB0900812-D	220	NA	0	NA	0	NA	0	NA	0	NA	0	39	3	2.8	5
1,2,3,7,8,9-HXCDF	1/4	147 J	0.5 - 1.2	NTC01SB0900812-D	37	NA	0	NA	0	NA	0	NA	0	NA	0	39	1	2.8	2
1,2,3,7,8-PECDD	2/4	9.1 - 1200 J	0.84 - 20	NTC01SB0900812-D	160	NA	0	NA	0	NA	0	NA	0	NA	0	3.9	3	0.28	3
1,2,3,7,8-PECDF	2/4	12 - 6400 J	1.2 - 8.4	NTC01SB0900812-D	810	NA	0	NA	0	NA	0	NA	0	NA	0	130	1	9	3
2,3,4,6,7,8-HXCDF	2/4	12 - 8000 J	1.2 - 10	NTC01SB0900812-D	1000	NA	0	NA	0	NA	0	NA	0	NA	0	39	1	2.8	3
2,3,4,7,8-PECDF	2/4	19 - 12000 J	1.3 - 11	NTC01SB0900812-D	1500	NA	0	NA	0	NA	0	NA	0	NA	0	13	3	0.93	3
2,3,7,8-TCDD	2/4	1.9 J - 140 J	0.4 - 9	NTC01SB0900812-D	20	NA	0	NA	0	NA	0	NA	0	NA	0	3.9	2	0.28	4
2,3,7,8-TCDF	2/4	10 J - 5500 J	1 - 11	NTC01SB0900812-D	700	NA	0	NA	0	NA	0	NA	0	NA	0	39	2	2.8	4
TEQ MAMMAL	4/4	0.2301 - 9042.8	--	NTC01SB0900812-D	1200	NA	0	NA	0	NA	0	NA	0	NA	0	3.9	5	0.28	5
TOTAL HPCDD	4/4	26 - 21000 J	--	NTC01SB0900812-D	3300	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
TOTAL HPCDF	4/4	7.3 - 47000 J	--	NTC01SB0900812-D	6000	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
TOTAL HXCDD	3/4	180 - 21000 J	3.8 - 3.8	NTC01SB0900812-D	2900	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
TOTAL HXCDF	2/4	21 J - 61000 J	3.3 - 13	NTC01SB0900812-D	7700	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
TOTAL PECDD	2/4	15 J - 16000 J	0.84 - 25	NTC01SB0900812-D	2100	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
TOTAL PECDF	2/4	47 J - 110000 J	4.4 - 7.3	NTC01SB0900812-D	14000	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
TOTAL TCDD	2/4	42 J - 8000 J	0.62 - 9	NTC01SB0900812-D	1000	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
TOTAL TCDF	3/4	23 - 100000 J	11 - 11	NTC01SB0900812-D	13000	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
Metals (mg/kg)																			
ALUMINUM	16/16	2750 - 10300	--	NTC01SB0921516	7170	NA	0	NA	0	NA	0	NA	0	NA	0	7600	8	NA	0
ANTIMONY	11/16	0.53 - 21.4	0.28 - 0.65	NTC01SB0900812	3.6	31	0	NA	0	NA	0	NA	0	NA	0	3.1	6	0.27	12
ARSENIC	16/16	4.4 - 19.6	--	NTC01SB0891112	10.0	NA	0	750	0	1200	0	25000	0	NA	0	0.39	18	0.29	18
BARIUM	16/16	35.9 J - 386 J	--	NTC01SB0900812	127	5500	0	690000	0	910000	0	870000	0	NA	0	540	0	82	10
BERYLLIUM	9/16	0.8 - 5.7	0.74 - 1.3	NTC01SB0950810	1.7	160	0	1300	0	2100	0	44000	0	NA	0	15	0	3.2	2
CADMIUM	7/16	0.14 - 2.3	0.051 - 0.12	NTC01SB1001012	0.4	78	0	1800	0	2800	0	59000	0	NA	0	3.7	0	0.38	6
CALCIUM	16/16	2840 - 66900	--	NTC01SB1031919	23300	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
CHROMIUM	16/16	6 J - 55.9 J	--	NTC01SB0981516	20.6	230	0	270	0	420	0	690	0	NA	0	30	2	2.1	18
COBALT	16/16	3.7 - 13	--	NTC01SB0981516	8.3	4700	0	NA	0	NA	0	NA	0	NA	0	140	0	0.17	18
COPPER	16/16	19.2 J - 1530 J	--	NTC01SB0991012-D	124	2900	0	NA	0	NA	0	NA	0	NA	0	310	2	560	2
IRON	16/16	11400 J - 102000 J	--	NTC01SB0981516	29600	NA	0	NA	0	NA	0	NA	0	NA	0	2300	18	NA	0
LEAD	16/16	11.9 J - 1410 J	--	NTC01SB0900812	209	400	3	NA	0	NA	0	NA	0	NA	0	400	3	NA	0
MAGNESIUM	16/16	855 J - 36600 J	--	NTC01SB1031919	9690	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
MANGANESE	16/16	59.1 J - 1000 J	--	NTC01SB0991012	416	3700	0	69000	0	91000	0	8700	0	NA	0	180	12	110	14
MERCURY	15/16	0.056 - 0.75 J	0.014 - 0.014	NTC01SB0941416	0.27	23	0	10	0	540000	0	52000	0	NA	0	2.3	0	0.1	15
NICKEL	16/16	11.6 J - 52.7 J	--	NTC01SB0981516	27.4	1600	0	13000	0	21000	0	440000	0	NA	0	160	0	14	14
POTASSIUM	16/16	420 - 1880	--	NTC01SB0921516	1090	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
SELENIUM	13/16	0.83 - 5.7	1.2 - 4.5	NTC01SB0891112	2.2	390	0	NA	0	NA	0	NA	0	NA	0	39	0	0.26	14
SILVER	10/16	0.34 J - 709	0.063 - 0.47	NTC01SB0991012	24.9	390	1	NA	0	NA	0	NA	0	NA	0	39	1	1.6	7
SODIUM	16/16	128 - 1240	--	NTC01SB0981516	394	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0	NA	0
THALLIUM	3/16	0.73 - 1.5	0.3 - 0.73	NTC01SB0950810	0.37	6.3	0	NA	0	NA	0	NA	0	NA	0	0.52	3	0.056	3
VANADIUM	16/16	13.8 - 122	--	NTC01SB0950810	32.4	550	0	NA	0	NA	0	NA	0	NA	0	7.8	18	260	0
ZINC	16/16	44.9 J - 2170 J	--	NTC01SB1001012	405	23000	0	NA	0	NA	0	NA	0	NA	0	2300	0	680	3
Miscellaneous Parameters (mg/kg)																			
CYANIDE	1/16	2.9	0.58 - 1.3	NTC01SB0941416	0.51	NA	0	NA	0	NA	0	NA	0	NA	0	120	0	2	1

J = The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
NA = No criterion available.
The original and field duplicate samples are counted as one sample in the frequency of detection.
Shaded chemical name / cell indicates that the concentration is greater than the TACO SRO Residential Ingestion criterion.
Shaded criteria indicates that the maximum chemical concentration exceeded the associated criterion.

Associated Samples:

NTC01SB0880708	NTC01SB0961012	NTC01SB2050414
NTC01SB0891112	NTC01SB0970304	NTC01SB2072838
NTC01SB0900812	NTC01SB0981516	NTC01SB2090717
NTC01SB0900812-D	NTC01SB0991012	
NTC01SB0910812	NTC01SB0991012-D	
NTC01SB0921516	NTC01SB1001012	
NTC01SB0930810	NTC01SB1010406	
NTC01SB0941416	NTC01SB1020408	
NTC01SB0950810	NTC01SB1031919	

TABLE 4-3

SUMMARY OF ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	NTC01MW01[1]		NTC01MW02	NTC01MW03	NTC01MW04	NTC01MW05	NTC01MW06	NTC01MW07	NTC01MW08	NTC01MW09	NTC01MW10	NTC01TW01[1]		NTC01TW02	NTC01TW03	NTC01TW04
	03/11/2007	03/12/2007	03/11/2007	03/12/2007	03/12/2007	03/12/2007	03/12/2007	03/11/2007	03/11/2007	03/11/2007	03/11/2007	12/19/2006	12/19/2006	12/19/2006	12/19/2006	03/12/2007
Volatile Organics (µg/L)																
1,4-DICHLOROBENZENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.27 J	0.27 J	1 U	1 U	1 U
ACETONE	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	2.7 J	5 U	5 J
BENZENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.32 J	0.26 J	0.44 J	1 U	1 U
CARBON DISULFIDE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.42 J	1 U	0.33 J	1 U	1 U
CHLOROBENZENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.71 J	0.76 J	1 U	1 U	1 U
CYCLOHEXANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.3	2.1	1 U	1 U	1 U
ISOPROPYLBENZENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.26 J	0.19 J	1 U	1 U	1 U
METHYL CYCLOHEXANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.3	1.7	1 U	1 U	1 U
TOLUENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.2 J	1 U	1 U	1 U	1 U
TOTAL XYLENES	3 U	3 U	0.65 J	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	1.6 J	1.2 J	3 U	3 U	3 U
Semivolatile Organics (µg/L)																
BENZALDEHYDE												13 U	1 J	10 U	11 U	
DIETHYL PHTHALATE												3.5 J	4 J	10 U	11 U	
NAPHTHALENE												4.4 J	5.2 J	10 U	11 U	
Polynuclear Aromatic Hydrocarbons (µg/L)																
2-METHYLNAPHTHALENE	0.97 U	0.96 U	0.96 U	0.98 U	1 U	0.96 U	1 U	0.95 U	0.95 U	0.95 U	0.97 U	1.3	1.5	1 U	1 U	
ACENAPHTHENE	0.97 U	0.96 U	0.96 U	0.98 U	1 U	0.96 U	1 U	0.95 U	0.95 U	0.95 U	0.97 U	0.19 J	0.23 J	1 U	1 U	
ACENAPHTHYLENE	0.97 U	0.96 U	0.96 U	0.98 U	1 U	0.96 U	1 U	0.95 U	0.95 U	0.95 U	0.97 U	5	5.9	1 U	1 U	
ANTHRACENE	0.19 U	0.19 U	0.19 U	0.2 U	0.2 U	0.19 U	0.2 U	0.19 U	0.19 U	0.19 U	0.19 U	0.035 J	0.039 J	0.2 U	0.2 U	
BAP EQUIVALENT	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
CARBAZOLE	0.97 U	0.96 U	0.96 U	0.98 U	1 U	0.96 U	1 U	0.95 U	0.95 U	0.95 U	0.97 U	0.15 J	0.17 J	1 U	1 U	
FLUORANTHENE	0.19 U	0.19 U	0.19 U	0.2 U	0.039 J	0.19 U	0.2 U	0.19 U	0.19 U	0.19 U	0.19 U	0.2 U	0.2 U	0.2 U	0.2 U	
FLUORENE	0.19 U	0.19 U	0.19 U	0.2 U	0.028 J	0.19 U	0.2 U	0.19 U	0.19 U	0.025 J	0.19 U	0.23 J	0.23 J	0.025 J	0.029 J	
NAPHTHALENE	0.97 U	0.96 U	0.96 U	0.98 U	1 U	0.96 U	1 U	0.95 U	0.95 U	0.95 U	0.97 U	5.9	6.8 J	1 U	1 U	
PHENANTHRENE	0.085 J	0.061 J	0.087 J	0.1 J	0.18 J	0.067 J	0.056 J	0.07 J	0.093 J	0.11 J	0.086 J	0.35	0.32	0.12 J	0.14 J	
PYRENE	0.19 U	0.19 U	0.19 U	0.025 J	0.043 J	0.19 U	0.2 U	0.19 U	0.19 U	0.19 U	0.19 U	0.039 J	0.043 J	0.2 U	0.2 U	
Metals (µg/L)																
ALUMINUM	73.4	57.4 U	28 U	8650	73	144	2980	50.2 U	68.3	53.8 U	160	132		90.2 U	27.9 U	
ARSENIC	3.3 U	3.3 U	3.3 U	3.3	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	2.4		2.4	1.7 U	
BARIUM	51.5	51.3	53.6	119	74.2	54	216	59.2	87.7	58.8	29.3	566		99.7	566	
CALCIUM	506000	500000	112000	144000	120000	85200	634000	38900	221000	135000	177000	53400		14300	44300	
CHROMIUM	0.93 U	1.1 J	0.93 U	14.1	0.93 U	0.93 U	5	0.93 U	2	1.8	0.93 U	1.6		0.85	0.65	
COBALT	0.92 U	0.9 U	0.53 U	11	3.6	0.85 U	12.1	0.53 U	12.1	3.1	6.9	3.6		0.53 U	0.53 U	
COPPER	5.4	5.4 J	1.2 U	12.4	1.2 U	1.6	7.4	1.2 U	1.2	1.2 U	1.8	2 U		0.55 U	0.39 U	
IRON	527	460	2100	11400	18.0 U	106	3650	647	1150	980	127	17600		198	3290	
LEAD	1.6 U	1.6 U	1.6 U	5.8	1.6 U	1.6 U	4.4	1.6 U	1.6 U	1.6 U	1.6 U	8.4		2	1.2	
MAGNESIUM	146000	144000	94300	133000	128000	42000	349000	46400	82100	65000	93800	69600		25300	106000	
MANGANESE	376	372	48.9	366	123	33.2	455	9.4	4510	5070	651	104		57.3	39.6	
NICKEL	12.4	12 J	1.2 U	27.4	10.2	1.9	33.4	1.2 U	12.4	2.9	5.5	3.5		2.5	1.1 U	
POTASSIUM	11000	11000	2530	7720	6630	1750	13800	2130	5720	1500	3170	42000 J		22300 J	30700 J	
SELENIUM	13.5	10.7	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	3.8 U		4 U	1.8 U	
SILVER	0.30 U	0.58	0.30 U	0.38	0.30 U	0.30 U	0.61	0.30 U	1.6	1.5	0.32	0.67 U		0.67 U	0.67 U	
SODIUM	43000	42900	22500	16500	41500	69600	601000	41700	25200	24200	19800	380000		367000	75800	
VANADIUM	7.9	8.4 J	3.7	20.7	4.1	1.6	10.7	2.6	3.6	4.2	4.8	2.8		1.7 U	3.1	
ZINC	309	272	36.3	55	7.4 U	8.3 U	27.2	6.3 U	64.4	7.4 U	10.9 U	19 U		6.8 U	7.3 U	
Metals Filtered (µg/L)																
BARIUM				76.3			178									
CALCIUM				116000			645000									
COBALT				5			8.5									
COPPER				0.73 U			1.2									
MAGNESIUM				117000			353000									
MANGANESE				165			293									
NICKEL				12.2			23.4									
POTASSIUM				3650			10900									
SILVER				0.59			0.73									
SODIUM				15300			629000									
VANADIUM				4.8			5.3									
Miscellaneous Parameters																
FLASHPOINT (°F)												> 200				
TOTAL ORGANIC CARBON (MG/L)						2.9		1.4		2						

1 - Duplicate samples.
J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
U = The value is not detected at the reported concentration and is considered not present in the sample.
UJ = The nonetected value is considered to be a quantitative estimated due to technical noncompliances.
Shaded chemical name / cell indicates that the concentration is greater than the TACO Groundwater Ingestion Tier 1 Criterion.
Blank cells indicate that the sample was not analyzed for those parameters.

TABLE 4-4

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI GROUNDWATER DATA
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Illinois TACO GRO Ingestion Tier 1	Illinois TACO GRO Ingestion Tier 1 Exceedances	USEPA Region 9 Tap Water PRG	USEPA Region 9 Tap Water PRG Exceedances	Federal MCL	Federal MCL Exceedances
Volatile Organics (µg/L)											
1,4-DICHLOROBENZENE	1/14	0.27 J	1 - 1	NTC01GWTW0101, NTC01GWTW0101-D	0.3	75	0	0.5	0	75	0
ACETONE	2/14	2.7 J - 5 J	5 - 5	NTC01GWTW0401	4	700	0	550	0	NA	0
BENZENE	2/14	0.26 J - 0.44 J	1 - 1	NTC01GWTW0201	0.4	5	0	0.35	1	5	0
CARBON DISULFIDE	2/14	0.33 J - 0.42 J	1 - 1	NTC01GWTW0101	0.4	700	0	100	0	NA	0
CHLOROBENZENE	1/14	0.73 J	1 - 1	NTC01GWTW0101-D	0.7	100	0	11	0	100	0
CYCLOHEXANE	1/14	2.2	1 - 1	NTC01GWTW0101	2	NA	0	1000	0	NA	0
ISOPROPYLBENZENE	1/14	0.22 J	1 - 1	NTC01GWTW0101	0.2	NA	0	66	0	NA	0
METHYL CYCLOHEXANE	1/14	2.0	1 - 1	NTC01GWTW0101	2	NA	0	520	0	NA	0
TOLUENE	1/14	0.2 J	1 - 1	NTC01GW1W0101	0.2	1000	0	72	0	1000	0
TOTAL XYLENES	2/14	0.65 J - 1.6 J	3 - 3	NTC01GWTW0101	1	10000	0	21	0	10000	0
Semivolatile Organics (µg/L)											
BENZALDEHYDE	1/3	1 J	10 - 13	NTC01GWTW0101-D	1	NA	0	360	0	NA	0
DIETHYL PHTHALATE	1/3	3.7 J	10 - 11	NTC01GWTW0101-D	4	5600	0	2900	0	NA	0
NAPHTHALENE	1/3	4.8 J	10 - 11	NTC01GWTW0101-D	5	140	0	0.62	2	NA	0
Polynuclear Aromatic Hydrocarbons (µg/L)											
2-METHYLNAPHTHALENE	1/13	1.4	0.95 - 1	NTC01GWTW0101-D	1	NA	0	0.62	2	NA	0
ACENAPHTHENE	1/13	0.21 J	0.95 - 1	NTC01GWTW0101-D	0.2	420	0	37	0	NA	0
ACENAPHTHYLENE	1/13	5.4	0.95 - 1	NTC01GWTW0101-D	5	NA	0	37	0	NA	0
ANTHRACENE	1/13	0.037 J	0.19 - 0.2	NTC01GWTW0101-D	0.04	2100	0	180	0	NA	0
BAP EQUIVALENT	13/13	0.2 - 0.2	--	NTC01GW0301, NTC01GWTW0101, NTC01GWTW0201, NTC01GW0401, NTC01GWTW0101-D, NTC01GW0601, NTC01GWTW0301	0.2	NA	0	NA	0	NA	0
CARBAZOLE	1/13	0.16 J	0.95 - 1	NTC01GWTW0101-D	0.2	NA	0	3.4	0	NA	0
FLUORANTHENE	1/13	0.039 J	0.19 - 0.2	NTC01GW0401	0.04	280	0	150	0	NA	0
FLUORENE	5/13	0.025 J - 0.23 J	0.19 - 0.2	NTC01GWTW0101, NTC01GWTW0101-D	0.07	280	0	24	0	NA	0
NAPHTHALENE	1/13	6.3 J	0.95 - 1	NTC01GWTW0101-D	6	140	0	0.62	2	NA	0
PHENANTHRENE	13/13	0.056 J - 0.35	--	NTC01GWTW0101	0.1	NA	0	18	0	NA	0
PYRENE	3/13	0.025 J - 0.043 J	0.19 - 0.2	NTC01GW0401, NTC01GWTW0101-D	0.04	210	0	18	0	NA	0

TABLE 4-4

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI GROUNDWATER DATA
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Illinois TACO GRO Ingestion Tier 1	Illinois TACO GRO Ingestion Tier 1 Exceedances	USEPA Region 9 Tap Water PRG	USEPA Region 9 Tap Water PRG Exceedances	Federal MCL	Federal MCL Exceedances
Metals (µg/L)											
ALUMINUM	8/13	68.3 - 8650	27.9 - 90.2	NTC01GW0301	1530	NA	0	3600	1	NA	0
ARSENIC	3/13	2.4 - 3.3	1.7 - 3.3	NTC01GW0301	2.7	50	0	0.045	3	10	0
BARIUM	13/13	29.3 - 566	--	NTC01GWTW0101, NTC01GWTW0301	157	2000	0	260	2	2000	0
CALCIUM	13/13	14300 - 634000	--	NTC01GW0601	176000	NA	0	NA	0	NA	0
CHROMIUM	8/13	0.65 - 14.1	0.93 - 0.93	NTC01GW0301	3.4	100	0	11	1	100	0
COBALT	7/13	3.1 - 12.1	0.53 - 0.92	NTC01GW0601, NTC01GW0801	7.5	1000	0	73	0	NA	0
COPPER	6/13	1.2 - 12.4	0.39 - 2	NTC01GW0301	5.0	650	0	150	0	1300	0
IRON	12/13	106 - 17600	18 - 18	NTC01GWTW0101	3480	5000	2	1100	6	NA	0
LEAD	5/13	1.2 - 8.4	1.6 - 1.6	NTC01GWTW0101	4.4	7.5	1	NA	0	15	0
MAGNESIUM	13/13	25300 - 349000	--	NTC01GW0601	106000	NA	0	NA	0	NA	0
MANGANESE	13/13	9.4 - 5070	--	NTC01GW0901	911	150	7	88	9	NA	0
NICKEL	10/13	1.9 - 33.4	1.1 - 1.2	NTC01GW0601	11.2	100	0	73	0	NA	0
POTASSIUM	13/13	1500 - 42000 J	--	NTC01GWTW0101	11600	NA	0	NA	0	NA	0
SELENIUM	1/13	12.1	1.8 - 4	NTC01GW0101	12.1	50	0	18	0	50	0
SILVER	6/13	0.32 - 1.6	0.3 - 0.67	NTC01GW0801	0.8	50	0	18	0	NA	0
SODIUM	13/13	16500 - 601000	--	NTC01GW0601	133000	NA	0	NA	0	NA	0
VANADIUM	12/13	1.6 - 20.7	1.7 - 1.7	NTC01GW0301	5.8	49	0	3.6	8	NA	0
ZINC	5/13	27.2 - 309	6.3 - 19	NTC01GW0101	94.7	5000	0	1100	0	NA	0
Metals Filtered (ug/L)											
BARIUM - FILTERED	2/2	76.3 - 178	--	NTC01GW0601	127	2000	0	260	0	2000	0
CALCIUM - FILTERED	2/2	116000 - 645000	--	NTC01GW0601	381000	NA	0	NA	0	NA	0
COBALT - FILTERED	2/2	5 - 8.5	--	NTC01GW0601	6.8	1000	0	73	0	NA	0
COPPER - FILTERED	1/2	1.2	0.73 - 0.73	NTC01GW0601	1.2	650	0	150	0	1300	0
MAGNESIUM - FILTERED	2/2	117000 - 353000	--	NTC01GW0601	235000	NA	0	NA	0	NA	0
MANGANESE - FILTERED	2/2	165 - 293	--	NTC01GW0601	229	150	2	88	2	NA	0
NICKEL - FILTERED	2/2	12.2 - 23.4	--	NTC01GW0601	17.8	100	0	73	0	NA	0
POTASSIUM - FILTERED	2/2	3650 - 10900	--	NTC01GW0601	7280	NA	0	NA	0	NA	0
SILVER - FILTERED	2/2	0.59 - 0.73	--	NTC01GW0601	0.66	50	0	18	0	NA	0
SODIUM - FILTERED	2/2	15300 - 629000	--	NTC01GW0601	322000	NA	0	NA	0	NA	0
VANADIUM - FILTERED	2/2	4.8 - 5.3	--	NTC01GW0601	5.1	49	0	3.6	2	NA	0
Miscellaneous Parameters											
FLASHPOINT (°F)	1/1	> 200	--	NTC01GWTW0101	200	NA	NA	NA	NA	NA	NA
TOTAL ORGANIC CARBON (µg	3/3	1.4 - 2.9	--	NTC01GW0501	2.1	NA	NA	NA	NA	NA	NA

J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
NA = No criterion available.
The original and field duplicate samples are counted as one sample in the frequency of detection.
Shaded chemical name indicates that the maximum chemical concentration exceeded the TACO Groundwater Remediation Objective.
Shaded criteria indicates that the maximum chemical concentration exceeded the associated criterion.

Associated Samples:

NTC01GW0101	NTC01GW0601	NTC01GWTW0101-D
NTC01GW0101-D	NTC01GW0701	NTC01GWTW0201
NTC01GW0201	NTC01GW0801	NTC01GWTW0301
NTC01GW0301	NTC01GW0901	NTC01GWTW0401
NTC01GW0401	NTC01GW1001	
NTC01GW0501	NTC01GWTW0101	

TABLE 4-5

SUMMARY OF ANALYTICAL RESULTS FOR SURFACE WATER SAMPLES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Location Sample date	NTC01SW/SD01 12/17/2006	NTC01SW/SD02 12/17/2006	NTC01SW/SD03 12/17/2006	NTC01SW/SD03[1] 12/17/2006	NTC01SW04 12/19/2006	NTC01SW05 12/18/2006
Volatile Organics (µg/L)						
1,1-DICHLOROETHANE	1 U	1 U	0.25 J	1 U	0.39 J	0.21 J
CIS-1,2-DICHLOROETHENE	0.99 J	1.1	1	1.2	1.7	1.6
VINYL CHLORIDE	1 U	1 U	1 U	0.25 J	0.34 J	1 U
Polynuclear Aromatic Hydrocarbons (µg/L)						
BAP EQUIVALENT	0.15	0.15	0.16	0.16	**0.22**	**0.22**
BAP EQUIVALENT ZEROND	0.048	0.049	0.045	0.05	0.0029	0.0032
BENZO(A)PYRENE	0.039 J	0.038 J	0.035 J	0.038 J	0.2 U	0.2 U
BENZO(B)FLUORANTHENE	0.051 J	0.059 J	0.058 J	0.065 J	0.2 U	0.2 U
BENZO(G,H,I)PERYLENE	0.061 J	0.063 J	0.057 J	0.065 J	0.044 J	0.049 J
CHRYSENE	0.039 J	0.039 J	0.038 J	0.041 J	0.2 U	0.034 J
FLUORANTHENE	0.17 J	0.12 J	0.12 J	0.12 J	0.12 J	0.1 J
FLUORENE	0.034 J	0.021 J	0.03 J	0.036 J	0.025 J	0.031 J
INDENO(1,2,3-CD)PYRENE	0.041 J	0.049 J	0.038 J	0.056 J	0.029 J	0.032 J
PHENANTHRENE	0.17 J	0.14 J	0.14 J	0.17 J	0.12 J	0.15 J
PYRENE	0.081 J	0.079 J	0.078 J	0.084 J	0.056 J	0.063 J
TOTAL PAHs ECO	1	1	1	1	0 U	0 U
Dioxins/Furans (pg/L)						
1,2,3,4,6,7,8,9-OCDD	29 U	26 U	22 U	30 U	44 U	130
TEQ FISH	0 U	0 U	0 U	0 U	0 U	0.013
TEQ MAMMAL	0 U	0 U	0 U	0 U	0 U	0.039
Metals (µg/L)						
ALUMINUM	386	407	273	224	311 U	296 U
ANTIMONY	2.4 U	3.2	3.6	2.4 U	2.4 U	2.4 U
BARIUM	48.8	49.8	49.1	49.3	51.8	52.4
CALCIUM	83300	85000	83700	83600	91300	88300
CHROMIUM	1.2 U	1.7 U	0.98 U	0.54 U	1.2	1.4
COPPER	1.5	1.4 U	1.4 U	1.4 U	1.8	2.6
IRON	677	671	499	462	524	505
LEAD	2.1	2.1	1.8 U	1.8 U	1.8 U	2
MAGNESIUM	30600	31000	30600	30400	33700	32700
MANGANESE	74.9	76.3	69.5	69.2	86	77.1
MERCURY	0.052	0.052	0.022 U	0.015 U	0.015 U	0.015 U
NICKEL	2.3	2.6	2.2	1.6	3 U	2.3 U
POTASSIUM	3670	3570	3470	3440	3510	3600
SODIUM	227000	231000	228000	226000	242000	253000
THALLIUM	**5.1**	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U
VANADIUM	1.5	1.4	1.4	0.86	0.73	0.8
ZINC	18.5 U	18.7 U	17.2 U	17.6 U	18.2 U	18.7

1 - Duplicate samples.
J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
U = The value is not detected at the reported concentration and is considered not present in the sample.
UJ = The nonetected value is considered to be a quantitative estimated due to technical noncompliances.
Shaded chemical name / cell indicates that the concentration is greater than the TACO Groundwater Ingestion Tier 1 Criterion.
Blank cells indicate that the sample was not analyzed for those parameters.

TABLE 4-6

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI SURFACE WATER DATA
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Illinois TACO GRO Ingestion Tier 1	Illinois TACO GRO Ingestion Tier 1 Exceedances	USEPA Region 9 Tap Water PRG	USEPA Region 9 Tap Water PRG Exceedances	Federal MCL	Federal MCL Exceedances	Ecological Screening Level	Ecological Screening Level Exceedances
Volatile Organics (µg/L)													
1,1-DICHLOROETHANE	3/5	0.21 J - 0.39 J	1 - 1	NTC01SW0400	0.28	700	0	81	0	NA	0	2000	0
CIS-1,2-DICHLOROETHENE	5/5	0.99 J - 1.7	--	NTC01SW0400	1.3	70	0	6.1	0	70	0	1100	0
VINYL CHLORIDE	2/5	0.25 J - 0.34 J	1 - 1	NTC01SW0400	0.3	2	0	0.02	2	2	0	4000	0
Polynuclear Aromatic Hydrocarbons (µg/L)													
BAP EQUIVALENT ZEROND	5/5	0.0029 - 0.050141	--	NTC01SW0300-D	0.03	0.2	0	0.0092	4	0.2	0	NA	0
BAP EQUIVALENT	5/5	0.153689 - 0.224234	--	NTC01SW0500	0.18	0.2	2	0.0092	6	0.2	2	NA	0
BENZO(A)PYRENE	3/5	0.035 J - 0.039 J	0.2 - 0.2	NTC01SW0100	0.04	0.2	0	0.0092	4	0.2	0	0.014	4
BENZO(B)FLUORANTHENE	3/5	0.051 J - 0.065 J	0.2 - 0.2	NTC01SW0300-D	0.06	0.18	0	0.092	0	NA	0	NA	0
BENZO(G,H,I)PERYLENE	5/5	0.044 J - 0.065 J	--	NTC01SW0300-D	0.06	NA	0	18	0	NA	0	NA	0
CHRYSENE	4/5	0.034 J - 0.041 J	0.2 - 0.2	NTC01SW0300-D	0.04	1.5	0	9.2	0	NA	0	NA	0
FLUORANTHENE	5/5	0.1 J - 0.17 J	--	NTC01SW0100	0.13	280	0	150	0	NA	0	6.16	0
FLUORENE	5/5	0.021 J - 0.036 J	--	NTC01SW0300-D	0.03	280	0	24	0	NA	0	3.9	0
INDENO(1,2,3-CD)PYRENE	5/5	0.029 J - 0.056 J	--	NTC01SW0300-D	0.04	0.43	0	0.092	0	NA	0	NA	0
PHENANTHRENE	5/5	0.12 J - 0.17 J	--	NTC01SW0100, NTC01SW0300-D	0.15	NA	0	18	0	NA	0	3.7	0
PYRENE	5/5	0.056 J - 0.084 J	--	NTC01SW0300-D	0.07	210	0	18	0	NA	0	0.025	6
TOTAL PAHs ECO	3/5	1 - 1	0 - 0	NTC01SW0100, NTC01SW0200, NTC01SW0300	1	NA	0	NA	0	NA	0	NA	0
Dioxins/Furans (pg/L)													
1,2,3,4,6,7,8,9-OCDD	1/5	130	22 - 44	NTC01SW0500	130	NA	0	1500	0	NA	0	NA	0
TEQ FISH	1/5	0.013	0 - 0	NTC01SW0500	0.01	NA	0	NA	0	NA	0	0.000003	1
TEQ MAMMAL	1/5	0.039	0 - 0	NTC01SW0500	0.04	NA	0	0.45	0	30	0	NA	0
Metals (µg/L)													
ALUMINUM	3/5	224 - 407	296 - 311	NTC01SW0200	347.17	NA	0	3600	0	NA	0	87	4
ANTIMONY	2/5	3.2 - 3.6	2.4 - 2.4	NTC01SW0300	2.8	6	0	1.5	2	6	0	30	0
BARIUM	5/5	48.8 - 52.4	--	NTC01SW0500	50.4	2000	0	260	0	2000	0	5000	0
CALCIUM	5/5	83300 - 91300	--	NTC01SW0400	86310	NA	0	NA	0	NA	0	116000	0
CHROMIUM	2/5	1.2 - 1.4	0.54 - 1.7	NTC01SW0500	1.3	100	0	11	0	100	0	11	0
COPPER	3/5	1.5 - 2.6	1.4 - 1.4	NTC01SW0500	1.97	650	0	150	0	1300	0	11.4	0
IRON	5/5	462 - 677	--	NTC01SW0100	571.5	5000	0	1100	0	NA	0	1000	0
LEAD	3/5	2 - 2.1	1.8 - 1.8	NTC01SW0100, NTC01SW0200	2.07	7.5	0	NA	0	15	0	15.9	0
MAGNESIUM	5/5	30400 - 33700	--	NTC01SW0400	31700	NA	0	NA	0	NA	0	82000	0
MANGANESE	5/5	69.2 - 86	--	NTC01SW0400	76.73	150	0	88	0	NA	0	1000	0
MERCURY	2/5	0.052 - 0.052	0.015 - 0.022	NTC01SW0100, NTC01SW0200	0.05	2	0	1.1	0	2	0	1.1	0
NICKEL	3/5	1.6 - 2.6	2.3 - 3	NTC01SW0200	2.27	100	0	73	0	NA	0	5	0
POTASSIUM	5/5	3440 - 3670	--	NTC01SW0100	3561	NA	0	NA	0	NA	0	53000	0
SODIUM	5/5	226000 - 253000	--	NTC01SW0500	236000	NA	0	NA	0	NA	0	680000	0
THALLIUM	1/5	5.1	2.6 - 2.6	NTC01SW0100	5.1	2	1	0.24	1	2	1	12	0
VANADIUM	5/5	0.73 - 1.5	--	NTC01SW0100	1.11	49	0	3.6	0	NA	0	20	0
ZINC	1/5	18.7	17.2 - 18.7	NTC01SW0500	18.7	5000	0	1100	0	NA	0	21.6	0

J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
NA = No criterion available.
The original and field duplicate samples are counted as one sample in the frequency of detection.
Shaded chemical name indicates that the maximum chemical concentration exceeded the TACO Groundwater Remediation Objective.
Shaded criteria indicates that the maximum chemical concentration exceeded the associated criterion.

Associated Samples: NTC01SW0100, NTC01SW0200, NTC01SW0300, NTC01SW0300-D, NTC01SW0400, NTC01SW0500

TABLE 4-7

SUMMARY OF ANALYTICAL RESULTS FOR SURFACE SEDIMENT SAMPLES (0 TO 4 cm BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Pararmeter	NTC01SD01	NTC01SW/SD02	NTC01SW/SD03	NTC01SD04	NTC01SD04[1]	NTC01SD05
Semivolatile Organics (µg/kg)						
ACENAPHTHENE	2500 U	740 J		240 J	130 J	
ACENAPHTHYLENE	2500 U	4400 U		87 J	4400 U	
ANTHRACENE	150 J	1800 J		510 J	270 J	
BENZO(A)ANTHRACENE	690 J	4400		2300 J	1500 J	
BENZO(A)PYRENE	810 J	4900		3200 J	2500 J	
BENZO(B)FLUORANTHENE	1100 J	6400		5100	4000 J	
BENZO(G,H,I)PERYLENE	680 J	2800 J		1900 J	2700 J	
BENZO(K)FLUORANTHENE	480 J	2600 J		2000 J	1700 J	
BIS(2-ETHYLHEXYL)PHTHALATE	940 J	580 J		1000 J	710 J	
BUTYL BENZYL PHTHALATE	150 J	4400 U		3700 U	4400 U	
CARBAZOLE	140 J	930 J		600 J	420 J	
CHRYSENE	960 J	5400		3700	2900 J	
DIBENZO(A,H)ANTHRACENE	150 J	770 J		500 J	530 J	
DIBENZOFURAN	2500 U	380 J		130 J	4400 U	
DI-N-OCTYL PHTHALATE	120 J	4400 U		3700 U	4400 U	
FLUORANTHENE	1900 J	12000		7400	5200	
FLUORENE	2500 U	920 J		280 J	160 J	
INDENO(1,2,3-CD)PYRENE	710 J	3100 J		2200 J	2600 J	
NAPHTHALENE	2500 U	160 J		3700 U	4400 U	
PHENANTHRENE	780 J	7600		3600 J	2300 J	
PYRENE	1500 J	9300		5800	4200 J	
Polynuclear Aromatic Hydrocarbons (µg/kg)						
2-METHYLNAPHTHALENE	180 J	570 J	1200 U	1500 U	1800 U	40 J
ACENAPHTHYLENE	220 J	420 J	340 J	280 J	200 J	62 J
ANTHRACENE	360	500	110 J	160 J	67 J	120
BAP EQUIVALENT	2200	2500	2800	1900	1800	570
BAP EQUIVALENT ZEROND	2200	2500	2800	1900	1700	570
BENZO(A)ANTHRACENE	1600	1600	1700	890	730	480
BENZO(A)PYRENE	1600	1900	2000	1300	1300	400
BENZO(B)FLUORANTHENE	1400	360 U	2400	1400 J	1300 J	400
BENZO(G,H,I)PERYLENE	1400	2000	2100	1500	1500	260
BENZO(K)FLUORANTHENE	800	360 U	1100	650 J	650 J	190
CARBAZOLE	290 J	420 J	1200 U	1500 U	1800 U	380 U
CHRYSENE	1800	1900	2000	1300	1200	460
DIBENZO(A,H)ANTHRACENE	190 J	280 J	240 J	180 J	360 U	50 J
FLUORANTHENE	5800	6000	3200	3600 J	3100 J	810
FLUORENE	130 J	260 J	250 U	300 U	360 U	39 J
INDENO(1,2,3-CD)PYRENE	1300	1700	1600	1400 J	1400 J	300
NAPHTHALENE	120 J	660 J	1200 U	1500 U	1800 U	380 U
PHENANTHRENE	2100	3100	460	1300	1100	410
PYRENE	3900	4300	2700	1800	1700 J	620
TOTAL PAHS ECO	23000	25000	20000	16000	14000	4600
Organochlorine Pesticides/PCBs (µg/kg)						
4,4'-DDD	5.5 J	17 J		11 J	8.9 J	
4,4'-DDE	10 J	32		18 J	14 J	
4,4'-DDT	4.9 J	4.9 J		7.4 J	6.2 R	
ALPHA-CHLORDANE	13 U	5.5 J		19 U	5 J	
DIELDRIN	13 U	23 U		4.4 J	23 U	
ENDOSULFAN II	13 U	23 U		4.8 J	3.6 J	
ENDRIN	13 U	23 U		6.7 J	2.7 J	
GAMMA-CHLORDANE	13 U	2.9 J		19 U	23 U	

TABLE 4-7

SUMMARY OF ANALYTICAL RESULTS FOR SURFACE SEDIMENT SAMPLES (0 TO 4 cm BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Pararmeter	NTC01SD01	NTC01SW/SD02	NTC01SW/SD03	NTC01SD04	NTC01SD04[1]	NTC01SD05
Dioxins/Furans (ng/kg)						
1,2,3,4,6,7,8,9-OCDD	1400	2300		1900	2300	
1,2,3,4,6,7,8,9-OCDF	130	250		170	220	
1,2,3,4,6,7,8-HPCDD	130	240		220	240	
1,2,3,4,6,7,8-HPCDF	30	65		64	62	
1,2,3,6,7,8-HXCDD	5.2 J	9.9 J		10 J	9.4 J	
1,2,3,7,8,9-HXCDD	6.8 J	9.2 J		11 J	11 J	
2,3,7,8-TCDD	0.76 J	0.62 U		0.84 U	0.72 U	
2,3,7,8-TCDF	1.3 J	5.1		4.5	4.6	
TEQ BIRD	3	7		7	7	
TEQ FISH	1.5	1.6		1.5	1.5	
TEQ MAMMAL	4.1	6.2		6	6.3	
TOTAL HPCDD	250	440		430	440	
TOTAL HPCDF	95	180		170	170	
TOTAL HXCDD	41	67		73	65	
TOTAL HXCDF	18	41		50	39	
TOTAL PECDF	5	15		9.7	13	
TOTAL TCDD	4.3	1.7		1.2	1.3 U	
TOTAL TCDF	18	77		65	65	
Metals (mg/kg)						
ALUMINUM	3530	8920	7760	8970	11800	1180
ANTIMONY	0.46 J	2.1 J	0.44 UJ	2.1 J	2 J	0.45 J
ARSENIC	3.3	8.1	8.4	7.9	10.1	2.1
BARIUM	45.5	78.5	65.9	71.2	101	10.3
CALCIUM	116000	39600	33700	29300 J	42800	117000
CHROMIUM	13.8	24.7	17.6	21.5	29.3	3.2
COBALT	3.7	10.9	9.3	9.6	12.8	2.2
COPPER	34.3	52.7	40.1	48.3	71.3	55.2
IRON	11700	23900	20100	21400	28500	5290
LEAD	30.1	42.3	54	34.1	51	33
MAGNESIUM	52100	22300	18800	17800 J	25100	67100
MANGANESE	355	654	555	912	1200	257
MERCURY	0.058 J	0.3 J	0.11 J	0.13 J	0.24 J	0.015 U
NICKEL	10.2	24.5	22.2	22.4	29.4	5.6
POTASSIUM	590	1390	1220	1410	1760	297
SELENIUM	0.35 U	1.9	1.4	1.6	2.5	0.26 U
SODIUM	559	765	239	579	820	271
THALLIUM	0.39 U	0.7 U	0.48 U	0.63	0.69 U	0.3 U
VANADIUM	11	25.7	23.5	22.9	31	4.9
ZINC	158	294	213	213	304	400
Miscellaneous Parameters (mg/kg)						
TOTAL ORGANIC CARBON	8830	54300	26800	39300	48900	2200

1 - Duplicate samples.
J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
U = The value is not detected at the reported concentration and is considered not present in the sample.
UJ = The nonetected value is considered to be a quantitative estimate due to technical noncompliances.
Shaded chemical name / cell indicates that the concentration is greater than the TACO SRO Residential Ingestion criterion.
Blank cells indicate that the sample was not analyzed for those parameters.

TABLE 4-8

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI SURFACE SEDIMENT DATA (0 TO 4 cm BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	TACO - Soil Remediation Objective for Residential Properties - Ingestion	TACO - Soil Remediation Objective for Residential Properties - Ingestion Exceedances	Screening Level Based on USEPA Region 9 PRG - Residential Soil	Screening Level Based on USEPA Region 9 PRG - Residential Soil Exceedances	Ecological Screening Level	Ecological Screening Level Exceedances
Semivolatile Organics (µg/kg)											
ACENAPHTHENE	2/3	130 J - 740 J	2500 - 2500	NTC01SD0200	460	4700000	0	370000	0	585	1
ACENAPHTHYLENE	1/3	87 J	2500 - 4400	NTC01SD0400	87	4700000	0	370000	0	186	0
ANTHRACENE	3/3	150 J - 1800 J	--	NTC01SD0200	780	23000000	0	2200000	0	85	4
BENZO(A)ANTHRACENE	3/3	690 J - 4400	--	NTC01SD0200	2300	900	3	620	4	287	4
BENZO(A)PYRENE	3/3	810 J - 4900	--	NTC01SD0200	2900	90	4	62	4	73	4
BENZO(B)FLUORANTHENE	3/3	1100 J - 6400	--	NTC01SD0200	4000	900	4	620	4	886	4
BENZO(G,H,I)PERYLENE	3/3	680 J - 2800 J	--	NTC01SD0200	1900	2300000	0	230000	0	170	4
BENZO(K)FLUORANTHENE	3/3	480 J - 2600 J	--	NTC01SD0200	1600	9000	0	6200	0	8860	0
BIS(2-ETHYLHEXYL)PHTHALATE	3/3	580 J - 1000 J	--	NTC01SD0400	790	46000	0	35000	0	130000	0
BUTYL BENZYL PHTHALATE	1/3	150 J	3700 - 4400	NTC01SD0100	150	16000000	0	1200000	0	6000	0
CARBAZOLE	3/3	140 J - 930 J	--	NTC01SD0200	530	32000	0	24000	0	110	4
CHRYSENE	3/3	960 J - 5400	--	NTC01SD0200	3200	88000	0	62000	0	400	4
DIBENZO(A,H)ANTHRACENE	3/3	150 J - 770 J	--	NTC01SD0200	480	90	4	62	4	60	4
DIBENZOFURAN	2/3	130 J - 380 J	2500 - 4400	NTC01SD0200	260	NA	0	15000	0	910	0
DI-N-OCTYL PHTHALATE	1/3	120 J	3700 - 4400	NTC01SD0100	120	1600000	0	240000	0	40600	0
FLUORANTHENE	3/3	1900 J - 12000	--	NTC01SD0200	6700	3100000	0	230000	0	2790	3
FLUORENE	2/3	160 J - 920 J	2500 - 2500	NTC01SD0200	570	3100000	0	270000	0	35	3
INDENO(1,2,3-CD)PYRENE	3/3	710 J - 3100 J	--	NTC01SD0200	2100	900	3	620	4	2500	2
NAPHTHALENE	1/3	160 J	2500 - 4400	NTC01SD0200	160	1600000	0	5600	0	340	0
PHENANTHRENE	3/3	780 J - 7600	--	NTC01SD0200	3800	2300000	0	230000	0	810	3
PYRENE	3/3	1500 J - 9300	--	NTC01SD0200	5300	2300000	0	230000	0	350	4
Polynuclear Aromatic Hydrocarbons (µg/kg)											
2-METHYLNAPHTHALENE	3/5	40 J - 570 J	1200 - 1800	NTC01SD0200	260	1600000	0	5600	0	368	1
ACENAPHTHYLENE	5/5	62 J - 420 J	--	NTC01SD0200	260	4700000	0	370000	0	186	5
ANTHRACENE	5/5	67 J - 500	--	NTC01SD0200	240	23000000	0	2200000	0	85	5
BAP EQUIVALENT ZEROND	5/5	570.36 - 2823	--	NTC01SD0300	2000	90	6	62	6	NA	0
BAP EQUIVALENT	5/5	570.36 - 2823	--	NTC01SD0300	2000	90	6	62	6	NA	0
BENZO(A)ANTHRACENE	5/5	480 - 1700	--	NTC01SD0300	1200	900	3	620	5	287	6
BENZO(A)PYRENE	5/5	400 - 2000	--	NTC01SD0300	1400	90	6	62	6	73	6
BENZO(B)FLUORANTHENE	4/5	400 - 2400	360 - 360	NTC01SD0300	1400	900	4	620	4	886	4
BENZO(G,H,I)PERYLENE	5/5	260 - 2100	--	NTC01SD0300	1500	2300000	0	230000	0	170	6
BENZO(K)FLUORANTHENE	4/5	190 - 1100	360 - 360	NTC01SD0300	690	9000	0	6200	0	8860	0
CARBAZOLE	2/5	290 J - 420 J	380 - 1800	NTC01SD0200	360	32000	0	24000	0	110	2
CHRYSENE	5/5	460 - 2000	--	NTC01SD0300	1500	88000	0	62000	0	400	6
DIBENZO(A,H)ANTHRACENE	5/5	50 J - 280 J	--	NTC01SD0200	190	90	4	62	4	60	4
FLUORANTHENE	5/5	810 - 6000	--	NTC01SD0200	3800	3100000	0	230000	0	2790	5
FLUORENE	3/5	39 J - 260 J	250 - 360	NTC01SD0200	140	3100000	0	270000	0	35	3
INDENO(1,2,3-CD)PYRENE	5/5	300 - 1700	--	NTC01SD0200	1300	900	5	620	5	2500	0
NAPHTHALENE	2/5	120 J - 660 J	380 - 1800	NTC01SD0200	390	1600000	0	5600	0	340	1
PHENANTHRENE	5/5	410 - 3100	--	NTC01SD0200	1500	2300000	0	230000	0	810	4
PYRENE	5/5	620 - 4300	--	NTC01SD0200	2700	2300000	0	230000	0	350	6
TOTAL PAHS ECO	5/5	4641 - 25190	--	NTC01SD0200	18000	NA	0	NA	0	NA	0
Organochlorine Pesticides/PCBs (µg/kg)											
4,4'-DDD	3/3	5.5 J - 17 J	--	NTC01SD0200	11	3000	0	2400	0	2	4
4,4'-DDE	3/3	10 J - 32	--	NTC01SD0200	19	2000	0	1700	0	2	4
4,4'-DDT	3/3	4.9 J - 7.4 J	--	NTC01SD0400	5.7	2000	0	1700	0	1	3
ALPHA-CHLORDANE	2/3	5 J - 5.5 J	13 - 19	NTC01SD0200	5.3	1800	0	1600	0	0.5	2
DIELDRIN	1/3	4.4 J	13 - 23	NTC01SD0400	4.4	40	0	30	0	50	0
ENDOSULFAN II	1/3	4.2 J	13 - 23	NTC01SD0400	4.2	470000	0	37000	0	0.15	2
ENDRIN	1/3	4.7 J	13 - 23	NTC01SD0400	4.7	23000	0	1800	0	19	0
GAMMA-CHLORDANE	1/3	2.9 J	13 - 23	NTC01SD0200	2.9	1800	0	1600	0	0.5	1
Dioxins/Furans (ng/kg)											
1,2,3,4,6,7,8,9-OCDD	3/3	1400 - 2300	--	NTC01SD0200, NTC01SD0400-D	1900	NA	0	13000	0	NA	0
1,2,3,4,6,7,8,9-OCDF	3/3	130 - 250	--	NTC01SD0200	190	NA	0	13000	0	NA	0
1,2,3,4,6,7,8-HPCDD	3/3	130 - 240	--	NTC01SD0200, NTC01SD0400-D	200	NA	0	390	0	NA	0
1,2,3,4,6,7,8-HPCDF	3/3	30 - 65	--	NTC01SD0200	53	NA	0	390	0	NA	0
1,2,3,6,7,8-HXCDD	3/3	5.2 J - 10 J	--	NTC01SD0400	8.3	NA	0	39	0	NA	0

TABLE 4-8

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI SURFACE SEDIMENT DATA (0 TO 4 cm BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	TACO - Soil Remediation Objective for Residential Properties - Ingestion	TACO - Soil Remediation Objective for Residential Properties - Ingestion Exceedances	Screening Level Based on USEPA Region 9 PRG - Residential Soil	Screening Level Based on USEPA Region 9 PRG - Residential Soil Exceedances	Ecological Screening Level	Ecological Screening Level Exceedances
1,2,3,7,8,9-HXCDD	3/3	6.8 J - 11 J	--	NTC01SD0400, NTC01SD0400-D	9	NA	0	39	0	NA	0
2,3,7,8-TCDD	1/3	0.76 J	0.62 - 0.84	NTC01SD0100	0.76	NA	0	3.9	0	0.12	1
2,3,7,8-TCDF	3/3	1.3 J - 5.1	--	NTC01SD0200	3.7	NA	0	39	0	NA	0
TEQ BIRD	3/3	3 - 7	--	NTC01SD0200, NTC01SD0400, NTC01SD0400-D	5.7	NA	0	NA	0	0.12	4
TEQ FISH	3/3	1.502 - 1.591	--	NTC01SD0200	1.6	NA	0	NA	0	0.12	4
TEQ MAMMAL	3/3	4.149 - 6.276	--	NTC01SD0400-D	5.5	NA	0	3.9	4	0.12	4
TOTAL HPCDD	3/3	250 - 440	--	NTC01SD0200, NTC01SD0400-D	380	NA	0	NA	0	NA	0
TOTAL HPCDF	3/3	95 - 180	--	NTC01SD0200	150	NA	0	NA	0	NA	0
TOTAL HXCDD	3/3	41 - 73	--	NTC01SD0400	59	NA	0	NA	0	NA	0
TOTAL HXCDF	3/3	18 - 50	--	NTC01SD0400	35	NA	0	NA	0	NA	0
TOTAL PECDF	3/3	5 - 15	--	NTC01SD0200	10	NA	0	NA	0	NA	0
TOTAL TCDD	3/3	1.2 - 4.3	--	NTC01SD0100	2.4	NA	0	NA	0	NA	0
TOTAL TCDF	3/3	18 - 77	--	NTC01SD0200	53	NA	0	NA	0	NA	0
Metals (mg/kg)											
ALUMINUM	5/5	1180 - 11800	--	NTC01SD0400-D	6360	NA	0	7600	4	58030	0
ANTIMONY	4/5	0.45 J - 2.1 J	0.44 - 0.44	NTC01SD0200, NTC01SD0400	1.3	31	0	3.1	0	2	2
ARSENIC	5/5	2.1 - 10.1	--	NTC01SD0400-D	6.2	NA	0	0.39	6	9.79	1
BARIUM	5/5	10.3 - 101	--	NTC01SD0400-D	57.3	5500	0	540	0	NA	0
CALCIUM	5/5	29300 J - 117000	--	NTC01SD0500	68500	NA	0	NA	0	NA	0
CHROMIUM	5/5	3.2 - 29.3	--	NTC01SD0400-D	16.9	230	0	30	0	43.4	0
COBALT	5/5	2.2 - 12.8	--	NTC01SD0400-D	7.5	4700	0	140	0	50	0
COPPER	5/5	34.3 - 71.3	--	NTC01SD0400-D	48.4	2900	0	310	0	31.6	6
IRON	5/5	5290 - 28500	--	NTC01SD0400-D	17200	NA	0	2300	6	20000	4
LEAD	5/5	30.1 - 54	--	NTC01SD0300	40.4	400	0	400	0	35.8	3
MAGNESIUM	5/5	17800 J - 67100	--	NTC01SD0500	36400	NA	0	NA	0	NA	0
MANGANESE	5/5	257 - 1200	--	NTC01SD0400-D	575	3700	0	180	6	460	4
MERCURY	4/5	0.058 J - 0.3 J	0.015 - 0.015	NTC01SD0200	0.16	23	0	2.3	0	0.18	2
NICKEL	5/5	5.6 - 29.4	--	NTC01SD0400-D	17.7	1600	0	160	0	30	0
POTASSIUM	5/5	297 - 1760	--	NTC01SD0400-D	1020	NA	0	NA	0	NA	0
SELENIUM	3/5	1.4 - 2.5	0.26 - 0.35	NTC01SD0400-D	1.8	390	0	39	0	NA	0
SODIUM	5/5	239 - 820	--	NTC01SD0400-D	507	NA	0	NA	0	NA	0
THALLIUM	1/5	0.63	0.3 - 0.7	NTC01SD0400	0.63	6.3	0	0.52	1	NA	0
VANADIUM	5/5	4.9 - 31	--	NTC01SD0400-D	18.4	550	0	7.8	5	NA	0
ZINC	5/5	158 - 400	--	NTC01SD0500	265	23000	0	2300	0	121	6
Miscellaneous Parameters (mg/kg)											
TOTAL ORGANIC CARBON	5/5	2200 - 54300	--	NTC01SD0200	27246	NA	0	NA	0	NA	0

J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
NA = No criterion available.
The original and field duplicate samples are counted as one sample in the frequency of detection.
Shaded chemical name indicates that the concentration is greater than the TACO SRO Residential Ingestion criterion.
Shaded criteria indicates that the maximum chemical concentration exceeded the associated criterion.

Associated Samples: NTC01SD0100, NTC01SD0200, NTC01SD0300, NTC01SD0400, NTC01SD0400-D, NTC01SD0500

TABLE 4-9

SUMMARY OF ANALYTICAL RESULTS FOR SUBSURFACE SEDIMENT SAMPLES (1 FOOT BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	NTC01SD01	NTC01SW/SD02	NTC01SW/SD03	NTC01SD04	NTC01SD05
Semivolatile Organics (µg/kg)					
2-METHYLNAPHTHALENE	220 J				
ACENAPHTHENE	1000 J				
ACENAPHTHYLENE	79 J				
ANTHRACENE	1600 J				
BENZO(A)ANTHRACENE	4500				
BENZO(A)PYRENE	4900				
BENZO(B)FLUORANTHENE	6400				
BENZO(G,H,I)PERYLENE	2200 J				
BENZO(K)FLUORANTHENE	2700 J				
BIS(2-ETHYLHEXYL)PHTHALATE	2100 J				
BUTYL BENZYL PHTHALATE	190 J				
CARBAZOLE	1100 J				
CHRYSENE	5500				
DIBENZO(A,H)ANTHRACENE	670 J				
DIBENZOFURAN	510 J				
DI-N-OCTYL PHTHALATE	180 J				
FLUORANTHENE	12000				
FLUORENE	1000 J				
INDENO(1,2,3-CD)PYRENE	2600 J				
NAPHTHALENE	440 J				
PHENANTHRENE	7400				
PYRENE	9400				
Polynuclear Aromatic Hydrocarbons (µg/kg)					
2-METHYLNAPHTHALENE	1300 J	23 J	240 J	170 J	110 J
ACENAPHTHYLENE	5800 U	160 J	350 J	390 J	150 J
ANTHRACENE	1300	28 J	300	260 J	130 J
BAP EQUIVALENT	5100	380	1200	2500	530
BAP EQUIVALENT ZEROND	5100	380	1200	2500	440
BENZO(A)ANTHRACENE	4100	110	950	1200	770
BENZO(A)PYRENE	3500	250	820	1700	180 U
BENZO(B)FLUORANTHENE	4000	200	880	2600	1100
BENZO(G,H,I)PERYLENE	2300	320	790	1900	1100
BENZO(K)FLUORANTHENE	1700	100	420	870	540
CARBAZOLE	5800 U	180 U	220 J	190 J	880 U
CHRYSENE	3600	160	960	1600	1100
DIBENZO(A,H)ANTHRACENE	440 J	67	120	260 J	140 J
FLUORANTHENE	9400	230	2300	4500	3100
FLUORENE	580 J	11 J	140	97 J	180 U
INDENO(1,2,3-CD)PYRENE	2900	280	690	1700	1100
NAPHTHALENE	5800 U	180 U	150 J	1500 U	880 U
PHENANTHRENE	5700	100	1500	1700	1200
PYRENE	6800	170	1600	3200	2100
TOTAL PAHs ECO	48000	2200	12000	22000	13000
Organochlorine Pesticides/PCBs (µg/kg)					
4,4'-DDD	86 J				
4,4'-DDE	79 J				
AROCLOR-1248	820				
ENDRIN ALDEHYDE	41 J				

TABLE 4-9

SUMMARY OF ANALYTICAL RESULTS FOR SUBSURFACE SEDIMENT SAMPLES (1 FOOT BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	NTC01SD01	NTC01SW/SD02	NTC01SW/SD03	NTC01SD04	NTC01SD05
Dioxins/Furans (ng/kg)					
1,2,3,4,6,7,8,9-OCDD	7700 J				
1,2,3,4,6,7,8,9-OCDF	330				
1,2,3,4,6,7,8-HPCDD	580				
1,2,3,4,6,7,8-HPCDF	99				
1,2,3,4,7,8,9-HPCDF	9				
1,2,3,6,7,8-HXCDD	23				
1,2,3,7,8,9-HXCDD	7.4 J				
2,3,7,8-TCDF	5.7				
TEQ BIRD	9				
TEQ FISH	3.1				
TEQ MAMMAL	13				
TOTAL HPCDD	1100				
TOTAL HPCDF	510				
TOTAL HXCDD	120				
TOTAL HXCDF	110				
TOTAL PECDF	29				
TOTAL TCDD	2.4				
TOTAL TCDF	81				
Metals (mg/kg)					
ALUMINUM	6130	7920	7980	9530	5350
ANTIMONY	0.42 UJ	0.43 UJ	0.33 UJ	1.3 J	1.2 J
ARSENIC	6.8	7.7	9.4	9.1	6.4
BARIUM	50.7	50.9	71.4	76.1	69.9
CADMIUM	0.48	0.08 U	0.06 U	0.1 U	0.12 U
CALCIUM	74600	34100	32600	35500	20700
CHROMIUM	44.2	19.5	16.2	23.8	16.9
COBALT	7.9	10.9	11.3	10.3	7.6
COPPER	83.3	29.3	82.5	51.6	36.7
IRON	18700	15100	19900	23800	14100
LEAD	113	53.4	53.1	46.6	46.8
MAGNESIUM	41700	21400	18100	20800	11600
MANGANESE	530	354	513	719	261
MERCURY	0.17 J	0.16 J	0.1 J	0.23 J	0.25 J
NICKEL	21.1	24.6	26.4	24	16.4
POTASSIUM	925	1130	1300	1370	875
SELENIUM	1.1	1.1	1.2	1.9	1.4
SILVER	0.35 U	0.38 U	0.39	0.3 U	0.5 U
SODIUM	1290	266	247	629	679
THALLIUM	0.46 U	0.47 U	0.35 U	0.63	0.7 U
VANADIUM	19	20.3	21.4	26.4	17
ZINC	439	136	362	250	180
Miscellaneous Parameters (mg/kg)					
TOTAL ORGANIC CARBON	33400	21800	18100	45600	54400

J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
U = The value is not detected at the reported concentration and is considered not present in the sample.
UJ = The nonetected value is considered to be a quantitative estimate due to technical noncompliances.
Shaded chemical name / cell indicates that the concentration is greater than the TACO SRO Residential Ingestion criterion.
Blank cells indicate that the sample was not analyzed for those parameters.

