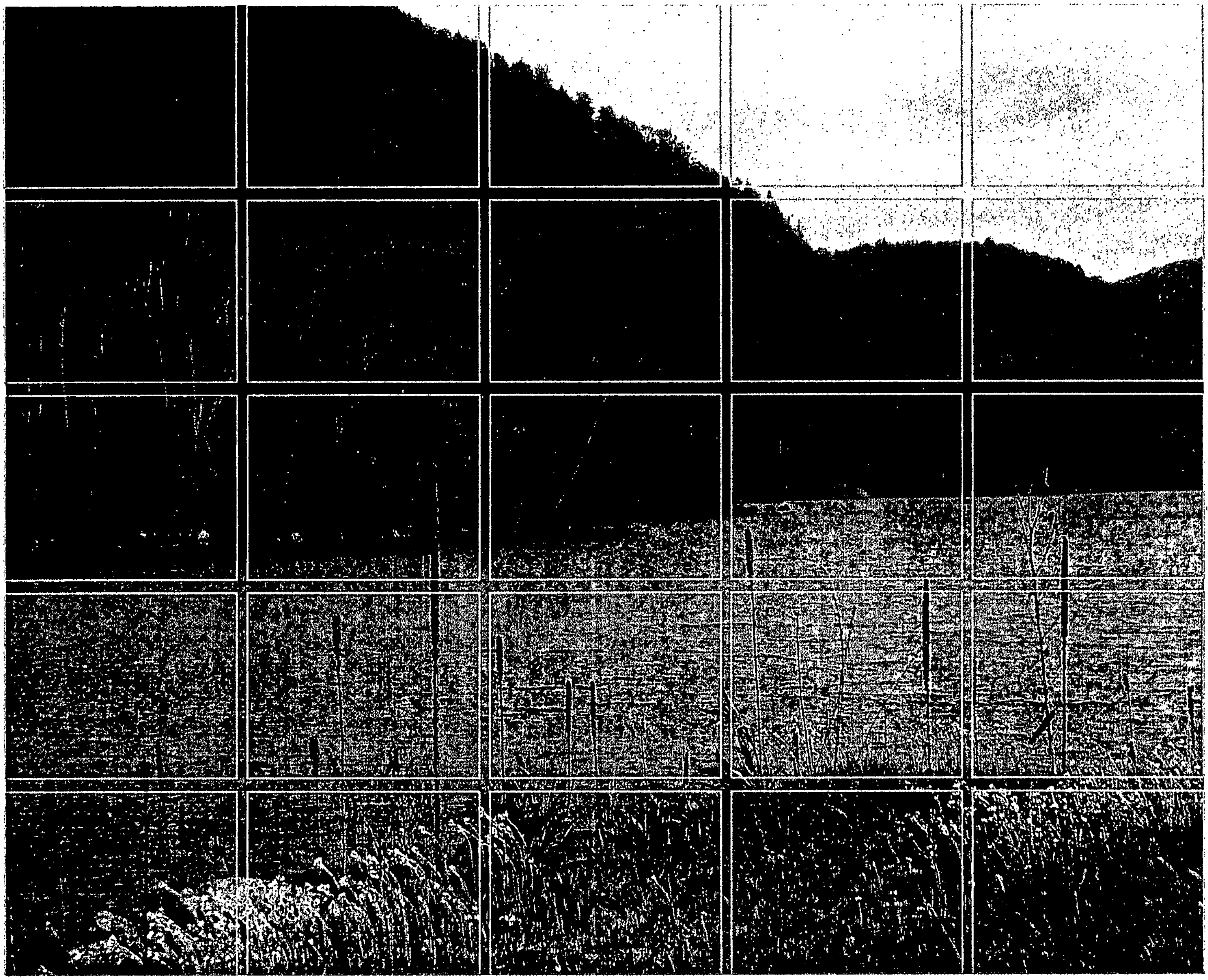


# Site Characterization Status Report

Yankee Nuclear Power Station
Site Closure Project
Rowe, Massachusetts

4 June 2004

ERM
399 Boylston St.
Boston, MA 02116
(617) 646-7800

www.erm.com

*Delivering sustainable solutions in a more competitive world*

Yankee Atomic Electric Company

# Site Characterization Status Report

## Yankee Nuclear Power Station
## Site Closure Project
## Rowe, Massachusetts

4 June 2004

John W. McTigue, P.G., LSP
*Principal-in-Charge*

Gregg A Demers

Gregg A. Demers, P.E., LSP
*Project Manager*

**Environmental Resources Management**
399 Boylston Street, 6th Floor
Boston, Massachusetts 02116
T: 617-646-7800
F: 617-267-6447

*LIST OF ACRONYMS* V

*EXECUTIVE SUMMARY* ES-1

*1.0 INTRODUCTION* 1

*1.1 BACKGROUND* 1

*1.2 PURPOSE AND SCOPE* 1

*2.0 METHODS* 3

*2.1 QUALITY ASSURANCE AND SAMPLING PLANS* 3
- 2.1.1 *Quality Assurance Project Plan (QAPP)* 3
- 2.1.2 *Media-Specific Field Sampling Plans* 4

*2.2 SOIL SAMPLING* 4
- 2.2.1 *Approach* 4
- 2.2.2 *QA/QC Samples & Procedures* 6
- 2.2.3 *Soil Sampling Methods* 6
- 2.2.4 *OHM Parameters* 7
- 2.2.5 *Modifications to Soil FSP* 8

*2.3 GROUNDWATER SAMPLING* 9
- 2.3.1 *Approach* 9
- 2.3.2 *QA/QC Samples & Procedures* 10
- 2.3.3 *Groundwater Gauging Methods* 10
- 2.3.4 *Groundwater Sampling Methods* 11
- 2.3.5 *OHM Parameters* 11
- 2.3.6 *Radiological Parameters* 12
- 2.3.7 *Modifications to July 2003 Groundwater FSP* 13
- 2.3.8 *Modifications to March 2004 Groundwater FSP* 13

*2.4 SEDIMENT SAMPLING* 14
- 2.4.1 *Approach* 14
- 2.4.2 *QA/QC Samples & Procedures* 14
- 2.4.3 *Sediment Sampling Methods* 14
- 2.4.4 *OHM Parameters* 15
- 2.4.5 *Modifications to Sediment FSP* 16

*2.5 DATA VALIDATION* 16

3.0 RESULTS 18

3.1 DATA VALIDATION 18

3.2 SOIL 19
- 3.2.1 Field Screening Results 19
- 3.2.2 Laboratory Analytical Data 20

3.3 GROUNDWATER 22
- 3.3.1 Gauging Data 22
- 3.3.2 Field Parameters Monitored During Low-Flow Sampling 25
- 3.3.3 Field Screening Results 25
- 3.3.4 Laboratory Analytical Data 25

3.4 SEDIMENT 28
- 3.4.1 Field Screening Data 28
- 3.4.2 Laboratory Analytical Data 28

4.0 CONCLUSIONS AND NEXT STEPS 31

4.1 CONCLUSIONS 31

4.2 NEXT STEPS 32

5.0 REFERENCES 34

## *List of Tables*

| | |
|---|---|
| *Table 1* | *Summary of Soil Analytical Screening Data* |
| *Table 2* | *Summary of Validated Soil Analytical Data – Background* |
| *Table 3* | *Summary of Validated Soil Analytical Data – Industrial Area* |
| *Table 4* | *Summary of Validated Soil Analytical Data – Non-Industrial Area* |
| *Table 5* | *Summary of Groundwater Gauging Data – 26 February 2004* |
| *Table 6* | *Summary of Vertical Hydraulic Gradient Data – 26 February 2004* |
| *Table 7* | *Summary of Geochemical Parameter Data* |
| *Table 8* | *Summary of Groundwater Analytical Screening Data* |
| *Table 9* | *Summary of Validated Groundwater Analytical Data – Summer and Fall 2003, Winter 2004* |
| *Table 10* | *Summary of Validated Sediment Analytical Data Background (400 series)* |
| *Table 11* | *Summary of Validated Sediment Analytical Data - Sherman Reservoir (002-041)* |
| *Table 12* | *Summary of Validated Sediment Analytical Data - Wheeler Brook (100 series)* |
| *Table 13* | *Summary of Validated Sediment Analytical Data - Deerfield River (200 series)* |
| *Table 14* | *Summary of Validated Sediment Analytical Data - West Storm Drain Ditch (300 series)* |

## *List of Figures*

| | |
|---|---|
| *Figure 1* | *Locus Map* |
| *Figure 2* | *Site Layout* |
| *Figure 3* | *Soil Sample Locations (Industrial and Non-Industrial Area) and Results Exceeding MCP Reportable Concentrations* |
| *Figure 4* | *Soil Sample Locations (Non-Industrial Area) and Results Exceeding MCP Reportable Concentrations* |
| *Figure 5* | *Groundwater Monitoring Well Locations and Results Exceeding MCP Reportable Concentrations* |
| *Figure 6* | *Shallow Groundwater Elevation Contour Map* |
| *Figure 7* | *Intermediate (Shallow) Groundwater Elevation Contour Map* |
| *Figure 8* | *Intermediate (Deep) Groundwater Elevation Contour Map* |
| *Figure 9* | *Bedrock Groundwater Elevation Contour Map* |
| *Figure 10* | *Sediment Sample Locations and Results Exceeding Background Reportable Concentrations* |
| *Figure 11* | *Background Sediment Sample Locations* |

## *Appendices*

| | |
|---|---|
| *Appendix A* | *Soil Field Sampling Plan* |
| *Appendix B* | *Groundwater Field Sampling Plan* |
| *Appendix C* | *Fall 2003 Groundwater Sampling Program;*<br>*March 2004 Groundwater Field Sampling Plan* |
| *Appendix D* | *Sediment Field Sampling Plan* |
| *Appendix E* | *Boring Logs* |
| *Appendix F* | *Soil Sampling Logs* |
| *Appendix G* | *Sediment Sampling Logs* |

## *LIST OF ACRONYMS*

| | |
|---|---|
| bgs | Below Ground Surface |
| CSA | Comprehensive Site Assessment |
| DCE | 1,1-Dichloroethene |
| DQO | Data Quality Objectives |
| DRO | Diesel Range Organics |
| EPA | United States Environmental Protection Agency |
| EPH | Extractable Petroleum Hydrocarbons |
| ERM | Environmental Resources Management |
| FID | Flame Ionization Detector |
| FSPs | Field Sampling Plans |
| FSS | Final Status Survey |
| GC/MS | Gas Chromatography/Mass Spectrometry |
| GPS | Global Positioning System |
| GRO | Gasoline Range Organics |
| IC | Ion Chromatography |
| ISFSI | Integrated Spent Fuel Storage Installation |
| IWPA | Interim Wellhead Protection Area |
| J | Estimated Result |
| LCS | Laboratory Control Sample |
| MA DEP | Massachusetts Department of Environmental Protection |
| MCL | Maximum Contaminant Levels |
| MCP | Massachusetts Contingency Plan |
| mg/kg | milligram per killogram |
| mg/L | milligram per liter |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicates |
| NRC | Nuclear Regulatory Commission |
| OHM | Oil and/or Hazardous Materials |
| ORP | Oxidation Reduction Potential |
| PAH | Polynuclear Aromatic Hydrocarbons |
| PARCCS | Precision, Accuracy, Representativeness, Comparability, Completeness and Sensitivity |
| PCBs | Polychlorinated Biphenyls |
| PP13 | Priority Pollutant 13 Metals |
| ppm | Parts per Million |
| QA/QC | Quality Assurance/Quality Control |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| R | Rejected Result |
| RC | Reportable Concentrations |
| RCA | Radiologically Controlled Area |

| | |
|---|---|
| RCGW | Reportable Concentrations Groundwater |
| RCS | Reportable Concentrations Soil |
| RNF | Release Notification Form |
| RSCS | Radiation Safety and Control Services, Inc. |
| RTN | Release Tracking Number |
| SCFA | Southeast Construction Fill Area |
| SCPP | Site Closure Project Plan |
| SDG | Sample Delivery Group |
| SMCL | Secondary Maximum Contaminant Level |
| STL | Severn Trent Laboratory |
| SVOCs | Semi-Volatile Organic Compounds |
| TG&B | TG&B Marine Services |
| TOC | Total Organic Carbon |
| TPH | Total Petroleum Hydrocarbons |
| U | Not Detected |
| UJ | Not Detected/Estimated Result |
| USGen NE | USGen New England, Inc. |
| VC | Vapor Container |
| VOCs | Volatile Organic Compounds |
| VPH | Volatile Petroleum Hydrocarbons |
| YAEC | Yankee Atomic Electric Company |
| YNPS | Yankee Nuclear Power Station |

# *EXECUTIVE SUMMARY*

On behalf of Yankee Atomic Electric Company (YAEC), Environmental Resources Management (ERM) prepared this Site Characterization Status Report (Status Report) for the Yankee Nuclear Power Station (YNPS) located at 49 Yankee Road in Rowe, Massachusetts. This Status Report is designed to inform interested stakeholders on the progress of site characterization efforts, results obtained and next steps planned toward completing a comprehensive site-wide environmental quality assessment. These efforts augment past and ongoing investigations being conducted to satisfy applicable regulatory requirements, with the goal of establishing that site environmental quality is suitable for future unrestricted use, or completing remedial actions to achieve that goal, where feasible. YAEC's goals for the site, and strategy to achieve those goals, are detailed in the Site Closure Project Plan (SCPP), updated 31 March 2004 (YAEC, 2004a).

This Status Report summarizes the methods employed and results obtained from assessment of site soil, groundwater and sediment quality completed between June 2003 and March 2004. Specific activities included:

- Collection and analysis of soil samples for hazardous constituents (oil and/or hazardous materials, OHMs, as defined under the Massachusetts Contingency Plan, MCP) at 102 locations to depths of up to 15 feet.

- Expansion of the groundwater monitoring well network deeper into overburden and bedrock and collection of soil and groundwater samples from 51 locations across the site for analysis of OHM and radiological constituents.

- Collection and analysis of sediment samples for OHM at 59 locations in Sherman Reservoir, Wheeler Brook, the West Storm Drain Ditch and the Deerfield River.

The rationale for selection of sampling locations was based on the review of past results, YNPS historical operations and decommissioning efforts as presented in the Baseline Environmental Report (ERM, 2004a) issued in May 2004.

The findings from this phase of site characterization include:

Soil

- Several isolated and localized areas have been identified that contain OHM exceeding MCP Reportable Concentrations (RCs). These impacts appear to be associated with incidental releases from past operations at YNPS. These impacts include polynuclear aromatic hydrocarbons (PAHs) near a parking area, polychlorinated biphenyls (PCBs) near the Transformer Yard, dioxin near a former incinerator, petroleum in a parking area adjacent to the Visitor's Center, lead in soil at a former shooting range and beryllium near the Interim Spent Fuel Storage Area (ISFSI) and the former cooling water discharge structure.

Groundwater

- 1,1-Dichloroethene (DCE) was detected in one intermediate well (MW-105C) slightly above MCP RCs.
- Volatile Petroleum Hydrocarbons (VPH ) (C5-C8 Aliphatics) were detected in one intermediate well (MW-101C) above MCP RCs.
- PCBs were detected in three wells at levels slightly above MCP RCs; one shallow overburden (MW-5), one intermediate overburden (MW-107D) and one bedrock (MW-107B) well.
- Tritium is the only site-related nuclide detected in groundwater in the intermediate overburden (MW-107C) at concentrations exceeding the United States Environmental Protection Agency (EPA) Maximum Contaminant Levels (MCLs) for drinking water. Tritium has been detected below MCLs in shallow overburden wells and in one bedrock well.

Sediment

- Impacts to site sediment at levels greater than three times background concentrations included total petroleum hydrocarbons (TPH), copper and lead in Sherman Reservoir, PAHs and lead in the West Storm Drain Ditch and copper in the Deerfield River. OHM were not detected in Wheeler Brook sediment at greater than three times background concentrations.

Next steps in the site characterization process include:

- Further assess or remove areas of soil impact. File a Release Notification Form (RNF) with the Massachusetts Department of Environmental Protection (MA DEP) for site soil impacts exceeding RCs where removal actions do not reduce impacts below RCs.
- Complete site soil characterization in portions of the site not previously accessible.
- Expand the groundwater monitoring well network and further characterize site groundwater quality for DCE, VPH, PCBs and tritium. File a Release Notification with MA DEP for confirmed OHM in groundwater exceeding RCs not previously reported.
- Implement additional sediment sampling to further define the nature and extent of OHM.
- Develop and implement characterization of surface water in water bodies adjacent to the site.
- Evaluate characterization data, develop plans for additional characterization, if necessary, and prepare characterization status report.

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

On behalf of Yankee Atomic Electric Company (YAEC), Environmental Resources Management (ERM) has prepared this Site Characterization Status Report (Status Report) for the Yankee Nuclear Power Station (YNPS) located at 49 Yankee Road in Rowe, Massachusetts. The YNPS property is shown in Figure 1. The layout of the developed portion of the property is shown in Figure 2.

The YNPS commercial power generation ceased in 1992 and YNPS is in the process of being decommissioned. YAEC has released a Site Closure Project Plan (SCPP) (YAEC, 2004a) to the public and various regulatory and non-regulatory stakeholders. The SCPP outlines the process by which YAEC will complete the decommissioning, environmental investigation, environmental remediation, site closure and post-closure transfer of YAEC property.

In May 2004, YAEC released a Baseline Environmental Report (Baseline Report, ERM, 2004a) to provide interested stakeholders with a general understanding of site physical characteristics, YNPS historical operations, decommissioning efforts and an overview of site environmental conditions based on past and on-going investigation efforts. The Baseline Environmental Report presents the basis for the design and implementation of a comprehensive site-wide assessment of site soil, groundwater, surface water and sediment for radiological and hazardous constituents. The first phase of the site-wide characterization program was completed between June 2003 and March 2004 and is the subject of this Status Report.

## 1.2 PURPOSE AND SCOPE

This Status Report summarizes the methods employed and results obtained from assessment of site soil, groundwater and sediment quality completed between June 2003 and March 2004. The goal of the site-wide characterization effort is to establish that site environmental quality is suitable for future unrestricted use and/or to support remedial actions necessary to achieve that goal, where feasible. These efforts were conducted in coordination with, and intended to supplement, those ongoing to satisfy applicable state and federal regulatory requirements. The scope of this phase of investigation included:

- Collection and analysis of soil samples for hazardous constituents (oil and/or hazardous materials, OHMs, as defined under the Massachusetts Contingency Plan, MCP) at 102 locations to a maximum depth of up to 15 feet.

- Expansion of the groundwater monitoring well network deeper into overburden and bedrock and the collection and analysis of soil samples and groundwater samples from 51 monitoring wells for OHM and radiological constituents.

- Collection and analysis of sediment samples for OHM at 59 locations in Sherman Reservoir, Wheeler Brook, the West Storm Drain Ditch and the Deerfield River.

The rationale for selection of sampling locations was based on the review of past results, YNPS historical operations, YNPS use and storage of radioactive and hazardous materials and wastes, and decommissioning efforts as presented in the Baseline Report issued in May 2004.

The radiological investigations on site are being developed to support a Final Status Survey (FSS) designed to satisfy Nuclear Regulatory Commission (NRC) regulations for License Termination. Groundwater monitoring activities at the site are being performed in accordance with YNPS procedures to meet this objective. Results of the 2003 groundwater investigations are provided in the Hydrogeologic Report of 2003 Supplemental Investigation (Hydrogeologic Report, YEAC, 2004b).

# 2.0 *METHODS*

## 2.1 *QUALITY ASSURANCE AND SAMPLING PLANS*

### 2.1.1 *Quality Assurance Project Plan (QAPP)*

A Quality Assurance Project Plan (QAPP) has been developed for the assessment and remediation activities and defines Quality Assurance/Quality Control (QA/QC) procedures to be followed in support of site characterization investigations at the YNPS (Gradient, 2003). The QAPP documents investigation procedures, analytical methods, sample management protocols, documentation procedures, data validation requirements and QA/QC review procedures that are applicable to on-going site characterization investigations. The QAPP was prepared to fulfill the practical requirements of Region I, United States Environmental Protection Agency (EPA) – New England Compendium QAPP Guidance, October, 1999 Final, Attachment A – Region I, EPA New England QAPP Manual, Draft, September 1998 (EPA, 1998a). The QAPP is intended to be a program document applicable to ongoing non-radiological site characterization activities at YNPS.

The procedures described in the QAPP are implemented to ensure that environmental samples are collected, transported and analyzed such that the Data Quality Objectives (DQOs)of the investigation are met and comply with EPA Region I and Massachusetts Department of Environmental Protection (MA DEP) requirements. The defined procedures also are intended to satisfy the Presumptive Certainty criteria set forth in MA DEP's QA/QC Guidelines for the Acquisition and Reporting of Analytical Data in Support of Response Actions for the MCP, 22 May 2003 (MA DEP, 2003). The QAPP includes procedures and defines criteria to assure precision, accuracy, representativeness, comparability, completeness and sensitivity (PARCCS) of the analytical data generated in support of site closure.

QA/QC guidelines for the assessment of radiological parameters are presented in YNPS procedures *AP-8601, Ground and Well Water Monitoring Program for the YNPS; DP-8603, Radiochemical Data Quality Assessment;* and *DP-9745, Ground Water Level Measurement and Sample Collection in Observation Wells.* These procedures outline the overall program for collection and validation of radiological groundwater data to support decommissioning activities at the YNPS.

### 2.1.2 *Media-Specific Field Sampling Plans*

ERM worked with YAEC and Gradient Corporation to develop media-specific Field Sampling Plans (FSPs) for each sampling event describing the approach and methods employed for sample collection, rationale for selection of sample locations and frequency of collection, field screening methods and QA/QC protocols for meeting QAPP DQOs. The following FSPs are included in Appendix A through D of this Status Report for soil, groundwater and sediment sampling events conduct between June 2003 and March 2004:

- Soil FSP (ERM, 2003a), YNPS, 49 Yankee Road, Rowe, Massachusetts, October 2003 (Appendix A).
- Groundwater FSP (ERM, 2003b), YNPS, 49 Yankee Road, Rowe, Massachusetts, July 2003 and addendum (Appendix B).
- Revised March 2004 Groundwater FSP (ERM, 2004b), YNPS, 49 Yankee Road, Rowe, Massachusetts, 15 March 2004 (Appendix C).
- Sediment FSP (ERM, 2003c), YNPS, 49 Yankee Road, Rowe, Massachusetts, August 2003 (Appendix D).

Modifications to sample locations and numbering were made during sample collection in response to field conditions. A summary of the actual sample identifications and associated analytical parameters are tabulated and included in each of the above appendices in front of the FSPs (Tables A-1, B-1, C-1, C-2 and D-1).

## 2.2 SOIL SAMPLING

### 2.2.1 *Approach*

Soil samples were collected during two sampling events completed between June 2003 and March 2004:

- Shallow targeted and grid sampling (up to 15 feet below ground surface (bgs) in depth) based on review of the YNPS past operations (outlined in the Baseline Report and the Soil FSP).
- Deep soil sampling conducted during advancement of borings for installation of monitoring wells.

### 2.2.1.1 *Shallow Soil Sampling*

Shallow soil samples (i.e., ground surface to up to 15 feet bgs) were collected from 102 locations from 14 October through 30 October 2003 (Figures 3 and 4). A summary of the soil sample locations, depths and laboratory analyses at each location is provided in the Soil FSP (Appendix A and Table A-1). Decommissioning activities at YNPS prevented access to approximately 70 soil sampling locations within the Industrial Area. Collection of samples at these locations will be conducted in 2004 under the existing Soil FSP when site activities permit safe access to the proposed locations.

Background soil samples were collected manually from undisturbed areas in the vicinity of the site. Background locations were intended to be representative of naturally-occurring conditions. At each background sample location, two soil samples were collected for analysis; one surface sample from the 0 to 6 inch bgs and one deeper sample from either 1 to 2 feet bgs or 2 to 3 feet bgs.

Site soil quality was evaluated using a combination of grid and target sampling methods (locations displayed on Figure 2):

- Grid Sampling – Samples were collected based on a grid-sampling scheme, utilizing a grid spacing of approximately 100 feet, to provide site-wide characterization.
- Targeted Sampling – Additional "targeted samples" were collected in the vicinity of potential source areas or where prior sampling suggested a potential for impact to site soil.

### 2.2.1.2 *Soil Sampling During Well Installation*

In the summer of 2003, YAEC initiated the expansion of the YNPS groundwater monitoring well network in support of the decommissioning activities. A total of 17 additional wells were installed, seven of which extended into upper bedrock (the MW-100 series). This work was initiated in support of requirements for monitoring of radiological constituents in groundwater. In addition, the investigation program was designed to support characterization of OHM in soil and groundwater. During the advancement of soil borings, continuous soil cores of the overburden were collected from ground surface to bedrock, visually inspected, classified and selected samples screened for radiological and non-radiological constituents. Borings logs describing soil classification and field screening results are included in Appendix E.

### 2.2.2 *QA/QC Samples & Procedures*

QA/QC samples including 10 field duplicates, four equipment blanks, 10 matrix spikes (MS)/matrix spike duplicates (MSD) and trip blanks were collected in accordance with the QAPP and FSP. Temperature blanks were issued by the analytical laboratory and re-submitted at a rate of one blank per cooler. ERM and YNPS personnel performed sample collection and logging. YNPS personnel performed sample processing and shipping.

### 2.2.3 *Soil Sampling Methods*

#### 2.2.3.1 *Shallow Soil Sampling*

A combination of Geoprobe and manual sampling techniques were used for collection of shallow target and grid samples:

- Shallow soil samples were collected using a hand auger to a depth of up to 3 feet bgs. Samples were generally collected and submitted for analysis from the 0 to 6 inches bgs and the 2 to 3 feet bgs interval from each location.
- Soil samples were generally collected to a depth of 15 feet bgs or to refusal using a Geoprobe. Samples were collected and submitted for analysis from 0 to 6 inches bgs, 2 to 3 feet bgs and the one foot interval above the water table or from a depth of 14 to 15 feet bgs (or refusal, whichever occurred first). Geoprobe soil samples were collected under ERM's oversight by Geosearch Environmental Contractors, Inc. of Sterling, MA. All Geoprobe sample locations were reviewed for subsurface structures prior to subsurface advancement of equipment.

During sample collection, the portion of the core to be submitted for laboratory analysis was field screened for volatiles using a flame ionization detector (FID) and MA DEP's jar headspace screening method, visually inspected and the soil stratigraphy classified. Field screening results were used to select samples for laboratory analysis of volatile organic compounds (VOCs). Soil samples yielding elevated field-screening results (greater than or equal to 5 parts per million (ppm)) were submitted for laboratory analysis of VOCs. Visual observations were logged on soil sampling forms. Field observations, including sampling location descriptions, soil stratigraphy and field-screening results were recorded on the soil sampling forms and are included in Appendix F.

### 2.2.3.2 *Soil Sampling During Well Installation*

Soil samples collected from borings advanced for installation of monitoring wells were field screened for total VOCs using a FID and the MA DEP's jar headspace screening method. Field screening results are presented on the boring logs included in Appendix E. Soil samples yielding elevated field-screening results (greater than or equal to 5 ppm) were submitted for laboratory analysis including:

- VOCs by gas chromatography/mass spectrometry (GC/MS), SW-846 Method 8260B (both low-level, de-ionized water-preserved, and medium-level, methanol preserved, soil samples were collected in accordance with SW846 Method 5035 VOC sampling procedures).

Screening of soil core or radionuclides was conducted by YNPS personnel at the YNPS on-site laboratory. Composite soil samples representative of each soil core collected from the borehole were analyzed for gamma emitting radionuclides using a gamma spectrometer. Radiological results are presented in the Hydrogeologic Report (YEAC, 2004b).

### 2.2.4 *OHM Parameters*

Soil samples collected under the Soil FSP in 2003 were submitted for laboratory analysis of OHM by one or more of the following methods:

- VOCs by GC/MS, SW-846 Method 8260B from locations with elevated FID (both low-level, de-ionized water-preserved, and medium-level, methanol preserved, soil samples were collected in accordance with SW846 Method 5035 VOC sampling procedures).
- Semi-volatile organic compounds (SVOCs) by GC/MS, SW-846 Method 8270C.
- Polychlorinated biphenyls (PCBs) by GC, SW-846 Method 8082.
- Diesel range organics (DRO) by GC, SW-846 Method 8015B.
- Gasoline range organics (GRO) by GC, SW-846 Method 8015B.
- Priority pollutant 13 metals (PP13 Metals) by SW-846 6010B/7000. PP13 metals consist of antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium and zinc.
- Herbicides by SW-846 Method 8151.
- Boron and Lithium by SW-846 6010B.

- Hydrazine by ion chromatography (IC).
- Dioxin.

Severn Trent Laboratory (STL)-Denver performed the hydrazine analyses, and STL-Knoxville performed the dioxin analyses. Northeast Laboratory Services, located in Waterville, Maine, conducted the remainder of the analyses for non-radiological parameters.

### 2.2.5 *Modifications to Soil FSP*

Soil sampling was completed in accordance with the Soil FSP with the following exceptions noted in response to field conditions:

- Sample locations deeper than six inches bgs were approved by the YNPS Safety Oversight Department and the Shift Supervisor prior to initiation of sampling activities.
- At locations where groundwater was encountered at depths shallower than the proposed sampling interval, sample depths were modified to the one foot interval above the water table.
- At locations where refusal occurred, sample depths were modified to the one-foot interval just above refusal.
- Due to ongoing decommissioning activities at YNPS, several proposed sample locations were moved to facilitate accessibility. YNPS personnel approved all modifications to sample locations prior to collection. Approximately 70 soil sample locations within the Industrial Area were not sampled due to ongoing decommissioning activities and will be sampled when safe access permits.
- Sample locations were recorded using a Global Positioning System (GPS) unit.
- Soil samples were screened by YNPS personnel for radiological parameters in accordance with YNPS screening procedures prior to shipment.
- Supplemental soil samples were collected from borings near the Visitor's Center in response to visual and olfactory observations (see Section 3.2.1.1).

## 2.3 GROUNDWATER SAMPLING

### 2.3.1 *Approach*

Groundwater samples were collected during advancement of borings for the installation of monitoring wells and during multiple sampling events (Groundwater FSPs, Appendices B and C).

#### 2.3.1.1 *Groundwater Sampling During Well Installation*

During the advancement of soil borings for installation of monitoring wells, groundwater samples were collected from water bearing intervals during the Summer 2003 drilling program.

#### 2.3.1.2 *Groundwater Monitoring Events*

Three quarterly rounds of groundwater monitoring were completed between June 2003 and March 2004, described below as the Summer 2003, Fall 2003 and Winter 2004 events. The Summer 2003 event was completed as a "baseline" monitoring round and included 46 monitoring wells (existing and new), two site potable water wells and Sherman Spring, which were analyzed for a comprehensive suite of radiological and OHM parameters. Details are described in the Groundwater Field Sampling Plan, July 2003 (Appendix B and Table B-1). Subsequent monitoring events in Fall 2003 and Winter 2004 (Appendix C and Table C-1, C-2) included all 51 site monitoring wells for radiological parameters and selected wells for OHM parameters where detections were reported in the previous round. Monitoring well locations are shown on Figure 5. The sampling events are described below:

*Summer 2003*

- A total of 34 monitoring wells, installed between 1977 and 2002, two site potable wells and Sherman Spring were sampled from 14 July through 7 August 2003 for radiological and OHM parameters.
- A total of 12 monitoring wells installed during the Summer 2003 drilling program were sampled from 8 through 12 September 2003 for radiological and OHM parameters. The remaining five monitoring wells installed during the Summer 2003 drilling program were sampled in Winter 2004.

*Fall 2003*

- Accessible site monitoring wells were sampled for radiological parameters. Monitoring wells CB-3, CB-4, CW-2, MW-5, MW-102C and MW-105C were re-sampled for OHM parameters during the Fall 2003 round.

*Winter 2004*

- Accessible site monitoring wells were sampled for radiological parameters and boron. Monitoring wells CB-4 , CW-10 , CB-9 , MW-5 , MW-6 , CW-2 , CB-3 , OSR-1 , MW-100A , MW-101C , MW-102A/C , MW-103B/C and MW-105C were re-sampled for OHM parameters during the Winter 2004 round. Monitoring wells MW-104B/C and MW-107B/C/D were sampled for "baseline" OHM parameters.

### 2.3.2 *QA/QC Samples & Procedures*

QA/QC samples collected to support each of the non-radiological groundwater sampling events are summarized below:

- Summer 2003 - Three field duplicate samples, three MS/MSDs samples and three equipment blanks.
- Fall 2003 - One field duplicate sample.
- Winter 2004 - Three field duplicate samples and two MS/MSDs.
- Temperature blanks were issued by the analytical laboratory, and re-submitted at a rate of one blank per cooler during all sampling events.
- Trip blanks were submitted for each cooler containing samples for VOCs or GRO analysis.

### 2.3.3 *Groundwater Gauging Methods*

Water levels were gauged in Summer and Fall 2003 prior to groundwater sampling using electronic water level meters. This gauging was conducted to support groundwater sampling that was completed over a period of several weeks and provided a preliminary estimate of water table elevations and groundwater flow relationships. A synoptic gauging event (i.e., gauging conducted during consistent atmospheric conditions) was conducted at YNPS on 26 February 2004 to more accurately assess groundwater flow patterns beneath the site. Groundwater contours for shallow, intermediate-shallow, intermediate-deep and bedrock intervals are displayed in Figures 6, 7, 8 and 9, respectively

### 2.3.4 *Groundwater Sampling Methods*

### 2.3.4.1 *Groundwater Screening During Well Installation*

Groundwater samples were collected for screening for radiological and OHM parameters from water bearing intervals during the Summer 2003 drilling program. Samples were collected using a stainless steel bailer after purging three well volumes to permit collection of groundwater representative of formation water.

Screening for VOCs was conducted on groundwater samples collected from selected water-bearing zones encountered within the boreholes advanced for expansion of the site monitoring well network during the Summer 2003 investigation program. A total of 41 groundwater samples were collected from eight boreholes and analyzed for VOCs by GC/MS, SW-846 Method 8260B during the well installation program.

### 2.3.4.2 *Sampling Monitoring Wells*

Monitoring wells were sampled using low-flow sampling techniques, using either peristaltic or submersible pumps, depending on the depth to water at each location. At each location, field parameters, including temperature, conductivity, pH, dissolved oxygen, turbidity and oxidation reduction potential (ORP), were monitored until stabilization was achieved. YSI or Horiba water quality instruments were used for collection of field parameters excluding turbidity, which was measured using a LaMotte 2020 Turbidimeter. Equipment was calibrated in accordance with manufacturer recommendations, and equipment was decontaminated prior to, and following, sample collection.

### 2.3.5 *OHM Parameters*

Groundwater samples collected via low-flow sampling during the Summer 2003, Fall, 2003 and Winter 2004 sampling events were submitted for laboratory analysis of one or more of the following parameters:

- VOCs by GC/MS, SW-846 Method 8260B.
- SVOCs by GC/MS, SW-846 Method 8270C.
- PCBs by GC, SW-846 Method 8082.
- Herbicides by GC, SW-846 Method 8151;
- DRO by GC, SW-846 Method 8015B.
- GRO by GC, SW-846 Method 8015B.

- PP13 Metals by SW-846 6010B/7000.
- Boron and Lithium by SW-846 6010B.

Analysis of the parameters listed above was completed during the initial sampling round at each well and constituted the "baseline" sampling round.

During the Winter 2004 round, analysis of DRO and GRO was replaced with the following analyses:

- Extractable Petroleum Hydrocarbons (EPH) – Standard by MADEP Method MADEP-EPH-98-1
- Volatile Petroleum Hydrocarbons (VPH) – Standard by MADEP Method MADEP-VPH-98-1.

Northeast Laboratory Services, of Waterville, Maine, conducted all non-radiological analyses with the exception of EPH/VPH, which was analyzed by Alpha Analytical Laboratory of Westborough, Massachusetts.

In accordance with the Solid Waste Regulations, nine wells (CFW-1, CFW-2, CFW-3, CFW-4, CFW-5, CFW-6, CFW-7, CB-5 and OSR-1 ) in the vicinity of the Southeast Construction Fill Area (SCFA, Figure 2) were sampled and analyzed as detailed in the Groundwater FSP (Appendix B) in order to satisfy requirements of the Massachusetts Solid Waste Regulations for annual monitoring around the landfill. The results from this sampling were provided to the MA DEP in the 2003 Annual Landfill Monitoring Report – SCFA, MA DEP Tracking Number 01-253-008 dated 14 October 2003 (YAEC, 2003a).

### 2.3.6 *Radiological Parameters*

Radiological samples were collected following collection of samples for OHM analysis. Samples were submitted for analysis for one or more of the following four categories:

- Category A – Gamma (including Co-60, Cs-134/137, Mn-54, Nb-94, Sb-125, Eu-152/154/155 and Ag-108m).
- Category B – Tritium and Gross Alpha/Beta.
- Category C – C-14, Fe-5, Ni-63 and Sr-90.
- Category D – Am-241, Pu-238, Pu-240/239, Pu-241 and Cm-243/244.

Framatome ANP Environmental Laboratory, part of the Areva Group, of Westborough, Massachusetts conducted all radiological analyses.

Screening for radiological parameters was conducted by YNPS personnel on groundwater samples collected from water-bearing zones encountered within the boreholes advanced for installation of monitoring wells. Groundwater samples were analyzed for tritium by liquid scintillation and for gamma-emitting radionuclides by gamma spectrometry. Radiological results are presented in the Hydrogeologic Report.

### 2.3.7 *Modifications to July 2003 Groundwater FSP*

Groundwater sampling was completed in accordance with the July 2003 Groundwater FSP with the following exceptions noted in response to field conditions:

- Monitoring wells pre-selected for QA/QC sampling were modified to reflect the order in which monitoring wells were sampled; (e.g., FD-003 at MW-103B rather than MW-102B as proposed in Groundwater FSP).
- Proposed monitoring well locations MW-101A, MW-106A and MW-106B were not installed due to modifications to the 2003 drilling program, and therefore, were not sampled.
- Monitoring wells MW-101C, MW-102C, MW-103C, MW-104C, MW-105C, MW-107B/C/D were added to the 2003 drilling program. Monitoring wells MW-101C, MW-102C, MW-103C and MW-105C were sampled for radiological and OHM parameters. Monitoring well locations MW-104B/C, MW-107B/C/D were sampled for radiological parameters only.

### 2.3.8 *Modifications to March 2004 Groundwater FSP*

Modifications to the March 2004 Groundwater FSP in response to field conditions were as follows:

- Monitoring well MW-107C was not analyzed for EPH/VPH and monitoring well MW-100A was not sampled due to access restrictions.

## 2.4 SEDIMENT SAMPLING

### 2.4.1 *Approach*

Sediment samples were collected at 59 locations from Sherman Reservoir, Wheeler Brook and the West Storm Drain between 12 to 14 August 2003 and from the Deerfield River on 24 September 2003. A summary of the sediment sample locations, depths and laboratory analyses at each location is provided in the Sediment FSP (Appendix D).

Sediment cores were collected in Sherman Reservoir to a depth of up to 18 inches bgs, or until refusal, along five transects parallel to the shoreline at: 25 feet, 50 feet, 100 feet, 200 feet and 500 feet (Figure 10). Samples were submitted for analysis from the 0 to 4 inch bgs core interval at each location. A sample was also collected for analysis from the bottom 4 to 6 inch bgs core interval along the 50-foot transect. The remaining core samples were stored in a freezer at YNPS. Surficial sediment samples (i.e., 0 to 4 inches bgs) were collected from Wheeler Brook, the West Storm Drain Ditch and the Deerfield River (Figure 10). Surficial sediment samples were also collected from the northern end of Sherman Reservoir (i.e., background samples) (Figure 11).

### 2.4.2 *QA/QC Samples & Procedures*

QA/QC samples including three field duplicates, one equipment blank, three MS/MSD and trip blanks were collected in accordance with the QAPP and FSP. Temperature blanks were issued by the analytical laboratory and re-submitted at a rate of one blank per cooler.

### 2.4.3 *Sediment Sampling Methods*

Sediment samples from Sherman Reservoir were collected under ERM's oversight by TG&B Marine Services (TG&B) of Falmouth, MA. Samples were collected in compliance with YNPS Procedure *DP-8124 Collection of Pond Sediment Samples for Site Characterization.* A boat-mounted Vibracore System was used to direct push or vibrate the core sampler into the sediment. The core sampler consisted of a two-foot stainless steel casing with a removable two-inch diameter polycarbonate sleeve. A plug was placed at the top of the polycarbonate sleeve to prevent sediment from extending above the sleeve height. When the Vibracore System was unsuccessful a direct-push technique was used. After coring, the sleeve was removed from the casing, capped, labeled and brought to shore for sampling. On shore, the portion of the core to be sampled was extracted and the remaining core was capped, placed in a sealed plastic bag and stored in a freezer at YNPS. The portion of the core to be submitted for laboratory analysis was cut open, visually inspected and sediment stratigraphy classified. Visual observations were recorded on sediment sampling forms (Appendix G). Samples submitted for VOC analysis were removed prior to core inspection.

Sediment samples from the Wheeler Brook, the West Storm Drain and the Deerfield River were collected manually by ERM personnel. Samples were collected in compliance with YNPS Procedure *DP-8120 Collection of Site Characterization and Site Release Samples.* A stainless steel trowel and/or hand auger were used to obtain each sediment sample from a depth of 0 to 4 inches bgs . Sampling was performed at downstream locations first, working upstream to reduce the potential for suspended sediments to impact the sample results. Visual observations of sediment type were recorded on sediment sampling forms (Appendix G).

Dedicated sampling equipment was used where feasible. Reused sampling equipment was decontaminated prior to, and following, sample collection in accordance with the YNPS QAPP.

### 2.4.4 *OHM Parameters*

Sediment samples were submitted for laboratory analysis of OHM for one or more of the following methods:

- VOCs by GC/MS, SW-846 Method 8260B (both low-level, deionized water-preserved, and medium-level, methanol preserved, sediment samples were collected at each sample location in accordance with SW846 Method 5035 VOC sampling procedures.
- SVOCs by GC/MS, SW-846 Method 8270C.
- PCBs by GC, SW-846 Method 8082.
- DRO by GC, SW-846 Method 8015B.
- GRO by GC, SW-846 Method 8015B.
- PP13 Metals by SW-846 6010B/7000. Chromium species were identified for detections.
- Boron and Lithium by SW-846 6010B.
- Hydrazine by IC.
- Total Organic Carbon (TOC).

STL-Denver performed the hydrazine analyses, and STL-Connecticut performed the TOC analyses. Northeast Laboratory Services, located in Waterville, Maine, conducted the remainder of the OHM analyses.

### 2.4.5 *Modifications to Sediment FSP*

Sediment sampling was completed in accordance with the Sediment FSP with the following exceptions noted in response to field conditions:

- Sediment sample locations pre-selected for QA/QC sampling were modified to reflect the order in which sampling occurred (e.g., duplicate not collected from SD-003 because location was not sampled).
- Multiple sampling techniques were utilized in Sherman Reservoir to adapt to varying bottom conditions. The Vibracore System was used at most locations. Direct-push technique, utilizing a tripod-base gravity push core, was used at locations where the Vibracore System was unsuccessful.
- Sediment samples from five locations in Sherman Reservoir (SD-001, SD-003, SD-005, SD-006 and SD-007) were not collected due to refusal, attributed to rip-rap near the dam.
- Multiple cores were collected from locations selected for QA/QC samples (MS/MSD and Field Duplicates). The recovered sample material was combined and homogenized in the field prior to submitting the samples for analysis.
- Actual sample collection locations varied from the proposed locations in several instances due to field conditions and attempts to locate depositional areas. Figures 10 and 11 show the locations of the actual sediment sample locations.

## 2.5 *DATA VALIDATION*

ERM conducted Modified Tier I and Tier II data validation of soil, groundwater and sediment data collected for analysis of OHM at the YNPS. The validation included a review for deliverable requirements and a reduced validation for technical compliance for the samples collected at the YNPS. The deliverables were validated for completeness consistent with the requirements of the FSP and the QAPP for Site Closure, YNPS, 29 September 2003 (Gradient, 2003).

The data have been validated according to the protocols and quality control requirements of the analytical methods in accordance with the following guidance documents:

- EPA, Region I Tiered Organic and Inorganic Data Validation Guidelines (EPA, 1993)
- EPA, Region I Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses (VOCs and SVOCs only) (EPA, 1996).
- EPA, Region I, EPA-New England Compendium of Quality Assurance Project Plan Guidance, Draft Final (EPA, 1998a).
- EPA, 1998, Region I Data Validation Functional Guidelines for Evaluating Organic Analyses, (PCBs only) (EPA, 1998b).
- EPA, Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses (EPA, 1998c).
- Final QAPP (Gradient, 2003).

QA/QC guidelines for the assessment of radiological parameters are presented in YNPS procedures *AP-8601, Ground and Well Water Monitoring Program for the YNPS; DP-8603, Radiochemical Data Quality Assessment;* and *DP-9745, Ground Water Level Measurement and Sample Collection in Observation Wells.* These procedures outline the overall program for collection and data validation of radiological groundwater samples to support decommissioning activities at the YNPS.

# 3.0 RESULTS

## 3.1 DATA VALIDATION

Soil, groundwater and sediment data validation results from the Tier I and Tier II review are presented in the Data Validation – Soil (ERM, 2004c), Data Validation – Groundwater (ERM, 2004d) and Data Validation – Sediment (ERM, 2004e) reports. The data validation reports present Quality Control (QC) outliers that resulted in qualification of the data for each Sample Delivery Group (SDG). Data qualifiers assigned to the analytical results during the data validation and included on the analytical data tables presented in this Status Report include:

- Estimated result (J).
- Rejected result (R). The associated value is unusable for project decisions.
- Not detected (U). The associated value is the sample detection/reporting limit.
- Result is not detected and is considered estimated (UJ) at the detection/reporting limit.

Soil, groundwater and sediment analytical data reported for OHM parameters were technically in compliance with the analytical methods and QAPP criteria, with exceptions discussed in the individual data validation reports. Following the data validation review, some compounds were rejected and considered unusable for project decisions. The majority of the affected results were herbicide or SVOC non-detects rejected due to very low Laboratory Control Sample (LCS) recoveries. In addition, numerous VOCs were rejected due to initial and continuing calibration exceedances. Additional data results were qualified as estimated (i.e., J or UJ) for miscellaneous QC exceedances, or were qualified U due to blank contamination. All data and qualifiers presented in this Status Report are considered final.

In accordance with the QAPP, Gradient Corporation is currently completing a data usability assessment of the analytical data in preparation for the site risk assessment.

Data validation results for the radiological assessment of groundwater were presented in the Data Assessment Report for Third Quarter (YAEC, 2003b) and the Data Assessment Report Fourth Quarter (YAEC, 2003c).

These reports, completed by Radiation Safety and Control Services, Inc. (RSCS), include data validation results and results of QA/QC review.

## 3.2 SOIL

### 3.2.1 *Field Screening Results*

### 3.2.1.1 *Shallow Soil Sampling*

Soil field screening results (i.e., headspace readings) were generated during collection of shallow samples (up to 15 feet bgs in depth) and deep samples (greater than 15 feet) collected during advancement of borings for installation of monitoring wells.

The following table summarizes FID readings at shallow soil boring locations where elevated headspace readings (greater than 5 ppm) were measured:

| Soil Boring Location | Interval | Jar Headpsace Readings |
|---|---|---|
| SB-048 | 0-5′ | 89.7 |
| SB-156 | 0-6″ | 0 |
| | 2′-3′ | 180 |
| | 5′-6′ | 199.8 |
| | 6′-6.8′ | 0 |

Sampling personnel noted a petroleum odor from samples SB-156 at depths of 2-3 feet bgs and 5-6 feet bgs where FID readings were elevated and at SB-157 at 2-3 feet bgs, where FID readings were not elevated (i.e., less that 5 ppm). ERM submitted additional samples for analysis of VOCs, SVOCs and GRO from SB-156 at 5-6 feet bgs to further characterize the nature of potential impact to soil (results presented in Section 3.2.2).

### 3.2.1.2 *Well Installation*

Field screening results for VOCs from soil samples collected from the boreholes advanced during the Summer 2003 well installation program are presented on the boring logs included in Appendix E. The following table summarizes FID readings at soil boring locations where elevated headspace readings (greater than 5 ppm) were measured:

| Boring Location | Interval (feet) | Jar Headpsace Readings |
|---|---|---|
| MW-102B | 15-20 | 6.3 [1] |
| | 20-25 | 6.1 [1] |
| | 85-86 | 6.3 [1] |
| | 86-88 | 4.9 [1] |
| | 88-90 | 7.1 [1,2] |
| MW-104B | 163-175 | 5.4 [1,2] |
| | 176-179 | 7.0 [1,2] |

[1] Elevated FID readings were attributed to melting of the polyethylene sleeve containing the sample due to heat generated from friction between the sampling device and the formation during boring advancement.

[2] Submitted for VOC analysis.

A total of three soil samples were submitted for analysis of VOCs based on the FID results. VOCs and inorganic elements were detected at concentrations below RCs. The soil screening data are presented in Table 1.

Soil samples collected during advancement of borings for installation of monitoring wells were also screened for radiological parameters by YNPS personnel. Composite soil samples representative of each soil core collected were analyzed for gamma emitting radionuclides using a gamma spectrometer. Radiological results are presented in the Hydrogeologic Report (YEAC, 2004b). No radiological parameters were detected above the minimum detected activity level.

### 3.2.2 *Laboratory Analytical Data*

*Evaluation Criteria*

Soil analytical results were compared to MCP Reportable Concentrations (RCs), concentration thresholds that trigger notification to MA DEP of a release of OHM to the environment. There are two categories of RCs applicable to site soil that are based on classified groundwater use at the site:

- Reporting Category for Soil – 1 (RCS-1) criteria apply to soil results from locations within the geographic boundaries of the portion of the site categorized as GW-1, i.e., the Interim Wellhead Protection Area (IWPA) for the public supply well on site (Figures 2 and 3).
- Reportable Category for Soil – 2 (RCS-2) apply to soil samples from the remainder of the site outside of the IWPA.

The soil sample locations corresponding to each reporting category, and results exceeding RCs are identified on Figures 3 and 4.

*Background Areas*

A total of 23 soil samples, which included three duplicate samples, were collected from ten background soil sample locations during the soil sampling event. Background soil sample locations are shown on Figures 3 and 4. Validated background soil analytical results are summarized in Table 2. None of the background samples exhibited OHM at levels exceeding RCs. None of the background soil samples were analyzed for VOCs because FID field screening results were not greater than or equal to 5 ppm.

*Industrial Areas*

A total of 83 shallow soil samples, which included three duplicate samples, were collected from 36 locations within the Industrial Area of the YNPS. Industrial Area soil sample locations are shown in Figure 3. Validated Industrial Area soil analytical results are summarized on Table 3. Results exceeding RCs are highlighted.

RCS-1 criteria were exceeded for dioxin at SB-020 and beryllium at SB-001. The detection of dioxin at SB-020 could be associated with operation of former incinerators at the plant and will require further evaluation, which is expected to be conducted in June 2004. The detection of beryllium at SB-001, which is located south of the ISFSI, is not related to known site activities.

RCS-2 criteria were exceeded for PCBs at SB-032. The detection of PCBs at SB-032 is located in an area targeted for soil excavation and is consistent with the findings of the Phase II - Comprehensive Site Assessment (CSA) (ERM, 2003d) that addressed a release of PCB-containing paint chips.

PCB impacts to soil in this portion of the site will be addressed under future remedial actions for soil planned for 2005.

*Non-Industrial Areas*

A total of 124 soil samples, which included four duplicate samples, were collected from 56 locations within the Non-Industrial Areas of the YNPS. Non-Industrial Area soil sample locations are shown in Figures 3 and 4. Validated Non-Industrial Area soil analytical results are summarized on Table 4. Results exceeding RCs are highlighted.

RCS-1 criteria was exceeded for total petroleum hydrocarbons (TPH) at locations SB-157 and SB-158, which are located within the Visitor Center Parking Lot and may be associated with incidental releases of petroleum from vehicle use on site. Additional soil samples will be collected during Summer 2004 in the Visitors Center Parking Lot to assess the nature and extent of TPH impacts.

RCS-2 criteria were exceeded for benzo(a)anthracene, benzo(a)pyrene and benzo(b)fluoranthene at SB-105, beryllium at SB-111 and lead at SB-135. The detection of PAHs at SB-105 may be associated with incidental releases of petroleum from vehicle use on site. The detection of lead at SB-135 may be related to residual impact from the Old Shooting Range. The detection of beryllium at SB-111 located near the cooling water discharge structure will require further evaluation. Additional soil samples will be collected from each of these areas during Summer 2004 to verify and assess the nature and extent of the detections.

## 3.3 GROUNDWATER

### 3.3.1 Gauging Data

Groundwater has been identified in three intervals beneath the YNPS as detailed in the Hydrogeologic Report (YAEC, 2004b) and as described below:

- Shallow Interval – Monitoring wells completed within the sandy outwash deposits (also referred to as stratified drift).
- Intermediate Interval – Monitoring wells completed within discrete sand lenses in both the upper and lower portions of glaciolacustrine sediments underlying the surficial aquifer.
- Bedrock Interval – Monitoring wells completed within fractured crystalline bedrock.

Groundwater gauging data collected during low-flow sampling events conducted in the Fall 2003 and Winter 2004 sampling events were presented in the Hydrogeologic Report (YAEC, 2004b). The groundwater gauging data presented in the Hydrogeologic Report was not collected during a synoptic event and may not be representative of groundwater flow beneath the site. Therefore, groundwater elevation data was collected during a synoptic well-gauging event on 26 February 2004 and is presented in Table 5. This table also presents the completion interval (i.e., shallow, intermediate, or bedrock) for each monitoring well. Groundwater contours for shallow, intermediate-shallow, intermediate-deep and bedrock intervals are displayed in Figures 6, 7, 8 and 9, respectively.

The direction of shallow groundwater flow beneath the YNPS trends in a predominantly northwesterly direction beneath the Radiologically Controlled Area (RCA) and changes to a westerly direction beneath the northeast portion of the Industrial Area (Figure 6). A groundwater flow divide exists in the area of the SCFA as shallow groundwater on the extreme eastern portion of the YNPS flows eastward towards a tributary to Wheeler Brook.

Groundwater flow in the upper portions of the glaciolacustrine unit appears to flow in a more northerly direction, towards a potential discharge location adjacent to Sherman Reservoir (Figure 7). Although Figure 7 is based on only three data points (MW-102A, MW-105C and MW-107C, all completed in sand lenses at a depth of about 30 feet bgs), a more northerly flow direction in the upper glaciolacustrine unit is consistent with a suspected source and observed distribution of tritium in groundwater.

Groundwater flow in deeper portions of the glaciolacustrine unit is depicted in Figure 8. The inferred northwesterly flow direction is similar to the flow regime in the outwash unit and indicates that groundwater in deeper portions of the glaciolacustrine unit discharges to the Deerfield River downstream of Sherman Dam.

Figure 9 depicts groundwater flow in the fractured bedrock unit. The flow is directed in a more westerly direction, with flow generally consistent with the topography of the bedrock surface.

The average horizontal hydraulic gradient in the shallow groundwater interval is estimated at approximately 0.05 feet per foot. The average hydraulic conductivity was 1.1 x $10^{-3}$ centimeters per second based on tests performed during the Summer 2003 well drilling program (YAEC, 2004b). Using these values with an estimated porosity value of 25 percent, average groundwater flow velocity in the outwash is calculated to be 0.6 feet per day.

The average horizontal hydraulic gradient in the intermediate groundwater interval is estimated at approximately 0.06 feet per foot. The hydraulic conductivity for the glaciolacustrine deposits that comprise the intermediate groundwater interval have not been estimated; therefore the groundwater velocities were not calculated. However, due to the stratified nature of the till and glaciolacustrine units, the relative permeability and flow rates within sand lenses or boulder layers within the till or the glaciolacustrine unit could be significantly greater than the average permeability of these units. Preferred flow pathways within the till and glaciolacustrine units are expected to dominate the majority of groundwater flow within these units. In some ways groundwater flow within the glaciolacustrine unit is believed to be similar to flow in fractured rock in that thin, discrete, permeable sand lenses will transmit most of the flow in the glaciolacustrine unit. Significant vertical hydraulic gradients exist between sand stringers that occur at different elevations within the silt/clay low-permeability glaciolacustrine sediments. The sand lenses are believed to be hydraulically interconnected to some extent both horizontally and, to a lesser extent, vertically.

The average horizontal hydraulic gradient in the bedrock groundwater is estimated at approximately 0.10 feet per foot. Flow within the bedrock is expected to occur primarily in the upper portions of the bedrock where weathering has increased fracture density, or within discrete fractures or fracture zones deeper within the bedrock.

Vertical hydraulic gradients were calculated using groundwater elevation data for the MW-100 series wells to evaluate the flow potential between the glaciolacustrine and bedrock units. Vertical hydraulic gradient data are presented in Table 6 and are summarized below:

- A downward component of groundwater flow was indicated at two well locations (MW-103 and MW-105) by vertical hydraulic gradient values between 0.05 and 0.13 feet per foot.
- An upward component of groundwater flow was indicated at four well locations, with vertical flow directed from the bedrock aquifer into the glaciolacustrine unit. Vertical hydraulic gradient values ranged between -0.21 to –0.34 feet per foot in wells that exhibited upward flow. The upward vertical gradients are important since upward vertical gradients below and downgradient of the Vapor

Container (VC) may have prevented the tritium plume from migrating into bedrock.

### 3.3.2 *Field Parameters Monitored During Low-Flow Sampling*

Geochemical field parameters, including temperature, conductivity, pH, dissolved oxygen, turbidity and oxidation-reduction potential, were measured for wells sampled by low-flow sampling techniques at the time of sample collection. Geochemical field parameters for the groundwater sampling events are presented in Table 7.

In general, the field parameters were consistent with expected values for groundwater. Elevated pH values (greater than 10 standard units) are consistently observed in two of the wells (MW-101C and MW-104B) installed during the Summer 2003 drilling program, possibly suggesting the presence of grout in the well screen.

### 3.3.3 *Field Screening Results*

Screening results for VOCs from groundwater samples collected from the boreholes advanced during the Summer 2003 drilling program are presented in Table 8. VOCs were not detected at concentrations above RCs in groundwater samples from the water bearing zones sampled during the 2003 drilling program.

On-site radiological screening results were presented in the Hydrogeologic Report and on the drilling logs (Appendix E). The radiological screening results indicate that tritium was detected in the outwash and the glaciolacustrine deposits beneath the YNPS. The radiological screening results were used to determine the locations of screen intervals for the monitoring wells constructed in each borehole.

### 3.3.4 *Laboratory Analytical Data*

#### *OHM Parameters*

#### *Evaluation Criteria*

Groundwater analytical results were compared to MCP RCs, which are concentration thresholds that trigger notification to MA DEP of a release of OHM to the environment. There are two categories of RCs applicable to site groundwater that are based on classified groundwater use at the site:

- Reporting Category for Groundwater – 1 (RCGW-1) criteria apply to groundwater results from monitoring well locations within the geographic boundaries of that portion of the site within the IWPA for the public supply well on site (Figures 2 and 5).
- Reportable Category for Groundwater – 2 (RCGW-2) apply to groundwater results from monitoring well locations from the remainder of the site outside of the IWPA.

The monitoring well locations, corresponding to each reporting category, and analytical results exceeding RCs are presented on Figure 5. Validated groundwater analytical results for Summer 2003, Fall 2003 and Winter 2004 are summarized on Table 9. Results exceeding applicable RCs are highlighted in Table 9.

*Shallow Monitoring Wells*

Each of the 35 shallow interval monitoring wells were sampled during either the Summer 2003, Fall 2003 or Winter 2004 groundwater sampling events. Exceedances of RCs for the following compounds were detected in shallow monitoring wells: DRO, PCBs and Silver. Confirmatory sampling was conducted at wells with detections greater than RCs. DRO and Silver were not confirmed at concentrations greater than RCs. Concentrations greater than RCs for dissolved PCBs at MW-5 was confirmed. Detection of PCBs in this well in the dissolved phase is not consistent with historical data for this well and warrants further investigation. Additional investigation for dissolved PCBs will be conducted during the Spring 2004 quarterly sampling event planned for May and June 2004.

*Intermediate Monitoring Wells*

Each of the seven intermediate monitoring wells were sampled during either the Summer 2003, Fall 2003 or Winter 2004 groundwater sampling events. Exceedances of RCs for the following compounds were detected in intermediate overburden monitoring wells: 1,1-dichloroethene (DCE), VPH, PCBs and Lead.

DCE at MW-105C exceeding the RC was confirmed. Chlorinated VOCs were used/stored in the nearby Turbine Building (Figure 2). Therefore, the source, nature and extent of DCE in groundwater will require further evaluation. Additional sampling for DCE at MW-105C will be conducted during the Spring 2004 quarterly sampling planned for May and June 2004.

VPH (i.e., C5-C8 Aliphatics) at MW-101C and PCBs at MW-107D were detected above RCs during the Winter 2004 sampling event. Groundwater sampling will be conducted at these wells during the Spring 2004 quarterly sampling event to further evaluate these detections.

Lead was not detected above RCs in subsequent confirmatory sampling.

*Bedrock Monitoring Wells*

Each of the nine bedrock monitoring wells were sampled during either the Summer 2003, Fall 2003, or Winter 2004 groundwater sampling events. Exceedances of RCs in bedrock monitoring wells consisted of PCBs and lead.

PCBs were detected above RCs at MW-107B during the Winter 2004 sampling event. Re-sampling will be conducted during the Spring 2004 quarterly sampling event to further evaluate this detection.

Lead was not detected above the RC in subsequent confirmatory sampling.

*SCFA Investigation*

Groundwater analytical results for the nine wells (CFW-1, CFW-2, CFW-3, CFW-4, CFW-5, CFW-6, CFW-7, CB-5 and OSR-1 ) sampled in accordance with the sampling parameters required under the Massachusetts Solid Waste Regulations for annual monitoring around the landfill are presented in Table 9. No VOCs were detected at concentrations greater than regulatory standards in samples collected from the monitoring wells.

Inorganics were compared to the Massachusetts Maximum Contaminant Level (MCL) and Secondary Maximum Contaminant Level (SMCL). Iron was detected above the SMCL reference standard of 0.3 milligram per liter (mg/L) at all monitoring wells, except CB-5. Manganese was detected above the SMCL reference standard of 0.05 mg/L at all monitoring wells, except CFW-1. These detections are consistent with historic data.

Landfill monitoring results for August 2003 were generally consistent with prior sampling events and the conclusions of the SCFA – CSA, dated 14 September 2001 (ERM, 2001). Additional results from surface water monitoring, landfill gas evaluation and peat investigation are presented in the 2003 Annual Landfill Monitoring Report, dated 14 October 2003 (YAEC, 2003a).

*Water Supply Wells*

The two water supply wells were sampled during the Summer 2003 and Winter 2004 sampling events. Results for the water supply wells are presented in Table 9. No compounds were detected above applicable RCs for either the Facility Water Supply Well or the Visitor Center Water Supply Well.

*Sherman Spring*

Sherman Spring was sampled during the Summer 2003 and Winter 2004 sampling events. Results for Sherman Spring are presented in Table 9. No compounds were detected above the method detection limits or RCs at Sherman Spring.

*Radiological Parameters*

Tritium was detected in groundwater in both the shallow and intermediate intervals beneath the YNPS . Tritium was detected above applicable EPA MCL at one well in the intermediate interval. The impacted area appears to be localized to within approximately 100 feet (laterally) of the Spent Fuel Pool/Ion Exchange Pit. Results from the radiological investigation are presented in the Hydrogeologic Report of 2003 Supplemental Investigation (YAEC, 2004b). Investigations to define the sources(s) and extent of impact associated with tritium are on-going.

## 3.4 SEDIMENT

### 3.4.1 Field Screening Data

Sediments are present below Sherman Reservoir, Wheeler Brook, Deerfield River and West Storm Drain Ditch. Sediments in all areas generally consist of sands and silts. Sediments in Sherman Reservoir also contained organic material. The lack of organic material in Wheeler Brook, Deerfield River and West Storm Drain Ditch is attributed to the surface water flow.

### 3.4.2 Laboratory Analytical Data

*Background Samples (400 series)*

A total of six surficial background sediment samples were collected from the north end of Sherman Reservoir (SD-401 to SD-406). Background sample locations and results are presented in Figure 11 and Table 10, respectively.

### *Comparison to Background*

Sediment sampling results for Sherman Reservoir, West Storm Drain, Deerfield River and Wheeler Brook were compared to background sediment results. Sampling results were compared to the maximum concentrations detected in background sediment samples for total VOCs, total SVOCs, DRO and individual metals. Total PCBs were not detected in background sediment samples. Therefore, PCB results were compared to the average method detection limit for total PCBs in background sediment samples.

### *Sherman Reservoir*

A total of 44 sediment samples, which included one duplicate, were collected from 36 sample locations in Sherman Reservoir (SD-002 to SD-041). Sample results are detailed in Table 11, and presented in Figure 10. Within Sherman Reservoir, copper (SD-008 and SD-009) and lead (SD-011) were detected at concentrations greater than five times background. Lead (SD-012) was detected at concentrations greater than three times background. Metals detected at concentrations above background are near the circulating water discharge structure (SD-008 and SD-009) and the cooling water intake pipe (SD-011 and SD-012).

DRO was detected at concentrations greater than three times background at SD-041. This detection does not appear to be related to known site activities due to its distance from the site (approximately 700 feet from the shoreline), and its upstream location in relation to the site.

### *Wheeler Brook (100 series)*

A total of six surficial sediment samples were collected and analyzed from Wheeler Brook (SD-101 to SD-106). Sample results are detailed in Table 12. Sample locations are presented in Figure 10. All compounds and compound groups detected in Wheeler Brook were below site-specific background concentrations.

### *Deerfield River (200 series)*

A total of seven surficial sediment samples, which included one duplicate, were collected and analyzed from the Deerfield River (SD-201 to SD-206). Sample results are detailed in Table 13, and are presented in Figure 10.

Within the Deerfield River, copper (SD-204) was detected at concentrations greater than three times background. SD-204 is located in proximity to the confluence of the Deerfield River and the West Storm Drain Ditch.

### *West Storm Drain Ditch (300 series)*

A total of six surficial sediment samples, which included one duplicate, were collected from the West Storm Drain Ditch (SD-301 to SD-305), which discharges to the Deerfield River. Sample results are detailed in Table 14. Sample locations are presented in Figure 10. Within the West Storm Drain Ditch, total SVOCs (SD-303) and lead (SD-301) were detected at concentrations greater than five times background. Total SVOCs (SD-302) and lead (SD-304) were detected at concentrations greater than three times background and may be associated with runoff from parking areas at YNPS.

# 4.0 CONCLUSIONS AND NEXT STEPS

## 4.1 CONCLUSIONS

Based on the results presented in the previous sections, ERM makes the following conclusions regarding the comprehensive site characterization activities:

1) ***Localized areas of soil impact have been detected at YNPS. PAHs, PCBs, Dioxin, petroleum hydrocarbons, lead and beryllium were detected above MCP RCs and will require further evaluation.***

   Impacts to soil at the site include PAHs near a parking area, PCBs near the Transformer Yard (consistent with prior MCP investigation activities), dioxin near a former incinerator, petroleum in a parking area adjacent to the Visitor's Center, lead in soil at a former shooting range and beryllium near the ISFSI and the former cooling water discharge structure. YEAC will conduct further assessment, remediation and/or filing a Release Notification with the MA DEP to address impacts above RCs to soil. Additional soil sampling in the Industrial Area will be performed when the areas are accessible.

2) ***The predominant groundwater flow direction is to the northwest towards the Deerfield River, with a component of flow in the upper portions of the glaciolacustrine unit to the north towards Sherman Reservoir.***

   The groundwater flow directions at YNPS are consistent with the area topography, but have been influenced by the presence of the Sherman Dam. The direction of shallow groundwater flow trends in a northwesterly direction beneath the Industrial Area, changing to a predominantly west-northwest direction beneath the RCA as it approaches its discharge location at the Deerfield River. Northerly groundwater flow in the upper portions of the glaciolacustrine unit is directed toward Sherman Reservoir. This flow pattern is consistent with the observed distribution of tritium in groundwater.

3) ***Impacts to groundwater at the site include DCE, VPH, PCBs and tritium.***

Impacts to groundwater at the site include DCE, VPH, PCBs, and tritium. DCE, VPH and PCBs were detected at isolated locations and do not suggest the presence of a plume. Tritium has been detected in numerous wells in the overburden indicating a plume in the shallow and intermediate overburden migrating with groundwater flow. The source of tritium appears to be the Spent Fuel Pool/Ion-Exchange Pit, but will require continued evaluation during 2004.

4) ***PCB results in sediment are consistent with historic sampling activities. Localized areas of impacts to sediments have been detected near facility outfalls. Additional sampling will be performed in the West Storm Drain Ditch and Deerfield River.***

The PCB sampling results were consistent with prior MCP investigation activities, which concluded that sediments with greater than 1 milligram per kilogram (mg/kg) of PCBs were limited to within 100 feet of the East Storm Drain Outfall and within 150 feet of the West Storm Drain Outfall. The locations with the highest concentrations of metals in sediment were located adjacent to the circulating water discharge structure and the cooling water intake pipe. The highest concentrations of SVOCs were detected in the West Storm Drain Ditch and may be associated with runoff from parking areas at YNPS. Additional sampling will be performed in June 2004 to assess elevated PCB concentrations in the Deerfield River and the West Storm Drain Ditch and SVOCs in the West Storm Drain Ditch.

## 4.2 *NEXT STEPS*

Based on the results presented in the previous sections, YAEC plans to undertake the following activities as part of the comprehensive site characterization effort:

1) ***Fulfill MCP requirements.***

YAEC will comply with MCP notification requirements for newly discovered reportable conditions. Yankee will be evaluating the need for additional investigation and/or remedial activities in areas of the site were impacts have been detected. The investigation activities will be incorporated into MCP and site characterization sampling programs and the results will be summarized in future MCP filings and site characterization status reports.

2) *Complete soil characterization program.*

YAEC will proceed with the remaining soil sampling activities in the Industrial Area, as described in the Soil FSP, once the area is accessible. In addition, sampling activities will be conducted to investigate potential impacts to soil detected at levels exceeding RCs including the parking lot at the Visitor's Center and the Old Shooting Range.

3) *Conduct further assessment of the source(s), nature and extent of groundwater impacts.*

YAEC plans to continue additional groundwater monitoring to further assess the source(s) and extent of the tritium plume and OHM in groundwater above RCs. Activities will include expansion of the monitoring well network during the Summer 2004 and quarterly sampling of groundwater.

4) *Develop and implement sediment and surface water FSPs.*

YAEC will develop and implement additional sediment and surface water FSPs to further evaluate detected impacts to sediment above background and evaluate surface water quality in Sherman Reservoir, the Deerfield River and Wheeler Brook.

5) *Evaluate characterization data in comprehensive multi-media risk assessment.*

YAEC will conduct a risk assessment to identify if any remediation activities will be necessary to achieve compliance with MA DEP's cancer and non-cancer risk management criteria (1 x $10^{-5}$ and 1, respectively) for combined radionuclide and non-radionuclide compounds. The risk assessment will evaluate both human health and ecological risks and will consider future residential/ unrestricted use of the site. (Note that this does not mean that a future residential use of the property is necessarily anticipated, only that such an unrestricted scenario will be the goal for assessing any remediation needs.)

## 5.0 REFERENCES

ERM. September 2001. *Comprehensive Site Assessment (CSA) Report Southeast Construction Fill Area, Yankee Nuclear Power Station.*

ERM. October 2003 (2003a). *Final Soil Field Sampling Plan, Yankee Nuclear Power Station.*

ERM. July 2003 (2003b). *Final Groundwater Field Sampling Plan, Yankee Nuclear Power Station.*

ERM. August 2003 (2003c). *Final Sediment Field Sampling Plan, Yankee Nuclear Power Station.*

ERM. 28 April 2003 (2003d). *Phase II Comprehensive Site Assessment, Yankee Nuclear Power Station.*

ERM. 30 April 2004 (2004a). *Baseline Environmental Report, Yankee Nuclear Power Station.*

ERM. 15 March 2004 (2004b). *Revised March 2004 Groundwater Field Sampling Plan, Yankee Nuclear Power Station.*

ERM. April 2004 (2004c). *Data Validation – Soil, Yankee Nuclear Power Station.*

ERM. February 2004 (2004d). *Data Validation – Groundwater, Yankee Nuclear Power Station.*

ERM. February 2004 (2004e). *Data Validation – Sediment, Yankee Nuclear Power Station.*

Gradient Corporation. 29 September 2003. *Quality Assurance Project Plan Site Closure, Yankee Nuclear Power Station.*

Massachusetts Department of Environmental Protection. 2003. *QA/QC Guidelines for the Acquisition and Reporting of Analytical Data in Support of Response Actions for the MCP.*

U.S. Environmental Protection Agency. 1993. *Region I Tiered Organic and Inorganic Data Validation Guidelines.*

U.S. Environmental Protection Agency. 1996. *Region I Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses (for volatile and semivolatile organic compounds).*

U.S. Environmental Protection Agency. 1998 (1998a). *Region I, EPA-New England Compendium of Quality Assurance Project Plan Guidance. Draft Final.*

U.S. Environmental Protection Agency. 1998 (1998b). *Region I Data Validation Functional Guidelines for Evaluating Organic Analyses, (for PCBs only).*

U.S. Environmental Protection Agency. 1998 (1998c). *Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses.*

YAEC. 14 October 2003. (2003a). *2003 Annual Landfill Monitoring Report – SCFA, MA DEP Tracking Number 01-253-008.*

YAEC. Third Quarter, 2003. (2003b). *Data Quality Assessment Report.*

YAEC. Fourth Quarter, 2003. (2003c). *Data Quality Assessment Report.*

YAEC. 31 March 2004 (2004a). *Site Closure Project Plan, Yankee Nuclear Power Station-site Closure Project, Revision 2.*

YAEC. 15 March 2004 (2004b). *Hydrogeologic Report of 2003 Supplemental Investigation.*

Table 1
Summary of Soil Analytical Screening Data
Yankee Nuclear Power Station
Rowe, MA

| **Station** | **MCP** | **MW-102B** | **MW-104B** | **MW-104B** |
|---|---|---|---|---|
| **Sample Designation** | **RCS-2** | **MW-102B 88-90'** | **MW-104B 163-175'** | **MW-104B 176-179'** |
| **Date Sampled** | | **7/23/2003** | **8/28/2003** | **8/28/2003** |
| *Total Petroleum Hydrocarbons (mg/kg)* | 2,000 | - | - | - |
| *Volatile Organic Compounds (ug/Kg)* | | | | |
| 1,1-Dichloroethene | 100 | 5 U | 45 | 15 |
| 2-Butanone | 40,000 | 10 U | 10 U | 5.5 J |
| Acetone | 60,000 | 41 | 7.5 J,B | 39 B |
| Carbon disulfide | NA | 2.6 J | 5 U | 10 |
| Chloromethane | 1,000,000 | 5 U | 19 | 6.2 |
| Methylene chloride | 200,000 | 29 B | 8.8 J | 35 |
| Toluene | 500,000 | 5 U | 5 U | 2.2 J |
| *Semi-Volatile Organic Compounds (ug/Kg)* | NA | - | - | - |
| *Polychlorinated Biphenyls (ug/Kg)* | 2,000 | - | - | - |
| *Inorganics (mg/Kg)* | | | | |
| Arsenic | 30 | 2.1 U | 0.72 | 0.19 U |
| Chromium | 2,500 | 16 | 15 | 30 |
| Copper | 10,000 | 12 | 16 | 13 |
| Lead | 600 | 5.2 | 0.89 | 1.2 |
| Nickel | 700 | 12 | 14 | 15 |
| Selenium | 2,500 | 5.6 | 2.6 U | 2.5 U |
| Zinc | 2,500 | 38 U | 55 | 57 |

Notes:
Summary of detected compounds only
Data not validated
Bold and shaded cells detected above applicable screening value
- = Not Detected
NA= Not Available
U= Not detected, value is the sample detection/reporting limit
B= Present in blank
J= Estimated result

## Table 2

## Summary of Validated Soil Analytical Data - Background

## Yankee Nuclear Power Station

## Rowe, MA

| Station | MCP | | SB-160 | SB-160 | SB-161 | SB-161 | SB-162 | SB-162 | SB-162 | SB-163 | SB-163 | SB-164 | SB-164 | SB-164 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1600006J | SB-1600203F | SB-1610006J | SB-1610203F | SB-1620006J | FD204102103 | SB-1620102F | SB-1630006J | SB-1630102F | SB-1640006J | FD2010006J | SB-1640203F |
| Date Sampled | | | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 |
| Applicable MCP Soil Standard | RCS-1 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | | | | | | | | DUP | | | | | DUP[1] | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | | | | | | | | | | | 4.4 | |
| TPH-GRO | 200 | 2,000 | | | | | | | | | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | 530 U | 400 U | | | | | | 590 UJ | | 430 UJ |
| Acenaphthylene | 100,000 | 1,000,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Anthracene | 1,000,000 | 2,500,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Benzo(a)anthracene | 700 | 1,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Benzo(a)pyrene | 700 | 700 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Benzo(b)fluoranthene | 700 | 1,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Benzoic acid | 1,000,000 | 10,000,000 | | | 2600 U | 1900 U | | | | | | 3500 J | | 2100 UJ |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Carbazole | NA | NA | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Chrysene | 7,000 | 10,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Dibenzo(a,h)anthracene | 700 | 700 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Dibenzofuran | 100,000 | 1,000,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Fluoranthene | 1,000,000 | 1,000,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Fluorene | 400,000 | 2,000,000 | | | 530 U | 400 U | | | | | | 590 UJ | | 430 UJ |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | 530 U | 400 U | | | | | | 590 U | | 430 U |
| Phenanthrene | 100,000 | 100,000 | | | 530 U | 400 U | | | | | | 590 UJ | | 430 UJ |
| Pyrene | 700,000 | 2,000,000 | | | 530 U | 400 U | | | | | | 590 UJ | | 430 UJ |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | |
| Total Dioxin TEQ | 4 | 6 | 1.1 | 0.6 | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 150 UJ | R | | | | | | | | | | |
| Aroclor-1260 | | | 150 UJ | R | | | | | | | | | | |
| Total PCBs | 2,000 | 2,000 | | | | | | | | | | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 1.8 | 1.8 | 2.9 | 1.5 | 1.5 | 1.7 | 1.6 | 1.6 | 0.7 | 2.5 | 2.2 | 1.2 |
| Beryllium | 0.7 | 0.8 | 1.1 U | 1.1 U | 1.1 U | 0.87 U | 1.2 U | 1.6 U | 1 U | 1.9 U | 0.96 U | 1.3 U | 0.81 U | 0.95 U |
| Boron | 100 | 1,000 | 18 | 19 | | | | | | | | | | |
| Cadmium | 30 | 80 | 1 U | 1 U | 1.1 U | 0.83 U | 1.1 U | 1.5 U | 0.99 U | 1.8 U | 0.91 U | 1.2 U | 0.77 U | 0.9 U |
| Chromium | 1,000 | 2,500 | 11 | 14 | 13 | 14 | 14 | 21 | 17 | 6.3 J | 15 J | 20 J | 10 J | 29 J |
| Copper | 1,000 | 10,000 | 1.7 U | 1.6 U | 1.7 U | 6.4 | 1.8 U | 2.4 U | 2.6 | 5.9 J | 3.6 J | 8.5 J | 19 J | 10 J |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | |
| Lead | 300 | 600 | 1.9 J | 2.4 J | 0.97 J | 1.3 J | 1.2 J | 3.8 J | 1.4 J | 3.4 J | 2 J | R | 2.6 J | 2.6 J |
| Lithium | 100 | 1,000 | 23 | 26 | | | | | | | | | | |
| Mercury | 20 | 60 | 0.8 U | 0.79 U | 0.69 U | 0.51 U | 0.87 U | 1.2 U | 0.69 U | 1.4 U | 0.76 U | 0.96 U | 0.56 U | 0.73 U |
| Nickel | 300 | 700 | 5.5 | 7.1 | 3.8 | 11 | 8.1 | 11 | 9.3 | 9.3 | 17 | 12 | 16 | 20 |
| Selenium | 400 | 2,500 | 3.2 U | 3.2 U | 3.3 U | 2.6 U | 3.6 U | 4.8 U | 3.1 U | 5.7 U | 2.8 U | 3.8 U | 2.4 U | 2.8 U |
| Silver | 100 | 200 | 0.33 U | 0.32 U | 0.34 U | 0.26 U | 0.36 U | 0.48 U | 0.31 U | 0.58 U | 0.29 U | 0.38 U | 0.24 U | 0.29 U |
| Thallium | 8 | 30 | 0.76 U | 0.75 U | 0.78 U | 0.61 U | 0.84 U | 1.1 U | 0.73 U | 1.3 U | 0.67 U | 0.89 U | 0.57 U | 0.66 U |
| Zinc | 2,500 | 2,500 | 66 | 69 | 39 | 51 | 62 | 77 | 62 | 54 | 60 | 49 | 53 | 71 |

| Station | SB-165 | SB-165 | SB-166 | SB-166 | SB-167 | SB-167 | SB-167 | SB-168 | SB-168 | SB-169 | SB-169 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | SB-1650006J | SB-1650102F | SB-1660006J | SB-1660102F | SB-1670006J | FD2000006J | SB-1670203F | SB-1680006J | SB-1680203F | SB-1690006J | SB-1690203F |
| Date Sampled | 10/14/2003 | 10/14/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 |
| Applicable MCP Soil Standard | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | | | | | | DUP | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | |
| 2-Butanone | | | | | | | | | | | |
| Acetone | | | | | | | | | | | |
| Nitrobenzene | | | | | | | | | | | |
| Toluene | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | |
| Acenaphthene | | | | | 460 U | 460 UJ | 500 UJ | | | | |
| Acenaphthylene | | | | | 460 U | 460 U | 500 U | | | | |
| Anthracene | | | | | 460 U | 460 U | 500 U | | | | |
| Benzo(a)anthracene | | | | | 460 UJ | 460 UJ | 500 UJ | | | | |
| Benzo(a)pyrene | | | | | 460 U | 460 U | 500 U | | | | |
| Benzo(b)fluoranthene | | | | | 460 U | 460 U | 500 U | | | | |
| Benzo(g,h,i)perylene | | | | | 460 U | 460 U | 500 U | | | | |
| Benzo(k)fluoranthene | | | | | 460 U | 460 U | 500 U | | | | |
| Benzoic acid | | | | | 2200 UJ | 2200 UJ | 2400 UJ | | | | |
| bis(2-Ethylhexyl)phthalate | | | | | 460 U | 460 U | 500 U | | | | |
| Butyl benzyl phthalate | | | | | 460 UJ | 460 UJ | 500 UJ | | | | |
| Carbazole | | | | | 460 U | 460 U | 500 U | | | | |
| Chrysene | | | | | 460 U | 460 U | 500 U | | | | |
| Dibenzo(a,h)anthracene | | | | | 460 U | 460 U | 500 U | | | | |
| Dibenzofuran | | | | | 460 U | 460 U | 500 U | | | | |
| Di-n-butyl phthalate | | | | | 460 U | 460 U | 500 U | | | | |
| Fluoranthene | | | | | 460 U | 460 U | 500 U | | | | |
| Fluorene | | | | | 460 U | 460 UJ | 500 UJ | | | | |
| Indeno(1,2,3-cd)pyrene | | | | | 460 U | 460 U | 500 U | | | | |
| Phenanthrene | | | | | 460 U | 460 UJ | 500 UJ | | | | |
| Pyrene | | | | | 460 U | 460 UJ | 500 UJ | | | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | |
| Total Dioxin TEQ | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | |
| Aroclor-1254 | | | | | | | | | | | |
| Aroclor-1260 | | | | | | | | | | | |
| Total PCBs | | | | | | | | | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | |
| Antimony | R | R | R | R | R | R | R | R | R | R | R |
| Arsenic | 2.1 | 1.6 | 1.9 | 1.6 | 2.1 | 2 | 1.2 | 3.2 | 1.3 | 2 | 1.1 |
| Beryllium | 1.4 U | 1.1 U | 1.4 U | 1.1 U | 0.97 U | 1 U | 1.1 U | 1 U | 0.89 U | 1.2 U | 0.87 U |
| Boron | | | | | | | | | | | |
| Cadmium | 1.3 U | 1 U | 1.4 U | 1.1 U | 0.93 U | 0.95 U | 1 U | 0.98 U | 0.84 U | 1.2 U | 0.83 U |
| Chromium | 7.9 | 17 | 11 | 16 | 15 | 15 | 15 | 15 J | 23 J | 15 J | 34 J |
| Copper | 2.1 U | 2.4 | 4.5 J | 1.7 U | 3.8 J | 3.4 J | 2.3 J | 9.3 J | 11 J | 7.4 J | 10 J |
| Hexavalent Chromium | | | | | | | | | | | |
| Lead | 55 | 31 | 57 J | 3.8 J | 4.3 J | 4.1 J | 1.9 J | 6.7 J | 2.4 J | 1.9 J | 2.9 J |
| Lithium | | | | | | | | | | | |
| Mercury | 1.1 U | 0.83 U | 1.1 U | 0.88 U | 0.71 U | 0.71 U | 0.81 U | 0.73 U | 0.61 U | 0.96 U | 0.65 U |
| Nickel | 6.5 | 7.5 | 10 J | 8.4 J | 9.3 J | 9.6 J | 8.9 J | 11 | 28 | 10 | 29 |
| Selenium | 4.1 U | 3.1 U | 4.2 U | 3.4 U | 2.9 U | 3 U | 3.1 U | 3.1 U | 2.6 U | 3.6 U | 2.6 U |
| Silver | 0.42 U | 0.32 U | 0.43 U | 0.34 U | 0.29 U | 0.3 U | 0.31 U | 0.31 U | 0.27 U | 0.37 U | 0.26 U |
| Thallium | 0.97 U | 1.5 U | 1 U | 0.79 U | 0.68 U | 0.7 U | 0.73 U | 0.72 U | 0.62 U | 0.86 U | 0.73 J |
| Zinc | 36 | 45 | 45 J | 57 J | 59 J | 58 J | 54 J | 50 | 67 | 58 | 64 |

Notes:
Summary of detected compounds only
NA = Not Available
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
[1] = Duplicate not analyzed for same parameter list as original sample due to field error

Table 3
Summary of Validated Soil Analytical Data - Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-001 | SB-001 | SB-002 | SB-002 | SB-003 | SB-003 | SB-004 | SB-004 | SB-008 | SB-008 | SB-009 | SB-009 | SB-012 | SB-012 | SB-013 | SB-013 | SB-018 | SB-018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB--00100061 | SB--0010203F | SB--00200061 | SB-0020203F | SB-00300061 | SB-0030203F | SB-00400061 | SB-0040102F | SB-00800061 | SB-0080102F | SB-00900061 | SB-0090102F | SB-01200061 | SB-0120203F | SB-01300061 | SB-0130203F | SB-01800061 | SB-0180203F |
| Date Sampled | | | 10/23/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/23/2003 | 10/22/2003 | 10/22/2003 | 10/20/2003 | 10/20/2003 | 10/22/2003 | 10/22/2003 | 10/20/2003 | 10/20/2003 | 10/22/2003 | 10/22/2003 |
| Applicable MCP Soil Standard | | | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-2 | RCS-2 | RCS-1 | RCS-1 | RCS-2 | RCS-2 | RCS-1 | RCS-1 | RCS-2 | RCS-2 | RCS-1 | RCS-1 | RCS-2 | RCS-2 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 6.8 | 7.4 | 10 | 3.2 | 9 | 16 | 11 | | 7.5 | 5.1 | 19 | 4.3 | 89 | 41 | 44 | 8.8 | 190 J | 32 |
| TPH-GRO | 200 | 2,000 | 2.5 U | 2.5 U | | | | | | | | | | | | | | | 4.2 U | 4.6 |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Acenaphthylene | 100,000 | 1,000,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Anthracene | 1,000,000 | 2,500,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Benzo(a)anthracene | 700 | 1,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Benzo(a)pyrene | 700 | 700 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Benzo(b)fluoranthene | 700 | 1,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Benzo(k)fluoranthene | 7,000 | 10,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Benzoic acid | 1,000,000 | 10,000,000 | 2100 U | 1900 U | | | | | | | | | | | | | | | 7700 U | 2100 U |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Carbazole | NA | NA | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Chrysene | 7,000 | 10,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Dibenzo(a,h)anthracene | 700 | 700 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Dibenzofuran | 100,000 | 1,000,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Di-n-butyl phthalate | 50,000 | 500,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Fluoranthene | 1,000,000 | 1,000,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Fluorene | 400,000 | 2,000,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Phenanthrene | 100,000 | 100,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| Pyrene | 700,000 | 2,000,000 | 430 U | 400 U | | | | | | | | | | | | | | | 1600 U | 430 U |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 40 U | 40 U | 190 | | 40 U | | 130 | | 150 | | 53 | | 16 J | | 140 | | 92 U | 26 J |
| Aroclor-1260 | | | 45 | 97 | 140 | | 310 | | 43 U | | 86 | | 53 U | | 46 U | | 50 U | | 92 U | 43 U |
| Total PCBs | 2,000 | 2,000 | 45 | 97 | 330 | | 310 | | 130 | | 236 | | 53 | | 16 | | 140 | | | 26 |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | R | R | R | 0.83 J | R | R | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 1.7 | 1.5 | 2.6 | 1.7 | 1.1 | 1.9 | 1.2 | 0.46 U | 1.4 | 1.2 | 1.4 J | 1.2 J | 1.6 | 0.89 | 2.5 J | 1.7 J | 5 | 2.4 |
| Beryllium | 0.7 | 0.8 | 0.9 U | 1 | 0.86 U | 0.8 U | 0.87 U | 0.83 U | 0.95 U | 0.83 U | 0.89 U | 0.89 U | 1.2 U | 1 U | 1 U | 0.97 U | 1.1 U | 0.5 U | 2 U | 0.97 U |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 0.86 U | 0.79 U | 0.82 U | 0.76 U | 0.83 U | 0.79 U | 0.9 U | 0.79 U | 0.84 U | 0.85 U | 1.1 U | 0.98 U | 0.96 U | 0.93 U | 1 U | 0.83 U | 1.9 U | 0.92 U |
| Chromium | 1,000 | 2,500 | 13 | 20 | 13 | 13 | 13 | 12 | 9.9 | 8.9 | 11 | 12 | 12 | 15 | 9.8 | 20 | 12 | 12 | 3.6 | 12 |
| Copper | 1,000 | 10,000 | 5.5 | 15 | 11 | 8.5 | 10 | 13 | 1.8 | 1.3 U | 12 | 14 | 1.7 U | 1.6 U | 1.5 U | 2 | 1.6 U | 1.3 U | 3 U | 1.5 U |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | 3.3 | 4.7 | 2.9 | 1.3 | 3.3 | 6.5 | 1.8 | 2 | 10 | 3.9 | 1.4 J | 1.8 J | R | 0.86 J | 0.99 J | 1.1 J | 150 J | 0.72 J |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.65 U | 0.62 U | 0.68 U | 0.6 U | 0.66 U | 0.55 U | 0.63 U | 0.62 U | 0.65 U | 0.61 U | 0.75 U | 0.74 U | 0.68 U | 0.68 U | 0.8 U | 0.67 U | 0.4 U | 0.74 U |
| Nickel | 300 | 700 | 11 | 14 | 12 | 10 | 10 | 9.8 | 7 | 9.6 | 10 | 14 | 5.6 | 7.9 | 4.5 | 7.7 | 4.9 | 6.2 | 6.5 | 4.9 |
| Selenium | 400 | 2,500 | 2.7 U | 2.5 U | 2.6 U | 2.4 U | 2.6 U | 2.5 U | 2.8 U | 2.5 U | 2.6 U | 2.6 U | 3.4 U | 3 U | 3 U | 2.9 U | 3.1 U | 2.6 U | 5.9 U | 2.9 U |
| Silver | 100 | 200 | 0.27 U | 0.25 U | 0.26 U | 0.24 U | 0.26 U | 0.25 U | 0.29 U | 0.25 U | 0.27 U | 0.27 U | 0.34 U | 0.31 U | 0.3 U | 0.29 U | 0.32 U | 0.26 U | 0.6 U | 0.29 U |
| Thallium | 8 | 30 | 0.7 U | 0.78 U | 0.63 U | 0.65 U | 0.61 U | 0.58 U | 0.94 U | 1.4 U | 0.62 U | 0.62 U | 0.8 U | 0.72 U | 0.71 U | 0.68 U | 0.73 U | 0.61 U | 1.4 U | 0.68 U |
| Zinc | 2,500 | 2,500 | 55 | 84 | 61 | 55 | 63 | 67 | 54 | 51 | 58 | 66 | 58 | 61 | 25 U | 53 | 44 | 40 | 50 U | 35 |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 3
Summary of Validated Soil Analytical Data - Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-019 | SB-019 | SB-020 | SB-020 | SB-020 | SB-022 | SB-022 | SB-022 | SB-025 | SB-025 | SB-026 | SB-026 | SB-027 | SB-027 | SB-030 | SB-030 | SB-031 | SB-031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-0190006I | SB-0190102F | SB-0200006I | SB-0200203F | FD205102203 | SB-0220006I | FD202102003 | SB-0220102F | SB-0250006I | SB-0250203F | SB-0260006I | SB-0260203F | SB-0270006I | SB-0270102F | SB-0300006J | SB-0300102F | SB-0310006I | SB-0310102F |
| Date Sampled | | | 10/20/2003 | 10/20/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 |
| Applicable MCP Soil Standard | RCS-1 | RCS-2 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | | | | | | | DUP | | DUP | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 140 | 40 | 7.4 | 2.4 U | 2.4 U | 28 | 25 J | 14 | 14 | 8.7 | 680 J | 45 | 2.2 U | 2.4 U | 240 | 18 | 39 | 26 |
| TPH-GRO | 200 | 2,000 | | | | | | 3 U | 3 U | 2.5 U | | | 6 U | 3.5 U | | | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Acenaphthylene | 100,000 | 1,000,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Anthracene | 1,000,000 | 2,500,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Benzo(a)anthracene | 700 | 1,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Benzo(a)pyrene | 700 | 700 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Benzo(b)fluoranthene | 700 | 1,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Benzoic acid | 1,000,000 | 10,000,000 | | | | | | 2200 U | 2100 U | 1900 U | | | 2400 J | 4000 U | | | | | | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Carbazole | NA | NA | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Chrysene | 7,000 | 10,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Dibenzo(a,h)anthracene | 700 | 700 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Dibenzofuran | 100,000 | 1,000,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Fluoranthene | 1,000,000 | 1,000,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Fluorene | 400,000 | 2,000,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Phenanthrene | 100,000 | 100,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| Pyrene | 700,000 | 2,000,000 | | | | | | 460 U | 430 U | 400 U | | | 960 U | 830 U | | | | | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | 6.7 | 0.4 | 0.2 | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 520 J | | 400 | | | 680 | 1100 | 40 U | 43 U | | 1100 | 120 | 96 | 120 | 480 | | 180 | |
| Aroclor-1260 | | | 56 U | | 180 | | | 46 U | 43 U | 40 U | 43 U | | 580 | 59 U | 36 U | 67 | 200 | | 43 U | |
| Total PCBs | 2,000 | 2,000 | 520 | | 580 | | | 680 | 1100 | | | | 1680 | 120 | 96 | 187 | 680 | | 180 | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | 0.76 J | R | R | R | R | R | R | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 1.3 J | 7.9 J | 1.3 | 1.8 | 0.19 U | 2 J | 0.22 UJ | 3.9 J | 1.3 | 1.4 | 4.4 | 2.1 | 0.68 | 0.66 | 3.2 | 1.6 | 1.2 | 0.22 U |
| Beryllium | 0.7 | 0.8 | 1.2 U | 1.1 U | 0.86 U | 0.83 U | 0.85 U | 1 U | 0.97 U | 0.86 U | 0.93 U | 0.97 U | 2.1 U | 1.3 U | 0.8 U | 0.88 U | 1.1 U | 0.9 U | 0.97 U | 1 U |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 1.2 U | 1.1 U | 0.81 U | 0.79 U | 0.81 U | 0.95 U | 0.92 U | 0.81 U | 0.88 U | 0.92 U | 2 U | 1.2 U | 0.76 U | 0.83 U | 1.1 U | 0.86 U | 0.92 U | 0.95 U |
| Chromium | 1,000 | 2,500 | 3.2 | 17 | 9.3 | 13 | 12 | 10 | 9.8 | 7.9 | 15 | 15 | 8.2 | 8.7 | 12 | 8.5 | 11 | 19 | 9.5 | 9.7 |
| Copper | 1,000 | 10,000 | 2.5 | 1.7 U | 6 | 2.9 | 3.5 | 3.7 | 3 | 15 | 1.4 U | 1.5 U | 3.2 U | 1.9 U | 12 | 8.5 | 1.7 U | 1.4 U | 2 | 1.5 U |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | R | R | 27 J | 2.4 J | 1.2 | R | R | 1 J | 0.69 J | 0.99 J | R | R | 2.4 J | 2.7 J | R | 0.68 J | 2 J | 0.76 J |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.95 U | 0.79 U | 0.63 U | 0.59 U | 0.68 U | 0.76 U | 0.68 U | 0.67 U | 0.69 U | 0.69 U | 1.5 U | 0.91 U | 0.53 U | 0.54 U | 0.83 U | 0.7 U | 0.7 U | 0.73 U |
| Nickel | 300 | 700 | 3.1 U | 6.8 | 9.7 | 8 | 8.5 | 7.6 | 7.3 | 5.8 | 3.5 | 5.7 | 5.4 U | 3.3 U | 9.1 | 8.1 | 5 | 9.5 | 5.7 | 5 |
| Selenium | 400 | 2,500 | 3.6 U | 3.3 U | 2.5 U | 2.5 U | 2.5 U | 3 U | 2.9 U | 2.5 U | 2.7 U | 2.9 U | 6.2 U | 3.8 U | 2.4 U | 2.6 U | 3.3 U | 2.7 U | 2.9 U | 3 U |
| Silver | 100 | 200 | 0.36 U | 0.34 U | 0.26 U | 0.25 U | 0.26 U | 0.3 U | 0.29 U | 0.26 U | 0.28 U | 0.29 U | 0.63 U | 0.38 U | 0.24 U | 0.26 U | 0.34 U | 0.27 U | 0.29 U | 0.3 U |
| Thallium | 8 | 30 | 0.94 U | 0.79 U | 0.6 U | 0.58 U | 0.6 U | 0.7 U | 0.68 U | 0.6 U | 0.65 U | 0.68 U | 1.4 U | 0.94 U | 0.56 U | 0.61 U | 0.78 U | 0.63 U | 0.68 U | 0.7 U |
| Zinc | 2,500 | 2,500 | 34 | 86 | 62 | 62 | 68 | 46 | 43 | 88 | 32 | 34 | 56 | 32 U | 55 | 46 | 28 U | 51 | 54 | 79 |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 3
Summary of Validated Soil Analytical Data - Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| **Station** | **MCP** | | **SB-032** | **SB-032** | **SB-033** | **SB-033** | **SB-035** | **SB-035** | **SB-048** | **SB-048** | **SB-049** | **SB-049** | **SB-054** | **SB-054** | **SB-054** | **SB-057** | **SB-057** | **SB-057** | **SB-057** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Designation** | | | **SB-0320006I** | **SB-0320102F** | **SB-0330006I** | **SB-0330102F** | **SB-0350006I** | **SB-0350102F** | **SB-0480006I** | **SB-0480203F** | **SB-0490006I** | **SB-0490203F** | **SB-0540006I** | **SB-0540203F** | **SB-0541415F** | **SB-0570006I** | **SB-0570203F** | **SB-0571415F** | **FD-208** |
| **Date Sampled** | | | **10/20/2003** | **10/20/2003** | **10/22/2003** | **10/22/2003** | **10/20/2003** | **10/20/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** |
| **Applicable MCP Soil Standard** | **RCS-1** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** |
| **Comment** | | | | | | | | | | | | | | | | | | | **DUP** |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 42 | 33 | 2.8 | 3 | 31 J | 60 J | 59 J | 4.1 | 2.4 U | 14 | 71 J | 2 U | 2.2 U | 8.2 | 4.8 | 2.2 U | 2 U |
| TPH-GRO | 200 | 2,000 | | | | | 2.5 U | 2.5 U | 2.5 U | 150 | | | 2.5 U | 2.5 U | 2.5 U | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | 10 U | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | 86 J | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | 35 | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | 5 U | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Acenaphthylene | 100,000 | 1,000,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Anthracene | 1,000,000 | 2,500,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Benzo(a)anthracene | 700 | 1,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Benzo(a)pyrene | 700 | 700 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Benzo(b)fluoranthene | 700 | 1,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Benzoic acid | 1,000,000 | 10,000,000 | | | | | 1700 U | 1700 U | 6600 U | 1800 U | | | 8100 U | 1600 U | 1700 U | | | | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Carbazole | NA | NA | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Chrysene | 7,000 | 10,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Dibenzo(a,h)anthracene | 700 | 700 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Dibenzofuran | 100,000 | 1,000,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Fluoranthene | 1,000,000 | 1,000,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Fluorene | 400,000 | 2,000,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Phenanthrene | 100,000 | 100,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| Pyrene | 700,000 | 2,000,000 | | | | | 350 U | 340 U | 1400 U | 380 U | | | 1700 U | 340 U | 350 U | | | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 2500 | | 570 | 150 | 530 | 33 U | 120 | 210 | 260 | 36 U | 33 U | 33 U | 33 U | 36 J | | | |
| Aroclor-1260 | | | 230 U | | 250 | 36 U | 350 | 33 U | 70 | 110 | 110 | 36 U | 33 U | 33 U | 33 U | 43 U | | | |
| Total PCBs | 2,000 | 2,000 | 2500 | | 820 | 150 | 880 | | 190 | 320 | 370 | | | | | 36 | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | 0.52 U | 0.52 U | R | R | R | R | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 0.22 UJ | 0.24 UJ | 0.98 | 0.93 | 1.6 | 0.94 | 4 J | 1.2 J | 3 J | 0.18 U | 1.2 J | 1.2 J | 0.86 J | 1.6 | 1.7 | 1.8 | 2.6 |
| Beryllium | 0.7 | 0.8 | 0.99 U | 1.1 U | 0.84 U | 0.82 U | 0.75 U | 0.75 U | 0.74 U | 0.82 U | 0.83 U | 0.82 U | 0.73 U | 0.73 U | 0.76 U | 0.98 U | 0.81 U | 0.77 U | 0.75 U |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 2.5 | 1 U | 0.8 U | 0.78 U | 0.71 U | 0.71 U | 0.71 U | 0.78 U | 0.79 U | 0.78 U | 0.7 U | 0.7 U | 0.73 U | 0.93 U | 1 U | 0.73 U | 0.71 U |
| Chromium | 1,000 | 2,500 | 20 | 26 | 16 | 15 | 9.1 | 8.4 | 10 | 16 | 8.6 | 21 | 13 | 20 | 4.5 | 13 | 11 | 19 | 18 |
| Copper | 1,000 | 10,000 | 24 | 7.6 | 49 | 16 | 31 | 13 | 15 | 19 | 12 | 25 | 15 | 23 | 4.4 | 19 | 16 | 16 | 25 |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | R | R | 3.1 J | 3 J | 1.8 J | 0.46 J | 0.48 J | 1.1 J | 0.63 J | 1.5 J | R | 0.85 J | R | R | 0.52 J | R | 0.75 J |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.67 U | 0.4 U | 0.52 U | 0.4 U | 0.64 U | 0.54 U | 0.011 J | 0.014 J | 0.008 J | 0.007 J | 0.009 J | 0.007 J | 0.009 J | 0.019 | 0.016 | 0.008 | 0.006 |
| Nickel | 300 | 700 | 8.9 | 14 | 15 | 15 | 11 | 9.2 | 16 | 17 | 11 | 23 | 16 | 14 | 5.6 | 14 | 13 | 13 | 16 |
| Selenium | 400 | 2,500 | 2.9 U | 3.2 U | 2.5 U | 2.4 U | 2.2 U | 2.2 U | 5.3 | 9.2 | 9.2 | 11 | 6.4 | 7.6 | 9.3 | 2.9 U | 7.4 | 8.7 | 8.2 |
| Silver | 100 | 200 | 0.3 U | 0.32 U | 0.25 U | 0.25 U | 0.23 U | 0.22 U | 0.22 U | 0.25 U | 0.25 U | 0.25 U | 0.22 U | 0.22 U | 0.23 U | 0.29 U | 0.24 U | 0.23 U | 0.23 U |
| Thallium | 8 | 30 | 0.69 U | 0.75 U | 0.59 U | 0.57 U | 0.52 U | 0.52 U | 0.52 U | 0.56 U | 0.58 U | 0.57 U | 0.51 U | 0.51 U | 0.53 U | 0.68 U | 0.57 U | 0.54 U | 0.52 U |
| Zinc | 2,500 | 2,500 | 750 | 330 | 67 | 63 | 84 | 35 | 49 | 70 | 520 | 82 | 45 | 61 | 57 | 44 | 50 | 51 | 61 |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 3
Summary of Validated Soil Analytical Data - Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| **Station** | **MCP** | | **SB-058** | **SB-058** | **SB-058** | **SB-059** | **SB-059** | **SB-059** | **SB-060** | **SB-060** | **SB-061** | **SB-061** | **SB-061** | **SB-062** | **SB-062** | **SB-062** | **SB-068** | **SB-068** | **SB-068** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Designation** | | | **SB-0580006I** | **SB-0580203F** | **SB-0580506F** | **SB-0590006I** | **SB-0590203F** | **SB-0591415F** | **SB-0600006I** | **SB-0600203F** | **SB-0610006J** | **SB-0610203F** | **SB-0611415F** | **SB-0620006I** | **SB-0620203F** | **SB-0620506F** | **SB-0680006I** | **SB-0680203F** | **SB-0680809F** |
| **Date Sampled** | | | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/30/2003** | **10/29/2003** | **10/29/2003** | **10/29/2003** |
| **Applicable MCP Soil Standard** | **RCS-1** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** | **RCS-2** |
| **Comment** | | | | | | | | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 20 J | 2.5 | 2.2 U | 2 U | 2.5 | 2.2 U | 17 J | 16 J | | | 2.2 U | | | 19 | 12 J | 2.2 U | 35 |
| TPH-GRO | 200 | 2,000 | 2.5 U | 2.5 U | 2.5 U | | | | | | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | 140 J | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Acenaphthylene | 100,000 | 1,000,000 | 360 U | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Anthracene | 1,000,000 | 2,500,000 | 130 J | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Benzo(a)anthracene | 700 | 1,000 | 380 | 130 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Benzo(a)pyrene | 700 | 700 | 310 J | 92 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Benzo(b)fluoranthene | 700 | 1,000 | 320 J | 86 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | 180 J | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | 280 J | 92 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Benzoic acid | 1,000,000 | 10,000,000 | 1700 U | 1800 U | 1800 U | | | | | | | | | | | | 1800 U | 1800 U | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | 360 U | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | 360 U | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Carbazole | NA | NA | 150 J | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Chrysene | 7,000 | 10,000 | 410 | 110 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Dibenzo(a,h)anthracene | 700 | 700 | 360 U | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Dibenzofuran | 100,000 | 1,000,000 | 110 J | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Di-n-butyl phthalate | 50,000 | 500,000 | 360 U | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Fluoranthene | 1,000,000 | 1,000,000 | 940 | 260 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Fluorene | 400,000 | 2,000,000 | 140 J | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | 230 J | 360 U | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Phenanthrene | 100,000 | 100,000 | 830 | 200 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| Pyrene | 700,000 | 2,000,000 | 690 | 200 J | 370 U | | | | | | | | | | | | 360 U | 370 U | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 350 | 36 U | 49 | 33 U | | | 190 | 200 | | | | | | | | | |
| Aroclor-1260 | | | 190 | 36 U | 36 U | 33 U | | | 120 | 140 | | | | | | | | | |
| Total PCBs | 2,000 | 2,000 | 540 | | 49 | | | | 310 | 340 | | | | | | | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | R | R | R | | | R | | | R | | | R |
| Arsenic | 30 | 30 | 27 | 1.6 | 2.4 | 2 | 1.3 | 3.1 | 2.5 J | 1.2 J | | | 0.93 J | | | 1.7 J | | | 1.7 J |
| Beryllium | 0.7 | 0.8 | 0.78 U | 0.8 U | 0.79 U | 0.76 U | 0.82 U | 0.87 U | 0.78 U | 0.79 U | | | 0.78 U | | | 0.79 U | | | 0.81 UJ |
| Boron | 100 | 1,000 | | | | | | | 140 | 240 | | | | | | | | | |
| Cadmium | 30 | 80 | 0.74 U | 0.76 U | 0.75 U | 0.72 U | 0.78 U | 0.83 U | 0.75 U | 0.76 U | | | 0.74 U | | | 0.75 U | | | 0.77 U |
| Chromium | 1,000 | 2,500 | 20 | 17 | 14 | 20 | 14 | 25 | 18 | 14 | | | 8.2 | | | 13 | | | 18 J |
| Copper | 1,000 | 10,000 | 36 | 17 | 22 | 15 | 17 | 23 | 29 | 42 | | | 20 | | | 18 | | | 20 J |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | 0.57 J | 1 J | 0.88 J | 0.44 J | R | 0.54 J | 5.6 J | 1.7 J | | | R | | | 1 J | | | 1.7 J |
| Lithium | 100 | 1,000 | | | | | | | 13 | 12 | | | | | | | | | |
| Mercury | 20 | 60 | 0.015 | 0.019 | 0.015 | 0.006 U | 0.014 | 0.009 | 0.011 J | 0.012 J | | | 0.007 J | | | 0.01 J | | | 0.61 UJ |
| Nickel | 300 | 700 | 16 | 15 | 19 | 15 | 15 | 22 | 17 | 24 | | | 13 | | | 14 | | | 16 J |
| Selenium | 400 | 2,500 | 2.3 U | 8.2 | 6.3 | 6.6 | 6.6 | 12 | 5.3 | 5.9 | | | 11 | | | 5.6 | | | 8.7 J |
| Silver | 100 | 200 | 0.23 U | 0.24 U | 0.24 U | 0.23 U | 0.25 U | 0.26 U | 0.24 U | 0.24 U | | | 0.24 U | | | 0.24 U | | | 0.24 UJ |
| Thallium | 8 | 30 | 0.54 U | 0.56 U | 0.55 U | 0.53 U | 0.57 U | 0.61 U | 0.55 U | 0.56 U | | | 0.55 U | | | 0.55 U | | | 0.57 UJ |
| Zinc | 2,500 | 2,500 | 57 | 61 | 59 | 47 | 48 | 86 | 87 | 200 | | | 81 | | | 58 | | | 60 J |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 3
Summary of Validated Soil Analytical Data - Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-069 | SB-069 | SB-069 | SB-083 | SB-083 | SB-087 | SB-087 | SB-088 | SB-088 | SB-089 | SB-089 | SB-090 | SB-090 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-0690006I | SB-0690203F | SB-0691415F | SB-0830006I | SB-0830203F | SB-0870006I | SB-0870102F | SB-0880006I | SB-0880102F | SB-0890006I | SB-0890102F | SB-0900006I | SB-0900102F |
| Date Sampled | | | 10/30/2003 | 10/30/2003 | 10/30/2003 | 10/30/2003 | 10/30/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 |
| Applicable MCP Soil Standard | | | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 2.2 U | 2.2 U | 2.2 U | 2 U | 11 | 6.5 J | 5.4 J | 3.4 | 2.2 U | 5.6 | 2 U | 15 | 6.5 |
| TPH-GRO | 200 | 2,000 | | | | | | | | | | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | | 330 U | 380 U | | | | | | | | |
| Acenaphthylene | 100,000 | 1,000,000 | | | | 330 U | 380 U | | | | | | | | |
| Anthracene | 1,000,000 | 2,500,000 | | | | 330 U | 380 U | | | | | | | | |
| Benzo(a)anthracene | 700 | 1,000 | | | | 330 U | 380 U | | | | | | | | |
| Benzo(a)pyrene | 700 | 700 | | | | 330 U | 380 U | | | | | | | | |
| Benzo(b)fluoranthene | 700 | 1,000 | | | | 330 U | 380 U | | | | | | | | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | | 330 U | 380 U | | | | | | | | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | | 330 U | 380 U | | | | | | | | |
| Benzoic acid | 1,000,000 | 10,000,000 | | | | 1600 U | 1800 U | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | | 330 U | 380 U | | | | | | | | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | | 330 U | 380 U | | | | | | | | |
| Carbazole | NA | NA | | | | 330 U | 380 U | | | | | | | | |
| Chrysene | 7,000 | 10,000 | | | | 330 U | 380 U | | | | | | | | |
| Dibenzo(a,h)anthracene | 700 | 700 | | | | 330 U | 380 U | | | | | | | | |
| Dibenzofuran | 100,000 | 1,000,000 | | | | 330 U | 380 U | | | | | | | | |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | | 330 U | 380 U | | | | | | | | |
| Fluoranthene | 1,000,000 | 1,000,000 | | | | 330 U | 110 J | | | | | | | | |
| Fluorene | 400,000 | 2,000,000 | | | | 330 U | 380 U | | | | | | | | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | | 330 U | 380 U | | | | | | | | |
| Phenanthrene | 100,000 | 100,000 | | | | 330 U | 380 U | | | | | | | | |
| Pyrene | 700,000 | 2,000,000 | | | | 330 U | 96 J | | | | | | | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | | | | | | 110 | 51 | 83 | 36 U | 300 | 33 U | 510 | 120 |
| Aroclor-1260 | | | | | | | | 74 | 36 U | 40 U | 36 U | 400 | 33 U | 33 U | 36 U |
| Total PCBs | 2,000 | 2,000 | | | | | | 184 | 51 | 83 | | 700 | | 510 | 120 |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | | | R | R | R | | | | | | | | |
| Arsenic | 30 | 30 | | | 1.4 | 4.1 J | 1.8 J | | | | | | | | |
| Beryllium | 0.7 | 0.8 | | | 0.8 U | 0.72 U | 0.83 U | | | | | | | | |
| Boron | 100 | 1,000 | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | | | 0.76 U | 0.69 U | 0.79 U | | | | | | | | |
| Chromium | 1,000 | 2,500 | | | 16 | 12 | 6.4 | | | | | | | | |
| Copper | 1,000 | 10,000 | | | 16 | 2.1 | 8 | | | | | | | | |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | |
| Lead | 300 | 600 | | | 0.48 J | 0.85 J | 0.58 J | | | | | | | | |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | |
| Mercury | 20 | 60 | | | 0.009 | 0.007 J | 0.011 J | | | | | | | | |
| Nickel | 300 | 700 | | | 17 | 23 | 8.1 | | | | | | | | |
| Selenium | 400 | 2,500 | | | 13 | 2.1 U | 2.5 U | | | | | | | | |
| Silver | 100 | 200 | | | 0.24 U | 0.22 U | 0.25 U | | | | | | | | |
| Thallium | 8 | 30 | | | 0.56 U | 0.5 U | 0.58 U | | | | | | | | |
| Zinc | 2,500 | 2,500 | | | 78 | 26 | 42 | | | | | | | | |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

**Table 4**

**Summary of Validated Soil Analytical Data - Non-Industrial Area**

**Yankee Nuclear Power Station**

**Rowe, MA**

| Station | MCP | | SB-100 | SB-100 | SB-101 | SB-101 | SB-102 | SB-102 | SB-103 | SB-103 | SB-104 | SB-104 | SB-105 | SB-105 | SB-105 | SB-106 | SB-106 | SB-107 | SB-107 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1000006I | SB-1000102F | SB-1010006I | SB-1010102F | SB-1020006I | SB-1020102F | SB-1030006I | SB-1030102F | SB-1040006I | SB-1040102F | SB-1050006I | FD203102103 | SB-1050102F | SB-1060006I | SB-1060102F | SB-1070006I | SB-1070102F |
| Date Sampled | | | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 |
| Applicable MCP Soil Standard | RCS-1 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | | | | | | | | | | | | | | DUP | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 5.2 | 6 | 5 | 4.2 | 7.9 | 3.8 | 23 | 20 | 11 | 16 | 5.9 J | 11 UJ | 180 J | 12 U | 12 U | 46 J | 2.2 U |
| TPH-GRO | 200 | 2,000 | | | 3 U | 2.5 U | | | | | | | 2.5 U | 2.5 U | 2.5 U | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 400 U | | | | |
| Acenaphthylene | 100,000 | 1,000,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 490 | | | | |
| Anthracene | 1,000,000 | 2,500,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 1100 | | | | |
| Benzo(a)anthracene | 700 | 1,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 2900 | | | | |
| Benzo(a)pyrene | 700 | 700 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 1600 | | | | |
| Benzo(b)fluoranthene | 700 | 1,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 3600 | | | | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 840 | | | | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 2300 | | | | |
| Benzoic acid | 1,000,000 | 10,000,000 | | | 1900 U | 2100 U | | | | | | | 1800 U | 1800 U | 1900 U | | | | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 400 U | | | | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 400 U | | | | |
| Carbazole | NA | NA | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 260 J | | | | |
| Chrysene | 7,000 | 10,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 4300 | | | | |
| Dibenzo(a,h)anthracene | 700 | 700 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 390 J | | | | |
| Dibenzofuran | 100,000 | 1,000,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 400 U | | | | |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 400 U | | | | |
| Fluoranthene | 1,000,000 | 1,000,000 | | | 400 U | 430 U | | | | | | | 360 U | 99 J | 6500 | | | | |
| Fluorene | 400,000 | 2,000,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 400 U | | | | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 970 | | | | |
| Phenanthrene | 100,000 | 100,000 | | | 400 U | 430 U | | | | | | | 360 U | 360 U | 290 J | | | | |
| Pyrene | 700,000 | 2,000,000 | | | 400 U | 430 U | | | | | | | 360 U | 81 J | 8600 | | | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 130 | | 36 J | 14 J | 350 | | 34 J | | 59 | | 36 U | 18 J | 40 U | 150 | | 84 | |
| Aroclor-1260 | | | 100 | | 40 U | 40 U | 270 | | 56 U | | 40 U | | 36 U | 36 U | 40 U | 40 U | | 36 U | |
| Total PCBs | 2,000 | 2,000 | 230 | | 36 | 14 | 620 | | 34 | | 59 | | | 18 | | 150 | | 84 | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | | | | | | | | | | | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | | | | | | | | | | | 1.5 J | 1.7 J | 1.5 J | 1.9 J | 2 J | 1.9 J | 1.4 J |
| Beryllium | 0.7 | 0.8 | | | | | | | | | | | 0.81 U | 0.78 U | 0.83 U | 0.86 U | 0.84 U | 0.78 U | 0.77 U |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | | | | | | | | | | | 0.77 U | 0.74 U | 0.79 U | 0.82 U | 0.8 U | 0.74 U | 0.73 U |
| Chromium | 1,000 | 2,500 | | | | | | | | | | | 12 | 11 | 15 | 12 | 15 | 13 | 13 |
| Copper | 1,000 | 10,000 | | | | | | | | | | | 18 | 14 | 16 | 19 | 19 | 16 | 16 |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | | | | | | | | | | | 2.2 J | 1.3 J | 1.8 J | 2.8 J | 1.7 J | 3.3 J | 1.5 J |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | | | | | | | | | | | 0.6 U | 0.56 U | 0.57 U | 0.62 U | 0.55 U | 0.54 U | 0.54 U |
| Nickel | 300 | 700 | | | | | | | | | | | 13 | 12 | 14 | 12 | 14 | 15 | 16 |
| Selenium | 400 | 2,500 | | | | | | | | | | | 2.4 U | 2.3 U | 2.5 U | 2.5 U | 2.5 U | 2.3 U | 2.3 U |
| Silver | 100 | 200 | | | | | | | | | | | 0.25 U | 0.24 U | 0.25 U | 0.26 U | 0.25 U | 0.24 U | 0.23 U |
| Thallium | 8 | 30 | | | | | | | | | | | 0.57 U | 0.55 U | 0.58 U | 0.6 U | 0.59 U | 0.55 U | 0.54 U |
| Zinc | 2,500 | 2,500 | | | | | | | | | | | 72 | 58 | 59 | 65 | 59 | 120 | 51 |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* = Sampling locations SB-147 to SB-150 were only analyzed for herbicides

Table 4
Summary of Validated Soil Analytical Data - Non-Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-108 | SB-108 | SB-109 | SB-109 | SB-110 | SB-110 | SB-111 | SB-111 | SB-112 | SB-112 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1080006I | SB-1080203F | SB-1090006I | SB-1090102F | SB-1100006I | SB-1100102F | SB-1110006I | SB-1110102F | SB-1120006I | SB-1120102F |
| Date Sampled | | | 10/21/2003 | 10/21/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/20/2003 |
| Applicable MCP Soil Standard | | | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 3.4 | 2.2 U | 4.6 | 2.2 U | 12 | 2.8 | 24 | 2 U | 2.3 | 2.2 U |
| TPH-GRO | 200 | 2,000 | | | 2.5 U | 2.5 U | | | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | 360 U | 360 U | | | | | | |
| Acenaphthylene | 100,000 | 1,000,000 | | | 360 U | 360 U | | | | | | |
| Anthracene | 1,000,000 | 2,500,000 | | | 360 U | 360 U | | | | | | |
| Benzo(a)anthracene | 700 | 1,000 | | | 360 U | 360 U | | | | | | |
| Benzo(a)pyrene | 700 | 700 | | | 360 U | 360 U | | | | | | |
| Benzo(b)fluoranthene | 700 | 1,000 | | | 360 U | 360 U | | | | | | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | 360 U | 360 U | | | | | | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | 360 U | 360 U | | | | | | |
| Benzoic acid | 1,000,000 | 10,000,000 | | | 1800 U | 1800 U | | | | | | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | 360 U | 360 U | | | | | | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | 360 U | 360 U | | | | | | |
| Carbazole | NA | NA | | | 360 U | 360 U | | | | | | |
| Chrysene | 7,000 | 10,000 | | | 360 U | 360 U | | | | | | |
| Dibenzo(a,h)anthracene | 700 | 700 | | | 360 U | 360 U | | | | | | |
| Dibenzofuran | 100,000 | 1,000,000 | | | 360 U | 360 U | | | | | | |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | 360 U | 360 U | | | | | | |
| Fluoranthene | 1,000,000 | 1,000,000 | | | 360 U | 360 U | | | | | | |
| Fluorene | 400,000 | 2,000,000 | | | 360 U | 360 U | | | | | | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | 360 U | 360 U | | | | | | |
| Phenanthrene | 100,000 | 100,000 | | | 360 U | 360 U | | | | | | |
| Pyrene | 700,000 | 2,000,000 | | | 360 U | 360 U | | | | | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | |
| Aroclor-1254 | | | 36 U | | 36 U | 36 U | 94 | | 50 | | 36 U | |
| Aroclor-1260 | | | 36 U | | 36 U | 36 U | 36 U | | 36 U | | 36 U | |
| Total PCBs | 2,000 | 2,000 | | | | | 94 | | 50 | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 0.68 J | 0.94 J | 1.2 J | 1.3 J | 1.1 J | 1.3 J | 0.96 J | 0.98 J | 2.1 J | 1.5 J |
| Beryllium | 0.7 | 0.8 | 0.8 U | 0.82 U | 0.79 U | 0.79 U | 0.81 U | 0.8 U | 0.8 U | 2 | 0.77 U | 0.79 U |
| Boron | 100 | 1,000 | | | | | | | | | | |
| Cadmium | 30 | 80 | 0.76 U | 0.78 U | 0.75 U | 0.75 U | 0.77 U | 0.76 U | 0.76 U | 0.72 U | 0.73 U | 0.75 U |
| Chromium | 1,000 | 2,500 | 9.7 | 16 | 6 | 11 | 8.5 | 12 | 8.9 | 25 | 11 | 11 |
| Copper | 1,000 | 10,000 | 11 | 15 | 12 | 26 | 23 | 16 | 17 | 350 | 12 | 15 |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | |
| Lead | 300 | 600 | 1.2 J | 1.2 J | 1.2 J | 1 J | 1.8 J | 1.3 J | 5 J | 230 J | 0.97 J | 1 J |
| Lithium | 100 | 1,000 | | | | | | | | | | |
| Mercury | 20 | 60 | 0.47 U | 0.6 U | 0.56 U | 0.58 U | 0.63 U | 0.55 U | 0.56 U | 0.4 U | 0.58 U | 0.6 U |
| Nickel | 300 | 700 | 10 | 14 | 7.8 | 12 | 9.7 | 12 | 12 | 230 | 9.6 | 9.9 |
| Selenium | 400 | 2,500 | 2.4 U | 2.4 U | 2.3 U | 2.3 U | 2.4 U | 2.4 U | 2.4 U | 2.3 U | 2.3 U | 2.3 U |
| Silver | 100 | 200 | 0.24 U | 0.25 U | 0.24 U | 0.24 U | 0.24 U | 0.24 U | 0.24 U | 0.23 U | 0.23 U | 0.24 U |
| Thallium | 8 | 30 | 0.56 U | 0.57 U | 0.55 U | 0.55 U | 0.57 U | 0.56 U | 0.56 U | 0.53 U | 0.54 U | 0.55 U |
| Zinc | 2,500 | 2,500 | 60 | 62 | 64 | 56 | 64 | 54 | 68 | 1200 | 39 | 33 |

| Station | SB-113 | SB-113 | SB-113 | SB-114 | SB-114 | SB-115 | SB-115 | SB-116 | SB-116 |
|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | SB-1130006I | FD-201102003 | SB-1130102F | SB-1140006I | SB-1140203F | SB-1150006I | SB-1150102F | SB-1160006I | SB-1160203F |
| Date Sampled | 10/20/2003 | 10/20/2003 | 10/20/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/15/2003 | 10/15/2003 |
| Applicable MCP Soil Standard | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | | DUP | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | |
| TPH-DRO | 8.8 | 11 | 9.4 | 2.2 | 3 | 2.2 U | 4 | 3.7 | 28 J |
| TPH-GRO | | | | 2.5 U | 2.5 U | 2.5 U | 2.5 U | | 3 U |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | |
| 2-Butanone | | | | | | | | | |
| Acetone | | | | | | | | | |
| Nitrobenzene | | | | | | | | | |
| Toluene | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | |
| Acenaphthene | | | | 360 UJ | 360 UJ | 360 UJ | 360 UJ | | 400 UJ |
| Acenaphthylene | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Anthracene | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Benzo(a)anthracene | | | | 360 U | 360 U | 360 U | 360 U | | 88 J |
| Benzo(a)pyrene | | | | 360 U | 360 U | 360 U | 360 U | | 96 J |
| Benzo(b)fluoranthene | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Benzo(g,h,i)perylene | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Benzo(k)fluoranthene | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Benzoic acid | | | | 1800 UJ | 1800 UJ | 1800 UJ | 1800 UJ | | 1900 UJ |
| bis(2-Ethylhexyl)phthalate | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Butyl benzyl phthalate | | | | 360 U | 360 U | 360 U | 360 U | | 400 UJ |
| Carbazole | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Chrysene | | | | 360 U | 360 U | 360 U | 360 U | | 110 J |
| Dibenzo(a,h)anthracene | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Dibenzofuran | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Di-n-butyl phthalate | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Fluoranthene | | | | 360 U | 83 J | 360 U | 360 U | | 180 J |
| Fluorene | | | | 360 UJ | 360 UJ | 360 UJ | 360 UJ | | 400 UJ |
| Indeno(1,2,3-cd)pyrene | | | | 360 U | 360 U | 360 U | 360 U | | 400 U |
| Phenanthrene | | | | 360 UJ | 360 UJ | 360 UJ | 360 UJ | | 400 UJ |
| Pyrene | | | | 360 UJ | 76 J | 360 UJ | 360 UJ | | 140 J |
| *Dioxin / Furan (pg/g)* | | | | | | | | | |
| Dioxin TEQ | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | |
| Aroclor-1254 | 44 | 35 J | | 33 U | 36 U | 36 U | 36 U | 36 U | 40 U |
| Aroclor-1260 | 40 U | 40 U | | 33 U | 36 U | 36 U | 36 U | 36 U | 40 U |
| Total PCBs | 44 | 35 | | | | | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | |
| Antimony | R | R | R | 0.53 UJ | 0.55 UJ | 0.54 UJ | 0.55 UJ | R | R |
| Arsenic | 1.8 J | 2.1 J | 1.9 J | 1.2 | 1.4 | 2.4 | 1 | 3.7 | 2.5 |
| Beryllium | 0.88 U | 0.87 U | 0.8 U | 0.5 U | 0.79 U | 0.77 U | 0.79 U | 0.81 U | 0.88 U |
| Boron | | | | | | | | | |
| Cadmium | 0.83 U | 0.83 U | 0.76 U | 0.73 U | 0.75 U | 0.73 U | 0.75 U | 0.77 U | 0.84 U |
| Chromium | 12 | 10 | 9.4 | 12 | 22 | 12 | 16 | 12 | 17 |
| Copper | 19 | 11 | 16 | 13 | 16 | 20 | 12 | 11 J | 330 J |
| Hexavalent Chromium | | | | | | | | | |
| Lead | 2.4 J | 2.9 J | 1.9 J | 0.88 J | 0.73 J | 1.3 J | 1.2 J | 57 J | 360 J |
| Lithium | | | | | | | | | |
| Mercury | 0.64 U | 0.59 U | 0.63 U | 0.52 U | 0.56 U | 0.54 U | 0.53 U | 0.61 U | 0.68 U |
| Nickel | 12 | 11 | 11 | 11 | 16 | 11 | 13 | 11 J | 13 J |
| Selenium | 2.6 U | 2.6 U | 2.4 U | 2.3 U | 2.3 U | 2.3 U | 2.3 U | 2.4 U | 2.6 U |
| Silver | 0.26 U | 0.26 U | 0.24 U | 0.23 U | 0.24 U | 0.23 U | 0.24 U | 0.24 U | 0.26 U |
| Thallium | 0.61 U | 0.61 U | 0.56 U | 0.53 U | 0.55 U | 0.54 U | 0.55 U | 0.57 U | 0.57 U |
| Zinc | 56 | 48 | 45 | 39 | 38 | 36 | 46 | 58 J | 460 J |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* = Sampling locations SB-147 to SB-150 were only analyzed for herbicides

Table 4
Summary of Validated Soil Analytical Data - Non-Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-117 | SB-117 | SB-118 | SB-118 | SB-122 | SB-122 | SB-122 | SB-123 | SB-123 | SB-123 | SB-124 | SB-124 | SB-124 | SB-125 | SB-125 | SB-125 | SB-126 | SB-126 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1170006I | SB-1170102F | SB-1180006I | SB-1180102F | SB-1220006I | SB-1220203F | SB-1221415F | SB-1230006I | SB-1230203F | SB-1230304F | SB-1240006I | SB-1240203F | SB-1240910F | SB-1250006I | SB-1250203F | SB-1250910F | SB-1260006I | SB-1260203F |
| Date Sampled | | | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 |
| Applicable MCP Soil Standard | | | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 17 J | 20 J | 22 | 46 J | 2.6 | 2.3 | 2.2 U | 2.7 | 6.1 | 5.7 | 20 | 7.1 | 2.2 U | 3.1 | 2.2 U | 2 U | 3 | 2.4 U |
| TPH-GRO | 200 | 2,000 | | 2.5 U | | 2.5 U | | | 2.5 U | | | 2.5 U | | | 2.5 U | | | 2.5 U | | 2.5 U |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | 430 UJ | | 430 UJ | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Acenaphthylene | 100,000 | 1,000,000 | | 430 U | | 190 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Anthracene | 1,000,000 | 2,500,000 | | 120 J | | 130 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Benzo(a)anthracene | 700 | 1,000 | | 260 J | | 420 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Benzo(a)pyrene | 700 | 700 | | 230 J | | 490 | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Benzo(b)fluoranthene | 700 | 1,000 | | 210 J | | 370 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | 140 J | | 340 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | 170 J | | 340 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Benzoic acid | 1,000,000 | 10,000,000 | | 2100 UJ | | 2100 UJ | | | 1700 U | | 1800 U | | | | 1700 U | | | 1600 U | | 1900 U |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | 430 U | | 430 U | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | 430 UJ | | 430 UJ | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Carbazole | NA | NA | | 430 U | | 430 U | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Chrysene | 7,000 | 10,000 | | 250 J | | 550 | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Dibenzo(a,h)anthracene | 700 | 700 | | 430 U | | 430 U | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Dibenzofuran | 100,000 | 1,000,000 | | 430 U | | 430 U | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Di-n-butyl phthalate | 50,000 | 500,000 | | 430 U | | 430 U | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Fluoranthene | 1,000,000 | 1,000,000 | | 590 | | 630 | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Fluorene | 400,000 | 2,000,000 | | 430 UJ | | 430 UJ | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | 430 U | | 430 U | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Phenanthrene | 100,000 | 100,000 | | 530 J | | 280 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| Pyrene | 700,000 | 2,000,000 | | 500 J | | 930 J | | | 360 U | | 370 U | | | | 350 U | | | 330 U | | 400 U |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 43 U | 43 U | 36 U | 43 U | | | 36 U | | 36 U | | | | 36 U | | | 33 U | | 29 J |
| Aroclor-1260 | | | 43 U | 43 U | 36 U | 43 U | | | 36 U | | 36 U | | | | 36 U | | | 33 U | | 40 U |
| Total PCBs | 2,000 | 2,000 | | | | | | | | | | | | | | | | | | 29 |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 2.8 | 3.1 | 4.9 | 2.3 | 1.6 J | 0.89 J | 2.2 J | 1.8 J | 1.7 J | 1.4 J | 2.7 J | 1.1 J | 2 J | 3.3 J | 1.2 J | 1.6 J | 2.3 J | 1.6 J |
| Beryllium | 0.7 | 0.8 | 0.92 U | 0.97 U | 0.81 U | 0.93 U | 0.9 UJ | 0.8 UJ | 0.77 UJ | 0.79 UJ | 0.8 UJ | 0.82 UJ | 0.79 UJ | 0.81 UJ | 0.77 UJ | 0.79 UJ | 0.81 UJ | 0.75 UJ | 0.82 UJ | 0.88 UJ |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 0.87 U | 0.92 U | 0.77 U | 0.88 U | 0.86 UJ | 0.76 UJ | 0.74 UJ | 0.75 UJ | 0.76 UJ | 0.78 UJ | 0.75 UJ | 0.77 UJ | 0.73 UJ | 0.75 UJ | 0.77 UJ | 0.71 UJ | 0.78 UJ | 0.84 UJ |
| Chromium | 1,000 | 2,500 | 16 | 15 | 17 | 11 | 12 J | 22 J | 17 J | 14 J | 14 J | 14 J | 12 J | 18 J | 5 J | 16 J | 22 J | 7 J | 12 J | 15 J |
| Copper | 1,000 | 10,000 | 14 J | 13 J | 9.3 J | 9.8 J | 11 J | 6.9 J | 53 J | 12 J | 14 J | 13 J | 14 J | 30 J | 4.6 J | 14 J | 23 J | 4.8 J | 12 J | 9.7 J |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | 8.9 J | 4.2 J | 17 J | 81 J | 3.1 J | 1 J | 0.62 J | 0.84 J | 1.5 J | 1.5 J | R | 0.89 J | 0.32 UJ | R | 0.72 J | 0.52 J | 2.2 J | 1.1 J |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.65 U | 0.72 U | 0.6 U | 0.62 U | 0.72 UJ | 0.4 UJ | 0.6 UJ | 0.55 UJ | 0.57 UJ | 0.63 UJ | 0.59 UJ | 0.73 J | 0.58 UJ | 0.55 UJ | 0.02 UJ | 0.53 UJ | 0.59 UJ | 0.68 UJ |
| Nickel | 300 | 700 | 14 J | 11 J | 14 J | 10 J | 9.8 J | 22 J | 21 J | 12 J | 12 J | 13 J | 12 J | 17 J | 5.7 J | 14 J | 18 J | 6.8 J | 11 J | 11 J |
| Selenium | 400 | 2,500 | 2.7 U | 2.9 U | 2.4 U | 2.7 U | 2.7 UJ | 13 J | 9.8 J | 7.7 J | 8.5 J | 9 J | 2.3 UJ | 9 J | 16 J | 5.5 J | 8.9 J | 2.2 UJ | 7.1 J | 8.4 J |
| Silver | 100 | 200 | 0.28 U | 0.29 U | 0.24 U | 0.28 U | 0.27 UJ | 0.24 UJ | 0.23 UJ | 0.24 UJ | 0.24 UJ | 0.25 UJ | 0.24 UJ | 0.81 J | 0.23 UJ | 0.24 UJ | 0.24 UJ | 0.22 UJ | 0.25 UJ | 0.26 UJ |
| Thallium | 8 | 30 | 0.64 U | 0.68 U | 0.57 U | 0.65 U | 0.63 UJ | 0.82 J | 0.54 UJ | 0.55 UJ | 0.56 UJ | 0.57 UJ | 0.55 UJ | 0.57 UJ | 0.6 J | 0.55 UJ | 0.57 UJ | 0.52 UJ | 0.58 UJ | 0.61 UJ |
| Zinc | 2,500 | 2,500 | 55 J | 41 J | 40 J | 40 J | 56 J | 63 J | 74 J | 51 J | 55 J | 56 J | 49 J | 97 J | 92 J | 43 J | 59 J | 20 J | 54 J | 41 J |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* = Sampling locations SB-147 to SB-150 were only analyzed for herbicides