TABLE 4-10

SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI SUBSURFACE SEDIMENT DATA (1 FOOT BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Average of All Results	TACO - Soil Remediation Objective for Residential Properties - Ingestion	TACO - Soil Remediation Objective for Residential Properties - Ingestion Exceedances	Screening Level Based on USEPA Region 9 PRG Residential Soil	Screening Level Based on USEPA Region 9 PRG - Residential Soil Exceedances
Semivolatile Organics (µg/kg)										
2-METHYLNAPHTHALENE	1/1	220 J	--	NTC01SD0101	220	220	1600000	0	5600	0
ACENAPHTHENE	1/1	1000 J	--	NTC01SD0101	1000	1000	4700000	0	370000	0
ACENAPHTHYLENE	1/1	79 J	--	NTC01SD0101	79	79	4700000	0	370000	0
ANTHRACENE	1/1	1600 J	--	NTC01SD0101	1600	1600	23000000	0	2200000	0
BENZO(A)ANTHRACENE	1/1	4500	--	NTC01SD0101	4500	4500	900	1	620	1
BENZO(A)PYRENE	1/1	4900	--	NTC01SD0101	4900	4900	90	1	62	1
BENZO(B)FLUORANTHENE	1/1	6400	--	NTC01SD0101	6400	6400	900	1	620	1
BENZO(G,H,I)PERYLENE	1/1	2200 J	--	NTC01SD0101	2200	2200	2300000	0	230000	0
BENZO(K)FLUORANTHENE	1/1	2700 J	--	NTC01SD0101	2700	2700	9000	0	6200	0
BIS(2-ETHYLHEXYL)PHTHALATE	1/1	2100 J	--	NTC01SD0101	2100	2100	46000	0	35000	0
BUTYL BENZYL PHTHALATE	1/1	190 J	--	NTC01SD0101	190	190	16000000	0	1200000	0
CARBAZOLE	1/1	1100 J	--	NTC01SD0101	1100	1100	32000	0	24000	0
CHRYSENE	1/1	5500	--	NTC01SD0101	5500	5500	88000	0	62000	0
DIBENZO(A,H)ANTHRACENE	1/1	670 J	--	NTC01SD0101	670	670	90	1	62	1
DIBENZOFURAN	1/1	510 J	--	NTC01SD0101	510	510	NA	0	15000	0
DI-N-OCTYL PHTHALATE	1/1	180 J	--	NTC01SD0101	180	180	1600000	0	240000	0
FLUORANTHENE	1/1	12000	--	NTC01SD0101	12000	12000	3100000	0	230000	0
FLUORENE	1/1	1000 J	--	NTC01SD0101	1000	1000	3100000	0	270000	0
INDENO(1,2,3-CD)PYRENE	1/1	2600 J	--	NTC01SD0101	2600	2600	900	1	620	1
NAPHTHALENE	1/1	440 J	--	NTC01SD0101	440	440	1600000	0	5600	0
PHENANTHRENE	1/1	7400	--	NTC01SD0101	7400	7400	2300000	0	230000	0
PYRENE	1/1	9400	--	NTC01SD0101	9400	9400	2300000	0	230000	0
Polynuclear Aromatic Hydrocarbons (µg/kg)										
2-METHYLNAPHTHALENE	5/5	23 J - 1300 J	--	NTC01SD0101	370	370	1600000	0	5600	0
ACENAPHTHYLENE	4/5	150 J - 390 J	5800 - 5800	NTC01SD0401	260	790	4700000	0	370000	0
ANTHRACENE	5/5	28 J - 1300	--	NTC01SD0101	400	400	23000000	0	2200000	0
BAP EQUIVALENT(1)	5/5	377.16 - 5060.6	--	NTC01SD0101	1900	1900	90	5	62	5
BAP EQUIVALENT	5/5	377.16 - 5060.6	--	NTC01SD0101	1900	1900	90	5	62	5
BENZO(A)ANTHRACENE	5/5	110 - 4100	--	NTC01SD0101	1400	1400	900	3	620	4
BENZO(A)PYRENE	4/5	250 - 3500	180 - 180	NTC01SD0101	1600	1300	90	4	62	4
BENZO(B)FLUORANTHENE	5/5	200 - 4000	--	NTC01SD0101	1800	1800	900	3	620	4
BENZO(G,H,I)PERYLENE	5/5	320 - 2300	--	NTC01SD0101	1300	1300	2300000	0	230000	0
BENZO(K)FLUORANTHENE	5/5	100 - 1700	--	NTC01SD0101	730	730	9000	0	6200	0
CARBAZOLE	2/5	190 J - 220 J	180 - 5800	NTC01SD0301	210	770	32000	0	24000	0
CHRYSENE	5/5	160 - 3600	--	NTC01SD0101	1500	1500	88000	0	62000	0
DIBENZO(A,H)ANTHRACENE	5/5	67 - 440 J	--	NTC01SD0101	210	210	90	4	62	5
FLUORANTHENE	5/5	230 - 9400	--	NTC01SD0101	3900	3900	3100000	0	230000	0
FLUORENE	4/5	11 J - 580 J	180 - 180	NTC01SD0101	210	180	3100000	0	270000	0
INDENO(1,2,3-CD)PYRENE	5/5	280 - 2900	--	NTC01SD0101	1300	1300	900	3	620	4
NAPHTHALENE	1/5	150 J	180 - 5800	NTC01SD0301	150	870	1600000	0	5600	0
PHENANTHRENE	5/5	100 - 5700	--	NTC01SD0101	2000	2000	2300000	0	230000	0
PYRENE	5/5	170 - 6800	--	NTC01SD0101	2800	2800	2300000	0	230000	0
TOTAL PAHS ECO	5/5	2209 - 47620	--	NTC01SD0101	19000	19000	NA	0	NA	0
Organochlorine Pesticides/PCBs (µg/kg)										
4,4'-DDD	1/1	86 J	--	NTC01SD0101	86	86	3000	0	2400	0
4,4'-DDE	1/1	79 J	--	NTC01SD0101	79	79	2000	0	1700	0
AROCLOR-1248	1/1	820	--	NTC01SD0101	820	820	1000	0	220	1
ENDRIN ALDEHYDE	1/1	41 J	--	NTC01SD0101	41	41	23000	0	1800	0
Dioxins/Furans (ng/kg)										
1,2,3,4,6,7,8,9-OCDD	1/1	7700 J	--	NTC01SD0101	7700	7700	NA	0	13000	0
1,2,3,4,6,7,8,9-OCDF	1/1	330	--	NTC01SD0101	330	330	NA	0	13000	0
1,2,3,4,6,7,8-HPCDD	1/1	580	--	NTC01SD0101	580	580	NA	0	390	1
1,2,3,4,6,7,8-HPCDF	1/1	99	--	NTC01SD0101	99	99	NA	0	390	0

TABLE 4-10

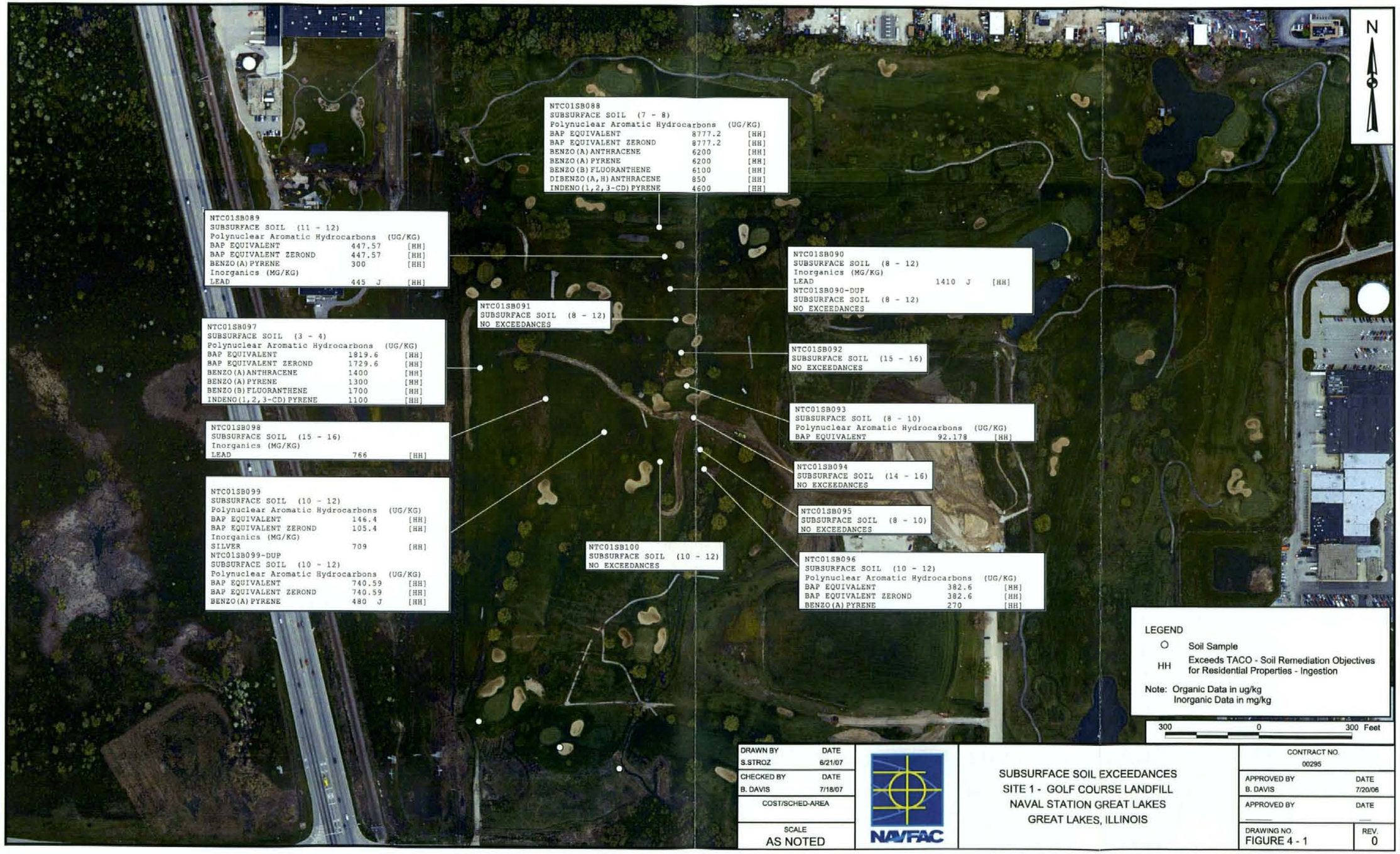
SUMMARY OF DESCRIPTIVE STATISTICS AND CRITERIA COMPARISONS FOR RI SUBSURFACE SEDIMENT DATA (1 FOOT BGS)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Range of Detects	Range of Nondetects	Location with Maximum Concentration	Average of Detected Concentrations	Average of All Results	TACO - Soil Remediation Objective for Residential Properties - Ingestion	TACO - Soil Remediation Objective for Residential Properties - Ingestion Exceedances	Screening Level Based on USEPA Region 9 PRG - Residential Soil	Screening Level Based on USEPA Region 9 PRG - Residential Soil Exceedances
1,2,3,4,7,8,9-HPCDF	1/1	9	--	NTC01SD0101	9.0	9.0	NA	0	390	0
1,2,3,6,7,8-HXCDD	1/1	23	--	NTC01SD0101	23	23	NA	0	39	0
1,2,3,7,8,9-HXCDD	1/1	7.4 J	--	NTC01SD0101	7.4	7.4	NA	0	39	0
2,3,7,8-TCDF	1/1	5.7	--	NTC01SD0101	5.7	5.7	NA	0	39	0
TEQ BIRD	1/1	9	--	NTC01SD0101	9.0	9.0	NA	0	NA	0
TEQ FISH	1/1	3.052	--	NTC01SD0101	3.1	3.1	NA	0	NA	0
TEQ MAMMAL	1/1	12.899	--	NTC01SD0101	13	13	NA	0	3.9	1
TOTAL HPCDD	1/1	1100	--	NTC01SD0101	1100	1100	NA	0	NA	0
TOTAL HPCDF	1/1	510	--	NTC01SD0101	510	510	NA	0	NA	0
TOTAL HXCDD	1/1	120	--	NTC01SD0101	120	120	NA	0	NA	0
TOTAL HXCDF	1/1	110	--	NTC01SD0101	110	110	NA	0	NA	0
TOTAL PECDF	1/1	29	--	NTC01SD0101	29	29	NA	0	NA	0
TOTAL TCDD	1/1	2.4	--	NTC01SD0101	2.4	2.4	NA	0	NA	0
TOTAL TCDF	1/1	81	--	NTC01SD0101	81	81	NA	0	NA	0
Metals (mg/kg)										
ALUMINUM	5/5	5350 - 9530	--	NTC01SD0401	7400	7400	NA	0	7600	3
ANTIMONY	2/5	1.2 J - 1.3 J	0.33 - 0.43	NTC01SD0401	1.3	0.62	31	0	3.1	0
ARSENIC	5/5	6.4 - 9.4	--	NTC01SD0301	7.9	7.9	NA	0	0.39	5
BARIUM	5/5	50.7 - 76.1	--	NTC01SD0401	63.8	63.8	5500	0	540	0
CADMIUM	1/5	0.48	0.06 - 0.12	NTC01SD0101	0.48	0.13	78	0	3.7	0
CALCIUM	5/5	20700 - 74600	--	NTC01SD0101	39500	39500	NA	0	NA	0
CHROMIUM	5/5	16.2 - 44.2	--	NTC01SD0101	24.1	24.1	230	0	30	1
COBALT	5/5	7.6 - 11.3	--	NTC01SD0301	9.6	9.6	4700	0	140	0
COPPER	5/5	29.3 - 83.3	--	NTC01SD0101	56.7	56.7	2900	0	310	0
IRON	5/5	14100 - 23800	--	NTC01SD0401	18300	18300	NA	0	2300	5
LEAD	5/5	46.6 - 113	--	NTC01SD0101	62.6	62.6	400	0	400	0
MAGNESIUM	5/5	11600 - 41700	--	NTC01SD0101	22700	22700	NA	0	NA	0
MANGANESE	5/5	261 - 719	--	NTC01SD0401	475	475	3700	0	180	5
MERCURY	5/5	0.1 J - 0.25 J	--	NTC01SD0501	0.18	0.18	23	0	2.3	0
NICKEL	5/5	16.4 - 26.4	--	NTC01SD0301	22.5	22.5	1600	0	160	0
POTASSIUM	5/5	875 - 1370	--	NTC01SD0401	1120	1120	NA	0	NA	0
SELENIUM	5/5	1.1 - 1.9	--	NTC01SD0401	1.3	1.3	390	0	39	0
SILVER	1/5	0.39	0.3 - 0.5	NTC01SD0301	0.39	0.23	390	0	39	0
SODIUM	5/5	247 - 1290	--	NTC01SD0101	622	622	NA	0	NA	0
THALLIUM	1/5	0.63	0.35 - 0.7	NTC01SD0401	0.63	0.32	6.3	0	0.52	1
VANADIUM	5/5	17 - 26.4	--	NTC01SD0401	20.8	20.8	550	0	7.8	5
ZINC	5/5	136 - 439	--	NTC01SD0101	273	273	23000	0	2300	0
Miscellaneous Parameters (mg/kg)										
TOTAL ORGANIC CARBON	5/5	18100 - 54400	--	NTC01SD0501	34660	34660	NA	0	NA	0

J =The value is considered a quantitative estimate because it was less than the reporting limit or because of another technical noncompliance.
NA = No criterion available.
The original and field duplicate samples are counted as one sample in the frequency of detection.
Shaded chemical name indicates that the concentration is greater than the TACO SRO Residential Ingestion criterion.
Shaded criteria indicates that the maximum chemical concentration exceeded the associated criterion.

Associated Samples: NTC01SD0101, NTC01SD0201, NTC01SD0301, NTC01SD0401, NTC01SD0501

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SITE 01-TAG\MAPS\SVOCs and PAHs TAG LAYOUT 7/18/07 SS



DRAWN BY	DATE
S.STROZ	6/21/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

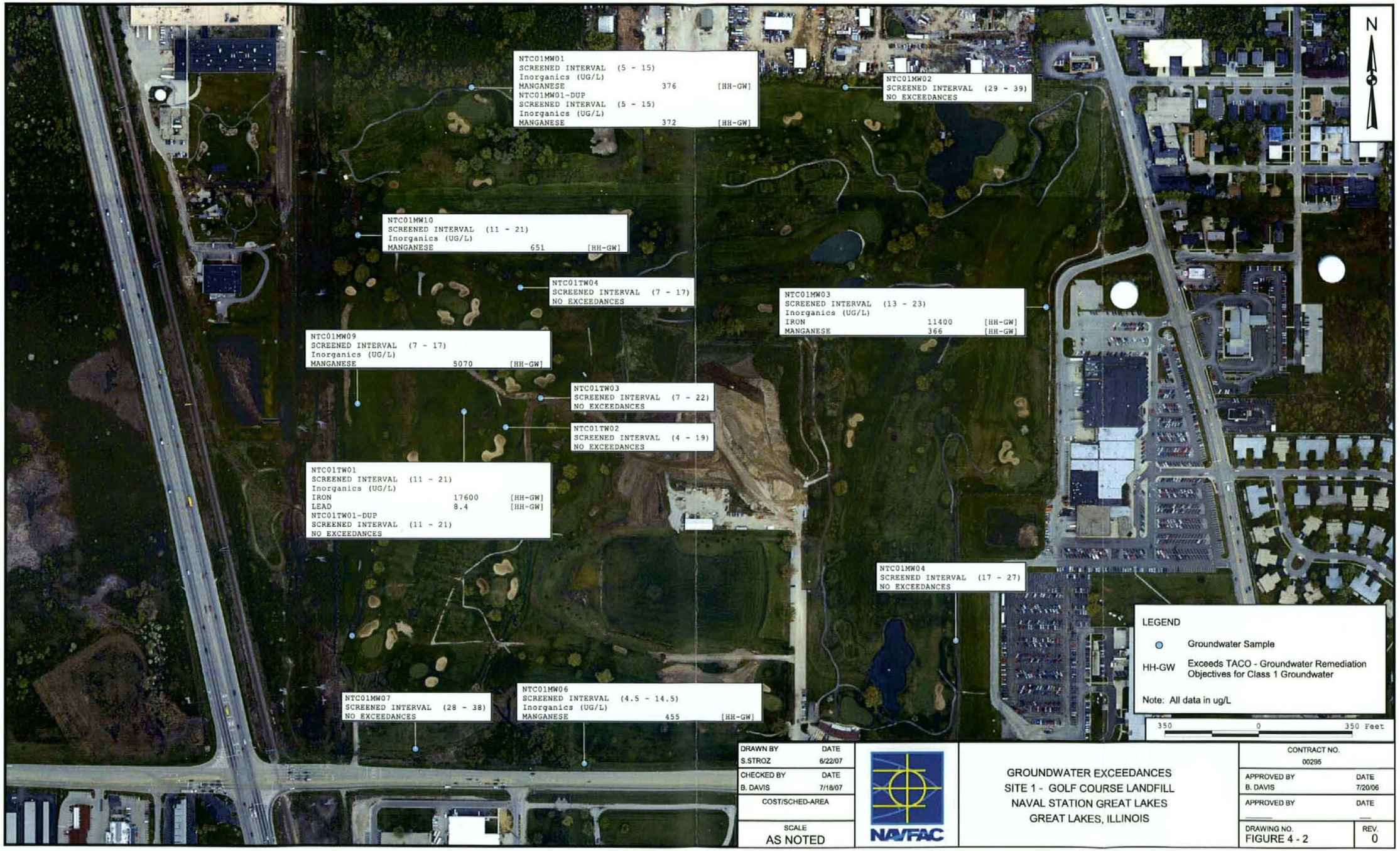
NAVFAC

SUBSURFACE SOIL EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4 - 1	0

0002144805Y

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\GROUNDWATER INORGANICS TAG LAYOUT 7/18/07 SS



DRAWN BY	DATE
S.STROZ	6/22/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

GROUNDWATER EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4 - 2	0

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SURFACE WATER PAHs AND INORGANICS TAG LAYOUT 7/18/07 SS

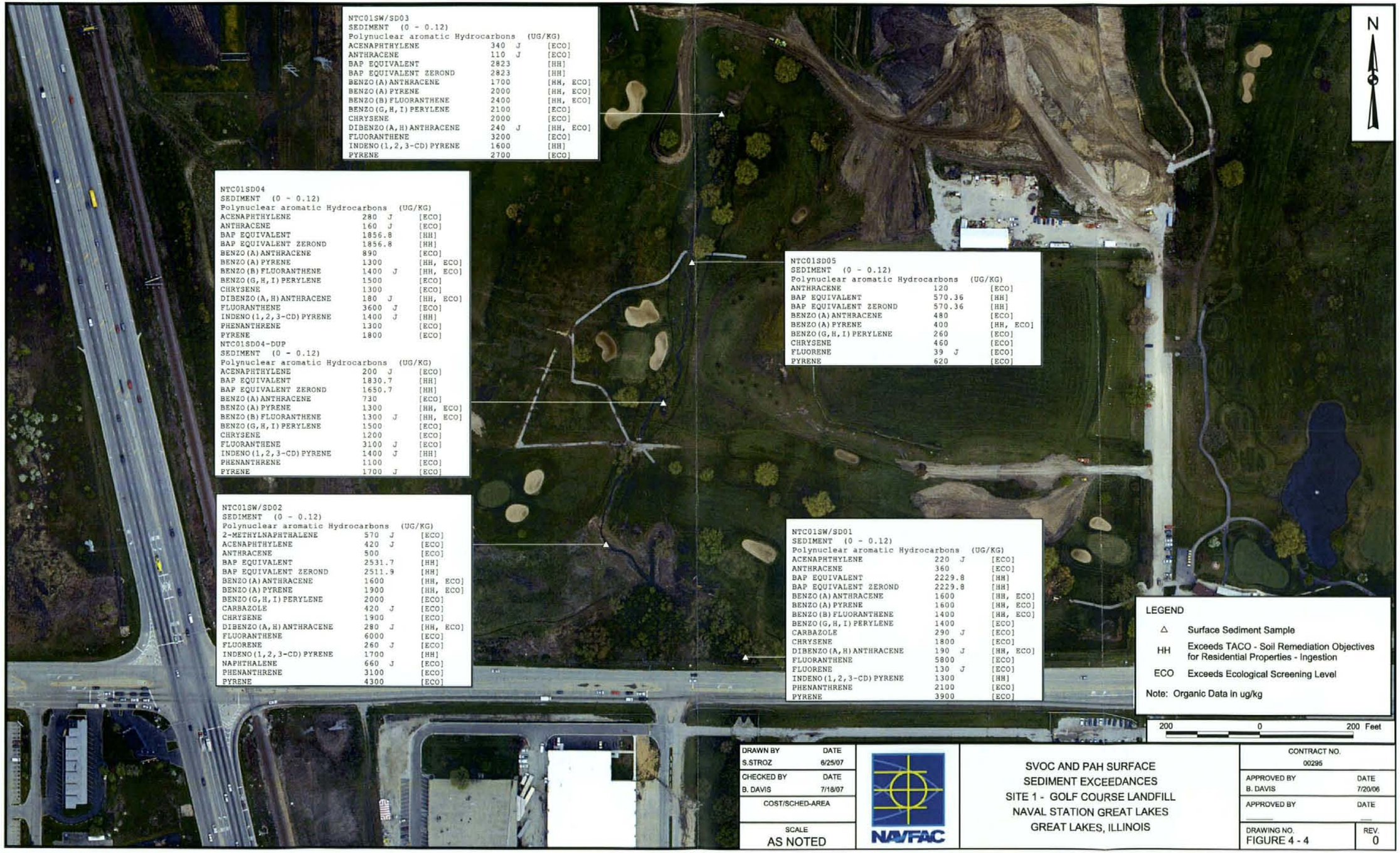
DRAWN BY	DATE
S.STROZ	6/22/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

SURFACE WATER EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4 - 3	0

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SURFACE SEDIMENT SVOCS AND PAHS TAG LAYOUT 7/18/07 SS



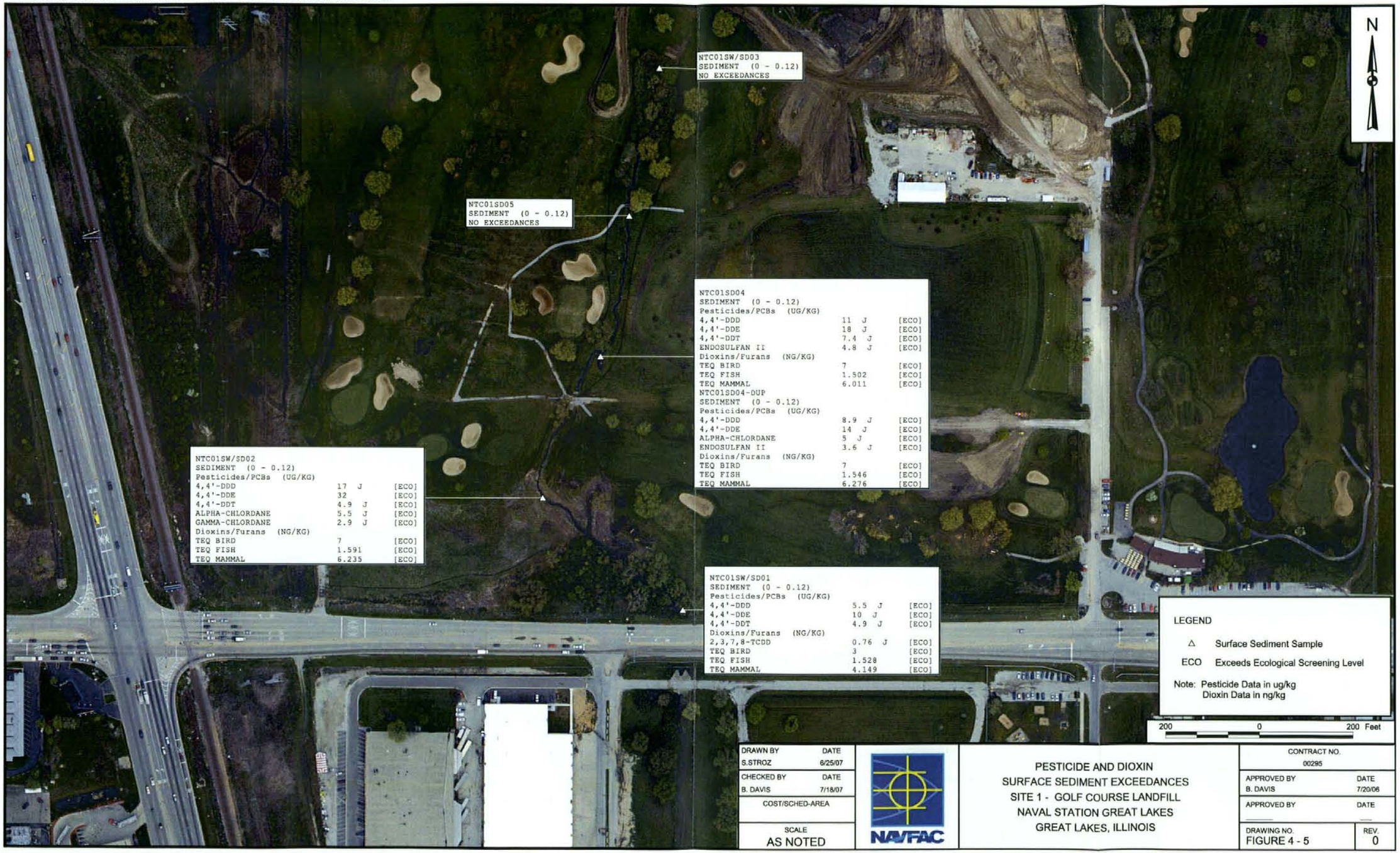
DRAWN BY	DATE
S.STROZ	6/25/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

SVOC AND PAH SURFACE
SEDIMENT EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4 - 4	0

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SITE01 TAG MAPS.APR\SURFACE SEDIMENT PESTICIDES AND DIOXINS TAG LAYOUT 7/18/07 SS



DRAWN BY	DATE
S.STROZ	6/25/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

PESTICIDE AND DIOXIN
SURFACE SEDIMENT EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4 - 5	0

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SURFACE SEDIMENT INORGANICS TAG LAYOUT 7/18/07 SS

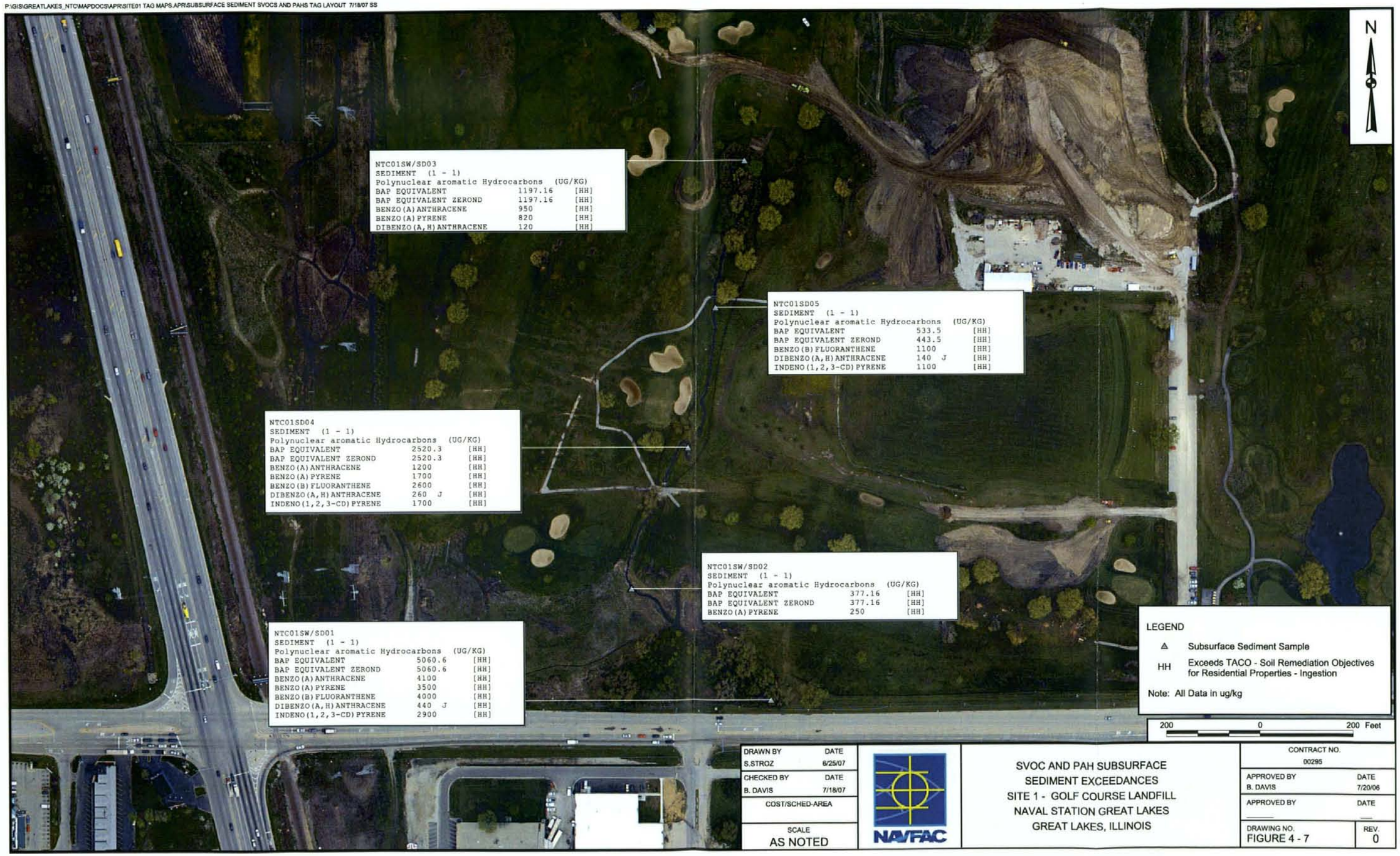
DRAWN BY	DATE
S.STROZ	6/25/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

INORGANIC SURFACE SEDIMENT EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4 - 6	0

P:\GIS\GREATLAKES_NTC\MAPDOCS\APR\SITE01 TAG MAPS.APR\SUBSURFACE SEDIMENT SVOCS AND PAHS TAG LAYOUT 7/18/07 SS



DRAWN BY	DATE
S.STROZ	6/25/07
CHECKED BY	DATE
B. DAVIS	7/18/07
COST/SCHED-AREA	
SCALE	
AS NOTED	

NAVFAC

SVOC AND PAH SUBSURFACE
SEDIMENT EXCEEDANCES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NO.	
00295	
APPROVED BY	DATE
B. DAVIS	7/20/06
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 4 - 7	0

5.0 CHEMICAL FATE AND TRANSPORT ANALYSIS

Knowledge of a contaminant's potential to migrate and persist in an environmental medium is critical when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. This section contains information on various aspects of contaminant fate and transport and the chemical properties affecting contaminant migration at Site 1. Section 5.1 contains a general discussion of the various chemical and physical properties of significant contaminants detected in the media. Section 5.2 reviews the various contaminant transport pathways. Section 5.3 presents a brief discussion of contaminant persistence in the environment, and Section 5.4 presents a summary of contaminant migration.

5.1 CHEMICAL AND PHYSICAL PROPERTIES IMPACTING FATE AND TRANSPORT

Table 5-1 presents the physical and chemical properties of the organic compounds detected at Site 1. Environmental fate and transport characteristics of inorganics detected at Site 1 are provided in Table 5-2. These properties can be used to determine the environmental mobility and fate of site contaminants. The properties of interest include the following:

- Specific gravity
- Vapor pressure
- Water solubility
- Octanol/water partition coefficient (K_{ow})
- Organic carbon partition coefficient (K_{oc})
- Henry's Law constant
- Bioconcentration factor (BCF)
- Distribution coefficient
- Mobility Index (MI)

Empirically determined literature values of the water solubility, K_{ow}, K_{oc}, vapor pressure, Henry's Law constant, BCF, and specific gravity are presented, when available. Calculated values obtained using approximation methods are presented when literature values are not available. A discussion of the environmental significance of each of these parameters follows.

5.1.1 Specific Gravity

Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. A chemical's specific gravity determines whether it will float or sink if it is present in water as a pure chemical or at very high concentrations. Chemicals with specific gravities greater than 1 tend to sink, whereas chemicals with specific gravities less than 1 tend to float. This parameter becomes important in discussions regarding the potential presence of free product in non-aqueous-phase liquids. As shown in Table 5-1, some of the VOCs (ketones and some monocyclic aromatics [toluene]) have specific gravities less than 1; however most chemicals detected at Site 1, including other VOCs (halogenated aliphatics), PAHs, PCBs, phthalate esters, and pesticides, have specific gravities greater than 1.

5.1.2 Vapor Pressure

Vapor pressure provides an indication of the rate at which a chemical volatilizes from both soil and water. It is of primary importance at environmental interfaces such as surface soil/air and surface water/air. Volatilization is not as important when evaluating contaminated groundwater and subsurface soils that are not exposed to the atmosphere. Vapor pressures for VOCs and nitrogen-containing compounds are generally many times higher than vapor pressures for PAHs, pesticides, and PCBs. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Volatilization is a significant loss process for VOCs in surface water or surface soil. Volatilization is not significant for inorganics. Surface water and surface sediments at Site 1 do not contain high concentrations of VOCs; therefore, volatilization may not be an important loss mechanism at Site 1.

5.1.3 Water Solubility

The rate at which a chemical is leached from soil or solid wastes by infiltrating precipitation is proportional to its water solubility. More soluble chemicals are more readily leached from soil than less soluble chemicals. VOCs are usually several orders of magnitude more water soluble than PAHs, pesticides, and PCBs.

The solubility of inorganics is strongly influenced by their valence state(s) and forms (hydroxides, oxides, carbonates, etc.). Their solubility is also dependent on pH, Eh (oxidation-reduction potential), temperature, and other ionic species in solution (the Debye-Huckel theory). The solubility products

reported in the literature vary with the type of complex formed, but generally it can be noted that, for example, cadmium and copper complexes are more soluble than lead and nickel complexes.

5.1.4 Octanol/Water Partition Coefficient

The K_{ow} is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between the K_{ow} and the uptake of chemicals by fatty tissues of animal and human receptors, the BCF, has been established (Lyman et al., 1990). The K_{ow} is also used to estimate BCFs in aquatic organisms. It is useful in characterizing the sorption of compounds by organic soils where experimental values are not available. Pesticides and PCBs are several orders of magnitude more likely to partition to fatty tissues than the more soluble VOCs.

5.1.5 Organic Carbon Partition Coefficient

The K_{oc} indicates the tendency of a chemical to adhere to soil particles containing organic carbon. Chemicals with high K_{oc} values generally have low water solubilities and vice versa. This parameter may be used to infer the relative rates at which more mobile chemicals (ketones, monocyclic aromatics, and halogenated aliphatics) are transported in groundwater. Chemicals such as most pesticides, PAHs, and PCBs are relatively immobile in the soil and are preferentially bound to soil. These compounds are not subject to groundwater transport to the extent that compounds with higher water solubilities are. However, these immobile chemicals are easily transported by erosional processes when they are present in surface soils.

5.1.6 Henry's Law Constant

Both the vapor pressure and the water solubility help determine volatilization rates from surface water bodies and groundwater. The ratio of these two parameters, the Henry's Law constant, is used to calculate the equilibrium chemical concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings. In general, chemicals having a Henry's Law constant of less than 1×10^{-5} atm-m^3/mole, such as pesticides and PCBs, should volatilize very little and be present only in minute amounts in the atmosphere or soil gas. For chemicals with a Henry's Law constant greater than 5×10^{-3} atm-m^3/mole, such as many VOCs (halogenated aliphatics), volatilization and diffusion in soil gas could be significant.

5.1.7 Bioconcentration Factor

The BCF represents the ratio of aquatic-animal-tissue concentration to water concentration. The ratio is both contaminant- and species specific. When site-specific values are not measured, literature values are used or the BCF is derived from the K_{ow}. Many pesticides, PCBs, and PAHs will bioconcentrate at levels three to five orders of magnitude greater than those concentrations found in the water, whereas VOCs and nitrogen-containing compounds are not as readily bioconcentrated.

5.1.8 Distribution Coefficient

The distribution coefficient (K_d) is a measure of the equilibrium distribution of a chemical or ion in soil/water systems. The distribution of organic chemicals is a function of both the K_{oc} and the amount of organic carbon in the soil. For ions (e.g., metals), K_d is the ratio of the concentration adsorbed on soil surfaces to the concentration in water. K_d for metals vary over several orders of magnitude because the K_d is dependent on the size and charge of the ion and the soil properties governing exchange sites on soil surfaces. Coulomb's Law predicts that the ion with the smallest hydrated radius and the largest charge will be preferentially accumulated over ions with larger radii and smaller charges.

5.1.9 Mobility Index

The MI is a quantitative assessment of mobility that uses water solubility, vapor pressure, and the K_{oc} (Laskowski, 1983). It is defined as:

$$MI = \log((\text{water solubility} * \text{vapor pressure})/K_{oc})$$

A scale to evaluate MI as presented by Ford and Gurba (1994) is as follows:

Relative MI	Mobility Description
> 5	extremely mobile
0 to 5	very mobile
-5 to 0	slightly mobile
-10 to -5	immobile
< -10	very immobile

Of the chemicals detected at Site 1, chlorinated solvents and ketones generally have MIs greater than 5 and are considered extremely mobile. Lighter molecular weight PAHs, such as naphthalene, have MIs

ranging form -5 to 0 and are considered slightly mobile and the heavier molecular weight PAHs (e.g., BaP) are classified as very immobile, with MIs less than -10. The MIs of phthalate esters detected at Site 1 range from -0.73 (diethylphthalate) to -15.22 (di-n-octylphthalate) and are therefore classified as slightly mobile to very immobile. The MIs of pesticides detected at Site 1 range from -0.637 (delta-BHC) to -15.8 (DDT), with most of the pesticides having MIs less than -10. Therefore, pesticides are generally considered to be very immobile in soil. The MIs of PCBs are less than -10, and these chemicals are classified as very immobile. The MIs for chemicals detected at Site 1 are presented in Table 5-1.

5.2 CONTAMINANT TRANSPORT PATHWAYS

This section presents a brief overview of contaminant fate and transport issues at Site 1. Based on the evaluation of existing conditions at Site 1, the following potential contaminant transport pathways have been identified:

- Leaching of soil contaminants to groundwater
- Migration of groundwater contaminants
- Leaching of sediment contaminants to surface water
- Migration of contaminants in surface water
- Erosion and runoff of contaminated soil and deposition in surface water bodies.

5.2.1 Leaching of Soil Contaminants to Groundwater

Contaminants that adhere to soil particles or have accumulated in soil pore spaces can leach and migrate vertically to groundwater as a result of infiltration or precipitation. The rate and extent of this leaching are influenced by the depth of the water table, amount of precipitation, rate of infiltration, physical and chemical properties of the soil, and physical and chemical properties of the contaminant.

5.2.2 Migration of Groundwater Contaminants

Contaminants can migrate in either a dissolved phase or as an immiscible liquid. A contaminant that is present in water above its solubility concentration will form an immiscible liquid. Based on the specific gravity of the contaminant, it will either float or sink in the water. In the case of chlorinated solvents (e.g., chlorobenzene), the contaminant will sink in the water because it has a higher specific gravity than water. Subsurface transport of the immiscible contaminants is governed by a set of factors different from those of dissolved contaminants. However, none of the chemicals detected in groundwater at Site 1 were at concentrations approaching or exceeding solubility levels. Therefore, transport of chemicals in site

groundwater is likely to occur in the dissolved phase. Contaminants in the dissolved phase may volatilize from groundwater to air, evaporate directly into air, or sorb from groundwater to solid surfaces.

Contaminant concentrations may be affected by one or more mechanisms during transport. Volatilization or precipitation may physically transform contaminants, or they may be chemically transformed through photolysis, hydrolysis, or oxidation-reduction. Contaminants may also be biologically transformed by biodegradation. Additionally, contaminants may accumulate in one or more media.

After a chemical is dissolved in groundwater, three general processes govern the migration of dissolved constituents: advection, dispersion, and retardation. Advection is a process by which solutes are carried by groundwater movement. Dispersion is a mixing of contaminated and uncontaminated water during advection. Retardation is a slowing of contaminant migration caused by the reaction of the solute with the particulate matter in the aquifer matrix.

5.2.3 Leaching of Sediment Contaminants to Surface Water

Contaminants that adhere to sediment particles or have accumulated in sediment pore spaces can leach and migrate to surface water. The rate and extent of this migration are influenced by the physical and chemical properties of the soil and the physical and chemical properties of the contaminant.

Site 1surface water and sediment data discussed in Section 4.0 appear to indicate that sediment contaminants are not leaching to surface water bodies within Site 1.

5.2.4 Migration of Contaminants in Surface Water

Contaminants in surface water can migrate as dissolved constituents in the direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: movement caused by the flow of surface water, movement caused by the irregular mixing of water, and chemical mechanisms occurring during the movement of surface water. In addition, sediment particles can disassociate from sediment into surface water and migrate by one of the aforementioned methods.

5.2.5 Erosion and Runoff of Contaminated Soil and Deposition in Surface Water Bodies

Chemicals adhering to particulate matter in soil (or sediment) may migrate by erosional processes, such as rainwater runoff, to drainage ditches or nearby streams. This is a potentially important migration

mechanism for environmentally immobile chemicals (i.e., PAHs, PCBs, pesticides, and metals) that tend to bind to soil and sediment. The contaminated soil (or sediment) particles may be moved by runoff or the intermittent flow in drainage ditches and be deposited in nearby streams. Sediment data from samples collected from water bodies in Site 1 indicate that erosional processes may have contributed to the presence of PAHs, PCBs, pesticides, and metals at this site.

5.3 CHEMICAL PERSISTENCE

The persistence of various classes of chemicals is discussed in this section. Several transformation mechanisms affect chemical persistence, such as hydrolysis, biodegradation, photolysis, and oxidation-reduction reactions. The following general classes of compounds are discussed:

- Ketones (e.g., 2-butanone and acetone)
- Monocyclic aromatics (e.g., phenol and toluene)
- Halogenated aliphatics (e.g., chlorobenzene and methylene chloride)
- PAHs (e.g., naphthalene, BaP, and pyrene)
- Phthalate esters [e.g., bis(2-ethylhexyl)phthalate]
- Pesticides (e.g., dieldrin, DDT and metabolites, and chlordanes)
- PCBs (e.g., Aroclor-1248, Aroclor-1254, and Aroclor-1260)
- Dioxins as 2,3,7,8-TCDD
- Metals

5.3.1 Ketones

Ketones are highly volatile and soluble, and these two characteristics dominate the fate of these compounds in the environment. Hydrolysis is generally not a significant fate process for this class of chemicals, nor is bioconcentration significant, based on the low K_{ow}s (Howard, 1990).

Acetone is completely miscible in water and is unlikely to adsorb to soil or sediments or bioaccumulate. It has a high vapor pressure and, once released to the air, photolysis and reaction with hydroxyl radicals result in an average half-life of 22 days (Howard, 1990).

2-Butanone (methyl ethyl ketone) may be removed from soil by direct photolysis, volatilization, or aerobic biodegradation. It is also susceptible to leaching and may be found in groundwater. If released to surface water, it is subject to direct photolysis and has an estimated atmospheric half-life of about 14 days.

2-Butanone does not significantly bioconcentrate or adsorb to soil and is expected to biodegrade under aerobic and anaerobic conditions (TOXNET, July 2006).

5.3.2 Monocyclic Aromatics

Monocyclic aromatic compounds such as phenol are not considered to be persistent in the environment, particularly compared to chemicals such as PAHs and pesticides. Monocyclic aromatics are subject to degradation via the actions of both soil and aquatic microorganisms. The biodegradation of these compounds in the soil matrix is dependent on the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, etc.

Although these compounds are amenable to microbial degradation, it is not anticipated that degradation will occur at an appreciable rate, although macronutrient availability is not known. In the event that these compounds discharge to surface water bodies, volatilization and biodegradation may occur relatively rapidly. For example, a reported first-order biodegradation rate constant for benzene is 0.11 day^{-1} in aquatic systems (Lyman et al., 1990). This corresponds to an aquatic half life of approximately 6 days. Other monocyclic aromatics are subject to similar degradation processes in aquatic environments (USEPA, December 1982).

Additional environmental degradation processes, such as hydrolysis and photolysis, are considered to be insignificant fate mechanisms for monocyclic aromatics in aquatic systems (USEPA, December 1982). However, some monocyclic aromatics such as toluene have been shown to undergo clay-, mineral-, and soil-catalyzed oxidation (Dragun, 1988).

5.3.3 Halogenated Aliphatics

In general, halogenated aliphatic hydrocarbons are subject to abiotic dehydrohalogenation. This process is an elimination reaction that results in the formation of an ethene from a saturated halogenated compound. Research indicates that microbial degradation of highly chlorinated ethanes is a relatively slow process. Hydrolysis, photolysis, and oxidation are generally not considered to be significant fate processes for chlorinated ethanes.

Under certain conditions, volatilization is a significant fate process for these compounds. Volatilization is only significant at the air-soil or air-water interface. Compounds such as chloroform and methylene chloride volatilize rapidly to the atmosphere from soil or surface water due to low adsorption properties.

Adsorption should not be considered as an important fate for these types of compounds when compared to more hydrophobic compounds. BCFs indicate that these compounds should not bioaccumulate.

Photolysis is not considered to be a relevant degradation mechanism for this class of compounds. Limited hydrolysis of saturated aliphatics (i.e., alkanes) may occur, but it does not appear to be a significant degradation mechanism for unsaturated species (i.e., alkenes) (USEPA, December 1982).

5.3.4 PAHs

PAHs have very low solubilities, vapor pressures, and Henry's Law constants and high K_{oc}s and K_{ow}s. As discussed in Section 5.1.9, the lower molecular weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) are more environmentally mobile than the higher-molecular-weight PAHs and are more likely to leach to groundwater. The high molecular weight PAHs [e.g., BaP, benz(a)anthracene, chrysene, etc.] are less mobile and tend to adhere to soil particles. Therefore, PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than to go into solution. PAHs are subject to degradation via aerobic bacteria but may be relatively persistent in the absence of microbial population or macronutrients such as phosphorus and nitrogen.

Bioconcentration of PAHs in aquatic organisms is greater for the higher molecular weight compounds than the lower molecular weight compounds. PAHs can be bioaccumulated from water, sediments, or lower organisms in the food chain.

Landspreading applications have indicated that PAHs are highly amenable to microbial degradation in soil. The rate of degradation is influenced by temperature, pH, oxygen concentrations, initial chemical concentrations, and moisture. Photolysis, hydrolysis, and oxidation are not important fate processes for the degradation of PAHs in soil (ATSDR, April 1989).

The most important fates of PAHs in water are photooxidation, chemical oxidation, and biodegradation. PAHs do not contain functional groups that are susceptible to hydrolytic action, and hydrolysis is considered to be an insignificant degradation mechanism. The rate of photodegradation is influenced by water depth, turbidity, and temperature. BaP and chrysene are reported to be resistant to photodegradation. PAHs may also be oxidized by chlorination and ozonation and may be metabolized by microbes under oxygenated conditions (ATSDR, April 1989).

5.3.5 Phthalate Esters

Phthalate esters are considered to be relatively persistent chemicals in the environment. Although numerous studies have demonstrated that phthalate esters undergo biodegradation, it appears that this is a slow process in both soil and water. Certain microorganisms have been shown to excrete products that increase the solubility of phthalate esters and enhance their biodegradation (Gibbions and Alexander, 1989).

Biodegradation of bis(2-ethylhexyl) phthalate and di-n-butyl phthalate in water is an important fate mechanism. However, hydrolysis of bis(2-ethylhexyl) phthalate is very slow, with a calculated half-life of 2000 years. In soil, microorganisms appear to be capable of degrading di-n-butyl phthalate rapidly. Bioaccumulation is also a significant fate process. Photolysis and volatilization are considered to be insignificant degradation mechanisms for phthalate esters (USEPA, December 1979; Howard, 1989).

5.3.6 Pesticides

Whether pesticides are sprayed, dusted, or applied directly to the soil, the soil is the ultimate sink for these chemicals. Surface soil runoff may carry pesticides to adjacent surface water bodies where they are likely to settle in the sediment. Bioconcentration of pesticides in the food chain is another important fate mechanism. Hydrolysis, oxidation, and photolysis are not generally important fate mechanisms for pesticides in soil or water. Hydrolysis half-lives for several pesticides are reported in periods of months to years (USEPA, December 1979). Some of the more common pesticides used in the past are discussed below.

- **4,4'-DDT and its metabolites** are considered to be persistent chemicals. They undergo extensive adsorption to soil and are not highly soluble. Biodegradation may occur under both aerobic and anaerobic conditions in the presence of certain soil microorganisms. Under aerobic conditions, 4,4'-DDT may be transformed to DDE, and under anaerobic conditions, 4,4'-DDD may result. These compounds are, however, somewhat volatile, with a reported half-life of 100 days for 4,4'-DDT. They are highly lipophilic and therefore readily bioaccumulate (ATSDR, October 1992). 4,4'-DDT is no longer produced in the United States.

- **Aldrin** is readily converted to **dieldrin.** Dieldrin is a particularly persistent pesticide but is no longer registered for general use. In soil, dieldrin will persist for long periods (more than 7 years) and may slowly evaporate. It does not readily leach to groundwater. Once in surface waters (via runoff),

dieldrin adsorbs strongly to sediments and bioconcentrates and slowly photodegrades. Biodegradation and hydrolysis are not significant (Howard, 1991 and ATSDR, February 1992).

- **Endrin and its metabolites** are no longer produced or used in the United States. These compounds will remain in soil and do not leach significantly, with half-lives of more than 14 years in soil. One common transportation and degradation mechanism is photochemical degradation. In water, endrin would not be expected to biodegrade or hydrolyze to any significant extent and therefore will bioconcentrate in aquatic organisms (USEPA, 1985).

- **Chlordane** is extremely persistent in the environment and in some soils may persist for greater than 20 years. Volatilization is an important removal mechanism in water and soil. Leaching to groundwater may occur at sites with high levels of organic solvents.

- **Heptachlor** was restricted to underground termite control in 1983. Heptachlor epoxide is formed by the biological transformation of heptachlor in the environment. These compounds sorb strongly to soil. Heptachlor is subject to biodegradation (forming heptachlor epoxide, which is highly resistant to biodegradation) and hydrolysis. Bioconcentration of both compounds is significant, and volatilization and photolysis are very slow (Howard, 1991).

5.3.7 PCBs

PCBs are considered to be very persistent organic chemicals. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded. Although some fungi (e.g., *Phanaerochaete chrysosporium*) may biodegrade PCBs, such fungi may not exist in local soil. There is experimental evidence to suggest that heavier PCBs (five or more chlorines per molecule) can undergo photolytic degradation, but there are no data to suggest that this process operates under environmental conditions. Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs (USEPA, December 1982).

5.3.8 Dioxins as 2,3,7,8-TCDD

2,3,7,8-TCDD is usually released to the environment primarily through emissions from the incineration of municipal and chemical wastes, in exhaust from automobiles using leaded gasoline, and from the improper disposal of certain chlorinated chemical wastes. If released to the atmosphere, vapor-phase TCDD may be degraded by reaction with hydroxyl radicals and direct photolysis. Particulate-phase TCDD may be physically removed from air by wet and dry deposition. If released to water, TCDD will

predominantly be associated with sediments and suspended material. TCDD near the water's surface may experience some photodegradation. Partitioning from the water column to sediment and suspended material will occur. Volatilization from the water column may be important, but adsorption to sediment will limit the overall rate by which TCDD is removed from water. The half-life of TCDD in lakes has been estimated to be in excess of 1.5 years. Bioconcentration in aquatic organisms has been demonstrated. If released to soil, TCDD is not expected to leach. Photodegradation on terrestrial surfaces may be an important transformation process. Volatilization from soil surfaces during warm conditions may be a major removal mechanism. The persistence half-life of TCDD on soil surfaces may vary from less than 1 year to 3 years, but half-lives in soil interiors may be as long as 12 years. Screening studies have shown that TCDD is generally resistant to biodegradation. The major route of exposure to the general population results from incineration processes and exhausts from leaded gasoline engines (TOXNET, July 2006).

5.3.9 Inorganics

Inorganics (metals) are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, or otherwise breakdown. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

The mobility of metals is influenced primarily by their physical and chemical properties, in combination with the physical and chemical characteristics of the soil matrix. Factors that assist in predicting the mobility of inorganic species are the soil/pore water pH, soil/pore water (Eh), and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity (see Table 5-2).

5.4 CONTAMINANT FATE AND TRANSPORT

This section focuses on some of the fate and transport issues associated with the major types of contaminants found at the site.

5.4.1 VOCs

VOCs are typically considered to be fairly soluble with a low capacity for retention by soil organic carbon; therefore, these are the organic compounds most frequently detected in groundwater and surface water. VOCs may migrate through the soil column as infiltrating precipitation solubilizes them after they were released through a spill or subsurface waste burial. Some fraction of these chemicals is retained by the

soil, but most continues migrating downward to the water table. In the groundwater, VOCs migrate primarily laterally, with the hydraulic gradient. Again, some portion may be retained by the saturated soil.

Compounds such as toluene have specific gravities less than that of water. If a spill is large enough, these compounds may move through the soil column as bulk liquids until they reach the water table. Therefore, instead of going into solution, the majority of the release may remain as a discrete layer on top of the water table, with some going into solution at the water/contaminant interface.

Compounds with specific gravities greater than that of water (e.g., methylene chloride) are often used in industrial applications such as degreasing. If a spill of these solvents is large enough, they may also migrate as bulk liquids but will not stop at the water table (i.e., they will mix and sink into the aquifer).

Low concentrations of various VOCs were detected in subsurface soil, groundwater, and surface water samples collected at Site 1. No VOCs were detected in sediment samples collected. As expected, the data indicate that the VOCs detected have a low capacity for retention by soil organic carbon. and VOCs were more often detected in groundwater and surface water samples. These data indicate that there is no appreciable migration of VOCs from surface to subsurface sediments. Because there is little migration, it also stands to reason that the sediment is not the source of VOCs in groundwater and surface water in this area. Conversely, groundwater or surface water is not the source of the VOCs in the surface sediment samples.

5.4.2 PAHs

PAHs are generally considered to be fairly immobile in the environment. They are large molecules with high K_{oc}s and low solubilities when compared to VOCs. These compounds generally do not migrate vertically through soil to a great extent. Instead, they are more likely to adhere to soil particles and be transported with the soil particles via surface runoff and erosional processes. Their limited presence in sediment may be a result of surface erosion, and their absence in surface water is consistent with their ability to bind to soil and sediment.

Although low concentrations of PAHs were detected in groundwater and surface water at Site 1, PAHs were detected more frequently and at higher concentrations in subsurface soil and sediment samples. This is consistent with the fact that PAHs are fairly immobile in the environment. The presence of the PAHs in sediment samples may be attributable to soil erosion and roadway runoff and deposition of the material in the surface water body or it may be attributable to increased vehicle traffic in the area of Site 1.

5.4.3 Pesticides

Like PAHs, pesticides as a class are not considered to be very mobile in the environment. These chemicals, upon application or disposal, tend to remain fixed to soil particles. Migration of pesticides occurs primarily by erosion, which can account for their presence in sediment.

No pesticides were detected in groundwater or surface water samples; however, pesticides were detected in subsurface soil samples, surface sediment samples, and subsurface sediment samples. This is consistent with the fact that pesticides are fairly immobile in the environment. The presence of the pesticides in sediment may be due to soil erosion and deposition in the surface water body.

5.4.4 PCBs

PCBs are considered to be very persistent organic chemicals. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded (USEPA, December 1979). Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs (USEPA, December 1982).

PCBs were detected in subsurface soil and subsurface sediment samples collected at Site 1. The presence of PCBs in sediment is most likely the result of soil erosion and deposition in the surface water body. PCBs were not detected in groundwater or surface water samples, indicating that PCBs are fairly immobile in the environment. PCBs were also not detected in surface sediment samples.

5.4.5 Inorganics

Because inorganics are frequently incorporated into the soil matrix and remain bound to particulate matter, they migrate from source areas via erosion.

There are some instances, however, where inorganics are found at such concentrations or in such forms (i.e., oxidation states) that they may migrate in solution. First, it is possible that uncontrolled industrial activities could saturate the available exchange sites in soil in the immediate vicinity of the activity and result in an inorganic being mobilized. Secondly, inorganics are more mobile under acidic conditions, which are possibly present in environments where metal plating-type activities occurred. Finally, an inorganic solution may be used in some industrial applications. In these cases, it is possible for inorganics to migrate vertically through the soil column and reach the groundwater. Therefore, the

inorganics detected in surface water samples may represent the total of dissolved inorganics (as a result of the processes just described) and inorganics adhering to suspended soil present in the water samples.

Inorganics are naturally occurring substances; therefore, it is not unusual that they were detected in the media at Site 1. Because inorganics tend to adhere to particulate matter (similar to PAHs and PCBs), their release and migration patterns are similar to these chemicals. Inorganic contamination at some locations may have been the result of past landfill operations. The presence of antimony, arsenic, chromium, copper, iron, lead, manganese, mercury, silver, thallium and zinc at Site 1 may be related to these past operations.