## Table 4
## Summary of Validated Soil Analytical Data - Non-Industrial Area
## Yankee Nuclear Power Station
## Rowe, MA

| Station | MCP | | SB-127 | SB-127 | SB-128 | SB-128 | SB-129 | SB-129 | SB-130 | SB-130 | SB-131 | SB-131 | SB-132 | SB-132 | SB-133 | SB-133 | SB-134 | SB-134 | SB-135 | SB-135 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1270006I | SB-1270102F | SB-1280006I | SB-1280203F | SB-1290006I | SB-1290102F | SB-1300006I | SB-1300203F | SB-1310006I | SB-1310203F | SB-1320006I | SB-1320203F | SB-1330006I | SB-1330102F | SB-1340006I | SB-1340203F | SB-1350006I | SB-1350203F |
| Date Sampled | | | 10/28/2003 | 10/28/2003 | 10/14/2003 | 10/14/2003 | 10/14/2003 | 10/14/2003 | 10/14/2003 | 10/14/2003 | 10/14/2003 | 10/14/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 | 10/22/2003 |
| Applicable MCP Soil Standard | | | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 2.6 U | 22 | 16 J | 20 J | 5.4 | 2.2 U | 5.5 | 11 | 2 U | 2 U | | | | | | | | |
| TPH-GRO | 200 | 2,000 | | 2.5 U | | | | | 2.5 U | | 2.5 U | | | | | | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | 400 U | | | | | 400 UJ | | 330 UJ | | | | | | | | | |
| Acenaphthylene | 100,000 | 1,000,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Anthracene | 1,000,000 | 2,500,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Benzo(a)anthracene | 700 | 1,000 | | 400 U | | | | | 400 UJ | | 330 UJ | | | | | | | | | |
| Benzo(a)pyrene | 700 | 700 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Benzo(b)fluoranthene | 700 | 1,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Benzoic acid | 1,000,000 | 10,000,000 | | 1900 U | | | | | 1900 UJ | | 1600 UJ | | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | 400 U | | | | | 400 UJ | | 330 UJ | | | | | | | | | |
| Carbazole | NA | NA | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Chrysene | 7,000 | 10,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Dibenzo(a,h)anthracene | 700 | 700 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Dibenzofuran | 100,000 | 1,000,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Di-n-butyl phthalate | 50,000 | 500,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Fluoranthene | 1,000,000 | 1,000,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Fluorene | 400,000 | 2,000,000 | | 400 U | | | | | 400 UJ | | 330 UJ | | | | | | | | | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | 400 U | | | | | 400 U | | 330 U | | | | | | | | | |
| Phenanthrene | 100,000 | 100,000 | | 400 U | | | | | 400 UJ | | 330 UJ | | | | | | | | | |
| Pyrene | 700,000 | 2,000,000 | | 400 U | | | | | 400 UJ | | 330 UJ | | | | | | | | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | | 130 | 36 U | | 33 | | 46 | | 33 U | | | | | | | | | |
| Aroclor-1260 | | | | 36 U | 36 U | | 33 U | | 36 U | | 33 U | | | | | | | | | |
| Total PCBs | 2,000 | 2,000 | | 130 | | | 33 | | 46 | | | | | | | | | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | 24 J | R |
| Arsenic | 30 | 30 | 3 J | 1.7 J | 3.8 | 1.6 | 0.98 | 0.97 | 0.87 | 1.1 | 0.71 | 0.76 | 1.6 J | 1.3 J | 2.1 J | 1 J | 1.8 | 2.9 | 2.4 | 1.8 |
| Beryllium | 0.7 | 0.8 | 0.96 UJ | 0.8 UJ | 0.77 U | 0.76 U | 0.76 U | 0.8 U | 0.82 U | 0.84 U | 0.75 U | 0.74 U | 0.76 U | 0.74 U | 0.87 U | 0.79 U | 0.88 U | 0.87 U | 0.86 U | 0.85 U |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 0.91 UJ | 0.76 UJ | 0.73 U | 0.73 U | 0.72 U | 76 U | 0.78 U | 0.8 U | 0.71 U | 0.7 U | 0.73 U | 0.7 U | 0.83 U | 0.75 U | 0.84 U | 0.83 U | 0.82 U | 0.81 U |
| Chromium | 1,000 | 2,500 | 15 J | 20 J | 18 | 28 | 11 | 8.9 | 13 | 17 | 18 | 12 | 7.4 | 10 | 12 | 14 | 13 | 13 | 17 | 13 |
| Copper | 1,000 | 10,000 | 17 J | 17 J | 19 | 15 | 10 | 6.9 | 9.6 | 9.9 | 15 | 15 | 11 | 14 | 13 | 17 | 12 | 12 | 16 | 13 |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | 2 J | 1.3 J | 10 | 7.9 | 6 | 5 | 8.3 | 8.8 | 5 | 4.9 | 0.79 J | 1.1 J | 1.7 J | 0.97 J | 120 | 22 | 2000 | 160 |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.7 UJ | 0.5 UJ | 0.62 U | 0.58 U | 0.54 U | 0.67 U | 0.69 U | 0.73 U | 0.54 U | 0.53 U | 0.51 U | 0.4 U | 0.56 U | 0.53 U | 0.67 U | 0.64 U | 0.61 U | 0.4 U |
| Nickel | 300 | 700 | 14 J | 18 J | 16 | 20 | 8 | 10 | 8.9 | 12 | 13 | 10 | 8.8 | 9.8 | 15 | 16 | 11 | 10 | 10 | 10 |
| Selenium | 400 | 2,500 | 8.9 J | 8.6 J | 2.3 U | 2.3 U | 2.3 U | 2.4 U | 2.4 U | 2.5 U | 2.2 U | 2.2 U | 2.3 U | 2.2 U | 2.6 U | 2.3 U | 2.6 U | 2.6 U | 2.6 U | 2.5 U |
| Silver | 100 | 200 | 0.29 UJ | 0.24 UJ | 0.23 U | 0.23 U | 0.23 U | 0.24 U | 0.25 U | 0.25 U | 0.23 U | 0.22 U | 0.23 U | 0.22 U | 0.26 U | 0.24 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U |
| Thallium | 8 | 30 | 0.67 UJ | 0.56 UJ | 0.54 U | 0.53 U | 0.53 U | 0.56 U | 0.57 U | 0.59 U | 0.37 U | 0.52 U | 0.53 U | 0.52 U | 0.61 U | 0.55 U | 0.68 U | 1.4 U | 0.68 U | 0.71 U |
| Zinc | 2,500 | 2,500 | 69 J | 65 J | 45 | 51 | 50 | 44 | 53 | 54 | 38 | 34 | 29 | 40 | 58 | 49 | 78 | 76 | 77 | 86 |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* = Sampling locations SB-147 to SB-150 were only analyzed for herbicides

Table 4

## Summary of Validated Soil Analytical Data - Non-Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-136 | SB-136 | SB-137 | SB-137 | SB-139 | SB-139 | SB-140 | SB-140 | SB-141 | SB-141 | SB-142 | SB-142 | SB-143 | SB-143 | SB-144 | SB-144 | SB-145 | SB-145 | SB-145 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1360006I | SB-1360102F | SB-1370006I | SB-1370102F | SB-1390006I | SB-1390203F | SB-1400006I | SB-1400203F | SB-1410006I | SB-1410203F | SB-1420006I | SB-1420102F | SB-1430006I | SB-1430102F | SB-1440006I | SB-1440102F | SB-1450006I | SB-1450102F | FD206102303 |
| Date Sampled | | | 10/23/2003 | 10/23/2003 | 10/16/2003 | 10/16/2003 | 10/23/2003 | 10/23/2003 | 10/23/2003 | 10/23/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/16/2003 | 10/23/2003 | 10/23/2003 | 10/23/2003 | 10/23/2003 | 10/23/2003 |
| Applicable MCP Soil Standard | | | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | | | | | | | | | | DUP |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 6 | 2.2 U | 6.5 | 6.4 | 22 J | 2.2 U | 15 | 5.9 | 110 | 37 | 19 J | 4.7 | 11 | 19 J | 320 J | 190 J | 2.2 | 2.2 J | 3.6 |
| TPH-GRO | 200 | 2,000 | | | | | 2.5 U | 2.5 U | | | 2.5 U | 2.5 U | | | 2.5 U | 2.5 U | | | 2.5 U | 2.5 U | 2.5 U |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | | | 400 U | 370 U | | | 690 UJ | 360 UJ | | | 360 UJ | 360 UJ | | | 360 U | 340 U | 350 U |
| Acenaphthylene | 100,000 | 1,000,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Anthracene | 1,000,000 | 2,500,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Benzo(a)anthracene | 700 | 1,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 76 J | | | 360 U | 340 U | 350 U |
| Benzo(a)pyrene | 700 | 700 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Benzo(b)fluoranthene | 700 | 1,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Benzoic acid | 1,000,000 | 10,000,000 | | | | | 1900 U | 1800 U | | | 3400 UJ | 1800 UJ | | | 1800 UJ | 1800 UJ | | | 1700 U | 1700 U | 1700 U |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 500 | 360 U | | | 360 U | 340 U | 350 U |
| Carbazole | NA | NA | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Chrysene | 7,000 | 10,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 85 J | | | 360 U | 340 U | 350 U |
| Dibenzo(a,h)anthracene | 700 | 700 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Dibenzofuran | 100,000 | 1,000,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Fluoranthene | 1,000,000 | 1,000,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 140 J | | | 360 U | 340 U | 350 U |
| Fluorene | 400,000 | 2,000,000 | | | | | 400 U | 370 U | | | 690 UJ | 360 UJ | | | 360 UJ | 360 UJ | | | 360 U | 340 U | 350 U |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | | | 400 U | 370 U | | | 690 U | 360 U | | | 360 U | 360 U | | | 360 U | 340 U | 350 U |
| Phenanthrene | 100,000 | 100,000 | | | | | 400 U | 370 U | | | 690 UJ | 360 UJ | | | 360 UJ | 360 UJ | | | 360 U | 340 U | 350 U |
| Pyrene | 700,000 | 2,000,000 | | | | | 400 U | 370 U | | | 690 UJ | 360 UJ | | | 360 UJ | 120 J | | | 360 U | 340 U | 350 U |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | | | | | 40 U | 36 U | 36 U | | | 28 J | | | 36 U | 120 | | | 36 U | 33 U | 33 U |
| Aroclor-1260 | | | | | | | 40 U | 36 U | 36 U | | | 36 U | | | 36 U | 36 U | | | 36 U | 33 U | 33 U |
| Total PCBs | 2,000 | 2,000 | | | | | | | | | | 28 | | | | 120 | | | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | R | R | R | 0.53 UJ | 0.57 UJ | 0.56 UJ | 0.56 UJ | 0.53 UJ | 0.55 UJ | R | 0.77 J | R | R | 0.56 J |
| Arsenic | 30 | 30 | 1.8 | 1.5 | 3.1 | 1.8 | 3.5 | 1.8 | 4.4 | 2 | 4.1 | 3.2 | 3.2 | 2.2 | 2.9 | 2.1 | 5.2 | 2 | 2.5 | 1.2 | 1.4 |
| Beryllium | 0.7 | 0.8 | 0.81 U | 0.82 U | 0.82 U | 0.82 U | 0.86 U | 0.79 U | 0.79 U | 0.84 U | 0.76 U | 0.81 U | 0.5 U | 0.8 U | 0.76 U | 0.79 U | 0.5 U | 0.76 U | 0.78 U | 0.76 U | 0.76 U |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 0.77 U | 0.78 U | 0.78 U | 0.78 U | 0.82 U | 0.75 U | 0.76 U | 0.8 U | 0.73 U | 0.77 U | 1 U | 0.76 U | 0.72 U | 0.75 U | 0.7 U | 0.72 U | 0.74 U | 0.72 U | 0.72 U |
| Chromium | 1,000 | 2,500 | 12 | 15 | 12 J | 14 J | 8.3 | 24 | 9.7 | 13 | 7.3 | 19 | 15 | 28 | 7.8 | 18 | 12 | 11 | 14 | 9.1 | 6.3 |
| Copper | 1,000 | 10,000 | 12 | 14 | 19 J | 27 J | 15 | 20 | 12 | 15 | 8.3 | 14 | 21 | 18 | 8.1 | 18 | 15 | 12 | 19 | 11 | 9.5 |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | 1.5 | 0.9 | 2.2 J | 3.1 J | 0.81 | 1.3 | 0.59 | 2.5 | 2.4 J | 8 J | 9.4 J | 2 J | 7.2 J | 4 J | 1.5 | 1.8 | 0.98 | 0.96 | 0.83 |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.6 U | 0.4 U | 0.65 U | 0.61 U | 1.3 U | 0.61 U | 0.55 U | 1.2 U | 0.6 U | 0.57 U | 0.62 U | 0.62 U | 0.52 U | 0.58 U | 0.61 U | 0.53 U | 0.52 U | 0.49 U | 0.51 U |
| Nickel | 300 | 700 | 12 | 14 | 15 | 20 | 9.3 | 20 | 9.9 | 11 | 6.1 | 18 | 13 | 21 | 6.7 | 23 | 13 | 11 | 15 | 11 | 8.7 |
| Selenium | 400 | 2,500 | 8.9 | 10 | 2.4 U | 2.4 U | 2.6 U | 13 | 2.4 U | 8.6 | 2.3 U | 2.4 U | 2.4 U | 2.4 U | 2.3 U | 2.4 U | 2.2 U | 2.2 U | 2.3 U | 2.2 U | 2.2 U |
| Silver | 100 | 200 | 0.24 U | 0.25 U | 0.25 U | 0.25 U | 0.26 U | 0.24 U | 0.24 U | 0.25 U | 0.23 U | 0.24 U | 0.24 U | 0.24 U | 0.23 U | 0.24 U | 0.22 U | 0.23 U | 0.23 U | 0.23 U | 0.23 U |
| Thallium | 8 | 30 | 0.57 U | 0.57 U | 0.57 U | 0.57 U | 0.6 U | 0.55 U | 0.56 U | 0.59 U | 0.53 U | 0.57 U | 0.56 U | 0.56 U | 0.53 U | 0.55 U | 0.52 U | 0.53 U | 0.54 U | 0.53 U | 0.53 U |
| Zinc | 2,500 | 2,500 | 51 | 52 | 57 | 68 | 42 | 64 | 30 | 56 | 22 | 45 | 69 | 71 | 46 | 60 | 39 | 42 | 38 | 30 | 27 |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* = Sampling locations SB-147 to SB-150 were only analyzed for herbicides

# Table 4
# Summary of Validated Soil Analytical Data - Non-Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-146 | SB-146 | SB-147* | SB-147* | SB-148* | SB-148* | SB-149* | SB-149* | SB-150* | SB-150* | SB-151 | SB-151 | SB-152 | SB-152 | SB-153 | SB-153 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1460006I | SB-1460102F | SB-1470006I | SB-1470203F | SB-1480006I | SB-1480203F | SB-1490006I | SB-1490203F | SB-1500006I | SB-1500203F | SB-1510006I | SB-1510102F | SB-1520006I | SB-1520102F | SB-1530006I | SB-1530203F |
| Date Sampled | | | 10/23/2003 | 10/23/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/21/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 |
| Applicable MCP Soil Standard | | | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-2 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 3.2 | 2.2 U | | | | | | | | | 3.7 | 8.4 | 11 | 7.1 | 20 J | 2 U |
| TPH-GRO | 200 | 2,000 | | | | | | | | | | | | | 2.5 U | 2.5 U | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | | | | | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | | | | | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | | | | | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | | | | | | | | | | | | | 370 U | 360 UJ | | |
| Acenaphthylene | 100,000 | 1,000,000 | | | | | | | | | | | | | 370 U | 360 U | | |
| Anthracene | 1,000,000 | 2,500,000 | | | | | | | | | | | | | 370 U | 360 U | | |
| Benzo(a)anthracene | 700 | 1,000 | | | | | | | | | | | | | 130 J | 360 UJ | | |
| Benzo(a)pyrene | 700 | 700 | | | | | | | | | | | | | 85 J | 360 U | | |
| Benzo(b)fluoranthene | 700 | 1,000 | | | | | | | | | | | | | 80 J | 360 U | | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | | | | | | | | | | | | | 370 U | 360 U | | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | | | | | | | | | | | | | 81 J | 360 U | | |
| Benzoic acid | 1,000,000 | 10,000,000 | | | | | | | | | | | | | 1800 U | 1800 UJ | | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | | | | | | | | | | | | | 370 U | 360 U | | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | | | | | | | | | | | | | 370 U | 360 UJ | | |
| Carbazole | NA | NA | | | | | | | | | | | | | 370 U | 360 U | | |
| Chrysene | 7,000 | 10,000 | | | | | | | | | | | | | 110 J | 360 U | | |
| Dibenzo(a,h)anthracene | 700 | 700 | | | | | | | | | | | | | 370 U | 360 U | | |
| Dibenzofuran | 100,000 | 1,000,000 | | | | | | | | | | | | | 370 U | 360 U | | |
| Di-n-butyl phthalate | 50,000 | 500,000 | | | | | | | | | | | | | 370 U | 360 U | | |
| Fluoranthene | 1,000,000 | 1,000,000 | | | | | | | | | | | | | 260 J | 360 U | | |
| Fluorene | 400,000 | 2,000,000 | | | | | | | | | | | | | 370 U | 360 UJ | | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | | | | | | | | | | | | | 370 U | 360 U | | |
| Phenanthrene | 100,000 | 100,000 | | | | | | | | | | | | | 170 J | 360 UJ | | |
| Pyrene | 700,000 | 2,000,000 | | | | | | | | | | | | | 200 J | 360 UJ | | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | | | | | | | | | | | | | 55 | 36 U | 46 | 33 U |
| Aroclor-1260 | | | | | | | | | | | | | | | 36 U | 36 U | 40 U | 33 U |
| Total PCBs | 2,000 | 2,000 | | | | | | | | | | | | | 55 | | 46 | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | | | | | | | | | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 4 | 2.5 | | | | | | | | | 3.9 | 2.7 | 3.5 | 1.5 | 2.5 | 0.88 |
| Beryllium | 0.7 | 0.8 | 0.76 U | 0.79 U | | | | | | | | | 0.82 U | 0.79 U | 0.79 U | 0.8 U | 0.83 U | 0.74 U |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 0.72 U | 0.75 U | | | | | | | | | 0.78 U | 0.75 U | 0.76 U | 0.76 U | 0.79 U | 0.7 U |
| Chromium | 1,000 | 2,500 | 17 | 15 | | | | | | | | | 12 | 12 | 11 | 10 | 13 | 9.8 |
| Copper | 1,000 | 10,000 | 22 | 22 | | | | | | | | | 22 J | 33 J | 12 J | 10 J | 10 J | 18 J |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | 0.43 | 1.3 | | | | | | | | | 2.6 J | 2.1 J | 230 J | 3.2 J | 4.2 J | 0.51 J |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.52 U | 0.62 U | | | | | | | | | 0.62 U | 0.61 U | 0.55 U | 0.57 U | 0.58 U | 0.43 U |
| Nickel | 300 | 700 | 14 | 16 | | | | | | | | | 37 J | 24 J | 12 J | 11 J | 13 J | 11 J |
| Selenium | 400 | 2,500 | 7.6 | 12 | | | | | | | | | 2.4 U | 2.3 U | 2.4 U | 2.4 U | 2.5 U | 2.2 U |
| Silver | 100 | 200 | 0.23 U | 0.24 U | | | | | | | | | 0.25 U | 0.24 U | 0.24 U | 0.24 U | 0.25 U | 0.22 U |
| Thallium | 8 | 30 | 0.53 U | 0.55 U | | | | | | | | | 0.57 U | 0.55 U | 0.56 U | 0.56 U | 0.58 U | 0.51 U |
| Zinc | 2,500 | 2,500 | 34 | 54 | | | | | | | | | 60 J | 71 J | 72 J | 55 J | 38 J | 37 J |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* = Sampling locations SB-147 to SB-150 were only analyzed for herbicides

Table 4
Summary of Validated Soil Analytical Data - Non-Industrial Area
Yankee Nuclear Power Station
Rowe, MA

| Station | MCP | | SB-154 | SB-154 | SB-155 | SB-155 | SB-156 | SB-156 | SB-156 | SB-157 | SB-157 | SB-157 | SB-157 | SB-158 | SB-158 | SB-158 | SB-158 | SB-159 | SB-159 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | SB-1540006I | SB-1540102F | SB-1550006I | SB-1550203F | SB-1560006I | SS1560506F | SB-1560607F | SB-1570006I | SB-1570203F | SS1570405F | SB-1570506F | SB-1580006I | SB-1580203F | FD207 | SB-1580506F | SB-1590006I | SB-1590203F |
| Date Sampled | | | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/15/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 | 10/28/2003 |
| Applicable MCP Soil Standard | | | RCS-2 | RCS-2 | RCS-2 | RCS-2 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 | RCS-1 |
| Comment | RCS-1 | RCS-2 | | | | | | | | | | | | | | DUP | | | |
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 200 | 2,000 | 8.2 | 15 J | 8 | 7.7 J | 3.5 | | 6 | 13 J | 320 J | 3.2 U | 79 J | 2.6 | 180 | 280 J | 140 | 3.6 | 2.4 U |
| TPH-GRO | 200 | 2,000 | 2.5 U | 2.5 U | | | | 4.8 U | | | | | | | | | | | |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 2-Butanone | 300 | 40,000 | | | | | | 130 J | | | | 41 J | | | | | | | |
| Acetone | 3,000 | 60,000 | | | | | | 730 J | | | | 390 J | | | | | | | |
| Nitrobenzene | 500,000 | 5,000,000 | | | | | | 8 UJ | | | | 5 UJ | | | | | | | |
| Toluene | 90,000 | 500,000 | | | | | | 14 J | | | | 2.4 J | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20,000 | 2,500,000 | 400 UJ | 360 UJ | | | 360 U | 530 U | | 360 U | | 360 U | | 350 U | | | | 1500 U | |
| Acenaphthylene | 100,000 | 1,000,000 | 400 U | 360 UJ | | | 360 U | 120 J | | 160 J | | 360 U | | 350 U | | | | 1500 U | |
| Anthracene | 1,000,000 | 2,500,000 | 400 U | 360 UJ | | | 360 U | 530 U | | 79 J | | 360 U | | 350 U | | | | 1500 U | |
| Benzo(a)anthracene | 700 | 1,000 | 400 UJ | 360 UJ | | | 360 U | 310 J | | 330 J | | 94 J | | 350 U | | | | 350 J | |
| Benzo(a)pyrene | 700 | 700 | 400 U | 360 UJ | | | 360 U | 300 J | | 390 | | 150 J | | 350 U | | | | 340 J | |
| Benzo(b)fluoranthene | 700 | 1,000 | 400 U | 360 UJ | | | 360 U | 250 J | | 370 | | 360 U | | 350 U | | | | 310 J | |
| Benzo(g,h,i)perylene | 1,000,000 | 2,500,000 | 400 U | 360 UJ | | | 360 U | 210 J | | 310 J | | 94 J | | 350 U | | | | 1500 U | |
| Benzo(k)fluoranthene | 7,000 | 10,000 | 400 U | 360 UJ | | | 360 U | 230 J | | 320 J | | 360 U | | 350 U | | | | 1500 U | |
| Benzoic acid | 1,000,000 | 10,000,000 | 1900 UJ | 1800 UJ | | | 1700 U | 2600 U | | 1700 U | | 1800 U | | 1700 U | | | | 7200 U | |
| bis(2-Ethylhexyl)phthalate | 100,000 | 300,000 | 400 U | 360 UJ | | | 360 U | 530 U | | 360 U | | 360 U | | 350 U | | | | 1500 U | |
| Butyl benzyl phthalate | 100,000 | 1,000,000 | 400 UJ | 360 UJ | | | 360 U | 530 U | | 360 U | | 360 U | | 350 U | | | | 1500 U | |
| Carbazole | NA | NA | 400 U | 360 UJ | | | 360 U | 530 U | | 360 U | | 360 U | | 350 U | | | | 1500 U | |
| Chrysene | 7,000 | 10,000 | 400 U | 360 UJ | | | 360 U | 360 J | | 360 | | 100 J | | 350 U | | | | 350 J | |
| Dibenzo(a,h)anthracene | 700 | 700 | 400 U | 360 UJ | | | 360 U | 530 U | | 360 U | | 360 U | | 350 U | | | | 1500 U | |
| Dibenzofuran | 100,000 | 1,000,000 | 400 U | 360 UJ | | | 360 U | 530 U | | 360 U | | 360 U | | 350 U | | | | 1500 U | |
| Di-n-butyl phthalate | 50,000 | 500,000 | 400 U | 360 UJ | | | 79 J | 530 U | | 84 J | | 360 U | | 74 J | | | | 1500 U | |
| Fluoranthene | 1,000,000 | 1,000,000 | 400 U | 79 J | | | 360 U | 770 | | 770 | | 74 J | | 350 U | | | | 650 J | |
| Fluorene | 400,000 | 2,000,000 | 400 UJ | 360 UJ | | | 360 U | 530 U | | 360 U | | 360 U | | 350 U | | | | 1500 U | |
| Indeno(1,2,3-cd)pyrene | 700 | 1,000 | 400 U | 360 UJ | | | 360 U | 170 J | | 260 J | | 360 U | | 350 U | | | | 1500 U | |
| Phenanthrene | 100,000 | 100,000 | 400 UJ | 360 UJ | | | 360 U | 600 | | 230 J | | 360 U | | 350 U | | | | 1500 U | |
| Pyrene | 700,000 | 2,000,000 | 400 UJ | 360 UJ | | | 360 U | 740 | | 680 | | 200 J | | 350 U | | | | 630 J | |
| *Dioxin / Furan (pg/g)* | | | | | | | | | | | | | | | | | | | |
| Dioxin TEQ | 4 | 6 | | | | | | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | | | 44 | 36 U | | | 36 U | | | 36 U | | | | 36 U | | | | 36 U | |
| Aroclor-1260 | | | 36 U | 36 U | | | 36 U | | | 36 U | | | | 36 U | | | | 36 U | |
| Total PCBs | 2,000 | 2,000 | 44 | | | | | | | | | | | | | | | | |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| Antimony | 10 | 40 | R | R | R | R | R | | R | R | R | | R | R | R | R | R | R | R |
| Arsenic | 30 | 30 | 2.1 | 1.7 | 3 | 2.3 | 1.3 J | | 0.16 UJ | 2.2 J | 1.2 J | | 0.89 J | 0.17 UJ | 0.93 J | 1.5 J | 1.4 J | 1.9 J | 2 J |
| Beryllium | 0.7 | 0.8 | 0.83 U | 0.81 U | 0.79 U | 0.81 U | 0.79 UJ | | 0.77 UJ | 0.78 UJ | 0.78 UJ | | 0.76 UJ | 0.77 UJ | 0.83 UJ | 0.81 UJ | 0.76 UJ | 0.81 UJ | 0.86 UJ |
| Boron | 100 | 1,000 | | | | | | | | | | | | | | | | | |
| Cadmium | 30 | 80 | 0.79 U | 0.77 U | 0.75 U | 0.77 U | 0.75 UJ | | 0.74 UJ | 0.74 UJ | 0.74 UJ | | 0.72 UJ | 0.73 UJ | 0.79 UJ | 0.77 UJ | 0.73 UJ | 0.77 UJ | 0.82 UJ |
| Chromium | 1,000 | 2,500 | 14 | 11 | 12 | 11 | 15 J | | 17 J | 15 J | 14 J | | 17 J | 10 J | 10 J | 15 J | 16 J | 11 J | 16 J |
| Copper | 1,000 | 10,000 | 12 J | 11 J | 9.5 J | 10 J | 18 J | | 3.8 J | 14 J | 16 J | | 13 J | 14 J | 8.3 J | 21 J | 9.6 J | 12 J | 7.5 J |
| Hexavalent Chromium | 200 | 600 | | | | | | | | | | | | | | | | | |
| Lead | 300 | 600 | 46 J | 40 J | 26 J | 17 J | 1.8 J | | R | 2.5 J | 1.6 J | | 0.6 J | R | 0.5 J | 1.4 J | 1.4 J | 2 J | 0.83 J |
| Lithium | 100 | 1,000 | | | | | | | | | | | | | | | | | |
| Mercury | 20 | 60 | 0.62 U | 0.65 U | 0.67 U | 0.64 U | 0.4 UJ | | 0.54 UJ | 0.52 UJ | 0.53 UJ | | 0.54 UJ | 0.59 UJ | 0.55 UJ | 0.59 UJ | 0.6 UJ | 0.58 UJ | 0.56 UJ |
| Nickel | 300 | 700 | 14 J | 11 J | 12 J | 10 J | 15 J | | 9.7 J | 16 J | 14 J | | 13 J | 10 J | 8.5 J | 13 J | 14 J | 11 J | 9.9 J |
| Selenium | 400 | 2,500 | 2.5 U | 2.4 U | 2.3 U | 2.4 U | 11 J | | 7 J | 8.2 J | 6.9 J | | 6.9 J | 5.9 J | 2.4 UJ | 9.2 J | 9.2 J | 6.3 J | 8.3 J |
| Silver | 100 | 200 | 0.25 U | 0.24 U | 0.24 U | 0.24 U | 0.24 UJ | | 0.23 UJ | 0.23 UJ | 0.23 UJ | | 0.23 UJ | 0.23 UJ | 0.25 UJ | 0.24 UJ | 0.23 UJ | 0.24 UJ | 0.26 UJ |
| Thallium | 8 | 30 | 0.58 U | 0.57 U | 0.55 U | 0.57 U | 0.55 UJ | | 0.51 UJ | 0.54 UJ | 0.54 UJ | | 0.53 UJ | 0.54 UJ | 0.58 UJ | 0.57 UJ | 0.53 UJ | 0.57 UJ | 0.6 UJ |
| Zinc | 2,500 | 2,500 | 39 J | 33 J | 34 J | 38 J | 55 J | | 29 J | 39 J | 41 J | | 35 J | 33 J | 27 J | 40 J | 44 J | 100 J | 42 J |

Notes:
Summary of detected compounds only
NA = Not Analyzed
Blank cells were not analyzed
Shaded values exceed Reportable Concentrations
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* = Sampling locations SB-147 to SB-150 were only analyzed for herbicides

Table 5

Summary of Groundwater Gauging Data - 26 February 2004

Yankee Nuclear Power Station

Rowe, MA

| Well Designation | Screened Interval | Elevation Top PVC (2003 survey) | Elevation Top Casing (2003 survey) | Ground Surface Elevation (2003 survey) | Depth to Water (feet) | Groundwater Elevation (feet above mean sea level) |
|---|---|---|---|---|---|---|
| B-1 | Till/Bedrock | 1126.86 | 1127.01 | 1125.8 | 18.50 | 1108.36 |
| CB-1 | Shallow | 1128.63 | 1128.63 | 1127.0 | - | - |
| CB-2 | Shallow | 1118.07 | 1118.47 | 1118.5 | 14.53 | 1103.54 |
| CB-3 | Shallow | 1138.62 | 1138.76 | 1138.8 | 5.21 | 1133.41 |
| CB-4 | Shallow | 1085.61 | 1085.86 | 1084.1 | 11.10 | 1074.51 |
| CB-5 | Shallow | 1181.38 | 1181.49 | 1177.7 | - | - |
| CB-6 | Shallow | 1112.06 | 1112.36 | 1110.1 | 14.90 | 1097.16 |
| CB-7 | Shallow | 1139.73 | 1139.93 | 1139.9 | 11.90 | 1127.83 |
| CB-8 | Shallow | 1139.14 | 1139.67 | 1139.6 | 4.01 | 1135.13 |
| CB-9 | Shallow | 1124.69 | 1125.04 | 1125.0 | - | - |
| CB-10* | Shallow | 1126.70 | No Access | 1126.7 | 3.97 | 1122.73 |
| CB-11A* | Shallow | 1129.00 | No Access | No Access | - | - |
| CB-12* | Shallow | 1134.20 | No Access | 1134.3 | 5.00 | 1129.20 |
| CFW-1 | Shallow | 1168.69 | 1169.59 | 1167.2 | - | - |
| CFW-2 | Shallow | 1178.34 | 1178.60 | 1175.9 | 23.50 | 1154.84 |
| CFW-3 | Shallow | 1182.83 | 1182.90 | 1179.4 | 36.50 | 1146.33 |
| CFW-4 | Shallow | 1181.77 | 1181.80 | 1177.6 | 35.60 | 1146.17 |
| CFW-5 | Shallow | 1143.93 | 1144.57 | 1140.9 | 4.60 | 1139.33 |
| CFW-6 | Shallow | 1140.07 | 1140.40 | 1137.0 | 6.00 | 1134.07 |
| CFW-7 | Shallow | 1180.58 | 1180.78 | 1177.4 | 25.90 | 1154.68 |
| CW-1 | Shallow | Gone | Gone | Gone | - | - |
| CW-2 | Shallow | 1136.87 | 1137.28 | 1137.3 | 12.42 | 1124.45 |
| CW-3 | Shallow | 1138.38 | 1138.91 | 1138.9 | 8.29 | 1130.09 |
| CW-4 | Shallow | 1139.13 | 1139.78 | 1139.8 | 7.26 | 1131.87 |
| CW-5 | Shallow | 1124.92 | 1125.27 | 1125.3 | - | - |
| CW-6 | Shallow | 1122.50 | 1123.02 | 1123.0 | 12.70 | 1109.80 |
| CW-7 | Shallow | 1126.16 | 1126.41 | 1126.4 | 19.95 | 1106.21 |
| CW-8 | Shallow | 1126.49 | 1126.74 | 1126.7 | - | - |
| CW-10 | Bedrock | 1124.53 | 1124.79 | 1124.8 | 19.32 | 1105.21 |
| CW-11* | Shallow | 1128.20 | No Access | No Access | - | - |
| MW-1 | Shallow | 1138.48 | 1138.88 | 1138.9 | - | - |
| MW-2 | Shallow | 1125.97 | 1126.19 | 1126.2 | - | - |
| MW-5* | Shallow | 1126.70 | No Access | 1126.4 | 5.72 | 1120.98 |
| MW-6 | Shallow | 1125.30 | 1127.10 | 1127.1 | 7.89 | 1117.41 |
| MW-100A* | Shallow | 1125.80 | No Access | No Access | - | - |
| MW-100B* | Bedrock | 1125.80 | No Access | No Access | - | - |
| MW-101B | Bedrock | 1125.68 | 1125.93 | 1125.9 | 20.74 | 1104.94 |
| MW-101C | Intermediate | 1125.43 | 1125.73 | 1125.7 | 31.32 | 1094.11 |
| MW-102A | Shallow | 1125.62 | 1125.82 | 1125.8 | 14.29 | 1111.33 |
| MW-102B | Bedrock | 1125.67 | 1125.87 | 1125.9 | 22.90 | 1102.77 |
| MW-102C | Intermediate | 1125.55 | 1125.88 | 1125.9 | 33.90 | 1091.65 |
| MW-103A | Shallow | 1110.65 | 1110.91 | 1110.9 | 19.25 | 1091.40 |
| MW-103B | Bedrock | 1110.92 | 1111.10 | 1111.1 | 55.96 | 1054.96 |
| MW-103C | Intermediate | 1110.59 | 1110.71 | 1110.7 | 34.63 | 1075.96 |
| MW-104B | Bedrock | 1117.75 | 1118.36 | 1118.4 | 9.72 | 1108.03 |
| MW-104C | Intermediate | 1118.17 | 1118.47 | 1118.5 | 40.35 | 1077.82 |
| MW-105B | Bedrock | 1126.29 | 1126.52 | 1126.5 | 20.98 | 1105.31 |
| MW-105C | Intermediate | 1126.22 | 1126.48 | 1126.5 | 18.72 | 1107.50 |
| MW-107B | Bedrock | 1124.58 | 1124.93 | 1124.9 | 21.52 | 1103.06 |
| MW-107C | Intermediate | 1124.65 | 1125.00 | 1125.0 | 13.92 | 1110.73 |
| MW-107D | Intermediate | 1124.68 | 1125.03 | 1125.0 | 30.12 | 1094.56 |
| OSR-1 | Shallow | 1159.73 | 1159.98 | 1158.2 | 7.40 | 1152.33 |

Notes:

* = Ground Surface Elevation value as documented in the "Hydrogeologic Report of 2003 Supplemental Investigation" YAEC, 2004b

\- = Not measured February 2004 gauging event

Table 6
Summary of Vertical Hydraulic Gradient Data - 26 February 2004
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Elevation (feet above MSL) | Depth to Water (feet) | Saturation Elevation (feet above MSL) | Head Elevation (feet) | Head Change (feet) | Length Change (feet) | Vertical Hydraulic Gradient [1] (feet per foot) | Vertical Flow Direction (Up/Down) |
|---|---|---|---|---|---|---|---|---|
| MW-101C | 1125.43 | 31.32 | 1028.93 | 1094.11 | -10.83 | 50.250 | -0.21552 | Up |
| MW-101B | 1125.68 | 20.74 | 978.68 | 1104.94 | | | | |
| MW-102C | 1125.55 | 33.90 | 1031.55 | 1091.65 | -11.12 | 32.380 | -0.34342 | Up |
| MW-102B | 1125.67 | 22.90 | 999.17 | 1102.77 | | | | |
| MW-103C | 1110.59 | 34.63 | 990.59 | 1075.96 | 21.00 | 169.670 | 0.12377 | Down |
| MW-103B | 1110.92 | 55.96 | 820.92 | 1054.96 | | | | |
| MW-104C | 1118.17 | 40.35 | 1026.17 | 1077.82 | -30.21 | 98.420 | -0.30695 | Up |
| MW-104B | 1117.75 | 9.72 | 927.75 | 1108.03 | | | | |
| MW-105C | 1126.22 | 18.72 | 1094.22 | 1107.50 | 2.19 | 37.930 | 0.05774 | Down |
| MW-105B | 1126.29 | 20.98 | 1056.29 | 1105.31 | | | | |
| MW-107D | 1124.68 | 30.12 | 1047.18 | 1094.56 | -8.50 | 27.600 | -0.30797 | Up |
| MW-107B | 1124.58 | 21.52 | 1019.58 | 1103.06 | | | | |

Notes:
[1] = Positive value represents downward vertical gradient, negative value represents upward vertical gradient
MSL = mean sea level

Table 7
Summary of Geochemical Parameter Data - Temperature
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Temperature (°C) | | |
|---|---|---|---|
| | Summer 2003 | Fall 2003 | Winter 2004 |
| B-1 | 15.68 | 12.17 | 10.47 |
| CB-1 | 15.19 | 12.39 | 6.13 |
| CB-2 | 15.69 | 12.20 | 7.40 |
| CB-3 | 18.42 | 10.98 (7.81) | 3.51 |
| CB-4 | 14.00 | 9.60 | 9.58 |
| CB-5 | 17.40 | - | 6.13 |
| CB-6 | 12.71 | 9.77 | 7.25 |
| CB-7 | 14.08 | - | 4.54 |
| CB-8 | 14.42 | - | 5.89 |
| CB-9 | 16.81 | 10.51 | 5.19 |
| CB-10 | 15.37 | 11.40 | 4.12 |
| CB-11A | 9.34 | 8.76 | - |
| CB-12 | 14.76 | 11.31 | 3.87 |
| CFW-1 | 17.03 | 7.27 | 3.21 |
| CFW-2 | 14.25 | 10.63 | 6.30 |
| CFW-3 | 17.83 | 13.40 | 14.20 |
| CFW-4 | 16.85 | 12.78 | 11.50 |
| CFW-5 | 16.11 | 5.16 | 2.50 |
| CFW-6 | 14.06 | 6.79 | 3.42 |
| CFW-7 | 15.23 | 10.68 | 5.81 |
| CW-2 | 17.69 | 13.07 | 6.80 |
| CW-3 | 16.08 | 12.20 | 5.14 |
| CW-4 | 17.34 | - | 6.43 |
| CW-5 | 18.83 | 11.99 | - |
| CW-6 | 14.36 | 13.13 | 5.32 |
| CW-7 | 15.64 | - | 8.05 |
| CW-8 | 10.53 | - | 2.93 |
| CW-10 | 20.60 | - | 7.14 |
| CW-11 | 13.21 | 9.04 | - |
| MW-1 | 12.01 | 12.10 | 4.14 |
| MW-2 | 13.02 (15.83) | 9.33 | 4.47 |
| MW-3 | 20.45 | - | - |
| MW-5 | 13.80 | 11.06 (8.86) | 6.15 |
| MW-6 | 16.65 | 12.15 | 5.53 |
| MW-100A | 17.73 | - | - |
| MW-100B | 15.24 | - | - |
| MW-101B | 14.23 | 10.43 | - |
| MW-101C | 15.37 | 10.57 | 8.51 |
| MW-102A | 16.16 | 10.70 | 8.61 |
| MW-102B | 15.69 | 10.03 | - |
| MW-102C | 13.65 | 12.47 | 7.36 |
| MW-103A | 16.79 | - | 9.20 |
| MW-103B | 13.18 | 9.26 | 8.86 |
| MW-103C | 15.47 | 7.82 | 6.30 |
| MW-104B | - | 9.42 | 8.79 |
| MW-104C | - | 13.82 | 4.59 |
| MW-105B | 14.11 | 11.51 | 8.65 |
| MW-105C | 14.37 | 11.72 | 9.65 |
| MW-107B | - | 11.35 | 10.75 |
| MW-107C | - | 12.74 | 5.72 |
| MW-107D | - | 11.60 | 10.50 |
| OSR-1 | 18.35 | - | 2.12 |
| Facility Water Supply (DW001) | 13.27 | - | 7.65 |
| Visitor Center (DW002) | 13.38 | - | 15.72 |
| Sherman Spring (SP001) | 16.76 | - | 7.57 |

Notes:
- = Not Sampled
( ) Monitoring well sampled twice during sampling event
Parameters based on stabilized low flow data

Table 7
Summary of Geochemical Parameter Data - pH
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | pH (standard units) | | |
|---|---|---|---|
| | Summer 2003 | Fall 2003 | Winter 2004 |
| B-1 | 6.67 | 6.75 | 6.70 |
| CB-1 | | 6.22 | 6.31 |
| CB-2 | 6.19 | 6.36 | 6.27 |
| CB-3 | 5.41 | 5.67 (6.02) | 5.92 |
| CB-4 | 5.40 | 6.20 | 6.53 |
| CB-5 | 6.16 | - | 6.65 |
| CB-6 | 5.53 | 5.85 | 5.89 |
| CB-7 | 6.17 | - | 6.10 |
| CB-8 | 5.31 | - | 5.83 |
| CB-9 | 6.39 | 6.46 | 6.41 |
| CB-10 | 7.35 | 7.25 | 7.22 |
| CB-11A | 6.91 | 6.62 | - |
| CB-12 | 5.88 | 6.13 | 6.07 |
| CFW-1 | 5.99 | 5.44 | 5.27 |
| CFW-2 | 5.84 | 5.79 | 6.07 |
| CFW-3 | 6.21 | 6.26 | 6.26 |
| CFW-4 | 5.90 | 6.09 | 6.05 |
| CFW-5 | 6.24 | 6.16 | 6.48 |
| CFW-6 | 6.02 | 5.26 | 6.23 |
| CFW-7 | 5.66 | 5.68 | 5.99 |
| CW-2 | 5.77 | 6.19 | 6.42 |
| CW-3 | 6.08 | 5.82 | 6.25 |
| CW-4 | 6.68 | - | 6.61 |
| CW-5 | 6.12 | 7.18 | - |
| CW-6 | 6.06 | 6.90 | 6.85 |
| CW-7 | 5.50 | - | 6.63 |
| CW-8 | 6.60 | - | 7.06 |
| CW-10 | 5.94 | - | 6.05 |
| CW-11 | 6.74 | 6.52 | - |
| MW-1 | 5.99 | 6.74 | 9.66 |
| MW-2 | 7.27 (6.90) | 8.20 | 7.50 |
| MW-3 | 7.08 | - | - |
| MW-5 | 7.03 | 7.16 (7.43) | 7.12 |
| MW-6 | 7.34 | 8.18 | 7.93 |
| MW-100A | 6.72 | - | - |
| MW-100B | 6.84 | - | - |
| MW-101B | 8.24 | 7.84 | - |
| MW-101C | 11.21 | 9.49 | 10.72 |
| MW-102A | 7.45 | 8.00 | 7.10 |
| MW-102B | 7.99 | 7.98 | - |
| MW-102C | 7.73 | 8.09 | 7.63 |
| MW-103A | 4.46 | - | 6.15 |
| MW-103B | 8.25 | 8.60 | 7.95 |
| MW-103C | 8.47 | 7.64 | 7.49 |
| MW-104B | - | 10.11 | 10.37 |
| MW-104C | - | 7.92 | 9.28 |
| MW-105B | 7.56 | 7.76 | 6.65 |
| MW-105C | 7.09 | 6.89 | 6.06 |
| MW-107B | - | 7.66 | 9.87 |
| MW-107C | - | 7.18 | 9.82 |
| MW-107D | - | 7.58 | 8.95 |
| OSR-1 | 6.06 | - | 6.10 |
| Facility Water Supply (DW001) | 7.90 | - | 6.45 |
| Visitor Center (DW002) | 7.50 | - | 7.28 |
| Sherman Spring (SP001) | 6.30 | - | 6.00 |

Notes:
- = Not Sampled
( ) Monitoring well sampled twice during sampling event
Parameters based on stabilized low flow data

Table 7
Summary of Geochemical Parameter Data - Oxidation Reduction Potential (ORP)
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Oxidation Reduction Potential (ORP) (mV) | | |
|---|---|---|---|
| | Summer 2003 | Fall 2003 | Winter 2004 |
| B-1 | 41 | -99 | 61 |
| CB-1 | 221 | 169 | 159 |
| CB-2 | 244 | 173 | 152 |
| CB-3 | 201 | 173 (167) | 13 |
| CB-4 | 523 | 232 | 191 |
| CB-5 | 335 | - | 85 |
| CB-6 | 520 | 322 | 14 |
| CB-7 | 289 | - | 195 |
| CB-8 | 218 | - | 192 |
| CB-9 | -0.4 | 138 | 16 |
| CB-10 | -149 | -150 | -153 |
| CB-11A | -100 | -58 | - |
| CB-12 | 138 | 179 | 208 |
| CFW-1 | 238 | 182 | 153 |
| CFW-2 | 15 | -238 | -22 |
| CFW-3 | -59 | -175 | -83 |
| CFW-4 | 8 | -179 | -47 |
| CFW-5 | -33 | -101 | -71 |
| CFW-6 | -44 | 2 | -9 |
| CFW-7 | 22 | -183 | -37 |
| CW-2 | 352 | 210 | 213 |
| CW-3 | 270 | 153 | 216 |
| CW-4 | 201 | - | 239 |
| CW-5 | 510 | 137 | - |
| CW-6 | 516 | 149 | 213 |
| CW-7 | 544 | - | 75 |
| CW-8 | 369 | - | 136 |
| CW-10 | 541 | - | 243 |
| CW-11 | -41 | -24 | - |
| MW-1 | -35 | -21 | 119 |
| MW-2 | -169 (115) | 305 | -139 |
| MW-3 | 182 | - | - |
| MW-5 | 29 | -13 (6) | 68 |
| MW-6 | 400 | 144 | 189 |
| MW-100A | 167 | - | - |
| MW-100B | -18 | - | - |
| MW-101B | -50 | -17 | 141 |
| MW-101C | -112 | -101 | -177 |
| MW-102A | -90 | 222 | -78 |
| MW-102B | 16 | -102 | - |
| MW-102C | -77 | -243 | -23 |
| MW-103A | 561 | - | 231 |
| MW-103B | -229 | -122 | -165 |
| MW-103C | -427 | -272 | -276 |
| MW-104B | - | -227 | -151 |
| MW-104C | - | -95 | 27 |
| MW-105B | -186 | -203 | -70 |
| MW-105C | -100 | -121 | 48 |
| MW-107B | - | 197 | -21 |
| MW-107C | - | -56 | 107 |
| MW-107D | - | -166 | -81 |
| OSR-1 | -27 | - | -111 |
| Facility Water Supply (DW001) | 729 | - | 207 |
| Visitor Center (DW002) | -126 | - | 148 |
| Sherman Spring (SP001) | 93 | - | 223 |

Notes:
- = Not Sampled
( ) Monitoring well sampled twice during sampling event
Parameters based on stabilized low flow data

Table 7
Summary of Geochemical Parameter Data - Dissolved Oxygen
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Dissolved Oxygen (mg/L) | | |
|---|---|---|---|
| | Summer 2003 | Fall 2003 | Winter 2004 |
| B-1 | 0.72 | 0.46 | 1.50 |
| CB-1 | 0.90 | 2.44 | 0.70 |
| CB-2 | 8.11 | 7.22 | 2.95 |
| CB-3 | 1.07 | 2.31 (2.76) | 0.65 |
| CB-4 | 6.40 | 3.76 | 4.47 |
| CB-5 | 1.54 | - | 1.03 |
| CB-6 | 7.53 | 3.60 | 5.85 |
| CB-7 | 5.72 | - | 4.49 |
| CB-8 | 0.90 | - | 0.00 |
| CB-9 | 0.74 | 3.55 | 0.79 |
| CB-10 | 0.46 | 0.36 | 0.71 |
| CB-11A | 0.71 | 0.42 | - |
| CB-12 | 7.83 | 7.45 | 10.81 |
| CFW-1 | 6.42 | 6.66 | 6.62 |
| CFW-2 | 0.36 | 0.27 | 0.00 |
| CFW-3 | 4.80 | 1.74 | 2.83 |
| CFW-4 | 3.36 | 2.02 | 1.30 |
| CFW-5 | 1.71 | 0.86 | 0.60 |
| CFW-6 | 2.69 | 1.89 | 0.00 |
| CFW-7 | 0.88 | 0.31 | 0.00 |
| CW-2 | 6.82 | 3.52 | 3.50 |
| CW-3 | 2.52 | 3.27 | 1.27 |
| CW-4 | 0.49 | - | 10.38 |
| CW-5 | 3.13 | 7.18 | - |
| CW-6 | 9.01 | 6.41 | 5.34 |
| CW-7 | 2.82 | - | 0.00 |
| CW-8 | 10.24 | - | 7.49 |
| CW-10 | 7.84 | - | 6.48 |
| CW-11 | 1.30 | 3.40 | - |
| MW-1 | 1.63 | 7.04 | 2.80 |
| MW-2 | 0.73 (0.41) | 3.53 | 10.76 |
| MW-3 | 3.40 | | - |
| MW-5 | 0.86 | 7.71 (1.44) | 0.00 |
| MW-6 | 5.79 | 9.94 | 9.33 |
| MW-100A | 2.69 | - | - |
| MW-100B | 0.34 | - | - |
| MW-101B | 1.21 | 3.96 | 9.32 |
| MW-101C | 2.70 | 3.80 | 0.00 |
| MW-102A | 0.87 | 6.55 | 0.00 |
| MW-102B | 0.87 | 0.59 | - |
| MW-102C | 1.25 | 0.24 | 0.00 |
| MW-103A | 8.00 | - | 8.50 |
| MW-103B | 0.73 | 0.21 | 0.76 |
| MW-103C | 0.15 | 0.00 | 0.69 |
| MW-104B | - | 3.95 | 1.12 |
| MW-104C | - | 1.13 | 1.94 |
| MW-105B | 0.75 | 0.59 | 0 |
| MW-105C | 0.88 | 0.61 | 0 |
| MW-107B | - | 0.43 | 1.2 |
| MW-107C | - | 3.99 | 0 |
| MW-107D | - | 2.14 | 0.73 |
| OSR-1 | 0.54 | - | 1.74 |
| Facility Water Supply (DW001) | 7.42 | - | 10.75 |
| Visitor Center (DW002) | 2.17 | - | 7.37 |
| Sherman Spring (SP001) | 10.04 | - | 8.93 |

Notes:
- = Not Sampled
( ) Monitoring well sampled twice during sampling event
Parameters based on stabilized low flow data

Table 7
Summary of Geochemical Parameter Data - Conductivity
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Conductivity (uS/cm) | | |
|---|---|---|---|
| | Summer 2003 | Fall 2003 | Winter 2004 |
| B-1 | 725 | 700 | 666 |
| CB-1 | 1,521 | 235 | 2,240 |
| CB-2 | 1,679 | 183 | 990 |
| CB-3 | 2,232 | 186 (1,400) | 7,300 |
| CB-4 | 1,643 | 1,100 | 64 |
| CB-5 | 98 | - | 111 |
| CB-6 | 3,391 | 977 | 1,600 |
| CB-7 | 4,611 | - | 191 |
| CB-8 | 1,651 | - | 256 |
| CB-9 | 599 | 802 | 638 |
| CB-10 | 341 | 420 | 2,170 |
| CB-11A | 991 | 3,400 | - |
| CB-12 | 2,133 | 130 | 1,460 |
| CFW-1 | 22 | 14 | 41 |
| CFW-2 | 333 | 221 | 36 |
| CFW-3 | 597 | 518 | 638 |
| CFW-4 | 220 | 224 | 254 |
| CFW-5 | 229 | 169 | 333 |
| CFW-6 | 368 | 63 | 27 |
| CFW-7 | 192 | 256 | 36 |
| CW-2 | 5,526 | 2,200 | 213 |
| CW-3 | 3,855 | 1,180 | 684 |
| CW-4 | 3,219 | - | 631 |
| CW-5 | 1,959 | 670 | - |
| CW-6 | 1,570 | 711 | 51 |
| CW-7 | 1,300 | - | 990 |
| CW-8 | 1,792 | - | 664 |
| CW-10 | 1,437 | - | 900 |
| CW-11 | 615 | 91 | - |
| MW-1 | 3,475 | 405 | 144 |
| MW-2 | 506 (554) | 669 | 1,190 |
| MW-3 | 329 | - | - |
| MW-5 | 507 | 489 (420) | 1,070 |
| MW-6 | 988 | 325 | 6,600 |
| MW-100A | 574 | - | - |
| MW-100B | 1,300 | - | - |
| MW-101B | 135 | 160 | 674 |
| MW-101C | 328 | 300 | 34 |
| MW-102A | 280 | 296 | 23 |
| MW-102B | 160 | 190 | - |
| MW-102C | 269 | 260 | 17 |
| MW-103A | 1,441 | - | 37 |
| MW-103B | 200 | 210 | 213 |
| MW-103C | 469 | 372 | 618 |
| MW-104B | - | 304 | 284 |
| MW-104C | - | 280 | 769 |
| MW-105B | 583 | 550 | 990 |
| MW-105C | 580 | 470 | 999 |
| MW-107B | - | 450 | 743 |
| MW-107C | - | 443 | 57 |
| MW-107D | - | 390 | 505 |
| OSR-1 | 402 | - | 399 |
| Facility Water Supply (DW001) | 162 | - | 999 |
| Visitor Center (DW002) | 285 | - | 26 |
| Sherman Spring (SP001) | 701 | - | 999 |

Notes:
- = Not Sampled
( ) Monitoring well sampled twice during sampling event
Parameters based on stabilized low flow data

Table 7
Summary of Geochemical Parameter Data - Turbidity
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Turbidity (NTU) | | |
|---|---|---|---|
| | Summer 2003 | Fall 2003 | Winter 2004 |
| B-1 | 3.4 | 0 | 7.6 |
| CB-1 | 1.0 | 2.7 | 3.2 |
| CB-2 | 0.7 | 80 | 47 |
| CB-3 | 2.7 | 13.1 (23) | 29 |
| CB-4 | 0 | 1.0 | 0 |
| CB-5 | 0.8 | - | 14 |
| CB-6 | 2.9 | 205 | 12 |
| CB-7 | 6.3 | - | 0 |
| CB-8 | 0 | - | 7.0 |
| CB-9 | 9.6 | 14 | 16 |
| CB-10 | 4.4 | 0.0 | 37 |
| CB-11A | 3.9 | 2.2 | - |
| CB-12 | 0 | 4.5 | 295 |
| CFW-1 | 84 | 10 | 43 |
| CFW-2 | 0.9 | 0.8 | 0 |
| CFW-3 | 950 | 340 | 300 |
| CFW-4 | 50 | 20 | 133 |
| CFW-5 | 9.3 | 75 | 50 |
| CFW-6 | 0 | 1.2 | 0 |
| CFW-7 | 1.4 | 0.9 | 0 |
| CW-2 | 1.5 | 0 | 1.1 |
| CW-3 | 0.9 | 3.2 | 0.0 |
| CW-4 | 0 | - | 11 |
| CW-5 | 1.2 | 9.7 | - |
| CW-6 | 1.9 | 36 | 39 |
| CW-7 | 0.8 | - | 69 |
| CW-8 | 1 | - | 16 |
| CW-10 | 0 | - | 8 |
| CW-11 | 6.8 | 43 | - |
| MW-1 | 52 | 87 | 31 |
| MW-2 | 10 | 57 | 24 |
| MW-3 | 450 | - | - |
| MW-5 | 0.6 | 9.3 (0) | 6 |
| MW-6 | 78 | 2.5 (124) | 54 |
| MW-100A | 3.3 | - | - |
| MW-100B | 2.3 | - | - |
| MW-101B | 9.0 | 146 | 213 |
| MW-101C | 40 | 39 | 181 |
| MW-102A | 4.1 | 10 | 0 |
| MW-102B | 5.8 | 6.8 | - |
| MW-102C | 220 | 467 | 0.9 |
| MW-103A | 0 | - | 5.4 |
| MW-103B | 31 | 98 | 47 |
| MW-103C | 550 | 30 | 83 |
| MW-104B | - | 83 | 264 |
| MW-104C | - | 129 | 34 |
| MW-105B | 8.3 | 10 | 1.2 |
| MW-105C | 0.5 | 19 | 17 |
| MW-107B | - | 29 | 280 |
| MW-107C | - | 52 | 11 |
| MW-107D | - | 0 | 131 |
| OSR-1 | 1.6 | - | 25 |
| Facility Water Supply (DW001) | 0.0 | - | 0 |
| Visitor Center (DW002) | 0.0 | - | 4.5 |
| Sherman Spring (SP001) | - | - | 0 |

Notes:
- = Not Sampled
( ) Monitoring well sampled twice during sampling event
Parameters based on stabilized low flow data

# Table 8
# Summary of Groundwater Analytical Screening Data
# Yankee Nuclear Power Station
# Rowe, MA

| **Station** | **MCP** | **MW-100B** | **MW-100B** | **MW-101B** | **MW-101B** | **MW-101B** | **MW-101B** | **MW-101B** |
|---|---|---|---|---|---|---|---|---|
| **Sample Interval** | **RCGW-2** | **16'-21'** | **29'-43'** | **11.5'-15'** | **35'-45'** | **61'-65'** | **77.5'-84'** | **85'-92'** |
| **Date Sampled** | | **8/1/2003** | **8/5/2003** | **8/6/2003** | **8/8/2003** | **8/8/2003** | **8/11/2003** | **8/12/2003** |
| *Volatile Organic Compounds (ug/L)* | | | | | | | | |
| 1,1-Dichloroethane | 9,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 2-Butanone | 50,000 | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U |
| 2-Hexanone | 10,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 3.1 J |
| 4-Isopropyltoluene | NA | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Methyl-2-pentanone | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Acetone | 50,000 | 10 U | 10 U | 10 U | 8.7 J | 14 | 10 U | 5.2 J |
| Benzene | 2,000 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Carbon disulfide | NA | 5 U | 0.52 J | 5 U | 1.4 J | 0.58 J | 5 U | 0.64 J |
| Chloroform | 400 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Chloromethane | 10,000 | 0.64 J | 5 U | 5 U | 1.6 J | 5 U | 5 U | 5 U |
| Ethylbenzene | 4,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| m+p-Xylenes | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Methylene chloride | 50,000 | 2 B | 0.71 J,B | 2 U | 2 U | 0.76 J, B | 0.52 JB | 0.55 J,B |
| Methyl-t-butyl ether | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Naphthalene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| o-Xylene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Toluene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |

Notes:

Summary of detected compounds only
Data not validated
NA= Not Available
Bold and shaded cells detected above
applicable screening value
U= Not detected, value is the sample reporting limit
B= Present in blank
J= Estimated result

# Table 8
# Summary of Groundwater Analytical Screening Data
# Yankee Nuclear Power Station
# Rowe, MA

| **Station**<br>**Sample Interval**<br>**Date Sampled** | **MCP**<br>**RCGW-2** | **MW-101B**<br>**118'-121'**<br>**8/12/2003** | **MW-101B**<br>**128.5'-130'**<br>**8/13/2003** | **MW-101B**<br>**130'-156'**<br>**8/13/2003** | **MW-101C**<br>**94'-99'**<br>**8/15/2003** | **MW-102B**<br>**10'-15'**<br>**7/18/2003** | **MW-102B**<br>**30'-35'**<br>**7/21/2003** | **MW-102B**<br>**42'-48'**<br>**7/22/2003** |
|---|---|---|---|---|---|---|---|---|
| *Volatile Organic Compounds (ug/L)* | | | | | | | | |
| 1,1-Dichloroethane | 9,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 0.65 J | 5 U |
| 2-Butanone | 50,000 | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U |
| 2-Hexanone | 10,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Isopropyltoluene | NA | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Methyl-2-pentanone | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Acetone | 50,000 | 7.2 J | 10 U | 39 | 10 U | 10 | 2.9 J | 10 U |
| Benzene | 2,000 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Carbon disulfide | NA | 5 U | 5 U | 1.3 J | 5 U | 5 U | 5 U | 1.3 J |
| Chloroform | 400 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Chloromethane | 10,000 | 0.8 J | 5 U | 5 U | 5 U | 5 U | 5 U | 1 J |
| Ethylbenzene | 4,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| m+p-Xylenes | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Methylene chloride | 50,000 | 0.61 J,B | 0.74 J,B | 0.72 J,B | 2 U | 2 U | 3.7 B | 1.4 JB |
| Methyl-t-butyl ether | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Naphthalene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| o-Xylene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Toluene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |

Notes:

Summary of detected compounds only
Data not validated
NA= Not Available
Bold and shaded cells detected above
applicable screening value
U= Not detected, value is the sample reporting limit
B= Present in blank
J= Estimated result

## Table 8
## Summary of Groundwater Analytical Screening Data
## Yankee Nuclear Power Station
## Rowe, MA

| **Station** | MCP | MW-102B | MW-102B | MW-103B | MW-103B | MW-103B | MW-103B | MW-103B |
|---|---|---|---|---|---|---|---|---|
| **Sample Interval** | RCGW-2 | 95'-100' | 115.5'-131.5' | 25'-29' | 59'-65' | 149'-155' | 165'-170' | 170'-185' |
| **Date Sampled** | | 7/23/2003 | 7/24/2003 | 6/10/2003 | 6/11/2003 | 6/23/2003 | 6/24/2003 | 6/27/2003 |
| *Volatile Organic Compounds (ug/L)* | | | | | | | | |
| 1,1-Dichloroethane | 9,000 | 1.6 J | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 2-Butanone | 50,000 | 10 U | 10 U | 5.8 J | 10 U | 10 U | 10 U | 10 U |
| 2-Hexanone | 10,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Isopropyltoluene | NA | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Methyl-2-pentanone | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 6.2 | 5 U |
| Acetone | 50,000 | 10 U | 4.2 J | 25 | 11 | 23 | 38 | 30 |
| Benzene | 2,000 | 1 U | 1 U | 45 | 5 U | 1 U | 1 U | 1 U |
| Carbon disulfide | NA | 5 U | 0.79 J | 5 U | 5 U | 5 U | 5 U | 5 U |
| Chloroform | 400 | 1 U | 1 U | 5 U | 5 U | 1 U | 1 U | 1 U |
| Chloromethane | 10,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Ethylbenzene | 4,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| m+p-Xylenes | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Methylene chloride | 50,000 | 1.1 J,B | 2 U | 5 U | 5 U | 2 U | 2 U | 7 |
| Methyl-t-butyl ether | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Naphthalene | 6,000 | 5 U | 5 U | 4.1 J | 5 U | 5 U | 5 U | 5 U |
| o-Xylene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Toluene | 6,000 | 5 U | 5 U | 12 | 5 U | 5 U | 5 U | 5 U |

Notes:
Summary of detected compounds only
Data not validated
NA= Not Available
Bold and shaded cells detected above
applicable screening value
U= Not detected, value is the sample reporting limit
B= Present in blank
J= Estimated result

## Table 8
## Summary of Groundwater Analytical Screening Data
## Yankee Nuclear Power Station
## Rowe, MA

| **Station**<br>**Sample Interval**<br>**Date Sampled** | **MCP**<br>**RCGW-2** | **MW-103B**<br>**DUP-170'-185'**<br>**6/27/2003** | **MW-103B**<br>**280'-295'**<br>**7/9/2003** | **MW-103B**<br>**DUP-1-07102003**<br>**7/10/2003** | **MW-104B**<br>**20'-25'**<br>**6/18/2003** | **MW-104B**<br>**35'-43'**<br>**8/25/2003** | **MW-104B**<br>**95'-104'**<br>**8/25/2003** | **MW-104B**<br>**115'-123'**<br>**8/26/2003** |
|---|---|---|---|---|---|---|---|---|
| *Volatile Organic Compounds (ug/L)* | | | | | | | | |
| 1,1-Dichloroethane | 9,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 2-Butanone | 50,000 | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U |
| 2-Hexanone | 10,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Isopropyltoluene | NA | 5 U | 5 U | 0.52 J | 5 U | 5 U | 5 U | 5 U |
| 4-Methyl-2-pentanone | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Acetone | 50,000 | 10 U | 28 | 45 | 10 U | 10 U | 10 U | 7.8 J |
| Benzene | 2,000 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Carbon disulfide | NA | 5 U | 0.71 J | 5 U | 5 U | 5 U | 5 U | 5 U |
| Chloroform | 400 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Chloromethane | 10,000 | 5 U | 1.7 J | 5 U | 5 U | 5 U | 0.77 J | 5 U |
| Ethylbenzene | 4,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| m+p-Xylenes | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Methylene chloride | 50,000 | 2 U | 2 U | 2 U | 2 U | 3.2 B | 2.3 B | 2.1 B |
| Methyl-t-butyl ether | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Naphthalene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| o-Xylene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Toluene | 6,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |

Notes:
Summary of detected compounds only
Data not validated
NA= Not Available
Bold and shaded cells detected above
applicable screening value
U= Not detected, value is the sample reporting limit
B= Present in blank
J= Estimated result

## Table 8
## Summary of Groundwater Analytical Screening Data
## Yankee Nuclear Power Station
## Rowe, MA

| **Station** | **MCP** | **MW-104B** | **MW-104B** | **MW-104B** | **MW-105B** | **MW-105B** | **MW-105B** | **MW-107B** |
|---|---|---|---|---|---|---|---|---|
| **Sample Interval** | **RCGW-2** | **136'-139.5'** | **163.5'-175'** | **185'-190'** | **20'-25'** | **39'-44'** | **61'-75'** | **41'-45'** |
| **Date Sampled** | | **8/27/2003** | **8/28/2003** | **9/4/2003** | **6/19/2003** | **8/19/2003** | **8/20/2003** | **9/14/2003** |
| *Volatile Organic Compounds (ug/L)* | | | | | | | | |
| 1,1-Dichloroethane | 9,000 | 5 U | 2.3 J | 5 U | 5 U | 1.4 J | 2.3 J | 1.8 J |
| 2-Butanone | 50,000 | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U | 10 U |
| 2-Hexanone | 10,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Isopropyltoluene | NA | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| 4-Methyl-2-pentanone | 50,000 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Acetone | 50,000 | 19 | 39 | 510 | 10 U | 4 J | 55 | 10 U |
| Benzene | 2,000 | 1 U | 6.8 | 1 U | 1 U | 1 U | 1 U | 1 U |
| Carbon disulfide | NA | 1.2 J | 5 U | 1.4 J,B | 5 U | 5 U | 5 U | 1.4 J,B |
| Chloroform | 400 | 0.54 J | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Chloromethane | 10,000 | 5 U | 5 U | 0.64 J | 5.2 | 5 U | 5 U | 5 U |
| Ethylbenzene | 4,000 | 5 U | 0.71 J | 5 U | 5 U | 5 U | 5 U | 5 U |
| m+p-Xylenes | 6,000 | 5 U | 0.9 J | 5 U | 5 U | 5 U | 5 U | 5 U |
| Methylene chloride | 50,000 | 2.4 B | 2.4 B | 2 U | 2 U | 1.5 J,B | 0.83 J,B | 2.4 B |
| Methyl-t-butyl ether | 50,000 | 5 U | 5 U | 5 U | 5 U | 4.4 J | 0.71 J | 5 U |
| Naphthalene | 6,000 | 5 U | 3.9 J | 5 U | 5 U | 5 U | 5 U | 5 U |
| o-Xylene | 6,000 | 5 U | 0.76 J | 5 U | 5 U | 5 U | 5 U | 5 U |
| Toluene | 6,000 | 5 U | 3.9 J | 5 U | 5 U | 5 U | 5 U | 5 U |

Notes:

Summary of detected compounds only

Data not validated

NA= Not Available

Bold and shaded cells detected above
applicable screening value

U= Not detected, value is the sample reporting limit

B= Present in blank

J= Estimated result

Table 8
Summary of Groundwater Analytical Screening Data
Yankee Nuclear Power Station
Rowe, MA

| **Station**<br>**Sample Interval**<br>**Date Sampled** | **MCP**<br>**RCGW-2** | **MW-107B**<br>**75'-81'**<br>**9/15/2003** | **MW-107B**<br>**90'-91'**<br>**9/16/2003** | **MW-107B**<br>**94'-110'**<br>**9/17/2003** |
|---|---|---|---|---|
| *Volatile Organic Compounds (ug/L)* | | | | |
| 1,1-Dichloroethane | 9,000 | 0.94 J | 25 U | 5 U |
| 2-Butanone | 50,000 | 10 U | 50 U | 10 U |
| 2-Hexanone | 10,000 | 5 U | 25 U | 5 U |
| 4-Isopropyltoluene | NA | 5 U | 25 U | 5 U |
| 4-Methyl-2-pentanone | 50,000 | 5 U | 25 U | 5 U |
| Acetone | 50,000 | 6.4 J | 25 J | 10 U |
| Benzene | 2,000 | 1 U | 5.1 | 1 U |
| Carbon disulfide | NA | 4 J,B | 7 J,B | 1.2 J,B |
| Chloroform | 400 | 1 U | 5 U | 1 U |
| Chloromethane | 10,000 | 5 U | 25 U | 5 U |
| Ethylbenzene | 4,000 | 5 U | 25 U | 5 U |
| m+p-Xylenes | 6,000 | 5 U | 25 U | 5 U |
| Methylene chloride | 50,000 | 2.2 B | 60 B | 9.6 B |
| Methyl-t-butyl ether | 50,000 | 0.59 J | 25 U | 5 U |
| Naphthalene | 6,000 | 5 U | 25 U | 5 U |
| o-Xylene | 6,000 | 5 U | 25 U | 5 U |
| Toluene | 6,000 | 5 U | 7.2 J | 15 |