TABLE 5-1

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical	Specific Gravity (@ 20/4°C)(1)	Vapor Pressure (mm Hg @ 20°C)(1)	Solubility (mg/L @ 20°C)(1)	Octanol/Water Partition Coefficient(1)	Organic Carbon Partition Coefficient(2)	Henry's Law Constant (atm-m3/mole)(1)	Bioconcentration Factor (mg/L/mg/kg)(2)	Mobility Index log((solubility*VP)/K_{oc})
KETONES								
2-Butanone	0.8054	1.0E+2 (25°C)	2.75E+05	1.82E+00	4.44E+0(3)	4.66E-5 (25°C)	9.3E-1(4)	6.79E+00
Acetone	0.7899	2.66E+2 (25°C)	Miscible	5.75E-01	7.08E+03 (5)	4.276E-5 (25°C)	3.81E-1(4)	NA
MONOCYCLIC AROMATICS								
1,4-Dichlorobenzene	1.29	1.20E+00	7.38E+01(9)	2.63E+03(9)	6.16E+02(9)	2.43E-03(9)	2.3E+02(6)	-8.42E-01
2-Methylphenol	1.047	2.99E-01	2.60E+04	9.55E+01	9.12E+01	1.20E-06	1.60E+01	1.93
4-Methylphenol	1.0178	1.1E-1 (25°C)	2.4E+4 (25°C)	8.32E+01	9.0E-1(4)	3.92E-07	1.7E+1(10)	3.47
Benzene	0.8765	9.50E+01	1.75E+03	1.35E+02	5.89E+01	5.55E-03	3.70E+01	3.45
Phenol	1.0576	3.5E-1 (25°C)	8E+4 (25°C)	2.88E+01	2.88E+01 (5)	1.3E-6 (25°C)	9.40E+00	2.99E+00
Toluene	0.8669	2.8E+1 (25°C)	5.15E+02	4.90E+02	1.82E+02 (5)	5.92E-3 (25°C)	1.48E+02	1.90E+00
HALOGENATED ALIPHATICS								
1,1-Dichloroethane	1.1757	2.34E+2 (25°C)	5.50E+03	1.67E+01	3.13E+01	5.871E-3 (25°C)	1.90E+01	4.61
Chlorobenzene	1.11	1.18E+01	4.72E+02(9)	7.24E+02(9)	2.24E+02(9)	2.43E-03(9)	7.9E+01(6)	1.40E+00
cis-1,2-Dichloroethene	1.2837	2.02E+2 (25°C)	8.00E+02	1.58E+02	3.55E+01 (5)	4.08E-3 (24.8°C)	1.4E+1(6)	3.66E+00
Methylene chloride	1.3266	4.29E+2 (25°C)	1.67E+4 (25°C)	1.78E+01	1.17E+01 (5)	3.19E-3 (25°C)	6.00E+00	5.79E+00
Vinyl chloride	0.9106	2.58E+03	1.1E+3 (25°C)	3.98E+00	1.86E+01 (5)	2.78E-2 (25°C)	5.70E+00	5.18E+00
Xylenes (Total)	0.86104-0.8801	1E+1 (27.3-32.1°C)	1.6E+2-1.75E+2(6)	5.89E+2-1.58E+3	3.63E+02-4.07E+02	4.184E-3-6.662E-3 (25°C)	7.5E+1-1.59E+2(10)	0.644-0.633
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs)								
2-Methylnaphthalene	1.0058	1E+1 (105°C)	2.6E+1 (25°C)	7.24E+03	7.27E+2 (3)	4.99E-4 (25°C)	5.1E+2 (4)	-4.47E-01
Acenaphthene	1.07	5.00E-03	4.24E+02	8.32E+03	7.08E+03	2.41E-04 (25°C)	1.10E+03	-3.52
Acenaphthylene	1.02	2.30E-02	1.61E+01	1.17E+04	2.00E+03	1.14E-04	3.80E+02	-3.73E+00
Anthracene	1.283 (25/4°C)	1.95E-4 (25°C)	1.29E+0 (25°C)	2.82E+04	2.95E+04 (5)	8.6E-5 (25°C)	4.70E+03	-8.07E+00
Benzaldehyde	1.05	1.27E-01	2.00E+03	3.02E+01	3.4E+01-1.5E+02	4.23E-05	4.2E+00-7.8E+00	8.7E-01 - 1.7E+00
Benzo(a)anthracene	1.274	5.00E-09	1E-2 (24°C)	4.07E+05	3.98E+05 (5)	6.60E-07	5.30E+04	-1.59E+01
Benzo(a)pyrene	1.351	5.00E-09	3.8E-3 (25°C)	9.55E+05	1.02E+06 (5)	4.9E-7 (25°C)	1.40E+05	-1.67E+01
Benzo(b)fluoranthene	NA	5.00E-07	1.2E-3 (25°C)	3.72E+06	1.23E+06 (5)	1.20E-05	1.40E+05	-1.53E+01
Benzo(g,h,i)perylene	1.35	1.00E-10	2.6E-4 (25°C)	1.70E+07	1.60E+06	1.4E-7 (25°C)	3.50E+05	-1.98E+01
Benzo(k)fluoranthene	NA	9.59E-11	5.5E-4 (25°C)	6.92E+06	1.23E+06 (5)	1.04E-03	1.40E+05	-1.94E+01
Carbazole	1.1	1.37E-06	7.48E+00	3.89E+03	3.39E+03	1.53E-08	5.01E+02	-8.52E+00
Chrysene	1.274 (20°C)	6.3E-9 (25°C)	6E-3 (25°C)	4.07E+05	3.98E+05 (5)	1.05E-6 (25°C)	5.30E+04	-1.60E+01
Dibenzo(a,h)anthracene	1.282	1.00E-10	5E-4 (25°C)	9.33E+05	3.80E+06 (5)	7.3E-8 (25°C)	6.90E+05	-1.99E+01
Dibenzofuran	1.0886	4.40E-02	4.22E+00	1.32E+04	8.13E+03	NA	8.00E+02	-4.64E+00
Fluoranthene	1.252	5.0E-6 (25°C)	2.65E-1 (25°C)	2.14E+05	1.07E+05 (5)	6.5E-6 (25°C)	1.20E+04	-1.09E+01
Fluorene	1.202	1.00E+01	1.98E+00	1.62E+04	1.38E+04	6.36E-05	3.80E+03	-2.84E+00
Indeno(1,2,3-cd)pyrene	NA	1E-10 (25°C)	6.20E-02	4.57E+07	3.47E+06 (5)	6.95E-8 (25°C)	3.50E+05	-1.77E+01
Isopropylbenzene	0.862	4.50E+00	6.13E+01	3.16E+03	2.29E+03	1.15E-02	2.70E+02	-0.92
Naphthalene	1.162	8.2E-2 (25°C)	3E+1 (25°C)	2.34E+03	2.00E+03 (5)	4.83E-4 (25°C)	4.20E+02	-2.91E+00
Phenanthrene	0.980 (4°C)	1E+0 (118.2°C)	8.16E-1 (21°C)	2.88E+04	1.40E+04	3.93E-5 (25°C)	4.70E+03	-4.23E+00
Pyrene	1.271 (23/4°C)	2.5E+0 (200°C)	1.6E-1 (26°C)	1.51E+05	1.05E+05 (5)	5.1E-6 (25°C)	1.20E+04	-5.42E+00
PHTHALATE ESTERS								
Bis(2-ethylhexyl)phthalate	0.99 (20/20°C)	1.2E+0 (200°C)	4E-1 (25°C)	2.00E+05	1.51E+07 (5)	3.00E-07	2.30E+08	-7.50E+00
Butylbenzylphthalate	1.113	8.60E-06	7.10E-01	6.92E+04	5.75E+04	1.26E-06	7.72E+02	-9.97E+00
Diethylphthalate	1.1175	5E-2 (70°C)	1.08E+3 (25°C)	9.12E+02	2.88E+02	8.46E-07	1.07E+02	-0.73
Di-n-butylphthalate	1.047 (20/20°C)	1E-1 (115°C)	4E+2 (25°C)	1.58E+05	3.39E+04 (5)	2.8E-7 (25°C)	4.70E+04	-2.93E+00
Di-n-octylphthalate	0.978	2.50E-06	2.00E-02	1.15E+08	8.32E+07	6.68E-05	2.6E+03 - 9.3E+03	-15.22
MISCELLANEOUS VOLATILE ORGANICS								
Carbon disulfide	1.2632	2.98E+02	2.90E+03	1.45E+04	4.57E+01	1.921E-2 (25°C)	2.6E+1 (6)	4.28
Cyclohexane	0.7781(13)	9.69E+01	5.5E+01(13)	2.75E+03(13)	1.6E+02(14)	2.0E+-01(14)	8.9E+01(13)	1.52E+00
Methyl Cyclohexane	0.7694(13)	4.60E+01	1.4E+01(13)	4.07E+03(13)	2.68E+02(11)	4.3E-01(13)	1.2E+02(11)	3.81E-01

TABLE 5-1

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical	Specific Gravity (@ 20/4°C)(1)	Vapor Pressure (mm Hg @ 20°C)(1)	Solubility (mg/L @ 20°C)(1)	Octanol/Water Partition Coefficient(1)	Organic Carbon Partition Coefficient(2)	Henry's Law Constant (atm-m3/mole)(1)	Bioconcentration Factor (mg/L/mg/kg)(2)	Mobility Index log((solubility*VP)/K_{oc})
PESTICIDES								
4,4'-DDD	1.476	1.0E-06 (30°C)	1.6E-1 (24°C)	9.77E+05	1.00E+06 (5)	2.16E-05	1.80E+05	-1.28E+01
4,4'-DDE	NA	6.50E-06	4.00E-02	4.90E+05	4.47E+06 (5)	2.34E-05	8.90E+05	-1.32E+01
4,4'-DDT	1.5 (15/4°C)	1.50E-07	3.1E-3 (25°C)	1.55E+06	2.63E+06 (5)	3.89E-5 (25°C)	8.00E+06	-1.58E+01
Aldrin	1.18	2.31E-05	1.80E-01	3.16E+06	2.45E+06	6.97E-03	1.10E+02	-1.18E+01
alpha-BHC	1.87	4.50E-05	2.00E+00	6.31E+03	1.23E+03	1.05E-05	2E+02 - 2E+03	-7.14E+00
alpha-Chlordane (7)	1.61 (25°C)	1E-5 (25°C)	5.60E-02	6.03E+02	1.20E+05	4.79E-05 (25°C)	4.00E+04	-1.13E+01
delta-BHC	1.87	1.75E-05	1.7E+01 (24°C)	1.38E+04	7.1E+02 - 2.7E+03	3.84E-07	8.00E+02	- 6.37E-01 - -6.96E-01
Dieldrin	1.75	1.8E-7 (25°C)	1.86E-01	1.23E+04	2.14E+04 (5)	5.84E-5 (25°C)	7.10E+02	-1.18E+01
Endosulfan I (8)	1.745 (20/20°C)	2.40E-5 (25°C)	5.1E-01(6)	1.26E+04(6)	2.04E+03(6)	1.12E-05(6)	2.9E+02(6)	-8.22E+00
Endosulfan II	1.745 (20/20°C)	2.40E-5 (25°C)	5.1E-01(6)	1.26E+04(6)	2.04E+03(6)	1.12E-05(6)	2.9E+02(6)	-8.22E+00
Endosulfan sulfate	NA	9.00E-03	1.17E-01	3.66E+00	3.76E+00	4.70E-07	3.56E+02	-3.55E+00
Endrin	1.65 (25°C)	2.0E-7 (25°C)	2.5E-01(6)	1.15E+05(6)	1.08E+04(6)	7.52E-06(6)	1.8E+03(6)	-1.13E+01
Endrin ketone	NA	NA	NA	NA	NA	NA	NA	NA
gamma-BHC (Lindane)	1.61 (25°C)	1E-5 (25°C)	6.80E+00	5.37E+03	1.07E+03	1.40E-05	4.00E+04	-1.13E+01
gamma-Chlordane (7)	1.61 (25°C)	1E-5 (25°C)	5.60E-02	6.03E+02	1.20E+05	4.79E-05 (25°C)	4.00E+04	-1.13E+01
Heptachlor	1.57 (9°C)	3E-04 (25°C)	5.6E-2 (25°C)	2.51E+04	1.41E+06(5)	1.48E-03	4.40E+03	-10.92
Heptachlor epoxide	NA	3.00E-04	3.5E-1(15°C)	5.00E+00	8.32E+04	3.90E-04	7.50E+03	-8.90E+00
Methoxychlor	1.41 (25°C)	NA	4.0E-02 (24°C)	4.91E+00	1.07E+05	1.60E-05	8.10E+03	NA
PCBs								
Aroclor-1248	1.405	1.84E-04	5.40E-02	6.31E+05	5.03E+05	4.40E-04	1.50E+04	-10.71
Aroclor-1254	1.50 (25°C)(2)	7.71E-5(2)	3.1E-2(2)	1.1E+6(2)	5.30E+05	2.6E-3(2)	1.30E+05	-11.30
Aroclor-1260	1.58 (25°C)(2)	4.05E-5(2)	2.7E-3(2)	1.4E+7(2)	6.70E+06	7.4E-1(2)	1.30E+06	-13.79
DIOXINS/FURANS								
TCDDs	NA	1.4E-8 (25°C)	3.3E-4 (25°C)	3.2E+06	1.1E+02 - 3.2E+08	1.70E-05	5.4E+03 - 7.9E+05	-1.66E+01
PeCDDs	NA	5.6E-10 (25°C)	1.18E-04	4.0E+06	7.1E+04 - 2.4E+06	2.60E-06	1.90E+05	-1.88E+01
HxCDDs	NA	4.4E-11 (25°C)	4.4E-6 (25°C)	2.0E+07	1.0E+05 - 1.3E+07	1.10E-05	1.7E+03 - 1.0E+05	-2.18E+01
HpCDDs	NA	3.2E-11 (25°C)	2.40E-06	1.0E+08	3.0E+05 - 6.3E+07	1.26E-05	5.1E+02 - 4.8E+04	-2.28E+01
OCDD	NA	8.25E-13 (25°C)	7.4E-8 (25°C)	1.6E+08	8.3E+05 - 7.9E+07	6.75E-06	7.9E+01 - 1.3E+04	-2.61E+01
TCDFs	NA	2.5E-8 (25°C)	4.2E-4 (22.7°C)	1.6E+06	1.6E+05 - 3.2E+07	1.40E-05	2.5E+03 - 6.6E+04	-1.73E+01
PeCDFs	NA	2.7E-9 (25°C)	2.4E-4 (22.7°C)	2.5E+06	3.9E+05 - 2.5E+07	5.00E-06	5.0E+03 - 1.4E+05	-1.87E+01
HxCDFs	NA	2.8E-10 (25°C)	1.3E-5 (22.7°C)	1.0E+07	2.50E+07	1.10E-05	8.90E+04	-2.18E+01
HpCDFs	NA	4.7E-11 (25°C)	1.4E-6 (22.7°C)	2.5E+07	1.0E+05 - 7.9E+07	1.40E-05	2.90E+04	-2.26E+01
OCDF	NA	3.75E-12 (25°C)	1.16E-6 (25°C)	1.0E+08	1.0E+06 - 2.5E+07	1.88E-06	5.9E+02 - 7.9E+03	-2.41E+01
HERBICIDES								
Pentachlorophenol	NA	1.10E-4 (25°C)	1.4E-1 (25°C)	5.12E+00	5.92E+02 (11)	2.45E-8 (25°C)	1.09E+02 (12)	-5.58E+00

NA - Not available.
1 USEPA, September 1992, Handbook of RCRA Groundwater Monitoring Constituents: Chemical and Physical Properties.
2 USEPA, December 1982, Aquatic Fate Process Data for Organic Priority Pollutants.
3 Lyman et al., 1990; Equation 4-5.
4 Lyman et al., 1990, Eq. 5-2.
5 USEPA, July 1996, Soil Screening Guidance.
6 Lyman et al., 1990; Equation 5-3, Handbook of Chemical Property Estimation Methods.
7 Chlordane data used.
8 Endosulfan II data used.
9 Mabey et al., 1982
10 Syracuse Research Corporation. Online Database: Interactive Physical Properties Database Demo. http://www.syrres.com/esc/chemfate.htm. Web site last updated October 17, 2001.
11 ORNL Risk Assessment Information System
12 USEPA, August 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waster Combustion Facilities, Appendix C Media-to-Receptor Bioconcentration Factors (BCFs).
13 TOXNET (Hazardous Substance Data Bank). Http://toxnet.nlm.nih.gov, July 2006.
14 USEPA Region 9 Preliminary Remediation Goal Tables (July 2006).

TABLE 5-2

PHYSICAL AND CHEMICAL PROPERTIES OF INORGANIC SITE CHEMICALS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical	Molecular Weight (g/mol) (1)	Specific Gravity (20/4 C) (1)	Vapor Pressure (25 C) (mm Hg) (1)	Solubility (25 C) (mg/L) (1)	Henry's Law Constant (25 C) (atm-m^3/mol) (1)	Bioconcentration Factor (L/kg) (2)
Inorganics						
Aluminum	26.98 (5)	2.708 (20°C) (5)	NA	NA	NA	36
Antimony	121.75	6.684 (25°C)	1 (886°C)	insoluble	NA	NA
Arsenic	74.9216	5.727 (14°C)	1 (372°C)	insoluble	NA	350
Barium	137.33	3.51 (20°C)	10 (1049°C)	hydrolyzes	NA	NA
Beryllium	9.01218	1.85 (20°C)	1 (1520°C)	insoluble	NA	NA
Cadmium	112.41	8.642 (UT)	NA	insoluble	NA	7400
Chromium	51.996	7.2 (28°C)	1 (1616°C)	insoluble	NA	1
Cobalt	58.9332	8.9 (UT)	30 (2375°C)	insoluble	NA	NA
Copper	63.546	8.92 (UT)	1 (1628°C)	insoluble	NA	23000
Cyanide	26.02	NA	NA	NA	NA	NA
Iron	55.85 (2)	7.9 (2)	NA (2)	NA (2)	NA (2)	NA
Lead	207.2	11.2960 (16°C)	1(970°C)	insoluble	NA	1700
Manganese	54.938 (4)	7.2 (4)	NA	decomposes (4)	NA	NA
Mercury	200.59	13.5939	100 (260°C)	0.056	1.14E-02 (UT)	3133 (3)
Nickel	58.69	8.9 (UT)	1 (1800°C)	insoluble	NA	110
Selenium	78.96	4.81 (20/4+1°C)	NA	NA	NA	5700
Silver	107.87	10.5	1 (1310°C)	insoluble	NA	28
Thallium	204.383	11.85 (UT)	1 (825°C)	insoluble	NA	130
Vanadium	50.9415	5.96 (UT)	NA	insoluble	NA	NA
Zinc	65.38	7.14 (UT)	1 (487°C)	insoluble	NA	970

1 USEPA, Handbook of RCRA Ground-Water Monitoring Constituents: Chemical and Physical Properties, September 1992.

2 USEPA, Superfund Chemical Data Matrix, 1997.

3 Lyman, W., Reehl, W., and Rosenblatt, D., 1990. Handbook of Chemical Property Estimation Methods.

4 Clement Associates, Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites, September 1985.

5 The Condensed Chemical Dictionary, Van Nostrand Reinhold Company, New York 1971.

UT There is no reference temperature available.

NA Not available.

6.0 HUMAN HEALTH RISK ASSESSMENT

This section presents results of the HHRA for Site 1 located at Naval Station Great Lakes. The objective of the risk assessment is to determine whether detected concentrations of chemicals at the site pose a significant threat to potential human receptors under current and/or future land use in the absence of remedial action. The results of the HHRA are also used to focus the evaluation of remedial action alternatives, if action is required.

The following risk assessment guidance documents were used to develop the framework for the Human Health Risk Assessment:

- USEPA, 1989. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response, Washington, D.C.

- USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. Washington, D.C.

- USEPA, 1993. Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C.

- USEPA, 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128. Office of Solid Waste and Emergency Response. Washington, D.C.

- USEPA, 1997. Exposure Factors Handbook. EPA/600/P-95/002Fa. Office of Health and Environmental Assessment, Washington, D.C.

- Department of the Navy, 2001, Conducting Human Health Risk Assessments under the Environmental Restoration Program. Ser N453E/1U595168. Washington, D.C.

- U.S.EPA, 2001. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments).

- USEPA, December 2002a. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Washington, D.C.

- USEPA, December 2002b. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10. Washington, D.C.

- USEPA, 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final Guidance.

- Department of the Navy, 2004. Navy Final Policy on the Use of Background Chemical Levels.

- Illinois EPA, 2007. TACO (Tiered Approach to Corrective Action Objectives). Illinois Environmental Protection Agency, Bureau of Land, available at http://www.epa.state.il.us/land/taco/, accessed online June, 2007.

The risk assessment is structured and reported according to the guidelines of the Risk Assessment Guidance for Superfund (RAGS), Human Health Evaluation Manual, Part D: Standardized Planning, Reporting, and Review of Superfund Risk Assessments (RAGS Part D) (USEPA, December 2001).

Three major aspects of chemical contamination and environmental fate and transport must be considered to evaluate potential risks: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action, (2) potential exposure points must exist, and (3) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of these factors is absent, the exposure route is regarded as incomplete, and no potential risks are considered to exist for human receptors. An HHRA consists of five major components:

- Data evaluation and identification of chemicals of potential concern (COPCs)
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis.

Chemicals identified as COPCs for Site 1 and their methods for selection of COPCs are described in Section 6.1, Data Evaluation. The data evaluation section is primarily concerned with the selection of

COPCs that are representative of the type and magnitude of potential human health effects. The COPC screening process involves the comparison of maximum site concentrations to risk-based screening levels and other health-based standards. A brief discussion of data usability is also provided.

Section 6.2, Exposure Assessment, identifies potential receptor populations and exposure pathways by which receptors may come in contact with contaminants at the site. Potential exposure routes under current and future land uses are developed from information on source areas, chemical concentrations, chemical release mechanisms, patterns of human activity, and other pertinent information. A concise conceptual site model (CSM) illustrates the potential receptors and exposure pathways evaluated in the baseline risk assessment. The exposure assessment also includes the calculation of quantitative estimates of chemical intakes for each identified receptor, pathway, and route of exposure under reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios. Equations and relevant exposure input parameters used in estimating chemical intakes are provided.

Section 6.3, Toxicity Assessment, presents the chemical-specific toxicity criteria for the identified COPCs used in the quantification of potential human health risks. These toxicity criteria, when integrated with the estimated chemical intakes developed in the exposure assessment, provide the basis for quantifying potential human health risks.

Section 6.4, Risk Characterization, presents the methods used for characterizing risks associated with noncarcinogenic and carcinogenic effects resulting from exposure to COPCs. Calculated numerical risks for potential receptors at Site 1 are also summarized and discussed in this section.

Section 6.5, Uncertainty Analysis, presents a discussion of the uncertainties associated with the risk assessment for Site 1. The uncertainty assessment is an important part of the risk assessment process because the quantitative risk estimates developed in the risk characterization are based on a number of assumptions (concerning exposure, land use, toxicity, etc.) that contain various degrees of uncertainty.

6.1 DATA EVALUATION

Data evaluation involves the compilation and assessment of analytical data. The main objective of the data evaluation is to develop a medium-specific list of COPCs that are used to quantitatively determine potential human health risks for site media. Appendix C summarizes and presents the results of data validation conducted for the data sets used in the risk assessment.

6.1.1 Data Usability

Analytical data for subsurface soil, groundwater, surface water, and sediment were used in the HHRA for Site 1. The data were collected as part of the RI field effort performed by TtNUS in December 2006 and March 2007. These data are expected to adequately characterize potential risks for direct and inadvertent exposure to contaminated site media. Surface soil was not evaluated in the HHRA because the site has been covered with clean soil during the reconstruction of the golf course (C.H. Guernsey & Company, Nocember 2002).

Quantitative analytical results from the field investigation were used in the risk assessment. Field measurements and data regarded as unreliable (i.e., qualified as R or UR during the data validation process) were not used in the quantitative risk assessment. Analytical data qualified as estimated (J, UJ) were used, even though the reported positive concentrations or sample-specific quantitation limits may be somewhat imprecise. The qualification of data during the data validation process is not expected to compromise the results of the baseline HHRA. The use of estimated data adds to the uncertainty associated with the risk assessment. However, the associated uncertainty is expected to be negligible compared to the other uncertainties inherent in the risk evaluation process (i.e., uncertainties with land uses, exposure scenarios, toxicological criteria, etc.).

Analytical data qualified for blank contamination (B) were also used in the baseline risk assessment. When determining exposure concentrations via statistical procedures, chemicals qualified 'B' or nondetected were conservatively assumed to be present at a concentration equal to one-half the sample-specific quantitation limit.

6.1.2 Methodology for Selection of COPCs

COPCs were selected through a qualitative screening process to limit the number of chemicals and exposure routes quantitatively evaluated in the risk assessment to those site-related constituents that dominate overall potential risks. Screening concentrations based on USEPA and Illinois EPA risk-based concentrations was used to focus the risk assessment on meaningful chemicals (i.e., COPCs) and exposure routes.

In general, a chemical is selected as a COPC and retained for further quantitative risk evaluation if the maximum detected concentration in a sampled medium exceeds the risk-based concentration(s) and is present at concentrations greater than background levels. Chemicals eliminated from further evaluation at this time are assumed to present minimal risks to potential human receptors.

Several screening criteria were used to identify COPCs for Site 1. Screening concentrations based on risk-based cleanup objectives developed by Illinois EPA (Illinois EPA, online, July 2007) and risk-based concentrations developed by USEPA Region 9 PRGs (USEPA, October 2004) were used, as well as other USEPA criteria. The risk-based screening concentrations correspond to a systemic hazard quotient (HQ) of 0.1 for noncarcinogens or an incremental lifetime cancer risk (ILCR) of 1 $x10^{-6}$ for carcinogens. The Illinois EPA and USEPA Region 9 PRGs for noncarcinogens are based on an HQ of 1.0 but the screening concentrations are based on an HQ of 0.1. The screening concentrations are based on a HQ of 0.1 to account for the potential cumulative effects of several chemicals affecting the same target organ or producing the same adverse noncarcinogenic effect. The screening levels used for each medium in the risk assessment are briefly discussed below.

6.1.2.1 Screening Concentrations for Soil

Exposure to surface soil was not evaluated in the risk assessment because the site has been covered with clean soil. Exposure to COPCs in subsurface soil could occur under future land use assuming that the subsurface soil was uncovered (e.g., during excavation) and brought to the surface. The following criteria were used to select COPCs for subsurface soil:

- Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties (Illinois EPA, online, July, 2007). These include remediation objectives for the soil ingestion exposure route and for the inhalation exposure route. The lowest Tier I objective for the receptors listed in the Tier 1 Tables (i.e., residential, industrial/commercial, or construction worker) was used for screening.

- USEPA Region 9 PRGs for Residential Soil (USEPA, October 2004).

- USEPA Generic Soil Screening Levels (SSLs) for the inhalation of volatiles and fugitive dusts calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the USEPA's Soil Screening Guidance (USEPA, 1996).

If the maximum concentration of a constituent exceeded any of these criteria and if the constituent was present at concentrations greater than concentrations of chemicals in background soil, the chemical was selected as a COPC for subsurface soil. The procedures for the elimination of chemicals on the basis of background concentrations are discussed in Section 6.1.2.7. Facility background concentrations for naturally occurring or anthropogenic chemicals have not been determined for Naval Station Great Lakes.

Therefore, maximum soil concentrations were compared to the concentrations of inorganic chemicals provided by Illinois EPA in Appendix A, Table G of TACO (Illinois EPA, online, July 2007).

The comparison of site soil data to USEPA generic inhalation SSLs for transfers from soil to air were used to identify whether a quantitative analysis of this exposure pathway is warranted. If the maximum soil concentration of a chemical exceeded the Inhalation SSL, a quantitative evaluation of potential risks from inhalation was performed. Otherwise, the risk associated with the inhalation pathway was considered insignificant, and the exposure pathway was eliminated from further evaluation. In this risk assessment, the concentrations of naphthalene and dioxins/furans in subsurface soil exceeded the USEPA inhalation SSLs. Therefore, risks from inhalation of particulates from soil were quantitatively evaluated for these COPCs.

To evaluate the potential for chemicals detected in soil to impact groundwater, maximum chemical concentrations were compared to USEPA and Illinois EPA SSLs for migration to groundwater. Migration-to-Groundwater SSLs were not used for COPC selection because quantitative risk assessments are typically based on direct contact with soil or inhalation of vapors and particulates. There is no methodology available for quantitative risk evaluation of indirect exposure based on migration to groundwater. Therefore, it is not appropriate to select COPCs for quantitative risk evaluation for direct exposure on the basis of the indirect soil-to-groundwater pathway. The soil-to-groundwater SSLs provide an indication of potential impacts of contamination in soil on groundwater quality but are not indicators of quantitative risk.

The following criteria were used for the migration from soil to groundwater comparisons:

- Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties for the Soil Component of the Groundwater Ingestion Exposure Route for Class I Groundwater (Illinois EPA, online, July 2007).

- USEPA generic SSLs for migration from soil to Groundwater calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the USEPA's Soil Screening Guidance (USEPA, 1996 and December 2002).

Results of the migration from soil-to-groundwater comparisons are presented in Section 6.1.3.1.

6.1.2.2 Screening Concentrations for Groundwater

Direct exposure to groundwater at Site 1 is not expected to occur under current and/or future land uses because Site 1 and the surrounding area are supplied by public water and there are no drinking water wells located immediately downgradient of the site. However, the residential groundwater scenario was evaluated based on the assumption that groundwater at the site will be used as a source of domestic drinking water in the future and industrial exposure to groundwater was evaluated to account for the possibility that future construction workers may contact groundwater during excavation or construction activities. Groundwater screening levels for evaluating vapor intrusion to indoor air are evaluated to identify chemical concentrations in groundwater that may adversely affect the indoor air quality of a building overlying subsurface VOC contamination. If concentrations of a chemical detected in groundwater exceed the vapor intrusion screening levels, risks for that chemical were quantitatively evaluated using the Johnson and Ettinger Vapor Intrusion Model (USEPA, June 2004).

Although groundwater at Site 1 is not a source of drinking water, the following criteria were conservatively used to select COPCs for groundwater:

- Illinois EPA Tier 1 Groundwater Remediation Objectives for Class 1 Groundwater (Illinois EPA, online, July 2007).
- USEPA Region 9 PRGs for Tap Water (USEPA, October 2004).
- USEPA Maximum Contaminant Levels (MCLs) (USEPA, Summer 2006)
- USEPA Groundwater screening levels for evaluating the vapor intrusion to indoor Air (USEPA, November 2002)

If the maximum concentration of a constituent exceeded any of these criteria, the chemical was selected as a COPC and carried through to the quantitative risk assessment.

6.1.2.3 Screening Concentrations for Sediment

Screening levels are currently not available for human exposure to sediment. Therefore, risk-based concentrations for residential soil were used as the basis of the sediment screening levels. The use of residential soil screening levels for sediment COPC identification is regarded as a conservative approach because exposure to sediment is expected to be less than exposure to soil. For example, the residential

soil screening levels assume that a potential receptor is exposed to chemicals in soil for 350 days per year. It is unlikely that a receptor would be exposed to sediment in the Skokie Ditch at this frequency in the Great Lakes area because of the long, cold winters.

The following screening concentrations were use to select COPCs for sediment in the Skokie Ditch:

- Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties (Illinois EPA, online, July 2007) for the Soil Ingestion Exposure Route.
- USEPA Region 9 PRGs for Residential Soil (USEPA, October 2004).

If the maximum concentration of a constituent exceeded any of these criteria (and the constituent was present at concentrations greater than the concentrations of inorganic or anthropogenic organic chemicals in background sediment), the chemical was selected as a COPC for sediment and carried through to the quantitative risk assessment.

As stated above, facility background concentrations for naturally occurring or anthropogenic chemicals have not been determined for Naval Station Great Lakes. The background analysis for sediment was performed by comparing maximum contaminant concentrations with background concentrations provided in Table 5 of the Evaluation of Illinois Sieved Stream Sediment Data, 1982 – 1995 (Illinois EPA, August 1997) and Table 3 of the Sediment Classification for Illinois Inland Lakes, 1996 Update. Maximum sediment concentrations were also compared to the concentrations of inorganic chemicals provided by Illinois EPA in Appendix A, Table G of TACO (Illinois EPA, online, July 2007) and concentrations of anthropogenic organic compounds (e.g., PAHs) were compared to the values listed in the proposed amendments to TACO (Illinois EPA, September 2005).

USEPA generic SSLs for transfers from soil to air and for migration to groundwater are not considered to be appropriate for sediment screening because of the high moisture content associated with sediment matrices.

6.1.2.4 Screening Concentrations for Surface Water

COPCs in surface water were selected by comparing maximum concentrations with Illinois EPA and USEPA drinking water criteria. The use of drinking water screening levels for surface water is a highly conservative approach to COPC selection because surface water in the Skokie Ditch is not currently used and will not be used in the future as a potable drinking water source. In addition, potential human exposure to surface water at Site 1 is expected to be limited to incidental exposures (such as that which

occurs during periodic recreational use), which is significantly less than the daily exposure assumed during the development of the tap water screening criteria. The following screening criteria were used to select COPCs for surface water in the Skokie Ditch:

- Illinois EPA Tier 1 Groundwater Remediation Objectives for Class 1 Groundwater (Illinois EPA, online, July 2007).
- USEPA Region 9 PRGs for Tap Water (USEPA, October 2004).
- USEPA MCLs (USEPA, Summer 2006).

If the maximum concentration of a constituent exceeded any of these criteria, the chemical was selected as a COPC and carried through to the quantitative risk assessment. Background or upgradient data for surface water are not available for Site 1. Therefore, no chemicals were eliminated as COPCs for surface water on the basis of background comparisons.

6.1.2.5 Screening Concentrations for Lead

Limited criteria are available to evaluate the potential risks associated with lead. There are no risk-based concentrations for this chemical because the USEPA has not derived toxicity values for lead. However, recommended screening levels available for lead in soil are used to indicate the need for response activities. Guidance from both the Office of Prevention, Pesticides, and Toxic Substances and the Office of Solid Waste and Emergency Response recommend 400 mg/kg as the lowest screening level for lead-contaminated soil in a residential setting where children are frequently present (USEPA, July, 1994). Office of Prevention, Pesticides, and Toxic Substances identifies 2,000 to 5,000 mg/kg as an appropriate range for areas where contact with soil by children in a residential setting is less frequent.

The Safe Drinking Water Act Action Level of 15 µg/L (USEPA, Summer, 2006) was used as the screening level for lead in groundwater and surface water.

6.1.2.6 Essential Nutrients and Chemicals without Toxicity Criteria

The essential nutrients calcium, magnesium, potassium, and sodium were not selected as COPCs for Site 1. These inorganic chemicals are naturally abundant in environmental matrices and are only toxic at high doses. In addition, because of the lack of toxicity criteria, risk-based COPC screening levels are not available for some chemicals (e.g., benzo(g,h,i)perylene, phenanthrene, and 2-methylnaphthalene). Appropriate surrogates were selected for some of these chemicals based on similar chemical structures.

For example, pyrene was used as the surrogate for benzo(g,h,i)perylene and phenanthrene, and naphthalene was used as the surrogate for 2-methylnaphthalene.

6.1.2.7 Determination of Site-Related Chemicals

Chemicals in site media found at concentrations indicative of background concentrations are not considered to be site-related contaminants and were not retained as COPCs for the quantitative risk assessment. In order to determine whether inorganic and anthropogenic organic chemicals are present at concentrations greater than background, the maximum detected concentrations of inorganic and anthropogenic organic chemicals (e.g., PAHs) in soil and sediment were compared to background levels provided by Illinois EPA (see Sections 6.1.2.1 and 6.1.2.3).

The elimination of chemicals as site-related COPCs on the basis of background comparisons follows the guidance provided in Navy Policy on the Use of Background Chemical Levels (Department of the Navy, January 2004). This document also presents the Navy's interpretation of USEPA guidance provided in the Role of Background in the CERCLA Cleanup Program (USEPA, April 2002) and details the methodology to be used in evaluating background under the Navy's Environmental Restoration and Base Realignment and Closure programs. Navy policy as it applies to risk assessments requires the following:

1. A clear and concise understanding of chemicals released from a site thus ensuring the Navy is focusing on remediating the release.

2. The use of background data in the screening-level risk assessment.
   a. The comparison of site chemical levels to risk-based screening criteria.
   b. The comparison of site chemical levels to background concentrations.
   c. The identification of site-related COPCs based on screening criteria comparisons and background comparisons. Site-related COPCs are those chemicals with concentrations exceeding risk-based screening criteria and background concentrations. To the extent possible, site-related COPCs are further evaluated quantitatively in the baseline risk assessment.

3. The consideration of background in the baseline risk assessment.
   a. The calculation of risk estimates for site-related COPCs only.
   b. The further evaluation of non-site-related COPCs in the risk characterization section (e.g., the evaluation of chemicals detected at concentrations exceeding screening criteria but less than background concentrations). The Navy considers this comparison to be consistent with USEPA's Role of Background in the CERCLA Cleanup Program (USEPA, April 2002). The uncertainty

associated with the elimination of chemicals on the basis of background is discussed in Section 6.5.1.4.

4. The selection of site cleanup remedial goals at levels not less than background concentrations. Additionally, cleanup levels should not be developed for chemicals not identified as chemicals of concern. As defined in the Navy guidance, chemicals of concern are site-related COPCs found to be the risk drivers in the baseline risk assessment and that may pose unacceptable human or ecological risks.

6.1.2.8 Decision Rules for Establishing COPCs

The following decision rules were used to select an initial list of COPCs for Site 1:

- A chemical detected in soil was selected as a COPC for soil if any detected chemical concentration exceeded the screening levels for soil and if the background screen indicated that the site concentrations were greater than Illinois EPA background concentrations for metals.

- A chemical detected in groundwater was selected as a COPC for groundwater if any detected chemical concentration exceeds the screening levels for groundwater.

- A chemical detected in sediment was selected as a COPC for sediment if any detected chemical concentration exceeded the screening levels for sediment and if the background screen indicated that the site concentrations were greater than the corresponding Illinois EPA background concentrations for metals or anthropogenic organics chemicals (e.g., PAHs).

- A chemical detected in surface water is selected as a COPC for surface water if any detected chemical concentration exceeds the screening levels for surface water.

Chemicals detected in any environmental medium at concentrations greater than screening levels but eliminated as COPCs on the basis of background comparisons are further discussed in Section 6.5.1.4.

6.1.3 Selection of COPCs

This section presents results of the COPC selection process for subsurface soil, groundwater, surface water, and sediment at Site 1. The COPC screening process and the results of the COPC screening are presented in Tables 6-1 through 6-6.

6.1.3.1 Selection of COPCs for Subsurface Soil

Sixteen subsurface soil samples were collected at Site 1 in December 2006 at depths ranging from 4 to 19 feet bgs. The sixteen samples were analyzed for VOCs, PAHs, metals, and cyanide. Four samples were analyzed for SVOCs, pesticides/PCBs, and dioxins/furans. The COPC selection for subsurface soil is presented in Tables 6-1 and 6-2. The following chemicals were retained as COPCs for direct contact exposure to subsurface soil:

- PAHs – benzo(a)anthracene, BaP, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene
- Dioxins/furans
- Metals – aluminum, antimony, arsenic, chromium, copper, iron, lead, manganese, silver, thallium, vanadium

These constituents were identified as COPCs in subsurface soil because maximum concentrations exceeded one or more of the human health risk screening levels for direct contact or inhalation under residential land use. Aluminum, antimony, copper, manganese, and thallium were selected as COPCs because their maximum detected concentrations exceeded the screening levels (set at a HI of 0.1) but did not exceed the USEPA Region 9 PRGs for residential land use, the Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties (ingestion and inhalation), or the generic USEPA SSLs for inhalation of volatiles and fugitive dusts. The maximum concentrations of dioxins/furans and several metals (e.g., lead) occurred in sample NTC01SB0900 which is located within the landfill and the sample was collected at 8 to 12 feet bgs and contained the burned waste materials. There is some uncertainty in the concentrations of analytes in this sample because the concentrations in the duplicate sample (NTC01SB0900812-D) collected at this location were considerably different. For example, the concentrations of lead in the sample and the duplicate were, 1410 mg/kg and 54.9 mg/kg, respectively. Conversely, the concentrations of the 2,3,7,8-TCDD TEQ in the sample and the duplicate were 90 ng/kg and 9,000 ng/kg, respectively. No chemicals in subsurface soil were eliminated as COPCs on the basis of background comparisons.

The maximum detected concentrations were also compared to USEPA SSLs for migration from soil to air (inhalation) and Illinois EPA Soil Remediation Objectives for inhalation. As shown in Table 6-1, the maximum concentrations of naphthalene and dioxins/furans were greater than the USEPA or Illinois EPA Soil Remediation Objectives for inhalation. Therefore, potential risks from inhalation of naphthalene (vapors and particulates) and dioxins/furans (particulates) were quantitatively evaluated in the risk

assessment for construction worker exposure to subsurface soil. The concentrations of naphthalene were less than the USEPA and Illinois EPA inhalation criteria for residential exposures.

Migration from Subsurface Soil to Groundwater

Table 6-2 presents the comparison of maximum concentrations detected in subsurface soil to USEPA and Illinois EPA SSLs for migration from soil to groundwater. The following chemicals were detected in subsurface soil at maximum concentrations that exceeded screening levels for migration from soil to groundwater:

- Methylene chloride
- 4-Methylphenol
- PAHs – benzo(a)anthracene, BaP, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, indeno(1,2,3-cd)pyrene
- Pesticides – alpha-BHC, dieldrin, gamma-BHC (Lindane)
- Pentachlorophenol
- Dioxins/furans
- Metals – antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, manganese, mercury, nickel, selenium, silver, thallium, zinc
- Cyanide

As indicated in Table 6-2, the maximum detected concentrations of these analytes (as well as detection limits of several nondetected chemicals) exceeded USEPA SSLs for migration from soil to groundwater for a DAF of 1. The concentrations of carcinogenic PAHs and alpha-BHC exceeded the Illinois EPA Soil Remediation Objective for migration to groundwater (which are based on a DAF of 20). The exceedances of USEPA and Illinois EPA SSLs indicate the potential for chemicals to leach to groundwater and impact water quality.

Of the organic chemicals that exceeded the soil-to-groundwater SSLs, only carbazole was detected in groundwater samples collected at the site (carbazole was detected in 1 of 13 groundwater samples at a concentration significantly less than well below the risk-based screening level).

Of the inorganic chemicals that exceeded the soil-to-groundwater SSLs, arsenic, barium, chromium, cobalt, copper, manganese, nickel, selenium, silver, and zinc were detected in unfiltered groundwater

samples. However, only barium, copper, manganese, nickel, and silver were detected in filtered samples and the concentrations of these five metals were less than concentrations in the unfiltered samples. These data indicate that turbidity in the unfiltered samples may have affected the analysis of the unfiltered samples resulting in elevated metal concentrations.

The data presented above appear to indicate that groundwater at Site 1 has not been significantly impacted by migration of chemicals from subsurface soil. In addition, a comparison of subsurface soil and groundwater chemical data presented in Tables 6-2 and 6-3 shows that the types of chemicals detected in these media are not similar. For example, various classes of SVOCs (e.g., phenols and phthalates), pesticides, PCBs, and dioxins/furans were detected in subsurface soil samples but were not detected in the groundwater samples. Conversely, several classes of VOCs (e.g., chlorobenzenes, cyclohexanes, and BTEX) were detected in groundwater samples but not in the subsurface soil samples. The contamination in groundwater is more likely due to landfill materials rather than from subsurface soil.

6.1.3.2 Selection of COPCs for Groundwater

The COPC selection for groundwater at Site 1 is presented in Table 6-3 and is based on analytical data for 14 unfiltered groundwater samples collected in December 2006 and March 2007. The groundwater samples were collected from four temporary monitoring wells along the proposed sewer routes and from ten permanent monitoring wells along the boundary of Site 1 and the landfill. The following chemicals were retained as COPCs for groundwater.

- Benzene
- SVOCs – naphthalene, 2-methylnaphthalene
- Metals – aluminum, arsenic, barium, chromium, iron, lead, manganese, vanadium

These constituents were identified as COPCs for groundwater because maximum concentrations exceeded one or more of the human health risk screening levels for residential use of groundwater (i.e., USEPA Region 9 risk-based screening levels, USEPA MCLs, or Illinois EPA Groundwater Remediation Objectives for Class 1 Groundwater). Aluminum, barium, chromium, and vanadium were selected as COPCs because the maximum detected concentrations exceeded the screening levels (set at an HI of 0.1) but did not exceed the USEPA Region 9 PRGs for residential tap water, USEPA MCLs, or Illinois EPA Class 1 groundwater criteria. Lead was selected as a COPC because the maximum detected concentration (8.4 ug/L) exceeded the Illinois EPA Class 1 Groundwater Objective (7.5 ug/L) but was less than the Federal Action Level (15 ug/L). The organic chemicals identified as COPCs were detected infrequently in the groundwater samples. Benzene was detected in 2 of 14 samples, and naphthalene

and 2-methylnaphthalene were detected in 1 of 13 samples. A comparison of filtered and unfiltered sample data indicates that turbidity in the samples may have affected the analysis of the unfiltered samples. For example, most metals selected as COPCs were not detected in the filtered groundwater samples (i.e., aluminum, arsenic, chromium, iron, and lead).

No chemicals in groundwater were eliminated as COPCs on the basis of background.

A comparison of maximum detected groundwater VOC concentrations to USEPA screening levels for chemical migration from groundwater through building foundations and into indoor air is presented in Table 6-4. The concentrations of VOCs detected in groundwater at Site 1 were less than the COPC screening levels for migration from groundwater to indoor air. Therefore, potential risks from inhalation of vapors in buildings are considered minimal and this exposure pathway was not evaluated quantitatively in the HHRA.

6.1.3.3 Selection of COPCs for Sediment

Ten sediment samples were collected at Site 1 in December 2006. The samples were collected the point where Skokie Ditch flows off the site (NTC01SD01), at the bend in Skokie Ditch (NTC01SD02), at the origination point of Skokie Ditch (NTC01SD03), equidistant between the origination point and the split (NTC01SW04), and in the sediment trap located near the split in Skokie Ditch (NTC01SD05),. At each location, sediment samples were collected from the surface at 0 to 4 centimeters bgs and at a depth of one foot. The samples were analyzed for VOCs, PAHs, metals, and cyanide. Four of the samples were analyzed for SVOCs, pesticides/PCBs, and dioxins/furans. The COPC selection for sediment is presented in Table 6-5. The following chemicals were retained as COPCs for sediment in the Skokie Ditch:

- PAHs – benzo(a)anthracene, BaP, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene
- Aroclor 1248
- Dioxins/furans
- Metals – aluminum, arsenic, chromium, iron, thallium, vanadium

These constituents were identified as COPCs for sediment because maximum concentrations exceeded one or more of the human health risk screening levels for direct contact under residential land use. The use of residential soil screening levels for sediment COPC identification is regarded as a conservative approach because exposure to sediment is expected to be less than exposure to soil. For example, the residential soil screening levels assume that a potential receptor is exposed to chemicals in soil 350 days

per year. However, it is unlikely that a receptor would be exposed to sediment in the Skokie Ditch at this frequency.

Aluminum, thallium, and vanadium were selected as COPCs because maximum detected concentrations exceeded screening levels (set at a HI of 0.1) but did not exceed the USEPA Region 9 PRGs for residential land use or the Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties for ingestion. One chemical, manganese, was eliminated as a COPC for sediment on the basis of background comparisons. The implications of not including manganese in the quantitative risk assessment are discussed in Section 6.5.1.4.

6.1.3.4 Selection of COPCs for Surface Water

The COPC selection for surface water was based on five samples collected in December 2006. One sample was collected from the point where Skokie Ditch flows off the site/under Buckley Road (NTC01SW01), one sample near the bend in Skokie Ditch (NTC01SW02), one from the origination point of Skokie Ditch (NTC01SW03), and two samples from manholes north of the golf course (NTC01SW04 and NTC01SW05). The samples were analyzed for VOCs, SVOCs, PAHs, pesticides/PCBS, metals, and cyanide. The COPC selection for surface water is presented in Table 6-6. The following chemicals were retained as COPCs for surface water at Site 1:

- Vinyl chloride
- PAHs – BaP
- Dioxins/furans
- Metals – antimony, thallium

These constituents were identified as COPCs for surface water because maximum concentrations exceeded one or more of the human health risk screening levels for residential use of groundwater (i.e., USEPA Region 9 risk-based screening levels, USEPA MCLs, or Illinois EPA Groundwater Remediation Objectives for Class 1 Groundwater). The use of drinking water screening levels for surface water is a highly conservative approach to COPC selection because surface water in the Skokie Ditch is not currently used and will not be used in the future as a potable drinking water source. In addition, potential human exposure to surface water at Site 1 is expected to be limited to incidental exposures (such as those that occur during periodic recreational use), which is significantly less than the daily exposure assumed during the development of the tap water screening criteria.

Antimony was selected as a COPC because the maximum detected concentration exceeded the screening level (set at a HI of 0.1) but did not exceed the USEPA Region 9 PRG for residential tap water, the USEPA MCL, or the Illinois EPA Remediation Level for Class 1 Groundwater. No chemicals in surface water were eliminated as COPCs on the basis of background.

6.1.3.5 COPC Summary Screening Tables

Table 6-7 summarizes the chemicals retained as COPCs for subsurface soil, groundwater, surface water, and sediment at Site 1. RAGS Part D tables for COPC selection are included in Appendix F-1.

6.2 EXPOSURE ASSESSMENT

The exposure assessment defines and evaluates, quantitatively or qualitatively, the type and magnitude of human exposure to the chemicals present at or migrating from a site. The exposure assessment is designed to depict the physical setting of the site, identify potentially exposed populations and applicable exposure pathways, determine concentrations of COPCs to which receptors might be exposed, and estimate chemical intakes under the identified exposure scenarios. Actual or potential exposures at Site 1 were determined based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has three components: (1) a source of chemicals that can be released to the environment, (2) a route of contaminant transport through an environmental medium, and (3) an exposure or contact point for a human receptor.

6.2.1 Conceptual Site Model

The development of a conceptual site model (CSM) is an essential component of the exposure assessment. The CSM integrates information regarding the physical characteristics of the site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors to be evaluated in the risk assessment. A well-developed CSM will allow for a better understanding of the risks at a site and will aid the risk managers in the identification of the potential need for remediation. The site-specific CSM for Site 1 is presented in this section and illustrated in Figure 6-1. The model was used to develop the proposed field investigation so that the data collected met the needs of the risk assessment. The CSM depicts the relationships among the following elements:

- Site sources of contamination
- Contaminant release mechanisms
- Transport/migration pathways
- Exposure routes

- Potential receptors

Table 6-8 presents a summary of the exposure routes addressed quantitatively for each human receptor. The elements of the CSM as they pertain to Site 1 are presented in the following sections.

6.2.1.1 Site Sources of Contamination

The Willow Glen Golf Course (Site 1) is located north of Buckley Road and east of Route 41. The golf course offers recreational activities for Naval Station Great Lakes and surrounding areas. The entire 18-hole golf course is approximately 125 acres. Underlying at least 50 acres of the present golf course 1s a landfill that was used as a trench/burn operation between 1942 and 1967 for an estimated 1.5 million tons of material. Types of waste reportedly include domestic refuse, sewage sludge, petroleum, oil, lubricants, solvents, coal ash, and materials contaminated by PCBs. The sources or contamination at Site 1 and a detailed description of the site are presented in Section 2.0.

Based on data from previous investigations, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media at Site 1:

- VOCs
- Phthalate esters
- PAHs
- Pesticides
- PCBs
- Metals
- Petroleum hydrocarbons

6.2.1.2 Contaminant Release Mechanisms and Transport/Migration Pathways

Past activities at Site 1 may have resulted in contaminant releases to the surrounding environment. The golf course overlays a landfill that was used for the trenching/burning of waste materials that included domestic refuse, sewage sludge, petroleum, oil and lubricants, solvents, coal ash, and materials contaminated by PCBs.

Based on information regarding past practices and chemical releases at the site, plausible contaminant release and migration mechanisms include the following:

- Transport of chemicals deposited in trenches to groundwater via infiltration, percolation, and migration within the shallow groundwater aquifer.

- Migration of contaminants in groundwater (i.e., lateral migration) via seepage to surface water and sediment in the Skokie Ditch.

- Migration of contaminants in surface water off site via the Skokie Ditch.

- Migration of fugitive dusts and VOCs from subsurface soil if construction/excavation activities occur in the future.

- Volatilization of VOCs from groundwater into the indoor air of future residential and commercial buildings. As shown in Table 6-4, the concentrations of the organic chemicals detected in groundwater at the site were less than vapor intrusion screening levels. Therefore, risks for this exposure pathway are considered to be minimal and were not considered further in this risk assessment.

- Transport/migration of wastes or contaminated soil by erosion through the current Skokie District storm sewer to the surface water and sediment in the Skokie Ditch.

6.2.1.3 Potential Receptors/Exposure Routes

Naval Station Great Lakes is an active facility and will remain so for the foreseeable future. Site 1 is a golf course and, therefore, access to the site is not restricted. To aid in risk management decisions, the risk assessment considers potential receptors, such as hypothetical future residents and occupational workers, who might be exposed to contaminants in site media or migrating from the site at some future time. The potential receptors were identified by analyzing current land use practices, potential future land uses, and the identified areas of contamination in order to focus the risk assessment on potential site-related exposures. The general receptor classes include the following:

- Golf Course Maintenance Workers – Potential receptors under current or future land use. Maintenance workers may include adult military or civilian personnel assigned to grounds keeping or similar activities at the site. This receptor potentially could be exposed to surface water and sediment by ingestion and dermal contact. Direct contact with subsurface soil is not anticipated for this receptor.

- Adult and adolescent recreational users/trespassers (e.g., golfers) – Potential receptors under current/future land use. These receptors were evaluated for exposure to surface water and sediment in the Skokie Ditch. Exposure to surface water and sediment was evaluated for incidental ingestion and dermal exposure. Swimming is not known to occur and has not been observed in the Skokie Ditch. Therefore, the dermal exposure scenario assumed that receptors are exposed only while wading. Direct contact with subsurface soil is not anticipated for this receptor.

- Construction Workers – Potential receptors under future land use. Construction workers are assumed to be civilian personnel who may be involved in a short-term, one-time construction project. Excavation and ground-intrusive activities may occur on the site in the future. If these excavation projects were to occur, construction workers could potentially be exposed to subsurface soil by ingestion, dermal contact, and inhalation, and to groundwater by dermal contact and inhalation. Construction workers were also evaluated for exposure to surface water and sediment.

- Occupational Workers – Potential receptors under future land use. Future occupational workers were evaluated to account for the possibility that Site 1 might be developed for commercial/industrial uses at some future time and to provide information that may be necessary for risk management decisions. Direct contact with subsurface soil is not anticipated for this receptor.

- Future Military Residents (Adults/Children) – Potential receptor under future land use. Military residents are not potential receptors under current land use because they do not live on the site. They were evaluated primarily for decision-making (risk management) purposes based on the assumption that the site could support military residential use in the future. Future military residents were assumed to be exposed to subsurface soil by ingestion, dermal contact, and inhalation of fugitive dust and vapors, to groundwater by ingestion, dermal contact and inhalation, to surface water by ingestion and dermal contact, and to sediment by incidental ingestion and dermal contact for a representative enlistment time of 6 years. Risks to military residents were evaluated by reference to future civilian residents because risks for these receptors are the same or slightly less than civilian residents.

- Future Civilian Residents (Adults/Children) – Potential receptor under future land use. Hypothetical future residents are not potential receptors under current land use but were evaluated to aid in risk management decisions by providing an indication of potential risks if the facility were to close and be developed for residential use. Future onsite residents were assumed to be exposed to subsurface soil by ingestion, dermal contact, and inhalation of fugitive dust and vapors, to groundwater by

ingestion, dermal contact, and inhalation, to surface water by ingestion and dermal contact, and to sediment by incidental ingestion and dermal contact.

- Navy recruits were also considered as potential receptors for Site 1. However, exposure for the recruits was assumed to be negligible because of the limited time recruits spend at Naval Station Great Lakes (i.e., 12 weeks) and because the lack of idle time allocated to recruits during training. Therefore, risks to Navy recruits were not evaluated in the risk assessment.

As stated previously, exposure to surface soil was not evaluated in the risk assessment because the site has been covered with clean soil. However, potential future residents and construction workers were evaluated for exposure to subsurface soil based on the assumption that subsurface soil will be brought to the surface in a future excavation project. If exposure to subsurface soil were to occur, a receptor may be exposed to soil via inadvertent ingestion of a small amount of soil, via dermal absorption of contaminants from the soil, or by inhalation of vapors or particulates.

Table 6-8 summarizes the exposure routes quantitatively addressed for each receptor at Site 1.

6.2.2 Central Tendency Exposure vs. Reasonable Maximum Exposure

Traditionally, exposures evaluated in the human health risk assessment were based on the concept of a RME only, which is defined as "the maximum exposure that is reasonably expected to occur at a site" (USEPA, December, 1989). However, more recent risk assessment guidance (USEPA, May 1993) indicates the need to address an average case or CTE.

To provide a full characterization of potential exposure, both RME and CTE scenarios were evaluated in the risk assessment for Site 1. The available guidance (USEPA, May, 1993) concerning the evaluation of CTE is limited. Therefore, professional judgment was used when defining CTE conditions for a particular receptor at the site.

6.2.3 Exposure Point Concentrations

The exposure point concentration (EPC), which is calculated for COPCs only, is an estimate of the chemical concentrations within an exposure unit (EU) that are likely to be contacted over time by a receptor and is used to estimate exposure intakes. The EUs evaluated and the guidelines for calculating the EPCs for the EUs within Site 1 are as follows:

- EUs for receptors potentially exposed to subsurface soil include the sampled locations within the study area. The data for subsurface soil suggest that hot spots may exist within the area (e.g., at locations NTC01SB088, NTC01SB097, and NTC01SB102).

- The EU for a groundwater receptor may be one well or a cluster of wells (e.g., in the heavily contaminated part of a plume) and is highly dependent on the distribution of the contamination. For this risk assessment, risks for exposure to groundwater were calculated using the maximum detected concentrations of COPCs. Because Illinois EPA requires that risks for each discrete monitoring well be acceptable, risks associated with exposure to chemical concentrations in individual wells were also calculated. Risks for each well are presented and discussed in the Uncertainty Section (Section 6.5.2.2).

- The EU for receptors potentially exposed to surface water and sediment include the sampled locations in the Skokie Ditch.

The following guidelines were used to calculate the EPCs:

- If a soil, surface water, or sediment data set for an EU contained fewer than 10 samples, the EPC for the RME and CTE cases was defined as the maximum detected concentration.

- If a soil, surface water, or sediment data set for an EU contained 10 or more samples, the 95-percent upper confidence limit (UCL) on the arithmetic mean, which is based on the distribution of the data set, was selected as the EPC for the RME and CTE cases. EPCs were calculated following USEPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA, December 2002) using the USEPA's ProUCL software and guidance (Singh, A., et al., April 2004). The version of ProUCL used by TtNUS is set up to flag cases that may require additional evaluation, e.g., large number of non-detects, high detection limits, or cases where the value recommended by ProUCL exceeds the maximum concentration. The ProUCL calculations are presented in Appendix F-2.

- For groundwater, Section 742.225a of TACO indicates that contaminant concentrations of discrete samples at each sample point should be evaluated. Risks for groundwater were characterized by assuming exposure to maximum detected groundwater concentrations. As discussed above, risks for each well were also evaluated and are presented in the Uncertainty Section (Section 6.5.2.2).

- As per USEPA guidance for the child and adult lead models, the EPCs for lead were the average concentrations for each medium evaluated (Sections 6.2.5 and 6.4.4.5).

Sample and duplicate analytical results were averaged for statistical use before the EPC is calculated. Data values less than sample-specific detection limits were substituted with one-half the detection limit. Table 6-9 summarizes the EPCs used in this HHRA. RAGS Part D Tables which summarize the statistical data for the EPCs are presented in Appendix F-1.

6.2.4 Chemical Intake Estimation

The methodologies and techniques used to estimate exposure via ingestion, dermal contact, or inhalation are presented in this section. Intakes for the identified potential receptor groups were calculated using USEPA risk assessment guidance (USEPA, December, 1989 and July 2004) and are presented in the risk assessment spreadsheets in Appendix F-1.

Noncarcinogenic intakes were estimated using the concept of an average annual exposure. Carcinogenic intakes were calculated as an incremental lifetime exposure that assumes a life expectancy of 70 years. Equations used to calculate estimated intakes are provided below.

Values of the exposure parameters and assumptions regarding exposure for receptors and exposure pathways are presented in Tables 6-10 and 6-11.

6.2.4.1 Dermal Contact with Soil/Sediment

Direct physical contact with soil may result in the dermal absorption of chemicals. Exposures associated with the dermal route were estimated in the following manner (USEPA, December, 1989 and July 2004):

$$Intake_{si} = (C_{si})(SA)(AF)(ABS)(CF)(EF)(ED) / (BW)(AT)$$

where:

$Intake_{si}$	=	amount of chemical "i" absorbed during contact with soil (mg/kg/day)
C_{si}	=	concentration of chemical "i" in soil/sediment (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	skin adherence factor (mg/cm^2)
ABS	=	absorption factor (dimensionless)
CF	=	conversion factor ($1x10^{-6}$ kg/mg)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
BW	=	body weight (kg)
AT	=	averaging time (days)
		for noncarcinogens, AT = ED x 365 days/yr

for carcinogens, AT = 70 yrs x 365 days/yr

Exposed surface areas of the body available for dermal contact were determined for each receptor based on assumed human activities and clothing worn during exposure events. USEPA guidance (USEPA, August 1997 and July 2004) was used to develop the default assumptions concerning the amount of skin surface area available for contact for a receptor. The skin surface areas used in risk assessment calculations and the rationale for the selection of the surface areas are as follows:

- For adolescent trespassers, 25 percent of the total body surface area of an adolescent (aged 7 to 16) was assumed to be available for contact with soil. The RME value (3,820 cm^2) was derived from the 95th percentile surface area data, and the CTE value (3,100 cm^2) was derived from the 50th percentile data, as provided in Table 6-6 of the Exposure Factors Handbook (USEPA, August, 1997).

- Maintenance workers and construction/excavation workers were assumed to be exposed on the head, hands, and forearms assuming that they wear a short-sleeved shirt, long pants, and shoes. As recommended in RAGS Part E (USEPA, July 2004), this skin surface area is assumed to be 3,300 cm^2 for the RME and CTE scenarios. This value represents the average of the 50th percentile areas of males and females more than 18 years old.

- For future military and civilian adult residents and adult recreational users assumed exposed to soil and sediment, the exposed surface areas available for contact were the values for the adult skin surface area for exposure to soil recommended in RAGS Part E (USEPA, July 2004), 5,700 cm^2 for the RME and for the CTE. This skin area assumed that head, hands, forearms, and lower legs of the adult are available for contact. For child residents (military and civilian) assumed to be exposed to soil and sediment, the exposed surface areas available for contact were the values for child skin surface area for exposure to soil recommended in RAGS Part E (USEPA, July 2004), 2,800 cm^2 for the RME and for the CTE. This skin area assumes that head, hands, forearms, lower legs, and feet of the child are available for contact. For child residents (military and civilian) assumed to be exposed to surface water while wading in the Skokie Ditch, the exposed surface area was assumed to be 50 percent of the total child skin surface area recommended in RAGS Part E (USEPA, July 2004), 3,300 cm^2 for the RME and for the CTE.

Values of soil adherence factors and chemical-specific dermal absorption factors provided in RAGS Part E (USEPA, July 2004) were used to evaluate risks from exposure to soil and sediment. The following soil adherence factors are used for the RME and CTE exposure scenarios:

- Maintenance and Occupational Workers – 0.2 mg/cm^2 for the RME and 0.02 mg/cm^2 for the CTE (Exhibit 3.5, USEPA, July 2004).
- Construction Workers – 0.3 mg/cm^2 for the RME and 0.1 mg/cm^2 for the CTE (Exhibit 3.3, USEPA, July 2004).
- Adolescent Recreational Users – 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE. (Exhibit 3.5, USEPA, July 2004).
- Future Adult Residents and Adult Recreational Users – 0.07 mg/cm^2 for the RME and 0.01 mg/cm^2 for the CTE (Exhibit 3.5, USEPA, July 2004)
- Future Child Residents – 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE (Exhibit 3.5, USEPA, July 2004).

For the constituents identified as COPCs in soil and sediment, the following absorption factors were used (USEPA, July 2004) in the risk calculations:

- PCBs – 0.14
- PAHs – 0.13
- Dioxins/furans – 0.03
- Arsenic – 0.03
- Cadmium – 0.001
- Semivolatile organics – 0.1
- Other inorganics and volatile organics – not evaluated for dermal contact with soil (USEPA, July 2004)

6.2.4.2 Incidental Ingestion of Soil/Sediment

Incidental ingestion of soil by potential receptors was assumed to coincide with dermal exposure. Exposures associated with incidental ingestion are estimated in the following manner (USEPA, December 1989):

$$Intake_{si} = (C_{si})(IR_s)(FI)(EF)(ED)(CF)/(BW)(AT)$$

where:

$Intake_{si}$	=	intake of contaminant "i" from soil/sediment (mg/kg/day)
C_{si}	=	concentration of contaminant "i" in soil/sediment (mg/kg)
IR_s	=	ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (dimensionless)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
CF	=	conversion factor (1E-6 kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days) for noncarcinogens, AT = ED x 365 days/yr

for carcinogens, AT = 70 yrs x 365 days/yr

The same exposure frequencies and durations used in the estimation of dermal intakes were used to estimate exposure via incidental ingestion. A default value of 1.0 (USEPA, December 1989) was used for the fraction ingested from the contaminated source for the RME and CTE scenarios. For the RME scenario, the ingestion rate was set at 330 mg/day for the construction worker (USEPA, December 2002), 200 mg/day for the future child resident, and 100 mg/day for the other potential receptors (the maintenance worker, occupational worker, future adult resident, and recreational users) (USEPA, May 1993). Ingestion rates for the CTE were assumed to be one-half of the RME values.

6.2.4.3 Inhalation of Air Containing Fugitive Dust/Volatiles Emitted from Soil

This inhalation pathway was quantitatively evaluated because the maximum concentrations of naphthalene and dioxins/furans exceeded the USEPA and Illinois EPA screening levels for migration from soil to air (see Table 6-1) and inhalation risks were calculated for these chemicals only.

The amount of chemical a receptor takes in as a result of respiration is determined using the concentration of the contaminant in air. Intakes of both particulates and vapors from soil were calculated using the same equation, as follows (USEPA, December 1991 and July 1996):

$$Intake_{ai} = [C_{si} \times IR_a \times ET \times EF \times ED \times (1/PEF + 1/VF)] / (BW \times AT)$$

where:	$Intake_{ai}$	=	intake of chemical "i" from air via inhalation (mg/kg/day)
	C_{si}	=	concentration of chemical "i" in soil (mg/kg)
	IR_a	=	inhalation rate (m^3/hr or day)
	ET	=	exposure time (hours/day)
	EF	=	exposure frequency (days/yr)
	ED	=	exposure duration (yr)
	PEF	=	Particulate Emission Factor (m^3/kg)
	VF	=	volatilization factor (chemical-specific) (m^3/kg)
	BW	=	body weight (kg)
	AT	=	averaging time (days) for noncarcinogens, AT = ED x 365 days/yr for carcinogens, AT = 70 yr x 365 days/yr

The concentration of a chemical in air was determined using the methodology provided in the USEPA's Soil Screening Guidance (USEPA, July 1996 and December 2002), measured soil concentrations, and additional site-specific information, such as source area and wind speed. The following inhalation rates were used to calculate the inhalation intakes: for construction/excavation workers, 2.5 m^3/hour for the RME and 1.5 m^3 per hour for the CTE (USEPA, August 1997 and December 2002), 20 m^3/day for adult

residents (USEPA, December 1989), and 10 m^3/day for child residents six years of age (USEPA, August 1997, Table 5-23). The volatilization factor for naphthalene was calculated based on the USEPA's Soil Screening Guidance (USEPA, December 2002). The particulate emission factor for and child and adult residents (1.36 x 10^9 m^3/kg) was obtained from the Soil Screening Guidance (USEPA, December 2002). The particulate emission factor for the construction/excavation worker (1.27 x 10^6 m^3/kg) was calculated using equations and input factors from the Soil Screening Guidance (USEPA, December 2002). Calculations of the volatilization and particulate emission factors for the construction worker are presented in Appendix F-1.

6.2.4.4 Dermal Contact with Groundwater

Dermal contact with groundwater was evaluated by methods and equations provided in RAGS Part E (USEPA, July 2004). Direct contact with groundwater at Site 1 is limited to exposure that would occur under hypothetical future residential and construction/excavation scenarios. Hypothetical future on-site residential receptors were assumed to use groundwater for domestic purposes (i.e., bathing, showering, and dish washing) that can result in dermal exposure. Short-term dermal exposure was assumed to occur for the construction worker during excavation activities. Groundwater at Site 1 is not currently used as a source of potable water.

The following equation was used to assess exposures resulting from dermal contact with water (USEPA, July 2004):

$$DAD_{wi} = (DA_{event})(EV)(ED)(EF)(A)/(BW)(AT)$$

where:

DAD_{wi}	=	dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event}	=	absorbed dose per event (mg/cm^2-event)
EV	=	event frequency (events/day)
ED	=	exposure duration (yr)
EF	=	exposure frequency (days/yr)
A	=	skin surface area available for contact (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days) for noncarcinogens, AT = ED x 365 days/yr for carcinogens, AT = 70 yrs x 365 days/yr

The exposed surface area of construction workers was based on assumed activities and on the assumptions outlined for dermal contact with soil. Current guidance (USEPA, July 2004) was used to

develop the following default assumptions concerning the amount of skin surface area available for contact for a receptor, as follows:

- For construction workers assumed exposed to groundwater, the surface area for the RME and CTE was assumed to be 3,300 cm^2, the value recommended for soil contact in the USEPA's dermal guidance (USEPA, July 2004).

- Dermal intakes for residents assumed total body exposure, 6,600 cm^2 for children (0 – 6 years of age) and 18,000 cm^2 for adults (USEPA, July 2004).

The absorbed dose per event (DA_{event}) was estimated using a nonsteady-state approach for organic compounds and a traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} < t^*, \text{ then: } DA_{event} = (2FA)(Kp)(C_{gw})(CF)\left(\sqrt{\frac{6\,\tau\, t_{event}}{\pi}}\right)$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (FA)(K_p)(C_{gw})(CF)\left(\frac{t_{event}}{1+B} + 2T\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right)$$

where:

t_{event}	=	duration of event (hr/event)
t^*	=	time it takes to reach steady-state conditions (hr)
FA	=	fraction absorbed (dimensionless)
K_p	=	permeability coefficient from groundwater through skin (cm/hr)
C_{gw}	=	concentration of chemical "i" in groundwater (mg/L)
T	=	lag time (hr)
π	=	constant (dimensionless; equal to 3.1416)
CF	=	conversion factor ($1x10^{-3}$ L/cm^3)
B	=	partitioning constant derived by Bunge Model (dimensionless)

The estimated length of time for a shower or bath was assumed to be 10 minutes for the CTE and 15 minutes for the RME. Receptors were assumed to spend an additional 5 minutes in the bathroom following their shower or bath. Construction/excavation workers were assumed to be exposed to shallow groundwater in a trench 4 hours per day for the RME and 2 hours per day for the CTE. An event frequency of one per day was assumed for the CTE and RME (residents were assumed to take one shower or bath per day).

Values for the chemical-specific parameters (t^*, K_p, T, and B) were obtained from the current dermal guidance (USEPA, July 2004).

The following steady-state equation was used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)\ (C_{gw})\ (t_{event})$$

The recommended default value of $1x10^{-3}$ was used for the dermal permeability of inorganic constituents, unless a chemical-specific value is provided in the USEPA guidance. For most metals, dermal absorption is not a significant pathway because penetration through the skin is minimal.

6.2.4.5 Ingestion of Groundwater

Hypothetical residents may be exposed to groundwater via direct ingestion. Intakes associated with ingestion of groundwater were evaluated using the following equation (USEPA, December 1989):

$$Intake_{wi} = \frac{(C_{wi})(IR_w)(EF)(ED)}{(BW)(AT)}$$

where:

$Intake_{wi}$	=	intake of chemical "i" from water (mg/kg/day)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
IR_w	=	ingestion rate for ground water (L/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days) for noncarcinogens, AT = ED x 365 days/year for carcinogens, AT = 70 years x 365 days/year

Water ingestion rates for the adult resident were 1.4 liters L per day (CTE) and 2.0 L per day (RME). For the child resident, water ingestion rates are 0.66 L per day (CTE) and 1.5 L per day (RME). The same exposure times, frequencies, and durations used to assess dermal exposure to water were used to estimate intakes for ingestion of water.

6.2.4.6 Inhalation of Volatiles from Groundwater while Showering

This pathway was quantitatively evaluated in the risk assessment because several VOCs (i.e., benzene and naphthalene) were identified as COPCs for groundwater. Groundwater exposure may also result in inhalation of volatiles, typically for residential receptors who may be exposed while showering, bathing, washing dishes, etc. Inhalation exposures were estimated using a mass transfer model developed specifically for this exposure route in combination with an air intake estimation model. The mass transfer model accounts for inhalation that occurs during a shower and after a shower while the receptor remains in the closed bathroom. The following method was used to estimate intakes from showering (Foster and Chrostowski, June 1987):

$$Intake_{si} = (S)(IR_{sh})(K)(EF)(ED) \ / \ (BW)(AT)(R_a)(CF)$$

$$K = D_s + \frac{\exp(-R_a \times D_t)}{R_a} - \frac{\exp R_a \times (D_s - D_t)}{R_a}$$

where:

$Intake_{wi}$	=	intake of chemical "i" from water via inhalation (mg/kg/day)
S	=	volatile chemical generation rate (ug/m^3-min - shower)
IR_{sh}	=	inhalation rate (L/min)
K	=	mass transfer coefficient (min)
EF	=	exposure frequency (showers/yr)
ED	=	exposure duration (yr)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)
R_a	=	air exchange rate (min^{-1})
CF	=	conversion factor (1 x 10^6 ug-L/mg-m^3)
D_s	=	shower duration (min)
D_t	=	total time in bathroom (min)

The estimated volatile chemical generation rate is based on two-phase film theory. The model uses contaminant-specific mass transfer coefficients, Henry's Law constants, droplet diameter, drop time, viscosity, and temperature. Shower inhalation rates are set at 10 liters per min for adult and child residents (USEPA, December, 1989). The shower model calculations are presented in Appendix F-1.

6.2.4.7 Exposure of Workers to Volatiles in a Construction/Utility Trench

This pathway was quantitatively evaluated in the risk assessment because several VOCs (i.e., benzene and naphthalene) were identified as COPCs for groundwater. There are no well-established models available for estimating migration of VOCs from groundwater into a construction/utility trench. This risk assessment used an approach suggested by the Virginia Department of Environmental Quality (VDEQ,

accessed online, July, 2007) that is based on a combination of a vadose zone model to estimate volatilization of gases from contaminated groundwater into a trench and a box model to estimate dispersion of the contaminants from the air inside the trench into the above-ground atmosphere to estimate the EPC for air in a construction trench. The VDEQ methodology is described in the following sections.

The airborne concentration of a contaminant in a trench can be estimated using the following equation:

$$C_{trench} = C_{GW} \times VF$$

where:

C_{trench}	=	air concentration of contaminant in the trench (ug/m^3)
C_{GW}	=	concentration of contaminant in groundwater (ug/L)
VF	=	volatilization factor (L/m^3)

The model used in this risk assessment assumes that a construction project could result in an excavation to 15 feet bgs or less. If the depth to groundwater at a site is less than 15 feet, the VDEQ model assumes that a worker would encounter groundwater when digging an excavation or a trench. The worker would then have direct exposure to the groundwater. The worker would also be exposed to contaminants in the air inside the trench that would result from volatilization from the groundwater pooling at the bottom of the trench.

The following equation is used to calculate the VF for a trench less than 15 feet deep:

$$VF = (K_i \times A \times F \times 10^{-3} \times 10^4 \times 3{,}600) / (ACH \times V)$$

where:

K_i	=	overall mass transfer coefficient of contaminant (cm/s)
A	=	area of the trench (m^2)
F	=	fraction of floor through which contaminant can enter (unitless)
ACH	=	air changes per hour = 360 h^{-1}
V	=	volume of trench (m^3)
10^{-3}	=	conversion factor (L/cm^3)
10^4	=	conversion factor (cm^2/m^2)
3,600	=	conversion factor (seconds/hr)

Studies of urban canyons suggest that if the ratio of trench width to trench depth, relative to wind direction, is less than or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of gas exchange with the atmosphere and the air changes per hour is assumed to be of 2 per hr based on measured ventilation rates of buildings. If the ratio of trench width to trench depth is greater than one, air exchange between the trench and above-ground atmosphere is not restricted, and ACH is assumed to be 360 per hr based upon the ratio of trench depth to the average wind speed. The risk

assessment assumes that the width to trench depth ratio is greater than 1 and the air changes per hour is assumed to be 360 per hour.

The overall mass transfer coefficient (K_i) is calculated as follows:

$$K_i = 1 / \{(1/k_iL) + [(RT) / (H_i\ k_iG)]\}$$

where:

k_iL	=	liquid-phase mass transfer coefficient of i cm/s
R	=	ideal gas constant (atm-m^3/mole-°K) = 8.2×10^{-5}
T	=	average system absolute temperature (°K) (Default = 298°K)
H_i	=	Henry's Law constant of i (atm-m^3/mol)
K_iG	=	gas-phase mass transfer coefficient of i (cm/s)

where:

kiL	=	$(MWO_2/MWi)^{0.5} \times (T/298) \times kL,O_2$
k_iL	=	liquid-phase mass transfer coefficient of component i (cm/s)
MWO_2	=	molecular weight of O_2 (g/mol)
MW_i	=	molecular weight of component i (g/mol)
kL, O_2	=	liquid-phase mass transfer coefficient of oxygen at 25°C (cm/s)

The value of kL, O_2 is 0.002 cm/s.

$$k_iG = (MWH_2O/MW_i)^{0.335} \times (T/298)^{1.005} \times kG,\ H_2O$$

where:

kiG	=	gas-phase mass transfer coefficient of component i (cm/s)
MWH_2O	=	molecular weight of water (g/mol)
kG,H_2O	=	gas-phase mass transfer coefficient of water vapor at 25°C (cm/s)

The value of kG, H_2O is 0.833 cm/s

Exposures for construction workers associated with the inhalation route are estimated in the following manner (USEPA, December 1989):

$$Intake_{trenchi} = \frac{(C_{trenchi})(IR_a)(ET)(EF)(ED)}{(BW)(AT)}$$

where:

$Intake_{trenchi}$	=	intake of chemical "i" from air via inhalation (mg/kg/day)
$C_{trenchi}$	=	concentration of chemical "i" in air (mg/m^3)

IR_a	=	inhalation rate (m^3/hr) = 2.5 m^3/hr (USEPA, December 2002)
ET	=	exposure time (hours/day)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
BW	=	body weight (kg)
AT	=	averaging time (days) for noncarcinogens, AT = ED x 365 days/yr for carcinogens, AT = 70 yr x 365 days/yr

Input assumptions and calculations of the VDEQ model are presented in Appendix F-1. Site-specific values of input parameters were used, if available. If site-specific values were not available, model default values were used. Chemical properties (e.g., Henry's Law constants) were obtained from the Soil Screening Guidance (USEPA, December 2002).

6.2.4.8 Incidental Ingestion of Surface Water

Potential receptors may incidentally ingest small amounts of surface water while wading in the Skokie Ditch. Intakes associated with ingestion of surface water were evaluated using the following equation (USEPA, December 1989):

$$\text{Intake}_{wi} = \frac{(C_{wi})(IR_w)(ET)(EF)(ED)}{(BW)(AT)}$$

where:

Intake_{wi}	=	intake of chemical "i" from water (mg/kg/day)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
IR_w	=	ingestion rate for surface water (L/hour)
ET	=	exposure time for surface water (hour/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days); for noncarcinogens, AT = ED x 365 days/year; for carcinogens, AT = 70 years x 365 days/year

An ingestion rate of 0.01 L per hour was used for adults and adolescents under CTE and RME conditions (USEPA Region 4, May 2000) and 0.05 L per hour for children (USEPA Region 4, May 2000). Exposure times, which are based on professional judgment with consideration of anticipated activities, were specified as 4 hour per day for construction workers and adolescent trespassers/recreational users, 2 hours per day for maintenance workers and hypothetical future residents, and 1 hour per day for adult recreational users (golfers) for RME. Exposure times for the CTE were assumed to be one-half the RME values. Because surface water and sediment exposure coincides, the same exposure durations and frequencies previously

identified for exposure to sediment were used to evaluate inadvertent surface water ingestion. Exposure factor values for ingestion of surface water are summarized in Tables 6-10 and 6-11.

6.2.4.9 Dermal Contact with Surface Water

The same equations used to assess dermal exposure to groundwater were used to evaluate dermal exposure to surface water. The following skin surface areas were used for evaluating dermal exposure to surface water: 3,300 cm^2 was used as the exposed surface area for excavation/construction workers and maintenance workers; 5,700 cm^2 for adult recreational users and future adult residents; 3,280 cm^2 for adolescent trespassers; and 3,300 cm^2 for child residents (one-half the total body area of the child) for the RME. The same exposed surface areas were used to evaluate risks for the CTE, with the exception of adolescent trespassers (surface area for the CTE is 3,100 cm^2 which represents 25 percent of the 50th percentile total body surface area of an adolescent). The same exposure times, frequencies, and durations used to assess ingestion of surface water were used to estimate intakes for dermal exposure.

6.2.5 Exposure to Lead

Lead was identified as a COPC for subsurface soil because the maximum detected concentration (1,410 mg/kg) exceeded the 400 mg/kg screening concentration. Lead was also identified as a COPC for groundwater because the maximum detected concentration (8.4 ug/L) exceeded the Illinois EPA Groundwater Remediation Objective for Class 1 Groundwater (7.5 ug/L). The equations and methodologies presented in the previous sections cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters. Exposure to lead was assessed using the latest version of the USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead (USEPA, May, 2002). This model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure.

Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. The threshold for toxic effects from this chemical is believed to be in the range of 10 µg/dL to 15 µg/dL. Blood lead levels greater than 10 µg/dL are considered to be a "concern."

The IEUBK Model for lead is used to address exposure to lead in children if detected groundwater concentrations exceed federal or state screening levels or if detected soil or sediment concentrations exceed the Office of Solid Waste and Emergency Response soil screening level of 400 mg/kg for

residential land use (USEPA, July 1994). Average lead concentrations, as well as model default values for some input parameters, were employed in the model calculations.

Adult exposure to lead in soil was quantified by the model provided by the USEPA's Technical Review Workgroup for Lead (USEPA, November 2003). In this model, adult exposure to lead in soil is addressed by an evaluation of the relationship between the site soil lead concentration and the blood lead concentration in the developing fetuses of adult women. The adult lead model generates a spreadsheet for each exposure scenario evaluated (i.e., workers and adult recreational users). The spreadsheets calculate a range of 95th percentile fetal blood lead concentrations from central estimates of blood lead concentrations in pregnant adult women. The spreadsheets also calculate 95th percentile blood lead concentrations in fetuses born to women exposed to lead in soil.

Input parameters and results of the child and adult lead models are presented in Appendix F-3.

6.3 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to identify the potential health hazards and adverse effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects were defined for the identified COPCs. Quantitative toxicity values determined during this component of the risk assessment were integrated with outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects for each receptor group.

The toxicity value used to evaluate noncarcinogenic health effects is the Reference Dose (RfD). Carcinogenic effects are quantified using the Cancer Slope Factor (CSF).

6.3.1 Toxicity Criteria

Oral and inhalation RfDs and CSFs used in the HHRA for Site 1 were obtained from the following primary literature sources (USEPA, December 2003):

- Integrated Risk Information System (IRIS) (Online).
- USEPA Provisional Peer Reviewed Toxicity Values – The Office of Research and Development/National Center for Environmental Assessment Superfund Health Risk Technical

Support Center develops Provisional Peer Reviewed Toxicity Values on a chemical-specific basis when requested by USEPA's Superfund program.

- Annual Health Effects Assessment Summary Tables (USEPA, July 1997) for chronic and subchronic toxicity values.

- Other Toxicity Values – These sources include but are not limited to California Environmental Protection Agency toxicity values and the Agency for Toxic Substances and Disease Registry Minimal Risk Levels.

Although RfDs and CSFs can be found in several toxicological sources, USEPA's IRIS online database is the preferred source for toxicity values. The USEPA Region 9 PRG tables and Region 3 Risk-Based Concentration tables were also used as sources of toxicity criteria. The RfDs and CSFs used in the risk assessment calculations for Site 1 are presented in Tables 6-12 through 6-15.

6.3.2 Toxicity Criteria for Dermal Exposure

RfDs and CSFs found in literature may be expressed as administered doses; therefore, these values are considered to be inappropriate for estimating the risks associated with dermal routes of exposure. Oral dose-response parameters based on administered doses must be adjusted to absorbed doses before the comparison to estimated dermal exposure intakes is made. Because this information is not always readily available, oral dose-response parameters were adjusted to an absorbed dose using chemical-specific absorption efficiencies published in available guidance (USEPA, July 2004) and the following equations:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

$$CSF_{dermal} = (CSF_{oral}) / (ABS_{GI})$$

where:

ABS_{GI} = absorption efficiency in the gastrointestinal tract

6.3.3 Toxicity Criteria for Carcinogenic Effects of PAHs

Limited toxicity values are available to evaluate the carcinogenic effects from exposure to PAHs. The most extensively studied PAH is BaP, classified by the USEPA as a known human carcinogen. Although CSFs are available of BaP, insufficient data are available to calculate CSFs for other carcinogenic PAHs. Toxic effects for these chemicals are evaluated using the concept of estimated orders of potential potency, as presented in USEPA guidance (USEPA, July 1993). These parameters are based on the carcinogenicity of BaP and are available for select carcinogenic PAHs. The equivalent oral and inhalation CSFs for these chemicals is derived by multiplying the CSF for BaP by the order of potential potency. Carcinogenic PAHs were evaluated as total BaP Equivalents in the risk assessment. If any carcinogenic PAH was identified as a COPC for any medium, the BAP Equivalent was calculated for that medium and was used as the EPC for estimating risk.

6.3.4 Calculation of Risks for Carcinogens that Act by a Mutagenic Mode of Action (PAHs)

The risk estimates for carcinogenic PAHs in soil at Site 1 were calculated using the methodology provided in RAGs-Part A and the methodology used by USEPA Region 9 in the calculation of the PRGs (see Section 4.1.2.4). In March 2005, the USEPA provided general direction on implementing the EPA's 2005 Guidelines for Carcinogen Risk Assessment and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens because of special considerations for carcinogens that act via a mutagenic mode of action (e.g., PAHs).

The aspect of the new guidelines that most directly affects the calculation of cancer risks is the use of age-dependent adjustment factors to adjust cancer risk for receptors whose exposure includes early life. For chemicals that the USEPA has determined to be carcinogenic via a mutagenic mode of action, special adjustments are applied in estimating cancer risks. For example, vinyl chloride has a chemical-specific adjustment, as described in IRIS. For the other chemicals (e.g., PAHs), where no chemical-specific age-dependent adjustment factors have been developed, default age-dependent adjustment factors are used: 10 for age 0 to 2, 3 for age 2 to16, and no adjustment for ages 16 and up. In October 2006, USEPA Region 3 began to use these default age-dependent adjustment factors to calculate its Risk-Based Concentrations for a number of chemicals, including PAHs.

For the Site 1, risks for future residents and adolescents could be affected by this new guidance. Risks calculated for workers would not be affected. The implications and uncertainties associated with the new guidance are discussed in the uncertainty section.

6.3.5 Toxicity of Dioxin/Furans

The USEPA has classified 2,3,7,8-TCDD as a B2 carcinogen (probable human carcinogen). An oral CSF for 2,3,7,8-TCDD is not available in IRIS, but a value of 1.5×10^5 $(mg/kg/day)^{-1}$ is available in Health Effects Assessment Summary Tables (USEPA, July 1997) and is specified in the Region 3 Risk-Based Concentration and Region 9 PRG tables. The oral CSF is currently under review by USEPA and may be revised in the future (USEPA, December 2003).

USEPA recommends that a Toxicity Equivalence Factor approach be used to evaluate chlorinated dioxin and furan congeners. The total amount of toxic dioxin and furan congeners present at a site is usually expressed as toxicity equivalents quotients (TEQs) of 2,3,7,8-TCDD present. The Toxicity Equivalence Factors recommended by the World Health Organization in June 2005 were used to calculate the 2,3,7,8-TCDD TEQs in the Site 1 risk assessment. The following table presents the World Health Organization TEFs.

Dioxin/furan Congener	World Health Organization Toxicity Equivalence Factors
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
HxCDDs	0.1
HpCDDs	0.01
OCDD	0.0003
Other CDDs	0
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
HxCDFs	0.1
HpCDFs	0.01
OCDF	0.0003
Other CDFs	0

Similar to PAHs, dioxins/furans were evaluated as total 2,3,7,8-TCDD equivalents (2,3,7,8-TCDD TEQ) in the risk assessment. If dioxins/furans were identified as COPCs in any medium, the 2,3,7,8-TCDD TEQ was calculated for that medium and was used as the EPC for estimating risk.

6.3.6 Toxicity Criteria for Chromium

Toxicity criteria are available for two different forms of chromium, the trivalent state and the hexavalent state, of which the latter is considered to be more toxic. The screening of chromium was conducted assuming that 100 percent of the reported total chromium is hexavalent. Should chromium, assumed to be all hexavalent, prove to be a significant contributor to risk, further investigation regarding the presence

and valence state of chromium may be necessary. The uncertainty associated with the assumption that all chromium is hexavalent chromium is discussed in the uncertainty section (Section 6.5.3.7).

6.4 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with potential exposures to COPCs at Site 1. Section 6.4.1 outlines the methods used to quantitatively estimate the type and magnitude of potential risks for human receptors. A summary of the risk characterization for Site 1 is provided in Section 6.4.4.

6.4.1 Quantitative Analysis

Quantitative estimates of risk were calculated according to risk assessment methods outlined in USEPA guidance (USEPA, December 1989). Lifetime cancer risks are expressed in the form of dimensionless probabilities, referred to as ILCRs, based on CSFs. Noncarcinogenic risk estimates are presented in the form of HQs that are determined through a comparison of intakes with published RfDs.

ILCR estimates were generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$\text{ILCR} = (\text{Estimated Exposure Intake})(\text{CSF})$$

If the above equation resulted in an ILCR greater than 0.01, the following equation (USEPA, 1989) was used:

$$\text{ILCR} = 1\text{-}[\exp(\text{-Estimated Exposure Intake})(\text{CSF})]$$

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

As mentioned previously, noncarcinogenic risks are assessed using the concept of HQs and HIs. The HQ for a COPC is the ratio of the estimated intake to the RfD, as follows:

$$\text{HQ} = (\text{Estimated Exposure Intake}) / (\text{RfD})$$

An HI is generated by summing the individual HQs for the COPCs. The HI is not a mathematical prediction of the severity of toxic effects and therefore is not a true "risk"; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

6.4.2 Comparison of Quantitative Risk Estimates to Benchmarks

Quantitative risk estimates are compared to typical benchmarks to interpret the quantitative risks and to aid risk managers in determining the need for remediation at a site. Calculated ILCRs are interpreted using the USEPA's "target range" ($1x10^{-4}$ to $1x10^{-6}$)and HIs are evaluated using a value of 1.0.

The USEPA has defined the range of $1x10^{-4}$ to $1x10^{-6}$ as the ILCR target range for most hazardous waste facilities addressed under CERCLA and RCRA. Individual or cumulative ILCRs greater than $1x10^{-4}$ are typically not considered as protective of human health, and ILCRs less than $1x10^{-6}$ are typically regarded as protective. Risk management decisions are necessary when the ILCR is within the $1x10^{-4}$ to $1x10^{-6}$ cancer risk range. Risks greater than $1x10^{-6}$ are discussed in the risk assessment. The Illinois EPA goal for carcinogenic risks, as specified in TACO, is $1x10^{-6}$.

An HI exceeding unity (1.0) indicates that there may be potential noncarcinogenic health risks associated with exposure. If an HI exceeded unity, a segregation of target organs effects associated with exposure to COPCs was performed. Only those chemicals that affect the same target organ(s) or exhibit similar critical effect(s) are regarded as truly additive. Consequently, it may be possible for a cumulative HI to exceed 1.0, but have no anticipated adverse health effects if the COPCs do not affect the same target organ or exhibit the same critical effect.

6.4.3 Qualitative Analysis

A qualitative evaluation of risk was made for the following exposure situations.

- The soil inhalation pathway was initially evaluated by a comparison of maximum site soil concentrations to USEPA Generic SSLs for transfers from soil to air and Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties (Illinois EPA, online, July, 2007) for the inhalation exposure route. If the maximum site concentration exceeds the SSL for a chemical, a quantitative analysis of this exposure pathway was performed. For Site 1, the concentrations of naphthalene and dioxins/furans in subsurface soil exceeded the soil-to-air criteria. Therefore, the inhalation of dioxins/furans and naphthalene on dust and particulate matter and the inhalation of

naphthalene vapors were quantitatively evaluated in the risk assessment for construction workers.

- A qualitative evaluation of the potential for migration of soil contaminants to groundwater was conducted by a comparison of maximum soil concentrations to Illinois EPA and USEPA SSLs for transfers from soils to groundwater in Table 6-2. SSLs based on DAFs of 1 and 20 were used in the evaluation. The comparisons are presented and discussed in Section 6.1.3.1.

6.4.4 Risk Characterization

This section contains a summary of the results of the risk characterization for Site 1. Quantitative risk estimates for potential human receptors were developed for those chemicals identified as COPCs. Uncertainties associated with the risk estimates are discussed in Section 6.5. The methodology used to calculate the risks presented in this section is provided in Sections 6.2 and 6.3. Potential cancer risks (ILCRs) and noncarcinogenic HIs were calculated for current/future maintenance workers, adolescent and adult trespassers/recreational users, and for future construction workers, occupational workers, and on-site civilian and military residents. Risks to military residents were evaluated by reference to the risks calculated for civilian residents because the civilian risks are slightly greater or the same as the military resident risks. The results of the risk assessment for these receptors are summarized in Tables 6-16 and 6-17 for the RME and CTE scenarios, respectively. Risks were calculated for subsurface soil, groundwater, and surface water and sediment in the Skokie Ditch. Results of the risk assessment in RAGS Part D format are included in Appendix F-1. Sample risk assessment calculations are presented in Appendix F-4.

6.4.4.1 Noncarcinogenic Risks - RME

Noncarcinogenic Risks for Exposure to Subsurface Soil - RME

The cumulative HI for the receptor most likely to be exposed to subsurface soil at Site 1, the future excavation/construction worker, was less than unity (1.0), indicating that adverse noncarcinogenic health effects are not anticipated for this receptor under the defined RME exposure conditions.

Noncarcinogenic Risks for Exposure to Surface Water and Sediment in the Skokie Ditch - RME

HIs for the potential receptors were less than unity (1.0) indicating that adverse noncarcinogenic health effects are not anticipated for these receptors under the defined RME exposure conditions.

Noncarcinogenic Risks for Exposure to Groundwater - RME

The cumulative HI for excavation/construction workers was less than 1 on a target-organ basis.

The cumulative groundwater HIs for future child and adult residents (HIs = 28 and 8, respectively) exceeded unity. The major contributors to the HIs were iron (child HQ = 2, adult HQ = 0.7), manganese (child HQ = 21, adult HQ = 6), and vanadium (child HQ = 2, adult HQ = 0.6). These risks were based on assumed exposure to the maximum detected concentrations of iron (17,600 ug/L), manganese (5,070 ug/L), and vanadium (20.7 ug/L) in unfiltered samples. As stated previously, comparisons of the filtered and unfiltered sample data indicates that turbidity in the samples may have affected the analysis of the unfiltered samples. For example, iron was not detected in the filtered groundwater samples and the maximum concentrations of manganese in the filtered groundwater samples were approximately an order of magnitude less than maximum concentrations in the unfiltered samples. Risk for exposure to the maximum concentrations in the filtered samples would be less than 1.

6.4.4.2 Carcinogenic Risks - RME

Carcinogenic Risks for Subsurface Soil - RME

The cumulative ILCR for the excavation/construction worker (ILCR = $5x10^{-6}$) assumed to be exposed to COPCs in subsurface soil was within the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$ but exceeded the Illinois EPA goal of $1x10^{-6}$. Ingestion of dioxins/furans accounted for more than 90 percent of the total subsurface soil ILCR. The dioxin/furan risk was based on exposure to the sample with the maximum TEQ concentration (NTC01SB090). As stated previously, there is considerable uncertainty in the concentrations of analytes in this sample because the concentrations in the duplicate sample (NTC01SB0900812-D) collected at this location were considerably different. For example, the concentrations of the 2,3,7,8-TCDD TEQs in the sample and the duplicate were, 90 ng/kg and 9,000 ng/kg, respectively, indicating that there is a great amount of uncertainty in the EPC used to estimate the risks for dioxins/furans.

Carcinogenic Risks for Exposure to Surface Water - RME

The cumulative ILCR for the excavation/construction worker ($7x10^{-7}$) was less than the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. Cumulative ILCRs for maintenance workers ($1x10^{-5}$), adolescent trespassers/ recreational users ($2x10^{-5}$), adult recreational users ($1x10^{-5}$), and future residents (total residential ILCR = $3x10^{-5}$) were within the USEPA target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. Dermal contact with PAHs and dioxins/furans was the major contributor to these ILCRs. There are uncertainties

in the risks estimates for dermal contact with PAHs and dioxins/furans that tend to greatly overestimate the risks for surface water. The nature and magnitude of this uncertainty are discussed in Section 6.5.3.3. In addition, the surface water risks were based on maximum detected concentrations.

Carcinogenic Risks for Exposure to Sediment - RME

Cumulative ILCRs for excavation/construction workers ($3x10^{-7}$) were less than the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. Cumulative ILCRs for maintenance workers ($3x10^{-6}$), adolescent trespassers/ recreational users ($3x10^{-6}$), adult recreational users ($2x10^{-6}$), and future residents (total residential ILCR = $7x10^{-6}$) were within the USEPA target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. PAHs (62 percent) and arsenic (28 percent) account for most of the total residential ILCR. The maximum concentration of arsenic (10.1 mg/kg) slightly exceeded the background concentration (8 mg/kg) and the average concentration across the site (7 mg/kg) was less than background.

Carcinogenic Risks for Exposure to Groundwater - RME

The cumulative ILCR for the construction worker ($1x10^{-9}$) was less than ($1x10^{-6}$). The total residential ILCR (child + adult = $9x10^{-5}$) was within the USEPA's target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. Arsenic accounted for more than 99 percent of the total ILCR. The risks for arsenic were based on ingestion of the maximum detected concentration (3.3 ug/L) which is significantly less than the USEPA MCL (10 ug/L) and the Illinois EPA Remediation Objective for Class 1 Groundwater (50 ug/L). Exposure to the MCL concentration results in a calculated risk greater than $1x10^{-4}$. In addition, the risks for arsenic were based on concentrations in unfiltered groundwater samples. However, arsenic was detected in only 3 of 13 unfiltered groundwater samples and was not positively detected in the filtered samples. Furthermore, the maximum detected concentration of arsenic is at the low end of the range of published background levels for the United States, less than 1 to 30 ug/L, (Dragun, 1988) and is also within the range of background wells in the State of Illinois in a study conducted by the Unitied States Geological Survey and reported online at http://water.usgs.gov/nawqa/trace/arsenic. Also, groundwater at the site is not currently used as a source of potable water nor is it expected to be used in the future.

6.4.4.3 Noncarcinogenic Risks - CTE

Noncarcinogenic Risks for Exposure to Subsurface Soil - CTE

Target-organ-specific HIs for the future excavation/construction worker were less than unity (1.0), indicating that adverse noncarcinogenic health effects are not anticipated for this receptor under the defined CTE exposure conditions.

Noncarcinogenic Risks for Exposure to Surface Water and Sediment in the Skokie Ditch - CTE

HIs for the potential receptors were less than unity (1.0) indicating that adverse noncarcinogenic health effects are not anticipated for these receptors under the defined CTE exposure conditions.

Noncarcinogenic Risks for Exposure to Groundwater - CTE

The cumulative HI for excavation/construction workers was less than 1.

The cumulative groundwater HIs for future child and adult residents (HIs = 9 and 4, respectively) exceeded unity. The major contributor to these HIs was manganese (child HQ = 6, adult HQ = 3). As discussed above, there are several uncertainties that tend to overestimate the calculated groundwater risks for manganese and other COPCs.

6.4.4.4 Carcinogenic Risks - CTE

Carcinogenic Risks for Subsuface Soil - CTE

The subsurface soil ILCR for the excavation/construction worker (ILCR = $2x10^{-6}$) was within the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$ but exceeded the Illinois EPA goal of $1x10^{-6}$. Ingestion of dioxins/furans accounted for most of the total subsurface soil ILCR. As stated previously, there is considerable uncertainty in the dioxin/furan EPC for subsurface soil because of very poor field duplicate precision.

Carcinogenic Risks for Exposure to Surface Water - CTE

The cumulative ILCR for excavation/construction workers ($5x10^{-7}$) was less than the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. Cumulative ILCRs for maintenance workers ($2x10^{-6}$), adolescent trespassers/ recreational users ($8x10^{-6}$), adult recreational users ($2x10^{-6}$), and future residents (total residential ILCR = $4x10^{-6}$) were within the USEPA target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. Dermal contact with PAHs and dioxins/furans accounted for most of the surface water ILCRs.

Carcinogenic Risks for Exposure to Sediment - CTE

Sediment ILCRs for the potential receptors evaluated were less than $1x10^{-6}$.

Carcinogenic Risks for Exposure to Groundwater - CTE

The cumulative ILCR for the construction worker ($6x10^{-10}$) was less than ($1x10^{-6}$). The total residential ILCR (child + adult = $1x10^{-5}$) was within the USEPA's target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. As with the RME scenario, arsenic accounted for most of the total ILCR and is subject to the same uncertainties discussed above.

6.4.4.5 Evaluation of Exposure to Lead

Lead was identified as a COPC for subsurface soil and groundwater at Site 1 because the maximum detected lead concentrations (1,410 mg/kg in soil and 8.4 ug/L in groundwater) exceeded the 400 mg/kg Office of Solid Waste and Emergency Response soil screening level for residential land use and the Illinois EPA Remediation Objective for Class I Groundwater (7.5 µg/L), respectively.

As discussed in Section 6.2.5, the methodology used to calculate the risks presented in Sections 6.4.4.1 through 6.4.4.4 cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters. Exposure to lead was assessed using the USEPA's IEUBK Model for lead, (USEPA, May 2002) and the USEPA's Adult Lead Model (USEPA, January 2003). The IEUBK model is typically used to evaluate lead exposure assuming a residential land use scenario, and the Adult Lead Model was used to evaluate lead exposure for non-residential land use scenarios.

The blood-lead concentration of a receptor is considered a key indicator of the potential for adverse health effects. The IEUBK and Adult Lead models calculate the probability of a receptor's blood-lead level exceeding 10 µg/dL. The USEPA goal is to limit the childhood risk of exceeding a 10 µg/dL blood-lead concentration to 5 percent.

Current USEPA guidance (USEPA, online at http://www.epa.gov/superfund/programs/lead/trwrisk.htm, July 2007) recommends using the average concentration to evaluate exposure to lead. Therefore, the average lead concentration for groundwater (2.2 ug/L) and the average lead concentration in subsurface soil (209 mg/kg), and model default values for other model parameters were used in the IEUBK and Adult Lead modeling. The results of the IEUBK Model and Adult Lead Model evaluations are presented in the following sections.

IEUBK Model Results

The results of the IEUBK modeling are presented in the following table.

IEUBK Model Results for Subsurface Soil and Groundwater at Site 1

Lead Concentration	Predicted Geometric Mean	Probability of the Child Blood-

	Blood-Lead Level (µg/dL) (USEPA Goal = 10)	Lead Level Exceeding 10 µg/dL (percent) (USEPA Goal = 5%)
Soil - 209 mg/kg Groundwater – 2.2 ug/L	3.4	1

The results of the IEUBK model evaluation for Site 1 indicate that the estimated geometric mean blood-lead level for a child resident is 3.4 µg/dL which is less than the established level of concern (10 µg/dL). Approximately 1 percent of children are expected to experience blood-lead levels greater than 10 µg/dL. This estimate is less than USEPA's goal of limiting exposure to lead so that no more than 5 percent of exposed children have an estimated blood-lead level greater than the established level of concern (i.e., 10 µg/dL). The IEUBK evaluation is conservative in several respects; it assumes exposure by a hypothetical child resident and assumes that the child is exposed to subsurface soil. Both of these scenarios are unlikely to occur at Site 1.

Adult Lead Model Results

The results of the adult lead modeling are presented in the following table.

Adult Lead Model Results for the Excavation/Construction Worker Exposure to Lead in Subsurface Soil

Lead Concentration	Predicted Geometric Mean Blood-Lead Level of a Worker (µg/dL) (USEPA Goal = 10)	Probability of the Fetus of a Worker Having Blood- Lead Levels Exceeding 10 µg/dL (percent) (USEPA Goal = 5%)
Soil – 209 mg/kg	2.2	2.0

The central estimate blood-lead level for construction workers exposed to the average concentration of lead in surface soil (209 mg/kg) was 2.2 µg/dL. The probability that blood-lead levels of fetuses of adult workers would be greater than 10 µg lead/dL of blood was 2 percent. This estimates are less than the USEPA's goal of limiting exposure to lead so that no more than 5 percent of exposed receptors have an estimated blood-lead level greater than the established level of concern (i.e., 10 µg/dL).

Summary of Lead Model Evaluation

The IEUBK and Adult Lead Model analysis of lead concentrations in subsurface soil and groundwater at Site 1 indicate that predicted blood levels for children and excavation/construction workers and the fetuses of the construction worker were acceptable (i.e., within USEPA's goals and the probabilities of

exceeding these goals from exposure to lead in soil were less than the USEPA goal of 5 percent). The results of the IEUBK and Adult Lead modeling are presented in Appendix F-3.

6.5 UNCERTAINTY ANALYSIS

There is uncertainty associated with all aspects of the HHRA. A summary of the uncertainties, including a discussion of how they may affect the final risk estimates, is provided in this section.

Uncertainty in the selection of COPCs is related to the current status of the predictive databases, the grouping of samples, the numbers, types, and distributions of samples, and the procedures used to include or exclude constituents as COPCs. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route or scenario, the assumptions made to determine EPCs, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing toxicity data needed to support dose-response relationships and the weight of evidence used to determine the carcinogenicity of COPCs. Uncertainty in risk characterization includes that associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier steps of the risk assessment process.

Whereas there are various sources of uncertainty, the direction of uncertainty can be influenced by the assumptions made throughout the risk assessment, including selection of COPCs and selection of values for dose-response relationships. Throughout the risk assessment, assumptions are biased toward a margin of safety so that the final calculated risks are overestimated.

Generally, risk assessments include two types of uncertainty: measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used.

Informational uncertainty is associated with inadequate availability of information needed to complete the toxicity and exposure assessments. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, on the biological mechanism of action of a chemical, or on the behavior of a chemical in soil.

After the risk assessment is complete, the results must be reviewed and evaluated to identify the types and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration

of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to make sure that the particular assumptions made are protective of sensitive subpopulations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward over predicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation is especially relevant when the risks exceed the point of departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are less than an acceptable risk level (i.e., 10^{-4} to 10^{-6}), the interpretation of no significant risk is typically straightforward. However, when risks calculated using a high degree of uncertainty exceed an acceptable risk level (i.e., 10^{-4}), a conclusion can be difficult unless uncertainty is considered.

6.5.1 Uncertainty in Selection of COPCs

The most significant issues related to uncertainty in COPC selection were the usability of existing databases (only validated data were used in this risk assessment) and the completeness, precision, and accuracy of the data set, the inclusion of chemicals potentially attributable to background in the quantitative risk assessment, the screening levels used, and the absence of screening levels for a few chemicals detected in site media. A brief discussion of each of these issues is provided in the remainder of this section.

6.5.1.1 Usability of Existing Databases

Data from samples collected for the RI were used to assess risks to potential human receptors. The RI samples were biased because they were collected in areas of known or suspected contamination. Because the sampling was biased, the uncertainty is expected to be minimal, and risks are not likely to be underestimated.

The data used in the HHRA were validated in accordance with the Quality Assurance Project Plan (TtNUS, February 2007). The qualification of data during the formal data validation process is not expected to impact the results of the baseline HHRA. Analytical data qualified as estimated were utilized, even though the reported concentrations or sample-specific quantitation limits may be somewhat

imprecise. The use of estimated data adds to the uncertainty associated with the risk assessment; however, the associated uncertainty is expected to be negligible compared to the other uncertainties inherent in the risk evaluation process (i.e., uncertainties with land uses, exposure scenarios, toxicological criteria, etc.). Analytical data attributable to blank contamination were used in the risk assessment. When determining exposure concentrations via statistical procedures, a chemical selected as a COPC but not detected in a particular sample was conservatively assumed to be present in that sample at a concentration equal to one-half the sample-specific quantitation limit. Analytical results for some chemicals were qualified "R," rejected, and were not used in the risk assessment. The rejection of a few chemicals in a few samples is not considered to be problematic because there were enough usable analytical data for these parameters to identify whether they are actually present at the site and to estimate the necessary data distribution parameters. Because the data have been validated, the uncertainty in the calculated risks associated with the data is minimal. This is especially true because the COPCs used in the quantitative risk calculations were minimally affected by data quality problems.

6.5.1.2 COPC Screening Levels

The use of risk-based screening concentrations, based on conservative land use scenarios (i.e., residential land use), corresponding to an ILCR of 10^{-6} and HI of 0.1 should make sure that significant contributors to risk from a site were evaluated. The elimination of chemicals present at concentrations that correspond to an ILCR less than 10^{-6} and an HI less than 0.1 should not affect the final conclusions of the risk assessment because these chemicals are not expected to cause a potential health concern at the detected concentrations.

6.5.1.3 Chemicals without Established Screening Levels

Risk-based screening levels are currently not available for some constituents [e.g., acenaphthylene, 2-methylnaphthalene, benzo(g,h,i)perylene, and phenanthrene]. Therefore, surrogates with similar chemical structures were selected for these chemicals. In the COPC screening, acenaphthene was used as a surrogate for acenaphthylene, naphthalene was used as a surrogate for 2-methylnaphthalene, pyrene was selected as a surrogate for benzo(g,h,i)perylene and phenanthrene, and chlordane was used as a surrogate for alpha- and gamma-chlordane. Applying toxicity values for one compound to another added to uncertainty in the risk assessment both in regard to the selection of COPCs and the subsequently calculated risks.

A number of constituents do not have USEPA SSLs or Illinois EPA Remediation Objectives for the migration from soil to air pathway. This uncertainty is expected to be small because potential risks associated with

exposures via inhalation are typically orders of magnitude lower than those associated with exposures via incidental ingestion and dermal contact with soil. A comparison of screening criteria for direct contact exposures with screening criteria for migration from soil to air shows that, in most cases, the direct contact screening criteria are at least an order of magnitude less than the soil-to-air migration screening criteria for the same compound. If there are unacceptable risks resulting from inhalation exposures, there are usually also unacceptable risks from exposures via the incidental ingestion and dermal contact exposure pathways.

6.5.1.4 Chemicals Potentially Attributable to Background

The background evaluation for Site 1 was, for the most part, not an important consideration in the COPC selection process. No site-specific or facility background concentrations are available for Naval Station Great Lakes. Background concentrations provided by Illinois EPA were used for soil and sediment background comparisons. No background or upgradient data were available for groundwater or surface water.

An examination of the COPC selection tables (Tables 6-1 through 6-6) shows that only one constituent (manganese in sediment) was eliminated as a COPC on the basis of comparison to background levels. However, the maximum detected concentration of manganese was less than the Region 9 PRG (based on an HI of 1) and the Illinois EPA Remediation Objective for Residential Soil (Table 6-1). Therefore, the risk estimates for sediment have likely not been underestimated by omitting manganese from the quantitative risk assessment.

In general, because only one constituent in one medium was eliminated from the risk assessment and because background concentrations were not available for some media, it is likely that risks for Site 1 have been overestimated for metals and anthropogenic organic compounds.

6.5.1.5 Uncertainty Associated with Turbidity in Groundwater Samples

Another significant source of uncertainty for the risk estimates developed for groundwater is the fact that elevated concentrations of some metals (e.g., arsenic, iron, and manganese in groundwater) selected as COPCs appear to be, in part, the result of particulate matter in unfiltered samples. As discussed in Section 6.4.4.1, risks for arsenic, iron, manganese, and vanadium in groundwater were based on assumed exposure to the maximum detected concentrations in unfiltered samples. Comparisons of filtered and unfiltered sample data indicate that turbidity in the samples may have affected the analysis of the unfiltered samples. For example, arsenic and iron were not detected in filtered groundwater samples, and the maximum concentration of manganese in filtered groundwater samples was approximately an

order of magnitude less than the maximum concentration in the unfiltered samples. Risks based on turbid samples might be greatly overestimated because groundwater that is turbid is unlikely to be used as a domestic water supply source and/or is often filtered before being used for drinking and other residential uses.

6.5.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises from the determination of land use conditions, in the methods used to calculate EPCs, in the selection of receptors and scenarios, and in the selection of exposure parameters. Each of these is discussed below.

6.5.2.1 Land Use

The current land use patterns at Site 1 are well established, thereby limiting the uncertainty associated with land use assumptions. The site is a golf course and access is not limited. The most likely receptors at the site are maintenance workers and recreational users. To be conservative and to aid in risk management decisions, risks to future excavation/construction workers and hypothetical future residents were estimated for the site.

6.5.2.2 Exposure Point Concentrations

Uncertainty is associated with the use of the 95-percent UCL on the mean concentration as the EPC. As a result of using the 95-percent UCL, the estimations of potential risk for the RME scenario are most likely overstated. The UCL is a representation of the upper limit that potential receptors would be exposed to over the entire exposure period. In some cases (because data sets contained less than 10 samples or because the UCL was greater than the maximum concentration), the maximum concentration was used as the EPC. Use of the maximum concentration tends to overestimate potential risks because receptors are assumed to be exposed continuously to the maximum concentration for the entire exposure period. Uncertainty is also introduced when non-detects are assigned a value of one-half the sample-specific quantitation limit in the calculation of the EPC. This may either overstate or understate the risks to the receptors.

There is also uncertainty in assuming that current groundwater and surface water concentrations will not change in the future, and this would introduce additional uncertainty in the EPCs and risks for the groundwater or surface water COPCs. Concentrations in groundwater and surface water may diminish over time due to natural attenuation processes involving source depletion and dilution.

As discussed in Section 6.2.3, the risks calculated for groundwater were based on maximum detected concentrations of COPCs. In order to eliminate some of the uncertainty associated with use of maximum concentrations to estimate groundwater risks, risk estimates for COPC concentrations detected in the other wells (permanent and temporary) were also calculated assuming residential exposures and are presented in the following table.

RISKS FOR DISCRETE GROUNDWATER WELLS
SITE 1 – GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Well No.	Carcinogenic Risks (ILCRs)			Noncarcinogenic His	
	Child Resident	Adult Resident	Total Residential	Child Resident	Adult Resident
GW0101	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	3.1	0.9
GW0201	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	1.5	0.4
GW0301	$4.1X\ 10^{-5}$	$4.7X\ 10^{-5}$	$7.4X\ 10^{-5}$	7.6	2.2
GW0401	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	1.5	0.5
GW0501	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	0.9	0.3
GW0601	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	4.6	1.4
GW0701	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	1	0.3
GW0801	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	20	5.9
GW0901	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	22	6.6
GW1001	$2.1X\ 10^{-5}$	$2.4X\ 10^{-5}$	$3.7X\ 10^{-5}$	3.8	1.1
TW0101	$3.0X\ 10^{-5}$	$3.4X\ 10^{-5}$	$5.4X\ 10^{-5}$	4.3	1.3
TW0201	$3.0X\ 10^{-5}$	$3.4X\ 10^{-5}$	$5.4X\ 10^{-5}$	1.2	0.4
TW0301	$1.1X\ 10^{-5}$	$1.2X\ 10^{-5}$	$1.9X\ 10^{-5}$	1.5	0.5
Maximum Concentrations	$4.1X\ 10^{-5}$	$4.7X\ 10^{-5}$	$7.4X\ 10^{-5}$	28	8.4

The elevated ILCRs shown in the table are mainly due to exposure to arsenic. Note that arsenic was positively detected in only three samples. One-half the detection limit of arsenic was used to calculate risks for the other samples. The elevated HIs were mainly due to exposure to iron, manganese, and vanadium. As discussed in Section 6.4.4.1, there are a number of significant uncertainties associated with the risks for these metals (e.g., turbidity in the samples and lack of background samples).

6.5.2.3 Exposure Routes and Receptor Identification

The determination of various receptor groups and exposure routes of potential concern was based on current land use observed at the site and the anticipated future land use. Therefore, the uncertainty associated with the selection of exposure routes and potential receptors is minimal because they are considered to be well defined. Although residential use of groundwater was evaluated as an exposure scenario, groundwater is not currently used at the site nor is it expected to be used in the future. Therefore, the evaluation of direct exposure to groundwater performed in this HHRA was included primarily to aid in risk management decision making.

6.5.2.4 Exposure Parameters

Each exposure factor (for RME and CTE scenarios) selected for use in the risk assessment has some associated uncertainty. Generally, exposure factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid underestimation of exposure, in most cases, the USEPA guidelines (USEPA March 1991 and May 1993) on the RME receptor were used, which generally specify the use of the 95th percentile for most parameters. Therefore, the selected values for the RME receptor represent the upper bound of the observed or expected habits of the majority of the population.

Generally, the uncertainty can be assessed quantitatively for many assumptions made in determining factors for calculating exposures and intakes. Many of these parameters were determined from statistical analyses on human population characteristics. Often, the database used to summarize a particular exposure parameter (i.e., body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty.

For many parameters for which limited information exists (i.e., dermal absorption of chemicals from soil), greater uncertainty exists. For example, current USEPA guidance (USEPA, July 2004) does not provide dermal absorption factors for exposure to VOCs and most metals (except arsenic and cadmium) in soil. Therefore, risks for dermal contact from soil and sediment are not evaluated for most metals in this risk assessment. Consequently, risks from exposure to soil and sediment may be underestimated.

Many of the exposure parameters used to calculate exposures and risks in this report were selected from a distribution of possible values, including USEPA guidance (USEPA, December 1991 and May 1993) and dermal guidance (USEPA, August 1997 and July 2004). For the RME scenario, the value representing the 95th percentile is generally selected for each parameter to ensure that the assessment bounds the actual risks from a postulated exposure. This risk number is used in risk management decisions but does not indicate what a more average or typical exposure might be or what risk range might be expected for individuals in the exposed population.

To address these issues, USEPA (USEPA, February 1992) suggested the use of the CTE receptor, whose intake variables are often set at approximately the 50th-percentile of the distribution. The risks for this receptor seek to incorporate the range of uncertainty associated with various intake assumptions. The USEPA does provide limited guidance for the CTE evaluation (USEPA, May 1993) but it was necessary to use professional judgment for some parameters in the CTE calculations.

6.5.2.5 Uncertainty Associated with Risk Estimates for Future Residential to Subsurface Soil

There is uncertainty in risk estimates developed for the hypothetical future resident because the HHRA did not assume that these receptors would be directly exposed to subsurface soil contamination. In order to determine the effects of possible exposure to subsurface soil, risk estimates were calculated for hypothetical residents assuming that these receptors are exposed to subsurface soil contamination (i.e., assuming that subsurface soils are excavated and brought to the surface). The results of the subsurface soil evaluation are presented in the following table.

Risk Estimates for Exposure of Future Residents to COPCs in Subsurface Soil – Site 1 (RME)		
Receptor	**Hazard Index (HI)**	**Incremental Lifetime Cancer Risk**
Future Child Resident	3	$1x10^{-3}$
Future Adult Resident	0.3	$4x10^{-4}$
Total Residential (Child + Adult)	NA	$1x10^{-3}$

As shown in the above table, the ILCRs for the hypothetical future resident exceed the USEPA's target risk range, $1x10^{-6}$ -$1x10^{-4}$. The elevated ILCRs were mainly due to exposure to dioxins/furans and PAHs that accounted for 84 percent and 14 percent of the total subsurface soil risks, respectively. HIs for the receptors evaluated for exposure to subsurface soil are less than the USEPA goal of 1 on a target- organ-specific basis.

6.5.3 Uncertainty in the Toxicological Evaluation

Uncertainties associated with the toxicity assessment (determination of RfDs and CSFs and use of available criteria) are presented in this section.

6.5.3.1 Derivation of Toxicity Criteria

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for the COPCs. The hazard assessment deals with characterizing the nature and strength of the evidence of causation or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination using USEPA methods. Positive animal cancer test data suggest that humans contain tissue(s) that may manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of

noncancer effects, however, positive animal data often suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arises from the nature and quality of the animal and human data. Uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route when the magnitude of the response is clearly dose related when pharmacokinetic data indicate a similar fate in humans and animals when postulated mechanisms of toxicity are similar for humans and animals and when the chemical of concern is structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation includes the determination of a CSF for the carcinogenic assessment and derivation of an RfD for the noncarcinogenic assessment. Uncertainty is introduced from interspecies (animal-to-human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also results from intraspecies variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity, including unusual sensitivity or tolerance to the COPC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not unusually sensitive to the chemical are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study and the database from which the quantitative estimate is derived. For cancer effects, the uncertainty associated with dose-response factors is mitigated by assuming the 95-percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. Evidence suggests however, that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic. Therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity.

For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for noncancer effects arises from the use of an effect level in the estimation of an RfD, because this estimation is predicated on the assumption of a threshold less than which adverse effects are not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises in estimation of an RfD for chronic exposure from subchronic data. Unless empirical data indicate

that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the subchronic study. Uncertainty in the derivation of RfDs is mitigated by the use of uncertainty and modifying factors that normally range between 3 and 10. The resulting combination of uncertainty and modifying factors may reach 1,000 or more.

The derivation of dermal RfDs and CSFs from oral values may cause uncertainty. This is particularly the case when no gastrointestinal absorption rates are available in the literature or when only qualitative statements regarding absorption are available.

6.5.3.2 Uncertainty Associated with Evaluation of the Dermal Exposure Pathway for Soil and Sediment

According to RAGS Part E (USEPA, July 2004), risks for dermal absorption of inorganics in soil are to be quantitatively evaluated for arsenic and cadmium only. Therefore, risks from dermal exposure to metals other than arsenic and cadmium in soil or sediment were not quantified in the risk assessment. Consequently, potential risks for these media may be underestimated as a result of the exclusion of these constituents from the dermal risk assessment calculations. The following paragraphs provide further discussion regarding the uncertainty associated with the evaluation of the dermal absorption of metals from soil and sediment.

The model for dermal exposure to soil and sediment assumes that only a very thin layer of soil of constant thickness is available for contaminant transfer to the stratum corneum and that a constant amount of contaminant, proportional to the soil concentration, will be absorbed per unit area of skin and per exposure event. However, adherence to skin varies with such factors as particle size, soil type, and organic carbon content. As estimated by USEPA (USEPA July 2004), the absorbed dermal dose could vary by as much as a factor of 50 from the model estimates, even assuming that activity patterns leading to the exposure duration applied in the experimental trials used to develop absorption factors.

Experimental determination of absorption rates indicates that interspecies differences are considerable, which, along with other variables related to condition and age of skin, differences in lag time, and site of application effects, yields appreciable uncertainty in estimated dermal exposures using published chemical-specific permeation functions. In addition, literature data indicate a variation by as much as a factor of 300 in chemical absorption rates for skin in different anatomical areas of the body. It should also be noted that children generally have greater absorption rates than adults.

6.5.3.3 Uncertainty Associated with Evaluation of the Aqueous Dermal Exposure Pathway

As discussed in Section 6.4.4.2, dermal contact with PAHs and dioxins/furans in surface water was the major contributor to risks for several receptors. As shown in Tables 6-16 and 6-17, and in the RAGS Part D tables in Appendix F-1, the risks for dermal contact were three to four orders of magnitude greater than risks by ingestion. The dermal risks were calculated using a USEPA model presented in RAGS Part E (USEPA, July 2004) which, according to the guidance, tends to overestimate intakes and risk for some chemicals (e.g., PAHs, PCBs, and dioxins). Appendices A and B of RAGS Part E discuss the uncertainties in the permeability coefficients for these chemicals and the limitations of the dermal absorption model when evaluating chemicals such as the PAHs and dioxins. In addition, studies have shown that PAHs in aqueous solutions do not penetrate the skin. For this reason, TtNUS was instructed by USEPA Region 4 via e-mail not to evaluate risks for dermal contact with PAHs in water (USEPA Region 4, July 2000). Based on the studies discussed in the e-mail, the uncertainty associated with the aqueous dermal pathway for PAHs is "greater than a billion fold".

6.5.3.4 Uncertainty in the Risks Calculated for Carcinogenic PAHs

The risk estimates for carcinogenic PAHs in subsurface soil, sediment, and surface water at Site 1 were calculated using the methodology provided in RAGS Part A and the methodology used by USEPA Region 9 in the calculation of the PRGs. In March 2005, the USEPA provided general direction on implementing the USEPA's 2005 Guidelines for Carcinogen Risk Assessment and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens because of special considerations for carcinogens that act via a mutagenic mode of action (e.g., PAHs).

The aspect of the new guidelines that most directly affects the calculation of cancer risks is the use of age-dependent adjustment factors to adjust cancer risk for receptors whose exposure includes early life. For chemicals that the USEPA has determined to be carcinogenic via a mutagenic mode of action, special adjustments are applied in estimating cancer risks. For example, vinyl chloride has a chemical-specific adjustment, as described in IRIS. For the other chemicals (e.g., PAHs), where no chemical-specific age-dependent adjustment factors have been developed, default age-dependent adjustment factors are used: 10 for age 0 to 2, 3 for age 2 to16, and no adjustment for ages 16 and up. In October 2006, USEPA Region 3 began to use these default age-dependent adjustment factors to calculate its Risk-Based Concentrations for a number of chemicals, including PAHs.

The implications of this new guidance for the risk assessment for Site 1 are that risks for future residents and adolescent trespassers may be underestimated by approximately three to four times based on the

default age-dependent adjustment factors used by USEPA Region 3. For example, in the risk assessment for Site 1, the total residential risk (child + adult) for sediment was $7x10^{-6}$ and the sediment risk for adolescent trespassers/recreational users was $3x10^{-6}$. If the new methodology and default age-dependent adjustment factors were used to calculate the risks for PAHs, the ILCRs for these receptors would be $3x10^{-5}$ and $1x10^{-5}$, respectively. Risks calculated for workers would not be affected by the new guidance.

6.5.3.5 Uncertainty Associated with Toxicity Criteria for Aluminum and Iron

National Center for Environmental Assessment provisional RfDs were used to evaluate noncarcinogenic effects from exposure to aluminum, copper, and iron. The provisional RfDs for these chemicals are based on allowable intakes rather than adverse effect levels. Therefore, there is some degree of uncertainty associated with the use of the RfDs. Some USEPA regions (e.g., Region 1) consider the use of the oral RfD for aluminum, cobalt, copper, and iron inappropriate and recommend that these metals not be evaluated quantitatively in risk assessments.

6.5.3.6 Alternate RfD for Manganese

The oral RfD for manganese listed in the Region 9 PRG table (0.024 mg/kg/day) was used to calculate risks for ingestion and dermal contact with groundwater. This value includes a modification factor of 3 and an adjustment factor for the dietary contribution, which is applied to the non-dietary RfD (0.14 mg/kg/day) presented in IRIS. IRIS indicates that an adjustment for the dietary contribution should be subtracted from this allowable intake. Using the modified and adjusted RfD results in risk estimates six times higher than if the non-dietary RfD were used. If the non-dietary RfD was used for groundwater at Site 1, the HQ for manganese for the future child resident would decrease from 21 to 3.5 and would still slightly exceed the goal of 1. The HQ for the adult resident would decrease from 6 to 1.

6.5.3.7 Uncertainty in the Toxicity Criteria for Chromium

Toxicity criteria are available for different forms of chromium, which is considered to be more toxic in the hexavalent state. Because there is no evidence that hexavalent chromium is present at the Site 1, speciation analyses were not performed for the medium at the site. Risks associated with this chemical were assessed by conservatively assuming that 100 percent of the reported total chromium result is attributable to hexavalent chromium. Therefore, the risks calculated for chromium in subsurface soil, groundwater, and sediment are likely overestimated. However, because the HQs calculated for chromium in these media were less than unity, the uncertainty introduced into the risk assessment is minimal.

6.5.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization resulted from assumptions made regarding additivity of effects from exposure to multiple COPCs from various exposure routes. High uncertainty exists when summing noncancer risks for several substances across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Even when compounds affect the same target organs, they may have different mechanisms of action or differ in their fate in the body, so additivity may not have been an appropriate assumption. However, the assumption of additivity was considered acceptable because in most cases it represented a conservative estimate of risk.