<u>Notes:</u>
Summary of detected compounds only
Data not validated
NA= Not Available
Bold and shaded cells detected above
applicable screening value
U= Not detected, value is the sample reporting limit
B= Present in blank
J= Estimated result

Table 9
Summary of Validated Groundwater Analytical Data
Summer 2003, Fall 2003 and Winter 2004
Yankee Nuclear Power Station
Rowe, MA

| Station/Sample Designation | MCP | MCP | B-1 | B-1 | CB-1 | CB-1 | CB-2 | CB-2 | CB-3 | CB-3 | CB-3 | CB-3 | CB-3 | CB-4 | CB-4 | CB-4 | CB-4 | CB-5 | CB-6 | CB-6 | CB-7 | CB-7 | CB-8 | CB-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | RCGW-1 | RCGW-2 | 7/16/2003 | 3/8/2004 | 7/21/2003 | 03/05/04 | 7/14/2003 | 03/02/04 | 7/16/2003 | 12/1/2003 | 12/1/2003 | 03/08/04 | 03/08/04 | 7/14/2003 | 11/5/2003 | 11/5/2003 | 03/01/04 | 7/29/2003 | 7/14/2003 | 03/10/04 | 7/23/2003 | 03/08/04 | 7/23/2003 | 03/02/04 |
| Applicable MCP Standard | | | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-1 | GW-1 | GW-1 | GW-1 | GW-1 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 |
| Comment | | | | | | | | | | | Alpha Lab | | DUP | | total | filtered | | | | | | | | |
| *Total Petroleum Hydrocarbons (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO (Diesel Range) | 200 | 1,000 | 33 | | 25 U | | 55 J | | **230** J | 45 | | 72 J | 46 J | 25 U | | | | 25 U | 46 | | 35 | | 69 | |
| TPH-GRO (Gasoline Range) | 200 | 1,000 | 10 U | | 10 U | | 10 U | | 10 U | | | | | 10 U | | | | 10 U | 10 U | | 10 U | | 10 U | |
| VPH | NA | NA | | | | | | | | | | | | | | | | | | | | | | |
| C5-C8 Aliphatics | 400 | 1,000 | | | | | | | | | 40 U | 40 U | 40 U | | | | | | | | | | | |
| C9-C12 Aliphatics | 1,000 | 1,000 | | | | | | | | | 40 U | 40 U | 40 U | | | | | | | | | | | |
| C9-C10 Aromatics | 200 | 4,000 | | | | | | | | | 40 U | 40 U | 40 U | | | | | | | | | | | |
| EPH | NA | NA | | | | | | | | | | | | | | | | | | | | | | |
| C9-C18 Aliphatics | 1,000 | 1,000 | | | | | | | | | 100 U | 100 U | 100 U | | | | | | | | | | | |
| C19-C36 Aliphatics | 5,000 | 20,000 | | | | | | | | | 100 U | 100 U | 100 U | | | | | | | | | | | |
| C11-C22 Aromatics | 200 | 30,000 | | | | | | | | | 100 U | 100 U | 100 U | | | | | | | | | | | |
| *Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | 9,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| 1,1-Dichloroethene | 1 | 1 | 2 U | | 2 UJ | | 2 U | | 2 UJ | | | | | 2 UJ | | | | 2 U | 2 U | | 2 UJ | | 2 UJ | |
| 1,2,4-Trimethylbenzene | 10,000 | 100,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| 1,3,5-Trimethylbenzene | 100 | 1,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| 4-Isopropyltoluene | NA | NA | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| 4-Methyl-2-pentanone | 400 | 50,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| Acetone | 3,000 | 50,000 | 10 U | | 10 U | | 10 U | | 10 UJ | | | | | 10 UJ | | | | 10 UJ | 10 U | | 10 UJ | | 10 U | |
| Benzene | 5 | 2,000 | 1 U | | 1 UJ | | 1 U | | 1 U | | | | | 1 U | | | | 1 U | 1 U | | 1 U | | 1 U | |
| Carbon disulfide | 1,000 | 10,000 | 5 U | | 5 U | | 5 U | | 5 UJ | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| Chloroform | 5 | 400 | 1 U | | 1 U | | 1 U | | 1 U | | | | | 1 U | | | | 1 U | 1 U | | 1 U | | 1 U | |
| Chloromethane | 1,000 | 10,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 UJ | 5 U | | 5 U | | 5 U | |
| Dichlorodifluoromethane | 10,000 | 100,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 0.67 J | | 5 UJ | |
| Ethylbenzene | 700 | 4,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| Iodomethane | 1,000 | 10,000 | 5 U | | 5 U | | 5 U | | 5 UJ | | | | | 5 UJ | | | | 5 U | 5 U | | 5 U | | R | |
| m+p-Xylenes | 6,000 | 6,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| Methylene chloride | 5 | 50,000 | 2 U | | 2 U | | 2 U | | 2 UJ | | | | | 2 U | | | | 2 U | 2 U | | 2 U | | 2 U | |
| Methyl-t-butyl ether | 70 | 50,000 | 0.68 J | | 5 U | | 5 U | | 0.77 J | | | | | 5 U | | | | 5 UJ | 5 U | | 5 U | | 5 U | |
| Naphthalene | 20 | 6,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| n-Butylbenzene | NA | NA | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 UJ | 5 U | | 5 U | | 5 U | |
| n-Propylbenzene | 1,000 | 10,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| o-Xylene | 6,000 | 6,000 | 5 U | | 5 U | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| Toluene | 1,000 | 6,000 | 5 U | | 5 UJ | | 5 U | | 5 U | | | | | 5 U | | | | 5 U | 5 U | | 5 U | | 5 U | |
| *Semi-Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20 | 5,000 | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 20 U | | | 0.2 UJ | | | | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Acenaphthylene | 300 | 3,000 | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 20 U | | | 0.2 UJ | | | | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 U | |
| Anthracene | 2,000 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Benzo(a)anthracene | 1 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| Benzo(a)pyrene | 0.2 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| Benzo(b)fluoranthene | 1 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| Benzo(g,h,i)perylene | 300 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| bis(2-Ethylhexyl)phthalate | 6 | 30 | 10 U | | 10 UJ | | 10 U | | 10 U | | | | | 10 UJ | | | | 10 U | 10 U | | 10 U | | 10 U | |
| Chrysene | 2 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| Dibenzo(a,h)anthracene | 0.5 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| Fluoranthene | 200 | 200 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| Fluorene | 300 | 3,000 | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 20 U | | | 0.2 UJ | | | | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Indeno(1,2,3-cd)pyrene | 0.5 | 3,000 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 U | 0.2 UJ | | 0.2 U | | 0.2 U | |
| Naphthalene | 20 | 6,000 | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 20 U | | | 0.2 UJ | | | | 0.16 J | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Pentachlorophenol | 1 | 80 | 1 UJ | | 1 UJ | | 1 UJ | | 1 UJ | | | | | 1 UJ | | | | 1 U | 1 UJ | | 1 U | | 1 U | |
| Phenanthrene | 50 | 50 | 0.2 UJ | | 0.2 U | | 0.2 UJ | | 0.2 U | | 20 U | | | 0.2 U | | | | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Phenol | 4,000 | 30,000 | 10 U | | R | | 10 U | | 10 U | | | | | 10 U | | | | 10 U | 10 U | | 10 U | | R | |
| Pyrene | 200 | 3,000 | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 20 U | | | 0.2 UJ | | | | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| *Polychlorinated Biphenyls (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | 0.3 | 0.3 | 0.25 U | | 0.25 U | | 0.25 U | | 0.25 U | | | | | 0.25 U | | | | 0.25 U | 0.25 U | | 0.25 U | | 0.25 U | |
| *Inorganics (mg/L)* | | | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 0.05 | 0.4 | 0.01 U | | 0.01 U | | 0.01 U | | 0.01 U | | | | | 0.01 U | | | | 0.01 U | 0.01 U | | 0.01 U | | 0.01 U | |
| Barium | 2 | 30 | | | | | | | | | | | | | | | | 0.011 | | | | | | |
| Boron | 1 | 10 | 0.27 | 0.16 | 0.49 | 0.44 | 0.13 | 0.1 | 0.1 U | | | 0.05 U | 0.05 U | 0.1 U | | | 0.05 U | 0.1 U | 0.1 U | 0.05 U | 0.1 U | 0.05 U | 0.1 U | 0.05 U |
| Chromium | 0.1 | 2 | 0.01 UJ | | 0.01 U | | 0.01 UJ | | 0.01 UJ | | | | | 0.01 UJ | | | | 0.01 U | 0.01 UJ | | 0.01 U | | 0.01 U | |
| Copper | 10 | 100 | 0.01 U | | 0.01 U | | 0.01 U | | 0.012 J | | | | | 0.01 UJ | | | | 0.01 U | 0.01 U | | 0.026 U | | 0.01 U | |
| Iron | NA | NA | | | | | | | | | | | | | | | | 0.23 | | | | | | |
| Lead | 0.02 | 0.03 | 0.0066 U | | 0.0063 | | 0.0052 U | | 0.005 U | | | | | 0.005 U | | | | 0.005 U | 0.0055 U | | 0.005 U | | 0.005 U | |
| Manganese | NA | NA | | | | | | | | | | | | | | | | 0.38 | | | | | | |
| Mercury | 0.001 | 0.001 | 0.0002 U | | 0.0003 J | | 0.0002 U | | 0.0002 U | | | | | 0.0002 U | | | | 0.00021 U | 0.0002 U | | 0.0002 U | | 0.0002 U | |
| Nickel | 0.08 | 0.08 | 0.01 U | | 0.01 U | | 0.003 U | | 0.021 | | | | | 0.01 UJ | | | | 0.01 U | 0.01 U | | 0.015 U | | 0.011 U | |
| Selenium | 0.05 | 0.08 | 0.05 U | | R | | 0.05 | | 0.05 U | | | | | 0.05 U | | | | 0.05 U | 0.05 U | | 0.05 U | | 0.05 U | |
| Silver | 0.007 | 0.007 | 0.005 U | | 0.005 U | | 0.005 U | | 0.005 UJ | | | | | **0.009** | 0.005 U | 0.01 U | 0.005 U | 0.005 U | 0.005 U | | 0.005 UJ | | 0.005 UJ | |
| Zinc | 0.9 | 0.9 | 0.05 U | | 0.05 U | | 0.05 U | | 0.83 | | | | | 0.05 U | | | | 0.05 U | 0.05 U | | 0.05 U | | 0.05 U | |

Notes:
Summary of detected compounds only
NA= Not Available
Blank cells were not analyzed
Bold and shaded cells detected above applicable screening value
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 9
Summary of Validated Groundwater Analytical Data
Summer 2003, Fall 2003 and Winter 2004
Yankee Nuclear Power Station
Rowe, MA

| Station/Sample Designation | MCP | MCP | CB-9 | CB-9 | CB-10 | CB-11A | CB-11A | CB-12 | CB-12 | CFW-1 | CFW-1 | CFW-2 | CFW-2 | CFW-3 | CFW-4 | CFW-5 | CFW-6 | CFW-7 | CFW-7 | CW-2 | CW-2 | CW-2 | CW-2 | CW-3 | CW-3 | CW-4 | CW-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | RCGW-1 | RCGW-2 | 7/24/2003 | 03/15/04 | 7/29/2003 | 7/24/2003 | 7/24/2003 | 7/29/2003 | 03/02/04 | 8/7/2003 | 03/18/04 | 7/28/2003 | 03/18/04 | 8/6/2003 | 8/6/2003 | 8/5/2003 | 8/11/2003 | 7/29/2003 | 03/18/04 | 7/24/2003 | 11/20/2003 | 11/20/2003 | 03/03/04 | 7/23/2003 | 03/09/04 | 7/24/2003 | 03/03/04 |
| Applicable MCP Standard | | | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-1 | GW-1 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-1 | GW-1 |
| Comment | | | | | | | DUP | | | | | | | | | | | | | | total | filtered | | | | | |
| *Total Petroleum Hydrocarbons (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO (Diesel Range) | 200 | 1,000 | 280 J | | 58 | 43 | 43 | 25 U | | 25 U | | 53 | | 92 UJ | 25 U | 25 U | 25 U | 65 | | 98 | | | | 57 | | 25 U | |
| TPH-GRO (Gasoline Range) | 200 | 1,000 | 10 U | | 10 U | 10 U | 10 U | 10 U | | 10 U | | 10 U | | 10 U | 10 U | 10 U | 10 U | 10 U | | 10 U | | | | 10 U | | 10 U | |
| VPH | NA | NA | | | | | | | | | | | | | | | | | | | | | | | | | |
| C5-C8 Aliphatics | 400 | 1,000 | | 40 U | | | | | | | | | | | | | | | | | | | | | | | |
| C9-C12 Aliphatics | 1,000 | 1,000 | | 40 U | | | | | | | | | | | | | | | | | | | | | | | |
| C9-C10 Aromatics | 200 | 4,000 | | 40 U | | | | | | | | | | | | | | | | | | | | | | | |
| EPH | NA | NA | | | | | | | | | | | | | | | | | | | | | | | | | |
| C9-C18 Aliphatics | 1,000 | 1,000 | | 95.2 U | | | | | | | | | | | | | | | | | | | | | | | |
| C19-C36 Aliphatics | 5,000 | 20,000 | | 238 | | | | | | | | | | | | | | | | | | | | | | | |
| C11-C22 Aromatics | 200 | 30,000 | | 95.2 U | | | | | | | | | | | | | | | | | | | | | | | |
| *Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | 9,000 | 0.8 J | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 UJ | 5 UJ | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| 1,1-Dichloroethene | 1 | 1 | 2 U | | 2 UJ | 2 U | 2 U | 2 UJ | | 2 U | | 2 U | | 2 U | 2 U | 2 UJ | 2 U | 2 U | | 2 U | | | | 2 UJ | | 2 UJ | |
| 1,2,4-Trimethylbenzene | 10,000 | 100,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| 1,3,5-Trimethylbenzene | 100 | 1,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| 4-Isopropyltoluene | NA | NA | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| 4-Methyl-2-pentanone | 400 | 50,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| Acetone | 3,000 | 50,000 | 3.4 J | | 10 UJ | 10 U | 10 U | 10 UJ | | R | | 10 UJ | | 9.1 J | 10 UJ | 10 UJ | 10 U | 10 UJ | | 10 U | | | | 10 U | | 10 U | |
| Benzene | 5 | 2,000 | 1 U | | 1 UJ | 1 U | 1 U | 1 UJ | | 1 U | | 1 U | | 1 U | 1 U | 1 UJ | 1 U | 1 U | | 1 U | | | | 1 U | | 1 U | |
| Carbon disulfide | 1,000 | 10,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| Chloroform | 5 | 400 | 1 U | | 1 UJ | 1 U | 1 U | 1 UJ | | 1 U | | 1 U | | 1 U | 1 U | 1 UJ | 1 U | 1 U | | 1 U | | | | 1 U | | 1 U | |
| Chloromethane | 1,000 | 10,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 UJ | | 5 UJ | 5 UJ | 5 UJ | 5 U | 5 UJ | | 5 U | | | | 5 U | | 5 U | |
| Dichlorodifluoromethane | 10,000 | 100,000 | 5 UJ | | 5 UJ | 5 UJ | 5 UJ | 0.84 J | | 5 U | | 5 U | | 5 UJ | 5 UJ | 5 UJ | 5 U | 5 U | | 5 UJ | | | | 5 UJ | | 5 UJ | |
| Ethylbenzene | 700 | 4,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| Iodomethane | 1,000 | 10,000 | R | | 5 UJ | R | R | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | R | | | | R | | R | |
| m+p-Xylenes | 6,000 | 6,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| Methylene chloride | 5 | 50,000 | 2 U | | 2 U | 2 U | 2 U | 2 U | | 2 U | | 2 U | | 2 UJ | 2 UJ | 2 UJ | 2 U | 2 U | | 2 U | | | | 2 U | | 2 U | |
| Methyl-t-butyl ether | 70 | 50,000 | 5 U | | 3.1 J | 5 U | 5 U | 5 UJ | | 5 U | | 5 UJ | | 5 U | 5 U | 5 UJ | 5 U | 5 UJ | | 5 U | | | | 5 U | | 5 U | |
| Naphthalene | 20 | 6,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 UJ | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| n-Butylbenzene | NA | NA | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 UJ | | 5 U | 5 UJ | 5 UJ | 5 U | 5 UJ | | 5 U | | | | 5 U | | 5 U | |
| n-Propylbenzene | 1,000 | 10,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| o-Xylene | 6,000 | 6,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| Toluene | 1,000 | 6,000 | 5 U | | 5 UJ | 5 U | 5 U | 5 UJ | | 5 U | | 5 U | | 5 U | 5 U | 5 UJ | 5 U | 5 U | | 5 U | | | | 5 U | | 5 U | |
| *Semi-Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20 | 5,000 | 0.2 UJ | | 0.16 J | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 U | 0.2 U | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | |
| Acenaphthylene | 300 | 3,000 | 0.2 UJ | | 0.17 J | 0.2 UJ | 0.2 UJ | 0.38 J | | 0.2 UJ | | 0.2 UJ | | 0.2 U | 0.2 U | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | |
| Anthracene | 2,000 | 3,000 | 0.2 UJ | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | |
| Benzo(a)anthracene | 1 | 3,000 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| Benzo(a)pyrene | 0.2 | 3,000 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| Benzo(b)fluoranthene | 1 | 3,000 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| Benzo(g,h,i)perylene | 300 | 3,000 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| bis(2-Ethylhexyl)phthalate | 6 | 30 | 3 J | | 10 U | 10 U | 2.6 J | 3.8 J | | 10 U | | 5.4 UJ | | 10 UJ | 10 U | 10 U | 10 U | 12 | | 10 U | | | | 10 U | | 10 U | |
| Chrysene | 2 | 3,000 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| Dibenzo(a,h)anthracene | 0.5 | 3,000 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| Fluoranthene | 200 | 200 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| Fluorene | 300 | 3,000 | 0.2 UJ | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 1 J | | 0.2 UJ | | 0.2 UJ | 0.68 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | |
| Indeno(1,2,3-cd)pyrene | 0.5 | 3,000 | 0.2 U | | 0.2 UJ | 0.2 U | 0.2 U | 0.2 UJ | | 0.2 UJ | | 0.2 U | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 U | | 0.2 U | | | | 0.2 U | | 0.2 U | |
| Naphthalene | 20 | 6,000 | 0.2 UJ | | 0.2 | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.34 | 0.19 J | 0.2 UJ | 0.22 J | 0.22 J | | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | |
| Pentachlorophenol | 1 | 80 | 1 UJ | | 1 UJ | 1 UJ | 1 UJ | 1 UJ | | 1 UJ | | 1 UJ | | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 U | | 1 UJ | | | | 1 U | | R | |
| Phenanthrene | 50 | 50 | 0.2 UJ | | 0.16 J | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | |
| Phenol | 4,000 | 30,000 | 10 U | | 10 U | 10 U | 10 U | 10 U | | 10 U | | R | | R | R | R | R | 10 U | | 10 U | | | | 10 U | | R | |
| Pyrene | 200 | 3,000 | 0.2 UJ | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.2 UJ | | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | |
| *Polychlorinated Biphenyls (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | 0.3 | 0.3 | 0.25 U | | 0.25 U | 0.25 U | 0.25 U | 0.25 U | | 0.25 U | | 5 U | | 0.25 U | 0.25 U | 0.25 U | 0.25 U | 0.25 U | | 0.25 U | | | | 0.25 U | | 0.25 U | |
| *Inorganics (mg/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 0.05 | 0.4 | 0.01 U | | 0.01 U | 0.01 U | 0.01 U | 0.01 U | | 0.01 U | | 0.01 U | | 0.01 U | 0.01 U | 0.01 U | 0.01 UJ | 0.01 U | | 0.01 U | | | | 0.01 U | | 0.01 U | |
| Barium | 2 | 30 | | | | | | | | 0.017 | | 0.097 | | 0.094 | 0.062 | 0.043 | 0.069 | 0.095 | | | | | | | | | |
| Boron | 1 | 10 | 0.13 | 0.33 | 0.26 | 0.1 U | 0.1 U | 0.1 U | 0.05 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.11 | | | 0.05 U | 0.1 U | 0.05 U | 0.1 U | 0.14 |
| Chromium | 0.1 | 2 | 0.01 U | | 0.01 UJ | 0.01 U | 0.01 U | 0.01 UJ | | 0.01 U | | 0.01 U | | 0.025 | 0.01 U | 0.01 U | 0.01 U | 0.01 U | | 0.01 U | | | | 0.01 U | | 0.01 U | |
| Copper | 10 | 100 | 0.01 U | | 0.01 UJ | 0.01 U | 0.01 U | 0.01 UJ | | 0.01 U | | 0.01 U | | 0.015 U | 0.036 | 0.015 U | 0.01 UJ | 0.01 U | | 0.01 U | | | | 0.039 U | | 0.018 U | |
| Iron | NA | NA | | | | | | | | 1.8 | | 74 | | 180 J | 10 | 38 | 67 | 100 | | | | | | | | | |
| Lead | 0.02 | 0.03 | 0.005 U | | 0.005 U | 0.005 U | 0.005 U | 0.005 U | | 0.005 U | | R | | 0.005 U | 0.005 U | R | 0.005 U | 0.005 U | | 0.005 U | | | | 0.005 U | | 0.005 U | |
| Manganese | NA | NA | | | | | | | | 0.047 | | 10 | | 8 | 5.7 | 3.5 | 8.8 | 9.6 | | | | | | | | | |
| Mercury | 0.001 | 0.001 | 0.0002 U | | 0.0002 U | 0.0002 U | 0.0002 U | 0.0002 U | | 0.0002 U | | 0.0002 U | | 0.0002 U | 0.0002 U | 0.0002 U | 0.0002 U | 0.0002 U | | 0.0002 U | | | | 0.0002 U | | 0.0002 U | |
| Nickel | 0.08 | 0.08 | 0.01 U | | 0.01 UJ | 0.01 U | 0.01 U | 0.01 UJ | | 0.01 U | | 0.013 | | 0.027 | 0.01 U | 0.01 U | 0.01 U | 0.01 U | | 0.01 U | | | | 0.011 U | | 0.01 U | |
| Selenium | 0.05 | 0.08 | 0.05 U | | 0.05 UJ | 0.05 U | 0.05 U | 0.05 UJ | | 0.05 U | | 0.05 U | | 0.05 U | 0.05 U | 0.05 U | 0.05 U | 0.05 U | | 0.05 U | | | | 0.05 U | | 0.05 U | |
| Silver | 0.007 | 0.007 | 0.005 U | | 0.005 UJ | 0.005 U | 0.005 | 0.005 UJ | | 0.005 UJ | | 0.005 U | | 0.005 UJ | 0.005 UJ | 0.005 UJ | 0.005 U | 0.005 U | | 0.014 U | 0.005 U | 0.01 U | 0.005 U | 0.005 UJ | | 0.005 UJ | |
| Zinc | 0.9 | 0.9 | 0.05 U | | 0.05 U | 0.05 U | 0.01 U | 0.05 U | | 0.05 U | | 0.05 U | | 0.05 U | 0.05 U | 0.057 U | 0.05 UJ | 0.05 U | | 0.01 U | | | | 0.01 U | | 0.01 U | |

Notes:
Summary of detected compounds only
NA= Not Available
Blank cells were not analyzed
Bold and shaded cells detected above applicable screening value
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 9
Summary of Validated Groundwater Analytical Data
Summer 2003, Fall 2003 and Winter 2004
Yankee Nuclear Power Station
Rowe, MA

| Station/Sample Designation | MCP | MCP | CW-5 | CW-6 | CW-6 | CW-6 | CW-7 | CW-7 | CW-8 | CW-8 | CW-10 | CW-10 | CW-11 | MW-1 | MW-1 | MW-2 | MW-2 | MW-5 | MW-5 | MW-5 | MW-5 | MW-5 | MW-5 | MW-6 | MW-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | RCGW-1 | RCGW-2 | 7/21/2003 | 7/15/2003 | 7/15/2003 | 03/19/04 | 7/15/2003 | 03/08/04 | 7/15/2003 | 03/19/04 | 7/15/2003 | 03/04/04 | 7/25/2003 | 7/23/2003 | 03/10/04 | 7/22/2003 | 03/05/04 | 7/22/2003 | 12/1/2003 | 12/1/2003 | 03/03/04 | 03/17/04 | 03/17/04 | 7/22/2003 | 03/04/04 |
| Applicable MCP Standard |  |  | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 |
| Comment |  |  |  |  | DUP |  |  |  |  |  |  |  |  |  |  |  |  |  | total | filtered |  | total | filtered |  |  |
| *Total Petroleum Hydrocarbons (ug/L)* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| TPH-DRO (Diesel Range) | 200 | 1,000 | 61 | 25 U | 25 U |  | 25 U |  | 25 U |  | 150 |  | 44 | 99 |  | 25 U |  | 32 |  |  |  |  |  | 110 |  |
| TPH-GRO (Gasoline Range) | 200 | 1,000 | 10 U | 10 U | 10 U |  | 10 U |  | 10 U |  | 10 U |  | 10 U | 10 U |  | 16 |  | 10 U |  |  |  |  |  | 10 U |  |
| VPH | NA | NA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| C5-C8 Aliphatics | 400 | 1,000 |  |  |  |  |  |  |  |  |  | 40 U |  |  |  |  |  |  |  |  |  |  |  |  | 40 U |
| C9-C12 Aliphatics | 1,000 | 1,000 |  |  |  |  |  |  |  |  |  | 40 U |  |  |  |  |  |  |  |  |  |  |  |  | 40 U |
| C9-C10 Aromatics | 200 | 4,000 |  |  |  |  |  |  |  |  |  | 40 U |  |  |  |  |  |  |  |  |  |  |  |  | 40 U |
| EPH | NA | NA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| C9-C18 Aliphatics | 1,000 | 1,000 |  |  |  |  |  |  |  |  |  | 100 U |  |  |  |  |  |  |  |  |  |  |  |  | 100 U |
| C19-C36 Aliphatics | 5,000 | 20,000 |  |  |  |  |  |  |  |  |  | 100 U |  |  |  |  |  |  |  |  |  |  |  |  | 454 |
| C11-C22 Aromatics | 200 | 30,000 |  |  |  |  |  |  |  |  |  | 100 U |  |  |  |  |  |  |  |  |  |  |  |  | 229 |
| *Volatile Organic Compounds (ug/L)* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1,1-Dichloroethane | 70 | 9,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| 1,1-Dichloroethene | 1 | 1 | 2 UJ | 2 U | 2 U |  | 2 U |  | 2 U |  | 2 UJ |  | 2 U | 2 UJ |  | 2 UJ |  | 2 UJ |  |  |  |  |  | 2 U |  |
| 1,2,4-Trimethylbenzene | 10,000 | 100,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| 1,3,5-Trimethylbenzene | 100 | 1,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| 4-Isopropyltoluene | NA | NA | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| 4-Methyl-2-pentanone | 400 | 50,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| Acetone | 3,000 | 50,000 | 10 UJ | 10 U | 10 U |  | 10 U |  | 10 U |  | 10 U |  | 10 UJ | 10 UJ |  | 10 U |  | 10 UJ |  |  |  |  |  | 10 U |  |
| Benzene | 5 | 2,000 | 1 U | 1 U | 1 U |  | 1 U |  | 1 U |  | 1 U |  | 1 U | 1 U |  | 1 UJ |  | 1 U |  |  |  |  |  | 1 U |  |
| Carbon disulfide | 1,000 | 10,000 | 5 U | 5 U | 5 U |  | 6.9 |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| Chloroform | 5 | 400 | 1 U | 1 U | 1 U |  | 1 U |  | 1 U |  | 1 U |  | 1 U | 1 U |  | 1 U |  | 1 U |  |  |  |  |  | 1 U |  |
| Chloromethane | 1,000 | 10,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 UJ |  | 5 UJ | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| Dichlorodifluoromethane | 10,000 | 100,000 | 5 UJ | 5 U | 5 U |  | 5 U |  | 5 U |  | 0.62 J |  | 5 U | 5 UJ |  | 5 U |  | 5 UJ |  |  |  |  |  | 5 U |  |
| Ethylbenzene | 700 | 4,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| Iodomethane | 1,000 | 10,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 UJ |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| m+p-Xylenes | 6,000 | 6,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| Methylene chloride | 5 | 50,000 | 2 U | 2 U | 2 U |  | 2 U |  | 2 U |  | 2 U |  | 2 U | 2 U |  | 2 U |  | 2 U |  |  |  |  |  | 2 |  |
| Methyl-t-butyl ether | 70 | 50,000 | 5 U | 5 U | 1.9 J |  | 2 J |  | 5 U |  | 5 U |  | 2.7 J | 5 U |  | 5 U |  | 14 |  |  |  |  |  | 5 U |  |
| Naphthalene | 20 | 6,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| n-Butylbenzene | NA | NA | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 UJ | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| n-Propylbenzene | 1,000 | 10,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| o-Xylene | 6,000 | 6,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 U |  | 5 U |  |  |  |  |  | 5 U |  |
| Toluene | 1,000 | 6,000 | 5 U | 5 U | 5 U |  | 5 U |  | 5 U |  | 5 U |  | 5 U | 5 U |  | 5 UJ |  | 5 U |  |  |  |  |  | 5 U |  |
| *Semi-Volatile Organic Compounds (ug/L)* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Acenaphthene | 20 | 5,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ | 0.2 UJ |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Acenaphthylene | 300 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ | 0.2 UJ |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Anthracene | 2,000 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 UJ | 0.2 UJ |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Benzo(a)anthracene | 1 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Benzo(a)pyrene | 0.2 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Benzo(b)fluoranthene | 1 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Benzo(g,h,i)perylene | 300 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| bis(2-Ethylhexyl)phthalate | 6 | 30 | 10 U | 10 U | 10 U |  | 10 U |  | 10 U |  | 12 |  | 10 U | 10 U |  | 10 U |  | 10 U |  |  |  |  |  | 10 U |  |
| Chrysene | 2 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Dibenzo(a,h)anthracene | 0.5 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Fluoranthene | 200 | 200 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Fluorene | 300 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ | 0.2 UJ |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Indeno(1,2,3-cd)pyrene | 0.5 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 U | 0.2 U |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Naphthalene | 20 | 6,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.15 J | 0.2 UJ |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Pentachlorophenol | 1 | 80 | 1 U | 1 UJ | 1 UJ |  | 1 UJ |  | 1 UJ |  | 1 UJ |  | 1 UJ | 1 U |  | 1 U |  | 1 U |  |  |  |  |  | 1 UJ |  |
| Phenanthrene | 50 | 50 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 U |  | 0.2 UJ | 0.2 UJ |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| Phenol | 4,000 | 30,000 | 10 U | 10 U | 10 U |  | 10 U |  | 10 U |  | 10 U |  | R | 10 U |  | 10 U |  | 10 U |  |  |  |  |  | 10 U |  |
| Pyrene | 200 | 3,000 | 0.2 U | 0.2 UJ | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ |  | 0.2 UJ | 0.2 UJ |  | 0.2 U |  | 0.2 U |  |  |  |  |  | 0.2 UJ |  |
| *Polychlorinated Biphenyls (ug/L)* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Aroclor-1254 | 0.3 | 0.3 | 0.25 U | 0.25 U | 0.25 U |  | 0.25 U |  | 0.25 U |  | 0.25 U |  | 0.25 U | 0.25 U |  | 0.25 U |  | **4.6** | **2.2** | **1.5** | 0.25 U | **3.1** | **1.5** | 0.25 U |  |
| *Inorganics (mg/L)* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Arsenic | 0.05 | 0.4 | 0.01 U | 0.01 U | 0.01 U |  | 0.01 U |  | 0.01 U |  | 0.01 U |  | 0.01 UJ | 0.01 U |  | 0.01 U |  | 0.01 U |  |  |  |  |  | 0.01 U |  |
| Barium | 2 | 30 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Boron | 1 | 10 | 0.1 U | 0.1 U | 0.12 | 0.1 U | 0.12 | 0.067 | 0.19 | 0.12 | 0.1 U | 0.4 | 0.17 | 0.1 U | 0.05 U | 0.2 | 0.12 | 0.14 |  |  | 0.11 |  |  | 0.1 U | 0.05 U |
| Chromium | 0.1 | 2 | 0.01 U | 0.01 UJ | 0.01 UJ |  | 0.01 UJ |  | 0.01 UJ |  | 0.01 UJ |  | 0.01 U | 0.01 U |  | 0.01 U |  | 0.01 U |  |  |  |  |  | 0.01 U |  |
| Copper | 10 | 100 | 0.026 | 0.01 U | 0.01 U |  | 0.01 U |  | 0.01 U |  | 0.01 UJ |  | 0.01 U | 0.023 U |  | 0.01 U |  | 0.01 U |  |  |  |  |  | 0.01 U |  |
| Iron | NA | NA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Lead | 0.02 | 0.03 | 0.005 U | 0.005 U | 0.0052 U |  | 0.0075 U |  | 0.005 U |  | 0.005 U |  | R | 0.005 U |  | 0.005 U |  | 0.005 U |  |  |  |  |  | 0.005 U |  |
| Manganese | NA | NA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mercury | 0.001 | 0.001 | 0.0002 U | 0.0002 U | 0.0002 U |  | 0.0002 U |  | 0.0002 U |  | 0.0002 U |  | 0.0002 U | 0.0002 U |  | 0.0002 U |  | 0.0002 U |  |  |  |  |  | 0.0002 U |  |
| Nickel | 0.08 | 0.08 | 0.01 U | 0.01 U | 0.01 U |  | 0.01 U |  | 0.01 U |  | 0.01 UJ |  | 0.01 U | 0.025 U |  | 0.01 U |  | 0.01 U |  |  |  |  |  | 0.01 U |  |
| Selenium | 0.05 | 0.08 | 0.05 U | 0.05 U | 0.05 U |  | 0.05 U |  | 0.05 U |  | 0.05 U |  | 0.05 U | 0.05 U |  | 0.05 U |  | 0.05 U |  |  |  |  |  | 0.05 U |  |
| Silver | 0.007 | 0.007 | 0.005 U | 0.005 U | 0.005 U |  | 0.005 U |  | 0.005 U |  | 0.005 UJ |  | 0.005 U | 0.005 UJ |  | 0.005 U |  | 0.005 U |  |  |  |  |  | 0.005 UJ |  |
| Zinc | 0.9 | 0.9 | 0.01 U | 0.05 U | 0.05 U |  | 0.05 U |  | 0.05 U |  | 0.05 U |  | 0.05 U | 0.36 |  | 0.05 U |  | 0.05 U |  |  |  |  |  | 0.05 U |  |

Notes:
Summary of detected compounds only
NA= Not Available
Blank cells were not analyzed
Bold and shaded cells detected above applicable screening value
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 9
Summary of Validated Groundwater Analytical Data
Summer 2003, Fall 2003 and Winter 2004
Yankee Nuclear Power Station
Rowe, MA

| Station/Sample Designation | MCP | MCP | MW-100A | MW-100B | MW-101B | MW-101B | MW-101C | MW-101C | MW-102A | MW-102A | MW-102B | MW-102C | MW-102C | MW-102C | MW-102C | MW-103A | MW-103A | MW-103B | MW-103B | MW-103B | MW-103B | MW-103C | MW-103C | MW-104B | MW-104B | MW-104B | MW-104B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | RCGW-1 | RCGW-2 | 9/11/2003 | 9/11/2003 | 9/12/2003 | 03/04/04 | 9/16/2003 | 03/03/04 | 9/10/2003 | 03/02/04 | 9/10/2003 | 9/10/2003 | 11/12/2003 | 11/12/2003 | 03/02/04 | 9/8/2003 | 03/01/04 | 9/9/2003 | 9/9/2003 | 03/09/04 | 03/09/04 | 9/11/2003 | 03/10/04 | 03/11/04 | 03/11/04 | 03/11/04 | 03/11/04 |
| Applicable MCP Standard | | | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 |
| Comment | | | | | | | | | | | | | total | filtered | | | | | DUP | total | filtered | | | total | filtered | DUP/total | DUP/filtered |
| *Total Petroleum Hydrocarbons (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO (Diesel Range) | 200 | 1,000 | 260 J | 25 U | 25 U | | 180 | | 430 J | | 25 U | 720 J | | | | 25 U | | 200 J | 310 J | | | 230 | | | | | |
| TPH-GRO (Gasoline Range) | 200 | 1,000 | 10 U | 10 U | 10 U | | 10 U | | 43 | | 10 U | 15 | | | | 10 U | | 10 U | 10 U | | | 10 U | | | | | |
| VPH | NA | NA | | | | | | | | | | | | | | | | | | | | | | | | | |
| C5-C8 Aliphatics | 400 | 1,000 | | | | | | **2390** | | 40 U | | | | | 40 U | | | | | 106 | | | 40 U | 97.3 J | | 368 J | |
| C9-C12 Aliphatics | 1,000 | 1,000 | | | | | | 400 U | | 40 U | | | | | 40 U | | | | | 40 U | | | 40 U | 40 U | | 40 U | |
| C9-C10 Aromatics | 200 | 4,000 | | | | | | 400 U | | 40 U | | | | | 40 U | | | | | 40 U | | | 40 U | 40 U | | 40 U | |
| EPH | NA | NA | | | | | | | | | | | | | | | | | | | | | | | | | |
| C9-C18 Aliphatics | 1,000 | 1,000 | | | | | | 100 U | | 100 U | | | | | 100 U | | | | | 100 U | | | 100 U | 95.2 U | | 95.2 U | |
| C19-C36 Aliphatics | 5,000 | 20,000 | | | | | | 205 | | 100 U | | | | | 100 U | | | | | 100 U | | | 100 U | 95.2 U | | 95.2 U | |
| C11-C22 Aromatics | 200 | 30,000 | | | | | | 120 | | 100 U | | | | | 100 U | | | | | 100 U | | | 100 U | 95.2 U | | 95.2 U | |
| *Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | 9,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 4.7 J | | 5 U | 0.87 J | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| 1,1-Dichloroethene | 1 | 1 | 2 UJ | 2 UJ | 2 UJ | | 2 UJ | | 2 UJ | | 2 U | 2 UJ | | | | 2 UJ | | 2 UJ | 2 UJ | | | 2 UJ | | 2 U | | 2 U | |
| 1,2,4-Trimethylbenzene | 10,000 | 100,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| 1,3,5-Trimethylbenzene | 100 | 1,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| 4-Isopropyltoluene | NA | NA | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| 4-Methyl-2-pentanone | 400 | 50,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 UJ | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| Acetone | 3,000 | 50,000 | 10 UJ | 10 UJ | 10 UJ | | 690 J | | 74 J | | 220 | 170 J | | | | 10 UJ | | 160 J | 310 J | | | 6200 J | | 1500 | | 1700 | |
| Benzene | 5 | 2,000 | 1 UJ | 1 UJ | 1 UJ | | 1 UJ | | 1 UJ | | 1 U | 1 UJ | | | | 1 UJ | | 1 UJ | 1 UJ | | | 1 UJ | | 1 U | | 1 U | |
| Carbon disulfide | 1,000 | 10,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 U | | 5 U | 5 UJ | | | | 5 U | | 5 J | 5 UJ | | | 5 U | | 0.87 J | | 7.6 | |
| Chloroform | 5 | 400 | 2 J | 1 UJ | 1 UJ | | 1.7 J | | 1 UJ | | 1 U | 1 UJ | | | | 1 UJ | | 1 UJ | 1.3 | | | 1 UJ | | 1 UJ | | 0.64 J | |
| Chloromethane | 1,000 | 10,000 | 1.6 J | 0.59 J | 5 UJ | | 5 UJ | | 5 UJ | | 5 UJ | 5 UJ | | | | 0.53 J | | 5 UJ | 5 UJ | | | 0.53 J | | 5 U | | 5 U | |
| Dichlorodifluoromethane | 10,000 | 100,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 UJ | 5 UJ | | | | 3 J | | 5 UJ | 5 UJ | | | 5 UJ | | 5 UJ | | 5 UJ | |
| Ethylbenzene | 700 | 4,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| Iodomethane | 1,000 | 10,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| m+p-Xylenes | 6,000 | 6,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| Methylene chloride | 5 | 50,000 | 2 UJ | 2 UJ | 3.8 U | | 2 UJ | | 2 UJ | | 2 U | 2 UJ | | | | 2 UJ | | 2 UJ | 2 UJ | | | 2 UJ | | 2 U | | 2 U | |
| Methyl-t-butyl ether | 70 | 50,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 UJ | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| Naphthalene | 20 | 6,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| n-Butylbenzene | NA | NA | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| n-Propylbenzene | 1,000 | 10,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| o-Xylene | 6,000 | 6,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| Toluene | 1,000 | 6,000 | 5 UJ | 5 UJ | 5 UJ | | 5 UJ | | 5 UJ | | 5 U | 5 UJ | | | | 5 UJ | | 5 UJ | 5 UJ | | | 5 UJ | | 5 U | | 5 U | |
| *Semi-Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20 | 5,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.06 J | | | | 0.2 UJ | | 0.2 UJ | 0.06 J | | | 0.2 UJ | | 10 U | | 10 U | |
| Acenaphthylene | 300 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | | 0.2 UJ | | 0.2 UJ | 0.05 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Anthracene | 2,000 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.15 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Benzo(a)anthracene | 1 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.15 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Benzo(a)pyrene | 0.2 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.13 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Benzo(b)fluoranthene | 1 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.16 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Benzo(g,h,i)perylene | 300 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.13 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| bis(2-Ethylhexyl)phthalate | 6 | 30 | 10 UJ | 10 U | 10 U | | 10 U | | 4.9 J | | 10 UJ | 3.6 J | | | | 10 U | | 12 J | 8.4 J | | | 13 J | | 3.2 J | | 10 UJ | |
| Chrysene | 2 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.15 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Dibenzo(a,h)anthracene | 0.5 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.11 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Fluoranthene | 200 | 200 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.18 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Fluorene | 300 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.06 J | | | | 0.2 UJ | | 0.05 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Indeno(1,2,3-cd)pyrene | 0.5 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.12 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Naphthalene | 20 | 6,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.11 J | 0.06 J | | | | 0.2 UJ | | 0.08 J | 0.17 J | | | 0.2 UJ | | 10 U | | 10 U | |
| Pentachlorophenol | 1 | 80 | 1 UJ | 1 U | 1 U | | 1 UJ | | 1 UJ | | 1 UJ | 1 UJ | | | | 1 UJ | | 1 UJ | 1 UJ | | | 1 UJ | | 50 U | | 50 U | |
| Phenanthrene | 50 | 50 | 0.2 UJ | 0.2 U | 0.2 U | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | 0.18 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| Phenol | 4,000 | 30,000 | 10 UJ | R | 10 U | | 10 U | | 10 U | | 10 U | 10 U | | | | 10 U | | 10 UJ | 10 UJ | | | 10 UJ | | 10 U | | 10 U | |
| Pyrene | 200 | 3,000 | 0.2 UJ | 0.2 U | 0.2 U | | 0.13 J | | 0.2 UJ | | 0.2 UJ | 0.3 J | | | | 0.2 UJ | | 0.2 UJ | 0.2 UJ | | | 0.2 UJ | | 10 U | | 10 U | |
| *Polychlorinated Biphenyls (ug/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | 0.3 | 0.3 | 0.25 U | 0.25 U | 0.25 U | | 0.25 U | | 0.25 U | | 0.25 U | 0.25 U | | | | 0.25 U | | 0.25 U | 0.25 U | | | 0.25 U | | 0.25 U | 0.25 U | 0.25 U | 0.25 U |
| *Inorganics (mg/L)* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 0.05 | 0.4 | 0.01 U | 0.01 U | 0.01 U | | 0.01 U | | 0.01 U | | 0.01 U | 0.034 | | | | 0.01 U | | 0.01 U | 0.028 | | | 0.068 | | 0.01 U | | 0.01 U | |
| Barium | 2 | 30 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Boron | 1 | 10 | 0.12 U | 0.1 U | 0.05 U | 0.19 | 0.05 U | 0.05 U | 0.22 U | 0.05 U | 0.17 | 0.13 U | | | 0.05 U | 0.11 | 0.05 U | 0.1 U | 0.16 U | 0.05 U | | 0.15 U | 0.05 U | 0.1 U | | 0.1 U | |
| Chromium | 0.1 | 2 | 0.01 UJ | 0.01 UJ | 0.01 UJ | | 0.01 UJ | | 0.01 UJ | | 0.01 U | 0.012 | | | | 0.01 UJ | | 0.015 | 0.013 | | | 0.04 | | 0.088 J | | 0.076 J | |
| Copper | 10 | 100 | 0.01 U | 0.01 UJ | 0.01 UJ | | 0.01 UJ | | 0.01 U | | 0.01 U | 0.01 U | | | | 0.01 UJ | | 0.01 U | 0.01 U | | | 0.01 U | | 0.01 U | | 0.01 U | |
| Iron | NA | NA | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lead | 0.02 | 0.03 | 0.005 U | 0.005 UJ | 0.005 UJ | | 0.005 UJ | | 0.005 U | | 0.005 U | **0.037** | 0.003 U | 0.003 U | 0.005 U | 0.005 U | | **0.1** | **0.31** | 0.005 U | 0.005 U | 0.02 | | 0.005 U | | 0.005 U | |
| Manganese | NA | NA | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mercury | 0.001 | 0.001 | 0.0002 U | 0.0002 U | 0.0002 U | | 0.0002 U | | 0.0002 U | | 0.0002 U | 0.0002 U | | | | 0.0002 U | | 0.0002 U | 0.0002 U | | | 0.0002 U | | 0.0002 U | | 0.0002 U | |
| Nickel | 0.08 | 0.08 | 0.01 U | 0.01 UJ | 0.01 UJ | | 0.01 UJ | | 0.01 U | | 0.01 U | 0.01 | | | | 0.01 UJ | | 0.01 U | 0.01 U | | | 0.031 | | 0.053 | | 0.046 | |
| Selenium | 0.05 | 0.08 | 0.05 UJ | 0.05 UJ | 0.05 UJ | | 0.05 UJ | | 0.05 UJ | | 0.05 UJ | 0.05 UJ | | | | 0.05 UJ | | 0.05 UJ | 0.05 UJ | | | 0.05 UJ | | 0.05 U | | 0.05 U | |
| Silver | 0.007 | 0.007 | 0.005 UJ | 0.005 UJ | 0.005 UJ | | 0.005 UJ | | 0.005 UJ | | 0.005 U | 0.005 UJ | | | | 0.005 UJ | | 0.005 U | 0.005 U | | | 0.005 UJ | | 0.005 U | | 0.005 U | |
| Zinc | 0.9 | 0.9 | 0.05 U | 0.05 U | 0.05 U | | 0.05 U | | 0.05 U | | 0.05 U | 0.05 U | | | | 0.05 U | | 0.05 U | 0.05 U | | | 0.13 | | 0.05 U | | 0.05 U | |

Notes:
Summary of detected compounds only
NA= Not Available
Blank cells were not analyzed
Bold and shaded cells detected above applicable screening value
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

Table 9
Summary of Validated Groundwater Analytical Data
Summer 2003, Fall 2003 and Winter 2004
Yankee Nuclear Power Station
Rowe, MA

| Station/Sample Designation | MCP | MCP | MW-104C | MW-105B | MW-105B | MW-105C | MW-105C | MW-105C | MW-105C | MW-107B | MW-107C | MW-107D | DW001 | DW001 | DW002 | DW002 | OSR-1 | OSR-1 | SP001 | SP001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | RCGW-1 | RCGW-2 | 03/16/04 | 9/9/2003 | 03/08/04 | 9/9/2003 | 11/26/2003 | 11/26/2003 | 03/05/04 | 03/13/04 | 03/13/04 | 03/13/04 | 7/17/2003 | 03/17/04 | 7/17/2003 | 03/17/04 | 8/7/2003 | 03/17/04 | 7/17/2003 | 03/17/04 |
| Applicable MCP Standard | | | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-2 | GW-1 | GW-1 | GW-1 | GW-1 | GW-2 | GW-2 | GW-2 | GW-2 |
| Comment | | | | | | | | Alpha Lab/DUP | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (ug/L)* | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO (Diesel Range) | 200 | 1,000 | | 25 U | | 25 U | | | | | | | 25 U | | 25 U | | 120 J | | 25 U | |
| TPH-GRO (Gasoline Range) | 200 | 1,000 | | 10 U | | 10 U | | | | | | | 10 U | | 10 U | | 10 U | | 10 U | |
| VPH | NA | NA | | | | | | | | | | | | | | | | | | |
| C5-C8 Aliphatics | 400 | 1,000 | 40 U | | | | | | | 40 U | | 40 U | | | | | | 40 U | | |
| C9-C12 Aliphatics | 1,000 | 1,000 | 40 U | | | | | | | 45.8 | | 40 U | | | | | | 40 U | | |
| C9-C10 Aromatics | 200 | 4,000 | 40 U | | | | | | | 40 U | | 40 U | | | | | | 40 U | | |
| EPH | NA | NA | | | | | | | | | | | | | | | | | | |
| C9-C18 Aliphatics | 1,000 | 1,000 | 100 U | | | | | | | 95.2 U | | 95.2 U | | | | | | 100 U | | |
| C19-C36 Aliphatics | 5,000 | 20,000 | 100 U | | | | | | | 95.2 U | | 95.2 U | | | | | | 100 U | | |
| C11-C22 Aromatics | 200 | 30,000 | 100 U | | | | | | | 95.2 U | | 95.2 U | | | | | | 100 U | | |
| *Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | 70 | 9,000 | 5 U | 4.8 J | | 3.4 J | 3.7 J | 3.8 U | 3.8 J | 5 U | 5 U | 0.81 J | 5 U | | 5 U | | 5 UJ | | 5 U | |
| 1,1-Dichloroethene | 1 | 1 | 2 U | 2 U | | **13 J** | **15 J** | **11** | **13 J** | 2 U | 2 U | 2 U | 2 U | | 2 U | | 2 UJ | | 2 U | |
| 1,2,4-Trimethylbenzene | 10,000 | 100,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 4.1 J | 8.8 | 1.8 J | 5 U | | 5 U | | 5 UJ | | 5 U | |
| 1,3,5-Trimethylbenzene | 100 | 1,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 1.5 J | 2.9 J | 0.71 J | 5 U | | 5 U | | 5 UJ | | 5 U | |
| 4-Isopropyltoluene | NA | NA | 0.72 J | 5 U | | 5 U | 5 U | | 5 U | 5 U | 1.1 J | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| 4-Methyl-2-pentanone | 400 | 50,000 | 5 U | 5 UJ | | 5 J | 5 U | 25 U | 5 U | 5 U | 5 U | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Acetone | 3,000 | 50,000 | 10 U | 460 | | 900 | 630 | 190 | 56 | 18 UJ | 11 J | 28 UJ | 10 U | | 10 U | | 10 UJ | | 10 U | |
| Benzene | 5 | 2,000 | 1 U | 1 U | | 1 U | 1 U | | 1 U | 1.5 | 1 U | 1 U | 1 U | | 1 U | | 1 UJ | | 1 U | |
| Carbon disulfide | 1,000 | 10,000 | 5 U | 5 U | | 5 U | 5 U | 25 U | 5 U | 5 U | 5 U | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Chloroform | 5 | 400 | 1 U | 1 U | | 0.86 J | 1 U | 3.8 U | 1 U | 1 U | 1 U | 1 U | 1 U | | 1 U | | 1 UJ | | 1 U | |
| Chloromethane | 1,000 | 10,000 | 5 U | 5 UJ | | 1.9 J | 5 U | 12 U | 2.3 J | 5 U | 0.65 J | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Dichlorodifluoromethane | 10,000 | 100,000 | 5 UJ | 5 UJ | | 5 UJ | 5 U | 25 U | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Ethylbenzene | 700 | 4,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 1.6 J | 2.4 J | 0.5 J | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Iodomethane | 1,000 | 10,000 | 5 U | 5 U | | 5 U | 5 U | | 1.2 J | 5 UJ | 5 U | 5 UJ | 5 U | | 5 U | | 5 UJ | | 5 U | |
| m+p-Xylenes | 6,000 | 6,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 6.7 | 10 | 2.6 J | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Methylene chloride | 5 | 50,000 | 2 U | 2 U | | 2 U | 2 U | 25 U | 2 U | 2 U | 2 U | 2 U | 2 U | | 2 U | | 2 UJ | | 2 U | |
| Methyl-t-butyl ether | 70 | 50,000 | 5 U | 1.9 J | | 3.6 J | 2.8 J | 5 U | 1.5 J | 1.5 J | 5 U | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Naphthalene | 20 | 6,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 1.6 J | 2.2 J | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| n-Butylbenzene | NA | NA | 5 U | 5 U | | 5 U | 5 U | | 5 U | 5 U | 0.71 J | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| n-Propylbenzene | 1,000 | 10,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 0.58 J | 1.4 J | 5 U | 5 U | | 5 U | | 5 UJ | | 5 U | |
| o-Xylene | 6,000 | 6,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 3.5 J | 5 | 1.4 J | 5 U | | 5 U | | 5 UJ | | 5 U | |
| Toluene | 1,000 | 6,000 | 5 U | 5 U | | 5 U | 5 U | | 5 U | 8.7 | 5.3 | 1.3 J | 5 U | | 5 U | | 5 UJ | | 5 U | |
| *Semi-Volatile Organic Compounds (ug/L)* | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 20 | 5,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Acenaphthylene | 300 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Anthracene | 2,000 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Benzo(a)anthracene | 1 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Benzo(a)pyrene | 0.2 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Benzo(b)fluoranthene | 1 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Benzo(g,h,i)perylene | 300 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| bis(2-Ethylhexyl)phthalate | 6 | 30 | 10 U | 7.9 J | | 10 UJ | | | | 10 U | 10 U | 10 U | 10 U | | 2.8 J | | 10 U | | 10 U | |
| Chrysene | 2 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Dibenzo(a,h)anthracene | 0.5 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Fluoranthene | 200 | 200 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Fluorene | 300 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Indeno(1,2,3-cd)pyrene | 0.5 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Naphthalene | 20 | 6,000 | 10 U | 0.09 J | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.18 J | | 0.2 UJ | |
| Pentachlorophenol | 1 | 80 | 50 U | 1 U | | 1 UJ | | | | 50 U | 2.3 J | 50 UJ | 1 UJ | | 1 UJ | | 1 UJ | | 1 UJ | |
| Phenanthrene | 50 | 50 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| Phenol | 4,000 | 30,000 | 10 U | 10 U | | 10 U | | | | 2.2 J | 10 UJ | 10 UJ | 10 U | | 10 U | | R | | 10 U | |
| Pyrene | 200 | 3,000 | 10 U | 0.2 UJ | | 0.2 UJ | | | | 10 U | 10 U | 10 U | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | | 0.2 UJ | |
| *Polychlorinated Biphenyls (ug/L)* | | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | 0.3 | 0.3 | 0.25 U | 0.25 U | | 0.25 U | | | | **5.5 J** | 0.25 U | **2** | 0.25 U | | 0.25 U | | 0.25 U | | 0.25 U | |
| *Inorganics (mg/L)* | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 0.05 | 0.4 | 0.01 U | 0.01 U | | 0.01 U | | | | 0.01 U | 0.01 U | 0.01 U | 0.01 U | | 0.01 U | | 0.01 U | | 0.01 U | |
| Barium | 2 | 30 | | | | | | | | | | | | | | | 0.086 | | | |
| Boron | 1 | 10 | 0.1 U | 0.18 | 0.05 U | 0.12 U | | | 0.05 U | 0.26 | 0.4 | 0.13 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Chromium | 0.1 | 2 | 0.013 | 0.01 U | | 0.01 U | | | | 0.026 J | 0.01 UJ | 0.01 UJ | 0.01 UJ | | 0.01 UJ | | 0.01 U | | 0.01 UJ | |
| Copper | 10 | 100 | 0.011 J | 0.01 U | | 0.01 U | | | | 0.016 | 0.01 U | 0.01 U | 0.01 UJ | | 0.01 UJ | | 0.01 U | | 0.01 UJ | |
| Iron | NA | NA | | | | | | | | | | | | | | | 110 | | | |
| Lead | 0.02 | 0.03 | 0.005 U | 0.005 U | | 0.005 U | | | | 0.016 J | 0.005 U | 0.005 U | 0.011 U | | 0.005 U | | 0.005 U | | 0.0066 U | |
| Manganese | NA | NA | | | | | | | | | | | | | | | 7.4 | | | |
| Mercury | 0.001 | 0.001 | 0.0002 U | 0.0002 U | | 0.0002 U | | | | 0.0002 UJ | 0.0002 UJ | 0.0002 UJ | 0.0002 U | | 0.0002 U | | 0.0002 U | | 0.0002 U | |
| Nickel | 0.08 | 0.08 | 0.01 U | 0.01 U | | 0.01 U | | | | 0.016 | 0.01 U | 0.01 U | 0.01 U | | 0.01 U | | 0.011 | | 0.01 U | |
| Selenium | 0.05 | 0.08 | 0.05 U | 0.05 UJ | | 0.05 UJ | | | | 0.05 U | 0.05 U | 0.05 U | 0.05 U | | 0.05 U | | 0.05 U | | 0.05 U | |
| Silver | 0.007 | 0.007 | 0.005 U | 0.005 U | | 0.005 U | | | | 0.005 U | 0.005 U | 0.005 U | 0.005 U | | 0.005 U | | 0.005 UJ | | 0.005 U | |
| Zinc | 0.9 | 0.9 | 0.05 U | 0.05 U | | 0.05 U | | | | 0.12 | 0.05 U | 0.05 U | 0.01 U | | 0.05 U | | 0.05 U | | 0.05 U | |

Notes:
Summary of detected compounds only
NA= Not Available
Blank cells were not analyzed
Bold and shaded cells detected above applicable screening value
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

## Table 10
## Summary of Validated Sediment Analytical Data
## Background (400 Series)
## Yankee Nuclear Power Station
## Rowe, MA

| Station<br>Sample Designation<br>Date Sampled | SD-401<br>SD-401-00-04-I<br>8/14/2003 | SD-402<br>SD-402-00-04-I<br>8/14/2003 | SD-403<br>SD-403-00-04-I<br>8/14/2003 | SD-404<br>SD-404-00-04-I<br>8/14/2003 | SD-405<br>SD-405-00-04-I<br>8/14/2003 | SD-406<br>SD-406-00-04-I<br>8/14/2003 |
|---|---|---|---|---|---|---|
| *Total Petroleum Hydrocarbons (mg/Kg)* | | | | | | |
| TPH-DRO (Diesel Range) | 27 | 34 | 13 UJ | 24 J | 80 J | 19 J |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | |
| 1,1-Dichloroethene | 23 J | 24 J | 15 J | 19 J | 21 | 7 UJ |
| 1,2,4-Trimethylbenzene | 6 UJ | 10 UJ | 5 UJ | 7 UJ | 9 UJ | 7 UJ |
| 2-Butanone | 30 J | 21 UJ | 11 J | 22 J | 67 | 32 J |
| 4-Isopropyltoluene | 6 UJ | 10 UJ | 5 UJ | 7 UJ | 9 UJ | 7 UJ |
| 4-Methyl-2-pentanone | 6 UJ | 10 UJ | 5 UJ | 7 UJ | 9 UJ | 7 UJ |
| Acetone | 110 J | 19 UJ | 42 J | 76 J | 280 | 190 J |
| Carbon disulfide | 6 UJ | 10 UJ | 5 UJ | 7 UJ | 9 UJ | 7 UJ |
| Chloromethane | 6 UJ | 10 UJ | 5 UJ | 7 UJ | 9 UJ | 7 UJ |
| Methylene chloride | 18 UJ | 31 UJ | 15 UJ | 21 UJ | 27 UJ | 21 UJ |
| Naphthalene | 6 UJ | 10 UJ | 5 UJ | 7 UJ | 9 UJ | 7 UJ |
| Toluene | 21 J | 31 J | 12 J | 27 J | 20 | 14 |
| TOTAL VOCs | 184 | 55 | 80 | 144 | 388 | 236 |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | |
| 2-Methylnaphthalene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| 2-Methylphenol | 150 J | 890 U | 430 U | 760 U | 960 U | 630 U |
| 3+4-Methylphenol | 630 U | 230 J | 430 U | 760 U | 960 U | 630 U |
| Acenaphthene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Anthracene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Benzo(a)anthracene | 630 U | 180 J | 430 U | 760 U | 200 J | 630 U |
| Benzo(a)pyrene | 630 U | 890 U | 430 U | 760 U | 230 J | 630 U |
| Benzo(b)fluoranthene | 630 U | 890 U | 430 U | 760 U | 220 J | 630 U |
| Benzo(g,h,i)perylene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Benzo(k)fluoranthene | 630 U | 890 U | 430 U | 760 U | 220 J | 630 U |
| bis(2-Ethylhexyl)phthalate | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Carbazole | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Chrysene | 630 U | 200 J | 430 U | 170 J | 230 J | 630 U |
| Dibenzo(a,h)anthracene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Dibenzofuran | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Di-n-octyl phthalate | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Fluoranthene | 630 U | 380 J | 170 J | 320 J | 430 J | 630 U |
| Fluorene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Indeno(1,2,3-cd)pyrene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Naphthalene | 630 U | 890 U | 430 U | 760 U | 960 U | 630 U |
| Phenanthrene | 630 U | 890 U | 140 J | 760 U | 960 U | 630 U |
| Pyrene | 630 U | 320 J | 130 J | 280 J | 380 J | 630 U |
| TOTAL SVOCs | 150 | 1,310 | 870 | 770 | 1,910 | - |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | |
| Aroclor-1254 | 59 U | 89 U | 43 U | 76 U | 1900 UJ | 1300 UJ |
| Aroclor-1260 | 59 U | 89 U | 43 U | 76 U | 1900 UJ | 1300 UJ |
| Total PCBs | - | - | - | - | - | - |
| *Inorganics (mg/Kg)* | | | | | | |
| Antimony | R | R | R | R | R | R |
| Arsenic | 1.6 | 2 J | 0.21 UJ | 1.7 J | 2.8 | 1.6 |
| Boron | | | | | | |
| Cadmium | 1.3 U | 1.8 U | 0.91 U | 1.6 U | 2 U | 1.3 U |
| Chromium | 9.8 | 19 | 4.5 | 17 | 21 | 16 |
| Chromium (Hexavalent) | 3.5 UJ | 5.2 UJ | 2.7 UJ | 4.7 UJ | 6 UJ | 3.9 UJ |
| Copper | 21 | 37 | 6.4 | 35 | 45 | 42 |
| Lead | 2.7 J | 2.8 J | 0.65 UJ | 2.8 J | 5.2 J | 2.7 J |
| Lithium | | | | | | |
| Mercury | 0.58 U | 0.4 U | 0.34 U | 0.69 U | 0.65 U | 0.32 U |
| Nickel | 11 | 25 | 12 | 20 | 28 | 23 |
| Selenium | 3.9 J | 5.7 UJ | 2.8 UJ | 4.9 J | UJ | 4.1 UJ |
| Silver | 0.4 J | 0.58 UJ | 0.29 UJ | 0.5 UJ | 0.64 UJ | 0.42 UJ |
| Thallium | 0.93 U | 1.4 U | 0.67 U | 1.2 U | 1.5 U | 0.97 U |
| Zinc | 130 | 270 | 49 | 170 | 250 | 200 |

Notes:
Summary of detected compounds only
- = All constituents below detection limits
Blank Cells Were Not Analyzed
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit

**Table 11**
**Summary of Validated Sediment Analytical Data**
**Sherman Reservoir (002-041)**
**Yankee Nuclear Power Station**
**Rowe, MA**

| Station | Site Background Maximum | Background 3X | Background 5X | SD-002 | SD-004 | SD-008 | SD-009 | SD-010 | SD-011 | SD-011 | SD-012 | SD-013 | SD-014 | SD-014 | SD-015 | SD-016 | SD-017 | SD-017 | SD-018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | | SD-002-00-04-I | SD-004-00-04-I | SD-008-00-04-I | SD-009-00-04-I | SD-010-00-04-I | SD-011-00-04-I | SD-011-05-09-I | SD-012-00-04-I | SD-013-00-04-I | SD-014-00-04-I | SD-014-06-12-I | SD-015-00-04-I | SD-016-00-04-I | SD-017-00-04-I | SD-017-04-08-I | SD-018-00-04-I |
| Date Sampled | | | | 8/14/2003 | 8/14/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/12/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 |
| Comment | | | | | | | | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 80 | 240 | 400 | 2.6 U | | 40 U | 36 | 32 U | 24 U | 5.2 | 26 U | 86 J | 48 J | 2.5 | 28 UJ | 12 J | 67 J | 8.4 | 17 UJ |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethene | 24 | | | 5 UJ | | | | | 5 U | 5 U | | | 5 UJ | 5 U | | | 40 J | 7.3 | |
| 1,2,4-Trimethylbenzene | ND | | | 5 UJ | | | | | 5 U | 4.2 J | | | 5 UJ | 5 U | | | 5 U | 5 U | |
| 2-Butanone | 67 | | | 10 UJ | | | | | 5.4 J | 6.6 J | | | 10 UJ | 10 U | | | 28 | 10 U | |
| 4-Isopropyltoluene | ND | | | 5 UJ | | | | | 5 U | 5 U | | | 5 UJ | 5 U | | | 5 U | 5 U | |
| 4-Methyl-2-pentanone | ND | | | 5 UJ | | | | | 5 U | 5 U | | | 5 UJ | 5 U | | | 2.8 J | 5 U | |
| Acetone | 280 | | | 10 UJ | | | | | 35 | 73 | | | 240 UJ | 10 UJ | | | 190 J | 3 J | |
| Carbon disulfide | ND | | | 5 UJ | | | | | 5 U | 5 U | | | 5 UJ | 5 U | | | 8.8 | 5 U | |
| Chloromethane | ND | | | 5 UJ | | | | | 5 U | 5 U | | | 5 UJ | 5 U | | | 5 U | 5 U | |
| Methylene chloride | ND | | | 15 UJ | | | | | 2.5 J | 15 U | | | 15 UJ | 15 UJ | | | 15 UJ | 15 UJ | |
| Naphthalene | ND | | | 5 UJ | | | | | 5 U | 5 U | | | 5 UJ | 5 U | | | 5 UJ | 5 U | |
| Toluene | 31 | | | 11 J | | | | | 2.7 J | 3.2 J | | | 24 UJ | 13 U | | | 22 | 5.2 U | |
| TOTAL VOCs | 402 | 1,206 | 2,010 | 11 | | | | | 45.6 | 142 | | | - | - | | | 346.6 | 10.3 | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | ND | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| 2-Methylphenol | 150 | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| 3+4-Methylphenol | 230 | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| Acenaphthene | ND | | | 460 U | | | | | 430 U | 160 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Anthracene | ND | | | 460 U | | | | | 430 U | 240 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Benzo(a)anthracene | 200 | | | 460 U | | | | | 430 U | 320 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Benzo(a)pyrene | 230 | | | 460 U | | | | | 430 U | 270 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Benzo(b)fluoranthene | 220 | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| Benzo(g,h,i)perylene | ND | | | 460 U | | | | | 430 U | 120 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Benzo(k)fluoranthene | 220 | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| bis(2-Ethylhexyl)phthalate | ND | | | 460 U | | | | | 140 J | 140 J | | | 730 UJ | 360 UJ | | | 590 UJ | 430 UJ | |
| Carbazole | ND | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| Chrysene | 230 | | | 460 U | | | | | 430 U | 290 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Dibenzo(a,h)anthracene | ND | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| Dibenzofuran | ND | | | 460 U | | | | | 430 U | 120 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Di-n-octyl phthalate | ND | | | 460 U | | | | | 320 J | 400 U | | | 730 UJ | 360 UJ | | | 590 UJ | 430 UJ | |
| Fluoranthene | 430 | | | 460 U | | | | | 120 J | 700 | | | 220 J | 360 U | | | 130 J | 430 U | |
| Fluorene | ND | | | 460 U | | | | | 430 U | 180 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Indeno(1,2,3-cd)pyrene | ND | | | 460 U | | | | | 430 U | 110 J | | | 730 U | 360 U | | | 590 U | 430 U | |
| Naphthalene | ND | | | 460 U | | | | | 430 U | 400 U | | | 730 U | 360 U | | | 590 U | 430 U | |
| Phenanthrene | 140 | | | 460 U | | | | | 430 U | 740 | | | 730 U | 360 U | | | 590 U | 430 U | |
| Pyrene | 380 | | | 460 U | | | | | 430 U | 520 | | | 180 J | 360 U | | | 120 J | 430 U | |
| TOTAL SVOCs | 2,430 | 7,290 | 12,150 | - | | | | | 580 | 3910 | | | 400 | - | | | 250 | - | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | ND | ND | ND | 43 U | 46 U | 63 U | 450 | 53 U | 170 | 47 | 460 | 76 U | 76 U | 36 U | 46 U | 43 U | 59 U | 40 U | 98 |
| Aroclor-1260 | ND | ND | ND | 43 U | 46 U | 63 U | 59 U | 53 U | 40 U | 40 U | 43 U | 76 U | 76 U | 36 U | 46 U | 43 U | 59 U | 40 U | 53 U |
| Total PCBs * | 578 | 1,734 | 2,890 | - | - | - | 450 | - | 170 | 47 | 460 | - | - | - | - | - | - | - | 98 |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| Antimony | ND | ND | ND | R | R | 0.67 U | 0.6 U | 0.56 U | 0.42 U | 0.41 U | 0.43 U | R | R | R | R | R | R | 1.7 J | R |
| Arsenic | 3 | 8 | 14 | 0.22 U | 0.22 U | 3.2 | 3.3 | 1.1 | 1 | 0.74 | 1.4 | R | R | R | R | 0.21 UJ | 1.2 J | 0.2 UJ | 0.88 J |
| Boron | NA | NA | NA | 11 U | 14 U | 28 | | | | | | | | | | | | | |
| Cadmium | ND | ND | ND | 0.92 U | 0.93 U | 6.7 | 3.1 | 2.1 U | 1.7 U | 1.6 U | 1.5 U | 2.3 UJ | 2.8 UJ | 1.4 UJ | 1.9 U | 0.88 U | 1.2 U | 0.86 U | 1.1 U |
| Chromium | 21 | 63 | 105 | 5.7 | 6.5 | 32 | 14 | 11 | 6.4 | 7.8 | 2.6 | 12 | 25 | 5.5 | 6.7 | 8.5 | 18 | 8.1 | 17 |
| Chromium (Hexavalent) | ND | ND | ND | 2.8 UJ | 2.8 UJ | 4 UJ | 3.4 UJ | 3.4 UJ | 2.6 UJ | 2.4 UJ | 2.65 UJ | 4.6 UJ | 4.4 UJ | 2.3 UJ | 2.7 UJ | 2.6 UJ | 3.5 UJ | 2.4 UJ | 3.2 UJ |
| Copper | 45 | 135 | 225 | 29 | 52 | **570** | **300** | 16 | 13 | 61 | 10 | 37 J | 67 J | 20 J | 13 | 11 | 27 | 11 | 25 |
| Lead | 5 | 16 | 26 | 2.7 J | 2.5 J | 6.5 | 15 | 6.4 | **34** | **18** | **17** | 0.7 UJ | 1.1 J | 0.34 UJ | 0.44 UJ | 0.78 J | 2.8 J | 0.6 J | 2.9 J |
| Lithium | NA | NA | NA | 12 | 14 | 23 | | | | | | | | | | | | | |
| Mercury | ND | ND | ND | 0.48 U | 0.45 U | 2.1 | 0.51 U | 0.38 U | 0.35 U | 0.38 U | 0.39 U | 0.67 U | 0.73 U | 0.53 U | 0.4 U | 0.43 U | 0.54 U | 0.47 U | 0.68 U |
| Nickel | 28 | 84 | 140 | 8.8 | 12 | 55 | 42 | 12 | 9.7 | 34 | 6.6 | 9.8 | 18 | 5.1 | 7.9 | 11 | 19 | 10 | 19 |
| Selenium | 5 | 15 | 25 | 2.9 J | 2.9 J | 4.6 | 6.8 U | 6.4 U | 5.4 U | 4.9 U | 4.7 U | 7.3 U | 8.8 U | 4.3 U | 5.9 UJ | 2.8 UJ | 3.9 UJ | 2.7 UJ | 3.5 U |
| Silver | 0.4 | 1 | 2 | 0.29 UJ | 0.3 J | 0.31 U | 0.69 U | 0.65 U | 0.55 U | 0.5 U | 0.48 U | 0.74 UJ | 0.89 UJ | 0.44 UJ | 0.6 U | 0.28 UJ | 0.39 UJ | 0.27 UJ | 0.36 UJ |
| Thallium | ND | ND | ND | 0.68 U | 0.69 U | 1.7 | 0.6 U | 0.56 U | 0.42 U | 0.41 U | 0.43 U | 1.2 U | 1.1 U | 0.57 U | 0.73 U | 0.65 U | 0.91 U | 0.63 U | 0.84 U |
| Zinc | 270 | 810 | 1,350 | 72 | 99 | 790 | 370 | 77 | 94 | 250 | 45 | 68 | 150 | 37 U | 72 J | 43 | 100 | 33 | 96 |

Notes:
Summary of detected compounds only
NA= Not Analyzed in Background
ND= Not Detected in Background
- = All constituents below detection limits
Blank Cells Were Not Analyzed
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
Value exceeds 3X Site Background maximum
Value exceeds 5X Site Background maximum
* PCBs not detected in background samples. Average of detections limits used to calculate Site background concentration.

## Table 11
## Summary of Validated Sediment Analytical Data
## Sherman Reservoir (002-041)
## Yankee Nuclear Power Station
## Rowe, MA

| Station | Site Background Maximum | Background 3X | Background 5X | SD-019 | SD-020 | SD-021 | SD-021 | SD-021 | SD-022 | SD-023 | SD-024 | SD-024 | SD-025 | SD-026 | SD-027 | SD-027 | SD-028 | SD-029 | SD-029 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Designation | | | | SD-019-00-04-I | SD-020-00-04-I | SD-021-04-08-I | FD002-081303 | SD-021-08-14-I | SD-022-00-04-I | SD-023-00-04-I | SD-024-00-04-I | SD-024-12-18-I | SD-025-00-04-I | SD-026-00-04-I | SD-027-00-04-I | SD-027-08-14-I | SD-028-00-04-I | SD-029-00-04-I | SD-029-08-14-I |
| Date Sampled | | | | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/13/2003 | 8/14/2003 | 8/14/2003 |
| Comment | | | | | | | DUP | | | | | | | | | | | | |
| *Total Petroleum Hydrocarbons (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | 80 | 240 | 400 | 24 J | 64 J | 68 | 42 J | 81 J | 34 J | 57 J | 170 J | 88 J | 71 J | 2.4 U | 24 | 4.4 U | 5.9 | 30 | 2.4 U |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 1,1-Dichloroethene | 24 | | | | | 24 | 28 J | 5 U | | | 11 | 31 | | | 3.5 J | 8.2 | | 8.6 UJ | 5.7 |
| 1,2,4-Trimethylbenzene | ND | | | | | 8 UJ | 5 UJ | 5 UJ | | | 9 UJ | 9 UJ | | | 5 U | 5 U | | 5 U | 5 U |
| 2-Butanone | 67 | | | | | 29 J | 13 J | 140 | | | 59 | 120 | | | 2.6 J | 10 U | | 5.6 J | 2.8 J |
| 4-Isopropyltoluene | ND | | | | | 8 UJ | 5 UJ | 5 UJ | | | 9 UJ | 9 UJ | | | 5 U | 5 U | | 5 U | 5 U |
| 4-Methyl-2-pentanone | ND | | | | | 8 UJ | 3.2 J | 5 U | | | 9 U | 9 U | | | 5 U | 5 U | | 5 UJ | 5 U |
| Acetone | 280 | | | | | 120 J | 120 J | 270 J | | | 190 J | 220 J | | | 20 J | 21 J | | 17 | 15 UJ |
| Carbon disulfide | ND | | | | | 8 UJ | 5.8 J | 5 U | | | 9 U | 5.2 J | | | 5 U | 5 U | | 5 UJ | 5 U |
| Chloromethane | ND | | | | | 8 UJ | 5 UJ | 5 U | | | 9 U | 9 U | | | 5 U | 5 U | | 5 U | 5 U |
| Methylene chloride | ND | | | | | 24 UJ | 15 UJ | 15 UJ | | | 27 UJ | 27 UJ | | | 15 UJ | 15 UJ | | 15 U | 15 UJ |
| Naphthalene | ND | | | | | 8 UJ | 5 UJ | 5 UJ | | | R | R | | | 5 UJ | 5 U | | 5 U | 5 U |
| Toluene | 31 | | | | | 34 J | 25 J | 5 U | | | 47 J | 52 J | | | 5.9 U | 11 U | | 14 | 2.6 U |
| TOTAL VOCs | 402 | 1,206 | 2,010 | | | 207 | 186 | 415 | | | 307 | 527.2 | | | 26.1 | 29.2 | | 36.6 | 8.5 |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| 2-Methylphenol | 150 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| 3+4-Methylphenol | 230 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Acenaphthene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Anthracene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Benzo(a)anthracene | 200 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 130 J | 400 U |
| Benzo(a)pyrene | 230 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Benzo(b)fluoranthene | 220 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Benzo(g,h,i)perylene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Benzo(k)fluoranthene | 220 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| bis(2-Ethylhexyl)phthalate | ND | | | | | 790 UJ | 530 UJ | 530 UJ | | | 920 UJ | 830 UJ | | | 460 UJ | 360 UJ | | 460 UJ | 400 UJ |
| Carbazole | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Chrysene | 230 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 120 J | 400 U |
| Dibenzo(a,h)anthracene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Dibenzofuran | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Di-n-octyl phthalate | ND | | | | | 790 UJ | 530 UJ | 530 UJ | | | 920 UJ | 830 UJ | | | 460 UJ | 360 UJ | | 460 UJ | 400 UJ |
| Fluoranthene | 430 | | | | | 250 J | 530 U | 530 U | | | 920 U | 200 J | | | 460 U | 360 U | | 330 J | 400 U |
| Fluorene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Indeno(1,2,3-cd)pyrene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Naphthalene | ND | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Phenanthrene | 140 | | | | | 790 U | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 460 U | 400 U |
| Pyrene | 380 | | | | | 190 J | 530 U | 530 U | | | 920 U | 830 U | | | 460 U | 360 U | | 250 J | 400 U |
| TOTAL SVOCs | 2,430 | 7,290 | 12,150 | | | 440 | - | - | | | - | 200 | | | - | - | | 830 | - |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | | | | | |
| Aroclor-1254 | ND | ND | ND | 570 | 69 U | 290 J | 53 U | 53 U | 180 | 63 U | 92 U | 190 J | 430 | 40 U | 46 U | 36 U | 36 U | 46 U | 40 U |
| Aroclor-1260 | ND | ND | ND | 50 U | 69 U | 79 U | 53 U | 53 U | 66 U | 63 U | 92 U | 82 U | 76 U | 40 U | 46 U | 36 U | 36 U | 46 U | 40 U |
| Total PCBs * | 578 | 1,734 | 2,890 | 570 | - | 290 | - | - | 180 | - | - | 190 | 430 | - | - | - | - | - | - |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | | | | | |
| Antimony | ND | ND | ND | R | R | R | R | R | R | R | R | R | R | R | R | R | R | 0.72 UJ | 0.003 UJ |
| Arsenic | 3 | 8 | 14 | 1.2 J | 0.34 UJ | 1.5 J | 1 J | 0.9 J | 1.8 | 0.3 UJ | 0.45 UJ | 1.4 J | 0.37 UJ | 0.19 UJ | 0.73 J | 1.6 | 0.18 UJ | 1.5 J | 0.19 UJ |
| Boron | NA | NA | NA | | | | | | | | | | | | | | | | |
| Cadmium | ND | ND | ND | 1.1 U | 1.5 U | 1.7 U | 1.1 U | 1.1 U | 1.4 U | 1.3 U | 1.9 U | 1.7 U | 1.6 U | 0.79 U | 0.99 U | 0.76 U | 0.76 U | 0.98 U | 0.83 U |
| Chromium | 21 | 63 | 105 | 15 | 19 | 22 | 13 | 12 | 16 | 13 | 21 | 22 | 12 | 6.6 | 12 | 6.8 | 8.2 | 9.8 | 7.8 |
| Chromium (Hexavalent) | ND | ND | ND | 3.1 UJ | 4.2 UJ | 4.6 UJ | 3.2 UJ | 3.4 UJ | 4.1 U | 3.7 UJ | 5.6 UJ | 5.1 UJ | 4.7 UJ | 2.3 UJ | 2.9 UJ | 2.1 UJ | 2.3 UJ | 3 UJ | 2.4 UJ |
| Copper | 45 | 135 | 225 | 26 | 33 | 65 | 9.7 | 7.8 | 32 | 18 | 44 | 27 | 20 | 8.4 | 9.6 | 6.8 | 6.6 | 13 | 9.2 |
| Lead | 5 | 16 | 26 | 2.3 J | 0.77 J | R | 2.4 J | 0.51 J | 4.9 J | 0.79 J | 1.5 J | 1.1 J | 2.2 J | 0.73 J | 0.7 J | 0.7 J | 0.95 J | R | R |
| Lithium | NA | NA | NA | | | | | | | | | | | | | | | | |
| Mercury | ND | ND | ND | 0.6 U | 0.98 U | 0.92 U | 0.67 U | 0.58 U | 0.66 U | 0.8 U | 0.36 U | 0.18 U | 0.79 U | 0.49 U | 0.29 U | 0.12 U | 0.38 U | 0.47 U | 0.36 U |
| Nickel | 28 | 84 | 140 | 17 | 21 | 26 | 11 | 9.9 | 18 | 14 | 24 | 24 | 14 | 7.5 | 14 | 8.7 | 8.2 | 13 | 8.2 |
| Selenium | 5 | 15 | 25 | 3.3 UJ | 4.5 UJ | 5.2 UJ | 3.4 UJ | 3.5 UJ | 4.4 U | 4 UJ | 6 UJ | 5.4 J | 4.9 U | 2.5 U | 3.1 UJ | 2.4 UJ | 2.4 U | 3.1 UJ | 2.6 UJ |
| Silver | 0.4 | 1 | 2 | 0.33 UJ | 0.46 UJ | 0.52 UJ | 0.35 UJ | 0.35 UJ | 0.45 UJ | 0.41 UJ | 0.61 UJ | 0.55 UJ | 0.5 UJ | 0.25 UJ | 0.31 UJ | 0.24 UJ | 0.24 UJ | 0.31 UJ | 0.26 UJ |
| Thallium | ND | ND | ND | 0.78 U | 1.1 U | 1.2 U | 0.81 U | 0.82 U | 1 U | 0.94 U | 1.4 U | 1.3 U | 1.2 U | 0.58 U | 0.73 U | 0.56 U | 0.56 U | 0.72 U | 0.01 U |
| Zinc | 270 | 810 | 1,350 | 120 | 140 | 220 | 61 | 56 | 140 | 92 | 160 | 140 | 100 | 36 | 62 | 36 | 39 | 48 | 30 |

Notes:
Summary of detected compounds only
NA= Not Analyzed in Background
ND= Not Detected in Background
- = All constituents below detection limits
Blank Cells Were Not Analyzed
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
🟩 Value exceeds 3X Site Background maximum
🟧 Value exceeds 5X Site Background maximum
* PCBs not detected in background samples. Average of detections limits used to calculate Site background concentration.

**Table 11**
**Summary of Validated Sediment Analytical Data**
**Sherman Reservoir (002-041)**
**Yankee Nuclear Power Station**
**Rowe, MA**

| **Station<br>Sample Designation<br>Date Sampled<br>Comment** | **Site Background Maximum** | **Background 3X** | **Background 5X** | **SD-030<br>SD-030-00-04-I<br>8/14/2003** | **SD-031<br>SD-031-00-04-I<br>8/14/2003** | **SD-032<br>SD-032-00-04-I<br>8/14/2003** | **SD-033<br>SD-033-00-04-I<br>8/14/2003** | **SD-034<br>SD-034-00-04-I<br>8/13/2003** | **SD-035<br>SD-035-00-04-I<br>8/13/2003** | **SD-036<br>SD-036-00-04-I<br>8/13/2003** | **SD-037<br>SD-037-00-04-I<br>8/13/2003** | **SD-038<br>SD-038-00-04-I<br>8/14/2003** | **SD-039<br>SD-039-00-04-I<br>8/14/2003** | **SD-040<br>SD-040-00-04-I<br>8/14/2003** | **SD-041<br>SD-041-00-04-I<br>8/14/2003** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Total Petroleum Hydrocarbons (mg/Kg)* | | | | | | | | | | | | | | | |
| TPH-DRO | 80 | 240 | 400 | 32 | 64 J | 28 | 52 J | 30 J | 48 J | 42 | 88 J | 100 J | 34 | 79 J | 250 J |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | |
| 1,1-Dichloroethene | 24 | | | | | | | | | | | | | | |
| 1,2,4-Trimethylbenzene | ND | | | | | | | | | | | | | | |
| 2-Butanone | 67 | | | | | | | | | | | | | | |
| 4-Isopropyltoluene | ND | | | | | | | | | | | | | | |
| 4-Methyl-2-pentanone | ND | | | | | | | | | | | | | | |
| Acetone | 280 | | | | | | | | | | | | | | |
| Carbon disulfide | ND | | | | | | | | | | | | | | |
| Chloromethane | ND | | | | | | | | | | | | | | |
| Methylene chloride | ND | | | | | | | | | | | | | | |
| Naphthalene | ND | | | | | | | | | | | | | | |
| Toluene | 31 | | | | | | | | | | | | | | |
| TOTAL VOCs | 402 | 1,206 | 2,010 | | | | | | | | | | | | |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | ND | | | | | | | | | | | | | | |
| 2-Methylphenol | 150 | | | | | | | | | | | | | | |
| 3+4-Methylphenol | 230 | | | | | | | | | | | | | | |
| Acenaphthene | ND | | | | | | | | | | | | | | |
| Anthracene | ND | | | | | | | | | | | | | | |
| Benzo(a)anthracene | 200 | | | | | | | | | | | | | | |
| Benzo(a)pyrene | 230 | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | 220 | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | ND | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | 220 | | | | | | | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | ND | | | | | | | | | | | | | | |
| Carbazole | ND | | | | | | | | | | | | | | |
| Chrysene | 230 | | | | | | | | | | | | | | |
| Dibenzo(a,h)anthracene | ND | | | | | | | | | | | | | | |
| Dibenzofuran | ND | | | | | | | | | | | | | | |
| Di-n-octyl phthalate | ND | | | | | | | | | | | | | | |
| Fluoranthene | 430 | | | | | | | | | | | | | | |
| Fluorene | ND | | | | | | | | | | | | | | |
| Indeno(1,2,3-cd)pyrene | ND | | | | | | | | | | | | | | |
| Naphthalene | ND | | | | | | | | | | | | | | |
| Phenanthrene | 140 | | | | | | | | | | | | | | |
| Pyrene | 380 | | | | | | | | | | | | | | |
| TOTAL SVOCs | 2,430 | 7,290 | 12,150 | | | | | | | | | | | | |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | | | | | | | |
| Aroclor-1254 | ND | ND | ND | 46 U | 120 J | 79 U | R | 59 U | 76 U | 980 J | 100 U | 120 J | 63 U | R | 97 J |
| Aroclor-1260 | ND | ND | ND | 46 U | R | 79 U | R | 59 U | 76 U | 99 U | 100 U | R | 63 U | R | R |
| Total PCBs * | 578 | 1,734 | 2,890 | - | 120 | - | R | - | - | 980 | - | 120 | - | R | 97 |
| *Inorganics (mg/Kg)* | | | | | | | | | | | | | | | |
| Antimony | ND | ND | ND | 0.72 UJ | R | 1.2 UJ | R | R | R | R | R | R | 0.95 UJ | 3.9 J | R |
| Arsenic | 3 | 8 | 14 | 0.88 J | 3.2 J | 0.39 UJ | 2.6 J | 0.94 J | 1.3 J | 2.1 J | 2.6 | 4.8 J | 1.9 | 3.8 J | 4.5 J |
| Boron | NA | NA | NA | | | | | | | | | | | | |
| Cadmium | ND | ND | ND | 0.97 U | R | 3 U | R | 1.3 U | 1.5 U | 2.1 U | 2.1 U | R | 1.3 U | R | R |
| Chromium | 21 | 63 | 105 | 9.8 | 27 J | 20 | 8.6 J | 18 | 16 | 23 | 24 | 34 J | 13 | 28 J | 30 J |
| Chromium (Hexavalent) | ND | ND | ND | 2.9 UJ | R | 5 UJ | R | 3.6 UJ | 4.4 UJ | 6.1 UJ | 6.1 UJ | R | 3.6 UJ | R | R |
| Copper | 45 | 135 | 225 | 11 | 120 J | 40 | 20 J | 26 | 28 | 42 | 48 | 100 J | 20 | 57 J | 89 J |
| Lead | 5 | 16 | 26 | 0.76 J | 3.8 J | 1.4 J | 3.6 J | 3.2 J | 5.5 J | 7 J | 9.5 J | 14 J | 2.9 J | 5.2 J | 8.3 J |
| Lithium | NA | NA | NA | | | | | | | | | | | | |
| Mercury | ND | ND | ND | 0.54 U | R | 0.68 U | R | 0.61 U | 0.78 U | 1.1 U | 1.1 U | R | 0.13 U | R | R |
| Nickel | 28 | 84 | 140 | 11 | 31 J | 22 | 9.2 J | 21 | 19 | 27 | 28 | 41 J | 13 | 31 J | 35 J |
| Selenium | 5 | 15 | 25 | 3 UJ | R | 9.4 UJ | R | 4 U | 4.8 U | 6.4 U | 6.6 U | R | 4 UJ | R | R |
| Silver | 0.4 | 1 | 2 | 0.31 UJ | R | 0.95 UJ | R | 0.4 UJ | 0.48 UJ | 0.65 UJ | 0.67 UJ | R | 0.41 UJ | R | R |
| Thallium | ND | ND | ND | 0.72 U | R | 1.2 U | R | 0.93 U | 1.1 U | 1.5 U | 1.6 U | R | 0.95 U | R | R |
| Zinc | 270 | 810 | 1,350 | 50 | 180 J | 180 | 60 J | 100 | 110 | 160 | 190 | 300 J | 80 | 220 J | 260 J |

Notes:
Summary of detected compounds only
NA= Not Analyzed in Background
ND= Not Detected in Background
- = All constituents below detection limits
Blank Cells Were Not Analyzed
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
Value exceeds 3X Site Background maximum
Value exceeds 5X Site Background maximum
* PCBs not detected in background samples. Average of detections limits used to calculate Site background concentration.

Table 12
Summary of Validated Sediment Analytical Data
Wheeler Brook (100 Series)
Yankee Nuclear Power Station
Rowe, MA

| Station<br>Sample Designation<br>Date Sampled | Site Background Maximum | Background 3X | Background 5X | SD-101<br>SD-101-00-04-I<br>8/13/2003 | SD-102<br>SD-102-00-04-I<br>8/13/2003 | SD-103<br>SD-103-00-04-I<br>8/13/2003 | SD-104<br>SD-104-00-04-I<br>8/13/2003 | SD-105<br>SD-105-00-04-I<br>8/13/2003 | SD-106<br>SD-106-00-04-I<br>8/13/2003 |
|---|---|---|---|---|---|---|---|---|---|
| *Total Petroleum Hydrocarbons (mg/Kg)* | | | | | | | | | |
| TPH-DRO | 80 | 240 | 400 | 2.8 U | 2.6 U | 45 J | 2.9 | 8.2 | 3.2 |
| *Volatile Organic Compounds (ug/Kg)* | | | | | | | | | |
| 1,1-Dichloroethene | 24 | | | 5 U | 5 U | R | 5 UJ | 5 U | 3.3 J |
| 1,2,4-Trimethylbenzene | ND | | | 5 U | 5 U | R | 5 UJ | 5 U | 5 U |
| 2-Butanone | 67 | | | 10 U | 10 U | R | 2.4 J | 14 | 10 U |
| 4-Isopropyltoluene | ND | | | 5 U | 5 U | R | 5 UJ | 5 U | 5 U |
| 4-Methyl-2-pentanone | ND | | | 5 U | 5 U | R | 5 UJ | 5 U | 5 U |
| Acetone | 280 | | | 39 UJ | 29 UJ | 190 J | 18 J | 10 UJ | 10 UJ |
| Carbon disulfide | ND | | | 5 U | 5 U | R | 5 UJ | 5 U | 5 U |
| Chloromethane | ND | | | 5 U | 5 U | R | 5 UJ | 5 U | 5 U |
| Methylene chloride | ND | | | 15 UJ | 15 UJ | R | 15 UJ | 15 UJ | 15 UJ |
| Naphthalene | ND | | | 5 U | 5 U | R | 5 UJ | 5 U | 5 U |
| Toluene | 31 | | | 5 U | 5 U | R | 7.7 UJ | 5 U | 5 U |
| TOTAL VOCs | 402 | 1,206 | 2,010 | - | - | 190 | 20.4 | 14 | 3.3 |
| *Semi-Volatile Organic Compounds (ug/Kg)* | | | | | | | | | |
| 2-Methylnaphthalene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| 2-Methylphenol | 150 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| 3+4-Methylphenol | 230 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Acenaphthene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Anthracene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Benzo(a)anthracene | 200 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Benzo(a)pyrene | 230 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Benzo(b)fluoranthene | 220 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Benzo(g,h,i)perylene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Benzo(k)fluoranthene | 220 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| bis(2-Ethylhexyl)phthalate | ND | | | 460 UJ | 430 UJ | R | 400 UJ | 460 UJ | 500 UJ |
| Carbazole | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Chrysene | 230 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Dibenzo(a,h)anthracene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Dibenzofuran | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Di-n-octyl phthalate | ND | | | 460 UJ | 430 UJ | R | 400 UJ | 460 UJ | 500 UJ |
| Fluoranthene | 430 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Fluorene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Indeno(1,2,3-cd)pyrene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Naphthalene | ND | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Phenanthrene | 140 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| Pyrene | 380 | | | 460 U | 430 U | R | 400 U | 460 U | 500 U |
| TOTAL SVOCs | 2430 | 7,290 | 12,150 | - | - | R | - | - | - |
| *Polychlorinated Biphenyls (ug/Kg)* | | | | | | | | | |
| Aroclor-1254 | ND | | | 46 U | 43 U | R | 40 U | 46 U | 46 U |
| Aroclor-1260 | ND | | | 46 U | 43 U | R | 40 U | 46 U | 46 U |
| Total PCBs | 578 | 1734 | 2890 | - | - | R | - | - | - |
| *Inorganics (mg/kg)* | | | | | | | | | |
| Antimony | ND | ND | ND | R | R | R | R | R | R |
| Arsenic | 2.8 | 8 | 14 | 0.64 UJ | 0.21 U | R | 0.2 U | R | R |
| Cadmium | ND | ND | ND | 1.9 U | 1.7 U | R | 1.5 U | 1.9 U | 1.9 U |
| Chromium | 21 | 63 | 105 | 7.7 | 7.2 | 9.8 J | 5 | 9.4 | 6.1 |
| Chromium (Hexavalent) | ND | ND | ND | 2.79 UJ | 2.6 UJ | R | 2.5 UJ | 2.87 UJ | 2.98 UJ |
| Copper | 45 | 135 | 225 | 3 U | 4.2 U | R | 2.4 U | 3.5 U | 5.9 U |
| Lead | 5.2 | 16 | 26 | 1.8 UJ | 0.44 | R | 1.1 J | 0.42 UJ | 0.44 UJ |
| Mercury | ND | ND | ND | 0.39 U | 0.29 U | R | 0.49 U | 0.41 U | 0.42 U |
| Nickel | 28 | 84 | 140 | 6.7 | 7.6 | 12 J | 4.1 U | 6 | 5.6 |
| Selenium | 4.9 | 15 | 25 | 5.8 UJ | 5.3 UJ | R | 4.6 UJ | 6 UJ | 6 UJ |
| Silver | 0.4 | 1 | 2 | 0.59 U | 0.54 U | R | 0.47 U | 0.61 U | 0.61 U |
| Thallium | ND | ND | ND | 0.47 U | 0.67 U | R | 0.61 U | 0.71 U | 0.73 U |
| Zinc | 270 | 810 | 1,350 | 49 U | 45 UJ | R | 39 UJ | 51 UJ | 51 UJ |

Notes:
Summary of detected compounds only
- = All constituents below detection limits
ND= Not Detected in Background
Blank Cells Were Not Analyzed
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
* PCBs not detected in background samples. Average of detections limits used to calculate Site background concentration.

**Table 13**
**Summary of Validated Sediment Analytical Data**
**Deerfield River (200 Series)**
**Yankee Nuclear Power Station**
**Rowe, MA**

| **Station**<br>**Sample Designation**<br>**Date Sampled** | **Site Background Maximum** | **Background 3X** | **Background 5X** | **SD-201**<br>**SD-201-00-04-I**<br>**9/24/2003** | **SD-202**<br>**SD-202-00-04-I**<br>**9/24/2003** | **SD-202**<br>**DUP-04**<br>**9/24/2003** | **SD-203**<br>**SD-203-00-04-I**<br>**9/24/2003** | **SD-204**<br>**SD-204-00-04-I**<br>**9/24/2003** | **SD-205**<br>**SD-205-00-04-I**<br>**9/24/2003** | **SD-206**<br>**SD-206-00-04-I**<br>**9/24/2003** |
|---|---|---|---|---|---|---|---|---|---|---|
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | | |
| TPH-DRO (Diesel Range) | 80 | 240 | 400 | 2.4 U | 2.2 J | 2.2 U | 6 J | 62 J | 14 J | 49 J |
| *Volatile Organic Compounds (ug/kg)* | | | | | | | | | | |
| 1,1-Dichloroethene | 24 | | | 15 U | 15 UJ | 27 UJ | 16 UJ | 35 UJ | 29 UJ | 69 UJ |
| 1,2,4-Trimethylbenzene | ND | | | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 6 UJ |
| 2-Butanone | 67 | | | 10 UJ | 10 UJ | 10 UJ | 10 UJ | 12 UJ | 12 J | 12 UJ |
| 4-Isopropyltoluene | ND | | | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 2 J | 6 UJ |
| 4-Methyl-2-pentanone | ND | | | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 6 UJ |
| Acetone | 280 | | | 10 UJ | 10 UJ | 28 UJ | 10 UJ | 10 UJ | 76 J | 88 UJ |
| Bromodichloromethane | NA | | | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 6 UJ |
| Bromoform | NA | | | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 6 UJ |
| Bromomethane | NA | | | 15 UJ | 15 UJ | 15 UJ | 15 UJ | 15 UJ | 15 UJ | 18 UJ |
| Carbon disulfide | ND | | | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 6 UJ |
| Chloromethane | ND | | | 1.2 J | 5 UJ | 5 UJ | 1.2 UJ | 5 UJ | 5 UJ | 6 UJ |
| Methylene chloride | ND | | | 15 UJ | 15 UJ | 15 UJ | 15 UJ | 53 UJ | 15 UJ | 18 UJ |
| Naphthalene | ND | | | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 5 UJ | 6 UJ |
| Toluene | 31 | | | 5 UJ | 5 UJ | 1.9 UJ | 5 UJ | 12 UJ | 5 UJ | 3.4 UJ |
| TOTAL VOCs | 402 | 1,206 | 2,010 | 1.2 | - | - | - | - | 90 | - |
| *Semi-Volatile Organic Compounds (ug/kg)* | | | | | | | | | | |
| 2-Methylnaphthalene | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| 2-Methylphenol | 150 | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| 3+4-Methylphenol | 230 | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Acenaphthene | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Anthracene | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Benzo(a)anthracene | 200 | | | 400 U | 360 U | 360 U | 430 U | 330 J | 400 U | 560 U |
| Benzo(a)pyrene | 230 | | | 400 U | 360 U | 360 U | 430 U | 320 J | 83 J | 120 J |
| Benzo(b)fluoranthene | 220 | | | 400 U | 360 U | 360 U | 430 U | 310 J | 79 J | 130 J |
| Benzo(g,h,i)perylene | ND | | | 400 U | 360 U | 360 U | 430 U | 210 J | 400 U | 560 U |
| Benzo(k)fluoranthene | 220 | | | 400 U | 360 U | 360 U | 430 U | 330 J | 78 J | 560 U |
| bis(2-Ethylhexyl)phthalate | ND | | | 400 U | 360 U | 360 U | 430 U | 120 J | 400 U | 560 U |
| Carbazole | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Chrysene | 230 | | | 400 U | 360 U | 360 U | 430 U | 380 J | 90 J | 120 J |
| Dibenzo(a,h)anthracene | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Dibenzofuran | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Di-n-octyl phthalate | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Fluoranthene | 430 | | | 400 U | 360 U | 360 U | 430 U | 670 | 150 J | 200 J |
| Fluorene | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Indeno(1,2,3-cd)pyrene | ND | | | 400 U | 360 U | 360 U | 430 U | 200 J | 400 U | 560 U |
| Naphthalene | ND | | | 400 U | 360 U | 360 U | 430 U | 430 U | 400 U | 560 U |
| Phenanthrene | 140 | | | 400 U | 360 U | 360 U | 430 U | 340 J | 80 J | 560 U |
| Pyrene | 380 | | | 400 U | 360 U | 360 U | 430 U | 540 | 120 J | 170 J |
| TOTAL SVOCs | 2430 | 7290 | 12150 | - | - | - | - | 3750 | 680 | 740 |
| *Polychlorinated Biphenyls (ug/kg)* | | | | | | | | | | |
| Aroclor-1254 | ND | | | 40 U | 36 U | 33 U | 43 U | 520 | 820 | 220 |
| Aroclor-1260 | ND | | | 40 U | 36 U | 33 U | 43 U | 190 | 200 | 180 |
| Total PCBs | 578 | 1734 | 2890 | - | - | - | - | 710 | 1020 | 400 |
| *Inorganics (mg/kg)* | | | | | | | | | | |
| Antimony | ND | ND | ND | 0.6 U | 0.53 U | 0.53 U | 0.64 U | 0.66 U | 0.59 U | 0.88 U |
| Arsenic | 3 | 8 | 14 | 0.19 U | 0.17 U | 0.52 | 1 | 2.5 | 1.4 | 1.6 |
| Cadmium | ND | ND | ND | 0.82 U | 0.69 U | 0.72 U | 0.87 U | 0.86 U | 0.74 U | 1.2 U |
| Chromium | 21 | 63 | 105 | 9.2 | 7.4 | 6.6 | 7.6 | 17 | 12 | 11 |
| Chromium (Hexavalent) | ND | ND | ND | 2.5 U | 2.1 U | 2.2 U | 2.5 U | 2.7 U | 2.4 U | 3.6 U |
| Copper | 45 | 135 | 225 | 11 | 9.7 | 7.6 | 11 | **150** | 28 | 43 |
| Lead | 5 | 16 | 26 | 2.6 | 1 | 1.9 | 2.6 | 13 | 8.4 | 10 |
| Mercury | ND | ND | ND | 1.1 U | 0.79 U | 0.72 U | 0.86 U | 0.86 U | 0.94 U | 1.2 U |
| Nickel | 28 | 84 | 140 | 13 | 9.3 | 8.8 | 9.4 | 17 | 11 | 13 |
| Selenium | 5 | 15 | 25 | 2.6 U | 2.1 U | 2.2 U | 2.7 U | 3.5 | 2.8 | 3.7 U |
| Silver | 0.4 | 1.2 | 2 | 0.26 U | 0.22 U | 0.23 U | 0.27 U | 0.27 U | 0.24 U | 0.38 U |
| Thallium | ND | ND | ND | 0.6 U | 0.53 U | 0.53 U | 0.64 U | 0.66 U | 0.59 U | 0.88 U |
| Zinc | 270 | 810 | 1,350 | 37 | 29 | 38 | 39 | 210 | 56 | 90 |

Notes:
Summary of detected compounds only
- = All constituents below detection limits
ND= Not Detected in Background
Blank Cells Were Not Analyzed
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
Value exceeds 3X Site Background maximum
Value exceeds 5X Site Background maximum
* PCBs not detected in background samples. Average of detections limits used to calculate Site background concentration.

**Table 14**
**Summary of Validated Sediment Analytical Data**
**West Storm Drain Ditch (300 Series)**
**Yankee Nuclear Power Station**
**Rowe, MA**

| **Station**<br>**Sample Designation**<br>**Date Sampled** | **Site Background Maximum** | **Background 3X** | **Background 5X** | **SD-301**<br>**SD-301-00-04-I**<br>**8/12/2003** | **SD-302**<br>**SD-302-00-04-I**<br>**8/12/2003** | **SD-303**<br>**SD-303-00-04-I**<br>**8/12/2003** | **SD-304**<br>**SD-304-00-04-I**<br>**8/12/2003** | **SD-304**<br>**FD-003-081203**<br>**8/12/2003** | **SD-305**<br>**SD-305-00-04-I**<br>**8/12/2003** |
|---|---|---|---|---|---|---|---|---|---|
| *Total Petroleum Hydrocarbons (mg/kg)* | | | | | | | | | |
| TPH-DRO (Diesel Range) | 80 | 240 | 400 | 25 | 24 UJ | 30 | 24 UJ | 24 U | 24 UJ |
| *Volatile Organic Compounds (ug/kg)* | | | | | | | | | |
| 1,1-Dichloroethene | 24 | | | 5 U | 21 | 11 J | 5 UJ | 5 U | 5 UJ |
| 1,2,4-Trimethylbenzene | ND | | | 5 U | 5 U | 5 UJ | 5 UJ | 5 U | 5 UJ |
| 2-Butanone | 67 | | | 10 U | 10 U | 10 UJ | 10 UJ | 10 U | 10 UJ |
| 4-Isopropyltoluene | ND | | | 5 U | 5 U | 5 UJ | 5 UJ | 5 U | 5 UJ |
| 4-Methyl-2-pentanone | ND | | | 5 U | 5 U | 5 UJ | 5 UJ | 5 U | 5 UJ |
| Acetone | 280 | | | 10 U | 10 U | 10 UJ | 10 UJ | 10 U | 10 UJ |
| Carbon disulfide | ND | | | 5 U | 5 U | 5 UJ | 5 UJ | 5 U | 5 UJ |
| Chloromethane | ND | | | 5 U | 5 U | 5 UJ | 5 UJ | 5 U | 5 UJ |
| Methylene chloride | ND | | | 15 U | 15 U | 15 UJ | 15 UJ | 15 U | 1.1 J |
| Naphthalene | ND | | | 5 U | 5.7 | 5 UJ | 5 UJ | 5 U | 5 UJ |
| Toluene | 31 | | | 5 U | 5 U | 5 UJ | 5 UJ | 0.89 J,B | 5 UJ |
| TOTAL VOCs | 402 | 1,206 | 2,010 | - | 27 | 11 | - | 1 | 1 |
| *Semi-Volatile Organic Compounds (ug/kg)* | | | | | | | | | |
| 2-Methylnaphthalene | ND | | | 400 U | 400 U | 280 J | 400 U | 400 U | 400 U |
| 2-Methylphenol | 150 | | | 400 U | 400 U | 430 U | 400 U | 400 U | 400 U |
| 3+4-Methylphenol | 230 | | | 400 U | 400 U | 430 U | 400 U | 400 U | 400 U |
| Acenaphthene | ND | | | 400 U | 400 U | 1800 J | 400 U | 400 U | 140 J |
| Anthracene | ND | | | 120 J | 160 J | 2200 J | 400 U | 400 U | 180 J |
| Benzo(a)anthracene | 200 | | | 250 J | 780 | 6600 J | 130 J | 400 U | 340 J |
| Benzo(a)pyrene | 230 | | | 260 J | 830 | 5800 J | 130 J | 400 U | 340 J |
| Benzo(b)fluoranthene | 220 | | | 250 J | 710 | 5600 J | 400 U | 400 U | 400 U |
| Benzo(g,h,i)perylene | ND | | | 180 J | 490 | 2900 J | 400 U | 400 U | 180 J |
| Benzo(k)fluoranthene | 220 | | | 240 J | 640 | 4600 J | 400 U | 400 U | 400 U |
| bis(2-Ethylhexyl)phthalate | ND | | | 400 U | 180 J | 200 J | 150 J | 400 U | 150 J |
| Carbazole | ND | | | 400 U | 400 U | 2200 J | 400 U | 400 U | 400 U |
| Chrysene | 230 | | | 280 J | 760 | 6200 J | 140 J | 400 U | 350 J |
| Dibenzo(a,h)anthracene | ND | | | 400 U | 400 U | 770 | 400 U | 400 U | 400 U |
| Dibenzofuran | ND | | | 400 U | 400 U | 1300 J | 400 U | 400 U | 400 U |
| Di-n-octyl phthalate | ND | | | 400 U | 400 U | 430 U | 400 U | 400 U | 400 U |
| Fluoranthene | 430 | | | 730 | 1500 | 14000 J | 310 J | 400 U | 820 |
| Fluorene | ND | | | 400 U | 400 U | 1900 J | 400 U | 400 U | 100 J |
| Indeno(1,2,3-cd)pyrene | ND | | | 150 J | 460 | 2900 J | 400 U | 400 U | 140 J |
| Naphthalene | ND | | | 400 U | 400 U | 470 | 400 U | 400 U | 400 U |
| Phenanthrene | 140 | | | 530 | 730 | 13000 J | 210 J | 400 U | 680 |
| Pyrene | 380 | | | 550 | 1300 | 9900 J | 240 J | 400 U | 630 |
| TOTAL SVOCs | 2,430 | 7,290 | 12,150 | 3,540 | **8,540** | **82,620** | 1,310 | - | 4,050 |
| *Polychlorinated Biphenyls (ug/kg)* | | | | | | | | | |
| Aroclor-1254 | ND | | | 64 | 950 | 77 | 350 | 72 | 220 |
| Aroclor-1260 | ND | | | 40 U | 40 U | 43 U | 40 U | 40 U | 40 U |
| Total PCBs | 578 | 1734 | 2890 | 64 | 950 | 77 | 350 | 72 | 220 |
| *Inorganics (mg/kg)* | | | | | | | | | |
| Antimony | ND | ND | ND | 1.6 | 0.62 U | 0.66 UJ | 0.62 UJ | 0.61 U | 0.41 U |
| Arsenic | 3 | 8 | 14 | 1.4 | 1.6 | 1.4 | 1.5 | 1.4 | 1.7 J |
| Cadmium | ND | ND | ND | 4.1 U | 1.5 U | 1.7 U | 1.6 U | 1.6 U | 1.7 U |
| Chromium | 21 | 63 | 105 | 13 | 7.2 | 4.9 | 5.6 | 4.2 | 4.4 |
| Chromium (Hexavalent) | ND | ND | ND | 2.3 UJ | 2.5 UJ | 2.5 UJ | 2.4 UJ | 2.5 UJ | 2.3 UJ |
| Copper | 45 | 135 | 225 | 58 | 19 | 23 | 19 | 16 | 18 |
| Lead | 5 | 16 | 26 | **30** | 3.7 | 2.7 UJ | 0.58 J | **17** | 13 J |
| Mercury | ND | ND | ND | 0.36 U | 0.33 U | 0.37 U | 0.38 U | 0.4 U | 0.29 U |
| Nickel | 28 | 84 | 140 | 20 | 7.7 | 9.2 | 6.4 | 8.4 | 5.3 |
| Selenium | 5 | 15 | 25 | 13 U | 4.7 U | 5.2 U | 4.9 U | 4.9 U | 5.2 U |
| Silver | 0.4 | 1.2 | 2.0 | 1.3 U | 0.48 U | 0.52 UJ | 0.5 UJ | 0.5 U | 0.53 UJ |
| Thallium | ND | ND | ND | 0.6 U | 0.62 U | 0.66 U | 0.62 U | 0.61 U | 0.41 U |
| Zinc | 270 | 810 | 1,350 | 310 | 86 | 83 | 86 | 59 | 81 |

Notes:
Summary of detected compounds only
- = All constituents below detection limits
ND= Not Detected in background
Blank Cells Were Not Analyzed
J= Estimated result
R= Rejected result, unusable for project decisions
U= Not detected, value is the sample detection/reporting limit
UJ= Not detected, value is an estimate of detection/reporting limit
Value exceeds 3X Site Background maximum
Value exceeds 5X Site Background maximum
* PCBs not detected in background samples. Average of detections limits used to calculate Site background concentration.

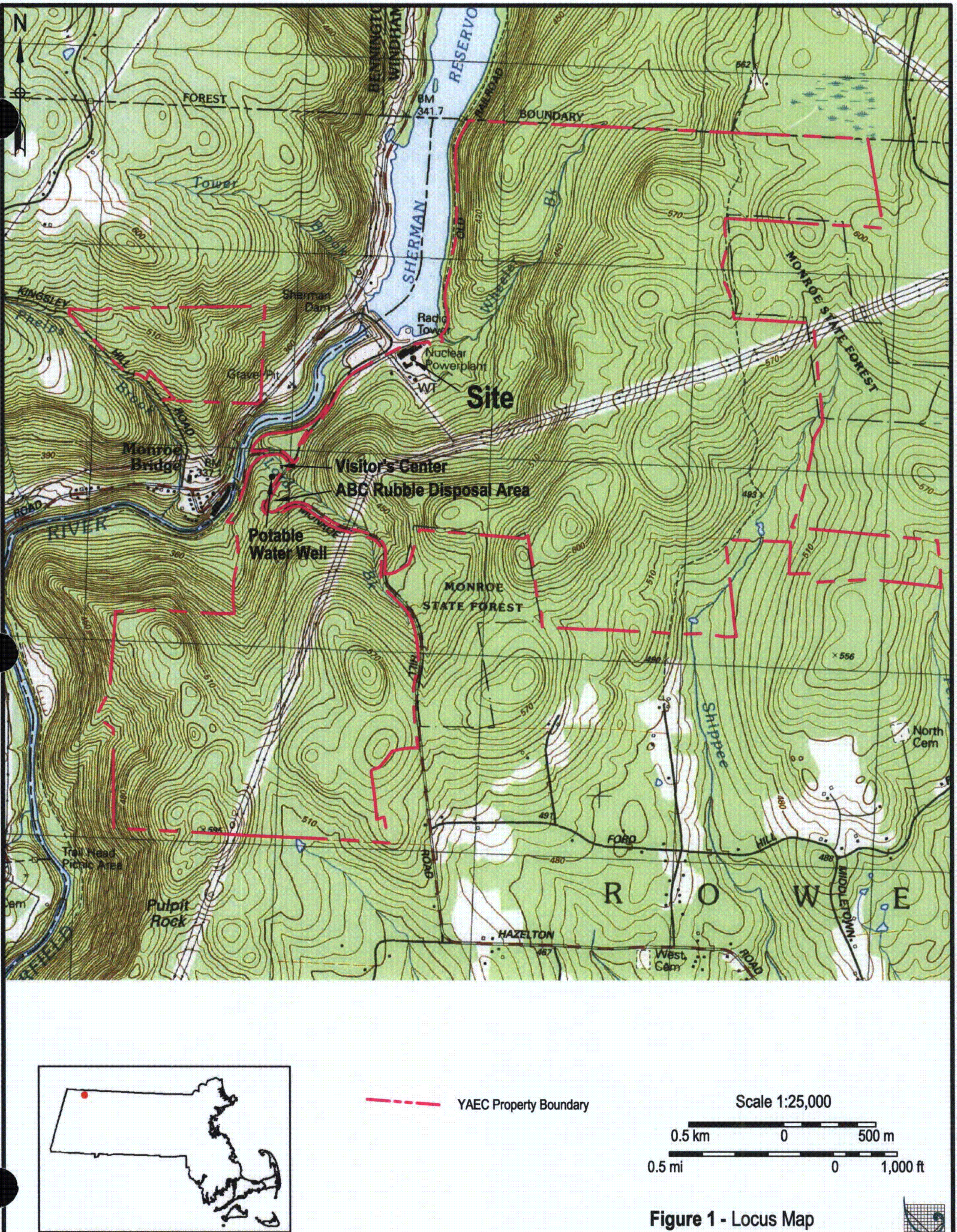


**Figure 1** - Locus Map
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Site Status Report.dwg (06/04/04 Boston)

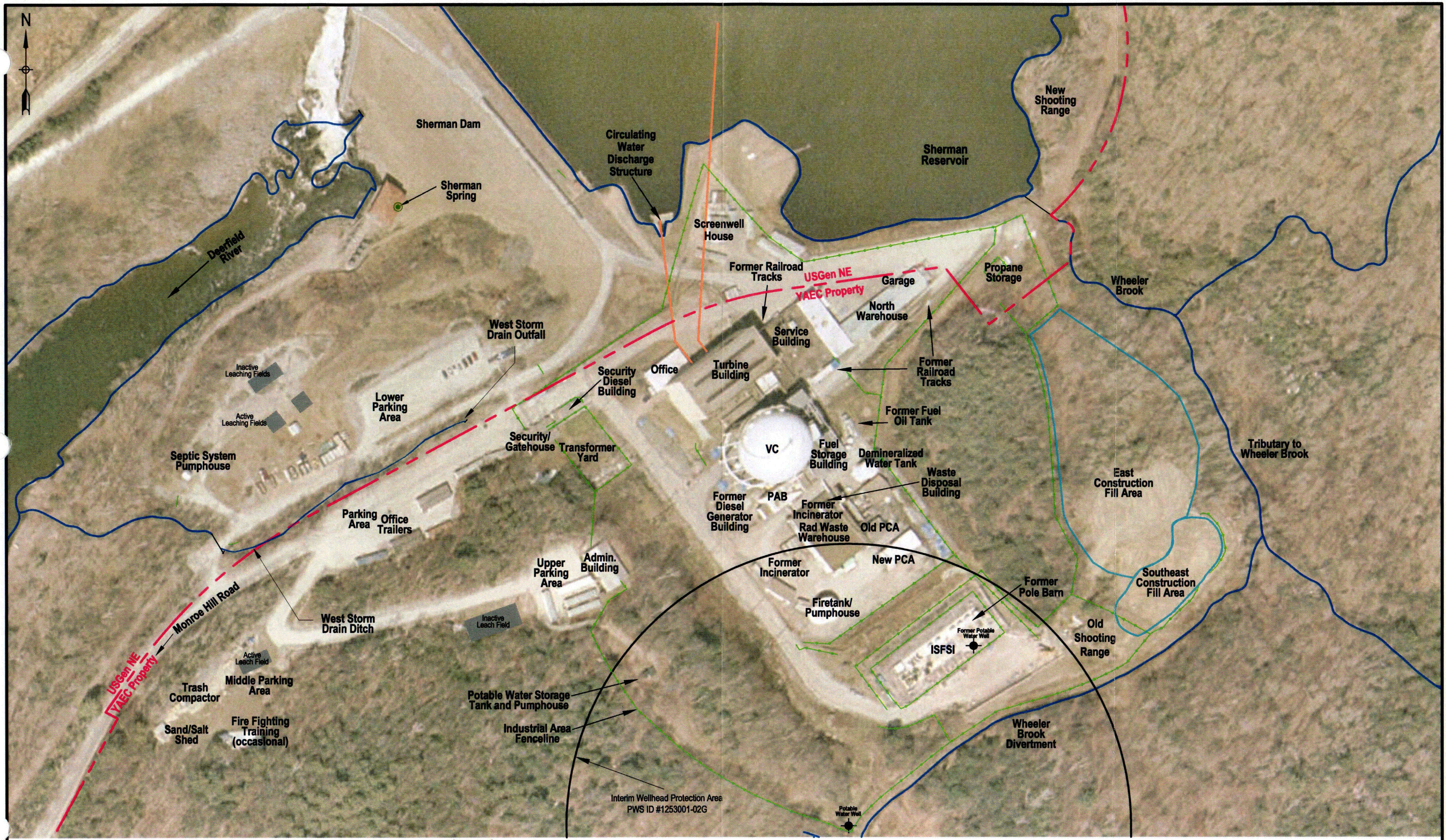
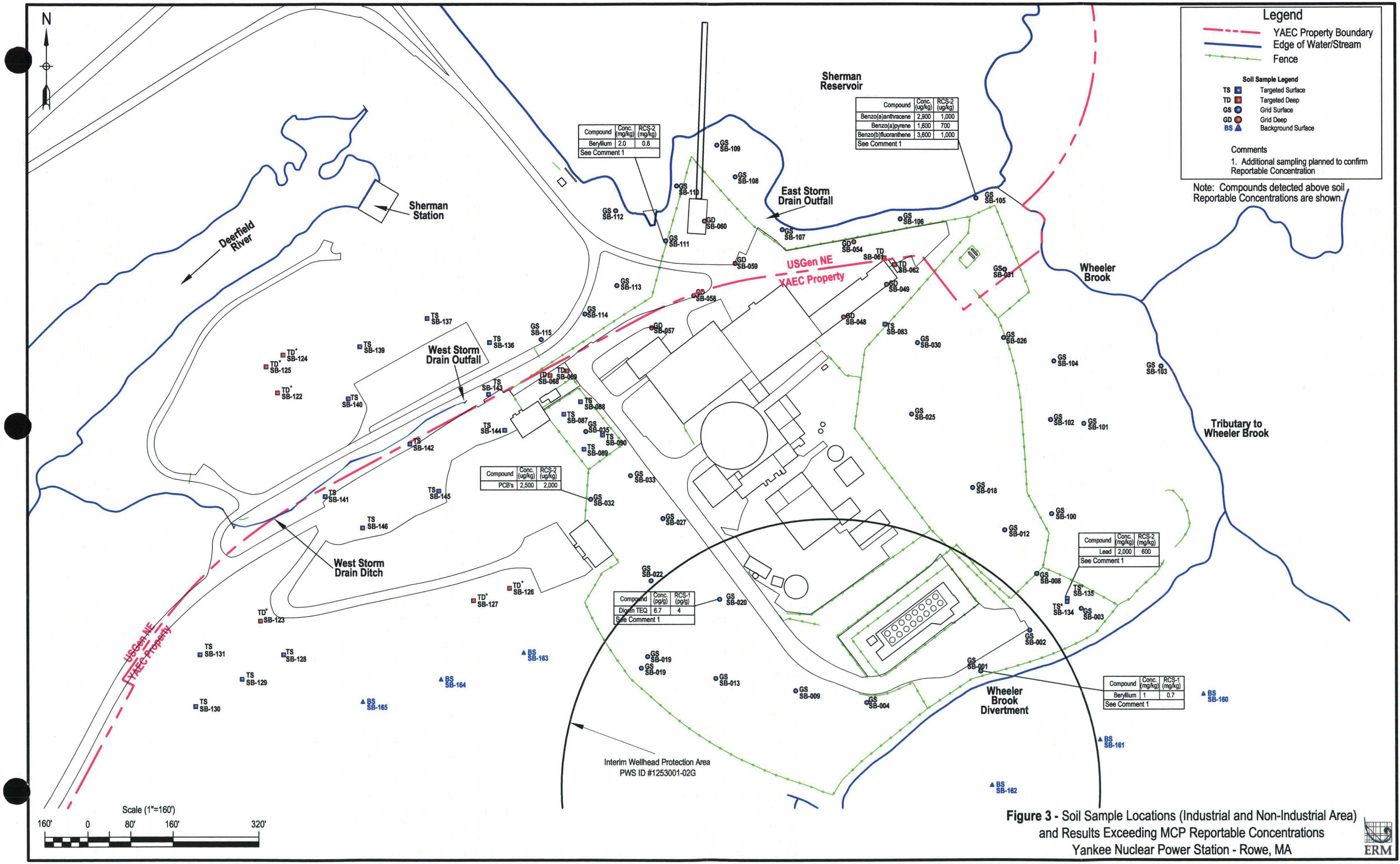


**Figure 2 -** Site Layout
Yankee Nuclear Power Station - Rowe, MA

ERM

R:\Yankee Atomic\Yankee Site Status Report.dwg (06/04/04 Boston)



| Compound | Conc. (mg/kg) | RCS-2 (mg/kg) |
|---|---|---|
| Beryllium | 2.0 | 0.8 |
| See Comment 1 | | |

| Compound | Conc. (ug/kg) | RCS-2 (ug/kg) |
|---|---|---|
| Benzo(a)anthracene | 2,900 | 1,000 |
| Benzo(a)pyrene | 1,600 | 700 |
| Benzo(b)fluoranthene | 3,600 | 1,000 |
| See Comment 1 | | |

| Compound | Conc. (ug/kg) | RCS-2 (ug/kg) |
|---|---|---|
| PCB's | 2,500 | 2,000 |

| Compound | Conc. (pg/g) | RCS-1 (pg/g) |
|---|---|---|
| Dioxin TEQ | 6.7 | 4 |
| See Comment 1 | | |

| Compound | Conc. (mg/kg) | RCS-2 (mg/kg) |
|---|---|---|
| Lead | 2,000 | 600 |
| See Comment 1 | | |

| Compound | Conc. (mg/kg) | RCS-1 (mg/kg) |
|---|---|---|
| Beryllium | 1 | 0.7 |
| See Comment 1 | | |

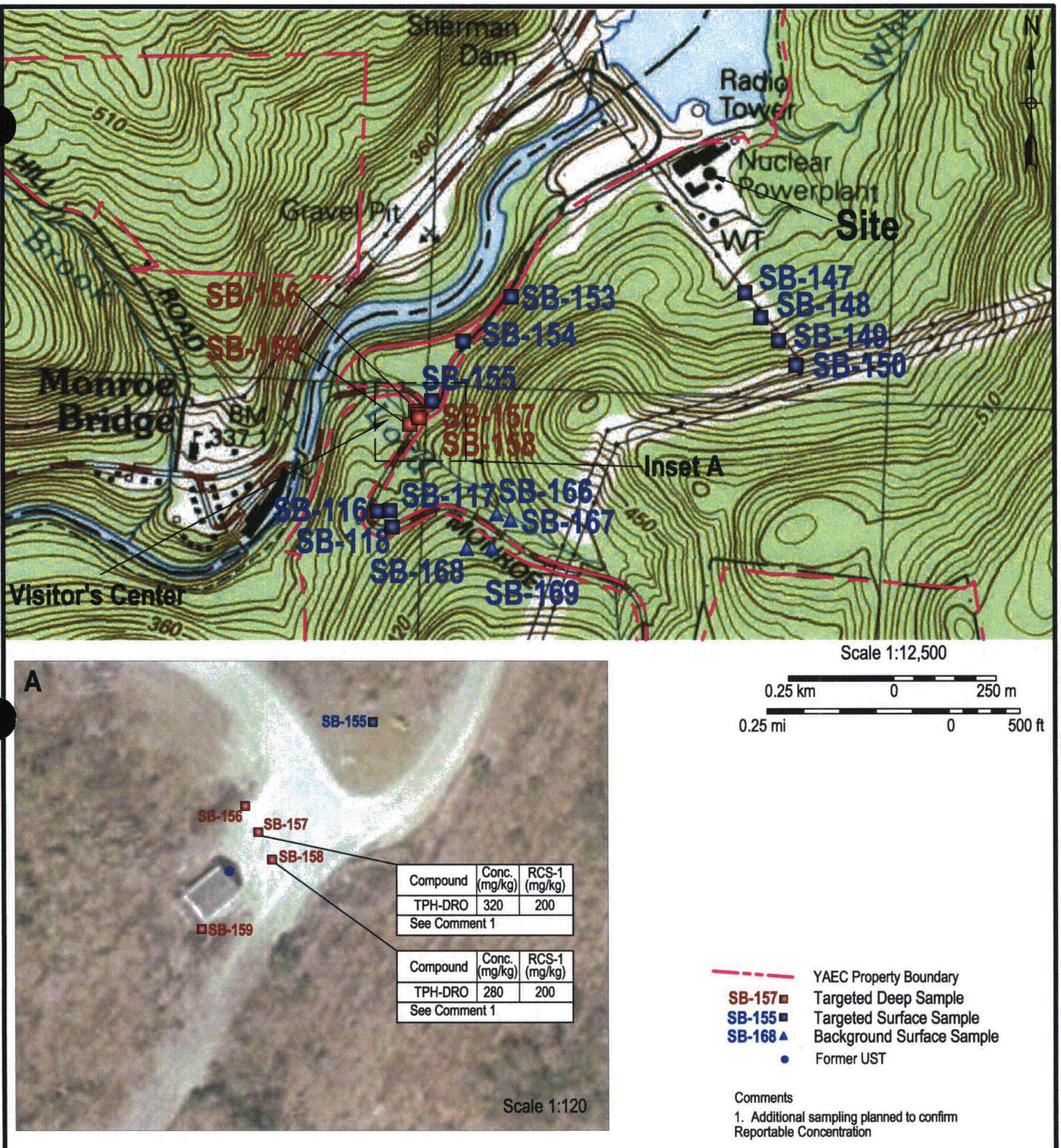
Comments

1. Additional sampling planned to confirm Reportable Concentration

Note: Compounds detected above soil Reportable Concentrations are shown.

**Figure 3** - Soil Sample Locations (Industrial and Non-Industrial Area) and Results Exceeding MCP Reportable Concentrations
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Site Status Report.dwg (04/05/04 Boston)



| Compound | Conc. (mg/kg) | RCS-1 (mg/kg) |
|---|---|---|
| TPH-DRO | 320 | 200 |
| See Comment 1 | | |

| Compound | Conc. (mg/kg) | RCS-1 (mg/kg) |
|---|---|---|
| TPH-DRO | 280 | 200 |
| See Comment 1 | | |

Comments

1. Additional sampling planned to confirm Reportable Concentration

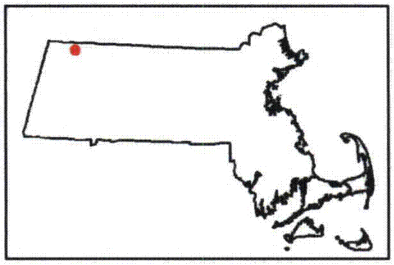
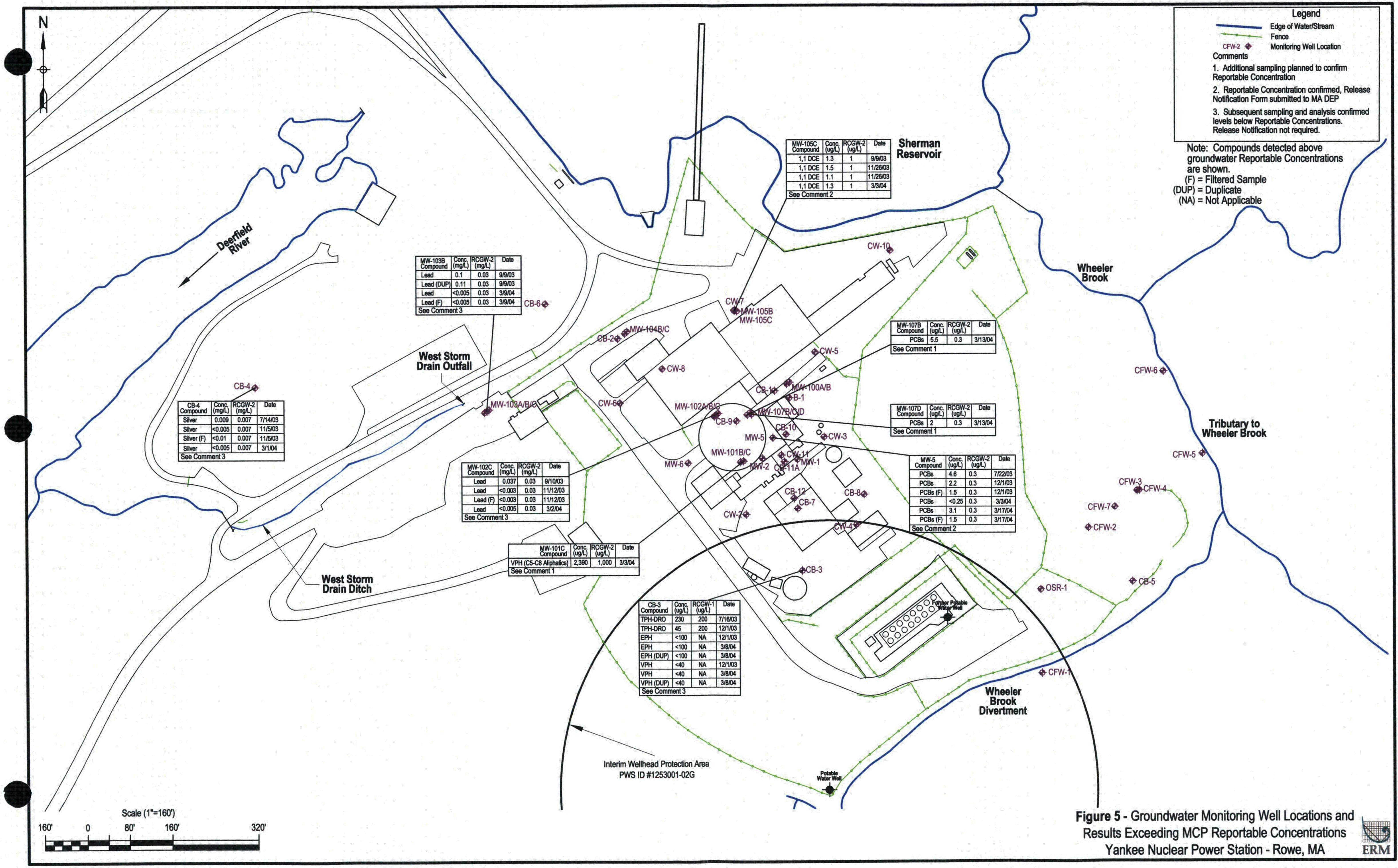


**Figure 4 -** Soil Sample Locations (Non-Industrial Area) and Results Exceeding MCP Reportable Concentrations
Yankee Nuclear Power Station - Rowe, MA

ERM

R:\Yankee Atomic\Yankee Site Status Report.dwg (04/05/04 Boston)



Legend

- ▬ Edge of Water/Stream
- -o-o- Fence
- CFW-2 ◆ Monitoring Well Location

Comments

1. Additional sampling planned to confirm Reportable Concentration
2. Reportable Concentration confirmed, Release Notification Form submitted to MA DEP
3. Subsequent sampling and analysis confirmed levels below Reportable Concentrations. Release Notification not required.

Note: Compounds detected above groundwater Reportable Concentrations are shown.