Risks to any individual may also have been overestimated by summing multiple assumed exposure pathway risks for any single receptor. Although every effort was made to develop reasonable scenarios, not all individual receptors may have been exposed via the pathways considered.

Also, the risk characterization did not consider antagonistic or synergistic effects. Little or no information was available to determine the potential for antagonism or synergism for the COPCs. Because chemical-specific interactions could not be predicted, the likelihood for risks to be over predicted or under predicted could not be defined, but the methodology used was based on current USEPA guidance.

6.6 SUMMARY AND CONCLUSIONS

This section summarizes the results of the HHRA performed for Site 1. The HHRA for the Site 1 was performed to characterize the potential risks to likely human receptors under current and potential future land use. Potential receptors under current land use are maintenance workers, adolescent trespassers/recreational users, and adult recreational users. Potential receptors under future land use are construction/excavation workers, occupational workers, and hypothetical child and adult residents. Military residents (child and adult) were evaluated by reference to hypothetical civilian residents. Although the site is not likely to be developed for residential use, potential future residential receptors were evaluated in the HHRA primarily for decision-making purposes.

The direct contact COPCs retained for quantitative risk evaluation at Site 1 are as follows:

- Subsurface soil – benzo(a)anthracene, BaP, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene, dioxins/furans, aluminum, antimony, arsenic, chromium, copper, iron, lead, manganese, silver, thallium, vanadium

- Groundwater – benzene, naphthalene, 2-methylnaphthalene, aluminum, arsenic, barium, chromium, iron, lead, manganese, vanadium

- Surface water – vinyl chloride, BaP, dioxins/furans, antimony, thallium

- Sediment – benzo(a)anthracene, BaP, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, Aroclor-1248, dioxins/furans, aluminum, arsenic, chromium, iron, thallium, vanadium

In addition to the COPCs based on direct contact listed above, COPCs were also identified for migration from soil to groundwater but these constituents were not evaluated in the quantitative risk assessment, as explained in Section 6.1.2. Table 6-3 also presents comparisons of concentrations in filtered groundwater samples to screening criteria.

The results of the HHRA for Site 1 are summarized by medium in the following sections.

6.6.1 Exposure to Subsurface Soil

The cumulative HI for the receptor most likely to be exposed to subsurface soil at Site 1, the future excavation/construction worker, were less than unity (1.0), indicating that adverse noncarcinogenic health effects are not anticipated for this receptor under the defined exposure conditions.

The cumulative ILCR for the excavation/construction worker (ILCR = $5x10^{-6}$) was within the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$ but exceeded the Illinois EPA goal of $1x10^{-6}$. Ingestion of dioxins/furans accounted for more than 90 percent of the total subsurface soil ILCR. There is a great deal of uncertainty in the EPC used for dioxins/furans because of discrepancies in the analysis of the samples. (see Sections 6.1.3.1 and 6.4.4.2).

6.6.2 Exposure to Surface Water in the Skokie Ditch

Risks for surface water were based on maximum detected concentrations. HIs for the potential receptors were less than unity (1.0), indicating that adverse noncarcinogenic health effects are not anticipated for these receptors under the defined RME exposure conditions.

The cumulative ILCR for the excavation/construction worker ($7x10^{-7}$) was less than the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. Cumulative ILCRs for maintenance workers ($1x10^{-5}$), adolescent trespassers/ recreational users ($2x10^{-5}$), adult recreational users ($1x10^{-5}$), and future residents (total residential ILCR = $3x10^{-5}$) were within the USEPA target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. Dermal contact with PAHs and dioxins/furans was the major contributor to these ILCRs. There are uncertainties in the risk estimates for dermal contact with PAHs and dioxins/furans in surface water that tend to greatly overestimate the risks (see Sections 6.4.4.2 and 6.5.3.3).

6.6.3 Exposure to Sediment in the Skokie Ditch

HIs for the potential receptors were less than unity (1.0), indicating that adverse noncarcinogenic health effects are not anticipated for these receptors under the defined RME exposure conditions.

Cumulative ILCRs for excavation/construction workers ($3x10^{-7}$) were less than the USEPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. Cumulative ILCRs for maintenance workers ($3x10^{-6}$), adolescent trespassers/ recreational users ($3x10^{-6}$), adult recreational users ($2x10^{-6}$), and future residents (total residential ILCR = $7x10^{-6}$) were within the USEPA target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. PAHs and arsenic accounted for most of the total ILCRs.

6.6.4 Exposure to Groundwater

The groundwater risks were based on assumed exposure to the maximum detected concentrations. The cumulative HI for excavation/construction workers was less than 1 on a target organ basis.

The cumulative groundwater HIs for future child and adult residents (HIs = 28 and 8, respectively) exceeded unity. The major contributors to the HIs were iron (child HQ = 2, adult HQ = 0.7), manganese (child HQ = 21, adult HQ = 6), and vanadium (child HQ = 2, adult HQ = 0.6). As discussed in Sections 6.4.4.1 and 6.5, there are several significant uncertainties associated with the risks for these metals.

The cumulative ILCR for the construction worker ($1x10^{-9}$) was less than ($1x10^{-6}$). The total residential ILCR (child + adult = $9x10^{-5}$) was within the USEPA's target risk range but exceeded the Illinois EPA goal of $1x10^{-6}$. The residential risks were due to arsenic which accounted for more than 99 percent of the total ILCR. However, the maximum detected concentration of arsenic (3.3 ug/L) is less than the USEPA MCL (10 ug/L) and the Illinois EPA Remediation Objective for Class 1 Groundwater (50 ug/L) and is probably within naturally occurring background levels.

In summary, noncarcinogenic risks (HIs) for subsurface soil, surface water, and sediment were less than USEPA and Illinois EPA benchmarks for the potential receptors evaluated at Site 1. Noncarcinogenic risks for potential residential use of groundwater exceeded criteria for children and adults. These risks were due to the assumed exposure to maximum detected concentrations of iron, manganese, and vanadium in unfiltered groundwater samples.

Carcinogenic risks (ILCRs) for subsurface soil, groundwater, surface water, and sediment were within the USEPA's target risk range ($1x10^{-6}$ to $1x10^{-4}$) but exceeded the Illinois EPA goal of $1x10^{-6}$ for most receptors in these media. Arsenic was the main contributor to risks for groundwater. PAHs and dioxins/furans accounted for most of the risk in the other media. As discussed in Sections 6.4.4 and 6.5, the risk estimates were subject to a number of significant uncertainties. Among these are the facts that background data are not available for groundwater and surface water, concentrations of metals in some groundwater samples appear to be elevated because of suspended matter in the samples, and groundwater is not currently used at Site 1 nor is it expected to be used in the future. Surface soil was not evaluated in the risk assessment because surface soil at Site 1 consists of clean fill to a depth of 2 feet.

TABLE 6-1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - DIRECT CONTACT AND INHALATION
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Region 9 PRGs - Residential Soil[5]	TACO - Soil Remediation Objective for Residential Properties[6] - Ingestion	Screening Level Based on USEPA Generic SSLs for Migration from Soil to Air - Residential[7]	TACO - Soil Remediation Objective for Residential Properties - Inhalation[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[8]
Volatile Organic Compounds (ug/kg)														
78-93-3	2-BUTANONE	3.2 J	12	NTC01SB1001012	3/16	4.5 - 16	12	NA	2200000 N	NA	24000000 sat	NA	No	BSL
67-64-1	ACETONE	6.4 J	59 J	NTC01SB1001012	2/16	18 - 62	59	NA	1400000 N	7800000	NA	100000000	No	BSL
75-09-2	METHYLENE CHLORIDE	2.1 J	2.3 J	NTC01SD0981516	2/16	4.5 - 16	2.3	NA	9100 C	85000	13000 C	13000	No	BSL
Semivolatile Organics (ug/kg)														
91-57-6	2-METHYLNAPHTHALENE	40 J	250 J	NTC01SB0991012	4/4	--	250	NA	5600 N[9]	1600000	NA	NA	No	BSL
95-48-7	2-METHYLPHENOL	39 J	39 J	NTC01SB0991012-D	1/4	400 - 2100	39	NA	310000 N	3900000	NA	NA	No	BSL
106-44-5	4-METHYLPHENOL	13 J	170 J	NTC01SB0991012-D	2/4	660 - 890	170	NA	31000 N	NA	NA	NA	No	BSL
83-32-9	ACENAPHTHENE	11 J	290 J	NTC01SB1020408	3/4	890 - 2100	290	NA	370000 N	4700000	NA	NA	No	BSL
208-96-8	ACENAPHTHYLENE	11 J	100 J	NTC01SB0900812-D	2/4	400 - 890	100	NA	370000 N[10]	4700000	NA	NA	No	BSL
120-12-7	ANTHRACENE	13 J	260 J	NTC01SB1020408	2/4	420 - 2100	260	NA	2200000 N	23000000	NA	NA	No	BSL
100-52-7	BENZALDEHYDE	110 J	150 J	NTC01SB0900812	2/4	400 - 2100	150	NA	610000 N	NA	NA	NA	No	BSL
56-55-3	BENZO(A)ANTHRACENE	320 J	520	NTC01SB0991012-D	2/4	400 - 2100	520	NA	620 C	900	NA	NA	No	BSL
50-32-8	BENZO(A)PYRENE	14 J	500	NTC01SB0991012-D	3/4	400 - 2100	500	NA	62 C	90	NA	NA	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	24 J	870	NTC01SB0991012-D	3/4	400 - 2100	870	NA	620 C	900	NA	NA	Yes	ASL
191-24-2	BENZO(G,H,I)PERYLENE	20 J	500	NTC01SB0991012-D	3/4	890 - 2100	500	NA	230000 N[11]	2300000	NA	NA	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	130 J	230 J	NTC01SB0991012-D	2/4	400 - 2100	230	NA	6200 C	9000	NA	NA	No	BSL
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	150 J	660 J	NTC01SB0900812-D	2/4	400 - 890	660	NA	35000 C	46000	NA	31000000	No	BSL
85-68-7	BUTYL BENZYL PHTHALATE	9.8 J	74 J	NTC01SB0950810	4/4	--	74	NA	1200000 N	16000000	NA	930000	No	BSL
86-74-8	CARBAZOLE	100 J	250 J	NTC01SB1020408	2/4	400 - 2100	250	NA	24000 C	32000	NA	NA	No	BSL
218-01-9	CHRYSENE	400 J	680	NTC01SB0991012-D	2/4	400 - 2100	680	NA	62000 C	88000	NA	NA	No	BSL
53-70-3	DIBENZO(A,H)ANTHRACENE	59 J	130 J	NTC01SB0991012-D	2/4	420 - 2100	130	NA	62 C	90	NA	NA	Yes	ASL
132-64-9	DIBENZOFURAN	19 J	100 J	NTC01SB1020408	3/4	890 - 2100	100	NA	15000 N	NA	NA	NA	No	BSL
84-66-2	DIETHYL PHTHALATE	18 J	430 J	NTC01SB0900812-D	2/4	400 - 890	430	NA	4900000 N	63000000	NA	2000000	No	BSL
84-72-2	DI-N-BUTYL PHTHALATE	56 J	340 J	NTC01SB0900812-D	1/4	400 - 890	340	NA	610000 N	7800000	NA	2300000	No	BSL
206-44-0	FLUORANTHENE	45 J	1400 J	NTC01SB0991012-D	3/4	890 - 2100	1400	NA	230000 N	3100000	NA	NA	No	BSL
86-73-7	FLUORENE	11 J	320 J	NTC01SB1020408	3/4	400 - 890	320	NA	270000 N	3100000	NA	NA	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	12 J	400	NTC01SB0991012-D	3/4	890 - 2100	400	NA	620 C	900	NA	NA	No	BSL
91-20-3	NAPHTHALENE	52 J	250 J	NTC01SB0900812-D	4/4	--	250	NA	5600 N	1600000	17000 N	1800	No	BSL
85-01-8	PHENANTHRENE	58 J	1700	NTC01SB1020408	4/4	--	1700	NA	230000 N[11]	2300000	NA	NA	No	BSL
108-95-2	PHENOL	22 J	93 J	NTC01SB0900812-D	2/4	400 - 890	93	NA	1800000 N	47000000	NA	NA	No	BSL
129-00-0	PYRENE	41 J	1300	NTC01SB1020408	3/4	890 - 890	1300	NA	230000 N	2300000	NA	NA	No	BSL
Polynuclear Aromatic Hydrocarbons (ug/kg)														
91-57-6	2-METHYLNAPHTHALENE	7.5 J	3500 J	NTC01SB1020408	15/16	400 - 400	3500	NA	5600 N[9]	1600000	NA	NA	No	BSL
83-32-9	ACENAPHTHENE	14 J	260 J	NTC01SB0991012-D	3/15	38 - 13000	260	NA	370000 N	4700000	NA	NA	No	BSL
208-96-8	ACENAPHTHYLENE	25 J	3100 J	NTC01SB0991012-D	10/16	38 - 13000	3100	NA	370000 N[10]	4700000	NA	NA	No	BSL
120-12-7	ANTHRACENE	1.8 J	5200	NTC01SB1020408	16/16	--	5200	NA	2200000 N	23000000	NA	NA	No	BSL
56-55-3	BENZO(A)ANTHRACENE	41	11000	NTC01SB1020408	9/15	7.8 - 40	11000	NA	620 C	900	NA	NA	Yes	ASL
50-32-8	BENZO(A)PYRENE	1.5 J	9300	NTC01SB1020408	14/16	7.8 - 18	9300	NA	62 C	90	NA	NA	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	4.9 J	14000	NTC01SB1020408	14/16	18 - 40	14000	NA	620 C	900	NA	NA	Yes	ASL
191-24-2	BENZO(G,H,I)PERYLENE	0.96 J	7300	NTC01SB1020408	16/16	--	7300	NA	230000 N[11]	2300000	NA	NA	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	1.8 J	4600	NTC01SB1020408	12/16	8.6 - 40	4600	NA	6200 C	9000	NA	NA	No	BSL
86-74-8	CARBAZOLE	12 J	4300 J	NTC01SB1020408	6/15	38 - 400	4300	NA	24000 C	32000	NA	NA	No	BSL
218-01-9	CHRYSENE	1.6 J	12000	NTC01SB1020408	15/16	18 - 18	12000	NA	62000 C	88000	NA	NA	No	BSL
53-70-3	DIBENZO(A,H)ANTHRACENE	4.4 J	850	NTC01SB0880708	7/15	7.8 - 180	850	NA	62 C	90	NA	NA	Yes	ASL
206-44-0	FLUORANTHENE	4.8 J	49000	NTC01SB1020408	16/16	--	49000	NA	230000 N	3100000	NA	NA	No	BSL
86-73-7	FLUORENE	14	3300	NTC01SB1020408	7/15	7.8 - 82	3300	NA	270000 N	3100000	NA	NA	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	1 J	6300	NTC01SB1020408	16/16	--	6300	NA	620 C	900	NA	NA	Yes	ASL
91-20-3	NAPHTHALENE	20 J	3100 J	NTC01SB1020408	13/16	38 - 4100	3100	NA	5600 N	1600000	17000 N	1800	Yes	ASL
85-01-8	PHENANTHRENE	7 J	26000	NTC01SB1020408	16/16	--	26000	NA	230000 N[11]	2300000	NA	NA	No	BSL
129-00-0	PYRENE	4 J	31000	NTC01SB1020408	16/16	--	31000	NA	230000 N	2300000	NA	NA	No	BSL
	BAP EQUIVALENT ZERO ND	0.25	13068	NTC01SB1020408	16/16	--	13068	NA	62 C	90	NA	NA	Yes	ASL
	BAP EQUIVALENT - HALF ND	4.2449	13068	NTC01SB1020408	16/16	--	13068	NA	62 C	90	NA	NA	Yes	ASL

TABLE 6-1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - DIRECT CONTACT AND INHALATION
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Region 9 PRGs - Residential Soil[5]	TACO - Soil Remediation Objective for Residential Properties[6] - Ingestion	Screening Level Based on USEPA Generic SSLs for Migration from Soil to Air - Residential[7]	TACO - Soil Remediation Objective for Residential Properties - Inhalation[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[8]
Organochlorine Pesticides/PCBs (ug/kg)														
72-54-8	4,4'-DDD	4.8	280 J	NTC01SB0991012-D	4/4	--	280	NA	2400 C	3000	NA	NA	No	BSL
72-55-9	4,4'-DDE	0.6 J	82 J	NTC01SB0991012-D	4/4	--	82	NA	1700 C	2000	NA	NA	No	BSL
50-29-3	4,4'-DDT	1.4 J	27 J	NTC01SB0991012-D	4/4	--	27	NA	1700 C	2000	750000 C	NA	No	BSL
309-00-2	ALDRIN	1.5 J	1.5 J	NTC01SB0991012-D	1/4	2.2 - 10	1.5	NA	29 C	40	3400 C	3000	No	BSL
319-84-6	ALPHA-BHC	1.7 J	1.7 J	NTC01SB0991012	1/4	2.2 - 10	1.7	NA	90 C	100	750 C	800	No	BSL
5103-71-9	ALPHA-CHLORDANE	2.2 J	2.8 J	NTC01SB0900812	2/4	2.2 - 10	2.8	NA	1600 C[12]	1800	72000 C	22000	No	BSL
12672-29-6	AROCLOR-1248	130 J	130 J	NTC01SB0991012	1/4	40 - 89	130	NA	220 C	1000	NA	NA	No	BSL
11097-69-1	AROCLOR-1254	33 J	33 J	NTC01SB0900812	1/4	40 - 89	33	NA	110 C	1000	NA	NA	No	BSL
11096-82-5	AROCLOR-1260	100 J	100 J	NTC01SB0991012	1/4	40 - 89	100	NA	220 C	1000	NA	NA	No	BSL
319-86-8	DELTA-BHC	1.2 J	1.2 J	NTC01SB0991012	1/4	2.2 - 10	1.2	NA	90 C	NA	NA	NA	No	BSL
60-57-1	DIELDRIN	0.55 J	1.2 J	NTC01SB0991012	2/4	2.2 - 10	1.2	NA	30 C	40	1100 C	1000	No	BSL
959-98-8	ENDOSULFAN I	3.1 J	3.1 J	NTC01SB0991012	1/4	2.2 - 10	3.1	NA	37000 N	470000	NA	NA	No	BSL
33213-65-9	ENDOSULFAN II	3.7 J	6.1 J	NTC01SB0991012	1/4	2.2 - 4.6	6.1	NA	37000 N	470000	NA	NA	No	BSL
1031-07-8	ENDOSULFAN SULFATE	2 J	2 J	NTC01SB0991012-D	1/4	2.2 - 10	2	NA	37000 N	470000	NA	NA	No	BSL
72-20-8	ENDRIN	1.6 J	9.6 J	NTC01SB0991012-D	2/4	2.2 - 10	9.6	NA	1800 N	23000	NA	NA	No	BSL
53494-70-5	ENDRIN KETONE	0.73 J	2.2 J	NTC01SB0991012	2/4	2.2 - 10	2.2	NA	1800 N	23000	NA	NA	No	BSL
58-89-9	GAMMA-BHC (LINDANE)	1.2 J	7.7 J	NTC01SB0991012-D	1/4	2.2 - 4.6	7.7	NA	440 C	500	NA	NA	No	BSL
5103-74-2	GAMMA-CHLORDANE	2 J	6.9 J	NTC01SB0991012	3/4	2.2 - 10	6.9	NA	1600 C[12]	1800	72000 C	22000	No	BSL
76-44-8	HEPTACHLOR	2.4 J	2.4 J	NTC01SB0991012-D	1/4	2.2 - 10	2.4	NA	110 C	100	4100 C	100	No	BSL
1024-57-3	HEPTACHLOR EPOXIDE	2 J	4.4 J	NTC01SB0991012	1/4	2.2 - 4.6	4.4	NA	53 C	70	4700 C	5000	No	BSL
72-43-5	METHOXYCHLOR	2.4 J	2.5 J	NTC01SB0991012-D	1/4	4.2 - 8.9	2.5	NA	31000 N	390000	NA	NA	No	BSL
Herbicides (ug/kg)														
87-86-5	PENTACHLOROPHENOL	4.2 J	4.2 J	NTC01SB0900812-D	1/4	12 - 27	4.2	NA	3000 C	3000	NA	NA	No	BSL
Dioxins/Furans (ng/kg)														
3268-87-9	1,2,3,4,6,7,8,9-OCDD	57	16000 J	NTC01SB0900812-D	4/4	--	16000	NA	13000 C[13]	NA	140000 C	NA	Yes	ASL
39001-02-0	1,2,3,4,6,7,8,9-OCDF	29	20000 J	NTC01SB0900812-D	2/4	5.7 - 38	20000	NA	13000 C[13]	NA	140000 C	NA	Yes	ASL
35822-46-9	1,2,3,4,6,7,8-HPCDD	14	11000 J	NTC01SB0900812-D	4/4	--	11000	NA	390 C[13]	NA	4200 C	NA	Yes	ASL
67562-39-4	1,2,3,4,6,7,8-HPCDF	7.3 J	34000 J	NTC01SB0900812-D	4/4	--	34000	NA	390 C[13]	NA	4200 C	NA	Yes	ASL
55673-89-7	1,2,3,4,7,8,9-HPCDF	3.6 J	3100 J	NTC01SB0900812-D	2/4	0.59 - 2.4	3100	NA	390 C[13]	NA	4200 C	NA	Yes	ASL
39227-28-6	1,2,3,4,7,8-HXCDD	5.8 J	1200 J	NTC01SB0900812-D	2/4	0.89 - 7.4	1200	NA	39 C[13]	NA	420 C	NA	Yes	ASL
70648-26-9	1,2,3,4,7,8-HXCDF	20	8900 J	NTC01SB0900812-D	2/4	3 - 13	8900	NA	39 C[13]	NA	420 C	NA	Yes	ASL
57653-85-7	1,2,3,6,7,8-HXCDD	15	2000 J	NTC01SB0900812-D	3/4	0.86 - 0.86	2000	NA	39 C[13]	NA	420 C	NA	Yes	ASL
57117-44-9	1,2,3,6,7,8-HXCDF	10	6700 J	NTC01SB0900812-D	2/4	1.6 - 7.4	6700	NA	39 C[13]	NA	420 C	NA	Yes	ASL
19408-74-3	1,2,3,7,8,9-HXCDD	12	1600 J	NTC01SB0900812-D	3/4	1.4 - 1.4	1600	NA	39 C[13]	NA	420 C	NA	Yes	ASL
72918-21-9	1,2,3,7,8,9-HXCDF	3.3 J	290 J	NTC01SB0900812-D	1/4	0.5 - 1.2	290	NA	39 C[13]	NA	420 C	NA	Yes	ASL
40321-76-4	1,2,3,7,8-PECDD	9.1	1200 J	NTC01SB0900812-D	2/4	0.84 - 20	1200	NA	3.9 C[13]	NA	42 C	NA	Yes	ASL
57117-41-6	1,2,3,7,8-PECDF	12	6400 J	NTC01SB0900812-D	2/4	1.2 - 8.4	6400	NA	130 C[13]	NA	1400 C	NA	Yes	ASL
60851-34-5	2,3,4,6,7,8-HXCDF	12	8000 J	NTC01SB0900812-D	2/4	1.2 - 10	8000	NA	39 C[13]	NA	420 C	NA	Yes	ASL
57117-31-4	2,3,4,7,8-PECDF	19	12000 J	NTC01SB0900812-D	2/4	1.3 - 11	12000	NA	13 C[13]	NA	140 C	NA	Yes	ASL
1746-01-6	2,3,7,8-TCDD	1.9 J	140 J	NTC01SB0900812-D	2/4	0.4 - 9	140	NA	3.9 C	NA	42 C	NA	Yes	ASL
51207-31-9	2,3,7,8-TCDF	10 J	5500 J	NTC01SB0900812-D	2/4	1 - 11	5500	NA	39 C[13]	NA	420 C	NA	Yes	ASL
	2,3,7,8-TCDD TEQ HALF ND	1.622905	9042.8	NTC01SB0900812-D	4/4	--	9042.8	NA	3.9 C[13]	NA	42 C	NA	Yes	ASL
	2,3,7,8-TCDD TEQ ZERO ND	0.2301	9042.8	NTC01SB0900812-D	4/4	--	9042.8	NA	3.9 C[13]	NA	42 C	NA	Yes	ASL
37871-00-4	TOTAL HPCDD	26	21000 J	NTC01SB0900812-D	4/4	--	21000	NA	NA	NA	NA	NA	No	NA
38998-75-3	TOTAL HPCDF	7.3	47000 J	NTC01SB0900812-D	4/4	--	47000	NA	NA	NA	NA	NA	No	NA
34465-46-8	TOTAL HXCDD	180	21000 J	NTC01SB0900812-D	3/4	3.8 - 3.8	21000	NA	NA	NA	NA	NA	No	NA
55684-94-1	TOTAL HXCDF	21	61000 J	NTC01SB0900812-D	2/4	3.3 - 13	61000	NA	NA	NA	NA	NA	No	NA
36088-22-9	TOTAL PECDD	15 J	16000 J	NTC01SB0900812-D	2/4	0.84 - 25	16000	NA	NA	NA	NA	NA	No	NA
30402-15-4	TOTAL PECDF	47 J	110000 J	NTC01SB0900812-D	2/4	4.4 - 7.3	110000	NA	NA	NA	NA	NA	No	NA
41903-57-5	TOTAL TCDD	42 J	8000 J	NTC01SB0900812-D	2/4	0.62 - 9	8000	NA	NA	NA	NA	NA	No	NA
55722-27-5	TOTAL TCDF	23	100000 J	NTC01SB0900812-D	3/4	11 - 11	100000	NA	NA	NA	NA	NA	No	NA

TABLE 6-1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - DIRECT CONTACT AND INHALATION
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Region 9 PRGs - Residential Soil[5]	TACO - Soil Remediation Objective for Residential Properties[6] - Ingestion	Screening Level Based on USEPA Generic SSLs for Migration from Soil to Air - Residential[7]	TACO - Soil Remediation Objective for Residential Properties - Inhalation[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[8]
Inorganics (mg/kg)														
7429-90-5	ALUMINUM	2750	10300	NTC01SB0921516	16/16	--	10300	9500	7600 N	NA	709000 N	NA	Yes	ASL
7440-36-0	ANTIMONY	0.53	21.4	NTC01SB0900812	11/16	0.28 - 0.65	21.4	4	3.1 N	31	NA	NA	Yes	ASL
7440-38-2	ARSENIC	4.4	19.6	NTC01SB0891112	16/16	--	19.6	13	0.39 C	NA	769 C	750	Yes	ASL
7440-39-3	BARIUM	35.9 J	386 J	NTC01SB0900812	16/16	--	386	110	540 N	5500	70900 N	690000	No	BSL
7440-41-7	BERYLLIUM	0.8	5.7	NTC01SB0950810	9/16	0.74 - 1.3	5.7	0.59	15 N	160	1380 N	1300	No	BSL
7440-43-9	CADMIUM	0.14	2.3	NTC01SB1001012	7/16	0.051 - 0.12	2.3	0.6	3.7 N	78	1840 N	1800	No	BSL
7440-70-2	CALCIUM	2840	66300	NTC01SB1031919	16/16	--	66300	9300	NA	NA	NA	NA	No	NUT
7440-47-3	CHROMIUM	6 J	55.9 J	NTC01SB0981516	16/16	--	55.9	16.2	30 C[14]	230	276 C	270	Yes	ASL
7440-48-4	COBALT	3.7	13	NTC01SB0981516	16/16	--	13	8.9	140 N[15]	4700	1180 N	NA	No	BSL
7440-50-8	COPPER	19.2 J	1530 J	NTC01SB0991012-D	16/16	--	1530	19.6	310 N	2900	NA	NA	Yes	ASL
7439-89-6	IRON	11400 J	102000 J	NTC01SB0981516	16/16	--	102000	15900	2300 N	NA	NA	NA	Yes	ASL
7439-92-1	LEAD	11.9 J	1410 J	NTC01SB0900812	16/16	--	1410	36	400	400	NA	NA	Yes	ASL
7439-95-4	MAGNESIUM	855 J	36600 J	NTC01SB1031919	16/16	--	36600	4820	NA	NA	NA	NA	No	NUT
7439-96-5	MANGANESE	59.1 J	1000 J	NTC01SB0991012	16/16	--	1000	636	180 N	3700	7090 N	8700	Yes	ASL
7439-97-6	MERCURY	0.056	0.75 J	NTC01SB0941416	15/16	0.014 - 0.014	0.75	0.06	2.3 N	23	1 N	10	No	BSL
7440-02-0	NICKEL	11.6 J	52.7 J	NTC01SB0981516	16/16	--	52.7	18	160 N	1600	NA	13000	No	BSL
7440-09-7	POTASSIUM	420	1880	NTC01SB0921516	16/16	--	1880	1268	NA	NA	NA	NA	No	NUT
7782-49-2	SELENIUM	0.83	5.7	NTC01SB0891112	13/16	1.2 - 4.5	5.7	0.48	39 N	390	NA	NA	No	BSL
7440-22-4	SILVER	0.34 J	709	NTC01SB0991012	10/16	0.063 - 0.47	709	0.55	39 N	390	NA	NA	Yes	ASL
7440-23-5	SODIUM	128	1240	NTC01SB0981516	16/16	--	1240	130	NA	NA	NA	NA	No	NUT
7440-28-0	THALLIUM	0.73	1.5	NTC01SB0950810	3/16	0.3 - 0.73	1.5	0.32	0.52 N	6.3	NA	NA	Yes	ASL
7440-62-2	VANADIUM	13.8	122	NTC01SB0950810	16/16	--	122	25.2	7.8 N	550	NA	NA	Yes	ASL
7440-66-6	ZINC	44.9 J	2170 J	NTC01SB1001012	16/16	--	2170	95	2300 N	23000	NA	NA	No	BSL
Miscellaneous Parameters (mg/kg)														
57-12-5	CYANIDE	2.9	2.9	NTC01SB0941416	1/16	0.58 - 1.3	2.9	0.51	120 N	NA	NA	NA	No	BSL

Shading indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes

1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 If the maximum concentration of a chemical is less than the Illinois EPA background concentration, that chemical is not selected as a COPC.
5 The risk-based COPC screening level for residential soil is presented. The value is based on a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (USEPA Region 9, October 2004).
6 Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties (Illinois EPA, online, July, 2007).
7 USEPA Soil Screening Levels. Calculated online at http://risk.lsd.ornl.gov/calc_start.htm (Soil to air SSLs for noncarcinogens are divided by 10).
8 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level and the Illinois EPA background level.
9 Naphthalene is used a the surroage for 2-methylnaphthalene.
10 Acenaphthene is used a the surroage for acenaphthylene.
11 Pyrene is used as the surrogate for benzo(g,h,i)perylene and phenanthrene.
12 Value is for chlordane.
13 Value is derived by multiplying carteria for 2,3,7,8-TCDD by WHO Toxicity Equivalent Factors (See Section 6.3.5 of text).
14 Value is for hexavalent chromium.
15 Screening level for cobalt is based on 0.1 of the noncarcinogenic PRG because this value is less than the carcinogenic PRG (USEPA, Region 9, October 2004).

Definitions:
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Noncarcinogen
NA = Not applicable/not available
PRG = Preliminary Remediation Goal
TACO = Illinois EPA Tiered Approach to Corrective Action Objectives.

Rationale Codes:
For selection as a COPC:
ASL = Above Screening Level

For Elimination as a COPC:
BKG = Within background levels
BSL = Below COPC screening level
NTX = No toxicity Information
NUT = essential nutrient

Associated Samples

NTC01SB08807(	NTC01SB0930810	NTC01SB0991012	NTC01SB1031919	NTC01SB2072838
NTC01SB08911	NTC01SB0941416	NTC01SB0991012-D	NTC01SB2050414	NTC01SB2090717
NTC01SB09008	NTC01SB0950810	NTC01SB1001012	NTC01SB2072838	NTC01SB2050414
NTC01SB09008	NTC01SB0961012	NTC01SB1010406	NTC01SB2090717	NTC01SB2072838
NTC01SB09108	NTC01SB0970304	NTC01SB1020408	NTC01SB2050414	NTC01SB2090717
NTC01SB09215	NTC01SB0981516			

TABLE 6-2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - MIGRATION FROM SOIL TO GROUNDWATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Generic SSLs for Migration from Soil to Groundwater (DAF 1) - Residential[5]	TACO - Soil Component of the Groundwater Ingestion Route Objective - Residential[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Volatile Organic Compounds (ug/kg)												
78-93-3	2-BUTANONE	3.2 J	12	NTC01SB1001012	3/16	4.5 - 16	12	NA	4400 N	NA	No	BSL
67-64-1	ACETONE	6.4 J	59 J	NTC01SB1001012	2/16	18 - 62	59	NA	6600 N	16000	No	BSL
75-09-2	METHYLENE CHLORIDE	2.1 J	2.3 J	NTC01SB0981516	2/16	4.5 - 16	2.3	NA	1.2 C	20	Yes	ASL
Semivolatile Organics (ug/kg)												
91-57-6	2-METHYLNAPHTHALENE	40 J	250 J	NTC01SB0991012	4/4	--	250	NA	NA	NA	No	BSL
95-48-7	2-METHYLPHENOL	39 J	39 J	NTC01SB0991012-D	1/4	400 - 2100	39	NA	700 N	15000	No	BSL
106-44-5	4-METHYLPHENOL	13 J	170 J	NTC01SB0991012-D	2/4	660 - 890	170	NA	66 N	NA	Yes	ASL
83-32-9	ACENAPHTHENE	11 J	290 J	NTC01SB1020408	3/4	890 - 2100	290	NA	31000 N	570000	No	BSL
208-96-8	ACENAPHTHYLENE	11 J	100 J	NTC01SB0900812-D	2/4	400 - 890	100	NA	NA	NA	No	BSL
120-12-7	ANTHRACENE	13 J	260 J	NTC01SB1020408	2/4	420 - 2100	260	NA	650000 N	12000000	No	BSL
100-52-7	BENZALDEHYDE	110 J	150 J	NTC01SB0900812	2/4	400 - 2100	150	NA	860 N	NA	No	BSL
56-55-3	BENZO(A)ANTHRACENE	320 J	520	NTC01SB0991012-D	2/4	400 - 2100	520	NA	160 MCL	2000	Yes	ASL
50-32-8	BENZO(A)PYRENE	14 J	500	NTC01SB0991012-D	3/4	400 - 2100	500	NA	410 MCL	8000	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	24 J	870	NTC01SB0991012-D	3/4	400 - 2100	870	NA	490 MCL	5000	Yes	ASL
191-24-2	BENZO(G,H,I)PERYLENE	20 J	500	NTC01SB0991012-D	3/4	890 - 2100	500	NA	NA	NA	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	130 J	230 J	NTC01SB0991012-D	2/4	400 - 2100	230	NA	490 MCL	49000	No	BSL
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	150 J	660 J	NTC01SB0900812-D	2/4	400 - 890	660	NA	180000 MCL	3600000	No	BSL
85-68-7	BUTYL BENZYL PHTHALATE	9.8 J	74 J	NTC01SB0950810	4/4	--	74	NA	840000 N	930000	No	BSL
86-74-8	CARBAZOLE	100 J	250 J	NTC01SB1020408	2/4	400 - 2100	250	NA	30 C	600	Yes	ASL
218-01-9	CHRYSENE	400 J	680	NTC01SB0991012-D	2/4	400 - 2100	680	NA	160 MCL	160000	Yes	ASL
53-70-3	DIBENZO(A,H)ANTHRACENE	59 J	130 J	NTC01SB0991012-D	2/4	420 - 2100	130	NA	1500 MCL	2000	No	BSL
132-64-9	DIBENZOFURAN	19 J	100 J	NTC01SB1020408	3/4	890 - 2100	100	NA	2400 N	NA	No	BSL
84-66-2	DIETHYL PHTHALATE	18 J	430 J	NTC01SB0900812-D	2/4	400 - 890	430	NA	23000 N	470000	No	BSL
84-74-2	DI-N-BUTYL PHTHALATE	56 J	340 J	NTC01SB0900812-D	1/4	400 - 890	340	NA	250000 N	2300000	No	BSL
206-44-0	FLUORANTHENE	45 J	1400 J	NTC01SB0991012-D	3/4	890 - 2100	1400	NA	310000 N	4300000	No	BSL
86-73-7	FLUORENE	11 J	320 J	NTC01SB1020408	3/4	400 - 890	320	NA	41000 N	560000	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	12 J	400	NTC01SB0991012-D	3/4	890 - 2100	400	NA	1400 MCL	14000	No	BSL
91-20-3	NAPHTHALENE	52 J	250 J	NTC01SB0900812-D	4/4	--	250	NA	3100 N	12000	No	BSL
85-01-8	PHENANTHRENE	58 J	1700	NTC01SB1020408	4/4	--	1700	NA	NA	NA	No	BSL
108-95-2	PHENOL	22 J	93 J	NTC01SB0900812-D	2/4	400 - 890	93	NA	2800 N	100000	No	BSL
129-00-0	PYRENE	41 J	1300	NTC01SB1020408	3/4	890 - 890	1300	NA	230000 N	4200000	No	BSL
Polynuclear Aromatic Hydrocarbons (ug/kg)												
91-57-6	2-METHYLNAPHTHALENE	7.5 J	3500 J	NTC01SB1020408	15/16	400 - 400	3500	NA	NA	NA	No	BSL
83-32-9	ACENAPHTHENE	14 J	260 J	NTC01SB0991012-D	3/15	38 - 13000	260	NA	31000 N	570000	No	BSL
208-96-8	ACENAPHTHYLENE	25 J	3100 J	NTC01SB0991012-D	10/16	38 - 13000	3100	NA	NA	NA	No	BSL
120-12-7	ANTHRACENE	1.8 J	5200	NTC01SB1020408	16/16	--	5200	NA	650000 N	12000000	No	BSL
56-55-3	BENZO(A)ANTHRACENE	41	11000	NTC01SB1020408	9/15	7.8 - 40	11000	NA	160 MCL	2000	Yes	ASL
50-32-8	BENZO(A)PYRENE	1.5 J	9300	NTC01SB1020408	14/16	7.8 - 18	9300	NA	410 MCL	8000	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	4.9 J	14000	NTC01SB1020408	14/16	18 - 40	14000	NA	490 MCL	5000	Yes	ASL
191-24-2	BENZO(G,H,I)PERYLENE	0.96 J	7300	NTC01SB1020408	16/16	--	7300	NA	NA	NA	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	1.8 J	4600	NTC01SB1020408	12/16	8.6 - 40	4600	NA	490 MCL	49000	Yes	ASL
86-74-8	CARBAZOLE	12 J	4300 J	NTC01SB1020408	6/15	38 - 400	4300	NA	30 C	600	Yes	ASL
218-01-9	CHRYSENE	1.6 J	12000	NTC01SB1020408	15/16	18 - 18	12000	NA	160 MCL	160000	Yes	ASL
53-70-3	DIBENZO(A,H)ANTHRACENE	4.4 J	850	NTC01SB0880708	7/15	7.8 - 180	850	NA	1500 MCL	2000	No	BSL
206-44-0	FLUORANTHENE	4.8 J	49000	NTC01SB1020408	16/16	--	49000	NA	310000 N	4300000	No	BSL
86-73-7	FLUORENE	14	3300	NTC01SB1020408	7/15	7.8 - 82	3300	NA	41000 N	560000	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	1 J	6300	NTC01SB1020408	16/16	--	6300	NA	1400 MCL	14000	Yes	ASL
91-20-3	NAPHTHALENE	20 J	3100 J	NTC01SB1020408	13/16	38 - 4100	3100	NA	3100 N	12000	No	BSL
85-01-8	PHENANTHRENE	7 J	26000	NTC01SB1020408	16/16	--	26000	NA	NA	NA	No	BSL
129-00-0	PYRENE	4 J	31000	NTC01SB1020408	16/16	--	31000	NA	230000 N	4200000	No	BSL
	BAP EQUIVALENT ZERO ND	0.25	13068	NTC01SB1020408	16/16	--	13068	NA	410 MCL	8000	Yes	ASL
	BAP EQUIVALENT - HALF ND	4.2449	13068	NTC01SB1020408	16/16	--	13068	NA	410 MCL	8000	Yes	ASL

TABLE 6-2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - MIGRATION FROM SOIL TO GROUNDWATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Generic SSLs for Migration from Soil to Groundwater (DAF 1) - Residential[5]	TACO - Soil Component of the Groundwater Ingestion Route Objective - Residential[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Organochlorine Pesticides/PCBs (ug/kg)												
72-54-8	4,4'-DDD	4.8	280 J	NTC01SB0991012-D	4/4	--	280	NA	710 C	16000	No	BSL
72-55-9	4,4'-DDE	0.6 J	82 J	NTC01SB0991012-D	4/4	--	82	NA	2200 C	54000	No	BSL
50-29-3	4,4'-DDT	1.4 J	27 J	NTC01SB0991012-D	4/4	--	27	NA	1300 C	32000	No	BSL
309-00-2	ALDRIN	1.5 J	1.5 J	NTC01SB0991012-D	1/4	2.2 - 10	1.5	NA	25 C	500	No	BSL
319-84-6	ALPHA-BHC	1.7 J	1.7 J	NTC01SB0991012	1/4	2.2 - 10	1.7	NA	0.036 C	0.5	Yes	ASL
5103-71-9	ALPHA-CHLORDANE	2.2 J	2.8 J	NTC01SB0900812	2/4	2.2 - 10	2.8	NA	480 MCL	10000	No	BSL
12672-29-6	AROCLOR-1248	130 J	130 J	NTC01SB0991012	1/4	40 - 89	130	NA	NA	NA	No	BSL
11097-69-1	AROCLOR-1254	33 J	33 J	NTC01SB0900812	1/4	40 - 89	33	NA	NA	NA	No	BSL
11096-82-5	AROCLOR-1260	100 J	100 J	NTC01SB0991012	1/4	40 - 89	100	NA	NA	NA	No	BSL
319-86-8	DELTA-BHC	1.2 J	1.2 J	NTC01SB0991012	1/4	2.2 - 10	1.2	NA	NA	NA	No	BSL
60-57-1	DIELDRIN	0.55 J	1.2 J	NTC01SB0991012	2/4	2.2 - 10	1.2	NA	0.23 C	4	Yes	ASL
959-98-8	ENDOSULFAN I	3.1 J	3.1 J	NTC01SB0991012	1/4	2.2 - 10	3.1	NA	980 N	18000	No	BSL
33213-65-9	ENDOSULFAN II	3.7 J	6.1 J	NTC01SB0991012	1/4	2.2 - 4.6	6.1	NA	980 N	18000	No	BSL
1031-07-8	ENDOSULFAN SULFATE	2 J	2 J	NTC01SB0991012-D	1/4	2.2 - 10	2	NA	980 N	NA	No	BSL
72-20-8	ENDRIN	1.6 J	9.6 J	NTC01SB0991012-D	2/4	2.2 - 10	9.6	NA	50 MCL	1000	No	BSL
53494-70-5	ENDRIN KETONE	0.73 J	2.2 J	NTC01SB0991012	2/4	2.2 - 10	2.2	NA	NA	NA	No	BSL
58-89-9	GAMMA-BHC (LINDANE)	1.2 J	7.7 J	NTC01SB0991012-D	1/4	2.2 - 4.6	7.7	NA	0.47 MCL	9	Yes	ASL
5103-74-2	GAMMA-CHLORDANE	2 J	6.9 J	NTC01SB0991012	3/4	2.2 - 10	6.9	NA	480 MCL	10000	No	BSL
76-44-8	HEPTACHLOR	2.4 J	2.4 J	NTC01SB0991012-D	1/4	2.2 - 10	2.4	NA	1100 MCL	23000	No	BSL
1024-57-3	HEPTACHLOR EPOXIDE	2 J	4.4 J	NTC01SB0991012	1/4	2.2 - 4.6	4.4	NA	33 MCL	700	No	BSL
72-43-5	METHOXYCHLOR	2.4 J	2.5 J	NTC01SB0991012-D	1/4	4.2 - 8.9	2.5	NA	7800 MCL	160000	No	BSL
Herbicides (ug/kg)												
87-86-5	PENTACHLOROPHENOL	4.2 J	4.2 J	NTC01SB0900812-D	1/4	12 - 27	4.2	NA	1.4 MCL	30	Yes	ASL
Dioxins/Furans (ng/kg)												
3268-87-9	1,2,3,4,6,7,8,9-OCDD	57	16000 J	NTC01SB0900812-D	4/4	--	16000	NA	930 C[8]	NA	Yes	ASL
39001-02-0	1,2,3,4,6,7,8,9-OCDF	29	20000 J	NTC01SB0900812-D	2/4	5.7 - 38	20000	NA	930 C[8]	NA	Yes	ASL
35822-46-9	1,2,3,4,6,7,8-HPCDD	14	11000 J	NTC01SB0900812-D	4/4	--	11000	NA	28 C[8]	NA	Yes	ASL
67562-39-4	1,2,3,4,6,7,8-HPCDF	7.3 J	34000 J	NTC01SB0900812-D	4/4	--	34000	NA	28 C[8]	NA	Yes	ASL
55673-89-7	1,2,3,4,7,8,9-HPCDF	3.6 J	3100 J	NTC01SB0900812-D	2/4	0.59 - 2.4	3100	NA	28 C[8]	NA	Yes	ASL
39227-28-6	1,2,3,4,7,8-HXCDD	5.8 J	1200 J	NTC01SB0900812-D	2/4	0.89 - 7.4	1200	NA	2.8 C[8]	NA	Yes	ASL
70648-26-9	1,2,3,4,7,8-HXCDF	20	8900 J	NTC01SB0900812-D	2/4	3 - 13	8900	NA	2.8 C[8]	NA	Yes	ASL
57653-85-7	1,2,3,6,7,8-HXCDD	15	2000 J	NTC01SB0900812-D	3/4	0.86 - 0.86	2000	NA	2.8 C[8]	NA	Yes	ASL
57117-44-9	1,2,3,6,7,8-HXCDF	10	6700 J	NTC01SB0900812-D	2/4	1.6 - 7.4	6700	NA	2.8 C[8]	NA	Yes	ASL
19408-74-3	1,2,3,7,8,9-HXCDD	12	1600 J	NTC01SB0900812-D	3/4	1.4 - 1.4	1600	NA	2.8 C[8]	NA	Yes	ASL
72918-21-9	1,2,3,7,8,9-HXCDF	3.3 J	290 J	NTC01SB0900812-D	1/4	0.5 - 1.2	290	NA	2.8 C[8]	NA	Yes	ASL
40321-76-4	1,2,3,7,8-PECDD	9.1	1200 J	NTC01SB0900812-D	2/4	0.84 - 20	1200	NA	0.28 C[8]	NA	Yes	ASL
57117-41-6	1,2,3,7,8-PECDF	12	6400 J	NTC01SB0900812-D	2/4	1.2 - 8.4	6400	NA	9.3 C[8]	NA	Yes	ASL
60851-34-5	2,3,4,6,7,8-HXCDF	12	8000 J	NTC01SB0900812-D	2/4	1.2 - 10	8000	NA	2.8 C[8]	NA	Yes	ASL
57117-31-4	2,3,4,7,8-PECDF	19	12000 J	NTC01SB0900812-D	2/4	1.3 - 11	12000	NA	0.93 C[8]	NA	Yes	ASL
1746-01-6	2,3,7,8-TCDD	1.9 J	140 J	NTC01SB0900812-D	2/4	0.4 - 9	140	NA	0.28 C	NA	Yes	ASL
51207-31-9	2,3,7,8-TCDF	10 J	5500 J	NTC01SB0900812-D	2/4	1 - 11	5500	NA	2.8 C[8]	NA	Yes	ASL
	2,3,7,8-TCDD TEQ HALF ND	1.622905	9042.8	NTC01SB0900812-D	4/4	--	9042.8	NA	0.28 C[8]	NA	Yes	ASL
	2,3,7,8-TCDD TEQ ZERO ND	0.2301	9042.8	NTC01SB0900812-D	4/4	--	9042.8	NA	0.28 C[8]	NA	Yes	ASL
37871-00-4	TOTAL HPCDD	26	21000 J	NTC01SB0900812-D	4/4	--	21000	NA	NA	NA	No	NTX
38998-75-3	TOTAL HPCDF	7.3	47000 J	NTC01SB0900812-D	4/4	--	47000	NA	NA	NA	No	NTX
34465-46-8	TOTAL HXCDD	180	21000 J	NTC01SB0900812-D	3/4	3.8 - 3.8	21000	NA	NA	NA	No	NTX
55684-94-1	TOTAL HXCDF	21	61000 J	NTC01SB0900812-D	2/4	3.3 - 13	61000	NA	NA	NA	No	NTX
36088-22-9	TOTAL PECDD	15 J	16000 J	NTC01SB0900812-D	2/4	0.84 - 25	16000	NA	NA	NA	No	NTX
30402-15-4	TOTAL PECDF	47 J	110000 J	NTC01SB0900812-D	2/4	4.4 - 7.3	110000	NA	NA	NA	No	NTX
41903-57-5	TOTAL TCDD	42 J	8000 J	NTC01SB0900812-D	2/4	0.62 - 9	8000	NA	NA	NA	No	NTX
55722-27-5	TOTAL TCDF	23	100000 J	NTC01SB0900812-D	3/4	11 - 11	100000	NA	NA	NA	No	NTX

TABLE 6-2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - MIGRATION FROM SOIL TO GROUNDWATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Generic SSLs for Migration from Soil to Groundwater (DAF 1) - Residential[5]	TACO - Soil Component of the Groundwater Ingestion Route Objective - Residential[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Inorganics (mg/kg)												
7429-90-5	ALUMINUM	2750	10300	NTC01SB0921516	16/16	--	10300	9500	NA N	NA	No	BSL
7440-36-0	ANTIMONY	0.53	21.4	NTC01SB0900812	11/16	0.28 - 0.65	21.4	4	0.27 MCL	NA	Yes	ASL
7440-38-2	ARSENIC	4.4	19.6	NTC01SB0891112	16/16	--	19.6	13	0.29 MCL	NA	Yes	ASL
7440-39-3	BARIUM	35.9 J	386 J	NTC01SB0900812	16/16	--	386	110	82 MCL	NA	Yes	ASL
7440-41-7	BERYLLIUM	0.8	5.7	NTC01SB0950810	9/16	0.74 - 1.3	5.7	0.59	3.2 MCL	NA	Yes	ASL
7440-43-9	CADMIUM	0.14	2.3	NTC01SB1001012	7/16	0.051 - 0.12	2.3	0.6	0.38 MCL	NA	Yes	ASL
7440-70-2	CALCIUM	2840	66300	NTC01SB1031919	16/16	--	66300	9300	NA	NA	No	NUT
7440-47-3	CHROMIUM	6 J	55.9 J	NTC01SB0981516	16/16	--	55.9	16.2	2.1 N	NA	Yes	ASL
7440-48-4	COBALT	3.7	13	NTC01SB0981516	16/16	--	13	8.9	0.17 N	NA	Yes	ASL
7440-50-8	COPPER	19.2 J	1530 J	NTC01SB0991012-D	16/16	--	1530	19.6	560 MCL	NA	Yes	ASL
7439-89-6	IRON	11400 J	102000 J	NTC01SB0981516	16/16	--	102000	15900	NA	NA	No	BSL
7439-92-1	LEAD	11.9 J	1410 J	NTC01SB0900812	16/16	--	1410	36	NA	NA	No	BSL
7439-95-4	MAGNESIUM	855 J	36600 J	NTC01SB1031919	16/16	--	36600	4820	NA	NA	No	NUT
7439-96-5	MANGANESE	59.1 J	1000 J	NTC01SB0991012	16/16	--	1000	636	110 N	NA	Yes	ASL
7439-97-6	MERCURY	0.056	0.75 J	NTC01SB0941416	15/16	0.014 - 0.014	0.75	0.06	0.1 MCL	NA	Yes	ASL
7440-02-0	NICKEL	11.6 J	52.7 J	NTC01SB0981516	16/16	--	52.7	18	14 N	NA	Yes	ASL
7440-09-7	POTASSIUM	420	1880	NTC01SB0921516	16/16	--	1880	1268	NA	NA	No	NUT
7782-49-2	SELENIUM	0.83	5.7	NTC01SB0891112	13/16	1.2 - 4.5	5.7	0.48	0.26 N	NA	Yes	ASL
7440-22-4	SILVER	0.34 J	709	NTC01SB0991012	10/16	0.063 - 0.47	709	0.55	1.6 N	NA	Yes	ASL
7440-23-5	SODIUM	128	1240	NTC01SB0981516	16/16	--	1240	130	NA	NA	No	NUT
7440-28-0	THALLIUM	0.73	1.5	NTC01SB0950810	3/16	0.3 - 0.73	1.5	0.32	0.056 N	NA	Yes	ASL
7440-62-2	VANADIUM	13.8	122	NTC01SB0950810	16/16	--	122	25.2	260 N	NA	No	BSL
7440-66-6	ZINC	44.9 J	2170 J	NTC01SB1001012	16/16	--	2170	95	680 N	NA	Yes	ASL
Miscellaneous Parameters (mg/kg)												
57-12-5	CYANIDE	2.9	2.9	NTC01SB0941416	1/16	0.58 - 1.3	2.9	0.51	2 MCL	NA	Yes	ASL

Shading indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes

1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 If the maximum concentration of a chemical is less than the Illinois EPA background concentration, that chemical is not selected as a COPC.
5 USEPA Generic Soil Screening Levels for Migration to Groundwater (dilution/attenuation factor of 1) calculated online at http://risk.lsd.ornl.gov/calc_start.shtml using methodology from the USEPA's Soil Screening Guidance (USEPA, July 1996).
6 Tier 1 Soil Remediation Objectives for Residential Properties for the Soil Component of the Groundwater Ingestion Exposure Route (dilution/attenuation factor of 20) (Illinois EPA, July 2007).
7 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level and the Illinois EPA background level.
8 Value is derived by multiplying carteria for 2,3,7,8-TCDD by WHO Toxicity Equivalent Factors (See Section 6.3.5 of text).

Associated Samples

NTC01SB08807(	NTC01SB0930810	NTC01SB0991012	NTC01SB1031919	NTC01SB2072838
NTC01SB08911	NTC01SB0941416	NTC01SB0991012-D	NTC01SB2050414	NTC01SB2090717
NTC01SB09008	NTC01SB0950810	NTC01SB1001012	NTC01SB2072838	NTC01SB2050414
NTC01SB09008	NTC01SB0961012	NTC01SB1010406	NTC01SB2090717	NTC01SB2072838
NTC01SB09108	NTC01SB0970304	NTC01SB1020408	NTC01SB2050414	NTC01SB2090717
NTC01SB09215	NTC01SB0981516			

Definitions:
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Noncarcinogen
NA = Not applicable/not available
PRG = Preliminary Remediation Goal
TACO = Illinois EPA Tiered Approach to Correctiv

Rationale Codes:
For selection as a COPC:
ASL = Above Screening Level

For Elimination as a COPC:
BKG = Within background levels
BSL = Below COPC screening level
NTX = No toxicity Information
NUT = essential nutrient

TABLE 6-3
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Sample with Maximum Concentration	Detection Frequency (1)	Range of Nondetects(2)	Concentration Used for Screening(3)	Background Value(4)	Risk-Based COPC Screening Level(5)		Federal Maximum Contaminant Level (MCL)(6)	TACO - Groundwater Remediation Objective for Class 1 Groundwater(7)	COPC Flag	Rationale for Contaminant Deletion or Selection(8)
Volatile Organics (ug/L)																
106-46-7	1,4-DICHLOROBENZENE	0.27	J	0.27	J	NTC01GWTW0101, NTC01GWTW0101-D	1/14	1	0.27	NA	0.5	C	75	75	No	BSL
67-64-1	ACETONE	2.7	J	5	J	NTC01GWTW0401	2/14	5	5	NA	550	N	NA	700	No	BSL
71-43-2	BENZENE	0.26	J	0.44	J	NTC01GWTW0201	2/14	1	0.44	NA	0.35	C	5	5	Yes	ASL
75-15-0	CARBON DISULFIDE	0.33	J	0.42	J	NTC01GWTW0101	2/14	1	0.42	NA	100	N	NA	700	No	BSL
108-90-7	CHLOROBENZENE	0.71	J	0.76	J	NTC01GWTW0101-D	1/14	1	0.76	NA	11	N	100	100	No	BSL
110-82-7	CYCLOHEXANE	2.1		2.1		NTC01GWTW0101	1/14	1	2.1	NA	1000	N	NA	NA	No	BSL
98-82-8	ISOPROPYLBENZENE	0.19	J	0.19		NTC01GWTW0101	1/14	1	0.19	NA	66	N	NA	NA	No	BSL
108-87-2	METHYL CYCLOHEXANE	1.7		1.7		NTC01GWTW0101	1/14	1	1.7	NA	520	N	NA	NA	No	BSL
108-88-3	TOLUENE	0.2	J	0.2		NTC01GWTW0101	1/14	1	0.2	NA	72	N	1000	1000	No	BSL
1330-20-7	TOTAL XYLENES	0.65	J	1.6	J	NTC01GWTW0101	2/14	3	1.6	NA	21	N	10000	10000	No	BSL
Semivolatile Organics (ug/L)																
100-52-7	BENZALDEHYDE	1	J	1		NTC01GWTW0101-D	1/3	10 - 13	1	NA	360	N	NA	NA	No	BSL
84-66-2	DIETHYL PHTHALATE	3.5	J	4		NTC01GWTW0101-D	1/3	10 - 11	4	NA	2900	N	NA	5600	No	BSL
91-20-3	NAPHTHALENE	4.4	J	5.2		NTC01GWTW0101-D	1/3	10 - 11	5.2	NA	0.62	N	NA	140	Yes	ASL
Polynuclear Aromatic Hydrocarbons (ug/L)																
91-57-6	2-METHYLNAPHTHALENE	1.3		1.5		NTC01GWTW0101-D	1/13	0.95 - 1	1.5	NA	0.62	N(9)	NA	NA	Yes	ASL
83-32-9	ACENAPHTHENE	0.19	J	0.23	J	NTC01GWTW0101-D	1/13	0.95 - 1	0.23	NA	37	N	NA	420	No	BSL
208-96-8	ACENAPHTHYLENE	5		5.9		NTC01GWTW0101-D	1/13	0.95 - 1	5.9	NA	37	N(10)	NA	NA	No	BSL
120-12-7	ANTHRACENE	0.035	J	0.039	J	NTC01GWTW0101-D	1/13	0.19 - 0.2	0.039	NA	180	N	NA	2100	No	BSL
86-74-8	CARBAZOLE	0.15	J	0.17	J	NTC01GWTW0101-D	1/13	0.95 - 1	0.17	NA	3.4	C	NA	NA	No	BSL
206-44-0	FLUORANTHENE	0.039	J	0.039		NTC01GW0401	1/13	0.19 - 0.2	0.039	NA	150	N	NA	280	No	BSL
86-73-7	FLUORENE	0.025	J	0.23	J	NTC01GWTW0101, NTC01GWTW0101-D	5/13	0.19 - 0.2	0.23	NA	24	N	NA	280	No	BSL
91-20-3	NAPHTHALENE	5.9		6.8	J	NTC01GWTW0101-D	1/13	0.95 - 1	6.8	NA	0.62	N	NA	140	Yes	ASL
85-01-8	PHENANTHRENE	0.056	J	0.35		NTC01GWTW0101	13/13	--	0.35	NA	18	N(11)	NA	NA	No	BSL
129-00-0	PYRENE	0.025	J	0.043	J	NTC01GW0401, NTC01GWTW0101-D	3/13	0.19 - 0.2	0.043	NA	18	N	NA	210	No	BSL
Metals (ug/L)																
7429-90-5	ALUMINUM	68.3		8650		NTC01GW0301	8/13	27.9 - 90.2	8650	NA	3600	N	NA	NA	Yes	ASL
7440-38-2	ARSENIC	2.4		3.3		NTC01GW0301	3/13	1.7 - 3.3	3.3	NA	0.045	C	10	50	Yes	ASL
7440-39-3	BARIUM	29.3		566		NTC01GWTW0101, NTC01GWTW0301	13/13	--	566	NA	260	N	2000	2000	Yes	ASL
7440-70-2	CALCIUM	14300		634000		NTC01GW0601	13/13	--	634000	NA	NA		NA	NA	No	NUT
7440-47-3	CHROMIUM	0.65		14.1		NTC01GW0301	8/13	0.93	14.1	NA	11	N(12)	100	100	Yes	ASL
7440-48-4	COBALT	3.1		12.1		NTC01GW0601, NTC01GW0801	7/13	0.53 - 0.92	12.1	NA	73	N	NA	1000	No	BSL
7440-50-8	COPPER	1.2		12.4		NTC01GW0301	6/13	0.39 - 2	12.4	NA	150	N	1300	650	No	BSL
7439-89-6	IRON	106		17600		NTC01GWTW0101	12/13	18	17600	NA	1100	N	NA	5000	Yes	ASL
7439-89-6	LEAD	1.2		8.4		NTC01GWTW0101	5/13	1.6	8.4	NA	NA		15	7.5	Yes	ASL
7439-95-4	MAGNESIUM	25300		349000		NTC01GW0601	13/13	--	349000	NA	NA		NA	NA	No	NUT
7439-96-5	MANGANESE	9.4		5070		NTC01GW0901	13/13	--	5070	NA	88	N	NA	150	Yes	ASL
7440-02-0	NICKEL	1.9		33.4		NTC01GW0601	10/13	1.1 - 1.2	33.4	NA	73	N	NA	100	No	BSL
7440-09-7	POTASSIUM	1500		42000	J	NTC01GWTW0101	13/13	--	42000	NA	NA		NA	NA	No	NUT
7782-49-2	SELENIUM	10.7		13.5		NTC01GW0101	1/13	1.8 - 4	13.5	NA	18	N	50	50	No	BSL
7440-22-4	SILVER	0.32		1.6		NTC01GW0801	6/13	0.3 - 0.67	1.6	NA	18	N	NA	50	No	BSL
7440-23-5	SODIUM	16500		601000		NTC01GW0601	13/13	--	601000	NA	NA		NA	NA	No	NUT
7440-62-2	VANADIUM	1.6		20.7		NTC01GW0301	12/13	1.7	20.7	NA	3.6	N	NA	49	Yes	ASL
7440-66-6	ZINC	27.2		309		NTC01GW0101	5/13	6.3 - 19	309	NA	1100	N	NA	5000	No	BSL

TABLE 6-3
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Sample with Maximum Concentration	Detection Frequency (1)	Range of Nondetects(2)	Concentration Used for Screening(3)	Background Value(4)	Risk-Based COPC Screening Level(5)		Federal Maximum Contaminant Level (MCL)(6)	TACO - Groundwater Remediation Objective for Class 1 Groundwater(7)	COPC Flag	Rationale for Contaminant Deletion or Selection(8)
Metals, Filtered (ug/L)																
7440-39-3	BARIUM - FILTERED	76.3		178		NTC01GW0601	2/2	--	178	NA	260	N	2000	2000	No	BSL
7440-70-2	CALCIUM - FILTERED	116000		645000		NTC01GW0601	2/2	--	645000	NA	NA		NA	NA	No	NUT
7440-48-4	COBALT - FILTERED	5		8.5		NTC01GW0601	2/2	--	8.5	NA	73	N	NA	1000	No	BSL
7440-50-8	COPPER - FILTERED	1.2		1.2		NTC01GW0601	1/2	0.73	1.2	NA	150	N	1300	650	No	BSL
7439-95-4	MAGNESIUM - FILTERED	117000		353000		NTC01GW0601	2/2	--	353000	NA	NA		NA	NA	No	NUT
7439-96-5	MANGANESE - FILTERED	165		293		NTC01GW0601	2/2	--	293	NA	88	N	NA	150	Yes	ASL
7440-02-0	NICKEL - FILTERED	12.2		23.4		NTC01GW0601	2/2	--	23.4	NA	73	N	NA	100	No	BSL
7440-09-7	POTASSIUM - FILTERED	3650		10900		NTC01GW0601	2/2	--	10900	NA	NA		NA	NA	No	NUT
7440-22-4	SILVER - FILTERED	0.59		0.73		NTC01GW0601	2/2	--	0.73	NA	18	N	NA	50	No	BSL
7440-23-5	SODIUM - FILTERED	15300		629000		NTC01GW0601	2/2	--	629000	NA	NA		NA	NA	No	NUT
7440-62-2	VANADIUM - FILTERED	4.8		5.3		NTC01GW0601	2/2	--	5.3	NA	3.6	N	NA	49	Yes	ASL

Shading indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes:

1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 No background or upgradient well data are available.
5 The risk-based COPC screening level for tap water use is presented. The value is based on a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (USEPA Region 9, October 2004).
6 Federal Maximum Contaminant Level (USEPA, Summaer 2006).
7 Illinois EPA Remediation Objectives for Class 1 Grounwater (Illinois EPA, online, July, 2007).
8 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level
9 Naphthalene is used a the surroage for 2-methylnaphthalene.
10 Acenaphthene is used as the surrogate for acenaphthylene.
11 Pyrene is used as the surrogate for phenanthrene.
12 Value is for hexavalent chromium.