(F) = Filtered Sample
(DUP) = Duplicate
(NA) = Not Applicable

| MW-105C Compound | Conc. (ug/L) | RCGW-2 (ug/L) | Date |
|---|---|---|---|
| 1,1 DCE | 1.3 | 1 | 9/9/03 |
| 1,1 DCE | 1.5 | 1 | 11/26/03 |
| 1,1 DCE | 1.1 | 1 | 11/26/03 |
| 1,1 DCE | 1.3 | 1 | 3/3/04 |
| See Comment 2 | | | |

| MW-103B Compound | Conc. (mg/L) | RCGW-2 (mg/L) | Date |
|---|---|---|---|
| Lead | 0.1 | 0.03 | 9/9/03 |
| Lead (DUP) | 0.11 | 0.03 | 9/9/03 |
| Lead | <0.005 | 0.03 | 3/9/04 |
| Lead (F) | <0.005 | 0.03 | 3/9/04 |
| See Comment 3 | | | |

| CB-4 Compound | Conc. (mg/L) | RCGW-2 (mg/L) | Date |
|---|---|---|---|
| Silver | 0.009 | 0.007 | 7/14/03 |
| Silver | <0.005 | 0.007 | 11/5/03 |
| Silver (F) | <0.01 | 0.007 | 11/5/03 |
| Silver | <0.005 | 0.007 | 3/1/04 |
| See Comment 3 | | | |

| MW-107B Compound | Conc. (ug/L) | RCGW-2 (ug/L) | Date |
|---|---|---|---|
| PCBs | 5.5 | 0.3 | 3/13/04 |
| See Comment 1 | | | |

| MW-107D Compound | Conc. (ug/L) | RCGW-2 (ug/L) | Date |
|---|---|---|---|
| PCBs | 2 | 0.3 | 3/13/04 |
| See Comment 1 | | | |

| MW-5 Compound | Conc. (ug/L) | RCGW-2 (ug/L) | Date |
|---|---|---|---|
| PCBs | 4.6 | 0.3 | 7/22/03 |
| PCBs | 2.2 | 0.3 | 12/1/03 |
| PCBs (F) | 1.5 | 0.3 | 12/1/03 |
| PCBs | <0.25 | 0.3 | 3/3/04 |
| PCBs | 3.1 | 0.3 | 3/17/04 |
| PCBs (F) | 1.5 | 0.3 | 3/17/04 |
| See Comment 2 | | | |

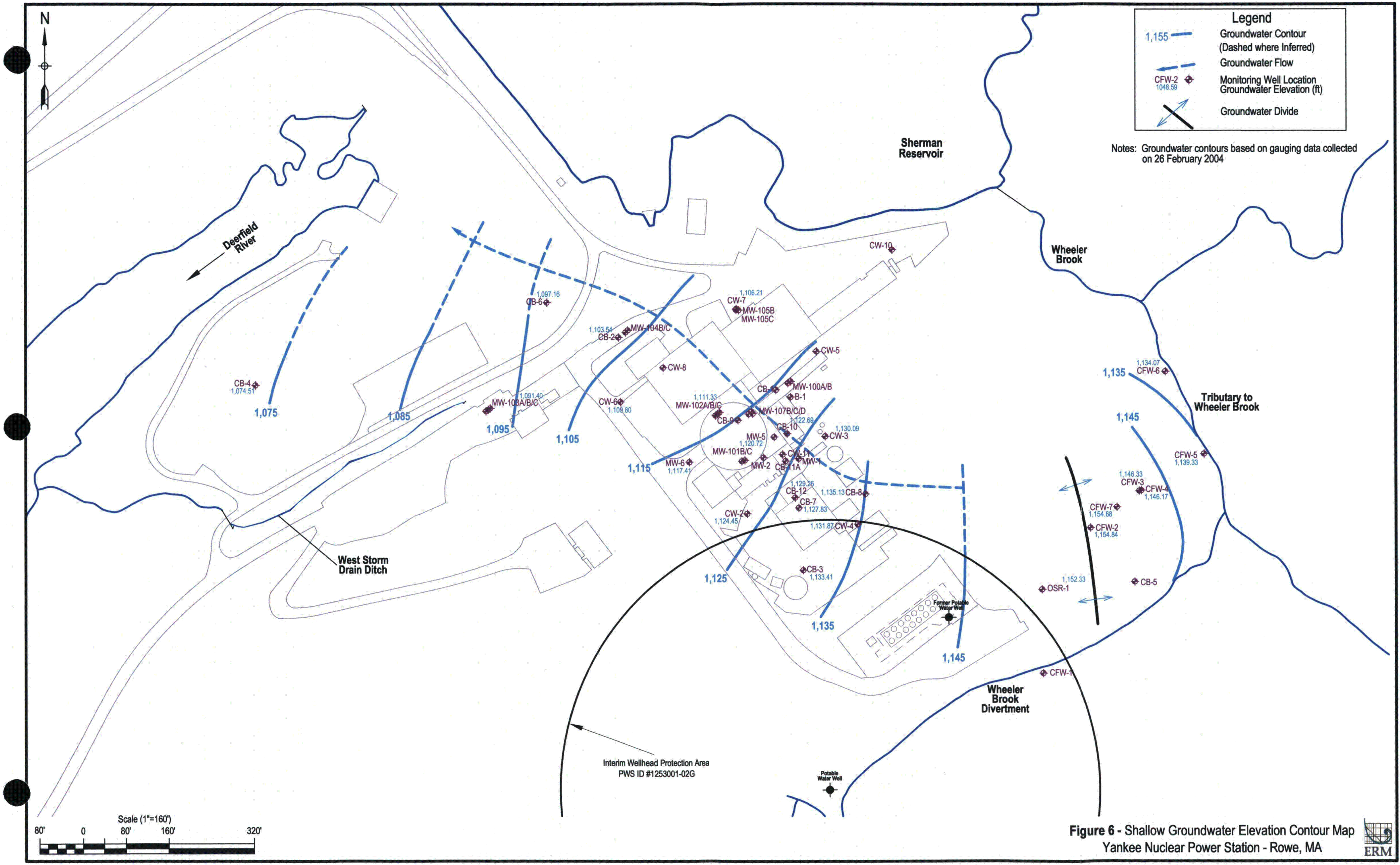
| MW-102C Compound | Conc. (mg/L) | RCGW-2 (mg/L) | Date |
|---|---|---|---|
| Lead | 0.037 | 0.03 | 9/10/03 |
| Lead | <0.003 | 0.03 | 11/12/03 |
| Lead (F) | <0.003 | 0.03 | 11/12/03 |
| Lead | <0.005 | 0.03 | 3/2/04 |
| See Comment 3 | | | |

| MW-101C Compound | Conc. (ug/L) | RCGW-2 (ug/L) | Date |
|---|---|---|---|
| VPH (C5-C8 Aliphatics) | 2,390 | 1,000 | 3/3/04 |
| See Comment 1 | | | |

| CB-3 Compound | Conc. (ug/L) | RCGW-1 (ug/L) | Date |
|---|---|---|---|
| TPH-DRO | 230 | 200 | 7/16/03 |
| TPH-DRO | 45 | 200 | 12/1/03 |
| EPH | <100 | NA | 12/1/03 |
| EPH | <100 | NA | 3/8/04 |
| EPH (DUP) | <100 | NA | 3/8/04 |
| VPH | <40 | NA | 12/1/03 |
| VPH | <40 | NA | 3/8/04 |
| VPH (DUP) | <40 | NA | 3/8/04 |
| See Comment 3 | | | |

**Figure 5** - Groundwater Monitoring Well Locations and Results Exceeding MCP Reportable Concentrations
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Site Status Report.dwg (04/12/04 Boston)

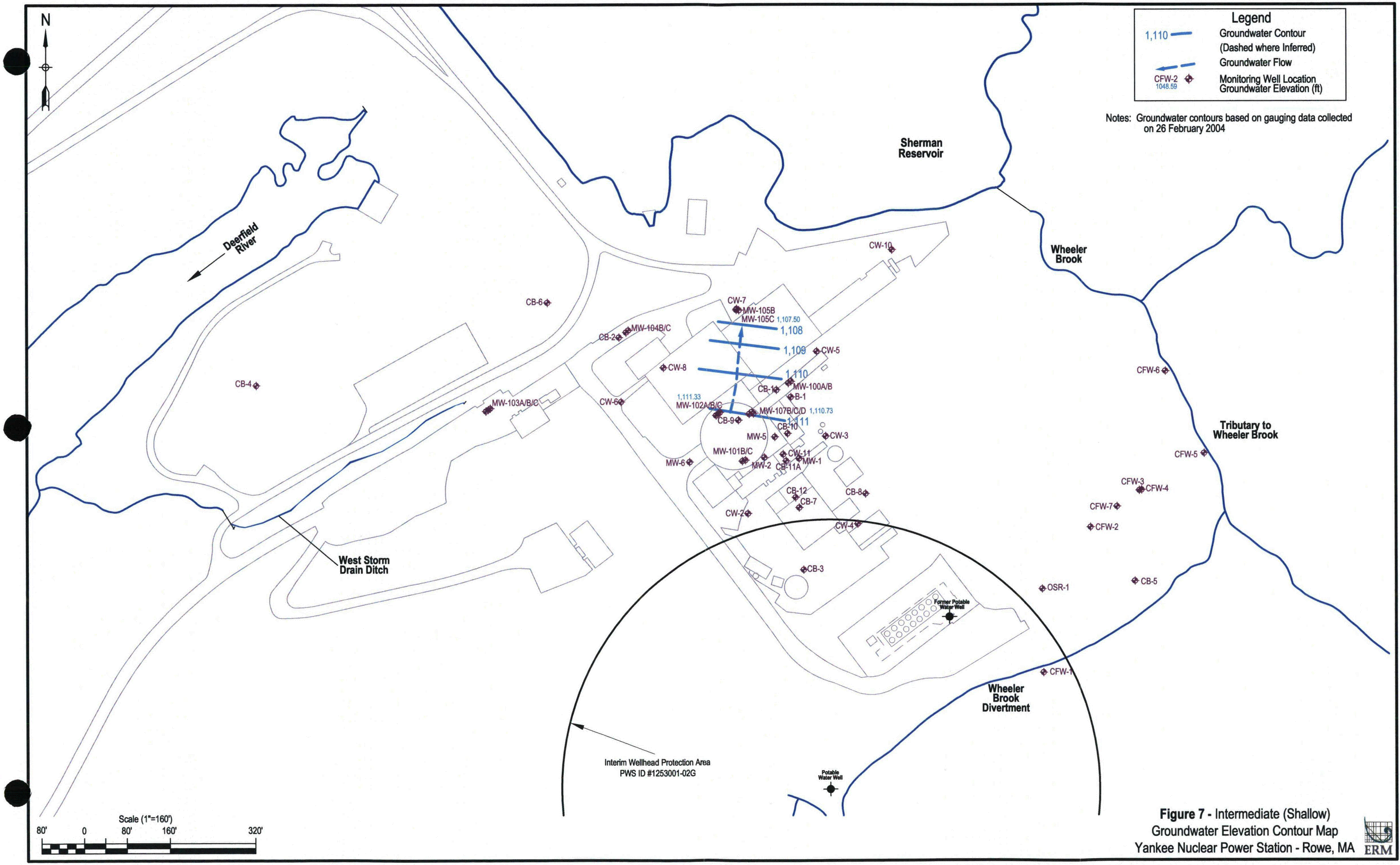


Notes: Groundwater contours based on gauging data collected on 26 February 2004

**Figure 6 -** Shallow Groundwater Elevation Contour Map
Yankee Nuclear Power Station - Rowe, MA

ERM

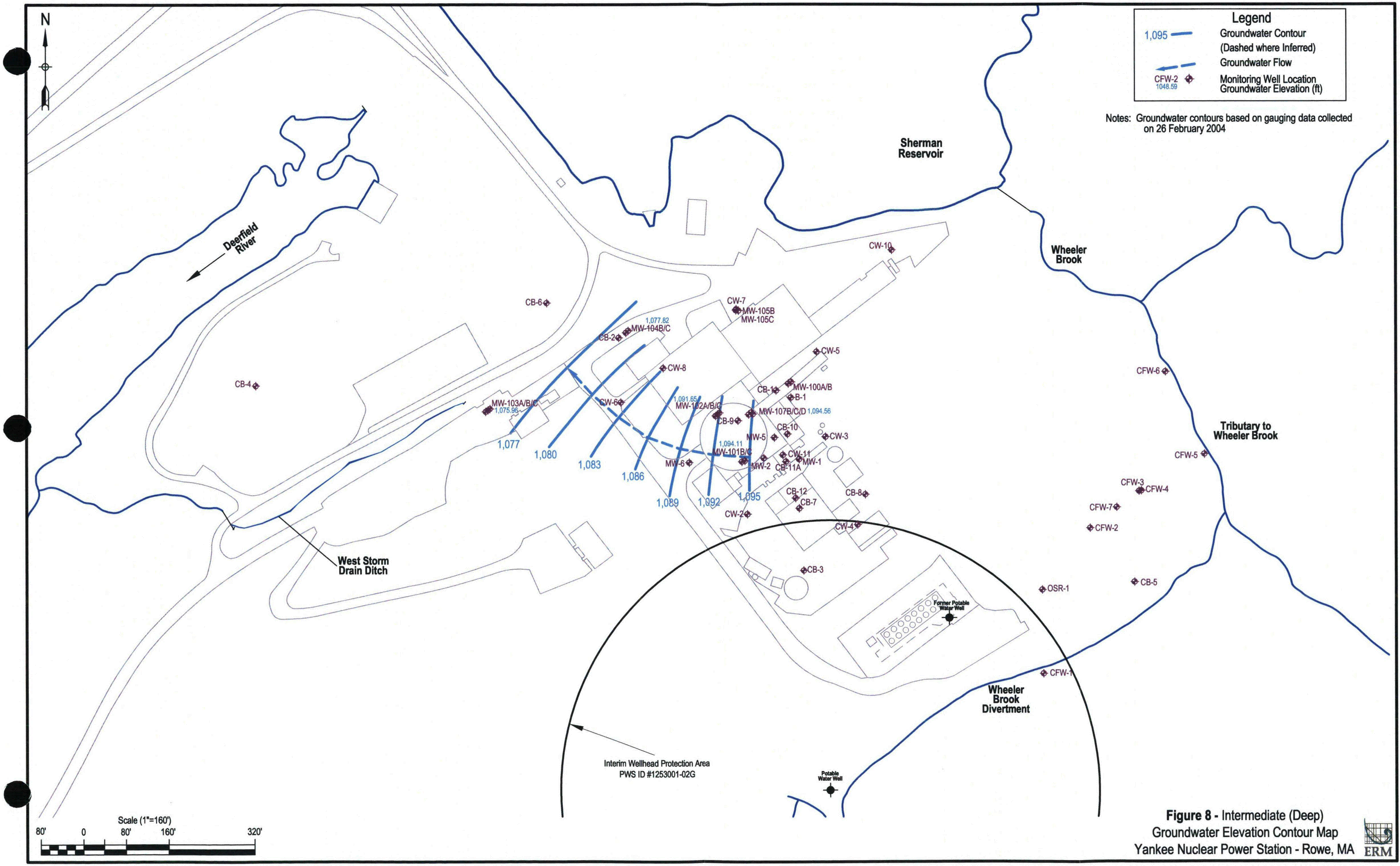
R:\Yankee Atomic\Yankee Site Status Report.dwg (05/12/04 Boston)



Notes: Groundwater contours based on gauging data collected on 26 February 2004

**Figure 7** - Intermediate (Shallow) Groundwater Elevation Contour Map
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Site Status Report.dwg (05/12/04 Boston)



Notes: Groundwater contours based on gauging data collected on 26 February 2004

**Figure 8** - Intermediate (Deep)
Groundwater Elevation Contour Map
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Site Status Report.dwg (05/12/04 Boston)

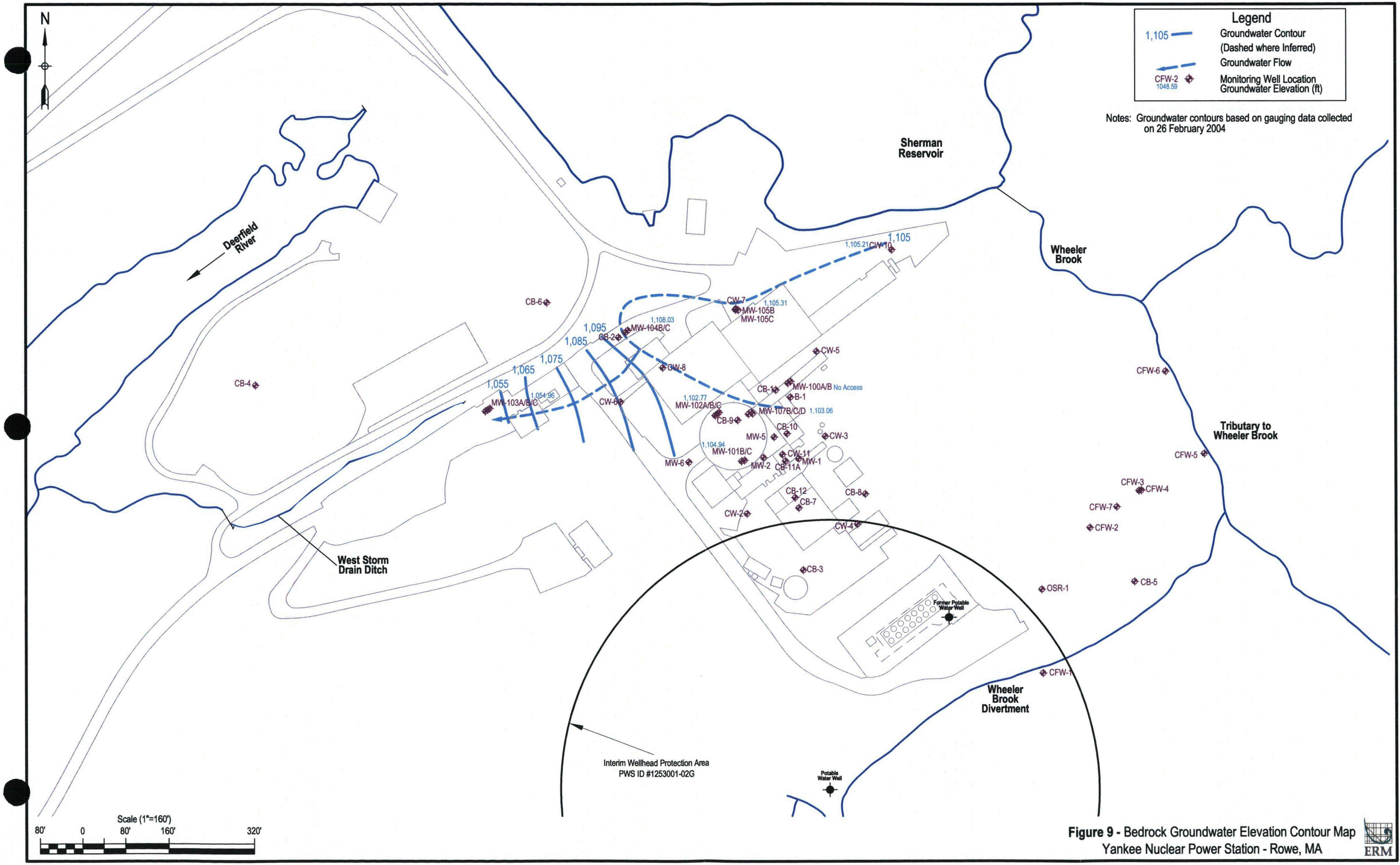
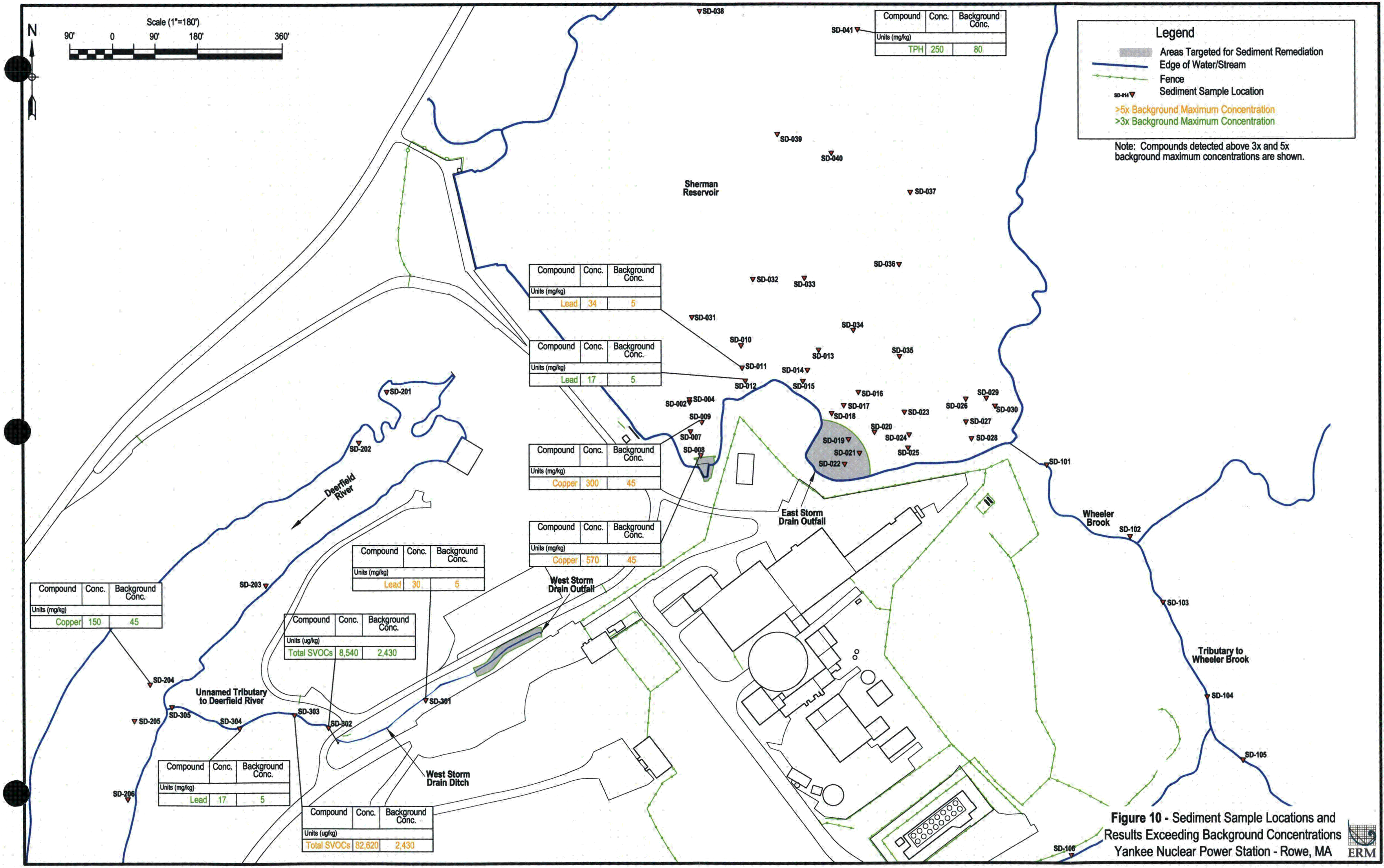


**Figure 9** - Bedrock Groundwater Elevation Contour Map
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Site Status Report.dwg (04/05/04 Boston)



Note: Compounds detected above 3x and 5x background maximum concentrations are shown.

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| TPH | 250 | 80 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| Lead | 34 | 5 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| Lead | 17 | 5 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| Copper | 300 | 45 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| Copper | 570 | 45 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| Lead | 30 | 5 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (ug/kg) | | |
| Total SVOCs | 8,540 | 2,430 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| Copper | 150 | 45 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (mg/kg) | | |
| Lead | 17 | 5 |

| Compound | Conc. | Background Conc. |
|---|---|---|
| Units (ug/kg) | | |
| Total SVOCs | 82,620 | 2,430 |

**Figure 10 -** Sediment Sample Locations and Results Exceeding Background Concentrations
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Site Status Report.dwg (05/06/04 Boston)

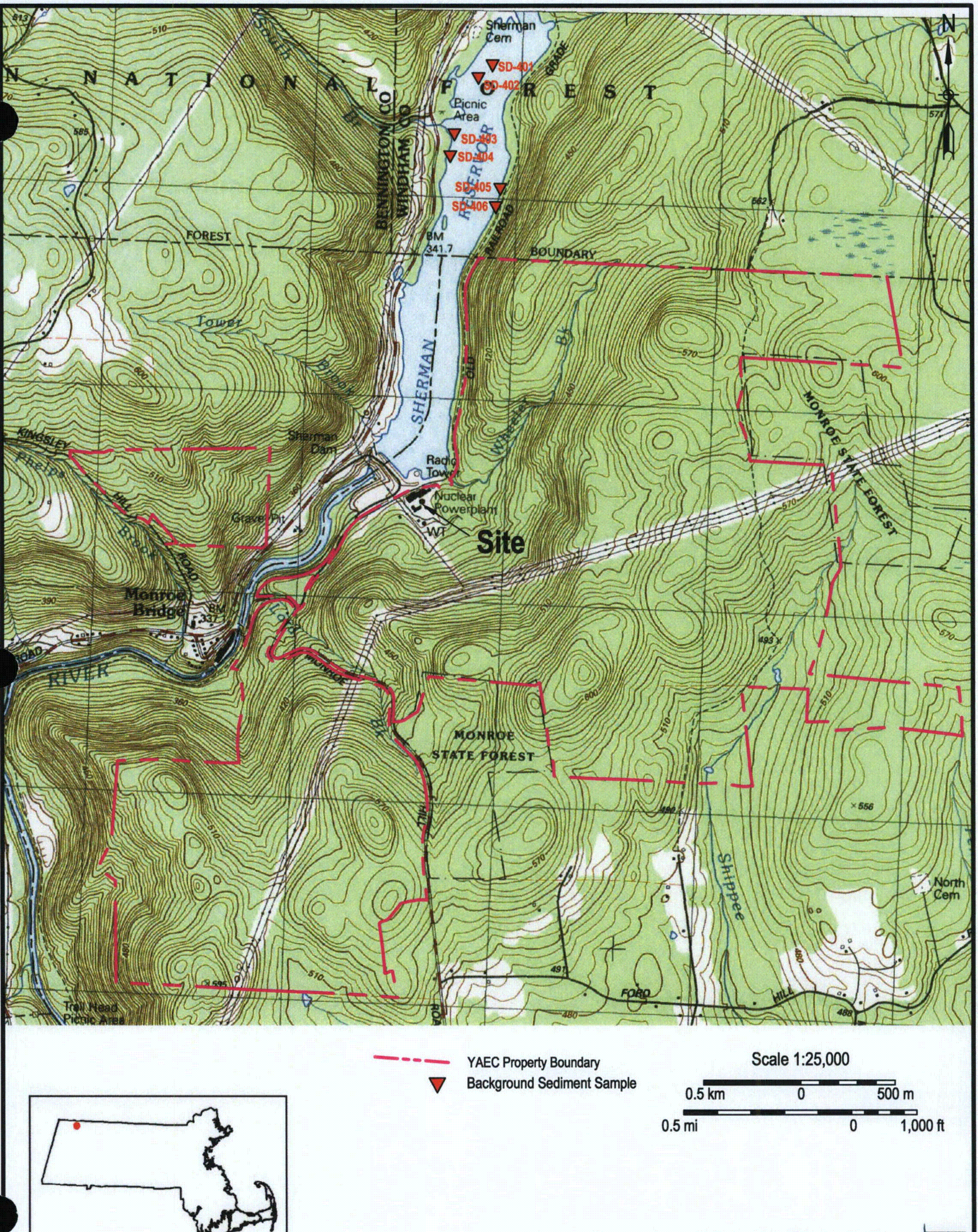


**Figure 11** - Background Sediment Sample Locations
Yankee Nuclear Power Station - Rowe, MA

ERM

R:\Yankee Atomic\Yankee Site Status Report.dwg (06/04/04 Boston)

# *Appendix A*

# *Table A-1*

Table A-1
Summary of 2003 Soil Sampling Program
Yankee Nuclear Power Station
Rowe, MA

| Location | | Sample Designation | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Area | Within Fence line | SB--001 0006I | | x | x | x | x | x | | | | |
| | | SB-001 0203F | | x | x | x | x | x | | | | |
| | | SB-002 0006I | | | x | x | | x | | | | |
| | | SB-002 0203F | | | | x | | x | | | | |
| | | SB-003 0006I | | | x | x | | x | | | | |
| | | SB-003 0203F | | | | x | | x | | | | |
| | | SB-004 0006I | | | x | x | | x | | | | |
| | | SB-004 0102F | | | | | | x | | | | |
| | | SB-008 0006I | | | x | x | | x | | | | |
| | | SB-008 0102F | | | | x | | x | | | | |
| | | SB-009 0006I | | | x | x | | x | | | | |
| | | SB-009 0102F | | | | x | | x | | | | |
| | | SB-012 0006I | | | x | x | | x | | | | |
| | | SB-012 0203F | | | | x | | x | | | | |
| | | SB-013 0006I | | | x | x | | x | | | | |
| | | SB-013 0203F | | | | x | | x | | | | |
| | | SB-018 0006I | | x | x | x | x | x | | | | |
| | | SB-018 0203F | | x | x | x | x | x | | | | |
| | | SB-019 0006I | | | x | x | | x | | | | |
| | | SB-019 0102F | | | | x | | x | | | | |
| | | SB-020 0006I | | | x | x | | x | | x | | |
| | | SB-020 0203F | | | | x | | x | | x | | |
| | | SB-022 0006I | | x | x | x | x | x | | | | |
| | | SB-022 0102F | | x | x | x | x | x | | | | |
| | | SB-025 0006I | | | x | x | | x | | | | |
| | | SB-025 0203F | | | | x | | x | | | | |
| | | SB-026 0006I | | x | x | x | x | x | | | | |
| | | SB-026 0203F | | x | x | x | x | x | | | | |
| | | SB-027 0006I | | | x | x | | x | | | | |
| | | SB-027 0102F | | | x | x | | x | | | | |
| | | SB-030 0006I | | | x | x | | x | | | | |
| | | SB-030 0102F | | | | x | | x | | | | |
| | | SB-031 0006I | | | x | x | | x | | | | |
| | | SB-031 0102F | | | | x | | x | | | | |
| | | SB-032 0006I | | | x | x | | x | | | | |
| | | SB-032 0102F | | | | x | | x | | | | |
| | | SB-033 0006I | | | x | x | | x | | | | |
| | | SB-033 0102F | | | x | x | | x | | | | |
| | | SB-035 0006I | | x | x | x | x | x | | | | |
| | | SB-035 0102F | | x | x | x | x | x | | | | |
| | | SB-048 0006I | | x | x | x | x | x | | | | |
| | | SB-048 0203F | x | x | x | x | x | x | | | | |
| | | SB-049 0006I | | | x | x | | x | | | | |
| | | SB-049 0203F | | | x | x | | x | | | | |
| | | SB-054 0006I | | x | x | x | x | x | | | | |
| | | SB-054 0203F | | x | x | x | x | x | | | | |
| | | SB-054 1415F | | x | x | x | x | x | | | | |
| | | SB-057 0006I | | | x | x | | x | | | | |
| | | SB-057 0203F | | | | x | | x | | | | |
| | | SB-057 1415F | | | | x | | x | | | | |
| | | SB-058 0006I | | x | x | x | x | x | | | | |
| | | SB-058 0203F | | x | x | x | x | x | | | | |
| | | SB-058 0506F | | x | x | x | x | x | | | | |
| | | SB-059 0006I | | | x | x | | x | | | | |
| | | SB-059 0203F | | | | x | | x | | | | |
| | | SB-059 1415F | | | | x | | x | | | | |
| | | SB-060 0006I | | | x | x | | x | | | x | |
| | | SB-060 0203F | | | x | x | | x | | | x | |

Table A-1
Summary of 2003 Soil Sampling Program
Yankee Nuclear Power Station
Rowe, MA

| Location | | Sample Designation | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Area | Former 1,000 gal Gasoline UST | SB-061 0006I | | | | | x | | | | | |
| | | SB-061 0203F | | | | | x | | | | | |
| | | SB-061 1415F | | | | x | x | x | | | | |
| | | SB-062 0006I | | | | x | | | | | | |
| | | SB-062 0203F | | | | x | | | | | | |
| | | SB-062 0506F | | | | x | x | x | | | | |
| | Former 500 gal Diesel UST | SB-068 0006I | | | | x | | | | | | |
| | | SB-068 0203F | | | | x | | | | | | |
| | | SB-068 0809F | | x | | x | | x | | | | |
| | Former 500 gal Diesel UST | SB-069 0006I | | | | x | | | | | | |
| | | SB-069 0203F | | | | x | | | | | | |
| | | SB-069 1415F | | x | | x | | x | | | | |
| | Former Railroad Tracks | SB-083 0006I | | x | | x | | x | | | | |
| | | SB-083 0203F | | x | | x | | x | | | | |
| | Transformer Yard | SB-087 0006I | | | x | x | | | | | | |
| | | SB-087 0102F | | | x | x | | | | | | |
| | | SB-088 0006I | | | x | x | | | | | | |
| | | SB-088 0102F | | | x | x | | | | | | |
| | | SB-089 0006I | | | x | x | | | | | | |
| | | SB-089 0102F | | | x | x | | | | | | |
| | | SB-090 0006I | | | x | x | | | | | | |
| | | SB-090 0102F | | | x | x | | | | | | |
| Non-Industrial Area | Outside Fence Line | SB-100 0006I | | | x | x | | x | | | | |
| | | SB-100 0102F | | | | x | | x | | | | |
| | | SB-101 0006I | | | x | x | x | x | | | | |
| | | SB-101 0102F | | | x | x | x | x | | | | |
| | | SB-102 0006I | | | x | x | | x | | | | |
| | | SB-102 0102F | | | | x | | x | | | | |
| | | SB-103 0006I | | | x | x | | x | | | | |
| | | SB-103 0102F | | | | x | | x | | | | |
| | | SB-104 0006I | | | x | x | | x | | | | |
| | | SB-104 0102F | | | | x | | x | | | | |
| | | SB-105 0006I | | x | x | x | x | x | | | | |
| | | SB-105 0102F | | x | x | x | x | x | | | | |
| | | SB-106 0006I | | | x | x | | x | | | | |
| | | SB-106 0102F | | | | x | | | | | | |
| | | SB-107 0006I | | | x | x | | x | | | | |
| | | SB-107 0102F | | | | x | | x | | | | |
| | | SB-108 0006I | | | x | x | | x | | | | |
| | | SB-108 0203F | | | | x | | x | | | | |
| | | SB-109 0006I | | x | x | x | x | x | | | | |
| | | SB-109 0102F | | x | x | x | x | x | | | | |
| | | SB-110 0006I | | | x | x | | x | | | | |
| | | SB-110 0102F | | | | x | | x | | | | |
| | | SB-111 0006I | | | x | x | | x | | | | |
| | | SB-112 0006I | | | x | x | | x | | | | |
| | | SB-112 0102F | | | | x | | x | | | | |
| | | SB-113 0006I | | | x | x | | x | | | | |
| | | SB-113 0102F | | | x | x | | x | | | | |
| | | SB-114 0006I | | x | x | x | x | x | | | | |
| | | SB-114 0203F | | x | x | x | x | x | | | | |
| | | SB-115 0006I | | x | x | x | x | x | | | | |
| | | SB-115 0102F | | x | x | x | x | x | | | | |
| | ABC Rubble Area | SB-116 0006I | | | x | x | | x | | | | |
| | | SB-116 0203F | | x | x | x | x | x | | | | |
| | | SB-117 0006I | | | x | x | | x | | | | |
| | | SB-117 0102F | | x | x | x | | x | | | | |
| | | SB-118 0006I | | | x | x | | x | | | | |
| | | SB-118 0102F | | x | x | x | x | x | | | | |

Table A-1
Summary of 2003 Soil Sampling Program
Yankee Nuclear Power Station
Rowe, MA

| Location | | Sample Designation | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-Industrial Area | Active leach fields | SB-122 0006I | | | x | x | | x | | | | |
| | | SB-122 0203F | | | x | x | | x | | | | |
| | | SB-122 1415F | | x | x | x | x | x | | | | |
| | | SB-123 0006I | | | x | x | | x | | | | |
| | | SB-123 0203F | | | x | x | | x | | | | |
| | | SB-123 0304F | | x | x | x | x | x | | | | |
| | Inactive leach fields | SB-124 0006I | | | x | x | | x | | | | |
| | | SB-124 0203F | | | x | | | | | | | |
| | | SB-124 0910F | | x | x | x | x | x | | | | |
| | | SB-125 0006I | | | x | x | | x | | | | |
| | | SB-125 0203F | | | x | x | | x | | | | |
| | | SB-125 0910F | | x | x | x | x | x | | | | |
| | | SB-126 0006I | | | x | x | | x | | | | |
| | | SB-126 0203F | | x | x | x | x | x | | | | |
| | | SB-127 0006I | | | x | x | | x | | | | |
| | | SB-127 0102F | | x | x | x | x | x | | | | |
| | Middle Parking | SB-128 0006I | | | x | x | | x | | | | |
| | | SB-128 0203F | | | x | x | | x | | | | |
| | | SB-129 0006I | | | x | x | | x | | | | |
| | | SB-129 0102F | | | x | x | | x | | | | |
| | | SB-130 0006I | | x | x | x | x | x | | | | |
| | | SB-130 0203F | | | x | x | | x | | | | |
| | | SB-131 0006I | | x | x | x | | x | | | | |
| | | SB-131 0203F | | | x | x | | x | | | | |
| | New Shooting Range | SB-132 0006I | | | | | | x | | | | |
| | | SB-132 0203F | | | | | | x | | | | |
| | | SB-133 0006I | | | | | | x | | | | |
| | | SB-133 0102F | | | | | | x | | | | |
| | Old Shooting Range | SB-134 0006I | | | | | | x | | | | |
| | | SB-134 0203F | | | | | | x | | | | |
| | | SB-135 0006I | | | | | | x | | | | |
| | | SB-135 0203F | | | | | | x | | | | |
| | Parking areas | SB-136 0006I | | | x | x | | x | | | | |
| | | SB-136 0102F | | | x | x | | x | | | | |
| | | SB-137 0006I | | | x | x | | x | | | | |
| | | SB-137 0102F | | | | x | | x | | | | |
| | | SB-139 0006I | | x | | x | x | x | | | | |
| | | SB-139 0203F | | x | | x | x | x | | | | |
| | | SB-140 0006I | | x | | x | x | x | | | | |
| | | SB-140 0203F | | x | | x | x | x | | | | |
| | | SB-141 0006I | | | | x | | x | | | | |
| | | SB-141 0203F | | | | x | | x | | | | |
| | Parking areas continued | SB-142 0006I | | | | x | | x | | | | |
| | | SB-142 0102F | | | | x | | x | | | | |
| | | SB-143 0006I | | x | | x | | x | | | | |
| | | SB-143 0102F | | x | | x | | x | | | | |
| | | SB-144 0006I | | | | x | | x | | | | |
| | | SB-144 0102F | | | | x | | x | | | | |
| | | SB-145 0006I | | x | | x | x | x | | | | |
| | | SB-145 0102F | | x | x | x | x | x | | | | |
| | | SB-146 0006I | | | | x | | x | | | | |
| | | SB-146 0102F | | | | x | | x | | | | |
| | Powerline | SB-147 0006I | | | | | | | x | | | |
| | | SB-147 0203F | | | | | | | x | | | |
| | | SB-148 0006I | | | | | | | x | | | |
| | | SB-148 0203F | | | | | | | x | | | |
| | | SB-149 0006I | | | | | | | x | | | |
| | | SB-149 0203F | | | | | | | x | | | |
| | | SB-150 0006I | | | | | | | x | | | |
| | | SB-150 0203F | | | | | | | x | | | |

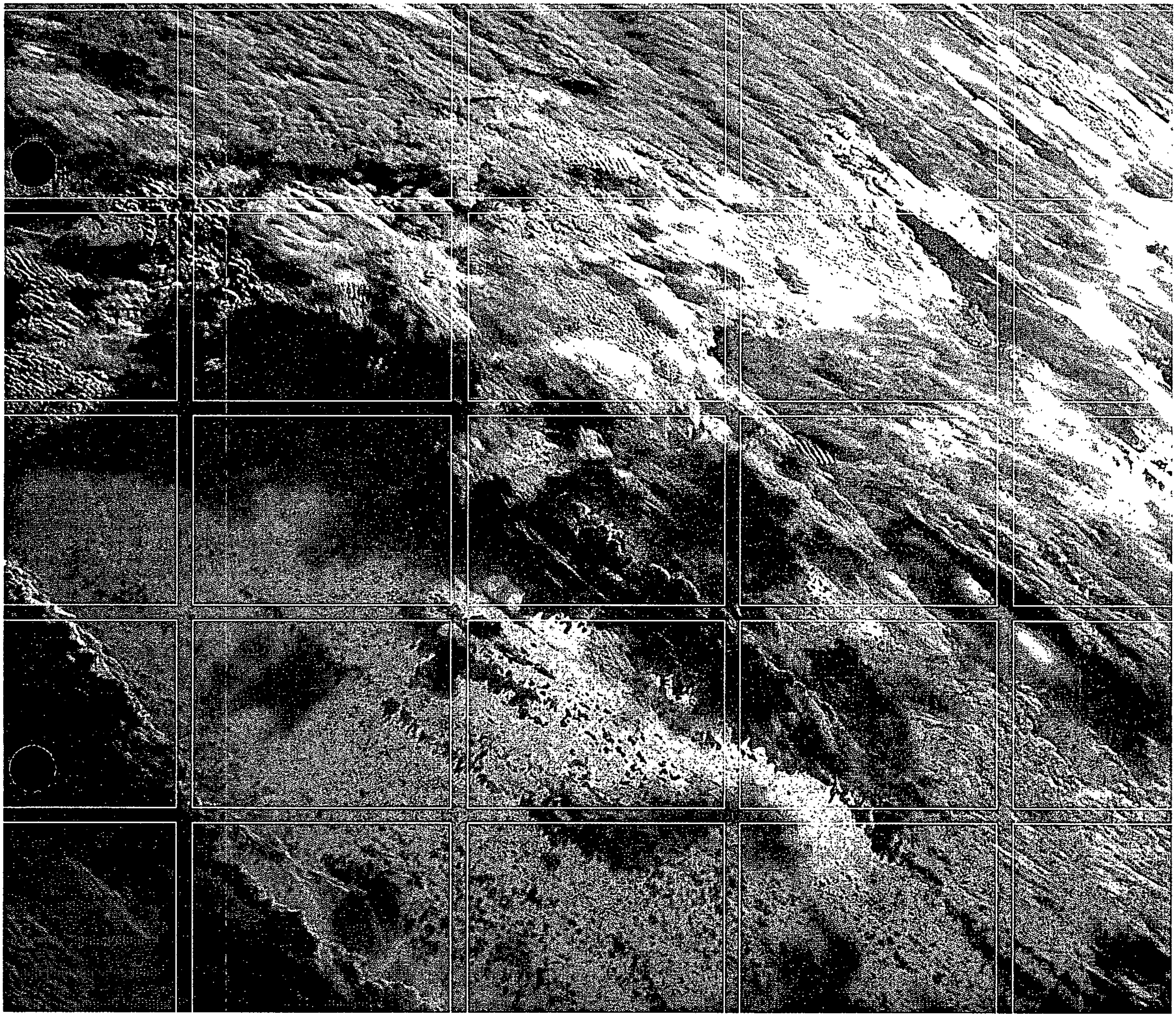
Table A-1
Summary of 2003 Soil Sampling Program
Yankee Nuclear Power Station
Rowe, MA

| Location | | Sample Designation | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-Industrial Area | Roadways | SB-151 0006I | | | | | | x | | | | |
| | | SB-151 0102F | | | | | | x | | | | |
| | | SB-152 0006I | | x | | x | x | x | | | | |
| | | SB-152 0102F | | x | | x | x | x | | | | |
| | | SB-153 0006I | | | | | | x | | | | |
| | | SB-153 0203F | | | | | | x | | | | |
| | | SB-154 0006I | | x | | x | x | x | | | | |
| | | SB-154 0102F | | x | | x | x | x | | | | |
| | | SB-155 0006I | | | | | | x | | | | |
| | | SB-155 0203F | | | | | | x | | | | |
| | Visitor Center | SB-156 0006I | | x | | x | | | | | | |
| | | SB-156 0506F | x | x | | | x | | | | | |
| | | SB-156 0607F | | | | x | | x | | | | |
| | | SB-157 0006I | | x | | x | | x | | | | |
| | | SB-157 0203F | | | | x | | x | | | | |
| | | SB-157 0405F | x | x | | x | | | | | | |
| | | SB-157 0506F | | | | x | | x | | | | |
| | | SB-158 0006I | | x | | x | | x | | | | |
| | | SB-158 0203F | | | | x | | x | | | | |
| | | SB-158 0506F | | | | x | | x | | | | |
| | | SB-159 0006I | | x | | x | | x | | | | |
| | | SB-159 0203F | | | | x | | x | | | | |
| Background | Background | SB-160 0006I | | | | | | x | x | x | x | x |
| | | SB-160 0203F | | | | | | x | x | x | x | x |
| | | SB-161 0006I | | x | | | | x | | | | |
| | | SB-161 0203F | | x | | | | x | | | | |
| | | SB-162 0006I | | | | | | x | | | | |
| | | SB-162 0102F | | | | | | x | | | | |
| | | SB-163 0006I | | | | | | x | | | | |
| | | SB-163 0102F | | | | | | x | | | | |
| | | SB-164 0006I | | x | | | x | x | | | | |
| | | SB-164 0203F | | x | | | | x | | | | |
| | | SB-165 0006I | | x | | | | x | | | | |
| | | SB-165 0102F | | | | | | x | | | | |
| | | SB-166 0006I | | | | | | x | | | | |
| | | SB-166 0102F | | | | | | x | | | | |
| | | SB-167 0006I | | x | | | | x | | | | |
| | | SB-167 0203F | | x | | | | x | | | | |
| | | SB-168 0006I | | | | | | x | | | | |
| | | SB-168 0203F | | | | | | x | | | | |
| | | SB-169 0006I | | | | | | x | | | | |
| | | SB-169 0203F | | | | | | x | | | | |
| Total Samples | | | 3 | 65 | 105 | 172 | 52 | 190 | 10 | 4 | 4 | 2 |

Table A-1
Summary of 2003 Soil Sampling Program
Yankee Nuclear Power Station
Rowe, MA

| Location | | Sample Designation | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QA/QC | **Field Duplicates** | FD200 /SB-167-00-06I | | x | | | | x | | | | |
| | | FD201 /SB-113-00-06I | | | x | x | | x | | | | |
| | | FD202 /SB-022-00-06I | | x | x | x | x | x | | | | |
| | | FD203 /SB-105-00-06I | | x | x | x | x | x | | | | |
| | | FD204 /SB-162-00-06I | | | | | | x | | | | |
| | | FD205 /SB-020-02-03F | | | | x | | x | | x | | |
| | | FD206 /SB-145-01-02F | | x | x | x | x | x | | | | |
| | | FD207 /SB-158-02-03F | | | | x | | x | | | | |
| | | FD208 /SB-057-14-15F | | | | x | | x | | | | |
| | | FD201 /SB-164-00-06I | | | | x | | x | | | | |
| | **Matrix Spike/Matrix Spike Duplicate** | MS/MSD SB0571415F | | | | x | | x | | | | |
| | | MS/MSD SB1580506F | | | | | | x | | | | |
| | | MS/MSD SB1450102F | | x | | x | x | x | | | | |
| | | MS/MSD SB1620006I | | | | | | x | | | | |
| | | MS/MSD SB0200203F | | | | | | x | | x | | |
| | | MS/MSD SB1130006I | | | x | x | | x | | | | |
| | | MS/MSD SB0190006I | | | x | x | | x | | | | |
| | | MS/MSD SB1050006I | | x | x | x | x | x | | | | |
| | | MS/MSD SB1640006I | | x | | | x | x | | | | |
| | | MS/MSD SB1530006I | | | | x | | x | | | | |
| Total QA/QC | | | 0 | 7 | 7 | 14 | 6 | 20 | 0 | 2 | 0 | 0 |

# *Soil Field Sampling Plan*



# Final

# Soil Field Sampling Plan

**Yankee Nuclear Power Station**
**49 Yankee Road**
**Rowe, Massachusetts**

October 2003

www.erm.com

ERM

*Delivering sustainable solutions in a more competitive world*

Yankee Nuclear Power Station

# Soil Field Sampling Plan

October 2003

0002107

49 Yankee Road
Rowe, Massachusetts

John W. McTigue, P.G., LSP

*Principal-in-Charge*

Gregg A Demers

Gregg A. Demers, P.E., LSP

*Project Manager*

**Environmental Resources Management**
399 Boylston Street, 6th Floor
Boston, Massachusetts 02116
T: 617-267-8377
F: 617-267-6447

1.0 INTRODUCTION 1

1.1 BACKGROUND 1

1.2 PURPOSE & SCOPE 1

2.0 SOIL SAMPLING PROGRAM 2

2.1 STANDARD OPERATING PROCEDURES 2

2.2 SAMPLE LOCATIONS AND DESIGNATIONS 2

2.3 SAMPLING PROCEDURES 3
2.3.1 Geoprobe Sampling 3
2.3.2 Manual Sampling 4

2.4 ANALYTICAL PROGRAM 4
2.4.1 Non-radiological Parameters 4
2.4.2 Radiological Parameters 5

2.5 SAMPLE SECURITY AND CUSTODY 5

2.6 MANAGEMENT OF INVESTIGATION DERIVED WASTES 6

2.7 SCHEDULE 6

3.0 QUALITY ASSURANCE AND QUALITY CONTROL 7

3.1 QUALITY ASSURANCE PROJECT PLAN 7

3.2 CLEANING AND DECONTAMINATION OF EQUIPMENT 7

3.3 QUALITY ASSURANCE / QUALITY CONTROL SAMPLES 8

4.0 PROJECT DOCUMENTATION 10

*TABLES*

*Table 1* *Soil Analytical Program and Locations*
*Table 2* *Soil Analytical Program Bottle Requirements*

*FIGURES*

*Figure 1* *Site Layout and Soil Sampling Locations*
*Figure 2* *Background Soil Sampling Locations*

*APPENDICES*

*Appendix A* *Soil Sampling Procedures*

# 1.0 *INTRODUCTION*

## 1.1 *BACKGROUND*

On behalf of Yankee Atomic Electric Company (Yankee), Environmental Resources Management (ERM) has prepared this Soil Field Sampling Plan (FSP) for the Yankee Nuclear Power Station (YNPS) located at 49 Yankee Road in Rowe, Massachusetts (Figure 1). The FSP has been prepared as a supplement to the *Draft Quality Assurance Project Plan, Site Closure, Yankee Nuclear Power Station, Rowe, Massachusetts* (QAPP). The FSP outlines the approach and methods for characterizing soil quality at the site as part of the overall site closure program. Other media-specific FSPs will be prepared as the site closure activities proceed. This FSP addresses soil characterization activities for non-radiological constituents. Radiological characterization of soil will be addressed under the License Termination Plan (LTP) and approval of the Nuclear Regulatory Commission (NRC).

## 1.2 *PURPOSE & SCOPE*

The purpose of the Soil FSP is to:

- establish the procedures and rationale for soil sampling activities in support of site closure;
- ensure that soil sampling is consistent with applicable procedures;
- ensure that the Data Quality Objectives (DQOs) for site closure are met; and
- support the site characterization and closure activities.

The data generated under the FSP will be used to assess the potential for impact to soil by oil and/or hazardous materials (OHM). The data generated under the FSP will be validated and input into the site database. The results from the soil sampling program will be used in conjunction with Data Usability reports that are being prepared regarding the historic data to determine the need for, and scope of, future soil sampling events. The data will also be used to support human health and ecological risk assessments that will be prepared as part of the site closure program.

The scope of the Soil FSP includes sampling of soils in both the Industrial and Non-Industrial Areas as defined in the QAPP (see Table 1 for a summary of soil sampling locations).

## 2.0 SOIL SAMPLING PROGRAM

### 2.1 STANDARD OPERATING PROCEDURES

YNPS Standard Operating Procedures (SOPs) applicable to the soil investigation include:

- DP-8123 Sample Security and Chain of Custody
- DP-8120 Collection of Site Characterization and Site Release Samples

Appendix A contains the YNPS SOPs applicable to this FSP.

### 2.2 SAMPLE LOCATIONS AND DESIGNATIONS

The sampling program and analytical parameters selected are based on the types of chemicals used at the plant as outlined in the QAPP. Two sampling approaches will be utilized to provide systematic sampling that provides spatial coverage to characterize the site within the Industrial and the Non-industrial Areas. The sampling approach is as follows:

- Grid Sampling - Samples will be collected based on a grid-sampling scheme, utilizing grid spacing set at 100 feet, to provide site-wide characterization; and
- Targeted Sampling - Additional "targeted samples" will be collected in the vicinity of potential source areas or where prior sampling has indicated possible impacts to soil.

A combination of Geoprobe and manual sampling techniques will be used for sample collection.

Geoprobe soil samples will be to a depth of up to 15 feet. Samples will be collected and submitted for analysis from 0 to 6 inches, 2 to 3 feet, and the one foot interval above the water table or from a depth of 14 to 15 feet (or refusal) if the water table is not encountered.

Manual soil samples will be collected using a hand auger or Geoprobe to a depth of up to 3 feet. Samples will be collected and submitted for analysis from the 0 to 6 inches and the 2 to 3 foot interval from each location.

Background samples will be collected manually from undisturbed areas in the vicinity of the site. Background samples are intended to be representative of naturally-occurring conditions in the vicinity of the site. Samples will be collected and submitted for analysis from the 0 to 6 inch and the 2 to 3 foot interval from each location.

The soil samples will be identified using unique sample identification. The sample designations will use the naming convention as detailed in the YNPS QAPP and in Table 1. Sample locations will be recorded using a Global Positioning System (GPS) unit or will be flagged and surveyed. The sample locations will also be marked with a flag, stake, or paint.

Bottle requirements are provided in Table 2. The soil sample locations are shown in Figure 1 and background locations are shown in Figure 2. The locations detailed on the figures are approximate and may be adjusted based on field observations.

## 2.3 SAMPLING PROCEDURES

### 2.3.1 Geoprobe Sampling

Geoprobe Soil samples will be collected under ERM's oversight by Geosearch Environmental Contractors, Inc. of Sterling, MA. Samples will be collected in compliance with YNPS Procedure *DP-8120 Collection of Site Characterization and Site Release Samples.* Direct push techniques, using dual tube sampling, will be used to push the two-inch diameter core sampler into the subsurface. The first set of rods is driven into the ground as an outer casing. These rods receive the driving force from the percussion hammer on the direct push machine, and provide a sealed hole from which soil samples may be recovered. The second, smaller set of rods is placed inside the outer casing. The smaller rods hold a sample liner in place as the outer casing is driven through the sampling interval. The small rods are then retracted to retrieve the filled liner.

After coring, the sleeve is removed from the casing, capped, and labeled. The portion of the core to be sampled will be extracted and the remaining core will be used to backfill the boring. The portion of the core to be submitted for laboratory analysis will be field screened for volatiles using a flame ionization detector (FID) and the jar headspace screening method, visually inspected and the soil stratigraphy will be classified. Visual observations will be logged on soil sampling forms. The results of field screening will be used to determine what sample interval will be submitted for analysis of volatile organic compounds.

Dedicated sampling equipment will be used where feasible. Reused sampling equipment will be decontaminated prior to, and following, sample collection in accordance with the YNPS QAPP.

### 2.3.2 *Manual Sampling*

Soil samples will be collected manually. Samples will be collected in compliance with YNPS Procedure *DP-8120 Collection of Site Characterization and Site Release Samples.* A stainless steel hand auger will be used to obtain each soil sample from a depth of 0 to 3 feet. Field observations, including sampling location descriptions, soil stratigraphy, and field-screening results will be recorded in a field logbook or sample collection log.

## 2.4 *ANALYTICAL PROGRAM*

### 2.4.1 *Non-radiological Parameters*

The soil analytical program is summarized in Table 1. The analytical parameters were selected based on the types of chemicals used at the plant as outlined in the QAPP.

The soil investigation will include the analysis of soil samples for the following non-radiological parameters:

- Volatile Organic Compounds (VOCs) by GC/MS, SW-846 Method 8260B (both low-level, de-ionized water-preserved, and medium-level, methanol preserved, soil samples will be collected at each sample location in accordance with SW846 Method 5035 VOC sampling procedures);
- Semi-Volatile Organic Compounds (SVOCs) by GC/MS, SW-846 Method 8270C;
- Polychlorinated Biphenyls (PCBs) by GC, SW-846 Method 8082;
- Diesel Range Organics (DRO) by GC, SW-846 Method 8015B
- Gasoline Range Organics (GRO) by GC, SW-846 Method 8015B
- Priority Pollutant 13 Metals (PP13) Metals by SW-846 6010B and 7000 Series (for antimony, arsenic, lead, selenium, and thallium);
- Herbicides by SW-846 Method 8151;
- Boron and Lithium by SW-846 6010B;
- Hydrazine by Ion Chromatography (IC); and

- Dioxin.

Northeast Laboratory Services, located in Waterville, Maine, will conduct the majority of the non-radiological analyses. Severn Trent Laboratory (STL)-Denver will perform the hydrazine analyses, and STL-Knoxville will perform the dioxin analyses. Contact information for the laboratories are as follows:

**Northeast Laboratories**
Project Manager: Kelly Perkins
PO Box 788
Waterville, Maine 04903

**STL-Connecticut**
Project Manager: Michele Sciongay
128 Long Hill Cross Rd
Shelton, CT 06484

**STL-Denver**
Project Manager: Betsy Farnaus
4944 Yarrow St.
Arvada, CO 80002

**STL-Knoxville**
Project Manager: Kevin Woodcock
5815 Middlebrook Pike
Knoxville, TN 37921

### 2.4.2 *Radiological Parameters*

Yankee personnel will screen soil samples on-site in accordance with YNPS screening procedures. Laboratory analysis for radiological constituents will not be performed on the soil samples. Collection of samples for radiological characterization purposes will be collected under a separate sampling program.

## 2.5 *SAMPLE SECURITY AND CUSTODY*

Soil samples will be submitted to the laboratory under proper chain-of-custody procedures. Samples will be preserved on ice or in a refrigerator and sample handling will be documented using chain-of-custody protocols in accordance with *DP-8123, Sample Security and Chain of Custody*.

## 2.6 *MANAGEMENT OF INVESTIGATION DERIVED WASTES*

Soil sampling waste, such as sampling equipment rinse water, will be containerized on-site. The wastes will be screened for radiological constituents. Following screening YNPS personnel will dispose of the wastes in accordance with the applicable YNPS procedures.

## 2.7 *SCHEDULE*

The soil sampling program is scheduled to begin on 14 October 2003. Soil sampling activities will be phased to accommodate the site decommissioning activities. Sampling activities in the central portion of the site will be performed once demolition in those areas is complete. It is anticipated that the soil sampling program will be completed in Spring 2004.

## 3.0 *QUALITY ASSURANCE AND QUALITY CONTROL*

## 3.1 *QUALITY ASSURANCE PROJECT PLAN*

A QAPP has been prepared to provide a standard method of assuring that data collected during site characterization activities is of sufficient quality to support future decisions regarding decommissioning activities and or remedial actions at the site. The primary purpose of the QAPP is to describe the means by which data collected in the field will be validated against predetermined standards, ensuring that data meets minimum quality standards prior to being used for decision-making purposes. The flow of data is important to data quality, as it ensures that appropriate project personnel have adequate opportunities to review data with importance to future site decisions. As such, the QAPP specifies the methods and means for ensuring the data generated during site characterization activities is of a quality necessary to serve its intended purpose.

The following provides a list of the sections of the QAPP that are most relevant to the field sampling activities:

| *QAPP Section* | *Topic* |
|---|---|
| 9.1 | Field Investigation and Documentation Procedures |
| 9.2 | Preparation of Sample Containers |
| 9.3 | Decontamination |
| 9.4 | Field Equipment Usage and Maintenance |
| 10.1 | Sample Tracking System |
| 10.2 | Sample Custody |
| 13.1 | Field Quality Control |

## 3.2 *CLEANING AND DECONTAMINATION OF EQUIPMENT*

To the degree possible, dedicated and/or disposable sampling equipment will be used for sampling. Non-dedicated sampling equipment used to collect samples will be cleaned and decontaminated prior to its initial use, between each sampling location and after the final use. The following general procedures will be adhered to concerning decontamination efforts:

1. If visual signs such as discoloration indicate that decontamination was insufficient, the equipment will again be decontaminated. If the situation persists, the equipment will be taken out of service until the situation can be corrected.

2. Verification of the non-dedicated sampling equipment cleaning procedures will be documented by the collection of field equipment rinsate blanks, at a frequency in accordance with the QAPP.

3. Properly decontaminated equipment will be stored in aluminum foil or plastic bags during storage and transport.

Decontamination protocols will be strictly adhered to in order to minimize the potential for cross-contamination between sampling locations and contamination of off-site areas. Liquids generated during the decontamination process will be collected, containerized and appropriately labeled for disposal. Waste liquids will be stored on site until determination of potential hazard class and final disposition.

Only pre-cleaned laboratory-certified sample containers will be used. The laboratories will also provide sample coolers, ice packs, trip blanks, and temperature blanks.

More specific decontamination procedures are outlined in the QAPP and SOPs.

## 3.3 *QUALITY ASSURANCE / QUALITY CONTROL SAMPLES*

The following Quality Assurance / Quality Control samples will be collected during the soil sampling:

- Trip blanks – At least one trip blank per cooler containing VOC or GRO samples (a minimum of one trip blank per 20 samples). Separate trip blanks will be prepared and analyzed for low-level (deionized water-preserved) 8260B VOCs, medium-level (methanol preserved) 8260B VOCs, and GRO.
- Temperature blanks – One temperature blank per cooler. The temperature of the trip blank will be measured upon receipt of the cooler at the laboratory.

- Equipment rinsate blank – The majority of geoprobe soil samples will be collected using dedicated sampling equipment. However, manual sampling will be conducted using a hand auger. A rinsate sample will be collected from the hand auger at a rate of one sample per 20 sampling locations. The rinsate blanks will be analyzed for the same parameters as the samples that were collected using the equipment.
- Field duplicates – Field duplicates will be collected at the rate of one duplicate per 20 samples. Samples locations where duplicates will be collected are listed in Table 1. Field duplicates will be submitted for the same analyses as the actual sample.
- Matrix spikes – Matrix spikes will be collected at the rate of one matrix spike per 20 samples. Samples locations where matrix spikes will be collected are listed in Table 1. Matrix spike/matrix spike duplicates (MS/MSDs) will be collected for organic parameters. Matrix spike/matrix duplicates (MS/MD) will be collected for inorganic and wet chemistry analyses.

# 4.0 PROJECT DOCUMENTATION

Data management tasks pertinent to project documentation and records, laboratory deliverables, data reporting formats, data handling and management, and data review assessment are presented in the QAPP.

The following field sample collection records will be completed as part of the sampling program:

- Field logbook
- Soil sampling field logs
- Chain of custody forms
- Shipping records (airbills), if any
- Photographs; as appropriate
- Telephone logs, as appropriate

The project documentation will be maintained by the Yankee Environmental staff and will be made available to the Yankee Environmental Oversight Supervisor at the completion of the sampling program. In addition, any deviations from the FSP will be documented in a memorandum to the Yankee Environmental Oversight Supervisor.