Associated Samples:

NTC01GW0101	NTC01GW0401	NTC01GW0801	NTC01GWTW0101-D
NTC01GW0101-D	NTC01GW0501	NTC01GW0901	NTC01GWTW0201
NTC01GW0201	NTC01GW0601	NTC01GW1001	NTC01GWTW0301
NTC01GW0301	NTC01GW0701	NTC01GWTW0101	NTC01GWTW0401

Definitions:

C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Noncarcinogen
NA = Not applicable.
TACO = Illinois EPA Tiered Approach to Corrective Action Objectives.

Rationale Codes:

For Selection as a COPC:
ASL = Above COPC screening level

For Elimination as a COPC:
BKG = Within background levels
BSL = Below COPC screening level
NUT = Essential nutrient

TABLE 6-4
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - VAPOR INTRUSION
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Entire Site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Sample with Maximum Concentration	Detection Frequency (1)	Range of Nondetects(2)	Concentration Used for Screening(3)	Background Value(4)	Risk-Based COPC Screening Level(5)		COPC Flag	Rationale for Contaminant Deletion or Selection(6)
Volatile Organics (ug/L)														
106-46-7	1,4-DICHLOROBENZENE	0.27	J	0.27	J	NTC01GWTW0101, NTC01GWTW0101-D	1/14	1	0.27	NA	8200	C	No	BSL
67-64-1	ACETONE	2.7	J	5	J	NTC01GWTW0401	2/14	5	5	NA	220000	N	No	BSL
71-43-2	BENZENE	0.26	J	0.44	J	NTC01GWTW0201	2/14	1	0.44	NA	5	C	No	BSL
75-15-0	CARBON DISULFIDE	0.33	J	0.42	J	NTC01GWTW0101	2/14	1	0.42	NA	560	N	No	BSL
108-90-7	CHLOROBENZENE	0.71	J	0.76	J	NTC01GWTW0101-D	1/14	1	0.76	NA	390	N	No	BSL
110-82-7	CYCLOHEXANE	2.1		2.1		NTC01GWTW0101	1/14	1	2.1	NA	NA	N	No	BSL
98-82-8	ISOPROPYLBENZENE	0.19	J	0.19		NTC01GWTW0101	1/14	1	0.19	NA	8.4	N	No	BSL
108-87-2	METHYL CYCLOHEXANE	1.7		1.7		NTC01GWTW0101	1/14	1	1.7	NA	710	N	No	BSL
108-88-3	TOLUENE	0.2	J	0.2		NTC01GWTW0101	1/14	1	0.2	NA	1500	N	No	BSL
1330-20-7	TOTAL XYLENES	0.65	J	1.6	J	NTC01GWTW0101	2/14	3	1.6	NA	22000	N	No	BSL
Semivolatile Organics (ug/L)														
100-52-7	BENZALDEHYDE	1	J	1		NTC01GWTW0101-D	1/3	10 - 13	1	NA	360000	N	No	BSL
84-66-2	DIETHYL PHTHALATE	3.5	J	4		NTC01GWTW0101-D	1/3	10 - 11	4	NA	NA	N	No	BSL
91-20-3	NAPHTHALENE	4.4	J	5.2		NTC01GWTW0101-D	1/3	10 - 11	5.2	NA	150	N	No	BSL
Polynuclear Aromatic Hydrocarbons (ug/L)														
91-57-6	2-METHYLNAPHTHALENE	1.3		1.5		NTC01GWTW0101-D	1/13	0.95 - 1	1.5	NA	3300	N	No	BSL
83-32-9	ACENAPHTHENE	0.19	J	0.23	J	NTC01GWTW0101-D	1/13	0.95 - 1	0.23	NA	NA	N	No	BSL
208-96-8	ACENAPHTHYLENE	5		5.9		NTC01GWTW0101-D	1/13	0.95 - 1	5.9	NA	NA	N	No	BSL
120-12-7	ANTHRACENE	0.035	J	0.039	J	NTC01GWTW0101-D	1/13	0.19 - 0.2	0.039	NA	NA	N	No	BSL
86-74-8	CARBAZOLE	0.15	J	0.17	J	NTC01GWTW0101-D	1/13	0.95 - 1	0.17	NA	NA	C	No	BSL
206-44-0	FLUORANTHENE	0.039	J	0.039		NTC01GW0401	1/13	0.19 - 0.2	0.039	NA	NA	N	No	BSL
86-73-7	FLUORENE	0.025	J	0.23	J	NTC01GWTW0101, NTC01GWTW0101-D	5/13	0.19 - 0.2	0.23	NA	NA	N	No	BSL
91-20-3	NAPHTHALENE	5.9		6.8	J	NTC01GWTW0101-D	1/13	0.95 - 1	6.8	NA	150	N	No	BSL
85-01-8	PHENANTHRENE	0.056	J	0.35		NTC01GWTW0101	13/13	--	0.35	NA	NA	N(8)	No	BSL
129-00-0	PYRENE	0.025	J	0.043	J	NTC01GW0401, NTC01GWTW0101-D	3/13	0.19 - 0.2	0.043	NA	NA	N	No	BSL

Footnotes:

1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 No background or upgradient well data are available.
5 Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (USEPA, November 2002). Values are from Table 2c and correspond to a target cancer risk level of 1E-6 or Hazard index =1, and an attenuation factor of 0.001.
6 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.

Associated Samples:

				NTC01GWTW0101-D
NTC01GW0101	NTC01GW0301	NTC01GW0601	NTC01GW0901	NTC01GWTW0201
NTC01GW0101-D	NTC01GW0401	NTC01GW0701	NTC01GW1001	NTC01GWTW0301
NTC01GW0201	NTC01GW0501	NTC01GW0801	NTC01GWTW0101	NTC01GWTW0401

Definitions:

C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Noncarcinogen
NA = Not applicable.

Rationale Codes:

For Selection as a COPC:
ASL = Above COPC screening level

For Elimination as a COPC:
BSL = Below COPC screening level

TABLE 6-5
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SEDIMENT
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Skokie Ditch

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Region 9 PRGs - Residential Soil[5]	TACO - Soil Remediation Objective for Residential Properties[6] - Ingestion	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Semivolatile Organics (ug/kg)												
91-57-6	2-METHYLNAPHTHALENE	220 J	220 J	NTC01SD0101	1/4	2500 - 4400	220	140	5600 N[8]	1600000	No	BSL
83-32-9	ACENAPHTHENE	130 J	1000 J	NTC01SD0101	3/4	2500 - 2500	1000	130	370000 N	4700000	No	BSL
208-96-8	ACENAPHTHYLENE	79 J	87 J	NTC01SD0400	2/4	2500 - 4400	87	70	370000 N[9]	4700000	No	BSL
120-12-7	ANTHRACENE	150 J	1800 J	NTC01SD0200	4/4	--	1800	400	2200000 N	23000000	No	BSL
56-55-3	BENZO(A)ANTHRACENE	690 J	4500 J	NTC01SD0101	4/4	--	4500	1800	620 C	900	Yes	ASL
50-32-8	BENZO(A)PYRENE	810 J	4900	NTC01SD0101, NTC01SD0200	4/4	--	4900	2100	62 C	90	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	110 J	6400	NTC01SD0101, NTC01SD0200	4/4	--	6400	2100	620 C	900	Yes	ASL
191-24-2	BENZO(G,H,I)PERYLENE	680 J	2800 J	NTC01SD0200	4/4	--	2800	1700	230000 N[10]	2300000	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	480 J	2700 J	NTC01SD0101	4/4	--	2700	1700	6200 C	9000	No	BSL
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	580 J	2100 J	NTC01SD0101	4/4	--	2100	2700	35000 C	46000	No	BSL
85-68-7	BUTYL BENZYL PHTHALATE	150 J	190 J	NTC01SD0101	2/4	3700 - 4400	190	NA	1200000 N	16000000	No	BSL
86-74-8	CARBAZOLE	140 J	1100 J	NTC01SD0101	4/4	--	1100	NA	24000 C	32000	No	BSL
218-01-9	CHRYSENE	960 J	5500	NTC01SD0101	4/4	--	5500	2700	62000 C	88000	No	BSL
53-70-3	DIBENZO(A,H)ANTHRACENE	150 J	770 J	NTC01SD0200	4/4	--	770	420	62 C	90	Yes	ASL
132-64-9	DIBENZOFURAN	130 J	510 J	NTC01SD0101	3/4	2500 - 4400	510	NA	15000 N	NA	No	BSL
117-84-0	DI-N-OCTYL PHTHALATE	120 J	180 J	NTC01SD0101	2/4	3700 - 4400	180	NA	240000 N	1600000	No	BSL
206-44-0	FLUORANTHENE	1900 J	12000	NTC01SD0101, NTC01SD0200	4/4	--	12000	4100	230000 N	3100000	No	BSL
86-73-7	FLUORENE	160 J	1000 J	NTC01SD0101	3/4	2500 - 2500	1000	180	270000 N	3100000	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	710 J	3100 J	NTC01SD0200	4/4	--	3100	1600	620 C	900	Yes	ASL
91-20-3	NAPHTHALENE	160 J	440 J	NTC01SD0101	2/4	2500 - 4400	440	200	5600 N	1600000	No	BSL
85-01-8	PHENANTHRENE	780 J	7600	NTC01SD0200	4/4	--	7600	2500	230000 N[10]	2300000	No	BSL
129-00-0	PYRENE	150 J	9400	NTC01SD0101	4/4	--	9400	3000	230000 N	2300000	No	BSL
Polynuclear Aromatic Hydrocarbons (ug/kg)												
91-57-6	2-METHYLNAPHTHALENE	23 J	1300 J	NTC01SD0101	8/10	1200 - 1800	1300	140	5600 N[8]	1600000	No	BSL
208-96-8	ACENAPHTHYLENE	62 J	420 J	NTC01SD0200	9/10	5800 - 5800	420	70	370000 N[9]	4700000	No	BSL
120-12-7	ANTHRACENE	28 J	1300	NTC01SD0101	10/10	--	1300	400	2200000 N	23000000	No	BSL
56-55-3	BENZO(A)ANTHRACENE	110	4100	NTC01SD0101	10/10	--	4100	1800	620 C	900	Yes	ASL
50-32-8	BENZO(A)PYRENE	250	3500	NTC01SD0101	9/10	180 - 180	3500	2100	62 C	90	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	200	4000	NTC01SD0101	9/10	360 - 360	4000	2100	620 C	900	Yes	ASL
191-24-2	BENZO(G,H,I)PERYLENE	260	2300	NTC01SD0101	10/10	--	2300	1700	230000 N[10]	2300000	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	100	1700	NTC01SD0101	9/10	360 - 360	1700	1700	6200 C	9000	No	BSL
86-74-8	CARBAZOLE	190 J	420 J	NTC01SD0200	4/10	180 - 5800	420	NA	24000 C	32000	No	BSL
218-01-9	CHRYSENE	160	3600	NTC01SD0101	10/10	--	3600	2700	62000 C	88000	No	BSL
53-70-3	DIBENZO(A,H)ANTHRACENE	50 J	440 J	NTC01SD0101	10/10	--	440	420	62 C	90	Yes	ASL
206-44-0	FLUORANTHENE	230	9400	NTC01SD0101	10/10	--	9400	4100	230000 N	3100000	No	BSL
86-73-7	FLUORENE	11 J	580 J	NTC01SD0101	7/10	180 - 360	580	180	270000 N	3100000	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	280	2900	NTC01SD0101	10/10	--	2900	1600	620 C	900	Yes	ASL
91-20-3	NAPHTHALENE	120 J	660 J	NTC01SD0200	3/10	180 - 5800	660	200	5600 N	1600000	No	BSL
85-01-8	PHENANTHRENE	100	5700	NTC01SD0101	10/10	--	5700	2500	230000 N[10]	2300000	No	BSL
129-00-0	PYRENE	170	6800	NTC01SD0101	10/10	--	6800	3000	230000 N	2300000	No	BSL
	BAP EQUIVALENT ZERO ND	377.1	5060.6	NTC01SD0101	10/10	--	5060.6	NA	62 C	90	Yes	ASL
	BAP EQUIVALENT - HALF ND	377.1	5060.6	NTC01SD0101	10/10	--	5060.6	NA	62 C	90	Yes	ASL
Organochlorine Pesticides/PCBs (ug/kg)												
72-54-8	4,4'-DDD	5.5 J	86 J	NTC01SD0101	4/4	--	86	NA	2400 C	3000	No	BSL
72-55-9	4,4'-DDE	10 J	79 J	NTC01SD0101	4/4	--	79	NA	1700 C	2000	No	BSL
50-29-3	4,4'-DDT	4.9 J	7.4 J	NTC01SD0400	3/4	150 - 150	7.4	NA	1700 C	2000	No	BSL
5103-71-9	ALPHA-CHLORDANE	5 J	5.5 J	NTC01SD0200	2/4	13 - 150	5.5	NA	1600 C[11]	1800	No	BSL
12672-29-6	AROCLOR-1248	82	820	NTC01SD0101	1/4	50 - 89	820	NA	220 C	1000	Yes	ASL

TABLE 6-5
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SEDIMENT
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Skokie Ditch

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Background Concentration[4]	Screening Level Based on USEPA Region 9 PRGs - Residential Soil[5]	TACO - Soil Remediation Objective for Residential Properties[6] - Ingestion	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
60-57-1	DIELDRIN	4.4 J	4.4 J	NTC01SD0400	1/4	13 - 150	4.4	NA	30 C	40	No	BSL
33213-65-9	ENDOSULFAN II	3.6 J	4.8 J	NTC01SD0400	1/4	13 - 150	4.8	NA	37000 N	470000	No	BSL
72-20-8	ENDRIN	2.7 J	6.7 J	NTC01SD0400	1/4	13 - 150	6.7	NA	1800 N	23000	No	BSL
7421-93-4	ENDRIN ALDEHYDE	41 J	41 J	NTC01SD0101	1/4	13 - 23	41	NA	1800 N	23000	No	BSL
5103-74-2	GAMMA-CHLORDANE	2.9 J	2.9 J	NTC01SD0200	1/4	13 - 150	2.9	NA	1600 C[11]	1800	No	BSL
Dioxins/Furans (ng/kg)												
3268-87-9	1,2,3,4,6,7,8,9-OCDD	1400	7700 J	NTC01SD0101	4/4	--	7700	NA	13000 C[12]	NA	No	BSL
39001-02-0	1,2,3,4,6,7,8,9-OCDF	13	330	NTC01SD0101	4/4	--	330	NA	13000 C[12]	NA	No	BSL
35822-46-9	1,2,3,4,6,7,8-HPCDD	13	580	NTC01SD0101	4/4	--	580	NA	390 C[12]	NA	Yes	ASL
67562-39-4	1,2,3,4,6,7,8-HPCDF	3	99	NTC01SD0101	4/4	--	99	NA	390 C[12]	NA	No	BSL
55673-89-7	1,2,3,4,7,8,9-HPCDF		9	NTC01SD0101	1/4	2.1 - 4.6	9	NA	390 C[12]	NA	No	BSL
57653-85-7	1,2,3,6,7,8-HXCDD	5 J	23	NTC01SD0101	4/4	--	23	NA	39 C[12]	NA	No	BSL
19408-74-3	1,2,3,7,8,9-HXCDD	6.8 J	11 J	NTC01SD0400, NTC01SD0400-D	4/4	--	11	NA	39 C[12]	NA	No	BSL
1746-01-6	2,3,7,8-TCDD	0.76 J	0.76 J	NTC01SD0100	1/4	0.62 - 0.84	0.76	NA	3.9 C[12]	NA	No	BSL
51207-31-9	2,3,7,8-TCDF	1 J	5.7	NTC01SD0101	4/4	--	5.7	NA	39 C[12]	NA	No	BSL
	2,3,7,8-TCDD TEQ HALF ND	5.303	15.723	NTC01SD0101	4/4	--	15.723	NA	3.9 C[12]	NA	Yes	ASL
	2,3,7,8-TCDD TEQ ZERO ND	4.149	12.899	NTC01SD0101	4/4	--	12.899	NA	3.9 C[12]	NA	Yes	ASL
37871-00-4	TOTAL HPCDD	250	1100	NTC01SD0101	4/4	--	1100	NA	NA	NA	No	NA
38998-75-3	TOTAL HPCDF	95	510	NTC01SD0101	4/4	--	510	NA	NA	NA	No	NA
34465-46-8	TOTAL HXCDD	41	120	NTC01SD0101	4/4	--	120	NA	NA	NA	No	NA
55684-94-1	TOTAL HXCDF	18	110	NTC01SD0101	4/4	--	110	NA	NA	NA	No	NA
30402-15-4	TOTAL PECDF	5	29	NTC01SD0101	4/4	--	29	NA	NA	NA	No	NA
41903-57-5	TOTAL TCDD	1	4.3	NTC01SD0100	4/4	--	4.3	NA	NA	NA	No	NA
55722-27-5	TOTAL TCDF	1	81	NTC01SD0101	4/4	--	81	NA	NA	NA	No	NA
Inorganics (mg/kg)												
7429-90-5	ALUMINUM	1180	11800	NTC01SD0400-D	10/10	--	11800	NA	7600 N	NA	Yes	ASL
7440-36-0	ANTIMONY	0.45 J	2.1 J	NTC01SD0200, NTC01SD0400	6/10	0.33 - 0.44	2.1	NA	3.1 N	31	No	BSL
7440-38-2	ARSENIC	2.1	10.1	NTC01SD0400-D	10/10	--	10.1	8	0.39 C	NA	Yes	ASL
7440-39-3	BARIUM	10	101	NTC01SD0400-D	10/10	--	101	145	540 N	5500	No	BSL,BKG
7440-43-9	CADMIUM	0.4	0.48	NTC01SD0101	1/10	0.05 - 0.12	0.48	0.5	3.7 N	78	No	BSL,BKG
7440-70-2	CALCIUM	20700	117000	NTC01SD0500	10/10	--	117000	NA	NA	NA	No	NUT
7440-47-3	CHROMIUM	3.2	44.2	NTC01SD0101	10/10	--	44.2	16	30 C[13]	230	Yes	ASL
7440-48-4	COBALT	2.2	12.8	NTC01SD0400-D	10/10	--	12.8	NA	140 N[14]	4700	No	BSL
7440-50-8	COPPER	29	83.3	NTC01SD0101	10/10	--	83.3	38	310 N	2900	No	BSL
7439-89-6	IRON	5290	28500	NTC01SD0400-D	10/10	--	28500	18000	2300 N	NA	Yes	ASL
7439-92-1	LEAD	30	113	NTC01SD0101	10/10	--	113	28	400	400	No	BSL
7439-95-4	MAGNESIUM	1160	67100	NTC01SD0500	10/10	--	67100	NA	NA	NA	No	NUT
7439-96-5	MANGANESE	257	1200	NTC01SD0400-D	10/10	--	1200	1300	180 N	3700	No	BKG
7439-97-6	MERCURY	0.058 J	0.3 J	NTC01SD0200	9/10	0.015 - 0.015	0.3	0.07	2.3 N	23	No	BSL
7440-02-0	NICKEL	5.6	29.4	NTC01SD0400-D	10/10	--	29.4	26	160 N	1600	No	BSL
7440-09-7	POTASSIUM	297	1760	NTC01SD0400-D	10/10	--	1760	1500	NA	NA	No	NUT
7782-49-2	SELENIUM	1	2.5	NTC01SD0400-D	8/10	0.26 - 0.35	2.5	NA	39 N	390	No	BSL
7440-22-4	SILVER	0.3	0.39	NTC01SD0301	1/10	0.076 - 0.5	0.39	NA	39 N	390	No	BSL
7440-23-5	SODIUM	239	1290	NTC01SD0101	10/10	--	1290	NA	NA	NA	No	NUT
7440-28-0	THALLIUM	0.6	0.63	NTC01SD0400, NTC01SD0401	2/10	0.3 - 0.7	0.63	NA	0.52 N	6.3	Yes	ASL
7440-62-2	VANADIUM	4	31	NTC01SD0400-D	10/10	--	31	NA	7.8 N	550	Yes	ASL
7440-66-6	ZINC	13	439	NTC01SD0101	10/10	--	439	80	2300 N	23000	No	BSL

TABLE 6-5
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SEDIMENT
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Skokie Ditch

CAS Number	Chemical	Minimum Concentration(1)	Maximum Concentration(1)	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects(2)	Concentration Used for Screening(3)	Background Concentration(4)	Screening Level Based on USEPA Region 9 PRGs - Residential Soil(5)	TACO - Soil Remediation Objective for Residential Properties(6) - Ingestion	COPC Flag	Rationale for Contaminant Deletion or Selection(7)
Miscellaneous Parameters (mg/kg)												
	TOTAL ORGANIC CARBON	2200	54400	NTC01SD0501	10/10	--	54400	NA	NA	NA	No	NTX

Shading indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 Illinois EPA background concentrations for sediment (See Section 6.1.2.3 of text)..
5 The risk-based COPC screening level for residential soil is presented. The value is based on a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (USEPA Region 9, October 2004).
6 Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties (Illinois EPA, online, July, 2007).
7 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level and the Illinois EPA background level.
8 Naphthalene is used a the surroage for 2-methylnaphthalene.
9 Acenaphthene is used a the surroage for acenaphthylene.
10 Pyrene is used as the surrogate for benzo(g,h,i)perylene and phenanthrene.
11 Value is for chlordane.
12 Value is derived by multiplying carteria for 2,3,7,8-TCDD by WHO Toxicity Equivalent Factors (See Section 6.3.5 of text).
13 Value is for hexavalent chromium.
14 Screening level for cobalt is based on 0.1 of the noncarcinogenic PRG because this value is less than the carcinogenic PRG (USEPA, Region 9, October 2004).

Associated Samples

NTC01SD0100	NTC01SD0400
NTC01SD0101	NTC01SD0400-D
NTC01SD0200	NTC01SD0401
NTC01SD0201	NTC01SD0500
NTC01SD0300	NTC01SD0501
NTC01SD0301	

Definitions:
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Noncarcinogen
NA = Not applicable/not available
PRG = Preliminary Remediation Goal
TACO = Illinois EPA Tiered Approach to Correcti

Rationale Codes:
For selection as a COPC:
ASL = Above Screening Level

For Elimination as a COPC:
BKG = Within background levels
BSL = Below COPC screening level
NTX = No toxicity Information
NUT = essential nutrient

TABLE 6-6
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE WATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Skokie Ditch

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Sample with Maximum Concentration	Detection Frequency (1)	Range of Nondetects(2)	Concentration Used for Screening(3)	Background Value(4)	Risk-Based COPC Screening Level(5)		Federal Maximum Contaminant Level (MCL)(6)	TACO - Groundwater Remediation Objectives for Class 1 Groundwater(7)	COPC Flag	Rationale for Contaminant Deletion or Selection(8)
Volatile Organics (ug/L)																
75-34-3	1,1-DICHLOROETHANE	0.21	J	0.39	J	NTC01SW0400	3/5	1 - 1	0.39	NA	81	N	NA	700	No	BSL
156-59-2	CIS-1,2-DICHLOROETHENE	0.9		1.7		NTC01SW0400	5/5	--	1.7	NA	6.1	N	70	70	No	BSL
75-01-4	VINYL CHLORIDE	0.25	J	0.34	J	NTC01SW0400	2/5	1 - 1	0.34	NA	0.02	C	2	2	Yes	ASL
Polynuclear Aromatic Hydrocarbons (ug/L)																
50-32-8	BENZO(A)PYRENE	0.035	J	0.039	J	NTC01SW0100	3/5	0.2 - 0.2	0.039	NA	0.0092	C	0.2	0.2	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	0.051	J	0.065	J	NTC01SW0300-D	3/5	0.2 - 0.2	0.065	NA	0.092	C	NA	0.18	No	BSL
191-24-2	BENZO(G,H,I)PERYLENE	0.044	J	0.065	J	NTC01SW0300-D	5/5	--	0.065	NA	18	N(9)	NA	NA	No	BSL
218-01-9	CHRYSENE	0.034	J	0.041	J	NTC01SW0300-D	4/5	0.2 - 0.2	0.041	NA	9.2	C	NA	1.5	No	BSL
206-44-0	FLUORANTHENE	0.1	J	0.17	J	NTC01SW0100	5/5	--	0.17	NA	150	N	NA	280	No	BSL
86-73-7	FLUORENE	0.021	J	0.036	J	NTC01SW0300-D	5/5	--	0.036	NA	24	N	NA	280	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	0.029	J	0.056	J	NTC01SW0300-D	5/5	--	0.056	NA	0.092	C	NA	0.43	No	BSL
85-01-8	PHENANTHRENE	0.12	J	0.17	J	NTC01SW0100, NTC01SW0300-D	5/5	--	0.17	NA	18	N(9)	NA	NA	No	BSL
129-00-0	PYRENE	0.056	J	0.084	J	NTC01SW0300-D	5/5	--	0.084	NA	18	N	NA	210	No	BSL
	BAP EQUIVALENT ZERO ND	0.0029		0.050141		NTC01SW0300-D	5/5	--	0.050141	NA	0.0092	C	0.2	0.2	Yes	ASL
	BAP EQUIVALENT - HALF ND	0.153689		0.224234		NTC01SW0500	5/5	--	0.224234	NA	0.0092	C	0.2	0.2	Yes	ASL
Dioxins/Furans (pg/L)																
3268-87-9	1,2,3,4,6,7,8,9-OCDD	130		130		NTC01SW0500	1/5	22 - 44	130	NA	1500	C(10)	NA	NA	No	BSL
	2,3,7,8-TCDD TEQ HALF ND	3.33171		3.76772		NTC01SW0300-D	5/5	--	3.76772	NA	0.45	C	30	NA	Yes	ASL
	2,3,7,8-TCDD TEQ ZERO ND	0.039		0.039		NTC01SW0500	1/5	0 - 0	0.039	NA	0.45	C	30	NA	No	BSL
Metals (ug/L)																
7429-90-5	ALUMINUM	224		407		NTC01SW0200	3/5	296 - 311	407	NA	3600	N	NA	NA	No	BSL
7440-36-0	ANTIMONY	3.2		3.6		NTC01SW0300	2/5	2.4 - 2.4	3.6	NA	1.5	N	6	6	Yes	ASL
7440-39-3	BARIUM	48.8		52.4		NTC01SW0500	5/5	--	52.4	NA	260	N	2000	2000	No	BSL
7440-70-2	CALCIUM	83300		91300		NTC01SW0400	5/5	--	91300	NA	NA		NA	NA	No	NUT
7440-47-3	CHROMIUM	1.2		1.4		NTC01SW0500	2/5	0.54 - 1.7	1.4	NA	11	N(11)	100	100	No	BSL
7440-50-8	COPPER	1.5		2.6		NTC01SW0500	3/5	1.4 - 1.4	2.6	NA	150	N	1300	650	No	BSL
7439-89-6	IRON	462		677		NTC01SW0100	5/5	--	677	NA	1100	N	NA	5000	No	BSL
7439-92-1	LEAD	2		2.1		NTC01SW0100, NTC01SW0200	3/5	1.8 - 1.8	2.1	NA	NA		15	7.5	No	BSL
7439-95-4	MAGNESIUM	30400		33700		NTC01SW0400	5/5	--	33700	NA	NA		NA	NA	No	NUT
7439-96-5	MANGANESE	69		86		NTC01SW0400	5/5	--	86	NA	88	N	NA	150	No	BSL
7439-97-6	MERCURY	0.052		0.052		NTC01SW0100, NTC01SW0200	2/5	0.015 - 0.022	0.052	NA	1.1	N	2	2	No	BSL
7440-02-0	NICKEL	1.6		2.6		NTC01SW0200	3/5	2.3 - 3	2.6	NA	73	N	NA	100	No	BSL
7440-09-7	POTASSIUM	3440		3670		NTC01SW0100	5/5	--	3670	NA	NA		NA	NA	No	NUT
7440-23-5	SODIUM	226000		253000		NTC01SW0500	5/5	--	253000	NA	NA		NA	NA	No	NUT
7440-28-0	THALLIUM	5.1		5.1		NTC01SW0100	1/5	2.6 - 2.6	5.1	NA	0.24	N	2	2	Yes	ASL
7440-62-2	VANADIUM	0.7		1.5		NTC01SW0100	5/5	--	1.5	NA	3.6	N	NA	49	No	BSL
7440-66-6	ZINC	18.7		18.7		NTC01SW0500	1/5	17.2 - 18.7	18.7	NA	1100	N	NA	5000	No	BSL

Shading indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

TABLE 6-6
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE WATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Skokie Ditch

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Sample with Maximum Concentration	Detection Frequency (1)	Range of Nondetects(2)	Concentration Used for Screening(3)	Background Value(4)	Risk-Based COPC Screening Level(5)	Federal Maximum Contaminant Level (MCL)(6)	TACO - Groundwater Remediation Objectives for Class 1 Groundwater(7)	COPC Flag	Rationale for Contaminant Deletion or Selection(8)

Footnotes:

1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 No background or upgradient well data are available.
5 The risk-based COPC screening level for tap water use is presented. The value is based on a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (USEPA Region 9, October 2004).
6 Federal Maximum Contaminant Level (USEPA, Summaer 2006).
7 Illinois EPA Remediation Objectives for Class 1 Grounwater (Illinois EPA, online, July, 2007).
8 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level
9 Pyrene is used as the surrogate for benzo(g,h,i)perylene and phenanthrene.
10 Value is derived by multiplying carteria for 2,3,7,8-TCDD by WHO Toxicity Equivalent Factors (See Section 6.3.5 of text).
11 Value is for hexavalent chromium.

Associated Samples:

NTC01SW0100	NTC01SW0300	NTC01SW0400
NTC01SW0200	NTC01SW0300-D	NTC01SW0500

Definitions:

C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Noncarcinogen
NA = Not applicable.
TACO = Illinois EPA Tiered Approach to Corrective Action Objectives.

Rationale Codes:

For Selection as a COPC:
ASL = Above COPC screening level

For Elimination as a COPC:
BSL = Below COPC screening level
NUT = Essential nutrient

TABLE 6-7

CHEMICALS RETAINED AS COPCs
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical	Subsurface Soil			Groundwater		Surface Water	Sediment
	Direct Contact	Soil to Air	Soil to Groundwater	Direct Contact	Vapor Intrusion		
Volatile Organic Compounds							
Benzene				X			
Methylene Chloride			X				
Vinyl Chloride						X	
Semivolatile Organic Compounds							
2-Methylnaphthalene				X			
4-Methylphenol			X				
Benzo(a)anthracene	X		X				X
Benzo(a)pyrene	X		X			X	X
Benzo(b)fluoranthene	X		X				X
Benzo(k)fluoranthene			X				
Carbazole			X				
Chrysene			X				
Dibenzo(a,h)anthracene	X						X
Indeno(1,2,3-cd)pyrene	X		X				X
Naphthalene	X	X		X			
Pesticides/PCBs							
alpha-BHC			X				
Aroclor-1248							X
Dieldrin			X				
gamma-BHC (Lindane)			X				
Herbicides							
Pentachlorophenol			X				
Dioxins/Furans							
2,3,7,8-TCDD TEQ	X	X	X			X	X
Inorganics							
Aluminum	X			X			X
Antimony	X		X			X	
Arsenic	X		X	X			X
Barium			X	X			
Beryllium			X				
Cadmium			X				
Chromium	X		X	X			X
Cobalt			X				
Copper	X		X				
Iron	X			X			X
Lead	X			X			
Manganese	X		X	X			
Mercury			X				
Nickel			X				
Selenium			X				
Silver	X		X				
Thallium	X		X			X	X
Vanadium	X			X			X
Zinc			X				
Cyanide			X				

Notes
X - Indicates chemical was retained as a COPC.

TABLE 6-8

EXPOSURE ROUTES FOR QUANTITATIVE EVALUATION
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptors	Exposure Routes
Maintenance Workers (current/future land use)	• Surface Water/Sediment - Dermal Contact • Surface Water/Sediment - Incidental Ingestion
Adolescent Trespassers/Recreational Users (current/future land use)	• Surface Water/Sediment - Dermal Contact • Surface Water/Sediment - Incidental Ingestion
Adult Recreational Users (golfers) (current/future land use)	• Surface Water/Sediment - Dermal Contact • Surface Water/Sediment - Incidental Ingestion
Construction Workers (future land use)	• Soil - Dermal Contact • Soil - Incidental Ingestion • Inhalation of Air/Dust/Emissions (from soil) • Groundwater - Dermal Contact (during excavation) • Groundwater Inhalation of Volatile Organics in a Trench (during excavation) • Surface Water/Sediment - Dermal Contact • Surface Water/Sediment - Incidental Ingestion
Occupational Workers (future land use)	• Inhalation of Indoor Air (vapors from groundwater)
On-Base Military Residents (adult/children) (future land use)	• Soil - Dermal Contact • Soil - Incidental Ingestion • Inhalation of Air/Dust/Emissions (from soil) • Groundwater - Dermal Contact • Groundwater - Ingestion • Inhalation of Indoor Air (vapors from groundwater) • Surface Water/Sediment Dermal Contact • Surface Water/Sediment Incidental Ingestion
On-site Civilian Residents (adult/children) (future land use)	• Soil - Dermal Contact • Soil - Incidental Ingestion • Inhalation of Air/Dust/Emissions (from soil) • Groundwater - Dermal Contact • Groundwater - Ingestion • Inhalation of Indoor Air (vapors from groundwater) • Surface Water/Sediment - Dermal Contact • Surface Water/Sediment - Incidental Ingestion

TABLE 6-9

EXPOSURE POINT CONCENTRATIONS FOR COPCS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical of Potential Concern	Exposure Point Concentration			
	Subsurface Soil[1]	Groundwater[2]	Sediment[1]	Surface Water[3]
	(mg/kg)	(ug/L)	(mg/kg)	(ug/L)
2,3,7,8-TCDD TEQ HALF ND	0.009[3]		0.000016[3]	0.000004
BAP EQUIVALENT - HALF ND	12		3	0.2
BENZENE		0.44		
VINYL CHLORIDE				0.34
NAPHTHALENE	1	6.8		
2-METHYLNAPHTHALENE		1.5		
AROCLOR-1248			0.82(3)	
ALUMINUM	8,030	8,650	8,520	
ANTIMONY	7.1			3.6
ARSENIC	12	3.3	8.5	
BARIUM		566		
CHROMIUM	26.1	14.1	26.6	
COPPER	627			
IRON	39,800	17,600	21,400	
LEAD	209[4]	2.2[4]		
MANGANESE	533	5,070		
SILVER	94.9			
THALLIUM	0.82		0.44	5.1
VANADIUM	42.9	20.7	23.7	

Blank spaces indicate that the chemical was not selected as A COPC for the specified medium

1 - UCLs calculated by the U.S EPA's ProUCL software, unless otherwise noted. See RAGS-Part D Table 3s in Appendix F-1 for details concerning the UCLs.
2 - Maximum concentrations are used as EPCs based on Illinois EPA guidance (see Section 6.2.3 of text).
3 - The maximum concentration is used as the EPC because the data set consists of less than 10 samples.
4 - As per IEUBK and Adult Lead Model guidance, the arithmetic average is used as the EPC for lead (see Section 6.4.4.5 of text).

TABLE 6-10

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident
All Exposures							
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Maximum	NA	Maximum	NA	NA	Maximum	Maximum
C_{sw} (µg/L)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	25[3]	25[3]	10[4]	24[5]	6[5]	24[5]
BW (kg)	70[5]	70[5]	70[5]	42[6]	70[5]	15[5]	70[5]
AT_n (days)	42[7]	9,125[8]	9,125[8]	3,650[8]	8,760[8]	2,190[8]	8,760[8]
AT_c (days)	25,550[8]	25,550[8]	25,550[8]	25,550[8]	25,550[8]	25,550[8]	25,550[8]
Incidental Ingestion/Dermal Contact with Soil							
IR (mg/day)	330[9]	NA	NA	NA	NA	200[5]	100[5]
EF-Soil (days/year)	30[10]	NA	NA	NA	NA	350[5]	350[5]
FI (unitless)	1[5]	NA	NA	NA	NA	1[5]	1[5]
SA (cm^2/day)	3,300[11]	NA	NA	NA	NA	2,800[11]	5,700[11]
AF (mg/cm^2)	0.3[11]	NA	NA	NA	NA	0.2[11]	0.07[11]
ABS (unitless)	chemical-specific[11]	NA	NA	NA	NA	chemical-specific[11]	chemical-specific[11]
CF (kg/mg)	1E-06	NA	NA	NA	NA	1E-06	1E-06
Inhalation Fugitive Dust/Volatile Emissions from Soil							
C_{air} (mg/m^3)	calculated[9]	NA	NA	NA	NA	calculated[9]	calculated[9]
InhR (m^3/hour)	2.5[6]	NA	NA	NA	NA	10 m^3/day[6]	20 m^3/day[9]
ET (hours/day)	8[12]	NA	NA	NA	NA	24[6]	24[9]
EF-Soil (days/year)	30[10]	NA	NA	NA	NA	350[5]	350[5]
PEF (m^3/kg)	1.27E+06[9]	NA	NA	NA	NA	1.36E+09[9]	1.36E+09[9]
Ingestion/Dermal Contact with Groundwater							
IR_{gw} (L/day)	NA	NA	NA	NA	NA	1.5[6]	2[5]
EF (days/year)	30[10]	NA	NA	NA	NA	350[5]	350[5]
ET (hours/day) and t_{event} (hours/event)	4[2]	NA	NA	NA	NA	0.25[6]	0.25[6]
EV (events/day)	1[2]	NA	NA	NA	NA	1[2]	1[2]

TABLE 6-10

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident
A (cm^2/day)	3,300[11]	NA	NA	NA	NA	6,600[11]	18,000[11]
K_p (cm/hour)	chemical-specific[11]	NA	NA	NA	NA	chemical-specific[11]	chemical-specific[11]
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[11]	NA	NA	NA	NA	chemical-specific[11]	chemical-specific[11]
Inhalation of Volatile Emissions while Showering							
C_{air} (mg/m^3)	NA	NA	NA	NA	NA	Calculated[13]	Calculated[13]
InhR (m^3/hour)	NA	NA	NA	NA	NA	0.6[7]	0.6[7]
EF (days/year)	NA	NA	NA	NA	NA	350[5]	350[5]
ET (hours/day)	NA	NA	NA	NA	NA	0.33[2]	0.33[2]
Inhalation of Volatile Emissions from Groundwater by Vapor Intrusion and in a Trench (Construction Workers)							
C_{air} (mg/m^3)	calculated[14]	NA	calculated[15]	NA	NA	calculated[15]	calculated[15]
InhR (m^3/hour)	2.5[6]	NA	2.5[9]	NA	NA	0.42[6]	0.833[9]
EF (days/year)	30[10]	NA	250[5]	NA	NA	350[5]	350[5]
ET (hours/day)	4[2]	NA	8[9]	NA	NA	24[6]	24[9]
Ingestion/Dermal Contact with Surface Water							
IR_{sw} (ml/hr)	0.01[16]	0.01[16]	NA	0.01[16]	0.01[16]	0.05[16]	0.01[16]
EF (days/year)	30[10]	30[17]	NA	60[18]	30[17]	30[17]	30[17]
ET (hours/day) and t_{event} (hours/event)	4[2]	2[2]	NA	4[2]	1[2]	2[2]	2[2]
EV (events/day)	1[2]	1[2]	NA	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	3,300[11]	3,300[11]	NA	3,280[19]	5,700[11]	3,300[20]	5,700[11]
K_p (cm/hour)	chemical-specific[11]	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[11]	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (L/cm^3)	1E-03	1E-03	NA	1E-03	1E-03	1E-03	1E-03

TABLE 6-10

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident
Incidental Ingestion/Dermal Contact with Sediment							
IR (mg/day)	330[9]	100[5]	NA	100[5]	100[5]	200[5]	100[5]
EF-Sediment (days/year)	30[10]	30[17]	NA	60[18]	30[17]	30[17]	30[17]
FI (unitless)	1[5]	1[5]	NA	1[5]	1[5]	1[5]	1[5]
SA (cm^2/day)	3,300[11]	3,300[11]	NA	3,280[19]	5,700[11]	2,800[11]	5,700[11]
AF (mg/cm^2)	0.3[11]	0.2[11]	NA	0.2[11]	0.07[11]	0.2[11]	0.07[11]
ABS (unitless)	chemical-specific[11]	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (kg/mg)	NA	1E-06	NA	1E-06	1E-06	1E-06	1E-06

A	Skin surface area available for contact	EF	Exposure frequency
ABS	Absorption factor	ET	Exposure time
AF	Soil-to-skin adherence factor	EV	Event frequency
AT_c	Averaging time for carcinogenic effects	FI	Fraction ingested from contaminated source
AT_n	Averaging time for non-carcinogenic effects	InhR	Inhalation rate
B	Bunge Model partitioning coefficient	IR	Ingestion rate (soil or groundwater)
BW	Body weight	K_p	Permeability coefficient from water through skin
CF	Conversion factor	SA	Skin surface area available for contact
IR	Ingestion rate	PEF	Particulate emission factor
$C_{soil/sed}$	Exposure concentration for soil/sediment	τ	Lag time
$C_{gw/sw}$	Exposure concentration for groundwater/surface water	t^*	Time it takes to reach steady-state conditions
C_{air}	Exposure concentration for air	t_{event}	Duration of event
ED	Exposure duration		

1 - USEPA, 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.
2 - Professional judgment.
3 - USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.
4 - Adolescents ages 7 to 16 years old.
5 - USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
6 - USEPA, 1997: Exposure Factors Handbook. EPA/600/8-95/002FA.
7 - Illinois EPA, Janaury 2003.
8 - USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.

TABLE 6-10

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident

9 - USEPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9365.4-24.
10 - Illinois EPA, April 2004.
11 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. PA/540/R/99/005.
12 - Assume an 8-hour work shift.
13 - Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.
14 - VDEQ, September 2004. Virginia Department of Environmental Quality (VDEQ, online -http://www.deq.state.va.us/brownfieldweb/vrp.html).
15 - USEPA, 2004: OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils.
16 - USEPA Region 4, 2000: Supplement Guidance to RAGS: Region 4 Bulletins.
17 - Assume one day a week in warm weather months for reasonable maximum exposure and every other week for central tendency exposure.
18 - Assume two days a week in warm weather months for reasonable maximum exposure and one day a week for central tendency exposure.
19 - Assume 25 percent of total body surface area is exposed, USEPA, 1997: Exposure Factors Handbook. EPA/600/8-95/002FA.
20 - Assume 50 percent of total body surface area is exposed, USEPA, 2004.

Note: The exposure factors for future civilian and military residents are the same, except for exposure duration (ED) for adult military residents. Exposure duration for adult military residents is assumed to be the typical enlistment times of 6 years, for the RME and CTE.

TABLE 6-11

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident
All Exposures							
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Maximum	NA	Maximum	NA	NA	Maximum	Maximum
C_{sw} (µg/L)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	9[3]	9[3]	10[4]	7[3]	2[3]	7[3]
BW (kg)	70[3]	70[3]	70[3]	42[5]	70[3]	15[3]	70[3]
AT_n (days)	42[6]	3,285[7]	3,285[7]	3,650[7]	2,555[7]	730[7]	2,555[7]
AT_c (days)	25,550[7]	25,550[7]	25,550[7]	25,550[7]	25,550[7]	25,550[7]	25,550[7]
Incidental Ingestion/Dermal Contact with Soil							
IR (mg/day)	165[8]	NA	NA	NA	NA	100[8]	50[8]
EF-Soil (days/year)	30[9]	NA	NA	NA	NA	234[3]	234[3]
FI (unitless)	1[3]	NA	NA	NA	NA	1[3]	1[3]
SA (cm^2/day)	3,300[10]	NA	NA	NA	NA	2,800[10]	5,700[10]
AF (mg/cm^2)	0.1[10]	NA	NA	NA	NA	0.04[10]	0.01[10]
ABS (unitless)	chemical-specific[10]	NA	NA	NA	NA	chemical-specific[10]	chemical-specific[10]
CF (kg/mg)	1E-06	NA	NA	NA	NA	1E-06	1E-06
Inhalation Fugitive Dust/Volatile Emissions from Soil							
C_{air} (mg/m^3)	calculated[11]	NA	NA	NA	NA	calculated[11]	calculated[11]
InhR (m^3/hour)	1.5[5]	NA	NA	NA	NA	10 m^3/day[5]	20 m^3/day[11]
ET (hours/day)	4[8]	NA	NA	NA	NA	24[5]	24[11]
EF-Soil (days/year)	30[9]	NA	NA	NA	NA	234[3]	234[3]
PEF (m^3/kg)	1.27E+06[11]	NA	NA	NA	NA	1.36E+09[11]	1.36E+09[11]
Ingestion/Dermal Contact with Groundwater							
IR_{gw} (L/day)	NA	NA	NA	NA	NA	0.66[5]	1.4[3]
EF (days/year)	30[9]	NA	NA	NA	NA	234[3]	234[3]
ET (hours/day) and t_{event} (hours/event)	2[8]	NA	NA	NA	NA	0.25[5]	0.25[5]
EV (events/day)	1[2]	NA	NA	NA	NA	1[2]	1[2]

TABLE 6-11

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident
A (cm^2/day)	3,300[10]	NA	NA	NA	NA	6,600[10]	18,000[10]
K_p (cm/hour)	chemical-specific[10]	NA	NA	NA	NA	chemical-specific[10]	chemical-specific[10]
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[10]	NA	NA	NA	NA	chemical-specific[10]	chemical-specific[10]
Inhalation of Volatile Emissions while Showering							
C_{air} (mg/m^3)	NA	NA	NA	NA	NA	Calculated[12]	Calculated[12]
InhR (m^3/hour)	NA	NA	NA	NA	NA	0.6[7]	0.6[7]
EF (days/year)	NA	NA	NA	NA	NA	234[3]	234[3]
ET (hours/day)	NA	NA	NA	NA	NA	0.25[2]	0.25[2]
Inhalation of Volatile Emissions from Groundwater by Vapor Intrusion and in a Trench (Construction Workers)							
C_{air} (mg/m^3)	calculated[13]	NA	calculated[14]	NA	NA	calculated[14]	calculated[14]
InhR (m^3/hour)	1.5[5]	NA	1.5[5]	NA	NA	0.42[5]	0.833[11]
EF (days/year)	30[9]	NA	219[3]	NA	NA	234[3]	234[3]
ET (hours/day)	2[8]	NA	8[11]	NA	NA	24[5]	24[11]
Ingestion/Dermal Contact with Surface Water							
IR_{sw} (ml/hr)	0.01[15]	0.01[15]	NA	0.01[15]	0.01[15]	0.05[15]	0.01[15]
EF (days/year)	30[9]	15[16]	NA	30[17]	15[16]	15[16]	15[16]
ET (hours/day) and t_{event} (hours/event)	2[8]	1[8]	NA	2[8]	1[2]	1[8]	1[8]
EV (events/day)	1[2]	1[2]	NA	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	3,300[10]	3,300[10]	NA	3,100[18]	5,700[10]	3,300[19]	5,700[10]
K_p (cm/hour)	chemical-specific[10]	chemical-specific[10]	NA	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[10]	chemical-specific[10]	NA	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]
CF (L/cm^3)	1E-03	1E-03	NA	1E-03	1E-03	1E-03	1E-03

TABLE 6-11

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident
Incidental Ingestion/Dermal Contact with Sediment							
IR (mg/day)	165[8]	50[8]	NA	50[8]	50[8]	100[8]	50[8]
EF-Sediment (days/year)	30[9]	15[16]	NA	30[17]	15[16]	15[16]	15[16]
FI (unitless)	1[5]	1[5]	NA	1[5]	1[5]	1[5]	1[5]
SA (cm^2/day)	3,300[10]	3,300[10]	NA	3,100[18]	5,700[10]	2,800[11]	5,700[10]
AF (mg/cm^2)	0.1[10]	0.01[10]	NA	0.04[10]	0.01[10]	0.04[10]	0.01[10]
ABS (unitless)	chemical-specific[10]	chemical-specific[10]	NA	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]
CF (kg/mg)	1E-06	1E-06	NA	1E-06	1E-06	1E-06	1E-06

Notes:

A	Skin surface area available for contact	EF	Exposure frequency
ABS	Absorption factor	ET	Exposure time
AF	Soil-to-skin adherence factor	EV	Event frequency
AT_c	Averaging time for carcinogenic effects	FI	Fraction ingested from contaminated source
AT_n	Averaging time for non-carcinogenic effects	InhR	Inhalation rate
B	Bunge Model partitioning coefficient	IR	Ingestion rate (soil or groundwater)
BW	Body weight	K_p	Permeability coefficient from water through skin
CF	Conversion factor	SA	Skin surface area available for contact
IR	Ingestion rate	PEF	Particulate emission factor
$C_{soil/sed}$	Exposure concentration for soil/sediment	τ	Lag time
$C_{gw/sw}$	Exposure concentration for groundwater/surface water	t^*	Time it takes to reach steady-state conditions
C_{air}	Exposure concentration for air	t_{event}	Duration of event
ED	Exposure duration		

1 - USEPA, 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.
2 - Professional judgment.
3 - USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
4 - Adolescents ages 7 to 16 years old.
5 - USEPA, 1997: Exposure Factors Handbook. EPA/600/8-95/002FA.
6 - Illinois EPA, Janaury 2003.
7 - USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.
8 - Central tendency exposure is assumed to be one-half the reasonable maximum exposure value.

TABLE 6-11

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User (Golfer)	On-Site Child Resident	On-Site Adult Resident

9 - Illinois EPA, April 2004.
10 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. PA/540/R/99/005.
11 - USEPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9365.4-24.
12 - Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.
13 - VDEQ September 2004. Virginia Department of Environmental Quality (VDEQ, online -http://www.deq.state.va.us/brownfieldweb/vrp.html).
14 - USEPA, 2004: OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils.
15 - USEPA Region 4, 2000: Supplement Guidance to RAGS: Region 4 Bulletins.
16 - Assume one day a week in warm weather months for reasonable maximum exposure and every other week for central tendency exposure.
17 - Assume two days a week in warm weather months for reasonable maximum exposure and one day a week for central tendency exposure.
18 - Assume 25 percent of of 50th percentile total body surface area is exposed, USEPA, 1997: Exposure Factors Handbook. EPA/600/8-95/002FA.
19 - Assume 50 percent of total body surface area is exposed, USEPA, 2004.

Note: The exposure factors for future civilian and military residents are the same, except for exposure duration (ED) for adult military residents. Exposure duration for adult military residents is assumed to be the typical enlistment times of 6 years, for the RME and CTE.

TABLE 6-12
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal[1]	Absorbed RfD for Dermal[2]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source	Date
Volatile Organic Compounds										
Benzene	Chronic	4.0E-03	mg/kg/day	1	4.0E-03	mg/kg/day	Blood	300/1	IRIS	5/2007
Vinyl Chloride	Chronic	3.0E-03	mg/kg/day	1	3.0E-03	mg/kg/day	Liver	30/1	IRIS	8/2005
Semivolatile Organic Compounds										
BAP EQUIVALENT	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/2007
Naphthalene	Chronic	2.0E-02	mg/kg/day	1	2.0E-02	mg/kg/day	Body Weight	3000/1	IRIS	5/2007
2-Methylnaphthalene	Chronic	4.0E-03	mg/kg/day	1	4.0E-03	mg/kg/day	Lungs	1000/1	IRIS	5/2007
Dioxins/Furans										
2,3,7,8-TCDD TEQ	NA	NA	NA	NA	NA	NA	NA	NA	5/2007	10/2004
Inorganics										
Aluminum	Chronic	1.0E+00	mg/kg/day	1	1.0E+00	mg/kg/day	Body Weight	NA	EPA 3	5/2007
Antimony	Chronic	4.0E-04	mg/kg/day	0.15	6.0E-05	mg/kg/day	Blood	1000/1	IRIS	5/2007
Arsenic	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Skin, CVS	3/1	IRIS	5/2007
Barium	Chronic	7.0E-02	mg/kg/day	0.07	4.9E-03	mg/kg/day	Kidney	3/1	IRIS	5/2007
Chromium	Chronic	3.0E-03	mg/kg/day	0.025	7.5E-05	mg/kg/day	Fetotoxicity/GS/Bone	300/3	IRIS	5/2007
Copper	Chronic	4.0E-02	mg/kg/day	1	4.0E-02	mg/kg/day	GS	NA	HEAST	7/1997
Iron	Chronic	7.0E-01	mg/kg/day	1	7.0E-01	mg/kg/day	NA	NA	NCEA	5/2007
Manganese (Soil)	Chronic	7.0E-02	mg/kg/day	0.04	2.8E-03	mg/kg/day	CNS	1/1	IRIS	5/2007
Manganese (Water)	Chronic	2.4E-02	mg/kg/day	0.04	9.6E-04	mg/kg/day	CNS	3/1	IRIS	5/2007
Silver	Chronic	5.0E-03	mg/kg/day	1	5.0E-03	mg/kg/day	Skin	3/1	IRIS	8/2005
Thallium	Chronic	7.0E-05	mg/kg/day	1	7.0E-05	mg/kg/day	Liver	NA	EPA 3	5/2007
Vanadium	Chronic	1.0E-03	mg/kg/day	0.026	2.6E-05	mg/kg/day	Kidney	300	NCEA	4/2005

Notes:

1 - USEPA, July 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.

Definitions:

CNS = Central nervous system

CVS = Cardiovascular system

GS = Gastrointestinal System

EPA 3 = USEPA Region 3 RBC Table, April, 2007.

HEAST= Health Effects Assessment Summary Tables

IRIS = Integrated Risk Information System

NA = Not applicable

NCEA = USEPA National Center for Environmental Assessment

TABLE 6-13
NON-CANCER TOXICITY DATA -- INHALATION
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD[1]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s)
Volatile Organic Compounds									
Benzene	Chronic	3.0E-02	mg/m^3	8.6E-03	(mg/kg/day)	Blood	300/1	IRIS	5/2007
Semivolatile Organic Compounds									
Naphthalene	Chronic	0.003	mg/m^3	8.6E-04	(mg/kg/day)	Nasal Effects	3000/1	IRIS	5/2007
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
1 - Extrapolated RfD = RfC *$20m^3$/day / 70 kg

Definitions:
IRIS = Integrated Risk Information System
NA = Not applicable

TABLE 6-14
CANCER TOXICITY DATA -- ORAL/DERMAL
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal[1]	Absorbed Cancer Slope Factor for Dermal[2]		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source	Date
Volatile Organic Compounds								
Benzene	5.5E-02	$(mg/kg/day)^{-1}$	1	5.5E-02	$(mg/kg/day)^{-1}$	A	IRIS	5/2007
Vinyl Chloride (child)	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	8//2005
Vinyl Chloride (adult)	7.2E-01	$(mg/kg/day)^{-1}$	1	7.2E-01	$(mg/kg/day)^{-1}$	A	IRIS	8//2005
Semivolatile Organic Compounds								
BAP EQUIVALENT	7.3E+00	$(mg/kg/day)^{-1}$	1	7.3E+00	$(mg/kg/day)^{-1}$	B2	IRIS	5/2007
Polychlorinated Biphenyls (PCBs)								
Aroclor1248	2.0E+00	$(mg/kg/day)^{-1}$	1	2.0E+00	$(mg/kg/day)^{-1}$	B2	IRIS	5/2007
Dioxins/Furans								
2,3,7,8-TCDD TEQ	1.5E+05	$(mg/kg/day)^{-1}$	1	1.5E+05	$(mg/kg/day)^{-1}$	B2	HEAST	7/1997
Metals								
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	10/2007

Notes:

1 - USEPA, July 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor / Oral Absorption Efficiency for Dermal.

Definitions:

IRIS = Integrated Risk Information System.

HEAST= Health Effects Assessment Summary Tables

USEPA Group:

A - Human carcinogen.

B1 - Probable human carcinogen - indicates that limited human data are available.

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans .

C - Possible human carcinogen.

D - Not classifiable as a human carcinogen.

E - Evidence of noncarcinogenicity.

TABLE 6-15
CANCER TOXICITY DATA - INHALATION
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor[1]		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source	Date
Volatile Organic Compounds							
Benzene	7.8E-03	$(mg/m^3)^{-1}$	2.7E-02	$(mg/kg/day)^{-1}$	A	IRIS	5/2007
Dioxins/Furans							
2,3,7,8-TCDD TEQ	4.3E+04	$(mg/m^3)^{-1}$	1.5E+05	$(mg/kg/day)^{-1}$	B2	HEAST	7/1997

Notes:

1 - Inhalation CSF = Unit Risk * 70 kg / $20m^3$/day.

Definitions:

IRIS = Integrated Risk Information System.

HEAST= Health Effects Assessment Summary Tables

USEPA Group:

A - Human carcinogen.

B1 - Probable human carcinogen - indicates that limited human data are available.

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans .

C - Possible human carcinogen.

D - Not classifiable as a human carcinogen.

E - Evidence of noncarcinogenicity.