# *Tables*

**Table 1 - Soil Analytical Program**
**Field Sampling Plan**
**Yankee Nuclear Power Station**
**Rowe, MA**

| Field Sample ID | Field Sample ID | Deep Sampling Locations (0-15 ft) | Shallow Sampling Location (0-3 ft) | Number of Samples | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin** | Boron; Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 105 | | | | | | | | | | | |
| Within Fence line (Industrial Area; Grid) | | | | | | | | | | | | | | |
| | SB001- 0006I | | x | x | x | x | x | x | x | x | | | | |
| | SB001- 0203F | | | x | x | x | x | x | x | x | | | | |
| | SB002- 0006I | | x | | | | x | x | | x | | | | |
| | SB002- 0203F | | | | | | | x | | x | | | | |
| | SB003- 0006I | | x | | | | x | x | | x | | | | |
| | SB003- 0203F | | | | | | | x | | x | | | | |
| | SB004- 0006I | | x | | | | x | x | | x | | | | |
| | SB004- 0203F | | | | | | | x | | x | | | | |
| | SB005- 0006I | | x | | | | x | x | | x | | | | |
| | SB005- 0203F | | | | | | | x | | x | | | | |
| | SB006- 0006I | | x | | | | x | x | | x | | | | |
| | SB006- 0203F | | | | | | | x | | x | | | | |
| | SB007- 0006I | | x | | | | x | x | | x | | | | |
| | SB007- 0203F | | | | | | | x | | x | | | | |
| | SB008- 0006I | | x | | | | x | x | | x | | | | |
| | SB008- 0203F | | | | | | | x | | x | | | | |
| | SB009- 0006I | | x | | | | x | x | | x | | | | |
| | SB009- 0203F | | | | | | | x | | x | | | | |
| | SB010- 0006I | | x | | | | x | x | | x | | | | |
| | SB010- 0203F | | | | | | | x | | x | | | | |
| | SB011- 0006I | | x | | | | x | x | | x | | | | |
| | SB011- 0203F | | | | | | | x | | x | | | | |
| | SB012- 0006I | | x | | | | x | x | | x | | | | |
| | SB012- 0203F | | | | | | | x | | x | | | | |
| | SB013- 0006I | | x | | | | x | x | | x | | | | |
| | SB013- 0203F | | | | | | | x | | x | | | | |
| | SB014- 0006I | | x | | x | x | x | x | x | x | | x | | |
| | SB014- 0203F | | | | x | x | x | x | x | x | | x | | |
| | SB015- 0006I | | x | | | | x | x | | x | | | | |
| | SB015- 0203F | | | | | | x | x | | x | | | | |
| | SB016- 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB016- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB017- 0006I | | x | | | | x | x | | x | | | | |
| | SB017- 0203F | | | | | | x | x | | x | | | | |
| | SB018- 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB018- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB019- 0006I | | x | | | | x | x | | x | | | | |
| | SB019- 0203F | | | | | | | x | | x | | | | |
| | SB020- 0006I | | x | | | | x | x | | x | | x | | |
| | SB020- 0203F | | | | | | | x | | x | | x | | |
| | SB021- 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB021- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB022- 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB022- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB023- 0006I | | x | | x | x | x | x | x | x | | x | | |
| | SB023- 0203F | | | | x | x | x | x | x | x | | x | | |
| | SB024- 0006I | | x | | | | x | x | | x | | | | |
| | SB024- 0203F | | | | | | x | x | | x | | | | |
| | SB025- 0006I | | x | | | | x | x | | x | | | | |
| | SB025- 0203F | | | | | | | x | | x | | | | |
| | SB026- 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB026- 0203F | | | | x | x | x | x | x | x | | | | |

**Table 1 - Soil Analytical Program**
**Field Sampling Plan**
**Yankee Nuclear Power Station**
**Rowe, MA**

| Field Sample ID | Field Sample ID | Deep Sampling Locations (0-15 ft) | Shallow Sampling Location (0-3 ft) | Number of Samples | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Within Fence line (Industrial Area; Grid) | SB027- 0006I | | x | | | | x | x | | x | | | | |
| | SB027- 0203F | | | | | | x | x | | x | | | | |
| | SB028- 0006I | | x | | | | x | x | | x | | | | |
| | SB028- 0203F | | | | | | x | x | | x | | | | |
| | SB029- 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB029- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB030- 0006I | | x | | | | x | x | | x | | | | |
| | SB030- 0203F | | | | | | | x | | x | | | | |
| | SB031- 0006I | | x | | | | x | x | | x | | | | |
| | SB031- 0203F | | | | | | | x | | x | | | | |
| | SB032- 0006I | | x | | | | x | x | | x | | | | |
| | SB032- 0203F | | | | | | | x | | x | | | | |
| | SB033- 0006I | | x | | | | x | x | | x | | | | |
| | SB033- 0203F | | | | | | x | x | | x | | | | |
| | SB034- 0006I | | x | | | | x | x | | x | | | | |
| | SB034- 0203F | | | | | | x | x | | x | | | | |
| | SB035- 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB035- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB036- 0006I | | x | | | | x | x | | x | | | | |
| | SB036- 0203F | | | | | | x | x | | x | | | | |
| | SB037- 0006I | x | | | | | x | x | | x | | | | |
| | SB037- 0203F | | | | | | x | x | | x | | | | |
| | SB037- 1415F | | | | | | | x | | x | | | | |
| | SB038- 0006I | x | | | x | x | x | x | x | x | | | | |
| | SB038- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB038- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB039- 0006I | x | | | | | x | x | | x | | | | |
| | SB039- 0203F | | | | | | x | x | | x | | | | |
| | SB039- 1415F | | | | | | | x | | x | | | | |
| | SB040- 0006I | x | | | | | x | x | | x | | | | |
| | SB040- 0203F | | | | | | x | x | | x | | | | |
| | SB040- 1415F | | | | | | | x | | x | | | | |
| | SB041- 0006I | x | | | x | x | x | x | x | x | | | | |
| | SB041- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB041- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB042- 0006I | x | | | x | x | x | x | x | x | | | | |
| | SB042- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB042- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB043- 0006I | x | | | | | x | x | | x | | | | |
| | SB043- 0203F | | | | | | x | x | | x | | | | |
| | SB043- 1415F | | | | | | | x | | x | | | | |
| | SB044- 0006I | x | | | x | x | x | x | x | x | | | | |
| | SB044- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB044- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB045- 0006I | x | | | | | x | x | | x | | | | |
| | SB045- 0203F | | | | | | x | x | | x | | | | |
| | SB045- 1415F | | | | | | | x | | x | | | | |
| | SB046- 0006I | x | | | x | x | x | x | x | x | | | | |
| | SB046- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB046- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB047- 0006I | x | | | | | x | x | | x | | | | |
| | SB047- 0203F | | | | | | x | x | | x | | | | |
| | SB047- 1415F | | | | | | | x | | x | | | | |
| | SB048- 0006I | x | | | x | x | x | x | x | x | | | | |
| | SB048- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB048- 1415F | | | | x | x | x | x | x | x | | | | |

**Table 1 - Soil Analytical Program**
**Field Sampling Plan**
**Yankee Nuclear Power Station**
**Rowe, MA**

| Field Sample ID | Field Sample ID | Deep Sampling Locations (0-15 ft) | Shallow Sampling Location (0-3 ft) | Number of Samples | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Within Fence line (Industrial Area; Grid) | SB049- 00061 | x | | | | | x | x | | x | | | | |
| | SB049- 0203F | | | | | | x | x | | x | | | | |
| | SB049- 1415F | | | | | | x | x | | x | | | | |
| | SB050- 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB050- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB050- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB051- 00061 | x | | | | | x | x | | x | | | | |
| | SB051- 0203F | | | | | | | x | | x | | | | |
| | SB051- 1415F | | | | | | | x | | x | | | | |
| | SB052- 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB052- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB052- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB053- 00061 | x | | | | | x | x | | x | | | | |
| | SB053- 0203F | | | | | | x | x | | x | | | | |
| | SB053- 1415F | | | | | | x | x | | x | | | | |
| | SB054- 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB054- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB054- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB055- 00061 | x | | | | | x | x | | x | | | | |
| | SB055- 0203F | | | | | | x | x | | x | | | | |
| | SB055- 1415F | | | | | | x | x | | x | | | | |
| | SB056- 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB056- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB056- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB057- 00061 | x | | | | | x | x | | x | | | | |
| | SB057- 0203F | | | | | | | x | | x | | | | |
| | SB057- 1415F | | | | | | | x | | x | | | | |
| | SB058- 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB058- 0203F | | | | x | x | x | x | x | x | | | | |
| | SB058- 1415F | | | | x | x | x | x | x | x | | | | |
| | SB059- 00061 | x | | | | | x | x | | x | | | | |
| | SB059- 0203F | | | | | | | x | | x | | | | |
| | SB059- 1415F | | | | | | | x | | x | | | | |
| | SB060- 00061 | x | | | | | x | x | | x | | | x | x |
| | SB060- 0203F | | | | | | x | x | | x | | | x | x |
| | SB060- 1415F | | | | | | | x | | x | | | x | x |
| Former 1,000 gal Gasoline UST (Industrial Area; Targeted) | SB061- 00061 | x | | | | | | | x | | | | | |
| | SB061- 0203F | | | | | | | | x | | | | | |
| | SB061- 1415F | | | | x | | | x | x | x | | | | |
| | SB062- 00061 | x | | | | | | | x | | | | | |
| | SB062- 0203F | | | | | | | | x | | | | | |
| | SB062- 1415F | | | | x | | | x | x | x | | | | |
| Former 2,000 gal Waste Oil UST (Industrial Area; Targeted) | SB063- 00061 | x | | | | | | x | | | | | | |
| | SB063- 0203F | | | | | | | x | | | | | | |
| | SB063- 1415F | | | | x | x | x | x | | x | | | | |
| | SB064- 00061 | x | | | | | | x | | | | | | |
| | SB064- 0203F | | | | | | | x | | | | | | |
| | SB064- 1415F | | | | x | x | x | x | | x | | | | |
| | SB065- 00061 | x | | | | | | x | | | | | | |
| | SB065- 0203F | | | | | | | x | | | | | | |
| | SB065- 1415F | | | | x | x | x | x | | x | | | | |
| Former 4,000 gal Diesel UST (Industrial Area; Targeted) | SB066- 00061 | x | | | | | | x | | | | | | |
| | SB066- 0203F | | | | | | | x | | | | | | |
| | SB066- 1415F | | | | x | x | | x | | x | | | | |
| | SB067- 00061 | x | | | | | | x | | | | | | |
| | SB067- 0203F | | | | | | | x | | | | | | |
| | SB067- 1415F | | | | x | x | | x | | x | | | | |
| Former 500 gal Diesel UST (Industrial Area; Targeted) | SB068- 00061 | x | | | | | | x | | | | | | |
| | SB068- 0203F | | | | | | | x | | | | | | |
| | SB068- 1415F | | | | x | x | | x | | x | | | | |
| | SB069- 00061 | x | | | | | | x | | | | | | |
| | SB069- 0203F | | | | | | | x | | | | | | |
| | SB069- 1415F | | | | x | x | | x | | x | | | | |
| Former Fuel Oil AST (Industrial Area; Targeted) | SB070- 00061 | x | | | x | x | | x | | x | | | | |
| | SB070- 0203F | | | | | | | x | | | | | | |
| | SB070- 1415F | | | | | | | x | | | | | | |
| | SB071- 00061 | | x | | x | x | | x | | | | | | |
| | SB071- 0203F | | | | | | | x | | | | | | |
| | SB072- 00061 | | x | | x | x | | x | | | | | | |
| | SB072 0203F | | | | | | | x | | | | | | |

**Table 1 - Soil Analytical Program**
**Field Sampling Plan**
**Yankee Nuclear Power Station**
**Rowe, MA**

| Field Sample ID | Field Sample ID | Deep Sampling Locations (0-15 ft) | Shallow Sampling Location (0-3 ft) | Number of Samples | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuel Storage (Industrial Area; Targeted) | SB073 00061 | x | | | x | x | x | x | | x | | | | |
| | SB073 0203F | | | | | | | x | | | | | | |
| | SB073 1415F | | | | | | | x | | | | | | |
| Incinerators (A) (Industrial Area; Targeted) | SB074 00061 | x | | | | x | x | x | | x | | x | | |
| | SB074 0203F | | | | | x | x | x | | x | | x | | |
| | SB074 1415F | | | | | | | x | | x | | x | | |
| Incinerators (B) (Industrial Area; Targeted) | SB075 00061 | x | | | | x | x | x | | x | | x | | |
| | SB075 0203F | | | | | x | x | x | | x | | x | | |
| | SB075 1415F | | | | | | | x | | x | | x | | |
| Former Diesel Generator Building (Industrial Area; Targeted) | SB076 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB076 0203F | | | | | | | x | | x | | | | |
| | SB076 1415F | | | | | | | x | | x | | | | |
| | SB077 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB077 0203F | | | | | | | x | | x | | | | |
| | SB077 1415F | | | | | | | x | | x | | | | |
| PAB (Industrial Area; Targeted) | SB078 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB078 0203F | | | | | | | x | | x | | | | |
| | SB078 1415F | | | | | | | x | | x | | | | |
| New PCA (Industrial Area; Targeted) | SB079 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB079 0203F | | | | | | | x | | x | | | | |
| | SB079 1415F | | | | | | | x | | x | | | | |
| | SB080 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB080 0203F | | | | | | | x | | x | | | | |
| | SB080 1415F | | | | | | | x | | x | | | | |
| Rad Waste Warehouse/Old PCA (Industrial Area; Targeted) | SB081 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB081 0203F | | | | | | | x | | x | | | | |
| | SB081 1415F | | | | | | | x | | x | | | | |
| | SB082 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB082 0203F | | | | | | | x | | x | | | | |
| | SB082 1415F | | | | | | | x | | x | | | | |
| Former Railroad Tracks (Industrial Area; Targeted) | SB083 00061 | | x | | | x | | x | | x | | | | |
| | SB083 0203F | | | | | x | | x | | x | | | | |
| Tank Area (Industrial Area; Targeted) | SB084 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB084 0203F | | | | | | | x | | x | | | | |
| | SB084 1415F | | | | | | | x | | x | | | | |
| | SB085 00061 | | x | | x | x | x | x | x | x | | | | |
| | SB085 0203F | | | | | | | x | | x | | | | |
| | SB086 00061 | | x | | x | x | x | x | x | x | | | | |
| | SB086 0203F | | | | | | | x | | x | | | | |
| Transformer Yard (Industrial Area; Targeted) | SB087 00061 | | x | | | | x | x | | | | | | |
| | SB087 0203F | | | | | | x | x | | | | | | |
| | SB088 00061 | | x | | | | x | x | | | | | | |
| | SB088 0203F | | | | | | x | x | | | | | | |
| | SB089 00061 | | x | | | | x | x | | | | | | |
| | SB089 0203F | | | | | | x | x | | | | | | |
| | SB090 00061 | | x | | | | x | x | | | | | | |
| | SB090 0203F | | | | | | x | x | | | | | | |
| Turbine Building (Industrial Area; Targeted) | SB091 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB091 0203F | | | | | | x | x | | x | | | | |
| | SB091 1415F | | | | | | x | x | | x | | | | |
| | SB092 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB092 0203F | | | | | | x | x | | x | | | | |
| | SB092 1415F | | | | | | x | x | | x | | | | |
| | SB093 00061 | x | | | x | x | x | x | x | x | | | | |
| | SB093 0203F | | | | | | x | x | | x | | | | |
| | SB093 1415F | | | | | | x | x | | x | | | | |
| Chemistry Lab (Industrial Area; Targeted) | SB094 00061 | x | | | x | x | x | x | | x | | | | |
| | SB094 0203F | | | | | | x | x | | x | | | | |
| | SB094 1415F | | | | | | x | x | | x | | | | |
| Water Treatment (Industrial Area; Targeted) | SB095 00061 | x | | | x | x | x | x | | x | | | x | x |
| | SB095 0203F | | | | | | x | x | | x | | | x | x |
| | SB095 1415F | | | | | | x | x | | x | | | x | x |
| Paved Access Areas (Industrial Area; Targeted) | SB096 00061 | | x | | | | x | x | | x | | | | |
| | SB096 00061 | | | | | | | x | | x | | | | |
| | SB097 00061 | | x | | | | x | x | | x | | | | |
| | SB097 0203F | | | | | | | x | | x | | | | |

**Table 1 - Soil Analytical Program**
**Field Sampling Plan**
**Yankee Nuclear Power Station**
**Rowe, MA**

| ield Sample ID | Field Sample ID | Deep Sampling Locations (0-15 ft) | Shallow Sampling Location (0-3 ft) | Number of Samples | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outside Fence Line (Non-industrial Area; Grid) | SB100 0006I | | x | | | | x | x | | x | | | | |
| | SB100 0203F | | | | | | | x | | x | | | | |
| | SB101 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB101 0203F | | | | x | x | x | x | x | x | | | | |
| | SB102 0006I | | x | | | | x | x | | x | | | | |
| | SB102 0203F | | | | | | | x | | x | | | | |
| | SB103 0006I | | x | | | | x | x | | x | | | | |
| | SB103 0203F | | | | | | | x | | x | | | | |
| | SB104 0006I | | x | | | | x | x | | x | | | | |
| | SB104 0203F | | | | | | | x | | x | | | | |
| | SB105 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB105 0203F | | | | x | x | x | x | x | x | | | | |
| | SB106 0006I | | x | | | | x | x | | x | | | | |
| | SB106 0203F | | | | | | | x | | x | | | | |
| | SB107 0006I | | x | | | | x | x | | x | | | | |
| | SB107 0203F | | | | | | | x | | x | | | | |
| | SB108 0006I | | x | | | | x | x | | x | | | | |
| | SB108 0203F | | | | | | | x | | x | | | | |
| | SB109 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB109 0203F | | | | x | x | x | x | x | x | | | | |
| | SB110 0006I | | x | | | | x | x | | x | | | | |
| | SB110 0203F | | | | | | | x | | x | | | | |
| | SB104 0006I | | x | | | | x | x | | x | | | | |
| | SB104 0203F | | | | | | | x | | x | | | | |
| | SB103 0006I | | x | | | | x | x | | x | | | | |
| | SB103 0203F | | | | | | | x | | x | | | | |
| | SB104 0006I | | x | | | | x | x | | x | | | | |
| | SB104 0203F | | | | | | | x | | x | | | | |
| | SB103 0006I | | x | | | | x | x | | x | | | | |
| | SB103 0203F | | | | | | | x | | x | | | | |
| | SB104 0006I | | x | | | | x | x | | x | | | | |
| | SB114 0203F | | | | | | | x | | x | | | | |
| Outside Fence Line (Non-industrial Area; Grid) | SB115 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB115 0203F | | | | x | x | x | x | x | x | | | | |
| ABC Rubble Area (Non-industrial Area; Target) | SB116 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB116 0203F | | | | | | x | x | | x | | | | |
| | SB117 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB117 0006I | | | | | | x | x | | x | | | | |
| | SB118 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB118 0203F | | | | | | x | x | | x | | | | |
| Active leach fields (Non- | SB119 0006I | x | | | | | | x | | x | | | | |
| | SB119 0203F | | | | | | | x | | x | | | | |
| | SB119 1415F | | | | x | x | x | x | x | x | | | | |
| | SB120 0006I | x | | | | | | x | | x | | | | |
| | SB120 0203F | | | | | | | x | | x | | | | |
| | SB120 1415F | | | | x | x | x | x | x | x | | | | |
| | SB121 0006I | x | | | | | | x | | x | | | | |
| | SB121 0203F | | | | | | | x | | x | | | | |
| | SB121 1415F | | | | x | x | x | x | x | x | | | | |
| | SB122 0006I | x | | | | | | x | | x | | | | |
| | SB122 0203F | | | | | | | x | | x | | | | |
| | SB122 1415F | | | | x | x | x | x | x | x | | | | |
| | SB123 0006I | x | | | | | | x | | x | | | | |
| | SB123 0203F | | | | | | | x | | x | | | | |
| | SB123 1415F | | | | x | x | x | x | x | x | | | | |
| Inactive leach fields (Non-i | SB124 0006I | x | | | | | | x | | x | | | | |
| | SB124 0203F | | | | | | | x | | x | | | | |
| | SB124 1415F | | | | x | x | x | x | x | x | | | | |
| | SB125 0006I | x | | | | | | x | | x | | | | |
| | SB125 0203F | | | | | | | x | | x | | | | |
| | SB125 1415F | | | | x | x | x | x | x | x | | | | |
| | SB126 0006I | x | | | | | | x | | x | | | | |
| | SB126 0203F | | | | | | | x | | x | | | | |
| | SB126 1415F | | | | x | x | x | x | x | x | | | | |
| | SB127 0006I | x | | | | | | x | | x | | | | |
| | SB127 0203F | | | | | | | x | | x | | | | |
| | SB127 1415F | | | | x | x | x | x | x | x | | | | |
| Middle Parking (Non- | SB128 0006I | | x | | | | x | x | | x | | | | |
| | SB128 0203F | | | | | | | x | | x | | | | |
| | SB129 0006I | | x | | | | x | x | | x | | | | |
| | SB129 0203F | | | | | | | x | | x | | | | |
| | SB130 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB130 0203F | | | | | | | x | | x | | | | |
| | SB131 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB131 0203F | | | | | | | x | | x | | | | |

## Table 1 - Soil Analytical Program
Field Sampling Plan
Yankee Nuclear Power Station
Rowe, MA

| Field Sample ID | Field Sample ID | Deep Sampling Locations (0-15 ft) | Shallow Sampling Location (0-3 ft) | Number of Samples | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New Shooting Range (Non | SB132 0006I | | x | | | | | | | x | | | | |
| | SB132 0203F | | | | | | | | | x | | | | |
| | SB133 0006I | | x | | | | | | | x | | | | |
| | SB133 0203F | | | | | | | | | x | | | | |
| Old Shooting Range (Non- | SB134 0006I | | x | | | | | | | x | | | | |
| | SB134 0203F | | | | | | | | | x | | | | |
| | SB135 0006I | | x | | | | | | | x | | | | |
| | SB135 0203F | | | | | | | | | x | | | | |
| Parking areas (Non- | SB136 0006I | | x | | | | | x | | x | | | | |
| | SB136 0203F | | | | | | | x | | x | | | | |
| | SB137 0006I | | x | | | | | x | | x | | | | |
| | SB137 0203F | | | | | | | x | | x | | | | |
| Parking Areas (Non- | SB138 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB138 0203F | | | | x | x | x | x | x | x | | | | |
| | SB139 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB139 0203F | | | | x | x | x | x | x | x | | | | |
| | SB140 0006I | | x | | | | | x | | x | | | | |
| | SB140 0203F | | | | | | | x | | x | | | | |
| | SB141 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB141 0203F | | | | x | x | x | x | x | x | | | | |
| | SB142 0006I | | x | | | | | x | | x | | | | |
| | SB142 0203F | | | | | | | x | | x | | | | |
| | SB143 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB143 0203F | | | | x | x | x | x | x | x | | | | |
| | SB144 0006I | | x | | | | | x | | x | | | | |
| | SB144 0203F | | | | | | | x | | x | | | | |
| | SB145 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB145 0203F | | | | x | x | x | x | x | x | | | | |
| | SB146 0006I | | x | | | | | x | | x | | | | |
| | SB146 0203F | | | | | | | x | | x | | | | |
| Powerline (Non-industrial | SB147 0006I | | x | | | | | | | | x | | | |
| | SB147 0203F | | | | | | | | | | x | | | |
| | SB148 0006I | | x | | | | | | | | x | | | |
| | SB148 0203F | | | | | | | | | | x | | | |
| | SB149 0006I | | x | | | | | | | | x | | | |
| | SB149 0203F | | | | | | | | | | x | | | |
| | SB150 0006I | | x | | | | | | | | x | | | |
| | SB150 0203F | | | | | | | | | | x | | | |
| Roadways (Non-industrial | SB151 0006I | | x | | | | | x | | x | | | | |
| | SB151 0203F | | | | | | | x | | x | | | | |
| | SB152 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB152 0203F | | | | x | x | x | x | x | x | | | | |
| | SB153 0006I | | x | | | | x | x | | x | | | | |
| | SB153 0203F | | | | | | x | x | | x | | | | |
| | SB154 0006I | | x | | x | x | x | x | x | x | | | | |
| | SB154 0203F | | | | x | x | x | x | x | x | | | | |
| | SB155 0006I | | x | | | | | x | | x | | | | |
| | SB155 0203F | | | | | | | x | | x | | | | |
| Visitor Center (Non- | SB156 0006I | | | | x | x | x | x | | x | | | | |
| | SB156 0203F | x | | | | | | x | | x | | | | |
| | SB156 1415F | | | | | | | x | | x | | | | |
| | SB157 0006I | | | | x | x | x | x | | x | | | | |
| | SB157 0203F | x | | | | | | x | | x | | | | |
| | SB157 1415F | | | | | | | x | | x | | | | |
| | SB158 0006I | | | | x | x | x | x | | x | | | | |
| | SB158 0203F | x | | | | | | x | | x | | | | |
| | SB158 1415F | | | | | | | x | | x | | | | |
| | SB159 0006I | | | | x | x | x | x | | x | | | | |
| | SB159 0203F | x | | | | | | x | | x | | | | |
| | SB159 1415F | | | | | | | x | | x | | | | |
| Background | SB160 0006I | | x | | | | | | | x | x | x | x | |
| | SB160 0203F | | | | | | | | | x | x | x | x | |
| | SB161 0006I | | x | | | x | | | | x | | | | |
| | SB161 0203F | | | | | x | | | | x | | | | |
| | SB162 0006I | | x | | | | | | | x | | | | |
| | SB162 0203F | | | | | | | | | x | | | | |
| | SB163 0006I | | x | | | | | | | x | | | | |
| | SB163 0203F | | | | | | | | | x | | | | |

**Table 1 - Soil Analytical Program**
**Field Sampling Plan**
**Yankee Nuclear Power Station**
**Rowe, MA**

| Field Sample ID | Field Sample ID | | Deep Sampling Locations (0-15 ft) | Shallow Sampling Location (0-3 ft) | Number of Samples | VOC* | SVOC | PCB | DRO | GRO | PP13 Metals | Herbicides | Dioxin ** | Boron, Lithium | Hydrazine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Background (Cont'd) | SB164 0006I | | | x | | | x | | | | x | | | | |
| | SB164 0203F | | | | | | x | | | | x | | | | |
| | SB165 0006I | | | x | | | | | | | x | | | | |
| | SB165 0203F | | | | | | | | | | x | | | | |
| | SB166 0006I | | | x | | | | | | | x | | | | |
| | SB166 0203F | | | | | | | | | | x | | | | |
| | SB167 0006I | | | x | | | x | | | | x | | | | |
| | SB167 0203F | | | | | | x | | | | x | | | | |
| | SB168 0006I | | | x | | | | | | | x | | | | |
| | SB168 0203F | | | | | | | | | | x | | | | |
| | SB169 0006I | | | x | | | | | | | x | | | | |
| | SB169 0203F | | | | | | | | | | | | | | |
| Field Duplicates (QA/QC) | FD001 | XX | Determined in the field. | | | | | | | | | x | x | x | x |
| | FD002 | XX | | | | | | | | | | | | | |
| | FD003 | XX | | | | | | | | | | | | | |
| | FD004 | XX | | | | | | | | | | | | | |
| | FD005 | XX | | | | | | | | | | | | | |
| | FD006 | XX | | | | | | | | | | | | | |
| | FD007 | XX | | | | | | | | | | | | | |
| | FD008 | XX | | | | | | | | | | | | | |
| | FD009 | XX | | | | | | | | | | | | | |
| | FD010 | XX | | | | | | | | | | | | | |
| Matrix Spike/Matrix Spike Duplicate (QA/QC) | MS/MSD001 | XX | Determined in the field. | | | | | | | | | x | x | x | x |
| | MS/MSD002 | XX | | | | | | | | | | | | | |
| | MS/MSD003 | XX | | | | | | | | | | | | | |
| | MS/MSD004 | XX | | | | | | | | | | | | | |
| | MS/MSD005 | XX | | | | | | | | | | | | | |
| | MS/MSD006 | XX | | | | | | | | | | | | | |
| | MS/MSD007 | XX | | | | | | | | | | | | | |
| | MS/MSD008 | XX | | | | | | | | | | | | | |
| | MS/MSD009 | XX | | | | | | | | | | | | | |
| | MS/MSD010 | XX | | | | | | | | | | | | | |
| ipment Blank (QA/QC) | EB001 | XX | | | | x | x | x | x | x | x | | | | |
| | EB002 | XX | | | | x | x | x | x | x | x | | | | |
| | EB003 | XX | | | | x | x | x | x | x | x | | | | |
| | EB004 | XX | | | | x | x | x | x | x | x | | | | |
| | EB005 | XX | | | | x | x | x | x | x | x | | | | |
| | EB006 | XX | | | | x | x | x | x | x | x | | | | |
| | EB007 | XX | | | | x | x | x | x | x | x | | | | |
| | EB008 | XX | | | | x | x | x | x | x | x | | | | |
| | EB009 | XX | | | | x | x | x | x | x | x | | | | |
| | EB010 | XX | | | | x | x | x | x | x | x | | | | |
| Total | | | | | 0 | 131 | 141 | 226 | 369 | 118 | 366 | 0 | 0 | 0 | 0 |

* Selection of samples for VOC analysis will be refined based on field screening results

** Dioxin samples will be collected at three grid sample locations downwind of the former incinerators

Table 2 - Soil Analytical Program Bottle Requirements
Field Sampling Plan
Yankee Nuclear Power Station
Rowe, MA

| Parameter | Sample Container | Preservation | Holding Time |
|---|---|---|---|
| Volatile Organics | 5 VOA vials | 3 VOA vials preserved with deionized water<br>1 VOA vial preserved with methanol<br>1 VOA vial unpreserved<br>Maintain at 4 oC | 14 days |
| Semivolatile Organics | (1) 4 oz soil jar | 4 °C | 14 days/40 days |
| PCB | (1) 4 oz soil jar | 4 °C | 14 days/40 days |
| DRO | (1) 4 oz soil jar | | 14 days/40 days |
| GRO | 1 VOA vials | 1 VOA vial preserved with methanol<br>1 VOA vial unpreserved | 14 days/40 days |
| PP 13 Metals (plus Boron and Lithium) | (1) 4 oz soil jar (plastic for boron and lithium analysis) | 4 °C | 28 days/6 months |
| Herbicides | (1) 4 oz soil jar | | 14 days/40 days |
| Hydrazine | (1) 4 oz soil jar | | NA |
| Dioxin | (1) 4 oz soil jar | 4 °C | 14 days/40 days |

# *Figures*

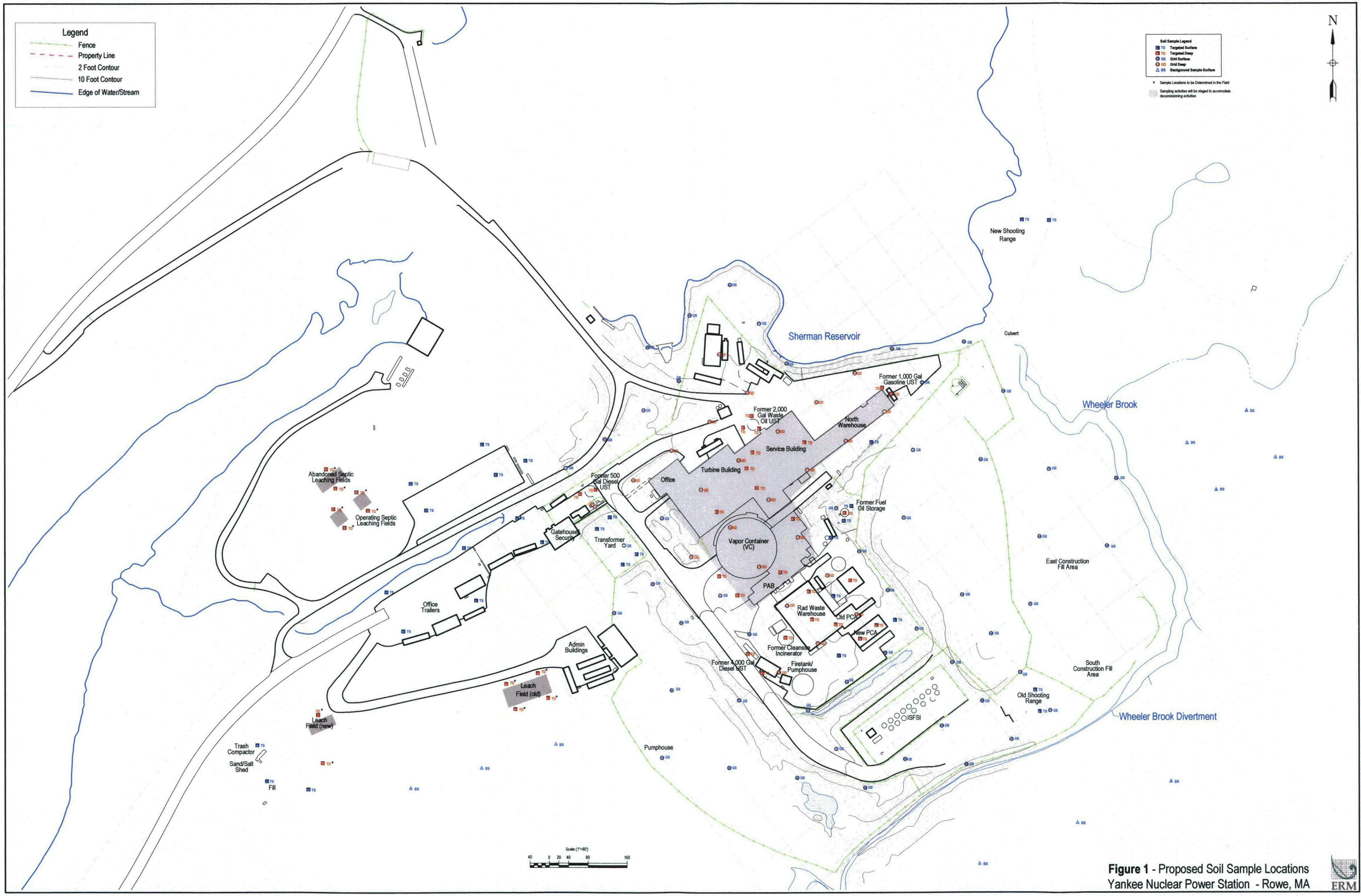
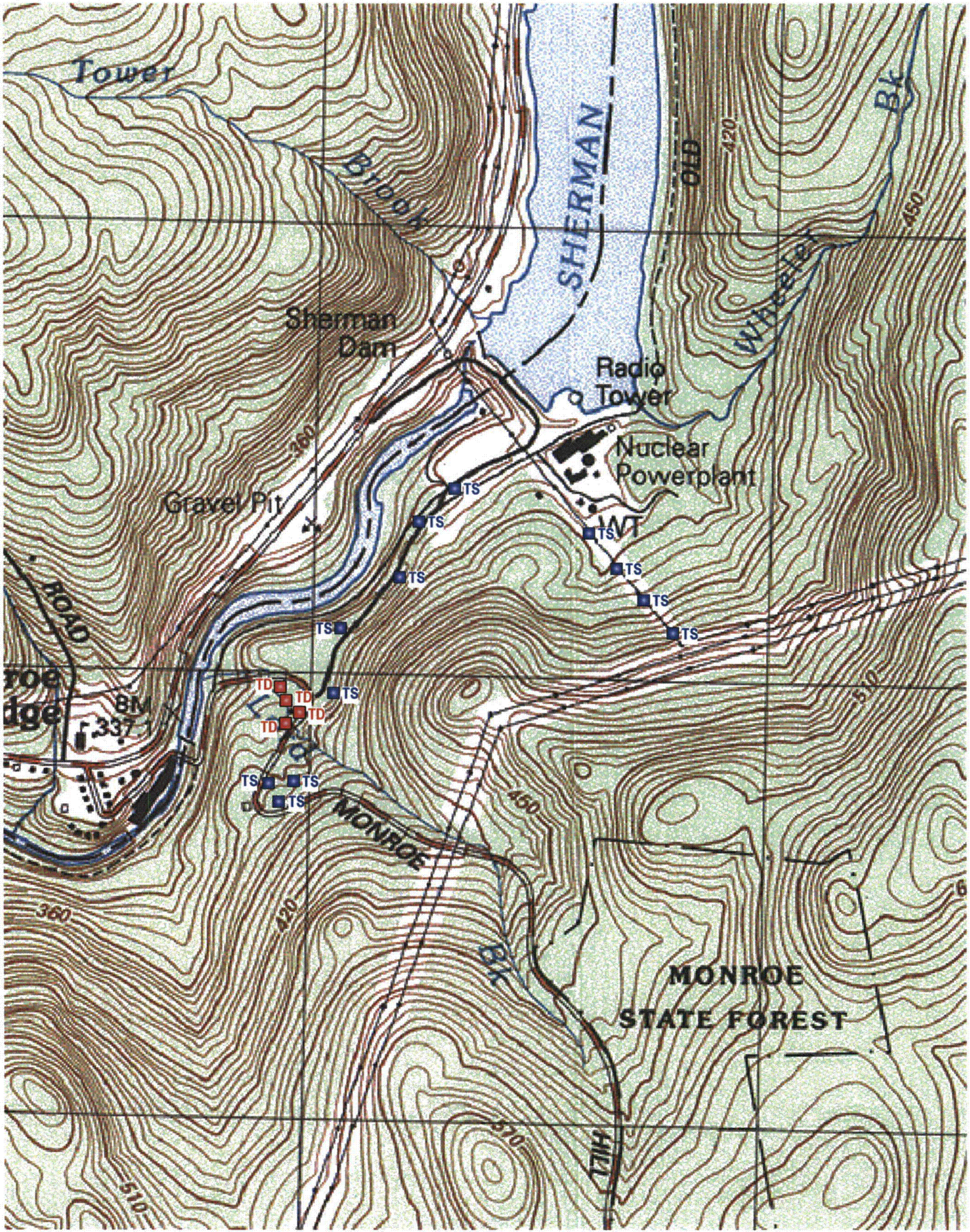


**Figure 1** - Proposed Soil Sample Locations
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Figures1.dwg (09/12/03 Boston)



Legend

🟥 TD Target Deep Soil Sample Location

🟦 TS Target Shallow Soil Sample Location

Scale - 1:12,000

**Figure 2 -** Proposed Soil Sample Locations
Yankee Nuclear Power Plant - Rowe, MA

R:\Yankee Atomic\Soil Sample Locations.fh11 (11-September-2003 Boston)

# *Appendix A*

## *DP – 8123*

## *Sample Security and Chain of Custody*

Proc. No. DP-8123
Rev. No. 9
Issue Date 04/2003
Review Date 05/2007

# SAMPLE SECURITY AND CHAIN OF CUSTODY

## SCOPE

This procedure addresses sample security and chain of custody for samples collected under the procedures cited in References 1 - 7. This includes collecting radiological or non-radiological samples, site characterization samples, as well as other site samples. The sample security portion applies to all such samples. The chain of custody portions apply only to samples that are analyzed off-site.

## ENCLOSURES

DP-8123 - Pgs. 1-6
DPF-8123.1 - Rev. 7

## REFERENCES

1. DP-8120, "Collection of Site Characterization and Site Release Samples"
2. DP-8121, "In-Plant Radiological Surveys to Support the Characterization Program"
3. DP-8122, "Subsurface Soil Sampling and Monitoring Well Installation"
4. DP-8124, "Collection of Pond Sediment Samples for Site Characterization"
5. DP-9725, "Potable Water Quality Monitoring"
6. DP-9745, "Ground Water Level Measurement and Sample Collection in Observation Wells"
7. DP-8813, "Sample Receipt and Preparation"

## DISCUSSION

To ensure the integrity of a sample and the defensibility of its analytical results, its chain of custody should be documented. For samples analyzed off-site, this is done with the chain of custody form. For samples analyzed at the YNPS site, this is done by logging samples in and out of each on-site facility (see DP-8813). Where a sample is tracked first on one system (e.g., the Sample Log), then on another (e.g., chain of custody form), the sample's custody should be traceable, without any gaps, across both systems.

Also important is to ensure the integrity of the sample's security. Proper security will prevent or minimize sample loss, tampering and inadvertent mishandling.

## PROCEDURE

A. Initiation of Chain of Custody Form

1. A Chain of Custody Form (DPF-8123.1) shall be initiated by the sample collector for all site characterization and other site samples that are analyzed offsite. Multiple samples may be included on a single form.

2. The sample collector shall initiate the Chain of Custody Form (DPF-8123.1) at the time of collection. Radiological samples that have been tracked in accordance with DP-8813 [7] may have their Chain of Custody Form initiated just prior to shipment off-site.

3. The sample collector shall fill out DPF-8123.1, and sign and date the form, using the guidance found in Appendix A. Ensure that the information entered on the sample container is the same as that entered on DPF-8123.1.

4. Note the chain of custody form number (found at the top of DPF-8123.1,) in the Field Log Book (if one is used).

5. Once a Chain of Custody Form has been initiated, the original copy of the form shall stay with the sample(s), at least until such time as described in Step B.3.

6. When an additional chain of custody form is to be initiated for a sample that is already on a chain of custody form (e.g., the sample has been split and each aliquot is to be sent to a different analytical laboratory), a notation shall be made in the "Comment" column on each form cross-referencing the two form numbers.

B. Transfer of Sample Custody

**NOTE**: Relinquishing custody of a sample is not required when the sample is transferred among members within any laboratory or count room, or between Chemistry, HP, or Environmental sample collectors and the site countroom or laboratory analysis.

1. When the sample collector turns the sample over to another individual (e.g., the Safety Oversight Department staff or the YNPS Sample Prep Trailer), that individual shall sign the first "Received by" block, including the date and time of receipt.

2. Each time the sample(s) changes custody, the relinquishing party and the receiving party shall sign and date the form within the next available location.

3. The analytical laboratory shall be instructed to return the white page of the completed Chain of Custody Form (DPF-8123.1) to the contact name on the form along with the analytical results.

4. The completed DPF-8123.1 shall be reviewed and filed by the contact person or his/her designee as part of the data package.

C. Use of Commercial Couriers

1. Just prior to turnover to a commercial courier, relinquish the samples by date and time of shipment and signature on DPF-8123.1.

2. Note in the "Sample Shipped Via" location on DPF-8123.1 the courier utilized if applicable and the Bill of Lading number which is printed at the top of each air bill in bold black numbers.

   **NOTE**: A "Received By" signature is not required until receipt by the analytical lab.

3. Remove and retain the rear-most carbon copy of DPF-8123.1.

4. Seal the original DPF-8123.1 in the container along with the samples.

5. When the original signed DPF-8123.1 returns from the analytical lab, attach the air bill and file with sample results.

6. The completed DPF-8123.1, with air bill and rear most carbon copy shall be reviewed and filed by the contact person or his/her designee as part of the data package.

D. On-Site Sample Security

1. Following sample collection, the sample collector shall do one of the following, in accordance with the transfer of custody requirements in this procedure:
   - Deliver the sample(s) to an on-site facility (e.g., sample preparation lab or count room);
   - Deliver the sample(s) to an off-site lab (either directly or by turning over to a courier);
   - Store the sample(s) in a secure manner (see below) until the sample(s) is delivered to the on-site sample preparation facility or count room, or until the sample(s) is sent to an off-site laboratory.

2. At any time following field collection, samples must be stored in a secure manner, which shall include one or more of the following:
   - Direct physical control or under direct visual observation by an individual;
   - Storage in a locked container, locked cabinet (e.g., refrigerator),or individual locked transport box (e.g. for concrete cores).
   - Storage in a locked room or building having limited access (e.g., the YNPS Sample Prep Trailer);
   - Tamper evident seal on the sample container. A single tamper evident seal may be used on a single container (e.g., cooler) containing multiple samples.

   **NOTE**: Smear samples shall be considered secure when loaded on a planchet rack in the Radiation Protection count room. (Tamper evident seals shall not be applied to planchet racks.) All samples shall be considered secure while on a detector in the Radiation Protection or Chemistry count room.

## FINAL CONDITIONS

1. Original chain of custody forms (DPF-8123.1) have been completed and filed for all samples as identified in this procedure's "Scope". Ensure completed DPF-8123.1 is transferred to the applicable data package. Commercial courier receipts or bills of lading, if applicable, are also filed.

2. Samples that are on-site are stored in a secure manner.

## APPENDIX A

## FILLING OUT CHAIN OF CUSTODY FORMS

### SCOPE

This appendix describes in detail the proper completion of the Chain of Custody Form (DPF-8123.1). The actual use of the form is described in the body of this procedure (DP-8123).

### PROCEDURE

NOTE: All entries shall be made in black ink.

NOTE: Some entries on DPF-8123.1 may not apply to a particular sample. In such cases, an entry of "NA" (i.e., "Not Applicable") is acceptable.

NOTE: Multiple samples may be included on a single Chain of Custody form (DPF-8123.1). Multiple samples may be shipped in a single container with the only tamper evident seal(s) being on the outside of the container.

NOTE: Each chain of custody form has a unique number pre-printed in the upper right hand corner.

A. Fill out the following header information:

1. Project Name - For YNPS purposes, designate YNPS and project type. (Example for Site Characterization "YNPS S.C.")

2. YAEC Contact Name & Phone - Generally the lead or cognizant person. Use at least the first initial and full last name (e.g., "J. Smith, 413-424-XXXX").

3. Analytical Lab - The name of the analytical laboratory, with city and state. (For the Framatome/ANP Environmental Laboratory, Framatome ANP Environmental Lab may be entered (without the city and state).

4. Requested Testing Completion Date - Date to be provided by the lead or cognizant person. If standard turn around times (e.g., two weeks) have been established with outside lab, this may be left blank.

B. For each sample container, fill out each column on form DPF-8123.1. The columns include:

1. Sample Designation - Transcribe the unique sample identification number appearing on the sample container label in the space provided.

2. Date and Time - Transcribe the date (mm/dd/yyyy) and time (hhmm) the sample was collected as it appears on the container label.

3. Media Code - Enter the Media Type code from Table 1

4. Sample Type Code - Enter the Sample Type code from Table 1.

5. Container Size and Type Code - Enter the Container Size, along with the Container Type from Table 1.

   For example: a) a sample for metals analysis collected in an 8-ounce plastic container will be identified as "8 oz P"; b) a sample for radiological analysis collected in a 12"x18" ziplock plastic bag will be identified as "12x18 BP".

6. Analyses Requested - Enter the type of analyses to be performed on each sample. Use as many spaces as needed to indicate all requested analyses for a given sample.

7. Comment, Preservation - Enter any comments as necessary in this section including the preservation method used.

   For example, if the preservation method was acidification, identify the method in this section such as "Acidified pH<2, Nitric Acid," or "Acidified pH<2, HCl." If any sample requires cooling to 4 degrees centigrade, identify the preservation method as "Ice or 4°C".

8. Notes: Enter any other information felt to be pertinent to the collection or custody of the sample(s).

9. Signature Blocks -

   a. Complete the signature blocks as instructed in steps A and B of this procedure.

   b. In situations where a chain of custody form is initiated for an existing sample (For example, see step A.6. of the procedure), the first two signature blocks (#1 and #2) may be left blank.

10. Samples Shipped Via - Check off the method of shipment. If a commercial courier, enter the bill of lading number.

11. Lab Use Only -

**NOTE**: Instruction should be provided to the offsite analytical laboratory in the proper completion of the Laboratory "Lab Use Only" shaded section.

   a. Comments - made by the laboratory pertinent to the receipt and condition of samples.

   b. Lab Sample ID. - A unique laboratory tracking number.

   c. Internal Container Temp - Obtain on receipt the internal temperature of the sample container.

   **NOTE**: Instructions should be provided not to obtain temperature from sample media to avoid contamination. A separate temperature blank will be provided in each shipment.

   d. Custody Sealed - Note presence or absence of custody seals.

   e. Custody Seal Intact - Note integrity of custody seals.

## TABLE 1

### Sample Codes for the Chain of Custody Form (DPF-8123.1)

| Media | Code |
|---|---|
| ground water | WG |
| surface water | WF |
| river water | WR |
| estuary water | WE |
| sea water | WS |
| effluent water | EW |
| soil | TS |
| sediment | SE |
| asphalt | AS |
| vegetation | TG |
| concrete | CT |
| smear | SM |
| other | (specify) |

| Sample Type | Code |
|---|---|
| grab | G |
| composite | C |
| core | CR |
| duplicate | D |
| split | S |
| field blank | FB |
| rinsate blank | RB |
| matrix spike | MS |
| matrix spike duplicate | MSD |
| other | (specify) |

| Container Type | Code |
|---|---|
| bag, plastic | BP |
| bag, cloth | BC |
| plastic | P |
| glass | G |
| amber glass | A |
| vial | V |
| steel can | SC |
| other | (specify) |

**Yankee Atomic Electric Company**
49 Yankee Road, Rowe, MA 01367
413-424-5261

# Chain of Custody Record

№

Project Name:

YAEC Contact Name & Phone:

Analytical Lab (Name, City, State):

Requested Testing Completion Date:

Lab Use Only

Comments:

| Sample Designation | Date | Time | Media Code | Sample Type Code | Container Size & Type Code | Analyses Requested | | | | | | Comment, Preservation | Lab Sample ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

NOTES:

| | | | |
|---|---|---|---|
| 1) Sampled By | Date/Time | 2) Received By | Date/Time |
| 3) Relinquished By | Date/Time | 4) Received By | Date/Time |
| 5) Relinquished By | Date/Time | 6) Received By | Date/Time |
| 7) Relinquished By | Date/Time | 8) Received By | Date/Time |

Samples Shipped Via:

☐ Fed Ex
☐ UPS
☐ Hand
☐ Other ____________

____________________
Bill of Lading #

Internal Container Temp.: ____ Deg. C

Custody Sealed?
Y ☐ N ☐

Custody Seal Intact?
Y ☐ N ☐

DPF-8123.1
Rev. 7

Adams Specialty & Printing Co.
(413) 743-9101

# DP – 8120
# Collection of Site Characterization and Site Release Samples

Proc. No. DP-8120
Rev. No. 7
Issue Date 06/2001
Review Date 05/2006

# COLLECTION OF SITE CHARACTERIZATION AND SITE RELEASE SAMPLES

## SCOPE

To provide instructions for the collection of surface and subsurface soils, shoreline sediments, asphalt and liquids. This procedure also provides instruction for the collection of soil, asphalt and concrete from ongoing or completed excavations, and the decontamination of equipment used to collect the samples. This procedure is intended to be used during the decommissioning period for both radiological and nonradiological site characterization and site release sampling.

Concrete core sampling is addressed in Procedure DP-8121.
Split spoon sampling is addressed in Procedure DP-8122.
Pond sediment sampling is addressed in Procedure DP-8124.
Groundwater monitoring is addressed in Procedure DP-9745.

## ENCLOSURES

DP-8120 Pgs. 1-10
Table 1 - Pg. 1 - Rev. 7
Appendix A - Pgs. 1-4 - Rev. 7
Appendix B - Pgs. 1-2 - Rev. 7
DPF-8120.1 - Rev. 7
DPF-8120.2 - Rev. 7

## REFERENCES

1. DP-8121, "In-Plant Radiological Surveys to Support the Radiological Characterization Program"
2. DP-8123, "Sample Custody and Control"
3. Deleted
4. EPA/625/12-91/002 "Description and Sampling of Contaminated Soils - A Field Pocket Guide"
5. EPA/600/R-92/128 "Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies"
6. 40 CFR Part 136
7. SW-846, "Test Methods for Evaluating Solid Waste", USEPA 3rd edition, March 1995.
8. OP-8100, "Establishing and Posting Radiological Areas"
9. DP-8813, "Sample Receipt and Preparation"
10. AP-0052, "Radiation Protection Release of Equipment, Material and Vehicles"
11. AP-0227, "Condition Reporting, Investigation and Self Assessment"
12. AP-0221, "Plant Record Management"

## DISCUSSION

Environmental samples are collected from surface soils, subsurface soils, sediments, asphalt, and liquids to identify a media's contamination status for site characterization and site release purposes. Soil, asphalt and concrete stock piles will be sampled to determine their final disposition (e.g., soil for back fill or release, asphalt and concrete for free release). The type of sample to be collected (e.g., grab, composite, etc.) and the suite of contaminants for which it will be analyzed should be identified in the field sampling plan. All samples will be prepared for analysis in accordance with DP-8813 [9]. Free release of soil, asphalt and concrete will be in accordance with AP-0052 [10]. This procedure addresses the steps to collect each type of sample.

Quality control measures will be an integral part of all activities related to obtaining and testing of samples. These measures are intended to help assure the accuracy of all data. They include:

- Implementation of all work based on written procedures
- Direction and documentation of all activities by a cognizant engineer
- Performance of key activities by individuals qualified to carry out such activities
- Precautions to prevent cross-contamination of samples
- Verification of analysis results by an independent laboratory
- Use of analytical laboratories with QA/QC programs
- Chain-of-custody documentation of samples

## PRECAUTIONS

1. All samples collected from within the Radiological Control Area (RCA) will be initially handled as if contaminated. A GM frisker will be used to periodically screen equipment and newly-collected samples for gross contamination. If radioactivity is detected above background. Label the sample as "Caution Radioactive Material" in accordance with OP-8100 [8] and take the necessary precautions to prevent the contamination of other samples, equipment or personnel.

2. Latex, nitrile or equivalent gloves shall be worn when handling sample material collected from on site, and when cleaning tools that were used in the collection of those samples. Clean gloves shall be used at each new sampling site.

3. When collecting samples in the RCA, hands and feet should be periodically monitored for contamination with a GM frisker.

4. For safety purposes, holes in concrete floors, soil or asphalt shall be patched or filled as soon as practicable.

5. For major excavations a Job Hazards Checklist will be completed and reviewed with the Safety department.

6. Methanol is flammable, do not use in the presence of open flame or ignition sources.

## PREREQUISITES

1. Each tool coming in contact with sampling media or any other potentially contaminated surface must be decontaminated prior to the collection of the next sample.

2. The type of sample being collected will determine which tools and materials are needed. Given below is a list of suggested tools and materials to choose from:

    - Site map
    - Chain of custody forms (DPF-8123.1)
    - Field Log Book
    - Location marking supplies, e.g., spray paint and stakes
    - 50 or 100-foot tape measure
    - Digging implements, e.g., trowel or shovel
    - Soil auger
    - Soil core sampler
    - Sample containers, e.g., "ZipTop" plastic bags or paint cans
    - Plastic bags (approx. 10 gal. size) for vegetation collection
    - Aluminum Foil
    - Hammer drill or demolition tool, with chisel or asphalt bits
    - Hearing and eye protection
    - Leather gloves

- Grass clippers
- Pruning shears
- Indelible pen
- Latex (or equivalent) gloves
- GM frisker
- Equipment cleaning supplies:

  Clean water
  Brushes
  Laboratory grade detergent (such as Alconox)
  Paper towels
  Trash bag for solid waste
  Methanol

- Concrete coring or cutting equipment:

  Drill rig, bits and extensions
  Hilti drill and bits
  Water hose
  Electrical extension cord w/ GFCI
  Adjustable wrench, hammer
  Hearing and eye protection

## PROCEDURE

### A. SAMPLING CONTAINERS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR SOIL AND LIQUID SAMPLES

The type of sample container, volume required for analysis, and the maximum holding time for various constituents and media are presented in Appendix A.

### B. SOIL and SEDIMENT SAMPLING

**NOTE**: These sampling techniques are not appropriate for soil and sediment collected for Volatile Organic Analysis (VOC). In addition, stainless steel tools or equivalent are to be used for the collection of samples for nonradiological analysis.

1. If soil is under a paved area or concrete floor, remove the asphalt or concrete.

   a. If an asphalt sample is to be collected, perform Section C before proceeding to step B.3.

   b. If a concrete sample is to be collected, refer to Reference 1.

2. If required, cut vegetation to approximately the soil surface level, and remove any "litter" on the ground surface (e.g., stones or dead/dry sticks and leaves that are not part of the soil humus layer).

   **NOTE**: If desired, cut vegetation may be saved for a separate analysis. In such a case, cut the vegetation over a measured area (e.g., one square meter), recording that area in the Field Log Book and place in a plastic bag.

3. Using a new or decontaminated (according to Section H of this procedure) stainless steel or equivalent tool (i.e. trowel, shovel, hand auger, etc.), remove soil or sediment at the selected sampling location (or locations for composite sampling) to the desired depth.

**NOTE**: Ideally enough soil should be collected to provide for a one liter sample after preparation.

**NOTE**: For soil samples collected outside of the Owner Controlled Area, dig a straight-sided hole with measured surface dimensions (e.g., 6" x 6") and record in the Field Log Book.

4. Place the sample into the appropriate container as specified in Appendix A. Ensure sufficient sample has been collected.

   a. If additional soil or sediment is required due to the number and volume of samples that must be collected, obtain the soil or sediment from a location immediately adjacent to the first by following steps 1 through 3 as necessary and remove a similar amount of sample.

   b. Composite samples collected for nonradiological analysis should be mixed in a stainless steel bowl or ziptop plastic bag.

5. Large sticks or rocks greater than approximately three inches in size should be discarded while digging the sample, unless otherwise instructed. Compensate for the lost volume at that depth by collecting additional sample from the same depth as the discarded rock/stick.

   **NOTE**: Where a large rock(s) prevents the collection of an adequate sample, the sampling point should be moved slightly to allow a better sample. In such a case, the movement and its reason should be noted in the Field Log Book.

   **NOTE**: Sticks and rocks less than three inches in size must remain in the sample. They will typically be removed at the laboratory during the sample preparation stage. Their weight will be accounted for at that time.

6. If required by Appendix A, preserve samples accordingly.

7. Close the container to prevent loss of material.

8. Label the container with the sample identification number (or bar code label), date of collection, time of collection, type of analysis (if non-rad), preservation method (if non-rad), and sampler's initials.

9. Ensure that the sample is secure and that the appropriate sample custody documentation (if required) is completed in accordance with DP-8123 [2] as soon as practicable.

## C. ASPHALT SAMPLING

**NOTE**: Ideally enough asphalt should be collected to provide for a one liter sample after preparation.

1. Using a hammer drill or demolition tool (with the appropriate bit), a cold chisel, or any other appropriate tool, cut a circular hole in the asphalt through its entire thickness.

2. Break up the asphalt sample into small pieces with the hammer drill.

**NOTE**: Be careful when breaking up the asphalt pieces with a power tool so that excessive mixing of the asphalt rubble with the upper layer of soil does not occur.

3. Remove the asphalt pieces, taking care to minimize any dirt clinging to the pieces. Place in a suitable container.

4. If required by Appendix A, preserve accordingly.

5. Close the container.

6. Label the container with the sample identification number (or bar code label), date of collection, time of collection, and sampler's initials.

7. Ensure that the sample is secure and that the appropriate sample custody documentation (if required) is completed in accordance with DP-8123 [2] as soon as practicable.

D. LIQUID SAMPLING

1. Using the appropriate sample collection container as identified in the Table in Appendix A, collect the sample directly into the container without pre-rinsing from the liquid.

2. Submerge the lip of the sample container below the liquid surface, filling the container until a slight headspace is present. Remove from the liquid and cap.

3. Samples collected for volatile organic analysis (e.g. VOC, pesticides) must contain no headspace or air bubbles after capping. To collect these samples:

   a. Collect the sample in a separate unused container.

   b. Pour the water to the appropriate container using a continuous stream into a pre-preserved container; do not overflow.

   c. When the container is full and a meniscus is present, cap the container and turn the container upside down and inspect for bubbles.

   d. If bubbles are present, remove cap and add sample to re-establish meniscus prior to capping. Repeat as necessary.

4. If required by Appendix A, preserve accordingly if not previously provided.

5. Label the container with the sample identification number, date of collection, time of collection, and sampler's initials.

6. Ensure that the sample is secure and that the appropriate sample custody documentation (if required) is completed in accordance with DP-8123 [2] as soon as practicable.

## E. IDENTIFICATION OF SAMPLING POINTS

1. If not already described in a sampling plan, describe the location of the sampling site in the Field Log Book by one of the following means:

    - Distance measurements to two or more structures (or other identifiable points)
    - Detailed drawings
    - Reference to a grid coordinate system
    - Global Positioning System (GPS) measurements
    - Any other equivalent method.

2. Mark the sample location with a semi-permanent marker (e.g., wood stake) when one of the methods in step 1 can not be used to identify the sample location.

3. A revised sample location code for radiological samples will be effective with Rev 7 of this procedure. The Safety Oversite Manager or designee will assign the first nine characters in the Location Code for each survey unit material listed using Table 1, Survey Location Codes and Appendix B, Survey Area Description, as guidance. The Location Code is composed of a 12 character alpha numeric string as follows:

    Characters 1-5 = Survey Area Identification

    Character 6 = Survey Unit Code

    Character 7 = Survey Unit Classification Code

    Character 8 = Survey Type Code

    Character 9 = Material Code

    Characters 10 - 12 = Survey Point

## F. SAMPLING SOIL, ASPHALT, AND CONCRETE FROM EXCAVATION STOCK PILES

1. STOCK PILE SEGREGATION AND IDENTIFICATION:

    a. Ensure that individual piles of soil, asphalt, and concrete are segregated on the following bases:

        1) Area of excavation - Soil, asphalt, and concrete excavated from any single area should be kept segregated from other piles until final disposition. Any pile consolidation must be documented.

        2) Type of material - Soil should be segregated from asphalt, concrete should be segregated from soil or asphalt. Other materials (e.g., wood, rebar, metals, or construction debris) are not addressed in this procedure and should be separated from the soil, asphalt and concrete.

        3) Contamination potential - Any soil, asphalt, or concrete known or suspected to be contaminated should be segregated; placed onto a poly tarp and sampled separately. This may be based on site characterization or other survey results, or on knowledge of the area's previous activities. Since site characterization surveys

have shown that soil contamination in the RCA is generally limited to the top six inches, initially, the top six-inch layer approximately should be segregated and sampled separately when excavating within the RCA.

b. The Safety Oversite Manager or designee will assign a unique number to each soil, asphalt, or concrete stock pile, log the number and other pertinent information on form DPF-8120.1, and provide the number to the RP Technician performing the sampling.

A revised pile numbering system will be effective with Rev. 7 of this procedure. The new system will consist of a 14 digit field starting with a P, designating Pile; followed by a 4 digit field for the year; a five digit field for the survey Area ID code; a two digit field for pile type (TS for soil, AS for Asphalt, CT for concrete); and a two digit sequential pile number. This method retains all of the features of the old system while adding the Survey Area ID so that the pile number identifies the origin of the excavated material.

For example;

P2000OG021TS04 is the fourth soil pile from survey area OG021 assigned in year 2000

P2000OG021AS01 is the first asphalt pile from survey area OG021 assigned in year 2000

**NOTE**: Form DPF-8120.1 will be controlled by the Safety Oversite Manager or his designee.

c. Prepare a suitable map to identify the location of each pile. Label the map with the pile number.

d. Write the pile number (obtained from the Safety Oversite Manager or designee) on two wooden stakes (with a Sharpie or other indelible pen) and drive the stakes solidly into the pile (front and back).

e. Cover each pile with a tarp to minimize the migration of potential contamination due to the forces of wind and rain, etc.

f. Where a pile is placed on a slope, place bales of hay or silt fence on the down-slope side to catch any run-off.

**NOTE**: In the event that piles are moved, the Safety Oversite Manager or designee should be notified so that the pile's location can be tracked, and to ensure that the pile is clearly labeled in its new location. The new location should be noted on Form DPF-8120.1.

2. SAMPLING FROM AN EXISTING PILE:

a. If the pile is large enough to make access to the inner volume of the pile difficult, split the pile into two or more sub-piles (e.g., with a backhoe) to allow access.

b. Collect approximately 30 samples of at least 100cc each, placing the samples into a plastic bag (more than one (1) plastic bag will be needed). In addition to the pile's unique number the plastic bags will be numbered "1 of ##" i.e., 1 of 2, 1 of 6, etc.

**NOTE**: A roughly determined grid should be used, and a shovel should be used to allow sampling at varying depths. The goal is to systematically (i.e., uniformly) sample throughout the entire pile volume. Use a Hilti drill as necessary to break up the asphalt and concrete into small pieces. Every effort should be made to ensure that one third of the samples collected are from the surface of the asphalt being excavated.

c. During sampling of soil piles, remove and return to the pile rocks and sticks greater than approximately ½ inch in size. For asphalt and concrete samples, such rocks bound up in the asphalt or concrete may be removed later during sample preparation.

**NOTE**: If any large man-made objects are encountered during sampling (e.g., barrel rings, sheet metal), remove them from the pile for separate monitoring. (Monitoring and disposition of this material is outside the scope of this procedure).

3. SAMPLING DURING EXCAVATION:

a. By talking to the excavating contractor, determine how often samples need to be collected to achieve 30 samples from each excavation/pile. A "pile" will consist of no more than approximately 15 cubic yards of soil, asphalt, or concrete.

**NOTE**: Multiple "piles" may result from a single excavation, based on the criteria in F.1.

b. At the frequency determined above, collect individual samples at least 100cc each directly from the bucket, placing all of these samples in a plastic bag (more than one (1) plastic bag will be needed). In addition to the stock pile's unique number the plastic bags will be numbered "1 of ##" i.e., 1 of 3, 1 of 5, etc.

**NOTE**: When the excavation is completed, 30 or more samples should have been collected from each stock pile. If not, collect enough additional samples from the stock pile (sample uniformly through the pile's volume) to achieve 30 samples.

c. During sampling, remove and return to the pile rocks and sticks greater than approximately ½ inch in size. For asphalt or concrete samples, such rocks bound up in the asphalt or concrete may be removed later during sample preparation.

**NOTE**: If any large man-made objects are encountered during sampling (e.g., barrel rings, sheet metal), remove them from the pile for separate monitoring. (Monitoring and disposition of this material is outside the scope of this procedure).

## G. SAMPLE DOCUMENTATION AND HANDLING

1. If the samples are part of site characterization:

   a. Record all appropriate information in the Field Log Book. As a minimum, include:

      - Sample date
      - Sample time
      - Sampler's name(s)
      - Sample location identification code/pile number
      - Sufficient description and/or measurements to allow the sampling site to be identified in the future.
      - map of area excavated and pile placement as appropriate.

   b. Any deviations from this procedure that are forced by field conditions (e.g., large rocks or ledge obstructing sampling, etc.) should be noted here.

   c. Record sampling information on DPF-8120.1 and DPF-8120.2 as appropriate.

2. If the samples are in support of site release, record sampling information in accordance with AP-0052 [10].

3. Deliver or arrange delivery of the samples to the designated sample prep or storage location, the DE&S Environmental Lab (DESEL) or another off-site analytical facility.

   a. Ensure that a tamper evident seal is affixed to each sample container. Seals shall be initialled and dated by the preparer.

   b. For samples submitted to the DESEL, complete form YELF 605.1 and send it with the samples.

   c. Fill out a chain of custody form in accordance with DP-8123 [2].

   d. Contact the Radwaste Coordinator for the shipment of any sample(s) containing plant-related radioactivity to any off-site facility.

## H. DECONTAMINATION OF EQUIPMENT

**NOTE**: Decontamination is performed in three stages, generally by using three buckets as described below. The same method may be used in a sink, if available, as long as the same three-step process is used and the drain line is suitably connected for radioactively contaminated waste. The first container is used for removal of gross residue and scrubbing with detergent. The second container, half-filled with clean water, is used for the first rinse. The third container, initially empty, is used to collect the rinsate from a spray bottle, and is generally used only in areas where contamination is suspected. Determine in advance whether the decontaminated tool is to be sprayed with methanol as a final step (non-radiological analysis only).

1. Set up three 5-gallon containers as follows:
   a. The first container is half filled with water and a small amount of laboratory grade detergent (such as Alconox).
   b. The second container is half-filled with clean water.
   c. The third container is initially empty. (This container is not needed in areas where contamination is not suspected, e.g., outside the Radiological Control Area.)
2. Don a new pair of latex, nitrile or equivalent gloves.
3. Remove any gross residue from the sampling tool, letting the material (e.g., soil) fall into the hole from which it was sampled. If the sampled hole is not immediately available, save the material for appropriate waste disposal. If the tool had last been used outside the Owner Controlled Fence, the material may simply fall onto the ground.
4. Place the used sampling tool in the first container and scrub with a brush.
5. Remove the tool from the first bucket and place the tool in the second bucket. Scrub with another brush.
6. Holding the tool over the third container (or over the ground if in an area where contamination is not suspected, e.g., outside the Radiological Control Area), completely rinse the tool with a squirt bottle of Methanol or clean water.
7. Wrap the cleaned tool in new aluminum foil.
8. Remove the gloves and dispose of appropriately.
9. Place the decontamination fluids into a container labeled "Decontamination Waste". Disposal should be based on a representative sample and analysis of the water, or as prescribed by the Radiation Protection Department.

## FINAL CONDITIONS

1. Samples have been collected and delivered to the appropriate laboratory in accordance with this procedure.
2. At the discretion of the Sample Manager/Senior Chemist, the YAEC Condition Reporting System, as defined in AP-0227 [11], has been initiated to report and evaluate adverse conditions potentially affecting data quality and to track corrective actions through completion.
3. Documentation has been reviewed and retained in accordance with AP-0221 [12].

## Table I - Survey Location Codes

<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>X</td><td>X</td><td>#</td><td>#</td><td>#</td><td>X</td><td>X</td><td>X</td><td>X</td><td>#</td><td>#</td><td>#</td></tr>
<tr><td colspan="5">Survey Area ID Code</td><td>Survey Unit Code</td><td>Survey Unit Classification Code</td><td>Survey Type Code</td><td>Survey Material Code</td><td colspan="3">Survey Point</td></tr>
<tr><td colspan="5">See Survey Area List</td><td>A = Upper Walls/Ceiling<br>B = Floors/Lower Walls<br>C = Ceiling<br>D = Sub Floor<br>E = Equipment<br>F = Floors<br>G = Grounds<br>L = Lower Walls<br>P = Pile[3]<br>S = System<br>U = Upper Walls<br>X = Structural Exterior</td><td>A = Affected<br>N = Non-Suspect Affected<br>S = Suspect Affected<br>U = Unaffected<br>1 = Class 1<br>2 = Class 2<br>3 = Class 3<br>4 = Non-Impacted<br>X = NA</td><td>C = Characterization<br>F = Final Status<br>G = General Information<br>I = Investigation<br>M = MARSSIM<br>R = Free Release<br>S = Special<br>T = Turnover</td><td>A = Asphalt (Exterior)<br>B = Poured Concrete Floor L1[1]<br>C = Concrete<br>D = Soil (Disturbed)<br>E = Poured Concrete Wall[1]<br>F = Poured Concrete Floor[1]<br>G = Generic<br>H = Block Wall[1]<br>I = Ignored<br>J = Generic[1]<br>K = Generic[2]<br>L = Sediment (Silt)<br>M = Asphalt (Interior)<br>N = Sediment (Sand)<br>O = Other<br>P = Porcelain<br>Q = Acoustic Ceiling Tile<br>R = Roof Material<br>S = Poured Concrete Floor L2[1]<br>T = Poured Concrete Floor L3[1]<br>U = Soil (Undisturbed)<br>V = Poured Concrete Ceiling L1[1]<br>W = Water<br>X = Poured Concrete Ceiling L2[1]<br>Y = Poured Concrete Ceiling L3[1]<br>Z = Generic L3</td><td colspan="3">Numbered Sequentially<br>**900 Series Sample Numbers Reserved for QA Samples**</td></tr>
</table>

---

[1] Survey material codes used for the Turbine Building survey units
[2] Survey material code used for the interior surfaces of System survey areas
[3] Piles of Soil, Asphalt or Concrete

## REQUIREMENTS FOR CONTAINERS, PRESERVATION TECHNIQUES, SAMPLE VOLUMES, AND HOLDING TIMES (Ref. 7)

| Name | Container[a] | Preservation[b,c,d] | Minimum Sample Volume or Weight | Maximum Holding Time |
|---|---|---|---|---|
| Alkalinity | G | 4°C | 100 ml | 14 days |
| Common anions | P,G | None Required | 50 ml | 28 Days for $Br^-$ $F^-$, and $SO_4^{-2}$, 48 hours for $NO_3^-$, $NO_2^-$, and $PO_4^{-3}$ |
| Cyanide, total and amenable to chlorination | P,G,T | 4°C; NaOH to pH>12, 0.6g ascorbic acid | 500 ml each | 14 days (water and soil) |
| Filterable residue | P,G | 4°C | 100 ml | 7 days |
| Nonfilterable residue | P,G | 4°C | 100 ml | 7 days |
| Hydrogen ion (pH) | P,G | None required | N/A | Analyze immediately |
| Nitrogen, nitrate + nitrite | P,G | 4°C, $H_2SO_4$ to pH <2 | 100 ml | 28 days |
| Conductance | P,G | None required | 100 ml | 28 days |
| Temperature | P,G | None required | N/A | Analyze immediately |
| Dissolved oxygen | G | None required | 500 ml | Analyze immediately |
| Turbidity | P,G | 4°C | 100 ml | 48 hours |
| Settleable Solids | P,G | None required | 1000 ml | 48 hours |
| Total organic carbon | P,G,T | 4°C, HCl or $H_2SO_4$ to pH <2 | 25 ml or 10 g | 28 days (water and soil) |
| Chromium (VI) | P,G,T | 4°C | 200 g | 24 hours (water and soil)[f] |
| Mercury | P,G,T | $HNO_3$ to pH <2, 4°C | 100 ml or 10 g | 28 days (water and soil) |
| Metals (except chromium (VI) and mercury) Includes Radiological[e] | P,G,T | $HNO_3$ to pH <2, 4°C | 200 ml or 10 g (1 liter or 500 g for radiological) | 180 days (water and soil) |

a. Polyethylene (P); glass(G); brass sleeves in the sample barrel, sometimes called California brass (T).

b. No pH adjustment for soil.

c. Preservation with 0.008 percent $NA_2S_2O_3$ is only required when residual chlorine is present.

d. Samples collected for radiological analysis do not require cooling to 4°C.

e. Do not acidify solutions to be analyzed for isotopes of Carbon, Technicium and Iodine.

f. The maximum recommended holding time for completion of extraction into water is 48 hours. The extract shall be analyzed within 24 hours of completion of extraction.

| Name | Container[a] | Preservation[b,c,d] | Minimum Sample Volume or Weight | Maximum Holding Time |
|---|---|---|---|---|
| Total petroleum hydrocarbons (TPH) - volatile | G, Teflon® - lined septum, T | 4°C,HCl to pH<2 | 2 x 40 ml or 4 ounces | 14 days (water and soil); 7 days if unpreserved by acid |
| Total petroleum hydrocarbons (TPH) - extractable | G,amber,T | 4°C | 1 liter or 8 ounces | 7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil) |
| Volatile aromatics | G, Teflon® - lined septum,T | 4°C, HCl to pH<2, 0.008% $Na_2S_2O_3$ | 2 x 40 ml or 4 ounces | 14 days (water and soil); 7 days if unpreserved by acid |
| Halogenated volatiles | G, Teflon® - lined septum,T | 4°C, HCl to pH<2, 0.008% $Na_2S_2O_3$ | 2 x 40 ml or 4 ounces | 14 days (water and soil); 7 days if unpreserved by acid |
| Nitrosamines | G, Teflon® - lined cap, T | 4°C | 1 liter or 10 g | 7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil) |
| Chlorinated herbicides | G, Teflon® - lined cap, T | 4°C, pH 5-9 | 1 liter or 10 g | 7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil) |

a. Polyethylene (P); glass(G); brass sleeves in the sample barrel, sometimes called California brass (T).

b. No pH adjustment for soil.

c. Preservation with 0.008 percent $NA_2S_2O_3$ is only required when residual chlorine is present.

| **Name** | **Container**[a] | **Preservation**[b,c,d] | **Minimum Sample Volume or Weight** | **Maximum Holding Time** |
|---|---|---|---|---|
| Organochlorine pesticides and polychlorinated biphenyls (PCBs) | G, Teflon® - lined cap, T | 4°C, pH 5-9 | 1 liter or 30 g | 7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil) |
| Organophosphorus pesticides/ compounds | G, Teflon® - lined cap, T | 4°C, pH 5-9 | 1 liter or 8 ounces | 7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil) |
| Semivolatile organics | G, Teflon® - lined cap, T | 4°C, 0.008% $Na_2S_2O_3$ | 1 liter or 8 ounces | 7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil) |
| Volatile organics | G, Teflon® - lined septum, T | 4°C, 0.008% $Na_2S_2O_3$ (HCl to pH <2 for volatile aromatics by SW8240 and SW8260)[b] | 2 x 40 ml or 4 ounces | 14 days (water and soil); 7 days if unpreserved by acid. |
| Polynuclear aromatic hydrocarbons (PAHs) | G, Teflon® - lined cap, T | 4°C, store in dark, 0.008% $Na_2S_2O_3$ | 1 liter or 10 g | 7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil) |

a. Polyethylene (P); glass(G); brass sleeves in the sample barrel, sometimes called California brass (T).

b. No pH adjustment for soil.

c. Preservation with 0.008 percent $NA_2S_2O_3$ is only required when residual chlorine is present.

| Name | Container [a] | Preservation [b,c,d] | Minimum Sample Volume or Weight | Maximum Holding Time |
|---|---|---|---|---|
| Dioxins and furans | G,Teflon®- lined cap, T | 4°C, 0.008% $Na_2S_2O_3$ | 1 liter or 10 g | 30 days until extraction and 45 days after extraction (water and soil) |
| Ethylene dibromide (EDB) | G,Teflon®- lined cap, T | 4°C, 0.008% $Na_2S_2O_3$ | 2 x 40 ml | 28 days (water) |
| Explosive residues | P,G,T | Cool, 4°C | 1 liter or 8 ounces | 7 days to extraction (water), 14 days to extraction (soil); analyze-within 40 days after extraction |
| TCLP | G,Teflon®- lined cap, T | Cool, 4°C | 1 liter or 250 g | 14 days to TCLP extraction and 14 days after extraction (volatiles); 14 days to TCLP extraction and 40 days after extraction (semivolatiles); 28 days to TCLP extraction and 28 days after extraction (mercury);180 days to TCLP extraction and 180 days after extraction (metals). |

a. Polyethylene (P); glass (G); brass sleeves in the sample barrel, sometimes called California brass (T).

b. No pH adjustment for soil.

c. Preservation with 0.008 percent $Na_2S_2O_3$ is only required when residual chlorine is present.