TABLE 6-16

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Construction/Excavation Worker	Subsurface Soil	Ingestion	4.E-06	- -	- -	Dioxins/Furans	0.7	- -
		Dermal Contact	5.E-07	- -	- -	- -	0.01	- -
		Inhalation	2.E-07	- -	- -	- -	0.1	- -
		Total	5.E-06	- -	- -	Dioxins/Furans	0.9	- -
	Sediment	Ingestion	2.E-07	- -	- -	- -	0.3	- -
		Dermal Contact	6.E-08	- -	- -	- -	0.009	- -
		Total	3.E-07	- -	- -	- -	0.3	- -
	Surface Water	Ingestion	2.E-09	- -	- -	- -	0.03	- -
		Dermal Contact	7.E-07	- -	- -	- -	0.02	- -
		Total	7.E-07	- -	- -	- -	0.05	- -
	Groundwater	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	1.E-09	- -	- -	- -	1	- -
		Inhalation (in a trench)	8.E-11	- -	- -	- -	0.02	- -
		Total	1.E-09	- -	- -	- -	1	- -
		Total Subsurface Soil	5.E-06	- -	- -	- -	0.9	- -
		Total Sediment	3.E-07	- -	- -	- -	0.35	- -
		Total Surface Water	7.E-07	- -	- -	- -	0.05	- -
		Total Groundwater	1.E-09	- -	- -	- -	1	- -
		Total Across the Entire Site	**6.E-06**	- -	- -	- -	**2**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Maintenance Worker	Sediment	Ingestion	2.E-06	- -	- -	- -	0.01	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.0007	- -
		Total	3.E-06	- -	- -	- -	0.01	- -
	Surface Water	Ingestion	2.E-08	- -	- -	- -	0.002	- -
		Dermal Contact	1.E-05	- -	- -	cPAHs[1], Dioxins/Furans	0.001	- -
		Total	1.E-05	- -	- -	cPAHs, Dioxins/Furans	0.003	- -
		Total Sediment	3.E-06	- -	- -	- -	0.01	- -
		Total Surface Water	1.E-05	- -	- -	- -	0.003	- -
		Total Across the Entire Site	**2.E-05**	- -	- -	- -	**0.02**	- -

TABLE 6-16

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Occupational Worker	Groundwater	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation (indoor air)	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
		Total Groundwater	NA	- -	- -	- -	NA	- -
		Total Across the Entire Site	**NA**	- -	- -	- -	**NA**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Adolescent Trespasser	Sediment	Ingestion	2.E-06	- -	- -	- -	0.04	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.002	- -
		Total	3.E-06	- -	- -	cPAHs	0.04	- -
	Surface Water	Ingestion	5.E-08	- -	- -	- -	0.01	- -
		Dermal Contact	2.E-05	- -	cPAHs	Dioxins/Furans	0.007	- -
		Total	2.E-05	- -	cPAHs	Dioxins/Furans	0.02	- -
		Total Sediment	3.E-06	- -	- -	- -	0.04	- -
		Total Surface Water	2.E-05	- -	- -	- -	0.02	- -
		Total Across the Entire Site	**3.E-05**	- -	- -	- -	**0.06**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Adult Recreational User	Sediment	Ingestion	2.E-06	- -	- -	- -	0.01	- -
		Dermal Contact	6.E-07	- -	- -	- -	0.0004	- -
		Total	2.E-06	- -	- -	- -	0.01	- -
	Surface Water	Ingestion	9.E-09	- -	- -	- -	0.001	- -
		Dermal Contact	1.E-05	- -	- -	cPAHs, Dioxins/Furans	0.001	- -
		Total	1.E-05	- -	- -	cPAHs, Dioxins/Furans	0.002	- -
		Total Sediment	2.E-06	- -	- -	- -	0.01	- -
		Total Surface Water	1.E-05	- -	- -	- -	0.002	- -
		Total Across the Entire Site	**2.E-05**	- -	- -	- -	**0.01**	- -

TABLE 6-16

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Future Child Resident	Sediment	Ingestion	4.E-06	- -	- -	cPAHs	0.1	- -
		Dermal Contact	9.E-07	- -	- -	- -	0.003	- -
		Total	5.E-06	- -	- -	cPAHs	0.1	- -
	Surface Water	Ingestion	1.E-07	- -	- -	- -	0.04	- -
		Dermal Contact	1.E-05	- -	- -	cPAHs, Dioxins/Furans	0.005	- -
		Total	1.E-05	- -	- -	cPAHs, Dioxins/Furans	0.05	- -
	Groundwater	Ingestion	4.E-05	- -	Arsenic	- -	27	Iron, Manganese, Vanadium
		Dermal Contact	7.E-08	- -	- -	- -	0.9	- -
		Inhalation (showering)	4.E-08	- -	- -	- -	0.2	- -
		Total	4.E-05	- -	Arsenic	- -	28	Iron, Manganese, Vanadium
		Total Sediment	5.E-06	- -	- -	- -	0.1	- -
		Total Surface Water	1.E-05	- -	- -	- -	0.05	- -
		Total Groundwater	4.E-05	- -	- -	- -	28	- -
		Total Across the Entire Site	**6.E-05**	- -	- -	- -	**29**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Future Adult Resident	Sediment	Ingestion	2.E-06	- -	- -	- -	0.01	- -
		Dermal Contact	6.E-07	- -	- -	- -	0.0004	- -
		Total	2.E-06	- -	- -	- -	0.01	- -
	Surface Water	Ingestion	2.E-08	- -	- -	- -	0.002	- -
		Dermal Contact	2.E-05	- -	cPAHs	Dioxins/Furans	0.002	- -
		Total	2.E-05	- -	cPAHs	Dioxins/Furans	0.004	- -
	Groundwater	Ingestion	5.E-05	- -	Arsenic	- -	8	Manganese
		Dermal Contact	2.E-07	- -	- -	- -	0.6	- -
		Inhalation (showering)	3.E-08	- -	- -	- -	0.04	- -
		Total	5.E-05	- -	Arsenic	- -	8	Manganese
		Total Sediment	2.E-06	- -	- -	- -	0.01	- -
		Total Surface Water	2.E-05	- -	- -	- -	0.004	- -
		Total Groundwater	5.E-05	- -	- -	- -	8	- -
		Total Across the Entire Site	**7.E-05**	- -	- -	- -	**8**	- -

TABLE 6-16

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE (RME)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Total Residential Risks	Sediment	Ingestion	5.E-06	- -	- -	cPAHs, Arsenic	NA	- -
		Dermal Contact	1.E-06	- -	- -	- -	NA	- -
		Total	7.E-06	- -	- -	cPAHs, Arsenic	NA	- -
	Surface Water	Ingestion	1.E-07	- -	- -	- -	NA	- -
		Dermal Contact	3.E-05	- -	cPAHs	Dioxins/Furans	NA	- -
		Total	3.E-05	- -	cPAHs	Dioxins/Furans	NA	- -
	Groundwater	Ingestion	9.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	2.E-07	- -	- -	- -	NA	- -
		Inhalation (showering)	7.E-08	- -	- -	- -	NA	- -
		Total	9.E-05	- -	Arsenic	- -	NA	- -
		Total Sediment	7.E-06	- -	- -	- -	NA	- -
		Total Surface Water	3.E-05	- -	- -	- -	NA	- -
		Total Groundwater	9.E-05	- -	- -	- -	NA	- -
		Total Across the Entire Site	**1.E-04**	- -	- -	- -	NA	- -

1 cPAHs = Carcinogenic PAHs
NA = Not applicable

TABLE 6-17

SUMMARY OF CANCER RISKS AND HAZARD INDICES - CENTRAL TENDENCY EXPOSURE (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and ≤ 1E-4	Chemicals with Cancer Risks > 1E-6 and ≤ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Construction/Excavation Worker	Subsurface Soil	Ingestion	2.E-06	- -	- -	- -	0.4	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.004	- -
		Inhalation	5.E-08	- -	- -	- -	0.04	- -
		Total	2.E-06	- -	- -	- -	0.4	- -
	Sediment	Ingestion	1.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.003	- -
		Total	1.E-07	- -	- -	- -	0.2	- -
	Surface Water	Ingestion	8.E-10	- -	- -	- -	0.02	- -
		Dermal Contact	5.E-07	- -	- -	- -	0.009	- -
		Total	5.E-07	- -	- -	- -	0.03	- -
	Groundwater	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	6.E-10	- -	- -	- -	0.4	- -
		Inhalation (in a trench)	2.E-11	- -	- -	- -	0.01	- -
		Total	6.E-10	- -	- -	- -	0.5	- -
		Total Subsurface Soil	2.E-06	- -	- -	- -	0.4	- -
		Total Sediment	1.E-07	- -	- -	- -	0.2	- -
		Total Surface Water	5.E-07	- -	- -	- -	0.03	- -
		Total Groundwater	6.E-10	- -	- -	- -	0.5	- -
		Total Across the Entire Site	**3.E-06**	- -	- -	- -	**1**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and £ 1E-4	Chemicals with Cancer Risks > 1E-6 and £ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Maintenance Worker	Sediment	Ingestion	1.E-07	- -	- -	- -	0.003	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.00003	- -
		Total	2.E-07	- -	- -	- -	0.003	- -
	Surface Water	Ingestion	2.E-09	- -	- -	- -	0.0005	- -
		Dermal Contact	2.E-06	- -	- -	- -	0.0003	- -
		Total	2.E-06	- -	- -	- -	0.0007	- -
		Total Sediment	2.E-07	- -	- -	- -	0.003	- -
		Total Surface Water	2.E-06	- -	- -	- -	0.0007	- -
		Total Across the Entire Site	**2.E-06**	- -	- -	- -	**0.004**	- -

TABLE 6-17

SUMMARY OF CANCER RISKS AND HAZARD INDICES - CENTRAL TENDENCY EXPOSURE (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and £ 1E-4	Chemicals with Cancer Risks > 1E-6 and £ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Occupational Worker	Groundwater	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation (indoor air)	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
		Total Groundwater	NA	- -	- -	- -	NA	- -
		Total Across the Entire Site	**NA**	- -	- -	- -	**NA**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and £ 1E-4	Chemicals with Cancer Risks > 1E-6 and £ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Adolescent Trespasser	Sediment	Ingestion	5.E-07	- -	- -	- -	0.01	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.0002	- -
		Total	7.E-07	- -	- -	- -	0.01	- -
	Surface Water	Ingestion	1.E-08	- -	- -	- -	0.003	- -
		Dermal Contact	8.E-06	- -	- -	cPAHs[1], Dioxins/Furans	0.002	- -
		Total	8.E-06	- -	- -	cPAHs, Dioxins/Furans	0.005	- -
		Total Sediment	7.E-07	- -	- -	- -	0.01	- -
		Total Surface Water	8.E-06	- -	- -	- -	0.005	- -
		Total Across the Entire Site	**9.E-06**	- -	- -	- -	**0.01**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and £ 1E-4	Chemicals with Cancer Risks > 1E-6 and £ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Adult Recreational User	Sediment	Ingestion	1.E-07	- -	- -	- -	0.003	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.00003	- -
		Total	1.E-07	- -	- -	- -	0.003	- -
	Surface Water	Ingestion	1.E-09	- -	- -	- -	0.0005	- -
		Dermal Contact	2.E-06	- -	- -	cPAHs	0.0004	- -
		Total	2.E-06	- -	- -	cPAHs	0.0009	- -
		Total Sediment	1.E-07	- -	- -	- -	0.003	- -
		Total Surface Water	2.E-06	- -	- -	- -	0.0009	- -
		Total Across the Entire Site	**2.E-06**	- -	- -	- -	**0.004**	- -

TABLE 6-17

SUMMARY OF CANCER RISKS AND HAZARD INDICES - CENTRAL TENDENCY EXPOSURE (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and £ 1E-4	Chemicals with Cancer Risks > 1E-6 and £ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Future Child Resident	Sediment	Ingestion	3.E-07	- -	- -	- -	0.03	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.0003	- -
		Total	3.E-07	- -	- -	- -	0.03	- -
	Surface Water	Ingestion	1.E-08	- -	- -	- -	0.01	- -
		Dermal Contact	2.E-06	- -	- -	- -	0.001	- -
		Total	2.E-06	- -	- -	- -	0.01	- -
	Groundwater	Ingestion	4.E-06	- -	- -	Arsenic	8	Iron, Manganese
		Dermal Contact	1.E-08	- -	- -	- -	0.5	- -
		Inhalation (showering)	5.E-09	- -	- -	- -	0.07	- -
		Total	4.E-06	- -	- -	Arsenic	9	Iron, Manganese
		Total Sediment	3.E-07	- -	- -	- -	0.03	- -
		Total Surface Water	2.E-06	- -	- -	- -	0.01	- -
		Total Groundwater	4.E-06	- -	- -	- -	9	- -
		Total Across the Entire Site	**6.E-06**	- -	- -	- -	**9**	- -

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and £ 1E-4	Chemicals with Cancer Risks > 1E-6 and £ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Future Adult Resident	Sediment	Ingestion	1.E-07	- -	- -	- -	0.003	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.00003	- -
		Total	1.E-07	- -	- -	- -	0.003	- -
	Surface Water	Ingestion	1.E-09	- -	- -	- -	0.0005	- -
		Dermal Contact	2.E-06	- -	- -	cPAHs	0.0004	- -
		Total	2.E-06	- -	- -	cPAHs	0.0009	- -
	Groundwater	Ingestion	6.E-06	- -	- -	Arsenic	4	Manganese
		Dermal Contact	2.E-08	- -	- -	- -	0.3	- -
		Inhalation (showering)	3.E-09	- -	- -	- -	0.02	- -
		Total	6.E-06	- -	- -	Arsenic	4	Manganese
		Total Sediment	1.E-07	- -	- -	- -	0.003	- -
		Total Surface Water	2.E-06	- -	- -	- -	0.0009	- -
		Total Groundwater	6.E-06	- -	- -	- -	4	- -
		Total Across the Entire Site	**9.E-06**	- -	- -	- -	**4**	- -

TABLE 5-17

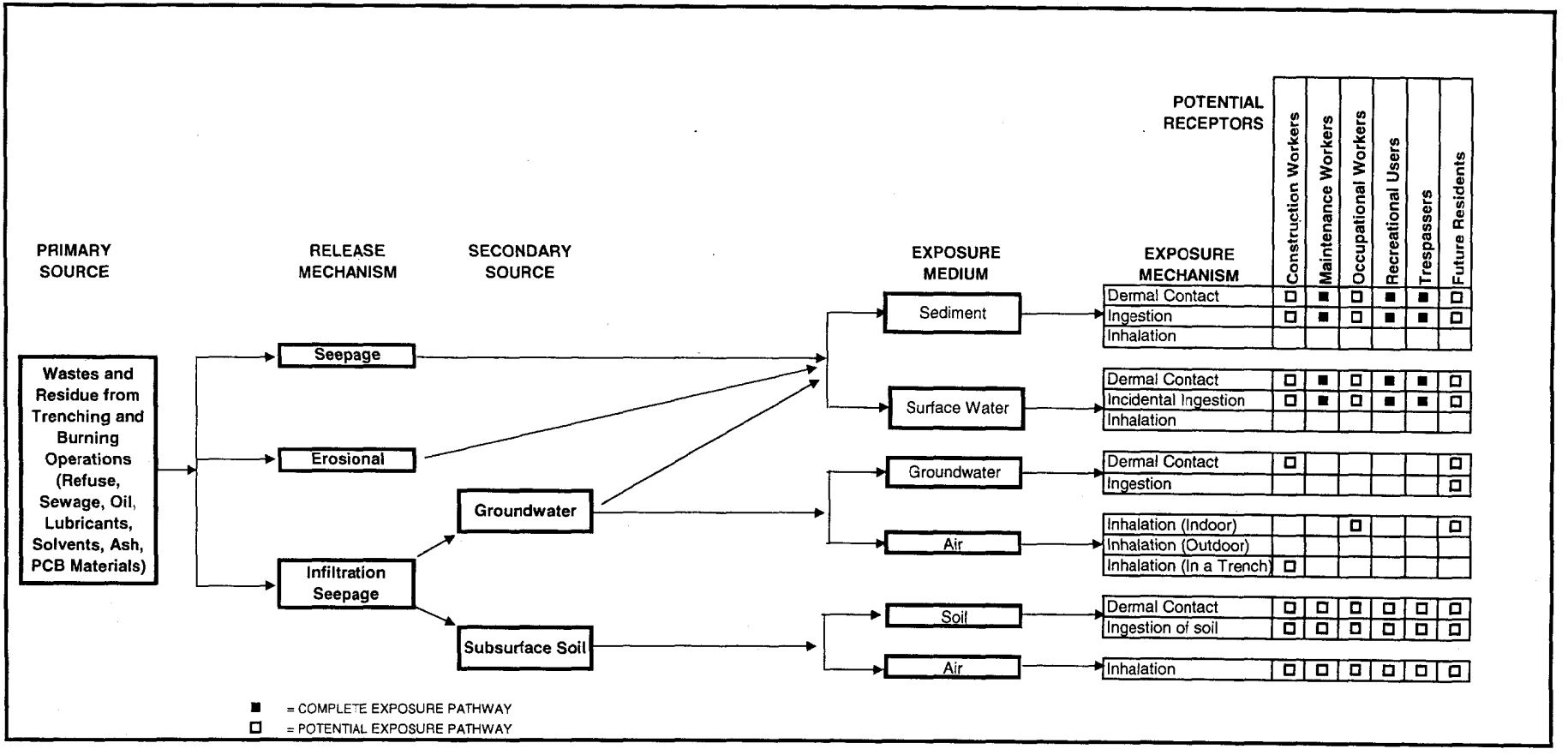
SUMMARY OF CANCER RISKS AND HAZARD INDICES - CENTRAL TENDENCY EXPOSURE (CTE)
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 1E-4	Chemicals with Cancer Risks > 1E-5 and £ 1E-4	Chemicals with Cancer Risks > 1E-6 and £ 1E-5	Hazard Index (HI)	Chemicals with HI > 1
Total Residential Risks	Sediment	Ingestion	4.E-07	- -	- -	- -	NA	- -
		Dermal Contact	4.E-08	- -	- -	- -	NA	- -
		Total	5.E-07	- -	- -	- -	NA	- -
	Surface Water	Ingestion	1.E-08	- -	- -	- -	NA	- -
		Dermal Contact	4.E-06	- -	- -	cPAHs	NA	- -
		Total	4.E-06	- -	- -	cPAHs	NA	- -
	Groundwater	Ingestion	1.E-05	- -	- -	Arsenic	NA	- -
		Dermal Contact	4.E-08	- -	- -	- -	NA	- -
		Inhalation (showering)	8.E-09	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	NA	- -
		Total Sediment	5.E-07	- -	- -	- -	NA	- -
		Total Surface Water	4.E-06	- -	- -	- -	NA	- -
		Total Groundwater	1.E-05	- -	- -	- -	NA	- -
		Total Across the Entire Site	**1.E-05**	- -	- -	- -	NA	- -

1 cPAHs = Carcinogenic PAHs
NA = Not applicable

FIGURE 6-1

HUMAN HEALTH CONCEPTUAL SITE MODEL
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS



Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.

7.0 ECOLOGICAL RISK ASSESSMENT

The goal of the ERA for Site 1 was to determine whether adverse ecological impacts are possible to ecological receptors as a result of exposure to chemicals. A phased approach to the Screening-Level ERA (SERA) was used that relied on environmental chemistry data and field observations (i.e., habitat) for the preliminary assessment. Biological sampling or testing is not part of this investigation.

The SERA methodology (Steps 1, 2, and 3a) used at Naval Station Great Lakes follows the guidance presented in the Final Guidelines for Ecological Risk Assessment (USEPA, April 1998), Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, June 1997), the Navy Policy for Conducting Ecological Risk Assessments (April 1999), and the Quality Assurance Project Plan (TtNUS, February 2007) prepared for this project. Figure 7-1 presents the Navy's Ecological Risk Assessment Tiered Approach. The first two steps are the SERA. Step 3a is the first step of the Baseline ERA and further refines the list of Chemicals of Potential Concern (COPCs) that are retained from the SERA and determines if Steps 3b through 7 of the Baseline ERA are necessary. Finally, Step 8, Risk Management, is incorporated throughout the ERA process, in cooperation with the Illinois EPA.

In the first phase of the ERA process (Steps 1 and 2), conservative exposure estimates are made for grouped or individual ecological receptors, and these exposure concentrations are compared to screening levels and threshold toxicity values. The SERA includes the following considerations:

- Screening-level problem formulation
- Screening-level ecological effects evaluation
- Screening-level exposure estimate
- Screening-level risk calculation

7.1 SCREENING-LEVEL PROBLEM FORMULATION

The screening-level problem formulation for an ERA includes identification of potential receptor groups, COPCs, and the mechanisms for fate/transport and toxicity. Complete exposure pathways that exist at a site are determined at this stage to facilitate receptor selection. As part of receptor identification, site habitats and potential ecological receptors are described.

7.1.1 Environmental Setting

Site 1 was a landfill on approximately 50 acres that is now partially covered by an 18-hole golf course, Willow Glen Golf Course, on approximately 125 acres. The landfill was operated as a trenching/burning operation and received an estimated 1.5 million tons of material during its years of operation. A description of the site is provided in Section 2.

The Skokie Ditch is a perennial stream that originates somewhere northwest of Site 1 and travels via an underground storm sewer until it surfaces in the middle of Site 1. The Skokie Ditch flows in a southerly direction from the site, passing the Supply Side area of the base and exits Navy property after passing the Green Bay Sewage Treatment Plant in Forrestal Village. From there, the Skokie Ditch becomes the Skokie River, which eventually discharges into the Chicago River. The Skokie Ditch is a sluggish, almost stagnant stream in this area, except immediately after a storm. No fishing has been reported in close proximity to the site (Rogers, Golden & Halpern, 1986).

The Skokie Ditch south of Buckley Road in the Supply and Forrestal section of the base was evaluated by Clayton Group Services, Inc., to determine whether there were wetlands along or adjacent to the ditch. The ditch in that area was steeply cut, with the normal water level approximately 10 feet below the top of the bank. The banks were mowed and dominant species in the area are turf grasses including Kentucky bluegrass (*Poa pratensis*) and fescue (F*estuca elatior*). Scattered trees such as weeping willows (*Salix babylonica*) and eastern cottonwoods (*Populus deltoids*) were also present. Representative test pits and general observations did not reveal any primary or secondary indicators of wetland hydrology, so the area did not qualify as a wetland. However, the channel of the Skokie Ditch does qualify as a jurisdictional "waters of the United States" below the ordinary high water mark which includes approximately the areas below the top of the bank of the Skokie Ditch.

Recent bird surveys documented 34 species of breeding birds and 100 species of migratory birds within the Main Installation (U.S. Navy, October 1995 and August 2000). Some of the breeding birds identified in the survey are the belted kingfisher (*Ceryle alcyon*), downy woodpecker (*Picoides pubescens*), red-winged blackbird (*Agelaius phoeniceus*), and the cooper's hawk (*Accipiter cooperii*). The greatest concentration and diversity of species are found in Pettibone Ravine and along the bluffs and beach areas where human impacts are least.

Mammals likely or known to occur on the Main Installation include the bat (species undetermined), coyote (*Canis latrans*), opossum (*Didelphis virginiana*), woodchuck (*Marmota monax*), meadow vole (*Microtus pennsylvanicus*), house mouse (*Mus musculus*), white-tailed deer (*Odocoileus virginianus*), raccoon

(*Procyon lotor*), gray squirrel (*Sciurus carolinensis*), eastern cottontail (*Sylvilagus floridanus*), and red fox (*Vulpes vulpes*) (Great Lakes Naval Training Center, July 2000). Larger species may be transient and have small populations due to limited amount of habitat, but smaller mammals that require less space have relatively large populations.

The US Fish and Wildlife Service lists four species of animals and four species of plants in Lake and Cook Counties as threatened or endangered, but lack of suitable habitat for most of these species and urbanization surrounding the installation greatly reduces the possibility of finding any federal-listed threatened or endangered species at the site (Department of Navy, February 2001). Ten species of plants on Naval Station Great Lakes are State-listed as threatened or endangered. A few species of birds seen on Site 01 are State-listed threatened or endangered but were classified by the survey investigator as migrants, and not breeding birds. Section 3.2.3 of the Implementation of an Integrated Natural Resources Management Plan (Department of Navy, February 2001) includes a more detailed discussion of the State-listed threatened or endangered plants and birds and their occurrences at Naval Station Great Lakes. No species of mammals, fish, reptiles, amphibians, or invertebrates recorded at Site 01 are on the State-listed threatened and endangered species lists (Department of Navy, February 2001).

7.1.2 Chemical Fate and Transport

Based on historical data from Site 01 (Section 2), several classes of chemicals have the potential to be present at the site. These include VOCs, PAHs and other SVOCs, pesticides, PCBs, and metals and petroleum hydrocarbons. Dioxins and furans may have the potential to be present at the site due to the burning activities at the landfill.

Physical and chemical characteristics of chemicals may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioaccumulation factors [BAFs for inorganic chemicals and biota sediment accumulation factors (BSAFs) for organic chemicals], K_{oc}s, and K_{ow}s. For this document, BSAFs for organic chemicals are referred to as BAFs because that is the common terminology used.

7.1.3 Potential Exposure Pathways

Figure 7-2 presents the conceptual site model. Because the landfill is covered by a portion of the golf course, there is not a complete exposure pathway for terrestrial receptors. For that reason, surface soil samples were not collected and risks to terrestrial ecological receptors were not evaluated in the SERA. Potential ecological receptors (e.g., benthic macroinvertebrates and fish) can be exposed to chemicals in

the surface water and sediment of Skokie Ditch by direct contact and incidental ingestion of surface water and surface sediment (0 to 4 centimeters bgs). Also, mammals and birds can be exposed to chemicals in the surface water and surface sediment of Skokie Ditch by direct contact, ingestion of contaminated food items, and incidental ingestion of surface water and surface sediment. Exposure of terrestrial wildlife to chemicals in surface water and surface sediment via dermal contact is unlikely to represent a major exposure pathway because fur and feathers are expected to minimize transfer of chemicals across dermal tissue. Therefore, the dermal pathway was not evaluated in the SERA.

7.1.4 Endpoints

7.1.4.1 Assessment Endpoints

Assessment endpoints are explicit expressions of the environmental values that are to be protected (USEPA, June 1997). The selection of endpoints is based on the habitats present, the migration pathways of probable chemicals, and the routes that chemicals may take to enter receptors. For this SERA, the assessment endpoints were protecting the following groups of receptors from adverse effects of chemicals on their growth, survival, and reproduction:

- Benthic invertebrates
- Fish
- Piscivorous birds and mammals

The following paragraphs discuss why the assessment endpoints were selected for this SERA.

Benthic Macroinvertebrates and Fish: Benthic macroinvertebrates and fish serve as a food source for higher trophic organisms (i.e., fish, amphibians, birds, mammals) and are likely to be present in Skokie Ditch. They may be at risk from direct exposure to chemicals in surface water or surface sediment. Also, benthic invertebrates and fish can accumulate chemicals that may be transferred to higher trophic organisms.

Piscivorous Birds and Mammals: Piscivorous birds and mammals consume sediment invertebrates and fish that are potentially present in Skokie Ditch and may be exposed to chemicals through food items they consume. However, because Skokie Ditch does not support large fish populations, this exposure route is not expected to be significant. This pathway is being evaluated to be conservative because piscivorous birds have been observed in the area.

7.1.4.2 Measurement Endpoints

Measurement endpoints are estimates of biological impacts (e.g., mortality, adverse effects on growth and reproduction) that are used to evaluate the assessment endpoints. The following measurement endpoints were used to evaluate the assessment endpoints in the SERA:.

- No observed adverse effects levels (NOAELs) for surrogate wildlife species – Survival, reproductive, and/or developmental effects to piscivorous birds and carnivorous mammals were evaluated by comparing ingested doses from chemicals in surface water, surface sediment, sediment invertebrates, and fish to NOAELs.

- Sediment screening values – Mortality and other adverse effects (i.e., on growth, feeding rates, and behavior) to fish and benthic macroinvertebrates were evaluated by comparing the measured concentrations of chemicals in surface sediment to screening values designed to be protective of ecological receptors.

- Surface water screening values – Mortality and other adverse effects (i.e., on growth, feeding rates, and behavior) to aquatic organisms were evaluated by comparing the measured concentrations of chemicals in surface water to screening values designed to be protective of ecological receptors.

7.1.4.3 Selection of Receptor Species

Many receptors in the aquatic environment are adequately described in general categories such as fish and sediment-dwelling (benthic) invertebrates. This is due to the general nature of the threshold values, effects values, or water quality criteria that are typically used to characterize risk for such organisms. Therefore, specific benthic invertebrates and fish species were not selected as indicator receptor species.

To evaluate potential risks to terrestrial wildlife, indicator species with known exposure factors (e.g., body weights and ingestion rates) were selected. The following indicator species were used for food-chain modeling (discussed in more detail later in the SERA):

- Piscivorous mammals: Raccoon
- Piscivorous birds: Belted Kingfisher

Receptor profiles for each of these species are presented in Appendix G.

7.2 ECOLOGICAL EFFECTS VALUES

The preliminary ecological effects evaluation is an investigation of the relationship between the magnitude of exposure to a chemical and the nature and magnitude of adverse effects resulting from exposure. In addition to being a toxicity study, it may also include descriptions of apparent effects seen during the site visit. Toxicity thresholds are usually expressed in units of concentration when the medium of concern is in intimate contact with the receptor, such as surface water for aquatic organisms or sediment for sediment invertebrates. For other receptors, such as terrestrial vertebrates, toxicity data are typically available as doses, with units equal to mass of chemical per unit of body mass per unit of time (usually mg/kg-day). The following sections describe the ecological effects values that were used in the SERA.

7.2.1 Sediment Screening Values

The sediment screening values used to select COPCs were compiled from different sources in coordination with Illinois EPA (see Table 7-1). The following bulleted list presents the sources and the order of preference in which they were used to compile the overall screening levels that were used in the SERA. The paragraphs following the bulleted list describe the sources:

- Illinois EPA Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments (September 2000)
- Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems (MacDonald et al., 2000)
- Ecotox Thresholds (USEPA, January 1996)
- Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (Ontario Ministry of Environment and Energy, August 1993)
- Secondary Chronic Values from the Toxicological Benchmarks for Screening Chemicals of Potential Concern for Effects on Sediment-Associated Biota: (Jones et al., 1997).
- Assessment and Remediation of Contaminated Sediment (ARCS) Project Benchmarks (USEPA, January 1996)

- USEPA Region 5 Ecological Screening Levels (August 2003)

Illinois EPA's Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments (September 2000) lists baseline sediment cleanup objectives and alternate sediment cleanup objectives for several organic chemicals. These values were used first because they were developed by the Illinois EPA. The Illinois EPA calculated/provided sediment screening values for several chemicals that were detected at another Naval Station Great Lakes site (Site 17) that did not have pre-established values. These values are presented in Table 7-1. These values were also calculated for other chemicals that are detected in sediment at Site 1 for evaluation in the SERA. Illinois EPA agreed that these values do not need to be calculated for the chemicals that are included on the analytical list. Therefore, other sources in the literature were used to select screening values for chemicals that did not have Illinois EPA screening values as follows:

- MacDonald, et al. (2000) developed consensus-based sediment quality guidelines for freshwater ecosystems by calculating the geometric mean across sediment guidelines from various sources. Two sets of values were developed by this method: (1) a Threshold Effects Concentration and (2) a Probable Effects Concentration. The Threshold Effects Concentration represents the concentration below which adverse impacts to benthic invertebrates are not expected. The Probable Effects Concentration is defined as a concentration above which adverse impacts to benthic invertebrates are expected to occur frequently.

- The sediment Ecotox Thresholds (USEPA, January 1996) include draft USEPA Sediment Quality Criteria that have been established for two chemicals (dieldrin and endrin), Sediment Quality Benchmarks that have been established using equilibrium partitioning, and Effects Range-Low values (Long et al., January 1995). Effects Range-Low values were not used for screening purposes in this SERA because Long et al. studies were based on saltwater environments not representative of the freshwater conditions at Naval Station Great Lakes. The Sediment Quality Criteria and Sediment Quality Benchmarks Ecotox Thresholds are based on an assumption of 1 percent organic carbon (10,000 mg/kg TOC). The Sediment Quality Benchmarks are based on freshwater data.

- The Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (Ontario Ministry of Environment and Energy, August 1993) are based on freshwater studies. The Lowest Effects Levels (see below) were used as the screening values. The Ontario Ministry of Environment and Energy guidelines establish three effects levels, as follows:

- ***No Effect Level:*** Sediment will not affect fish or sediment-dwelling organisms. In addition, no transfer through the food chain and no effect on water quality is expected.

- ***Lowest Effect Level:*** Sediment is considered marginally polluted but will not affect the majority of sediment-dwelling organisms.

- ***Severe Effect Level:*** Sediment is considered highly polluted and likely to affect the health of sediment-dwelling organisms.

- Jones et al. (1997) developed sediment quality benchmarks using equilibrium partitioning, similar to what was done for the Ecotox Sediment Quality Benchmarks described above. They termed the values secondary chronic values (Table 3 in Jones et al., 1997). The secondary chronic values are based on an assumption of 1 percent organic carbon, using various surface water screening levels. As footnoted on the table in Jones et al., (1997), some of the values are for polar nonionic organic compounds, for which the equilibrium partitioning model is likely to provide a conservative estimate of exposure.

- The National Biological Service produced a set of benchmarks for the USEPA Great Lakes National Program Office as part of the Assessment and Remediation of Contaminated Sediment (ARCS) Project (USEPA, 1996 as cited in Jones, et al., 1997). The benchmarks were developed with the same procedures that were used to develop the Effects Range-Low and Effects Range-Medium values (Long et al., January 1995); however, these benchmarks are representative of freshwater conditions. The three concentration levels include the no effect concentration, the probable effect concentration, and the threshold effect concentration, similar to Ontario Ministry of Environment and Energy effects levels.

- USEPA Region 5 developed a list of sediment screening levels for the initial screening of chemical concentrations in sediment samples (USEPA, August 2003). The sediment screening levels were either compiled from various sources in the literature, some of which are cited above, or were developed using equilibrium partitioning.

7.2.2 Surface Water Screening Values

The surface water screening values used to select COPCs were compiled from several different sources (see Table 7-2) in coordination with Illinois EPA. The following bulleted list presents the sources and the

order of preference in which they were used to compile the overall screening levels used in the SERA. For example, the Illinois water quality standards (WQSs) were used first and then the water quality criteria (WQCs) were used for chemicals that did not have a WQS. The paragraphs following the bulleted list describe the following sources:

- Illinois EPA WQSs (March 2006)
- Illinois EPA WQCs (July 2006)
- USEPA-recommended WQCs (2006)
- Oak Ridge National Laboratory Surface Water Benchmarks (Suter and Tsao, June 1996)
- USEPA Region 3 Biological Technical Assistance Group Screening Levels (USEPA, October 2005)
- Screening Quick Reference Tables (Buchman, October 1999)

The Illinois EPA WQSs are the concentrations of toxic substances that will not result in acute or chronic toxicity to aquatic life. The values from Subpart B of the regulations were used because Skokie Ditch is not located within the Lake Michigan Basin (Illinois EPA, March 2006). Illinois EPA has also developed WQCs for several chemicals for which WQSs were not developed that are used to evaluate the quality of surface water bodies (Illinois EPA, July 2006). These values were selected first because they are specific to Illinois and are enforceable standards.

The USEPA-recommended WQCs were developed by USEPA to provide states with guidance on developing their own criteria (USEPA, 2006). These values are set to protect the majority of aquatic organisms from adverse impacts from chemicals in surface water. These values were used next because they are based on USEPA guidance.

The Suter and Tsao (June 1996) benchmarks were calculated for Oak Ridge National Laboratory using Tier II methodology as described in USEPA's Proposed Water Quality Guidance for the Great Lakes System (USEPA, April 1993). Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for the USEPA WQCs. These values were used next because they are commonly used as screening values in ERAs; however, most of them are not regulatory in nature.

The Region 3 Biological Technical Assistance Group freshwater surface water screening values were developed to serve as conservative guidelines for evaluating sample data collected from Superfund sites

(USEPA, October 2005). BTAG values consider the most sensitive receptor organisms specific to each chemical and medium and were compiled from various sources.

Finally, Screening Quick Reference Tables values were used when other sources had no established values for a given analyte. SQuiRT values (Buchman, October 1999) were compiled by the Coastal Protection and Restoration Division of the National Oceanic and Atmospheric Administration to serve as initial screening values in identifying potential impacts of hazardous waste sites to coastal habitats.

7.2.2 Toxicity Reference Values

The screening values are not designed to evaluate risk to wildlife. Therefore, in addition to comparing the surface water and surface sediment concentrations to screening values, risk to wildlife from chemicals in sediment was calculated by estimating the dose and comparing the dose to Toxicity Reference Values (TRVs) representing acceptable daily doses in mg/kg-day. The TRVs were developed from No Observable Adverse Effects Level (NOAELs) and Lowest Observable Adverse Effects Level (LOAELs) obtained from wildlife studies, when available. The majority of the TRVs were obtained from the Oak Ridge National Lab Toxicological Benchmarks for Wildlife (Sample et al., 1996) and the USEPA Ecological Soil Screening Level (Eco SSL) documents but were supplemented with other toxicity information when necessary.

Appendix G presents the TRVs for the mammals and birds that were used in the ERA and the source of the TRVs. If a subchronic study was used to develop the TRV, the final value was multiplied by a factor of 0.1 to account for uncertainty between subchronic and chronic effects. Also, the LOAEL was multiplied by a factor of 0.1 to estimate a NOAEL TRV if only a LOAEL study was available. The Eco SSL document provided NOAELs and LOAELs for various studies, but overall mean values were only calculated for NOAELs in the chemical-specific Eco SSL documents (see Appendix G). Therefore, the data from the chemical-specific Eco SSL documents (USEPA, 2005) were used to calculate overall LOAEL values for several metals as the geometric mean of growth and reproduction data.

7.3 EXPOSURE ESTIMATE

Benthic invertebrates and fish are exposed to chemicals in surface water and surface sediment through direct contact and/or ingestion of contaminated media so surface water and surface sediment concentrations detected in Site 1 samples were used as the exposure concentrations. The exposure of chemicals for mammals and birds are more complex and need to account for bioaccumulation of

chemicals in various food items. Therefore, exposure of terrestrial receptors to the chemicals in surface water, surface sediment, invertebrates, and fish were determined by estimating the daily doses in mg/kg-day using exposure dose equations. The following equations were used to estimate daily intake for the kingfisher:

$$\text{Dose(inorganics)} = \frac{[(Cs * BAF_f * If) + (Cs * Is) + (Cw * Iw)] * SUF}{BW}$$

$$\text{Dose(organics)} = \frac{[(Cs * BSAF_f * \frac{\%L}{\%TOC}) * If) + (Cs * Is) + (Cw * Iw)] * SUF}{BW}$$

The following equations were used to estimate daily intake for the raccoon:

$$\text{Dose(inorganics)} = \frac{[(If * Cs * BAF_f)/2 + (If * Cs * BAF_i)/2 + (Iw * Cw) + (Is * Cs)] * SUF}{BW}$$

$$\text{Dose(organics)} = \frac{[(If * Cs * BSAF_f * \frac{\%L}{\%TOC})/2 + (If * Cs * BSAF_i)/2 + (Iw * Cw) + (Is * Cs)] * SUF}{BW}$$

Where:

Dose	=	daily dose (mg/kg-day)
Cs	=	Chemical concentration in sediment (mg/kg)
BAF_f	=	Sediment-to fish bioaccumulation factor (for inorganics) (unitless)
BAF_i	=	Sediment-to invertebrate bioaccumulation factor (for inorganics) (unitless)
$BSAF_f$	=	Sediment-to fish bioaccumulation factor (for organics) (unitless)
$BSAF_i$	=	Sediment-to invertebrate bioaccumulation factor (for organics) (unitless)
If	=	Ingestion rate of food (kg/day)
%L	=	Percent lipids of the fish (assumed to be ≈14.2 percent dry weight)
%TOC	=	Percent total organic carbon of the sediment (average measured value)
Is	=	Rate of incidental sediment ingestion (kg/day)
Cw	=	Chemical concentration in water using unfiltered metals data (mg/L)
Iw	=	Ingestion rate of water (L/day)
SUF	=	Site use factor (Contaminated area/home area range area ratio [unitless])

BW = Body weight (kg)

The following input parameters were used in the dose equation for conservative models:

- Maximum surface water concentration
- Maximum sediment concentration
- Minimum receptor body weight
- Conservative receptor ingestion rate
- Site use factor equal to 1 (i.e., receptors spend 100 percent of their time at the site)

The following input parameters were used in the dose equation for average exposure models:

- Average surface water and sediment concentration
- Average receptor body weight
- Average receptor ingestion rate
- Site use factor based on the ratio of the sampled contaminated area to the receptor home ranges.

The SERA used sediment-to-invertebrate and sediment-to-fish BAFs and BSAFs to estimate chemical concentrations in invertebrates and fish that are used as inputs to the food-chain model for piscivorous wildlife (Appendix G). The following sources of BAFs and BSAFs were used in the SERA:

- Fish BSAFs – PAHs, PCBs, and Pesticides: The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Volume 1: National Sediment Quality Survey (USEPA, November 2004). These BSAFs were used to estimate fish concentrations from chemical concentrations in sediment.

- Sediment Invertebrate BSAFs - PCBs and Inorganics: Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation (Ooak Ridge National Lab, August 1988). These BSAFs were used to estimate accumulation from the sediment to benthic invertebrates. The 90th percentile sediment-to-invertebrate BSAF was used for the conservative food-chain model and the median sediment-to-invertebrate value was used for the less conservative food-chain model.

Chemicals that do not have BAFs or BSAFs were assigned a default value of 1.0

The percent lipid value for fish is assumed to be 14.2 (dry weight). It was assumed that the raccoon's diet is comprised of 50 percent fish and 50 percent invertebrates, and the belted kingfisher's diet is comprised fully (100 percent) of fish. This difference is reflected in the above dose equations. PAHs were not included in the kingfisher food-chain model because they are metabolized in fish tissue and do not accumulate; however, PAHs were included in the invertebrates portion of the raccoon food-chain model because invertebrates may not metabolize PAHs (Eisler, May 1987; USEPA, November 2000). Sediment-to-fish BSAFs were used for organic parameters in the belted kingfisher models. However, because sediment-to-fish BAFs are not available for inorganic chemicals, sediment-to-invertebrate BAFs were used as surrogates. The 90th percentile BAFs and BSAFs were used in the conservative input models, and the median BAFs and BSAFs were used in the average input food-chain models.

The surrogate species exposure assumptions (i.e., ingestion rates and body weights) were obtained from the Wildlife Exposure Factors Handbook (USEPA, December 1993). Because sediment concentrations are presented on a dry weight basis, the ingestion rates from USEPA (1993) were also converted to a dry weight basis for consistentcy. Table 7-3 presents the exposure parameters that were used in the SERA. Appendix G presents the values that will be used to calculate the exposure parameters and a discussion of how the values were calculated.

7.4 ECOLOGICAL RISK CHARACTERIZATION

The risk characterization compares exposure concentrations/doses to ecological effects concentrations/doses using an Ecological Effects Quotient (EEQ) approach. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a chemical are evaluated. An EEQ less than 1.0 indicates that potential risk to the receptors is low. An EEQ greater than 1.0 does not indicate that potential receptors are at risk; it only indicates that the conservative screening values are exceeded and the data should be further evaluated. The EEQ is not an expression of probability, and the meaning of values greater than 1.0 must be interpreted in light of uncertainties in ecological risk management.

The EEQs for aquatic receptors were calculated as follows:

$$EEQ = \frac{C_{sw}}{SWSV} \text{ or } \frac{C_{sd}}{SSV}$$

Where: EEQ = Ecological effects quotient (unitless)

C_{sw} = Chemical concentration in surface water (µg/L)

C_{sd} = Chemical concentration in sediment (µg/kg or mg/kg)

SWSV = Surface water screening value (µg/L)

SSV = Sediment screening value (µg/kg or mg/kg)

The EEQs for the wildlife models were calculated as follows:

$$EEQ = \frac{Dose}{TRV}$$

Where: EEQ = Ecological effects quotient (unitless)

Dose = Daily intake dose (mg/kg-day)

TRV = Toxicity Reference Value (NOAEL or LOAEL) (mg/kg-day)

7.5 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

As the first step in the ecological effects evaluation, COPCs were selected by comparing the chemical concentrations in surface water and surface sediment to screening values developed for each medium. Chemicals that were not selected as COPCs are assumed to present negligible risk to ecological receptors and were not considered for further evaluation in the SERA. Chemicals that were retained as COPCs were evaluated further in Step 3a as discussed below. Ecological COPCs were selected using the following procedures:

- Chemicals with EEQs greater than 1.0 (using screening values) were retained as COPCs for further evaluation because they have a potential to cause risk to benthic invertebrates, fish, and other aquatic organisms.

- Chemicals with EEQs greater than 1.0 based on the food-chain model using NOAELs were retained as COPCs because they have the potential to cause risk to piscivorous mammals (raccoons) and birds (kingfishers).

- Calcium, magnesium, potassium, and sodium were not retained as COPCs because they are essential nutrients that can be tolerated by living systems even at high concentrations. No evidence indicates that these chemicals are related to site operations, and they are not considered hazardous chemicals.

If a chemical was not detected at the reporting limit in any sample in a particular medium, but the reporting limit exceeded the screening level, the chemical was not quantitatively carried through the risk assessment as a COPC. If a chemical was detected in at least one sample at a concentration greater than the reporting limit, one-half of the reporting limit was substituted for the non-detect value for calculating summary statistics (e.g., mean concentrations).

7.5.1 Risks to Aquatic Organisms

7.5.1.1 Sediment

Twenty-two SVOCs, eight organochlorine pesticides, eight dioxins/furans and 20 inorganics were detected in the surface sediment samples from the Skokie Ditch (Table 7-4). Sixteen SVOCs (acenaphthene, 2-methylnaphthalene, acenaphthalene, anthracene, benzo[a]anthracene, BaP, benzo[b]fluoranthene, benzo[g,h,i]perylene, carbazole, chrysene, dibenzo[a,h]anthracene, fluoranthene, fluorine, naphthalene, phenanthrene, and pyrene) were retained as COPCs for aquatic organisms because their concentrations were greater than their respective ecological screening levels. Of those sixteen, all but 2-methylnaphthalene, carbazole, and naphthalene were retained for food-chain modeling. Additionally, two SVOCs (benzo[k]fluoranthene and indeno[1,2,3-cd]pyrene) were retained as COPCs for food-chain modeling only. Also, total PAHs (calculated by summing only positive detections) were retained as COPCs because the maximum concentration was greater than the screening level. Note that total PAHs were not retained for food chain modeling because food chain modeling was conducted for the individual PAHs.

Six of the eight organochlorine pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, endosulfan II, and gamma-chlordane) were retained as COPCs for aquatic organisms and were retained for food-chain modeling. Additionally, dieldrin and endrin were retained for food-chain modeling only. The seven detected dioxins/furans (1,2,3,4,6,7,8,9-OCDD, 1,2,3,4,6,7,8,9-OCDF, 1,2,3,4,6,7,8-HPCDD, 1,2,3,4,6,7,8-HPCDF, 1,2,3,6,7,8-HXCDD, 1,2,3,7,8,9-HXCDD, and 2,3,7,8-TCDD) and seven total dioxins/furans were retained as COPCs for aquatic organisms because they did not have screening levels. 2,3,7,8-TCDD and the toxicity equivalent dose (TEQ) fish value were retained as COPCs because their maximum detected concentrations exceeded their screening levels. Although the dioxin/furan compounds are considered bioaccumulative, only the toxicity equivalent dose (TEQ) bird and mammal values are retained for food chain modeling. The concentrations of the individual dioxins are incorporated into the TEQ calculations, so it is not necessary to conduct food chain modeling on the individual dioxin/furan compounds.

Eight inorganics (antimony, arsenic, copper, iron, lead, manganese, mercury, and zinc) were retained as COPCs for aquatic organisms because detected concentrations exceeded sediment screening values. Of those, five (arsenic, copper, lead, mercury, and zinc) were also retained for food-chain modeling. Barium, selenium, thallium, vanadium were retained because they do not have sediment screening values and selenium was also retained for food-chain modeling. Two additional inorganics (chromium and nickel) were retained for food-chain modeling because they are considered bioaccumulative.

7.5.1.2 Surface Water

Three VOCs, nine SVOCs, one dioxin/furan and 17 inorganics were detected in surface water samples at Site 1 (Table 7-5). None of the detected VOCs were retained as COPCs for aquatic organisms or food-chain modeling. Two SVOCs (BaP and pyrene) were retained as COPCs because detected concentrations exceeded their surface water screening values. Four SVOCS (benzo[b]fluoranthene, benzo[g,h,i]perylene, chrysene, and indeno[1,2,3-cd]pyrene) were retained as COPCs because they do not have surface water screening values. The aforementioned SVOCs, as well as fluoranthene, fluorine, and phenanthrene (which had concentrations less than their surface water screening values) were retained for food-chain modeling. One dioxin/furan, 1,2,3,4,6,7,8,9-OCDD, and TEQ fish were retained as COPCs for aquatic organisms. Although 1,2,3,4,6,7,8,9-OCDD is considered bioaccumulative, only the TEQ bird and mammal values are retained for food chain modeling. The concentration of 1,2,3,4,6,7,8,9-OCDD is incorporated into the TEQ calculations. One inorganic, aluminum, was retained as a COPC for aquatic organism because detected concentrations exceeded the surface water screening value. Additionally, six inorganics (chromium, copper, lead, mercury, nickel, and zinc) were retained as COPCs for food-chain modeling.

7.5.2 Risks to Terrestrial Wildlife

Table 7-6 presents a summary of the detected chemicals selected as COPCs for food-chain modeling and their calculated NOAEL and LOAEL EEQs based on maximum inputs (see Section 7.3) in the terrestrial wildlife food-chain models. Chemicals were retained as COPCs if their calculated NOAEL EEQ values exceeded 1.0.

Three inorganics (copper, mercury, and nickel) were retained as COPCs for risks to piscivorous mammals in the conservative exposure scenario (see Table 7-6). Additionally, six inorganics (copper, lead, mercury, nickel, selenium, and zinc) were retained as COPCs for risks to piscivorous birds in the conservative exposure scenario (see Table 7-7).

7.6 STEP 3A – REFINEMENT OF COPCs

Step 3a consists of a refinement of the conservative exposure assumptions/concentrations to evaluate the potential risks to ecological receptors (i.e., invertebrates and wildlife receptors). The objective of the Step 3a refinement is to better define those chemicals that contribute to potentially unacceptable levels of ecological risk, and to identify and eliminate from further consideration those COPCs that are retained because of the use of very conservative exposure scenarios. The Step 3a evaluation is designed to eliminate chemicals from further evaluation for certain groups of receptors. For example, a chemical may not be retained as a COPC in sediment based on risks to sediment invertebrates but may be retained based on risks to wildlife. This evaluation also includes (but is not necessarily limited to) a consideration of the following topics:

- Magnitude of criterion exceedance: Although risks may not relate directly to the magnitude of a criterion exceedance, the magnitude may be one factor used in a weight-of-evidence approach to determine the need for further site evaluation.

- Frequency of chemical detection: A chemical that was detected at a low frequency typically was of less concern than a chemical detected at a high frequency provided that toxicities and concentrations of the chemicals are similar. All else being equal, chemicals detected frequently were given greater consideration than those detected relatively infrequently.

- Chemical bioavailability: Many chemicals (especially metals) are present in the environment in forms that are typically not bioavailable, and limited bioavailability was considered when evaluating the exposures of receptors to site chemicals.

- Habitat: Although exceedences of criteria may occur, potential risks to ecological receptors may be minimal if there is little habitat for those receptors. Therefore, the extent of habitat was used qualitatively when considering the site for additional evaluation.

- Alternate Benchmarks: Less conservative values based on toxicity data were used to re-evaluate the chemicals that were retained as COPCs to determine whether detected concentrations exceed the higher effects levels (i.e., severe effect levels and probable effect levels).

- Less Conservative Food-Chain Models: The exposure doses from the terrestrial food-chain models were recalculated using less conservative exposure assumptions (e.g., average ingestion rates, body weights and chemical concentrations). The doses were then compared to NOAELs and LOAELs in this step to further refine probable/improbable risks to ecological receptors.

In addition, Illinois sediment background values (see Table 7-2) were used in Step 3a to further evaluate sediment data.

7.6.1 Risks to Aquatic Receptors

7.6.1.1 Surface Sediment

SVOCs

Sixteen SVOCs (see Table 7-4) were retained as COPCs because maximum concentrations exceeded sediment screening values. No SVOCs were retained as COPCs for aquatic biota because maximum or average values were below calculated site specific or state-wide Illinois EPA (2000) Tier 2 sediment screening concentrations (see Table 7-7). Site specific Tier 2 sediment screening concentrations were calculated using the following equation. Illinois EPA water quality criteria (when available) or final chronic values from USEPA (2003) were used as the water quality criteria as shown in Table 7-7:

$$SSC = WQC \times K_{OC} \times f_{OC}$$

Where: SSC = sediment screening concentration (mg/kg)

WQC = water quality criterion (mg/L)

K_{OC} = organic carbon partition coefficient (l/kg), and

f_{OC} = fraction organic carbon measured in sediment (unitless) (average site percent TOC)

Pesticides

Three pesticides, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT, were retained as COPCs because the maximum concentrations exceeded associated sediment screening values. The maximum detected 4,4'-DDD

concentration at 17 µg/kg in sample NTC01SD0200 is less than the probable effects concentration (MacDonald, 2000) of 28 µg/kg. The maximum detected 4,4'-DDE concentration at 32 µg/kg in sample NTC01SD0400 was only slightly above the probable effects concentration (MacDonald, 2000) (31.3 µg/kg) and the average concentration (19 µg/kg) was well below this concentration. The maximum detected 4,4'-DDT concentration at 7.4 µg/kg in sample NTC01SD0400 is much less than the probable effects concentration (MacDonald, 2000) of 63 µg/kg. For these reasons, risks to benthic invertebrates from 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT are not expected, and these pesticides are not retained further as COPCs for aquatic biota.

Three pesticides, alpha-chlordane, gamma-chlordane, and endosulfan II, were retained as COPCs because their maximum concentrations exceeded sediment screening values. However, the maximum detected concentrations of alpha-chlordane (5.5 µg/kg) and gamma-chlordane in sample NTC01SD0200 were less than the probable effects concentration (MacDonald, 2000) value of 18 µg/kg for chlordane. Furthermore, the sum of both maximum concentrations of the chlordanes (8.4 µg/kg) does not exceed this probable effects concentration (MacDonald, 2000) for chlordane. Endosulfan II was detected with a maximum concentration of 4.8 µg/kg in sample NTC01SD0400. This is less than the EcoTox Threshold of 14 µg/kg (USEPA, January 1996). For these reasons, alpha-chlordane, gamma-chlordane, and endosulfan II are not expected to impact benthic invertebrates and are not retained as COPCs.

Dioxins/Furans

The concentrations of the eight dioxins/furans retained as COPCs were standardized to 2,3,7,8-TCDD toxic equivalent quotients (TEQs) (fish) using the toxic equivalent factor guidelines proposed by the World Health Organization (Van den Berg et al., 1998). The maximum fish TEQ (1.6 ng/kg) in sample NTC01SD0200 was significantly less than the probable apparent effects threshold value of 7.2 for 2,3,7,8-TCDD (Cubbage et al., 1997), which is the only threshold value available. For this reason, dioxins/furans are not expected to have adverse effects on aquatic biota and were not retained further as COPCs.

Metals

Antimony was retained as a COPC because the maximum detected concentration (2.1 mg/kg) in samples NTC01SD0200 and NTC01SD0400 exceeded the sediment screening value of 2 mg/kg. The maximum value is only slightly greater than the sediment screening value and the Illinois EPA background concentration (2 mg/kg). Therefore, antimony concentrations are not site-related and are not likely to impact benthic invertebrates. Additionally, the maximum concentration is less than the lowest apparent

effects threshold of 3 mg/kg (Cubbage et al., 1997). For these reasons, antimony is not retained as a COPC for aquatic biota.

Arsenic was retained as a COPC because the maximum detected concentration (10.1 mg/kg) in the duplicate of sample NTC01SD0400 slightly exceeded the sediment screening value of 9.79 mg/kg. The maximum value was less than the probable effects concentration (33 mg/kg) (MacDonald, 2000). The average concentration (6.2 mg/kg) was less than the Illinois EPA background concentration (8 mg/kg). Therefore, arsenic concentrations are not site-related. For these reasons, arsenic was not retained as a COPC for aquatic biota.

Barium was retained as a COPC because no screening level is available for comparison. The maximum concentration (101 mg/kg) in the duplicate of sample NTC01SD0400 is less than the Illinois EPA background (1997) value for barium (145 mg/kg). Therefore, barium concentrations are not site-related and are not likely to impact benthic invertebrates. For this reason barium, was not further retained as a COPC for aquatic biota.

Copper was retained as a COPC because the maximum detected concentration (71.3 mg/kg) in the duplicate of sample NTC01SD0400 exceeded the sediment screening value of 31.6 mg/kg. The maximum value is less than the probable effects concentration (MacDonald, 2000) of 149 mg/kg. For this reason, copper is not expected to pose a threat to aquatic biota and is not retained further as a COPC.

Iron was retained as a COPC because the maximum concentration (28,500 mg/kg) in the duplicate sample of NTC01SD0400 exceeded the sediment screening value of 20,000 mg/kg. The average concentration (17,200 mg/kg) is less than the Illinois EPA background value (18,000 mg/kg). Therefore, iron concentrations are not site-related. For this reason, iron is not expected to pose a threat to aquatic biota and is not retained as a COPC.

Lead was retained as a COPC because the maximum concentration (54 mg/kg) in sample NTC01SD0300 exceeded the sediment screening value of 35.8 mg/kg. The maximum value is less than the probable effects concentration (MacDonald, 2000) of 128 mg/kg. Furthermore, the average concentration (40.4 mg/kg) is only slightly greater than the sediment screening value of 35.8 mg/kg, but lead did not exceed the sediment screening value in the most downstream sample. For these reasons, lead is not expected to pose a threat to aquatic biota and was not retained further as a COPC.

Manganese was retained as a COPC because the maximum concentration (1,200 mg/kg) in the duplicate of sample NTC01SD0400 exceeded the sediment screening value of 460 mg/kg. This maximum concentration is less than the Illinois EPA (1997) background concentration of 1,300 mg/kg. Therefore,

manganese concentrations are not site-related. For this reason, manganese is not retained further as a COPC for aquatic biota.

Mercury was retained as a COPC because the maximum concentration (0.3 mg/kg) in sample NTC01SD0200 exceeded the sediment screening value of 0.18 mg/kg. The maximum value is less than the probable effects concentration (MacDonald, 2000) value of 1.06 mg/kg. Furthermore, the average concentration (0.16 mg/kg) is less than the conservative sediment screening value (MacDonald, 2000) threshold effects concentration of 0.18 mg/kg. For these reasons, mercury was not retained as a COPC for aquatic biota.

Selenium, thallium, and vanadium with respective maximum concentrations of 2.5 mg/kg, 0.63 mg/kg and 31 mg/kg were initially retained as COPCs because no sediment screening values are available and were evaluated quantitatively. However, because of the lack of alternate benchmarks, these chemicals cannot be evaluated further and were not retained further as COPCs for aquatic biota.

Zinc was retained as a COPC because the maximum concentration (400 mg/kg) in sample NTC01SD0500 exceeded the sediment screening value of 121 mg/kg. The maximum value is less than the probable effects concentration (MacDonald, 2000) of 459 mg/kg. Concentrations of zinc appears to decrease in a downstream direction from the maximum concentration (Figure 4-6). For these reasons, zinc is not retained further as a COPC for aquatic biota.

In summary no SVOCs, pesticides, dioxins/furans, or inorganics were retained as COPCs for aquatic biota in Skokie Ditch at Site 1.

7.6.1.2 Surface Water

SVOCs

Several PAHs were retained as COPCs because either no surface water screening value is available or the concentration exceeded the surface water screening value. When compared to USEPA (2003) PAH-specific final chronic values, no PAHs were further retained as COPCs for aquatic biota from surface water because the values were less than this criteria (see Table 7-8).

Dioxins/Furans

One dioxin (1,2,3,4,6,7,8,9-OCDD) was retained as a COPC because a screening level was not available. The maximum concentration was 130 pg/L. This value was converted to a 2,3,7,8-TCDD dioxin TEQ for fish value of 0.013 pg/L using the World Health Organization (Van den Berg et al., 1998) toxic equivalent

factor for 1,2,3,4,6,7,8,9-OCDD. This value is significantly less than the USEPA (1993) Interim Report on Data and Methods for Assessment of 2,3,7,8-TCDD Risks to Aquatic Life and Associated Wildlife low-risk water concentration of 0.6 pg/L (assuming the conservative particulate organic carbon concentration in water value of 0.2). Therefore, risks from dioxins/furans are expected to be low and dioxins/furans were not retained further as COPCs for aquatic biota.

Metals

Aluminum was retained as a COPC for surface water because the maximum concentration (407 µg/L) exceeded the surface water screening value of 87 µg/L. The maximum value is less than the Oak Ridge National Lab (1996) lowest chronic value of 430 µg/L, which is based on protection of aquatic life including plants. Additionally, the surface water samples were not filtered. Concentrations in non-filtered samples are considered less bioavailable. Therefore risks associated with aluminum in surface water to aquatic biota would be minimal, and aluminum is not retained further as a COPC.

7.6.2 Risks to Terrestrial Wildlife

Appendix G presents EEQs calculated using the terrestrial wildlife model NOAELs and LOAELs and based on average input parameters for the belted kingfisher and raccoon. The average concentrations detected in surface water and sediment samples were used for the average food-chain model. Metals data for average input calculations were based on unfiltered sample results.

Table 7-9 presents a summary of chemicals retained as COPCs and their calculated NOAEL and LOAEL EEQs based on average inputs (see Section 7.3) in the terrestrial food chain models.

Three inorganics (copper, mercury and nickel) were retained as COPCs for risks to piscivorous mammals in the conservative exposure scenario (see Table 7-6). Additionally, six inorganics (copper, lead, mercury, nickel, selenium, and zinc) were retained as COPCs for risks to piscivorous birds in the conservative exposure scenario (see Table 7-6). When re-evaluating these chemicals with average input values in the food-chain models (see Table 7-9), no EEQs were greater than 1.0 for the raccoon model, and only three inorganics (copper, mercury and zinc) had EEQs greater than 1.0 for the kingfisher. The average exposure scenario assumed that the kingfisher would receive all of its food from Skokie Ditch, which is highly unlikely. The ditch does not support large enough quantities of fish to sustain the daily diet of the kingfisher due to lack of suitable habitat; therefore; a kingfisher could not feed on this segment of Skokie Ditch alone located in Site 1. Also, the average home range of the kingfisher is 1.16 kilometer or 3,800 feet and the length of the measured area of contamination is only 1,400 feet. Therefore, a site use factor of 0.37 was used to recalculate risks based on the area of contamination versus the

kingfisher's home range. When the site use factor is applied to the average food-chain model scenario only the zinc NOAEL EEQ is greater than 1.0 (1.507). This is only slightly greater than 1.0, the LOAEL HQ is much less than 1.0 (0.1668). Based on the lack of aquatic organisms in the ditch, as stated above, it is highly unlikely that a kingfisher would obtain 37 percent of its food from the ditch. Therefore, it is highly unlikely that zinc would pose a risk to piscivorous birds. For these reasons, no COPCs were further retained for risks to piscivorous mammals or birds from Skokie Ditch at Site 1.

7.7 ECOLOGICAL RISK UNCERTAINTY ANALYSIS

This section presents some of the uncertainties associated with the ERA.

7.7.1 Measurement and Assessment Endpoints

Measurement endpoints are used to evaluate the assessment endpoints that are selected for the SERA. For this SERA, the measurement endpoints are not the same as the assessment endpoints. Therefore, the measures were used to predict effects to the assessment endpoints by selecting surrogate species that were evaluated.

Several endpoints were not quantitatively evaluated in this SERA. For example, risks to reptiles and amphibians were not quantitatively evaluated because exposure factors are not established for most species and because toxicity data are very limited.

7.7.2 Exposure Characterization

The contaminant dose to terrestrial wildlife is calculated using an equation that incorporates ingestion rates, body weights, BAFs, and other exposure factors. These exposure factors were obtained from literature studies or predicted using various equations. Ingestion rates and body weights vary between species, especially between species inhabiting different areas.

Bioaccumulation of contaminants into various biological media (i.e., fish and invertebrates) depends on characteristics of the media such as pH, organic carbon, etc. Therefore, actual BAFs and BSAFs at the site may be different than those used in the SERA that were obtained from literature sources. Also, bioavailability of chemicals is not considered in this SERA. The chemicals are assumed to be 100 percent bioavailable at the detected concentrations, which is unlikely for contaminants in the environment.

There is uncertainty in the chemical data collected at the site. Measured concentrations of chemicals are only estimates of the true site chemical concentrations. For samples that are deliberately biased toward

known or suspected high concentrations (i.e., collecting samples in depositional areas), predicted doses to receptors may be higher than actual doses. This is because it is not likely that the receptor will feed only in contaminated areas.

Under the conservative exposure scenario, terrestrial wildlife were assumed to live and feed only at the site. These assumptions tended to over-predict risk because it is unlikely that most receptors obtain their food from within the site boundaries. Less conservative exposure assumptions were used in the Step 3a refinement to calculate and refine exposure estimates for potential ecological receptors. An average dose was calculated for chemicals that were retained as COPCs. There is also uncertainty in the calculation of the dose based on a site use factor. This value may over or under estimate the potential exposure from food sources.

7.7.3 Ecological Effects Data

There is uncertainty in the ecological toxicity value comparisons. The WQCs developed by USEPA in theory protect 95 percent of exposed species. Therefore, some sensitive species present at the site may not be protected by the use of these criteria. With the exception of hardness for a few metals, the surface water screening values do not account for site-specific factors such as TOC or pH that may affect toxicity. There may also be situations where the screening levels are over-predictive of risk if the sensitive species used to develop the criteria do not inhabit the site. Additional uncertainty exists in the benchmarks used for the screening process. For example, four inorganic chemicals (arsenic, copper, manganese, and silver) have sediment screening values less than Illinois EPA (1997) background concentrations. The sediment screening values for these chemicals are overly conservative, and risks for these chemicals were possibly over predicted.

The toxicity of chemical mixtures is not well understood. The toxicity information used in the SERA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect organisms very differently than individual chemicals because of synergistic or antagonistic effects.

Finally, toxicological data for some of the contaminants may not exist. Therefore, there is uncertainty in the conclusions involving the potential impacts to ecological receptors from these constituents.

7.7.4 Risk Characterization

Risks are projected if an EEQ is greater than or equal to unity (1.0) regardless of the magnitude of the EEQ. Although the relationship between the magnitude of an EEQ and toxicity is not necessarily linear, the

magnitude of an EEQ can be used as rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used. Finally, there is uncertainty in how the predicted risks to individuals at the site translate into risk to the population in the area as a whole.

7.8 SUMMARY AND CONCLUSIONS

Several chemicals detected in surface water and/or surface sediment were initially retained as COPCs because their chemical concentrations exceeded screening levels or because they were bioaccumulative chemicals with EEQs greater than 1.0 based on the conservative exposure scenarios. These chemicals were then re-evaluated in Step 3a of this SERA to determine which chemicals had the greatest potential for causing risks to ecological receptors and therefore should be retained as COPCs for further discussion/evaluation. The two primary ecological endpoints evaluated in this SERA were aquatic organisms (i.e., fish and invertebrates) and mammals and birds that consume invertebrates and/or fish. Therefore, different lists of chemicals were retained as COPCs for these different endpoints.

None of the initially selected COPCs for surface sediment or surface water were retained as COPCs for aquatic biota. None of the initially selected COPCs for piscivorous mammals or birds were retained as COPCs for further evaluation. Therefore, because contaminant concentrations are low and because of the lack of suitable ecological habitat, fish and aquatic organisms, the overall risk to ecological receptors is small from contaminants in the Skokie Ditch.

TABLE 7-1

SEDIMENT ECOLOGICAL SCREENING LEVELS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINIOS
PAGE 1 OF 2

Analyte	Screening Value (mg/kg)	Illinois EPA Background (Illinois EPA, 1997)(1) (mg/kg)		Illinois EPA (September, 2000) Tier 1 (mg/kg)		Tier 2 (mg/kg)		MacDonald, 2000 TEC (mg/kg)	PEC (mg/kg)	EcoTox (USEPA, January 1996)[10] (mg/kg)		OMOE, 1993 LEL (mg/kg)	SEL[10] (mg/kg)	ORNL (1997) SCV[10] (mg/kg)	USEPA, 1996 TEC (mg/kg)	PEC	NEC	USEPA Region 5 (2003) ESL[11] (mg/kg)
POLYNUCLEAR AROMATIC HYDROCARBONS																		
2-Methylnaphthalene	0.368			0.368	(4)	0.67	(4)											
Acenaphthylene	0.186			0.186	(5)	0.662	(5)											
Anthracene	0.085			0.085		0.96		0.0572	0.845			0.22	3.7	0.22	0.03162	0.54772	1.7	
Benzo(a)arthracene	0.287			0.287		1.6		0.108	1.05			0.32	14.8	0.11	0.26	4.2	3.5	
Benzo(a)pyrene	0.073			0.073		2.5		0.15	1.45			0.37	14.4	0.14	0.35	0.3937	0.44	
Benzo(b)fluoranthene	0.886			0.886														
Benzo(g,h,i)perylene	0.17											0.17	3.2		0.29	6.3	3.8	
Benzo(k)fluoranthene	8.86			8.86								0.24	13.4					
Carbazole	0.11			0.11	(3)	0.4	(3)											
Chrysene	0.4			0.4		2.8		0.166	1.29			0.34	4.6		0.5	5.2	4	
Dibenzo(a,h)anthracene	0.06			0.06		0.26		0.033				0.06	1.3			0.0282	0.87	
Fluoranthene	2.79			2.79		9.92		0.423	2.23			0.75	10.2		0.06423	0.83427	7.5	
Fluorene	0.035			0.035		0.64		0.0774	0.536	0.54		0.19	1.6	0.54	0.03464	0.65192	1.8	
Indeno(1,2,3-cd)pyrene	2.5			2.5								0.2	3.2		0.078	0.83666	3.8	
Naphthalene	0.34			0.34		2.1		0.176	0.561	0.48				0.24	0.03275	0.68739	0.29	
Phenanthrene	0.81			0.81		2.88		0.204	1.17			0.56	9.5					
Pyrene	0.35			0.35		2.2		0.195	1.52			0.49	8.5		0.57	3.225	6.1	
TAL METALS																		
Aluminum	58030															58030	73160	
Antimony	2			2		25												
Arsenic	9.79	8						9.79	33			6	33		12.1	57	92.9	
Barium		145	(2)															
Calcium																		
Chromium	43.4	16						43.4	111			26	110		56	159	312	
Cobalt	50											50						
Copper	31.6	38						31.6	149			16	110		28	77.7	54.8	
Iron	20000	18000										20000	40000					
Lead	35.8	28						35.8	128			31	250		34.2	396	68.7	
Magnesium																		
Manganese	460	1300										460	1100		1673	1081	819	
Mercury	0.18	0.07						0.18	1.06			0.2	2					
Nickel	30	26	(2)	30		50		22.7	48.6			16	75		39.6	38.5	37.9	
Potassium		1500	(2)															
Selenium																		
Sodium																		
Thallium																		
Vanadium																		
Zinc	121	80						121	459			120	820		159	1532	541	
TCL SEMIVOLATILE ORGANIC COMPOUNDS																		
Acenaphthene	0.585			0.585														
Bis(2-ethylhexyl)phthalate	130			130	(3,5)	92000	(3,5)							890				
Butyl benzyl phthalate	6			6	(3)	21	(3)			11				11				
Di-n-octyl phthalate	40.6																	40.6
ORGANOCHLORINE PESTICIDES																		
4,4'-DDD	0.002			0.002	(3)	0.02	(3)	0.0049	0.028			0.008	0.06	0.11				
4,4'-DDE	0.002			0.002	(3)	0.015	(3)	0.0032	0.0313			0.005	0.19					
4,4'-DDT	0.001			0.001	(3)	0.007	(3)	0.0042	0.0629			0.008	0.71	0.34				
alpha-Chlordane	0.0005			0.0005	(3,6)	0.006	(3,6)	0.0032	0.0176			0.007 (6)	0.06 (7)					
Dieldrin	0.05			0.05	(3)	0.18	(3)	0.0019	0.0618	0.052		0.002	0.91					
Endosulfan II	0.00015			0.0002	(3,8)	0.0005	(3,8)			0.014				0.0055				
Endrin	0.019			0.019	(3)	0.067	(3)	0.0022	0.207	0.02	(9)	0.003	1.3					
gamma-Chlordane	0.0005			0.0005	(3,6)	0.006	(3,6)	0.0032	0.0176			0.007 (6)	0.06 (7)					

TABLE 7-1

SEDIMENT ECOLOGICAL SCREENING LEVELS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINIOS

Analyte	Screening Value (mg/kg)	Illinois EPA Background (Illinois EPA, 1997)(1) (mg/kg)		Illinois EPA (September, 2000) Tier 1 (mg/kg)		Illinois EPA (September, 2000) Tier 2 (mg/kg)		MacDonald, 2000 TEC (mg/kg)		MacDonald, 2000 PEC (mg/kg)		EcoTox (USEPA, January 1996)[10] (mg/kg)		OMOE, 1993 LEL (mg/kg)		OMOE, 1993 SEL[10] (mg/kg)		ORNL (1997) SCV[10] (mg/kg)		USEPA, 1996 TEC (mg/kg)		USEPA, 1996 PEC (mg/kg)	USEPA, 1996 NEC (mg/kg)	USEPA Region 5 (2003) ESL[11] (mg/kg)
DIOXINS/FURANS (ng/kg)																								
1,2,3,4,6,7,8,9-OCDF																								
1,2,3,4,6,7,8,9-OCDD																								
1,2,3,4,6,7,8-HPCDF																								
1,2,3,4,6,7,8-HPCDD																								
1,2,3,6,7,8-HXCDD																								
1,2,3,7,8,9-HXCDD																								
2,3,7,8-TCDF																								
2,3,7,8-TCDD	0.00000012																							0.00000012
TOTAL HPCDF																								
TOTAL HPCDD																								
TOTAL HXCDF																								
TOTAL HXCDD																								
TOTAL PECDF																								
TOTAL TCDF																								
TOTAL TCDD																								

IEPA (Illinois Environmental Protection Agency), 1997. Evaluation of Illinois Sieved Stream Sediment Data, 1982-1995. Bureau of Water. IEPA/BOW/97-016. August,
IEPA (Illinois Environmental Protection Agency), 2000. Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments. Draft. Update 2. Office of Chemical Safety. September 21.
MacDonald, D.D., C.G. Ingersoll, and T.A. Berger, 2000. "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems." Archives of Environmental Contamination and Toxicology, Vol. 39, pp. 20-31.
EcoTox USEPA, 1996. ECO Update, Ecotox Thresholds. U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. Intermittent Bulletin, Volume 3, Number 2. EPA540/F-95/038. January.
OMOE, 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of Environment and Energy. August.
ORNL (1997)Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Oak Ridge national Lab. ES/ER/TM-95/R4.
USEPA, 1996. Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyallela azteca and the Midge Chironomus riparius. Great Lakes National Program Office, Chicago, IL. USEPA 905-R96-008.
USEPA, 2003. Ecological Screening Levels. USEPA Region 5 (http://www.epa.gov/reg5rcra/ca/edql.htm). August.

1 - Illinois EPA Background values for unsieved data
2 - Illinois EPA Background values for sieved data
3 - Calculated using Illinois EPA unpublished derived water quality criteria (Illinois EPA, 2002)
4 - Total Methylnaphthalenes
5 - Value is provisional; insufficient toxicological data available to fully develop criteria pursuant to Illinois EPA document 35 IAC 302.Subpart F
6 - Chlordane value
7 - Endrin value used to create surrogate
8 - Endosulfan, mixed isomers
9 - USEPA L-SQG (USEPA, September 1993a,b)
10 - Values assume 1% organic carbon.
11 - The Region 5 ESLs are only presented for chemicals that do not have screening levels from any of the other sources listed on this table.

TABLE 7-2

SURFACE WATER ECOLOGICAL SCREENING LEVELS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINIOS
PAGE 1 OF 1

Analyte	Screening Level (ug/L)	Illinois EPA WQS 2006[1]				Illinois EPA WQC 2006[2]				USEPA WQC 2006[3]				Suter and Tsao, 1996[4]		USEPA Region 3 BTAG (2005)[5] (ug/L)
		Acute (ug/L)		Chronic (ug/L)		Acute (ug/L)		Chronic (ug/L)		Acute (ug/L)		Chronic (ug/L)		Acute (ug/L)	Chronic (ug/L)	
TCL VOLATILE ORGANIC COMPOUNDS																
1,1-Dichloroethane	2000					20000	(6)	2000	(6)					830	47	47
cis-1,2-Dichloroethene	1100					14000		1100						1100	590	
Vinyl chloride	4000					40000	(6)	4000	(6)							930
POLYNUCLEAR AROMATIC HYDROCARBONS																
Benzo(a)pyrene	0.014													0.24	0.014	0.015
Benzo(b)fluoranthene																
Benzo(g,h,i)perylene																
Chrysene																
Fluoranthene	6.16													33.6	6.16	0.04
Fluorene	3.9													70	3.9	3
Indeno(1,2,3-cd)pyrene																
Phenanthrene	3.7					46		3.7						30	6.3	0.4
Pyrene	0.025															0.025
TAL METALS																
Aluminum	87									750		87				87
Antimony	30													180	30	30
Barium	5000			5000										110	4	4
Calcium	116000															116000
Chromium	11	16		11						16		11				85
Copper	11.4	17		11.4	(7)					13	(7)	9	(7)			9
Iron	1000			1000								1000				300
Lead	15.9	75.7	(7)	15.9	(7)					65	(7)	2.5	(7)			2.5
Magnesium	82000															82000
Manganese	1000			1000										2300	120	120
Mercury	1.1	2.2		1.1						1.4		0.77			1.3[8]	0.026
Nickel	5	82.4	(7)	5	(7)					470	(7)	52	(7)			52
Potassium	53000															53000
Sodium	680000															680000
Thallium	12													110	12	0.8
Vanadium	20													280	20	20
Zinc	21.6	119	(7)	21.6	(7)					120	(7)	120	(7)			120
DIOXINS/FURANS (pg/L)																
1,2,3,4,6,7,8,9-OCDD																

1 - IEPA, 2006. Title 35: Environmental Protection Subtitle C: Water Pollution Chapter I: Pollution Control Board Part 302 Water Quality Standards. Effective March 2006.
2 - IEPA, 2006. Derived Water Quality Criteria pursuant to 35 Ill. Adm. Code 302, Subpart F. http://www.epa.state.il.us/water/water-quality-standards/water-quality-criteria.html. Downloaded August 2006.
3 - USEPA, 2006. National Recommended Water Quality Criteria: 2006. Office of Water.
4 - Suter, G.W. II. and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Constituents of Concern for Effects on Aquatic Biota:1996 Revision. Environmental Sciences Division, Oak Ridge National Laboratory. ES
5 - USEPA, 2005. Region 3 Freshwater Surface Water Screening Benchmarks. October. http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fw/screenbench.htm
6 - Values were not calculated according to the regulations due to limited data; these values should only be used for advisory purposes such as establishing "reasonable potential"
7 - Criteria derived from calculated hardness (210 mg/L) and the dissolved value for cadmium, chromium III, copper, lead, nickel, and zinc (USEPA, 2001).
8 - The chronic value is used as the benchmark to protect aquatic life.

TABLE 7-3

EXPOSURE PARAMETERS FOR TEST SPECIES AND SURROGATE WILDLIFE SPECIES
SITE 1 GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Species/Exposure Inputs	Conservative Inputs		Average Inputs		Source
	Values	Units	Values	Units	
Raccoon					
Body Weight = BW	5.340E+00	kg	6.865E+00	kg	USEPA, 1993
Food Ingestion Rate = If	2.703E-01	kg/day	2.176E-01	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	7.354E-01	L/day	5.664E-01	L/day	USEPA, 1993
Sediment Ingestion Rate - Is	2.540E-02	kg/day	2.045E-02	kg/day	Beyer, 1993
Home Range = HR	Assume 100% on site		3.855E+02	acres	USEPA, 1993
Belted Kingfisher					
Body Weight = BW	1.360E-01	kg	1.520E-01	kg	USEPA, 1993
Food Ingestion Rate = If	2.125E-02	kg/day	1.73E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	1.870E-02	L/day	1.672E-02	kg/day	USEPA, 1993
Soil Ingestion Rate - Is	7.013E-04	kg/day	5.706E-04	kg/day	Beyer, 1993
Home Range = HR	Assume 100% on site		1.160E+00	km	USEPA, 1993

TABLE 7-4

ECOLOGICAL COPC SELECTION TABLE - SURFACE SEDIMENT
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average of Detections	Average of All Results[1]	Location with Maximum Concentration	Ecological Screening Level	Ecological Effects Quotient	COPC for Aquatic Organisms[2]	Rationale for COPC Selection[3]	Retained for Food Chain Modeling[2]	Rationale for Food Chain Modeling[3]
Semivolatile Organics (ug/kg)												
ACENAPHTHENE	2/3	130 J	740 J	460	730	NTC01SD0200	585	1.3	YES	ASL	YES	BIO
BIS(2-ETHYLHEXYL)PHTHALATE	3/3	580 J	1000 J	790	790	NTC01SD0400	130000	0.008	NO	BSL	NO	NONBIO
BUTYL BENZYL PHTHALATE	1/3	150 J	150 J	150	1500	NTC01SD0100	6000	0.03	NO	BSL	NO	NONBIO
DIBENZOFURAN	2/3	130 J	380 J	260	590	NTC01SD0200	910	0.42	NO	BSL	NO	NONBIO
DI-N-OCTYL PHTHALATE	1/3	120 J	120 J	120	1400	NTC01SD0100	40600	0.003	NO	BSL	NO	NONBIO
Polynuclear Aromatic Hydrocarbons (ug/kg)												
2-METHYLNAPHTHALENE	3/5	40 J	570 J	260	440	NTC01SD0200	368	1.5	YES	ASL	NO	NONBIO
ACENAPHTHYLENE	5/5	62 J	420 J	260	260	NTC01SD0200	186	2.3	YES	ASL	YES	BIO
ANTHRACENE	5/5	67 J	500	240	240	NTC01SD0200	85	5.9	YES	ASL	YES	BIO
BENZO(A)ANTHRACENE	5/5	480	1700	1200	1200	NTC01SD0300	287	5.9	YES	ASL	YES	BIO
BENZO(A)PYRENE	5/5	400	2000	1400	1400	NTC01SD0300	73	27.4	YES	ASL	YES	BIO
BENZO(B)FLUORANTHENE	4/5	400	2400	1400	1100	NTC01SD0300	886	2.7	YES	ASL	YES	BIO
BENZO(G,H,I)PERYLENE	5/5	260	2100	1500	1500	NTC01SD0300	170	12.4	YES	ASL	YES	BIO
BENZO(K)FLUORANTHENE	4/5	190	1100	690	580	NTC01SD0300	8860	0.12	NO	BSL	YES	BIO
CARBAZOLE	2/5	290 J	420 J	360	470	NTC01SD0200	110	3.8	YES	ASL	NO	NONBIO
CHRYSENE	5/5	460	2000	1500	1500	NTC01SD0300	400	5	YES	ASL	YES	BIO
DIBENZO(A,H)ANTHRACENE	5/5	50 J	280 J	190	190	NTC01SD0200	60	4.7	YES	ASL	YES	BIO
FLUORANTHENE	5/5	810	6000	3800	3800	NTC01SD0200	2790	2.2	YES	ASL	YES	BIO
FLUORENE	3/5	39 J	260 J	140	140	NTC01SD0200	35	7.4	YES	ASL	YES	BIO
INDENO(1,2,3-CD)PYRENE	5/5	300	1700	1300	1300	NTC01SD0200	2500	0.68	NO	BSL	YES	BIO
NAPHTHALENE	2/5	120 J	660 J	390	480	NTC01SD0200	340	1.9	YES	ASL	NO	NONBIO
PHENANTHRENE	5/5	410	3100	1500	1500	NTC01SD0200	810	3.8	YES	ASL	YES	BIO
PYRENE	5/5	620	4300	2700	2700	NTC01SD0200	350	12.3	YES	ASL	YES	BIO
TOTAL PAHS ECO	5/5	4600	25000	18000	18000	NTC01SD0200	4000	6.3	YES	ASL	NO	NA
Organochlorine Pesticides/PCBs (ug/kg)												
4,4'-DDD	3/3	5.5 J	17 J	11	11	NTC01SD0200	2	8.5	YES	ASL	YES	BIO
4,4'-DDE	3/3	10 J	32	19	19	NTC01SD0200	2	16	YES	ASL	YES	BIO
4,4'-DDT	3/3	4.9 J	7.4 J	5.7	5.7	NTC01SD0400	1	7.4	YES	ASL	YES	BIO
ALPHA-CHLORDANE	2/3	5 J	5.5 J	5.3	5.7	NTC01SD0200	0.5	11	YES	ASL	YES	BIO
DIELDRIN	1/3	4.4 J	4.4 J	4.4	7.5	NTC01SD0400	50	0.09	NO	BSL	YES	BIO
ENDOSULFAN II	1/3	3.6 J	4.8 J	4.2	7.4	NTC01SD0400	0.15	32	YES	ASL	YES	BIO
ENDRIN	1/3	2.7 J	6.7 J	4.7	7.6	NTC01SD0400	19	0.35	NO	BSL	YES	BIO
GAMMA-CHLORDANE	1/3	2.9 J	2.9 J	2.9	6.6	NTC01SD0200	0.5	5.8	YES	ASL	YES	BIO
Dioxins/Furans (ng/kg)												
1,2,3,4,6,7,8,9-OCDD	3/3	1400	2300	1900	1900	NTC01SD0200, NTC01SD0400-D	NV	NV	YES	NSL	No	NA
1,2,3,4,6,7,8,9-OCDF	3/3	130	250	190	190	NTC01SD0200	NV	NV	YES	NSL	No	NA
1,2,3,4,6,7,8-HPCDD	3/3	130	240	200	200	NTC01SD0200, NTC01SD0400-D	NV	NV	YES	NSL	No	NA
1,2,3,4,6,7,8-HPCDF	3/3	30	65	53	53	NTC01SD0200	NV	NV	YES	NSL	No	NA
1,2,3,6,7,8-HXCDD	3/3	5.2 J	10 J	8.3	8.3	NTC01SD0400	NV	NV	YES	NSL	No	NA
1,2,3,7,8,9-HXCDD	3/3	6.8 J	11 J	9	9	NTC01SD0400, NTC01SD0400-D	NV	NV	YES	NSL	No	NA
2,3,7,8-TCDD	1/3	0.76 J	0.76 J	0.76	0.49	NTC01SD0100	0.12 [4]	6.3	YES	ASL	No	NA
2,3,7,8-TCDF	3/3	1.3 J	5.1	3.7	3.7	NTC01SD0200	NV	NV	YES	NSL	No	NA
TEQ BIRD	3/3	3	7	5.7	5.7	NTC01SD0200, NTC01SD0400, NTC01SD0400-D	NV	NV	YES	NSL	YES	BIO
TEQ FISH	3/3	1.5	1.6	1.6	1.6	NTC01SD0200	0.12 [4]	13.3	YES	ASL	No	NA
TEQ MAMMAL	3/3	4.1	6.3	5.5	5.5	NTC01SD0400-D	NV	NV	YES	NSL	YES	BIO

TABLE 7-4

ECOLOGICAL COPC SELECTION TABLE - SURFACE SEDIMENT
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average of Detections	Average of All Results[1]	Location with Maximum Concentration	Ecological Screening Level	Ecological Effects Quotient	COPC for Aquatic Organisms[2]	Rationale for COPC Selection[3]	Retained for Food Chain Modeling[2]	Rationale for Food Chain Modeling[3]
TOTAL HPCDD	3/3	250	440	380	380	NTC01SD0200, NTC01SD0400-D	NV	NV	YES	NSL	No	NA
TOTAL HPCDF	3/3	95	180	150	150	NTC01SD0200	NV	NV	YES	NSL	No	NA
TOTAL HXCDD	3/3	41	73	59	59	NTC01SD0400	NV	NV	YES	NSL	No	NA
TOTAL HXCDF	3/3	18	50	35	35	NTC01SD0400	NV	NV	YES	NSL	No	NA
TOTAL PECDF	3/3	5	15	10	10	NTC01SD0200	NV	NV	YES	NSL	No	NA
TOTAL TCDD	3/3	1.2	4.3	2.4	2.4	NTC01SD0100	NV	NV	YES	NSL	No	NA
TOTAL TCDF	3/3	18	77	53	53	NTC01SD0200	NV	NV	YES	NSL	No	NA
Metals (ug/kg)												
ALUMINUM	5/5	1180	11800	6360	6360	NTC01SD0400-D	58030	0.20	NO	BSL	NO	NONBIO
ANTIMONY	4/5	0.45 J	2.1 J	1.3	1.1	NTC01SD0200, NTC01SD0400	2	1.1	YES	ASL	NO	NONBIO
ARSENIC	5/5	2.1	10.1	6.2	6.2	NTC01SD0400-D	9.79	1.0	YES	ASL	YES	BIO
BARIUM	5/5	10.3	101	57.3	57.3	NTC01SD0400-D	NV	NV	YES	NSL	NO	NONBIO
CALCIUM	5/5	29300 J	117000	68500	68500	NTC01SD0500	NV	NV	NO	NUT	NO	NUT
CHROMIUM	5/5	3.2	29.3	16.9	16.9	NTC01SD0400-D	43.4	0.68	NO	BSL	YES	BIO
COBALT	5/5	2.2	12.8	7.5	7.5	NTC01SD0400-D	50	0.26	NO	BSL	NO	NONBIO
COPPER	5/5	34.3	71.3	48.4	48.4	NTC01SD0400-D	31.6	2.3	YES	ASL	YES	BIO
IRON	5/5	5290	28500	17200	17200	NTC01SD0400-D	20000	1.4	YES	ASL	NO	NONBIO
LEAD	5/5	30.1	54	40.4	40.4	NTC01SD0300	35.8	1.5	YES	ASL	YES	BIO
MAGNESIUM	5/5	17800 J	67100	36400	36400	NTC01SD0500	NV	NV	NO	NUT	NO	NUT
MANGANESE	5/5	257	1200	575	575	NTC01SD0400-D	460	2.6	YES	ASL	NO	NONBIO
MERCURY	4/5	0.058 J	0.3 J	0.16	0.13	NTC01SD0200	0.18	1.7	YES	ASL	YES	BIO
NICKEL	5/5	5.6	29.4	17.7	17.7	NTC01SD0400-D	30	0.98	NO	BSL	YES	BIO
POTASSIUM	5/5	297	1760	1020	1020	NTC01SD0400-D	NV	NV	NO	NUT	NO	NUT
SELENIUM	3/5	1.4	2.5	1.8	1.1	NTC01SD0400-D	NV	NV	YES	NSL	YES	BIO
SODIUM	5/5	239	820	507	507	NTC01SD0400-D	NV	NV	NO	NUT	NO	NUT
THALLIUM	1/5	0.63	0.63	0.63	0.31	NTC01SD0400	NV	NV	YES	NSL	NO	NONBIO
VANADIUM	5/5	4.9	31	18.4	18.4	NTC01SD0400-D	NV	NV	YES	NSL	NO	NONBIO
ZINC	5/5	158	400	265	265	NTC01SD0500	121	3.3	YES	ASL	YES	BIO
Miscellaneous Parameters (mg/kg)												
TOTAL ORGANIC CARBON	5/5	2200	54300	27246	27246	NTC01SD0200	NV	NV	NA	NA	NA	NA

The original and field duplicate samples were counted as one sample for frequencies of detection, but were counted as separate samples when determining minimum and maximum detected concentrations.
1 - The average concentrations were calculated by using one-half the detection limit for non-detects.
2 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation.
3 - Rationale for COPC selection/deletion:
4 - The dioxin value is based on food-chain impacts from 2,3,7,8-TCDD and not direct toxicity
ASL = Above Screening Level
BSL = Below Screening Level
NSL = No Screening Level
BIO = Bioaccumulative chemical
NONBIO = Non-Bioaccumulative chemical
NUT = Nutrient
J =The value is considered a quantitative estimate because it was less than the reporting limit or another technical noncompliance.
NA - Not applicable.
NV - No value or value not available
Associated Samples:

NTC01SD0100	NTC01SD0400
NTC01SD0200	NTC01SD0400-D
NTC01SD0300	NTC01SD0500

TABLE 7-5

ECOLOGICAL COPC SELECTION TABLE - SURFACE WATER
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average of Detections	Average of All Results (1)	Location with Maximum Concentration	Ecological Screening Level	Ecological Effects Quotient	COPC for Aquatic Organisms(2)	Rationale for COPC Selection(3)	COPC for Food Chain Modeling(2)	Rationale for COPC Selection(3)
Volatile Organics (ug/L)												
1,1-DICHLOROETHANE	3/5	0.21 J	0.39 J	0.28	0.37	NTC01SW0400	2000	0.0002	NO	BSL	NO	NONBIO
CIS-1,2-DICHLOROETHENE	5/5	0.99 J	1.7	1.3	1.3	NTC01SW0400	1100	0.0015	NO	BSL	NO	NONBIO
VINYL CHLORIDE	2/5	0.25 J	0.34 J	0.3	0.42	NTC01SW0400	4000	0.0001	NO	BSL	NO	NONBIO
Polynuclear Aromatic Hydrocarbons (ug/L)												
BENZO(A)PYRENE	3/5	0.035 J	0.039 J	0.04	0.06	NTC01SW0100	0.014	2.79	YES	ASL	YES	BIO
BENZO(B)FLUORANTHENE	3/5	0.051 J	0.065 J	0.06	0.07	NTC01SW0300-D	NV	NV	YES	NSL	YES	BIO
BENZO(G,H,I)PERYLENE	5/5	0.044 J	0.065 J	0.06	0.06	NTC01SW0300-D	NV	NV	YES	NSL	YES	BIO
CHRYSENE	4/5	0.034 J	0.041 J	0.04	0.05	NTC01SW0300-D	NV	NV	YES	NSL	YES	BIO
FLUORANTHENE	5/5	0.1 J	0.17 J	0.13	0.13	NTC01SW0100	6.16	0.028	NO	BSL	YES	BIO
FLUORENE	5/5	0.021 J	0.036 J	0.03	0.03	NTC01SW0300-D	3.9	0.009	NO	BSL	YES	BIO
INDENO(1,2,3-CD)PYRENE	5/5	0.029 J	0.056 J	0.04	0.04	NTC01SW0300-D	NV	NV	YES	NSL	YES	BIO
PHENANTHRENE	5/5	0.12 J	0.17 J	0.15	0.15	NTC01SW0100, NTC01SW0300-D	3.7	0.046	NO	BSL	YES	BIO
PYRENE	5/5	0.056 J	0.084 J	0.07	0.07	NTC01SW0300-D	0.025	3.36	YES	ASL	YES	BIO
Dioxins/Furans (pg/L)												
1,2,3,4,6,7,8,9-OCDD	1/5	130	130	130	38.5	NTC01SW0500	NV	NV	YES	NSL	NO	NA
TEQ BIRD	1/5	0.013	0.013	0.01	0.0026	NTC01SW0500	3.10E-03 (4)	4	YES	NSL (4)	YES	BIO
TEQ FISH	1/5	0.013	0.013	0.01	0.0026	NTC01SW0500	3.10E-03 (4)	4	YES	NSL (4)	NO	NA
TEQ MAMMAL	1/5	0.039	0.039	0.04	0.0078	NTC01SW0500	3.10E-03 (4)	12.58064516	YES	NSL (4)	YES	BIO
Metals (ug/L)												
ALUMINUM	3/5	224	407	347.17	269	NTC01SW0200	87	4.68	YES	ASL	NO	NONBIO
ANTIMONY	2/5	3.2	3.6	2.8	1.84	NTC01SW0300	30	0.12	NO	BSL	NO	NONBIO
BARIUM	5/5	48.8	52.4	50.4	50.4	NTC01SW0500	5000	0.010	NO	BSL	NO	NONBIO
CALCIUM	5/5	83300	91300	86310	86310	NTC01SW0400	116000	0.787	NO	NUT	NO	NUT
CHROMIUM	2/5	1.2	1.4	1.3	0.89	NTC01SW0500	11	0.127	NO	BSL	YES	BIO
COPPER	3/5	1.5	2.6	1.97	1.46	NTC01SW0500	11.4	0.228	NO	BSL	YES	BIO
IRON	5/5	462	677	571.5	571.5	NTC01SW0100	1000	0.677	NO	BSL	NO	NONBIO
LEAD	3/5	2	2.1	2.07	1.6	NTC01SW0100, NTC01SW0200	15.9	0.132	NO	BSL	YES	BIO
MAGNESIUM	5/5	30400	33700	31700	31700	NTC01SW0400	82000	0.411	NO	NUT	NO	NUT
MANGANESE	5/5	69.2	86	76.73	76.73	NTC01SW0400	1000	0.086	NO	BSL	NO	NONBIO
MERCURY	2/5	0.052	0.052	0.05	0.03	NTC01SW0100, NTC01SW0200	1.1	0.047	NO	BSL	YES	BIO
NICKEL	3/5	1.6	2.6	2.27	1.89	NTC01SW0200	5	0.52	NO	BSL	YES	BIO
POTASSIUM	5/5	3440	3670	3561	3561	NTC01SW0100	53000	0.069	NO	NUT	NO	NUT
SODIUM	5/5	226000	253000	236000	236000	NTC01SW0500	680000	0.372	NO	NUT	NO	NUT
THALLIUM	1/5	5.1	5.1	5.1	2.06	NTC01SW0100	12	0.425	NO	BSL	NO	NONBIO
VANADIUM	5/5	0.73	1.5	1.11	1.11	NTC01SW0100	20	0.075	NO	BSL	NO	NONBIO
ZINC	1/5	18.7	18.7	18.7	11.02	NTC01SW0500	21.6	0.866	NO	BSL	YES	BIO

The original and field duplicate samples were counted as one sample in the frequencies of detection, but wee counted as separate samples when determining minimum and maximum detected concentrations.
1 - The average concentrations were calculated by using one-half the detection limit for non-detects.
2 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation.
3 - Rationale for COPC selection/deletion:
4 - The dioxin value is based on food-chain impacts from 2,3,7,8-TCDD and not direct toxicity
ASL = Above Screening Level
BSL = Below Screening Level
NSL = No Screening Level
BIO = Bioaccumulative chemical
NONBIO = Non-Bioaccumulative chemical
NUT = Essential Nutrient
J =The value is considered a quantitative estimate because it was less than the reporting limit or another technical noncompliance.
NV- Value not available/could not be calculated

Associated Samples:
NTC01SW0100
NTC01SW0200
NTC01SW0300
NTC01SW0300-D
NTC01SW0400
NTC01SW0500

TABLE 7-6
TERRESTRIAL WILDLIFE MODEL NOAEL AND LOAEL EEQS-AVERAGE EXPOSURE FACTORS SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Raccoon NOAEL HQ	Raccoon LOAEL HQ	Kingfisher NOAEL HQ	Kingfisher LOAEL HQ
Semivolatile Organics				
ACENAPHTHENE	1.27E-03	6.36E-04	NA	NA
Polynuclear Aromatic Hydrocarbons				
ACENAPHTHYLENE	1.80E-04	1.80E-05	NA	NA
ANTHRACENE	1.50E-04	1.50E-05	NA	NA
BENZO(A)ANTHRACENE	3.01E-01	3.01E-02	NA	NA
BENZO(A)PYRENE	6.01E-02	6.01E-03	NA	NA
BENZO(B)FLUORANTHENE	1.80E-02	1.80E-03	NA	NA
BENZO(G,H,I)PERYLENE	8.77E-03	8.77E-04	NA	NA
BENZO(K)FLUORANTHENE	4.59E-03	4.59E-04	NA	NA
CHRYSENE	3.54E-01	3.54E-02	NA	NA
DIBENZO(A,H)ANTHRACENE	6.33E-03	6.33E-04	NA	NA
FLUORANTHENE	1.44E-02	7.22E-03	NA	NA
FLUORENE	6.26E-04	3.13E-04	NA	NA
INDENO(1,2,3-CD)PYRENE	7.10E-03	7.10E-04	NA	NA
PHENANTHRENE	9.32E-02	9.32E-03	NA	NA
PYRENE	1.72E-02	1.03E-02	NA	NA
Organochlorine Pesticides/PCBs				
4,4'-DDD	4.55E-03	2.44E-03	1.75E-02	1.41E-02
4,4'-DDE	6.20E-02	3.32E-02	8.85E-01	7.15E-01
4,4'-DDT	4.29E-03	2.30E-03	4.45E-02	3.59E-02
ALPHA-CHLORDANE	2.25E-04	1.13E-04	1.00E-02	2.00E-03
DIELDRIN	2.63E-02	3.10E-04	9.13E-02	8.09E-03
ENDOSULFAN II	2.87E-03	2.87E-04	7.06E-04	7.06E-05
ENDRIN	6.52E-03	6.52E-04	9.52E-01	9.52E-02
GAMMA-CHLORDANE	6.55E-05	3.28E-05	2.46E-03	4.91E-04

TABLE 7-6
TERRESTRIAL WILDLIFE MODEL NOAEL AND LOAEL EEQS-AVERAGE EXPOSURE FACTORS SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Raccoon NOAEL HQ	Raccoon LOAEL HQ	Kingfisher NOAEL HQ	Kingfisher LOAEL HQ
Dioxins/Furans				
2,3,7,8-TCDD	2.35E-02	2.35E-03	1.39E-03	1.39E-04
TEQ MAMMAL	1.95E-01	1.95E-02	NA	NA
TEQ BIRD	NA	NA	1.28E-02	1.28E-03
Metals				
ARSENIC	1.62E-01	8.81E-02	5.09E-01	2.53E-01
CHROMIUM	3.47E-01	1.43E-02	8.63E-01	1.47E-01
COPPER	3.31E+00	2.37E-01	1.45E+01	1.69E+00
LEAD	4.08E-01	1.03E-02	3.31E+00	1.21E-01
MERCURY	1.41E+00	2.81E-01	2.12E+01	2.12E+00
NICKEL	2.11E+00	2.43E-01	1.61E+00	5.82E-01
SELENIUM	6.92E-01	4.19E-01	1.01E+00	5.04E-01
ZINC	9.64E-01	4.82E-01	3.26E+01	3.61E+00

Shaded cells indicate HQ > 1.0
NA = Not applicable; not a COPC for that receptor

TABLE 7-7

ILLINOIS EPA TIER 2 SEDIMENT SCREENING CONCENTRATIONS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Maximum Detected Concentration	Average of All Results[1]	IEPA Tier 2 SSC (µg/kg)[2]	Site Specific IEPA Tier 2 SSC (µg/kg)[3]	WQC	K_{OC}[4]	f_{OC}[5]
SVOCs/PAHs							
ACENAPHTHENE	740 J	730	2080	11994	62 [6]	7100	0.027246
2-METHYLNAPHTHALENE	570 J	440	670	2230	12 [6]	6820	0.027246
ACENAPHTHYLENE	420 J	260	662	1128	15 [6]	2760	0.027246
ANTHRACENE	500	240	960	NV	NV	29500	0.027246
BENZO(A)ANTHRACENE	1700	1200	1600	NV	NV	398000	0.027246
BENZO(A)PYRENE	2000	1400	2500	NV	NV	1020000	0.027246
BENZO(B)FLUORANTHENE	2400	1100	NV	22701	0.6774 [7]	1230000	0.027246
BENZO(G,H,I)PERYLENE	2100	1500	NV	46156	0.4391 [7]	3858000	0.027246
CARBAZOLE	420 J	470	NV	683	7.4 [6]	3390	0.027246
CHRYSENE	2000	1500	2800	NV	NV	398000	0.027246
DIBENZO(A,H)ANTHRACENE	280 J	190	260	NV	NV	3800000	0.027246
FLUORANTHENE	6000	3800	9920	NV	NV	107000	0.027246
FLUORENE	260 J	140	640	NV	NV	13800	0.027246
NAPHTHALENE	660 J	480	2100	3705	68 [6]	2000	0.027246
PHENANTHRENE	3100	1500	2880	2671	3.7 [6]	26500	0.027246
PYRENE	4300	2700	2200	28923	10.11 [7]	105000	0.027246

1 - The average concentrations were calculated by using one-half the detection limit for non-detects.
2 - Values taken from Illinois EPA (2000). Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments.
3 - Values calculated using equation in IEPA (2000): SSC = WQC x K_{OC} x f_{OC}
4 - K_{OC} values from Illinois EPA (2000). Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments when given; otherwise values are from USEPA 2002, "Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites" App. C.
5 - Average site %TOC
6 - Values from IEPA (2006). Derived Water Quality Criteria. http://www.epa.state.il.us/water/water-quality-standards/water-quality-criteria.html
7 - Values are Final Chronic Values (FCVs) for pore water from USEPA (U.S. Environmental Protection Agency). 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. EPA/600/R-02/013. November.

NV = No Value Available
SSC = sediment screening concentration (µg/kg)
WQC = Water Quality Criteria (µg/L)
K_{OC} = organic carbon partition coefficient (L/kg)
f_{OC} = fraction organic carbon measured in the sediment (unitless)

TABLE 7-8

SURFACE WATER PAH FINAL CHRONIC VALUES
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Maximum Detected Concentration (µg/L)	Average of All Results [1] (µg/L)	Average of Detections	Ecological Screening Level (ESL) (µg/L)	Final Chronic Value (FCV)[2] (µg/L)
Polynuclear Aromatic Hydrocarbons					
BENZO(A)PYRENE	0.039 J	0.06	0.04	0.014	0.9573
BENZO(B)FLUORANTHENE	0.065 J	0.07	0.06	NV	0.6674
BENZO(G,H,I)PERYLENE	0.065 J	0.06	0.06	NV	0.4391
CHRYSENE	0.041 J	0.05	0.04	NV	2.042
INDENO(1,2,3-CD)PYRENE	0.056 J	0.04	0.04	NV	0.275
PYRENE	0.084 J	0.07	0.07	0.025	10.11

1 - The average concentrations were calculated by using one-half the detection limit for non-detects.

2 - Values from USEPA (2003). Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. EPA/600/R-02/013. November.

TABLE 7-9

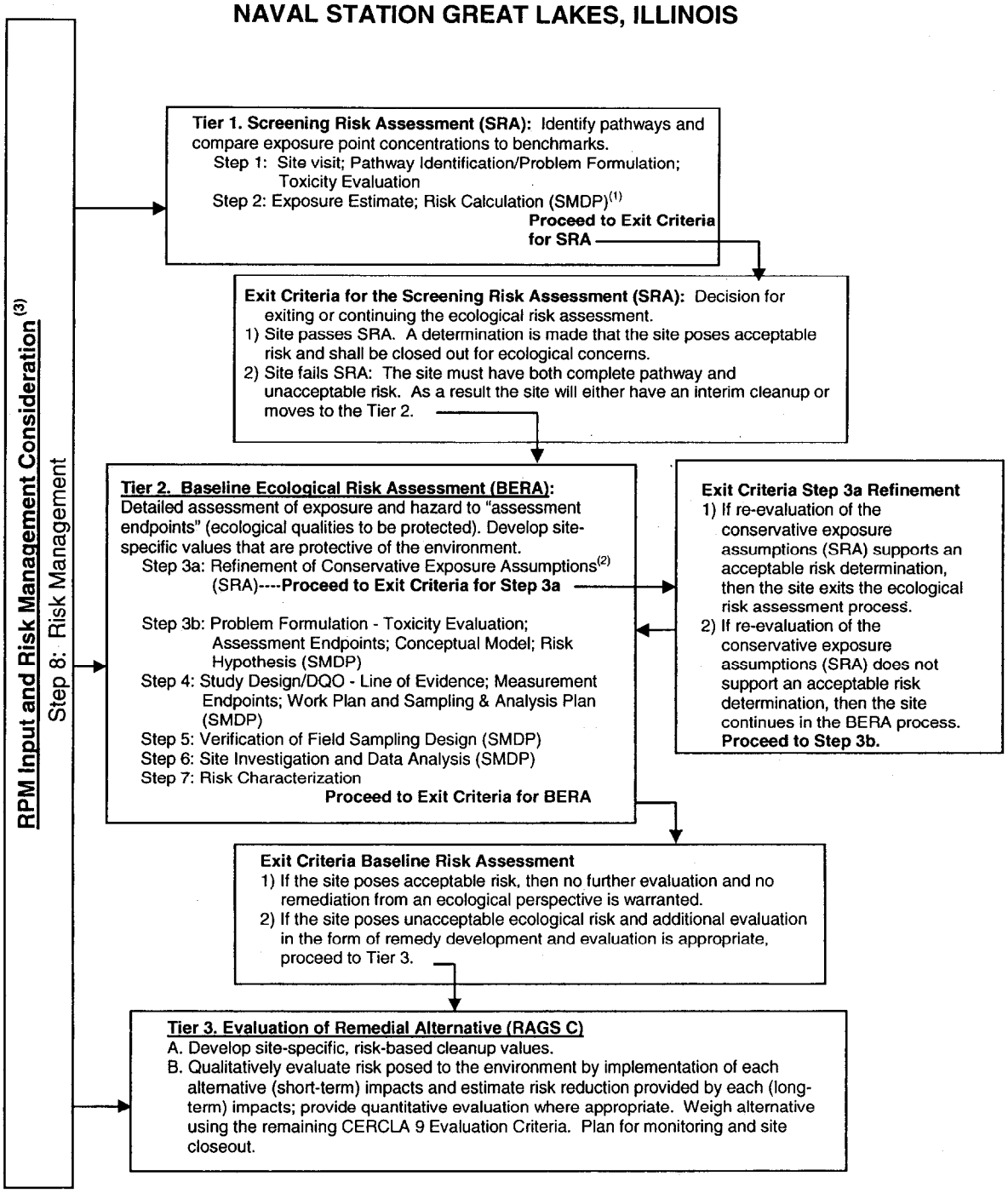
TERRESTRIAL WILDLIFE MODEL NOAEL AND LOAEL EEQS-AVERAGE CONCENTRATIONS
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS

Parameter	Raccoon NOAEL HQ	Raccoon LOAEL HQ	Kingfisher NOAEL HQ	Kingfisher LOAEL HQ	Kingfisher NOAEL HQ (w/ SUF)	Kingfisher LOAEL HQ (w/ SUF)
Metals						
COPPER	4.349E-01	3.109E-02	2.160E+00	2.517E-01	1.439E-02	1.235E-01
LEAD	NA	NA	2.933E-01	1.071E-02	NA	NA
MERCURY	1.584E-01	3.169E-02	2.702E+00	2.702E-01	1.173E-02	1.173E-01
NICKEL	1.915E-01	2.203E-02	1.558E-01	5.628E-02	NA	NA
SELENIUM	NA	NA	3.231E-01	1.616E-01	NA	NA
ZINC	NA	NA	4.096E+00	4.534E-01	1.507E+00	1.668E-01

Shaded cells indicate HQ > 1.0
SUF = Site Use factor = contaminated area / home range
NA = Not applicable; not a COPC for that receptor
Only chemicals with a conservative FCM NOAEL HQ > 1.0 were calculated in the average FCM scenario

FIGURE 7-1

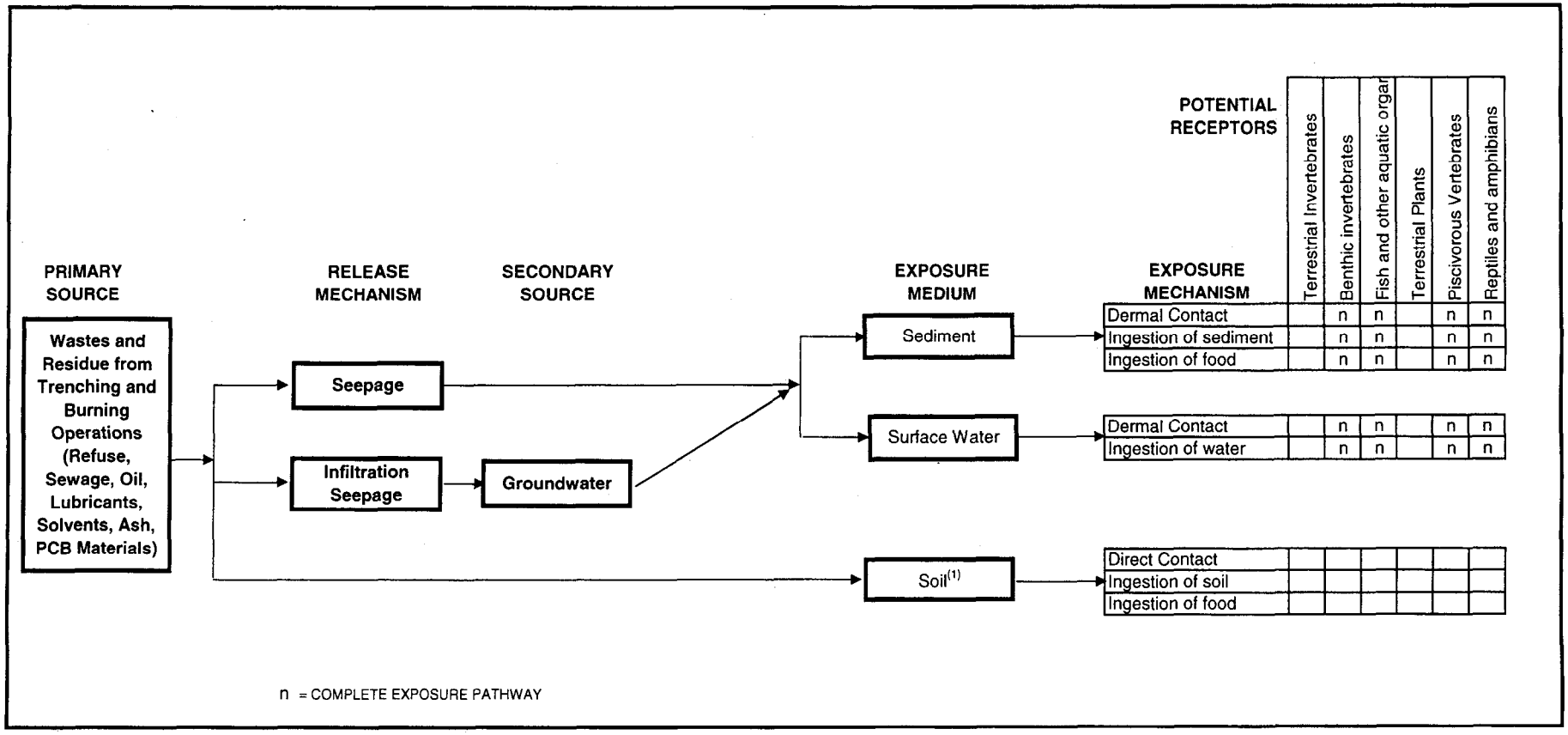
NAVY ECOLOGICAL RISK ASSESSMENT TIERED APPROACH
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS



Notes:
1 See U.S. EPA's 8 Steps ERA Process for requirements for each Scientific Management Decision Point (SMDP).
2 Refinement Includes but is not limited to background, bioavailability, detection frequency, etc.
3 Risk management is incorporated throughout the tiered approach.

FIGURE 7-2

ECOLOGICAL CONCEPTUAL SITE MODEL
SITE 1 - GOLF COURSE LANDFILL
NAVAL STATION GREAT LAKES, ILLINOIS



Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This section provides a summary of the conclusions drawn during the RI and recommendations for future activities related to the site.

8.1 CONCLUSIONS

This section briefly summarizes the conclusions based on RI activities including the results of the subsurface soil, groundwater, surface water, and sediment sampling, the HHRA, and the ERA.

The RI was completed at Site 1 at Naval Station Great Lakes. Site 1 was a landfill that operated between 1942 and 1967 as a trench/burn facility. It received an estimated 1.5 million tons of material total during its years of operation. Types of waste reportedly disposed at the landfill included domestic refuse, sewage sludge, petroleum, oil, and lubricants, solvents, coal ash, and materials contaminated by PCBs. The site now offers recreational activities for Naval Station Great Lakes and the surrounding area as an 18-hole golf course that covers approximately 125 acres. The conclusions are as follows:

- Visual observation of soil from 89 borings was utilized to establish a perimeter outside the active area of the former landfill.

- Low concentrations of VOCs, below TACO criteria, were detected at the site.

- PAHs were detected in the subsurface soil, groundwater, sediment, and surface water at the site with many results exceeding screening criteria. However, interpretation of PAH data must consider that PAHs are common, anthropogenic contaminants frequently detected as a result of wide spread use of petroleum products.

- Pesticides were detected in subsurface soil and sediment samples at the site, with some exceeding screening criteria for ecological receptors.

- Low concentrations of PCBs were detected in several subsurface soil samples and one sediment sample; these concentrations were less than applicable screening criteria.

- Herbicides were detected in one subsurface soil sample at a concentration less than the applicable screening criteria.

- Several metals were detected in the subsurface soil, groundwater, sediment, and surface water samples at concentrations greater than TACO screening criteria, including lead, silver, iron, manganese, and thallium.

- The results of the HHRA indicated that HIs for the subsurface soil, sediment, and surface water were less than 1; however the groundwater for future site residents (the major contributors to risk were iron, manganese, and vanadium). Residential use of this property and subsequent use of the shallow groundwater for drinking water purposes is highly unlikely.

- Carcinogenic risks to a site construction worker were less than the Illinois EPA goal of 1×10^{-6}.

- Carcinogenic risks were within the USEPA target risk range (1×10^{-4} to 1×10^{-6}), but exceeded the Illinois EPA goal of 1×10^{-6} for most other receptors in the subsurface soil, groundwater, sediment, and surface water. Arsenic was the main contributor to risk in groundwater, although the maximum arsenic concentration was less than the USEPA MCL and Illinois EPA Remediation Objective for Class 1 groundwater; PAHs and dioxins/furans were the main contributors in the other media. As discussed in Section 6, these risk estimates were subject to significant uncertainties.

- The ERA concluded that the overall risk to ecological receptors in Skokie Ditch is small.

8.2 RECOMMENDATIONS

The following future actions are recommended for this site:

- Based on the results of the RI, no additional investigation at the site is warranted.

- A feasibility study for the site should be prepared. Based on the results of the RI, it is unlikely that active remedial actions will be required, and the alternatives evaluated in the feasibility study should include the presumptive remedy for landfills. In general, the presumptive remedy includes maintaining the surface cover (golf course), establishing a perimeter groundwater monitoring protocol, and instituting land use controls for use of the site land and groundwater.

- The fire fighter training unit, located within the boundaries of Site 1, should be incorporated in to the feasibility study and subsequent decision documents.

REFERENCES

AQTESOLV for Windows, 1996. Registered trademark of Geraghty & Miller, Inc. Distributed by HydroSolve, Inc., 2303 Horseferry Court, Reston, VA, 22091

Bouwer, H., and Rice, R. C., 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells", Water Resources Research, Vol. 12, No. 3, pp. 424-428.

Brown & Root Environmental, 1996. Technical Memorandum for Support of the Relative Risk Evaluation at Various Activities, Southern Division Naval Facilities Engineering Command, North Charleston, South Carolina, March.

Buchman, M. F., 1999. NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration. http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html

C.H. Guernsey & Company, 2002. Final Environmental Assessment, Willow Glen Golf Course, Reconstruction of the Back-nine Holes. November.

C.H. Guernsey & Company, 2003. Subsurface Environmental Investigation Report. February.

Cubbage, J., D. Batts, and S. Breidenbach. 1997. Creation and Analysis of Freshwater Sediment Quality Values in Washington State. Washington State Department of Ecology. Publication No. 97-323a. July.

Dames & Moore, 1991. Technical Memorandum on the Remedial Investigation Verification Step for the Naval Training Center Great Lakes, NEESA 21-011, Volume 2A, Main Report and Appendices A-F, Naval Energy and Environmental Support Activity, Port Hueneme, California 93043, November.

Department of the Navy. 1999. Navy Policy for Conducting Ecological Risk Assessments. Memo from Chief of Naval Operations to Commander, Naval Facilities Engineering Command, 05 April 1999. Department of the Navy, Washington, DC.

Department of the Navy, 2001, Conducting Human Health Risk Assessments under the Environmental Restoration Program. Ser N453E/1U595168. Washington, D.C.

Department of Navy, 2001. Environmental Assessment, Implementation of an Integrated Natural Resources Management Plan at Naval Training Center, Great Lakes, Illinois. Southern Division, Naval Facilities Engineering Command. North Charleston, South Carolina. February.

Department of the Navy, 2004. Navy Final Policy on the Use of Background Chemical Levels.

Eisler, Ronald. 1987. Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. US Department of Interior - Fish and Wildlife Service. Biological Report 85 (1.11). May

Fetter, C. W., 1980. Applied Hydrogeology 2nd Edition, Merrill Publishing Company, A Bell & Howell Information Company, Columbus, Ohio.

Freeze, R. A., and Cherry, John A., 1979, "Groundwater", Prentice-Hall, Inc., Englewood Cliffs, NJ, 604 pp.

Great Lakes Naval Training Center, July 2000. Restoration and Maintenance Plan for Pettibone Creek Ravine. Survey report prepared by Environmental Quality Management, Inc.

Illinois EPA, August 1997. Evaluation of Illinois Sieved Stream Sediment Data, 1982-1995. Bureau of Water. IEPA/BOW/97-016.

Illinois EPA, 2000. Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments. Draft, Update 2. Office of Chemical Safety. September 21.

Illinois EPA. 2006. Title 35: Environmental Protection Subtitle C: Water Pollution Chapter I: Pollution Control Board Part 302 Water Quality Standards. March.

Illinois EPA. 2006. Listing of Derived Water Quality Criteria Pursuant to 35 Ill. Adm. Code 302, Subpart F. June.

Illinois EPA, 2007. Tiered Approach to Corrective Action Objectives (TACO). Illinois Environmental Protection Agency, Bureau of Land, available at http://www.ipcb.state.il.us/documents/dsweb/Get/Document-54263, accessed online June.

Jones, D.S., R.N. Hull, and G.W. Suter II, 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Risk Assessment Program, Health Sciences Division, Oak Ridge, Tennessee. ES/ER/TM-95/R4. November.

Long, Edward, R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management, Vol. 19, No. 1, pp. 81-97.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger, 2000. "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems." Archives of Environmental Contamination and Toxicology, Vol. 39, pp. 20-31.

Naval Facilities Engineering Service Center, 1998. Procedural Guidance for Statistically Analyzing Environmental Background Data, Naval Facilities Engineering Command.

Oak Ridge National Laboratory. 1998. Biota Sediment Accumulation Factors for Invertebrates: Review and recommendations for the Oak Ridge Reservation. BJC/OR-112. August.

Ontario Ministry of Environment and Energy (OMOE), 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. August.

Rogers, Golden & Halpern, 1986. Initial Assessment Study, Naval Complex Great Lakes, Illinois. March.

Sample, B.E., D.M. Opresko, and G.W. Suter II. June 1996. Toxicological Benchmarks for Wildlife. Oak Ridge National Laboratory. ES/ER/TM-86/R3.

Suter, G.W. II. and C.L. Tsao. June 1996. Toxicological Benchmarks for Screening Potential Constituents of Concern for Effects on Aquatic Biota. Environmental Sciences Division, Oak Ridge National Laboratory. ES/ER/TM-96/R2.

Tetra Tech NUS, Inc. (TtNUS), 1998. Technical Memorandum Site Sampling in Support of Relative Risk Evaluation at Various Activities, Addendum 1. August.

TtNUS, 2003. Quality Assurance Project Plan, Site 7 - RTC Silk Screening Shop, Site 17 - Pettibone Creek & Boat Basin, Remedial Investigation & Risk Assessment, Naval Training Center Great Lakes, Great Lakes Illinois. June.

TtNUS, 2007. Quality Assurance Project Plan, Site 1 – Willow Glen Golf course, Remedial Investigation & Risk Assessment, Naval Station Great Lakes, Great Lakes Illinois. February.

TolTest, Inc, 2004. Delivery Order Closure Report Split-Spoon Soil Sampling and Soil Disposal, Willow Glen Golf Course, Naval Station Great Lakes, Great Lakes Illinois. March.

United States Environmental Protection Agency (USEPA), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. EPA/540/G-89/004. Office of Solid Waste and Emergency Response (OSWER), Washington, D.C. October.

USEPA, 1989. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response, Washington, D.C.

USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. Washington, D.C.

USEPA, 1993a. Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA, 1993b. Interim Report on Data and Methods for Assessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Risks to Aquatic Life and Associated Wildlife. Office of Research and Development. EPA/600/R-93/055. March.

USEPA, 1993c. Water Quality Guidance for the Great Lakes System and Correction: Proposed Rules. Federal Register. 58(72) 20802-21047. April.

USEPA, 1993d. Region 5 Standard Operating Procedure for Validation of CLP Organic Data. USEPA Region 5 Environmental Sciences Division, Central Regional Laboratory, Chicago, IL, August.

USEPA, 1993e. Region 5 Standard Operating Procedure for Validation of CLP Inorganic Data. USEPA Region 5 Environmental Sciences Division, Central Regional Laboratory, Chicago, IL, September.

USEPA, 1993f. Wildlife Exposure Factors Handbook. Office of Research and Development. Washington, D.C. EPA/600/R-93/187a. December.

USEPA, 1996a. ECO Update, Ecotox Thresholds. U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. Intermittent Bulletin, Volume 3, Number 2. EPA540/F-95/038. January.

USEPA, 1996b. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128. Office of Solid Waste and Emergency Response. Washington, D.C.

USEPA, 1996c. Assessment and Remediation of Contaminated Sediment (ARCS) Project Benchmarks. Fox, R.G., and M. Tuchman. 1996. *J. Great Lakes Res.* 22:493-494. January.

USEPA, 1997a. Exposure Factors Handbook. EPA/600/P-95/002Fa. Office of Health and Environmental Assessment, Washington, D.C.

USEPA. 1997b. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. Environmental Response Team. June 5.

USEPA. 1998. Final Guidelines for Ecological Risk Assessment. Effective April 30.

USEPA, 1999. U. S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, October.

USEPA, 2000c. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, Third Edition. Office of Water (4305), Washington, D.C. EPA 823-B-00-007. November.

U.S.EPA, 2001. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments).

USEPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Washington, D.C., December.

USEPA, 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10. Washington, D.C., December.

USEPA, 2003a. Ecological Screening Levels. USEPA Region 5 (http://www.epa.gov/reg5rcra/ca/edgl.htm). August.

USEPA (U.S. Environmental Protection Agency). 2003b. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. EPA/600/R-02/013. November.

USEPA, 2004a. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final Guidance.

USEPA, 2004b. Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA-540/R-94/013. Office of Solid Waste and Emergency Response, Washington, DC, February.

USEPA, 2004c. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Volume 1:National Sediment Quality Survey: Second Edition. Office of Science and Technology. Washington, D.C. EPA 823-R-04-007. November.

USEPA, 2005a. Ecological Soil Screening Level for Dieldrin, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-57. March.

USEPA, 2005b. Ecological Soil Screening Level for Chromium, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-66. March.

USEPA, 2005c. Ecological Soil Screening Level for Lead, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-70. March.

USEPA, 2005d. Ecological Soil Screening Level for Arsenic, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-62. March.

USEPA. 2005e. Region III BTAG Screening Levels. Region III Biological Technical Assistance Group. Philadelphia, PA. October.

USEPA, 2006a. National Recommended Water Quality Criteria: 2002. Office of Water.

USEPA, 2006c. Region 9 Preliminary Remediation Goals (PRGs), USEPA Region 9, 75 Hawthorne Street, San Francisco, California, 94105, July.

USEPA, 2006d. Ecological Soil Screening Level for Copper, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-68. July.

USEPA, 2007. Ecological Soil Screening Level for Nickel, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-76. March.

U.S. Navy, 1995. Integrated Natural Resources Plan, Great Lakes Naval Training Center. Naval Training Center, Great Lakes, Illinois. October.

U.S. Navy, 2000. Flora and fauna survey, Naval Training Center Great Lakes, Illinois. Survey report prepared by Environmental Quality Management, Inc. August.

Van den Berg, M., L. Birnbaum, A.T.C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. kennedy, T. Kubiak, J.C. Larsen, F.X. Rolaf van Leeuwen, A.K. Djien Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski. 1998. Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife. Environmental Health Perspective, Volume 106, No. 12, December.