## APPENDIX B

## SURVEY AREA DESCRIPTION

| Area | Survey Area Description |
|---|---|
| DG001 | 'A' Diesel Generator Room |
| DG002 | 'B' Diesel Generator Room |
| DG003 | 'C' Diesel Generator Room |
| DG004 | MCC Switchgear Room |
| DG005 | Battery Room |
| DG006 | Safety Injection System Area |
| DG007 | Accumulator Tank Room |
| DG008 | Electrical Manhole |
| OB001 | Maintenance Pole Building |
| OB002 | Training Complex |
| OB003 | YAEC Visitors Center |
| OB004 | Gate House |
| OB005 | Office Building |
| OB006 | Pump House |
| OB007 | Modular Office Building |
| OB008 | Warehouse |
| OB009 | South Trailer Complex |
| OB010 | North Trailer Complex |
| OB011 | Security Diesel Generator Building |
| OE001 | Southwest Structural Exteriors |
| OE002 | Northwest Structural Exteriors |
| OE003 | North Structural Exteriors |
| OE004 | Northeast Structural Exteriors |
| OE005 | East Structural Exteriors |
| OE006 | Warehouse Exterior |
| OG001 | Northwest Buffers Zone |
| OG002 | Northeast Buffers Zone |
| OG003 | Southeast Buffers Zone |
| OG004 | Southwest Buffers Zone |
| OG005 | Switch Yard Area |
| OG006 | Southwest Open Land Area |
| OG007 | South Open Land Area |
| OG008 | Southeast Construction Fill Area |
| OG009 | East Open Land Area |
| OG010 | Northeast Open Land Area |
| OG011 | North Open Land Area |
| OG012 | Northwest Open Land Area |
| OG013 | East Storm Drain Outfall Area |
| OG014 | Training Center Parking Lot |
| OG015 | Primary Parking Lot |
| OG016 | East Construction Fill Area |
| OG017 | West Storm Drain Outfall |
| OG018 | North Buffers Zone |
| OG019 | Sherman Pond Outfall Area |
| OG020 | South Buffer Zone |
| OG021 | ISFSI Access Road |
| PA001 | Charging / Purification Cubicles |
| PA009 | PAB Sump/Gravity Drain Tank Cubicle |
| PA012 | Primary Drain Collection Tank Room |
| PA013 | Cubicle Corridor Pipe Trench |
| PA014 | Vertical Pipe Chase |
| PA015 | LPST / SDC Cubicles |
| PA020 | CCW/EFW Pumps Area |
| PA021 | Cubicle Corridor |
| PA022 | South General Area |
| PA023 | North General Area |
| PA024 | Hydrogen Storage Room |
| PA025 | CCW HTX/Surge Tank Room |
| PA026 | Chem Sample/PASS Room |
| PA027 | Valve Room |
| PA028 | Low Pressure Surge Tank Room |
| PA029 | Ventilation Equipment Room |
| PA030 | Non-Radioactive Pipe Gallery |
| PA031 | Radioactive Pipe Tunnel |
| PR001 | YAEC Property Residuum |
| SB001 | South Decontamination Room |
| SB002 | North Decontamination Room |
| SB003 | Hot Weld Shop |
| SB004 | Maintenance Shop |
| SB005 | Decon Room |
| SB006 | Radiation Protection Counting Room |
| SB007 | RCA Egress Area |
| SB008 | RCA Access Area |
| SB009 | RCA Dressout Area |
| SB010 | Radiochemistry Laboratory |
| SB011 | Locker Room |
| SB012 | Body Count Room/Clean Facilities |
| SB013 | Plant Laboratory |
| SB014 | Service Building Main Corridor |
| SB015 | Water Treatment Room |
| SB016 | Radiation Protection Office Areas |

| Area | Survey Area Description |
|---|---|
| SB017 | Clean Maintenance Shop Tool Crib |
| SB018 | Clean Maintenance Shop |
| SB019 | Clean Maintenance Shop Mezzanine 2nd Floor |
| SB020 | Northeast Office Areas |
| SB021 | Service Building East Corridor |
| SB022 | Service Building Main Stores Area |
| SB023 | Document Control Center |
| SB024 | Instrumentation Calibration Laboratory |
| SB025 | Service Building Southeast Stores Area |
| SB026 | Service Building Lunch Room |
| SB027 | Second Floor Corridor |
| SB028 | Second Floor West Offices |
| SB029 | Second Floor East Offices |
| SB030 | Second Floor South Offices |
| SB031 | Mechanical Equipment Room |
| SS003 | Circulating Water/Service Water |
| SS010 | Fire Protection and Detection |
| SS016 | Turbine Building Floor Drains |
| SS027 | Potable H2O |
| SS028 | Roof Drains i/s OCA and o/s RCA |
| SS029 | Roof Drains i/s RCA |
| SS030 | Misc. Ventilation |
| TB001 | Southwest Stairwell - Ground Floor |
| TB002 | Boiler Feed Pump Area - West |
| TB003 | Boiler Feed Pump Area - East |
| TB004 | Turbine Building Elevator/Machine Room |
| TB005 | Heating and Boiler Room |
| TB006 | Ground Floor - Southeast General Area |
| TB007 | Ground Floor - South Central General Area |
| TB008 | Ground Floor - Southwest General Area |
| TB009 | Ground Floor - Northwest General Area |
| TB010 | Ground Floor - West Central General Area |
| TB011 | Ground Floor - North Central General Area |
| TB012 | Ground Floor - Central General Area |
| TB013 | Ground Floor - East Central General Area |
| TB014 | Ground Floor - Northeast General Area |
| TB015 | Ground Floor - Lube Oil Room |
| TB016 | Southwest Stairwell - Mezzanine Floor |
| TB017 | Switchgear Room |
| TB018 | Battery Rooms |
| TB019 | Fan Room |
| TB020 | Mezzanine Floor - Northeast General Area |
| TB021 | Mezzanine Floor - Southeast General Area |
| TB022 | Mezzanine Floor - Southwest General Area |
| TB023 | Mezzanine Floor - Northwest General Area |
| TB024 | Control Room Kitchen Area |
| TB025 | Control Room |
| TB027 | Operating Floor - Southeast Hallway |
| TB028 | Operating Floor - Southeast General Area |
| TB029 | Operating Floor - South Central General Area |
| TB030 | Operating Floor - Southwest General Area |
| TB031 | Operating Floor - Northwest General Area |
| TB032 | Operating Floor - Modular Offices |
| TB033 | Operating Floor - North Central General Area |
| TB035 | Operating Floor - Northeast General Area |
| TB036 | Operating Floor Crane |
| TB037 | Operating Floor Ceiling |
| TB038 | Cable Tray Room |
| UA007 | Unaffected 75 Percent GLV |
| UG001 | Under Primary Auxiliary Building |
| UG002 | Under Waste Disposal Building |

| Area | Survey Area Description |
|---|---|
| UG004 | Under PCA Storage Building #1 |
| VC001 | VC Skin Under BioShield - SW Quad |
| VC002 | VC Skin Under BioShield - NW Quad |
| VC003 | VC Skin Under BioShield - NE Quad |
| VC004 | VC Skin Under BioShield - SE Quad |
| VC005 | Underside of BioShield - SW Quad |
| VC006 | Underside of BioShield - NW Quad |
| VC007 | Underside of BioShield - NE Quad |
| VC008 | Underside of BioShield - SE Quad |
| VC009 | VC Skin Lower Section - SW Quad |
| VC010 | VC Skin Lower Section - NW Quad |
| VC011 | VC Skin Lower Section - NE Quad |
| VC012 | VC Skin Lower Section - SE Quad |
| VC013 | Lower Outer BioShield Wall - SW Quad |
| VC014 | Lower Outer BioShield Wall - NW Quad |
| VC015 | Lower Outer BioShield Wall - NE Quad |
| VC016 | Lower Outer BioShield Wall - SE Quad |
| VC017 | Brass Drain Box Sloped Floor Area - South |
| VC018 | Brass Drain Box Sloped Floor Area - North |
| VC019 | VC Equipment Hatch |
| VC020 | Brass Drain Box Area |
| VC021 | Loop #1 Mezzanine Area |
| VC022 | Pressurizer Mezzanine Area |
| VC023 | Loop #2 Mezzanine Area |
| VC024 | Loop #3 Mezzanine Area |
| VC025 | Loop #4 Mezzanine Area |
| VC026 | Feed & Bleed HTX Room |
| VC027 | Loop#1 Area |
| VC028 | Pressurizer Area |
| VC029 | Loop#2 Area |
| VC030 | Loop#3 Area |
| VC031 | Loop#4 Area |
| VC032 | Shield Tank Cavity |
| VC033 | Reactor Vessel Bioshield Concrete |
| VC034 | Charging Floor - Loop#1 G/A |
| VC035 | Charging Floor - Loop#2 G/A |
| VC036 | Charging Floor - Loop#3 G/A |
| VC037 | Charging Floor - Loop#4 G/A |
| VC038 | Charging Floor - Central G/A |
| VC039 | Upper Outer BioShield Wall - SW Quad |
| VC040 | Upper Outer BioShield Wall - NW Quad |
| VC041 | Upper Outer BioShield Wall - NE Quad |
| VC042 | Upper Outer BioShield Wall - SE Quad |
| VC043 | VC Skin Upper Section - SW Quad |
| VC044 | VC Skin Upper Section - NW Quad |
| VC045 | VC Skin Upper Section - NE Quad |
| VC046 | VC Skin Upper Section - SE Quad |
| VC047 | VC Skin Dome Area - SW Quad |
| VC048 | VC Skin Dome Area - NW Quad |
| VC049 | VC Skin Dome Area - NE Quad |
| VC050 | VC Skin Dome Area - SE Quad |
| VC052 | VC Airlock and Platform |
| VC900 | Vapor Container Test |
| VC907 | VC Weighted Mean |
| WD001 | PCA Warehouse - West General Area |
| WD002 | PCA Warehouse - East General Area |
| WD003 | Waste Disposal Building Corridor |
| WD004 | Drumming Pit |
| WD005 | Drum Drying Area |
| WD006 | Waste Compactor Building |
| WD007 | North General Area |
| WD008 | Waste Disposal Building Pipe Trenches |
| WD009 | Liquid Waste Transfer Pump Room |
| WD010 | Distillate Accumulator Cubicle |
| WD011 | Evaporator Cubicle |
| WD012 | Waste Gas Compressor Room |
| YE001 | Turbine Building Exterior |
| YE002 | Auxiliary Bay Exterior |
| YE003 | Service Building Exterior |
| YE004 | Vapor Container Exterior - Top Half |
| YE005 | Vapor Container Exterior - Bottom Half |
| YE006 | Diesel Generator Building Exterior |
| YE007 | Primary Auxiliary Building Exterior |
| YE008 | Primary Auxiliary Building Roof |
| YE009 | Safe Shutdown System Building Exterior |
| YE010 | Fire Water Storage Tank/Pumphouse Exterior |
| YE011 | Waste Disposal Building Exterior |
| YE012 | PCA Storage Building #2 Exterior |
| YE013 | PCA Storage Building #1 Exterior |

| Area | Survey Area Description |
|---|---|
| YE015 | VC Elevator Structural Exterior |
| YE016 | Small Activated Area on Top of VC |
| YE017 | Exterior Surface of VC Below Equipment Hatch |
| YE018 | Miscellaneous Yard Exteriors |
| YG001 | Transformer Yard |
| YG002 | Northwest Yard Area |
| YG003 | Southwest Yard Area |
| YG004 | South Yard Area |
| YG005 | Southeast Yard Area |
| YG006 | Northeast Yard Area |
| YG007 | Central Yard Area |
| YG008 | Tank Farm |
| YS001 | Fire Water Pump House |
| YS002 | Safe Shutdown System Building - South |
| YS003 | Safe Shutdown System Building - Center |
| YS004 | Safe Shutdown System Building - North |
| YS005 | PCA Storage Building #2 |
| YS006 | PCA Storage Building #1 |
| YS007 | Waste Holdup Tank Moat |
| YS008 | Activity Dilution Storage Tank Moat |
| YS009 | Ion Exchange Pit Pipe Trench |
| YS010 | Ion Exchange Pit |
| YS011 | Vapor Container Elevator |
| YS012 | Miscellaneous Yard Structures |
| YS013 | Radioactive Laboratory Sump Cubicle |

## DECOMMISSIONING SOIL, ASPHALT, AND CONCRETE EXCAVATIONS

## SAMPLE COLLECTION LOG

| PILE NO.* | SAMPLE NOS. | SAMPLE DATE | LOCATION DESCRIPTION | COMMENTS | ANALYSES REQUESTED |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* e.g., P2000OG021TS04 is the fourth soil pile from survey area OG021 assigned in year 2000
P2000OG021AS01 is the first asphalt pile from survey area OG021 assigned in year 2000

# DECOMMISSIONING EXCAVATION
# SAMPLE RESULTS AND PILE DESCRIPTION

Pile Number ____________________ Date/Time of Sample Collection ______________/______

Samplers Name ________________________________

Soil [ ]
Asphalt [ ]
Concrete [ ]

Part 1: **LABORATORY RESULTS**

| Sample Number | Spectrum Number | Net Positive Activity (pCi/g) | | Fraction of Guideline[2] (Each Nuclide) | Sum of Fractions[2] (Total Sample) |
|---|---|---|---|---|---|
| | | Nuclides | Concentration[1] | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

[1] "ND" indicates no positive activity detected
[2] Soil only

Evaluation performed by________________________________Date_______________

Part 2: **DISPOSITION OF MATERIAL**

The determination of acceptance of material for unconditional release is accomplished utilizing AP-0052.

Disposition of pile: ________________________________Date:______________

Final Review by: ________________________________Date:______________
(RP Supervision)

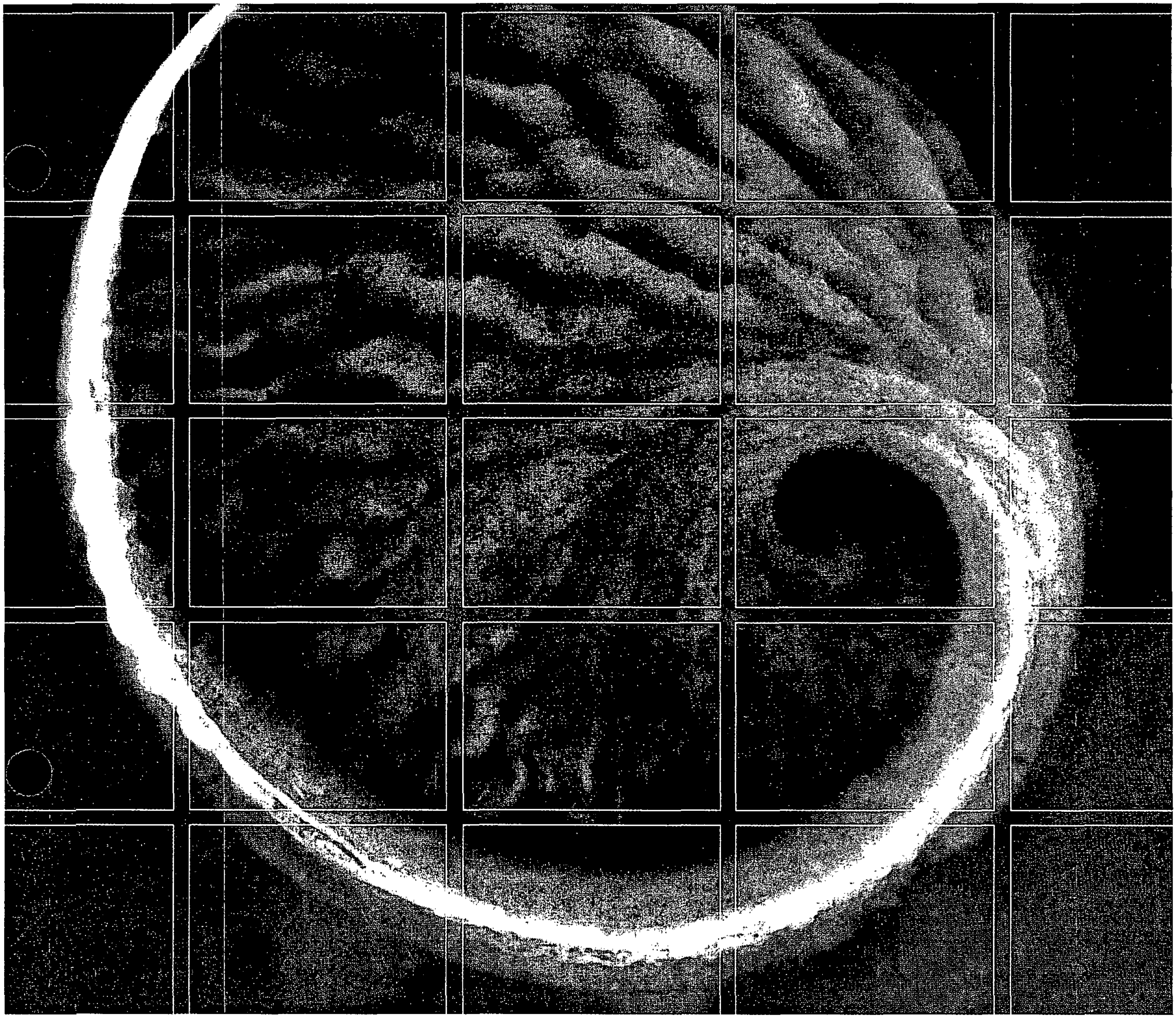
# *Appendix B*

*Table B-1*

Table B-1
Summary of Summer 2003 Groundwater Sampling Program
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Nonradiological | | | | | | | South Construction Fill Area (SCFA) Monitoring | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | VOC | SVOC | PCB | Herbicides | DRO | GRO | PP13 Metals | Barium | Alkalinity | TDS | Cyanide | Chloride | Sulfate | COD |
| B-1 | X | X | X | X | X | X | X | | | | | | | |
| CB-1 | X | X | X | X | X | X | X | | | | | | | |
| CB-2 | X | X | X | X | X | X | X | | | | | | | |
| CB-3 | X | X | X | X | X | X | X | | | | | | | |
| CB-4 | X | X | X | X | X | X | X | | | | | | | |
| CB-5 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CB-6 | X | X | X | X | X | X | X | | | | | | | |
| CB-7 | X | X | X | X | X | X | X | | | | | | | |
| CB-8 | X | X | X | X | X | X | X | | | | | | | |
| CB-9 | X | X | X | X | X | X | X | | | | | | | |
| CB-10 | X | X | X | X | X | X | X | | | | | | | |
| CB-11A DUP | X | X | X | X | X | X | X | | | | | | | |
| CB-12 | X | X | X | X | X | X | X | | | | | | | |
| CFW-1 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CFW-2 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CFW-3 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CFW-4 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CFW-5 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CFW-6 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CFW-7 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CW-2 | X | X | X | X | X | X | X | | | | | | | |
| CW-3 | X | X | X | X | X | X | X | | | | | | | |
| CW-4 | X | X | X | X | X | X | X | | | | | | | |
| CW-5 | X | X | X | X | X | X | X | | | | | | | |
| CW-6 | X | X | X | X | X | X | X | | | | | | | |
| CW-7 DUP | X | X | X | X | X | X | X | | | | | | | |
| CW-11 | X | X | X | X | X | X | X | | | | | | | |
| MW-1 | X | X | X | X | X | X | X | | | | | | | |
| MW-2 | X | X | X | X | X | X | X | | | | | | | |
| MW-5 | X | X | X | X | X | X | X | | | | | | | |
| MW-6 | X | X | X | X | X | X | X | | | | | | | |
| MW-100A | X | X | X | X | X | X | X | | | | | | | |
| MW-100B | X | X | X | X | X | X | X | | | | | | | |
| MW-101C | X | X | X | X | X | X | X | | | | | | | |
| MW-101B | X | X | X | X | X | X | X | | | | | | | |
| MW-102A | X | X | X | X | X | X | X | | | | | | | |
| MW-102B | X | X | X | X | X | X | X | | | | | | | |
| MW-102C | X | X | X | X | X | X | X | | | | | | | |
| MW-103A | X | X | X | X | X | X | X | | | | | | | |
| MW-103B | X | X | X | X | X | X | X | | | | | | | |
| MW-103B DUP | X | X | X | X | X | X | X | | | | | | | |
| MW-103C | X | X | X | X | X | X | X | | | | | | | |
| MW-105B | X | X | X | X | X | X | X | | | | | | | |
| MW-105C | X | X | X | X | X | X | X | | | | | | | |
| OSR-1 | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Sherman Spring (SP001) | X | X | X | X | X | X | X | | | | | | | |
| Facility Water Supply (DW001) | X | X | X | X | X | X | X | | | | | | | |
| Visitor Center Water Supply Well (DW002) | X | X | X | X | X | X | X | | | | | | | |
| **Total** | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

# *Groundwater Field Sampling Plan*



# Final

# Groundwater Field Sampling Plan

Yankee Nuclear Power Station
49 Yankee Road
Rowe, Massachusetts

July 2003

www.erm.com

*Delivering sustainable solutions in a more competitive world*

ERM

Yankee Nuclear Power Station

# Groundwater Field Sampling Plan

July 2003

0002107

49 Yankee Road
Rowe, Massachusetts

John W. McTigue, P.G., LSP

*Principal-in-Charge*

Gregg A Demers

Gregg A. Demers, P.E., LSP

*Project Manager*

**Environmental Resources Management**
399 Boylston Street, 6th Floor
Boston, Massachusetts 02116
T: 617-267-8377
F: 617-267-6447

1.0 INTRODUCTION 1

1.1 BACKGROUND 1

1.2 PURPOSE & SCOPE 1

2.0 GROUNDWATER SAMPLING PROGRAM 3

2.1 STANDARD OPERATING PROCEDURES 3

2.2 SAMPLE LOCATIONS AND DESIGNATIONS 3

2.3 SAMPLING PROCEDURES 3
2.3.1 Monitoring Well Sampling 3
2.3.2 Water Supply Well Sampling 4
2.3.3 Spring Sampling 4

2.4 ANALYTICAL PROGRAM 5
2.4.1 Non-radiological Parameters 5
2.4.2 Radiological Parameters 6

2.5 SAMPLE SECURITY AND CUSTODY 6

2.6 MANAGEMENT OF INVESTIGATION DERIVED WASTES 7

2.7 SCHEDULE 7

3.0 QUALTIY ASSURANCE AND QUALTIY CONTROL 8

3.1 QUALITY ASSURANCE PROJECT PLAN 8

3.2 CLEANING AND DECONTAMINATION OF EQUIPMENT 8

3.3 QUALITY ASSURANCE / QUALITY CONTROL SAMPLES 9

4.0 PROJECT DOCUMENTATION 11

## *TABLES*

*Table 1* *Groundwater Sampling Locations*
*Table 2* *Groundwater Analytical Program*
*Table 3* *Groundwater Analytical Program Bottle Requirements*

## *FIGURES*

*Figure 1* *Site Layout and Groundwater Sampling Locations*

## *APPENDICES*

*Appendix A* *Groundwater Sampling Procedures*

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

On behalf of Yankee Atomic Electric Company (Yankee), Environmental Resources Management (ERM) has prepared this Groundwater Field Sampling Plan (FSP) for the Yankee Nuclear Power Station (YNPS) located at 49 Yankee Road in Rowe, Massachusetts (Figure 1). The FSP has been prepared as a supplement to the *Draft Quality Assurance Project Plan, Site Closure, Yankee Nuclear Power Station, Rowe, Massachusetts.* The FSP outlines the approach and methods for characterizing groundwater quality at the site as part of the overall site closure program. Other media-specific FSPs will be prepared as the site closure activities proceed. This FSP address both non-radiological and radiological groundwater characterization activities.

## 1.2 PURPOSE & SCOPE

The purpose of the Groundwater FSP is to:

- establish the procedures and rationale for groundwater sampling activities in support of site closure;
- ensure that groundwater sampling data are consistent with applicable procedures;
- ensure that the Data Quality Objectives (DQOs) for site closure are met;
- provide data to support preparation of the License Termination Plan (as required by the Nuclear Regulatory Commission);
- provide data to support annual sampling requirements of the Southeast Construction Fill Area (as required by the Massachusetts Department of Environmental Protection); and
- support the site characterization and closure activities.

The initial sampling round under the FSP will serve as a baseline sampling round. The data generated under the FSP will be validated and input into the site database. The results from the baseline sampling round will be used in conjunction with Data Usability reports that are being prepared regarding the historic data to determine the need for, and scope of, future groundwater sampling events. The data will also be used to support human health and ecological risk assessments that will be prepared as part of the site closure program.

The non-radiological and radiological characterization of groundwater quality has been combined in this sampling round since the timing and scopes of the programs overlap.

The scope of the Groundwater FSP includes sampling of all existing wells at the site (currently 34 wells), sampling the wells currently being installed (8 to 12 wells are expected to be installed), sampling the two Yankee water supply wells (one for the plant and one for the Visitor's Center), and the sampling of a spring located downgradient of the site approximately 50 feet east of the Deerfield River (see Table 1 for a summary of groundwater sampling locations).

## 2.0 GROUNDWATER SAMPLING PROGRAM

### 2.1 STANDARD OPERATING PROCEDURES

Standard Operating Procedures (SOPs) applicable to the groundwater investigation include:

- DP-9745 Groundwater Level Measurement and Sampler Collection in Observation Wells
- DP-8123 Sample Security and Chain of Custody
- AP-8601 Ground and Well Water Monitoring Program for the Yankee Nuclear Power Station Site
- Water Level Measurements
- Groundwater Sample Collection from Wells Having Pump Systems in Place
- Multi-Parameter Water Quality Monitoring
- Surface Water and Sediment Sample Collection

Appendix A contains the SOPs applicable to this FSP.

### 2.2 SAMPLE LOCATIONS AND DESIGNATIONS

A list of locations to be sampled for groundwater is provided in Table 1. The groundwater sample locations are shown in Figure 2.

The groundwater samples will be identified using a unique sample identification. The sample designations will use the naming convention as detailed in the YNPS QAPP. The sample designations for the groundwater sampling program are detailed in Table 2.

### 2.3 SAMPLING PROCEDURES

#### 2.3.1 *Monitoring Well Sampling*

The newly installed wells will be developed and allowed at least one week to come into equilibrium with the aquifer prior to sampling.

To accurately determine groundwater flow direction across the Site, Yankee is in the process of completing a survey of the location and elevation of the existing wells and will incorporate the new wells into the site survey following each phase of well installation. Elevations are being surveyed relative to a common site datum.

All of the monitoring wells will be gauged prior to sampling in accordance with *DP-9745 Groundwater Level Measurement and Sampler Collection in Observation Wells.* Water level measurements will be made using an electronic water level probe marked in 0.01-foot intervals.

After gauging, the monitoring wells will be sampled from the midpoint of the well screen using low-flow sampling techniques, as outlined in *DP-9745 Groundwater Level Measurement and Sampler Collection in Observation Wells.* Geochemical field parameters will be measured for wells sampled by low-flow sampling techniques at the time of sample collection, including: temperature, conductivity, pH, dissolved oxygen, turbidity, and oxidation-reduction potential. The field meters used during groundwater sampling will include a YSI water quality instrument for collection of field parameters and a Solinst electric water level meter. In accordance with the QAPP, all equipment be calibrated and operated in accordance with the manufacturer's recommended procedures.

Dedicated sampling equipment will be used where feasible. At wells where the depth to water is greater than 30 feet, a low-flow submersible or bladder pump will need to be used. All reused sampling equipment will be decontaminated prior to, and following, sample collection in accordance with the QAPP.

### 2.3.2 *Water Supply Well Sampling*

The two existing water supply wells will be sampled at the faucet or spigot closest to the well. The sample will be collected in accordance with SOP for Groundwater Sample Collection from Wells having Pump Systems in Place (Appendix A).

### 2.3.3 *Spring Sampling*

The spring located to the west of YNPS will be sampled in accordance with the SOP for Surface Water and Sediment Sample Collection (Appendix A).

## 2.4 *ANALYTICAL PROGRAM*

### 2.4.1 *Non-radiological Parameters*

The groundwater analytical program is summarized in Table 2. The bottle requirements are detailed in Table 3. The groundwater investigation will include the analysis of all groundwater samples for the following non-radiological parameters:

- Volatile Organic Compounds (VOCs) by GC/MS, SW-846 Method 8260B VOCs;
- Semi-Volatile Organic Compounds (SVOCs) by GC/MS, SW-846 Method 8270C SVOCs;
- Polychlorinated Biphenyls (PCBs) by GC, SW-846 Method 8082PCBs;
- Chlorinated Herbicides by GC, SW-846 Method 8151;
- Diesel Range Organics (DRO) by GC, SW-846 Method 8015B
- Gasoline Range Organics (GRO) by GC, SW-846 Method 8015B
- Priority Pollutant 13 Metals (PP13) Metals by SW-846 6010B

Non-radiological samples will not be filtered. The data from this event will be analyzed to evaluate whether filtering is required during future sampling.

In addition to the parameters listed above, wells in the vicinity of the Southeast Construction Fill Area will be analyzed for the following parameters in order to satisfy requirements of the Massachusetts Solid Waste Regulations for annual monitoring around the landfill:

- Barium by EPA Method 6010B
- Manganese by EPA Method 6010B
- Iron by EPA Method 6010B
- Alkalinity by EPA Method 310.1
- Total Dissolved Solids by EPA Method 2540C
- Cyanide by EPA Method 9010
- Chloride by EPA Method 9056
- Sulfate by EPA Method 9056
- Nitrate Nitrogen (as Nitrogen) by EPA Method 9056
- Chemical Oxygen Demand by EPA Method 5220C

The need for targeted analysis of other parameters identified in the QAPP as constituents of potential concern, such as cyanide, dioxin, and hydrazine, will be evaluated following the completion of the baseline groundwater sampling round and the collection of samples in other media, such as soil.

Northeast Laboratory Services, located in Waterville, Maine, will conduct non-radiological analyses.

### 2.4.2 *Radiological Parameters*

Groundwater samples will also be collected for radiological site characterization activities. The radiological samples will be collected following the collection of non-radiological samples. Table 2 provides a summary of the radiological analytical program. The bottle requirements are detailed in Table 3. The following is a list of the four categories of radiological samples:

- Category A – Gamma (including $^{60}$Co, $^{134/137}$Cs, $^{54}$Mn, $^{94}$Nb, $^{125}$Sb, $^{152/154/155}$Eu, $^{108m}$Ag)
- Category B – Tritium, Gross Alpha/Beta
- Category C – $^{14}$C, $^{55}$Fe, $^{63}$Ni, $^{90}$Sr
- Category D – $^{241}$Am, $^{238}$Pu, $^{240/239}$Pu, $^{241}$Pu, $^{243/244}$Cm

The sample will be labeled for the laboratory to filter the sample prior to analysis if the turbidity at the time of sample collection is greater that 5 NTU. A duplicate sample will not be collected for unfiltered analysis.

Framatome ANP Environmental Laboratory in Westborough, Massachusetts will conduct the radiological analyses.

## 2.5 *SAMPLE SECURITY AND CUSTODY*

Groundwater samples will be submitted to the laboratory under proper chain-of-custody procedures. Non-radiological samples will be preserved on ice or in a refrigerator and radiological samples will be stored at roomSample handling will be documented using chain-of-custody protocols in accordance with *DP-8123, Sample Security and Chain of Custody.*

## 2.6 MANAGEMENT OF INVESTIGATION DERIVED WASTES

All purge water generated during well sampling activities will be containerized on-site. The fluids will be screened for radiological constituents. Following screening YNPS personnel will dispose of the wastes in accordance with the applicable YNPS procedures.

## 2.7 SCHEDULE

The groundwater sampling program is scheduled to begin on 14 July. The existing wells will be sampled initially. Once the new wells are completed, developed and stabilized, they will be sampled. The completion schedule for the new wells is dependent on field conditions, but the wells are expected to be completed by the end of August 2003. Therefore, the baseline groundwater sampling is expected to be completed by the end of September 2003. The wells are listed in the proposed order of sample collection in Table 2.

## 3.0 QUALTIY ASSURANCE AND QUALTIY CONTROL

### 3.1 QUALITY ASSURANCE PROJECT PLAN

A QAPP has been prepared to provide a standard method of assuring that data collected during site characterization activities is of sufficient quality to support future decisions regarding decommissioning activities and or remedial actions at the site. The primary purpose of the QAPP is to describe the means by which data collected in the field will be validated against predetermined standards, ensuring that data meets minimum quality standards prior to being used for decision-making purposes. The flow of data is important to data quality, as it ensures that appropriate project personnel have adequate opportunities to review data with importance to future site decisions. As such, the QAPP specifies the methods and means for ensuring the data generated during site characterization activities serves the purpose of site closure and property transfer.

The following provides a list of the sections of the QAPP that are most relevant to the field sampling activities:

| *QAPP Section* | *Topic* |
|---|---|
| 9.1 | Field Investigation and Documentation Procedures |
| 9.2 | Preparation of Sample Containers |
| 9.3 | Decontamination |
| 9.4 | Field Equipment Usage and Maintenance |
| 10.1 | Sample Tracking System |
| 10.2 | Sample Custody |
| 13.1 | Field Quality Control |

### 3.2 CLEANING AND DECONTAMINATION OF EQUIPMENT

To the degree possible, dedicated and/or disposable sampling equipment will be used for sampling. Non-dedicated sampling equipment used to collect samples will be cleaned and decontaminated prior to its initial use, between each sampling location and after the final use. The following general procedures will be adhered to concerning decontamination efforts:

1. If visual signs such as discoloration indicate that decontamination was insufficient, the equipment will again be decontaminated. If the situation persists, the equipment will be taken out of service until the situation can be corrected.

2. Verification of the non-dedicated sampling equipment cleaning procedures will be documented by the collection of field equipment rinsate blanks, at a frequency in accordance with the QAPP.

3. All properly decontaminated equipment will be stored in aluminum foil or plastic bags during storage and transport.

Decontamination protocols will be strictly adhered to in order to minimize the potential for cross-contamination between sampling locations and contamination of off-site areas. Liquids generated during the decontamination process will be collected, containerized and appropriately labeled for disposal. Waste liquids will be stored on site until determination of potential hazard class and final disposition.

Only pre-cleaned laboratory-certified sample containers will be used. The laboratory will also provide sample coolers, ice packs, trip blanks, and temperature blanks.

More specific decontamination procedures are outlined in the QAPP and SOPs.

## 3.3 *QUALITY ASSURANCE / QUALITY CONTROL SAMPLES*

The following Quality Assurance / Quality Control samples will be collected during the groundwater sampling for nonradiological samples:

- Trip blanks – One trip blank per VOA vial. The trip blanks will be analyzed for VOCs and DRO.
- Temperature blanks – One temperature blank per cooler. The temperature of the trip blank will be measured upon receipt of the cooler at the laboratory.
- Equipment rinsate blank – The majority of groundwater samples will be collected using dedicated sampling equipment. However, where the depth to water is greater than 30 feet, a submersible pump will be used. A rinsate sample will be collected from the pump at a rate of one

sample per 20 sampling locations. The rinsate blanks will be analyzed for the same parameters as the samples that were collected using the equipment.

- Field duplicates – Field duplicates will be collected at the rate of one duplicate per 20 samples. Samples locations where duplicates will be collected are listed in Table 2. Field duplicates will be submitted for the same analyses as the actual sample.
- Matrix spikes – Matrix spikes will be collected at the rate of one matrix spike and one matrix spike duplicate per 20 samples. Samples locations where matrix spikes will be collected are listed in Table 2. Matrix spikes/matrix spikes duplicates will be analyzed for the same analyses as the actual sample.

The following Quality Assurance / Quality Control samples will be collected during the groundwater sampling for radiological samples:

- Field duplicates – Field duplicates will be collected at the rate of one duplicate per 20 samples. Samples locations where duplicates will be collected are listed in Table 2. Field duplicates will be submitted for the same analyses as the actual sample. Three cubi-style containers, two preserved with hydrochloric acid and one unpreserved will be collected for the duplicate sample.
- Matrix spikes – Matrix spikes will be collected at the rate of one matrix spike per 20 samples. Samples locations where matrix spikes will be collected are listed in Table 2. Matrix spike will be analyzed for the same analyses as the actual sample. Three cubi-style containers, two preserved with hydrochloric acid and one unpreserved will be collected for the matrix spike.

## 4.0 PROJECT DOCUMENTATION

Data management tasks pertinent to project documentation and records, laboratory deliverables, data reporting formats, data handling and management, and data review assessment are presented in the QAPP.

The following field sample collection records will be completed at the time of sample collection:

- Field logbook
- Groundwater sampling field logs
- Chain of custody forms
- Shipping records (airbills), if any
- Telephone logs, as appropriate

The project documentation will be provided to the Yankee Environmental Oversight Supervisor at the completion of each sampling event. In addition, any deviations from the FSP will be documented in a memorandum to the Yankee Environmental Oversight Supervisor.

# *Tables*

Table 1 - Groundwater Sampling Locations
Field Sampling Plan
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Location | Date Installed | Appox. Surface Elev. (plant datum) (ft) | Approx. Bottom Screen Interval (ft) | Well Depth (ft) | Depth to Screen Top (ft) | Approx. Top Screen Interval (ft) | Depth to Screen Bottom (ft) | Approx. Well Depth Elevation |
|---|---|---|---|---|---|---|---|---|---|
| B-1 | NE side Fuel Bldg. (RCA) | 14-Dec-77 | 1022.7 | 973.7 | 78.5 | 39 | 983.7 | 49 | 944.20 |
| CB-1 | Inside Fuel Transfer Enclosure (RCA) | 27-Apr-93 | 1021.1 | 996.1 | 25.5 | 15 | 1006.1 | 25 | 995.60 |
| CB-10 | Ion Exchange Pit (RCA) | 19-Dec-97 | 1021 | 1009.5 | 11.5 | 6.5 | 1014.5 | 11.5 | 1009.50 |
| CB-11A | PAB Cubicle Corridor Trench (RCA) | 18-Dec-97 | 1020.5 | 1001.5 | 20 | 9 | 1011.5 | 19 | 1000.50 |
| CB-12 | Ash Dewatering Pit-Waste Disposal Bldg. (RCA) | 10-Dec-97 | 1028.6 | 1022 | 7 | 1.6 | 1027 | 6.6 | 1021.60 |
| CB-2 | North of Office Bldg. (Secondary Side) | 21-Apr-93 | 1014.2 | 989.7 | 25 | 14.5 | 999.7 | 24.5 | 989.20 |
| CB-3 | East of Fire Tank (RCA) | 29-Apr-93 | 1034.3 | 1021.3 | 15 | 3 | 1031.3 | 13 | 1019.30 |
| CB-4 | Old Leach Field (PG&E Property) | 5-May-93 | 978.8 | 959.8 | 20 | 9 | 969.8 | 19 | 958.80 |
| CB-5 | SCFA (South of Plant) | 9-Sep-94 | 1070.4 | 1011.4 | 60.5 | 29 | 1041.4 | 59 | 1009.90 |
| CB-6 | Sherman Spring (PG&E Property) | 13-Sep-94 | 1004.9 | 979.9 | 26 | 15 | 989.9 | 25 | 978.90 |
| CB-7 | PCA Warehouse at WDB wall (RCA) | 7-Jan-97 | 1035.7 | 1018.7 | 17 | 7 | 1028.7 | 17 | 1018.70 |
| CB-8 | North of Old PCA Warehouse (RCA) | 20-Sep-94 | 1035.2 | 1016.2 | 19 | 14 | 1021.2 | 19 | 1016.20 |
| CB-9 | Below VC Equipment Hatch (RCA) | 19-Sep-94 | 1021.2 | 997.2 | 24 | 14 | 1007.2 | 24 | 997.20 |
| CFW-1 | Southeast Construction Fill Area Well | 13-Dec-99 | 1060.2 | 1052.2 | 8 | 3 | 1057.2 | 8 | 1052.20 |
| CFW-2 | Southeast Construction Fill Area Well | 15-Dec-99 | 1072 | 1052 | 20 | 10 | 1062 | 20 | 1052.00 |
| CFW-3 | Southeast Construction Fill Area Well | 15-Dec-99 | 1070.1 | 1036.1 | 34 | 24 | 1046.1 | 34 | 1036.10 |
| CFW-4 | Southeast Construction Fill Area Well | 13-Dec-99 | 1074.5 | 1021.5 | 53 | 43 | 1031.5 | 53 | 1021.50 |
| CFW-5 | Southeast Construction Fill Area Well | 14-Dec-99 | 1033.6 | 1028.6 | 5 | 0.5 | 1033.1 | 5 | 1028.60 |
| CFW-6 | Southeast Construction Fill Area Well | 14-Dec-99 | 1029.6 | 1023.6 | 6 | 1 | 1028.6 | 6 | 1023.60 |
| CFW-7 | Southeast Construction Fill Area Well | 3-Aug-01 | 1070 | 1040 | 30 | 20 | 1050 | 30 | 1040.00 |
| CW-10 | N of Warehouse (Secondary Side) | 8-Jun-98 | 1014 | 984 | 30.5 | 15 | 999 | 30 | 983.50 |
| CW-11 | PAB N side, LP Pump area down gradient of CB-11A (RCA) | 11-Jun-98 | 1022.5 | 1013.5 | 9.5 | 2 | 1020.5 | 9 | 1013.00 |
| CW-2 | W of Safety Injection Tanks (RCA) | 29-Apr-93 | 1032.9 | 1012.9 | 21 | 9 | 1023.9 | 20 | 1011.90 |
| CW-3 | SE of Ion Exchange Pit (RCA) | 3-May-93 | 1034.5 | 1011.5 | 23 | 8 | 1026.5 | 23 | 1011.50 |
| CW-4 | NW of PCA Warehouse (RCA) | 4-May-93 | 1035.5 | 1018.5 | 17 | 7 | 1028.5 | 17 | 1018.50 |
| CW-5 | S of Service Bldg (RCA) | 27-Apr-93 | 1021 | 1004.5 | 21.5 | 6.5 | 1014.5 | 16.5 | 999.50 |
| CW-6 | W of Turbine Bldg (Secondary Side) | 23-Apr-93 | 1018.8 | 996.8 | 24 | 12 | 1006.8 | 22 | 994.80 |
| CW-7 | W of Service Bldg. (Secondary Side) | 13-Sep-94 | 1022.2 | 991.2 | 31 | 21 | 1001.2 | 31 | 991.20 |
| CW-8 | SW Turbine Bldg. interior (Secondary side) | 14-Sep-94 | 1022.6 | 996.6 | 26 | 16 | 1006.6 | 26 | 996.60 |
| MW-1 | South wall PAB exterior (RCA) | 24-Apr-98 | 1034 | 1014 | 21 | 10 | 1024 | 20 | 1013.00 |
| MW-2 | North wall of PAB exterior (RCA), under VC | 24-Apr-98 | 1021 | 1004 | 18 | 7 | 1014 | 17 | 1003.00 |
| MW-5 | N of PAB (RCA), under VC | 13-Oct-99 | 1021 | 1001 | 20 | 10 | 1011 | 20 | 1001.00 |
| MW-6 | NW of SI/DG Bldg, W of VC (RCA) | 14-Oct-99 | 1021 | 1005.5 | 17 | 5.5 | 1015.5 | 15.5 | 1004.00 |
| OSR-1 | Old Shooting Range SE of ISFSI (South of plant) | 22-Oct-97 | 1050.6 | 1037.3 | 13.3 | 3.3 | 1047.3 | 13.3 | 1037.30 |
| MW-100A | East of Alley | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-100B | East of Alley | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-101A | Under South Side of VC | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-101B | Under South Side of VC | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-102A | Under North Side of VC | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-102B | Under North Side of VC | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-103A | Under North Side of VC | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-103B | Under North Side of VC | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-104B | In Road North of Turbine Building | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-105B | Turbine Bay Door | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-106A | By PG&E Dam | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| MW-106B | By PG&E Dam | Pending | Pending | Pending | Pending | Pending | Pending | Pending | Pending |
| Spring | | | | | | | | | |
| Sherman Spring | | | | | | | | | |
| Potable Wells | | | | | | | | | |
| Facility Water Supply | | | | | | | | | |
| Visitor Center Water Supply | | | | | | | | | |

Table 2 - Groundwater Analytical Program
Field Sampling Plan
Yankee Nuclear Power Station
Rowe, MA

| Well Designation | Sample ID | Nonradiological [a] | | | | | | | Radiological [b] | | | | Radiological Sampling Frequency | SCFA Montioring [c] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VOC | SVOC | PCB | Herbicides | DRO | GRO | PP13 Metals | A | B | C | D | | Alkalinity | Barium | Chloride | COD | Cyanide | Iron | Manganese | Nitrate Nitrogen (as Nitrogen) | Sulfate | TDS |
| **Existing Wells** | | | | | | | | | | | | | | | | | | | | | | | |
| CB-4 | CB-4 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CB-4 | CB-4-MS001 | X | X | X | X | X | X | X | | | | | Quarterly | | | | | | | | | | |
| CB-4 | CB-4-MSD001 | X | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| CB-6 | CB-6 | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | |
| CB-6 | CB-6-MS001 | | | | | | | | X | X | X | X | Quarterly | | | | | | | | | | |
| CB-2 | CB-2 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CW-6 | CW-6 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CW-6 | CW-6-FD001 | | | | | | | | X | X | X | X | Quarterly | | | | | | | | | | |
| CW-7 | CW-7 | X | X | X | X | X | X | X | X | X | | | Quarterly | | | | | | | | | | |
| CW-7 | FD001 | X | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| CW-8 | CW-8 | X | X | X | X | X | X | X | X | X | | | Quarterly | | | | | | | | | | |
| CW-10 | CW-10 | X | X | X | X | X | X | X | | X | | | Semi-Annually | | | | | | | | | | |
| CW-5 | CW-5 | X | X | X | X | X | X | X | X | X | | | Quarterly | | | | | | | | | | |
| CB-1 | CB-1 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| B-1 | B-1 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CB-9 | CB-9 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-2 | MW-2 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CB-10 | CB-10 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-5 | MW-5 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-6 | MW-6 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CW-11 | CW-11 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CW-11 | CW-11-MS002 | X | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| CW-11 | CW-11-MSD002 | X | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| CB-11A | CB-11A | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CB-11A | CB-11A-FD002 | | | | | | | | X | X | X | X | Quarterly | | | | | | | | | | |
| CB-11A | FD002 | X | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| CB-11A | CB-11A-MS002 | | | | | | | | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-1 | MW-1 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| CW-3 | CW-3 | X | X | X | X | X | X | X | X | X | | | Quarterly | | | | | | | | | | |
| CB-12 | CB-12 | X | X | X | X | X | X | X | X | X | | | Quarterly | | | | | | | | | | |
| CB-7 | CB-7 | X | X | X | X | X | X | X | X | X | | | Semi-Annually | | | | | | | | | | |
| CW-2 | CW-2 | X | X | X | X | X | X | X | | X | | | Semi-Annually | | | | | | | | | | |
| CB-8 | CB-8 | X | X | X | X | X | X | X | | X | | | Semi-Annually | | | | | | | | | | |
| CW-4 | CW-4 | X | X | X | X | X | X | X | | X | | | Semi-Annually | | | | | | | | | | |
| CB-3 | CB-3 | X | X | X | X | X | X | X | | X | | | Semi-Annually | | | | | | | | | | |
| CB-5 | CB-5 | X | X | X | X | X | X | X | | X | | | Semi-Annually | X | X | X | X | X | X | X | X | X | X |
| OSR-1 | OSR-1 | X | X | X | X | X | X | X | | X | | | Semi-Annually | X | X | X | X | X | X | X | X | X | X |
| CFW-1 | CFW-1 | X | X | X | X | X | X | X | | X | | | Quarterly | X | X | X | X | X | X | X | X | X | X |
| CFW-2 | CFW-2 | X | X | X | X | X | X | X | | X | | | Quarterly | X | X | X | X | X | X | X | X | X | X |
| CFW-3 | CFW-3 | X | X | X | X | X | X | X | | X | | | Quarterly | X | X | X | X | X | X | X | X | X | X |
| CFW-4 | CFW-4 | X | X | X | X | X | X | X | | X | | | Quarterly | X | X | X | X | X | X | X | X | X | X |
| CFW-5 | CFW-5 | X | X | X | X | X | X | X | | X | | | Quarterly | X | X | X | X | X | X | X | X | X | X |
| CFW-6 | CFW-6 | X | X | X | X | X | X | X | | X | | | Quarterly | X | X | X | X | X | X | X | X | X | X |
| CFW-7 | CFW-7 | X | X | X | X | X | X | X | | X | | | Quarterly | X | X | X | X | X | X | X | X | X | X |
| **Spring** | | | | | | | | | | | | | | | | | | | | | | | |
| Sherman Spring | SP 001 | X | X | X | X | X | X | X | | X | | | Quarterly | | | | | | | | | | |
| **Potable Wells** | | | | | | | | | | | | | | | | | | | | | | | |
| Facility Water Supply | DW 001 | X | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| Visitor Center Water Supply | DW 002 | X | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| **Newly Installed Wells** | | | | | | | | | | | | | | | | | | | | | | | |
| MW-100A | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-100B | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-101A | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-101B | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-102A | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-102B | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-102B | FD 003 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-103A | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-103B | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-103B | MS 003 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-103B | MSD 003 | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-104B | MW | X | X | X | X | X | X | X | | X | | | Semi-Annually | | | | | | | | | | |
| MW-105B | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-106A | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| MW-106B | MW | X | X | X | X | X | X | X | X | X | X | X | Quarterly | | | | | | | | | | |
| Total | | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 38 | 54 | 32 | 32 | | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

Notes:
Wells are listed in proposed sample order.
Trip Blanks, Temperature Blanks, and Equipment Rinsate Blanks will be collected and labelled as detailed in the YNPS QAPP.

[a] Nonradiological Parameter Suite:
VOC: Volatile Organic Compound by GC/MS, SW-846 Method 8260B
SVOC: Semi-Volatile Organic Compound by GC/MS, SW-846 Method 8270C
PCB: Polychlorinated Biphenyls by GC, SW-846 Method 8082
Herbicides: Chlorinated Herbicides by GC, SW-846 Method 8151
DRO: Diesel Range Organics by GC, SW-846 Method 8015B
GRO: Gasoline Range Organics by GC, SW-846 Method 8015B
Priority Pollutant 13 Metals

[b] Radiological Parameter Suite:
Category A - Gamma (including $^{60}$Co, $^{134/137}$Cs, $^{54}$Mn, $^{94}$Nb, $^{125}$Sb, $^{152/154/155}$Eu, $^{108m}$Ag)
Category B - Tritium, Gross Alpha/Beta
Category C - $^{14}$C, $^{55}$Fe, $^{63}$Ni, $^{90}$Sr
Category D - $^{241}$Am, $^{238}$Pu, $^{240/239}$Pu, $^{241}$Pu, $^{243/244}$Cm

[c] SCFA Monitoring
Barium by EPA Method 6010B
Manganese by EPA Method 6010B
Iron by EPA Method 6010B
Alkalinity by EPA Method 310.1
Total Dissolved Solids by EPA Method 2540C
Cyanide by EPA Method 9010
Chloride by EPA Method 9056
Sulfate by EPA Method 9056
Nitrate Nitrogen (as Nitrogen) by EPA Method 9056
Chemical Oxygen Demand by EPA Method 5220C

[d] TBD: To be determined

## Table 3 - Groundwater Analytical Program Bottle Requirements
Field Sampling Plan
Yankee Nuclear Power Station
Rowe, MA

| Parameter | Sample Container | Preservation | Holding Time |
|---|---|---|---|
| Alkalinity | (1) 500 ml polyethylene | 4 °C | 14 days |
| TDS | | | 7 days |
| Chloride | | | 28 days |
| Sulfate | | | 28 days |
| Nitrate | | | 48 hours |
| Barium, Manganese, Iron | (1) 500 ml polyethylene- use containers previously supplied for PP13 metals | 4 °C/HNO3 | 6 months |
| COD | (1) 500 ml polyethylene | 4 °C/H2SO4 | 28 days |
| Cyanide | (1) 1 liter polyethylene | 4 °C/NaOH | 14 days |
| Diesel Range Organics | (2) 1 liter amber glass | 4 °C, HCl | 7 days/40 days |
| Gasoline Range Organics | (2) 40 ml VOA vials | 4 °C, HCl | 14 days |
| Herbicides | (2) 1 liter amber glass | 4 °C | 7 days/40 days |
| Polychlorinated Biphenyls | (2) 1 liter amber glass | 4 °C | 7 days/40 days |
| Priority Pollutant Metals | (1) 500 ml polyethylene | 4 °C/HNO3 | 28 days/6 months |
| Radiological Suite A,B, | (1) 4 Liter cubi-containers | HCl | NA |
| Radiological Suite A,B,C,D | (3) 4 Liter cubi-containers | HCl | NA |
| Radiological Suite B | (0.5) 4 Liter cubi-containers | HCl | NA |
| Semi-volatile Organic Compounds | (2) 1 liter amber glass | 4 °C | 7 days/40 days |
| Volatile Organic Compounds | (3) 40 ml VOA vials | 4 °C, HCl | 14 Days |

# *Figures*

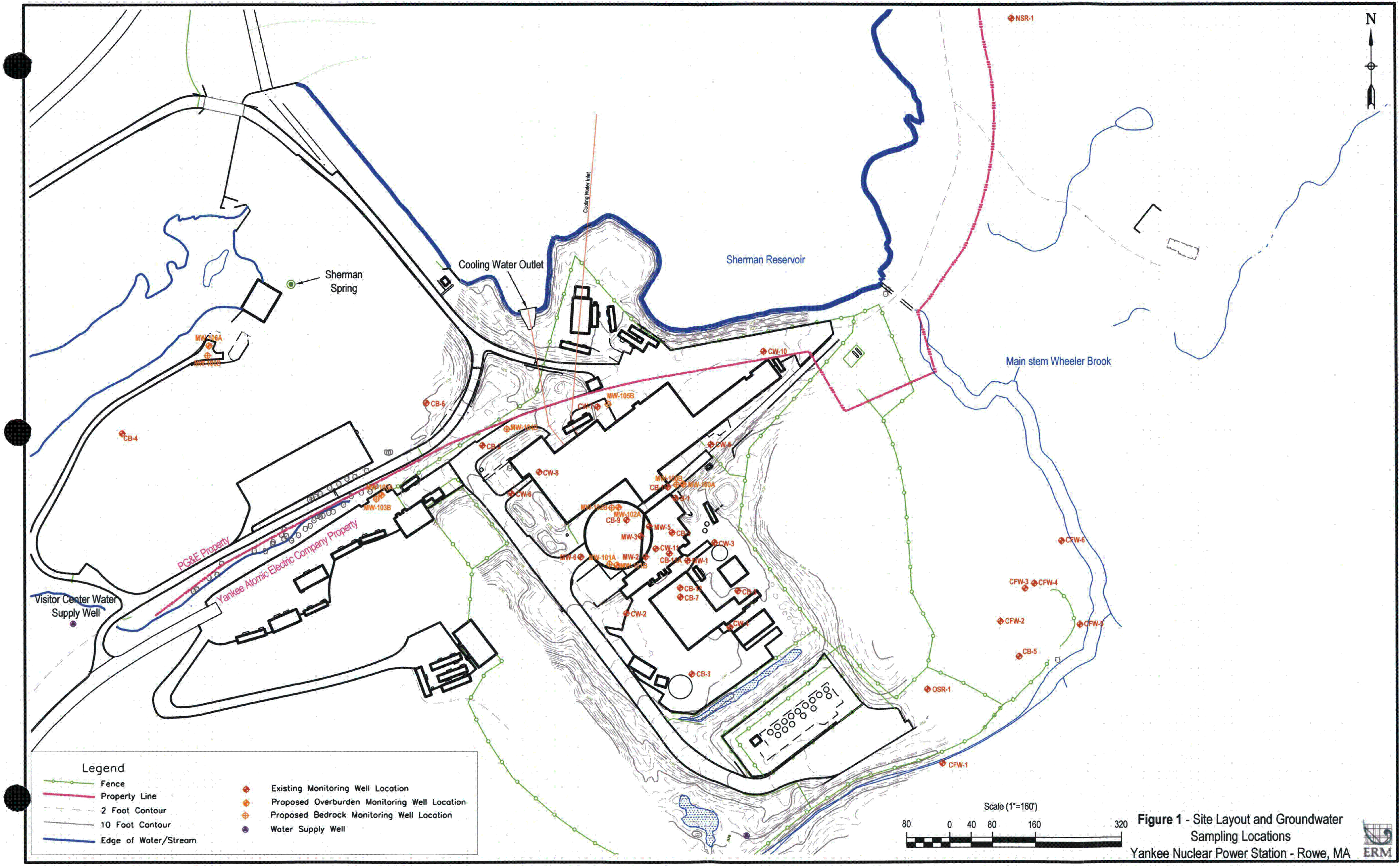


**Figure 1** - Site Layout and Groundwater Sampling Locations
Yankee Nuclear Power Station - Rowe, MA

R:\Yankee Atomic\Yankee Figures.dwg (07/09/03 Boston)

# Appendix A
# Groundwater Sampling Procedures

# *DP-9745 Groundwater Level Measurement and Sample Collection in Observation Wells*

## Attachment C
## Justification for Procedure Change

**Note:** Above and beyond the requirements of AP-0001 the following guidance must be followed to ensure any change made to this procedure does not affect the DQO, Sample Integrity, Sample Validity, Reproducibility of Sampling, or Data obtained.

I. Procedure Number DP-9745 Procedural Step(s) Changed 15, 17 and new step and note after step 17.

Date Required July 14th, 2003

II. Identify the type of procedure change being made:

☒ Change of procedural steps

III. Description of Change:

Step 15 is being changed to 5 NTU from 10 NTU to be consistent with guidance on radiological sampling parameters needed for filtration.

Step 17 is being changed to reflect the fact that not all samples require preservation in a cooler at $4^0$C.

New step after step 17 and the associated note, identify alternate methods of temperature preservation for radiological samples.

These changes are consistent with sample preservation techniques in current practice. The change also addresses the chemical requirements for sample preservation are to be provided by the contract laboratory. The chemical preservation techniques for these samples and the guidance from the change on temperature preservation will provide adequate assurance of sample integrity and reproducibility.

IV. Does the change negatively effect:

| | |
|---|---|
| • The DQOs | NO |
| • The Sample Integrity or Validity | NO |
| • The Reproducibility of Sampling or Data | NO |

V. Approval

Safety Oversight Manager_________ Date___________

## Changes to DP-9745 for Sample Preservation Requirements

Attachment B, "Low Flow Sampling" needs
- A change to step 17,
- A change to step 15, and
- an additional step and note between Step 17 and 18

Insert the following:

Step 15: After the phrase, "...> 10 NTUs, ...", add the following parenthetical statement: "...(for radionuclide analysis this value is > 5 NTUs)". A duplicate sample is not required if turbidity > 5NTU.

Step 17. At the end of the sentence, "Immediately place sample in cooler" add, "..., if required".

New Step. "Samples, which are being analyzed for radionuclides, may be stored in a cool (17-27$^0$ C) dark location for periods up to about one week. Other sample preservation requirements (addition of chemicals) are based on the specific analytical method for the radionuclide being determined. These will be provided by the contract laboratory."

New Note to follow new step: "If samples will be stored for a period of time longer than about one week, refrigeration at 4-6 $^0$ C, should be evaluated."

Proc. No. DP-9745
Rev. No. 7 Major
Issue Date 05/2003
Review Date 05/2008

# GROUND WATER LEVEL MEASUREMENT AND SAMPLE COLLECTION IN OBSERVATION WELLS

## SCOPE

This procedure describes methods for measurement of ground water levels and collection of ground water samples in observation wells. Measurements of ground water levels may be taken independently from sampling. Samples are intended to be analyzed for radiological or nonradiological constituents. There are two methods of sampling described in this procedure. The first is sampling with a Bailer, which may disturb accumulated sediment in the well. The second is low-flow sampling. The objective of low-flow sampling is to collect a representative groundwater sample while minimizing the amount of purge water generated. It also produces a less turbid sample. The low-flow sample technique involves pumping the groundwater at a low flow rate through a flow cell where water quality parameters are monitored until they stabilize, after which a groundwater sample is collected for laboratory analysis. All samples are subject to documentation for transfer to a testing lab as detailed in Reference 1.

## ENCLOSURES

DP-9745 Pgs. 1-2
DPF-9745.1 - Pgs. 1-2 - Rev. 7
DPF-9745.2 - Pg. 1 - Rev. 7
DPF-9745.3 - Pg. 1 - Rev. 7
DPF-9745.4 - Pgs. 1-2 - Rev. 7
Attachment A - Pgs. 1-5 - Rev. 7
Attachment B - Pgs. 1-4 - Rev. 7

## REFERENCES

1. DP-8123, "Sample Security and Chain of Custody"
2. AP-8122, "Subsurface Soil Sampling and Monitoring Well Installation"
3. DP-8120, "Collection of Site Characterization and Site Release Samples"
4. AP-9601, "Yankee Nuclear Power Station Site Characterization and Site Release Quality Assurance Program Plan (QAPP) for Sample Data Quality"
5. ERM New England Low Flow SOP Rev. 2003

## DISCUSSION

Observation wells may be measured for ground water levels and sampled for studies related to site characterization. Typical well construction is shown in DPF-9745.2 (figure 1). Measurements of water levels may be done independently of sampling; however, such level measurements are also required as a preliminary step in well sampling.

Ground water sampling is conducted periodically, as required for study purposes. Wells may be added to or removed from those measured or sampled as investigations continue.

## PRECAUTIONS

1. As listed in Attachment A or B.

## EQUIPMENT AND MATERIALS

1. As listed in Attachment A or B.

## PROCEDURE

1. Use Attachment A for Sampling with a Bailer.

2. Use Attachment B for Low Flow sampling.

**NOTE**: The Bailer method and the low-flow method do not purge the well to the same extent. Using the bailer three (3) well volumes are extracted prior to sampling; using the low-flow method well water is purged until chemical parameters have stabilized. These are two (2) different purge conditions and will not provide reproducible sampling.

3. Proper sample containers and preservatives.

   Prior to sampling, contact the laboratory which will analyze the samples to determine the appropriate sample containers, the necessary volume of sample media that must be collected, and any required preservation methods. Also determine the holding times for each sample to be collected to ensure that samples are not held beyond their prescribed time period prior to analysis. Typical sample containers, volumes, preservation methods, and holding times are provided in Appendix A of DP-8120.

## FINAL CONDITIONS

1. As per Attachment A or B.

# Ground Water Sampling Data

| Well No. | Well Depth (ft) | Well Diam. (in) | Middle of Screen Depth (ft) | Observations/Remarks |
|---|---|---|---|---|
| CB-1 | 25 | 2.5 | 20 | |
| CB-2 | 24.5 | 2.5 | 19.5 | |
| CB-3 | 13 | 2.5 | 8 | |
| CB-4 | 19 | 2.5 | 14 | |
| CB-5 | 60.7 | 2.5 | 45.7 | |
| CB-6 | 25 | 2.5 | 20 | |
| CB-7 | 17 | 2.5 | 12 | |
| CB-8 | 19 | 2.5 | 16.5 | |
| CB-9 | 24 | 2.5 | 19 | |
| CB-10 | 11.5 | 2 | 9 | |
| CB-11A | 19 | 2 | 14 | |
| CB-12 | 6.6 | 2 | 4.1 | |
| CW-2 | 20 | 2.5 | 14.5 | |
| CW-3 | 23 | 2.5 | 15.5 | |
| CW-4 | 17 | 2.5 | 12 | |
| CW-5 | 16.5 | 2.5 | 11.5 | |
| CW-6 | 22 | 2.5 | 17 | |
| CW-7 | 31 | 2.5 | 26 | |
| CW-8 | 26 | 2.5 | 21 | |
| CW-10 | 30 | 2 | 22.5 | |
| CW-11 | 9 | 2 | 5.5 | |
| B-1 | 49 | 4 | 44 | |
| OSR-1 | 13.3 | 2.5 | 8.3 | |
| MW-1 | 20 | 2 | 15 | |
| MW-2 | 17 | 2 | 12 | |
| MW-5 | 20 | 2 | 15 | |
| MW-6 | 17 | 2 | 10.5 | |
| CWF-1 | 8.3 | 2 | 5.8 | |
| CWF-2 | 26.6 | 2 | 21.6 | |

| Well No. | Well Depth (ft) | Well Diam. (in) | Middle of Screen Depth (ft) | Observations/Remarks |
|---|---|---|---|---|
| CWF-3 | 37.8 | 2 | 32.8 | |
| CWF-4 | 54.6 | 2 | 49.6 | |
| CWF-5 | 5.3 | 2 | 3.05 | |
| CWF-6 | 6.1 | 2 | 3.6 | |
| CWF-7 | 30 | 2 | 25 | |

Volume of water in well (VW)

| | | | |
|---|---|---|---|
| 1.5" diameter well | (0.0917 x LWC) | ______________ | (gal) |
| 2.0" diameter well | (0.163 x LWC) | ______________ | (gal) |
| 2.5" diameter well | (0.254 x LWC) | ______________ | (gal) |
| 4.0" diameter well | (0.652 x LWC) | ______________ | (gal) |
| 0.62" micro-well | (0.0157 x LWC) | ______________ | (gal) |

# Ground Water Sampling Data

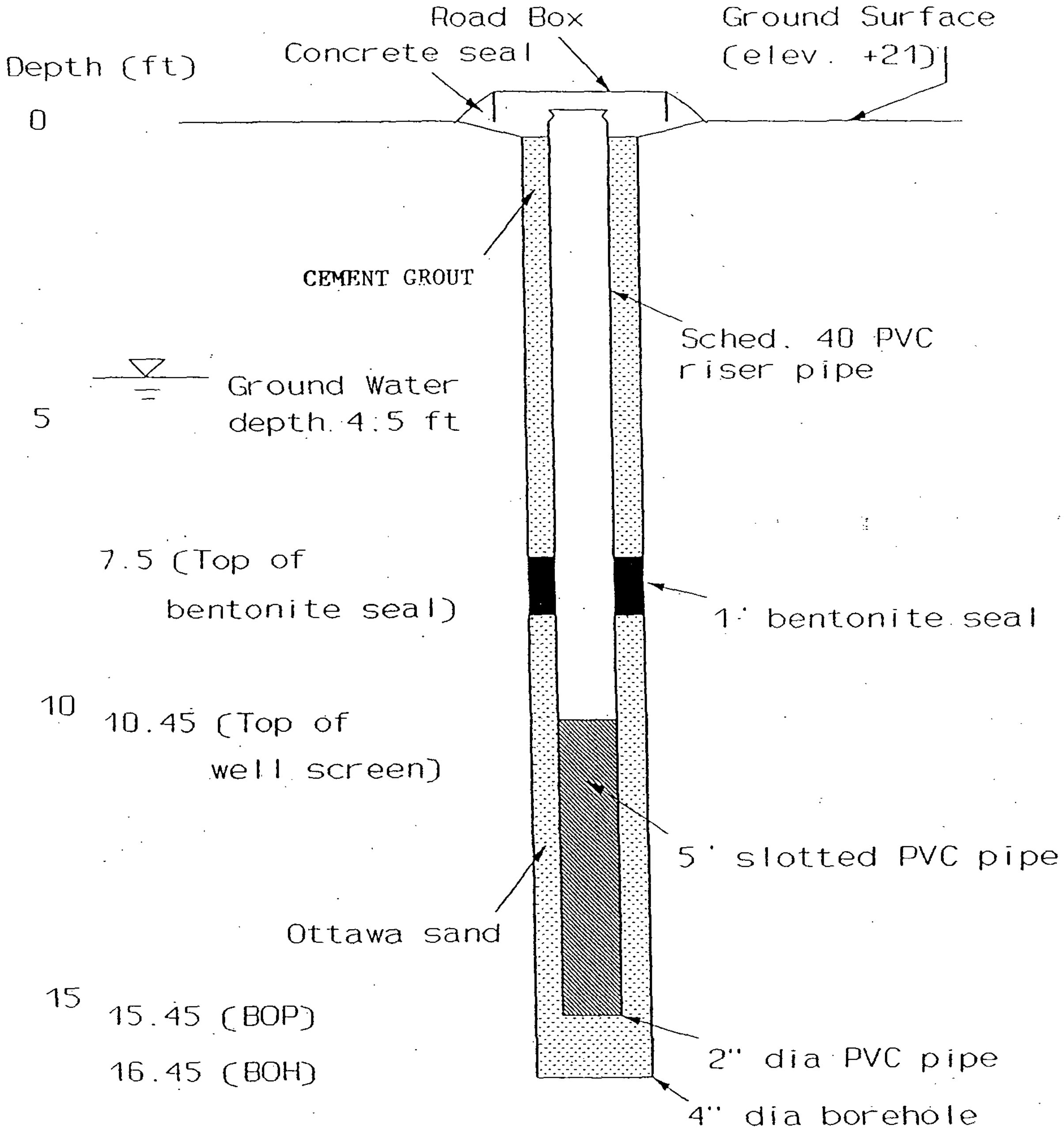
| Well No. | Well Depth (ft) | Well Diam. (in) | Middle of Screen Depth (ft) | Observations/Remarks |
|---|---|---|---|---|
| CB-1 | 25 | 2.5 | 20 | |
| CB-2 | 24.5 | 2.5 | 19.5 | |
| CB-3 | 13 | 2.5 | 8 | |
| CB-4 | 19 | 2.5 | 14 | |
| CB-5 | 60.7 | 2.5 | 45.7 | |
| CB-6 | 25 | 2.5 | 20 | |
| CB-7 | 17 | 2.5 | 12 | |
| CB-8 | 19 | 2.5 | 16.5 | |
| CB-9 | 24 | 2.5 | 19 | |
| CB-10 | 11.5 | 2 | 9 | |
| CB-11A | 19 | 2 | 14 | |
| CB-12 | 6.6 | 2 | 4.1 | |
| CW-2 | 20 | 2.5 | 14.5 | |
| CW-3 | 23 | 2.5 | 15.5 | |
| CW-4 | 17 | 2.5 | 12 | |
| CW-5 | 16.5 | 2.5 | 11.5 | |
| CW-6 | 22 | 2.5 | 17 | |
| CW-7 | 31 | 2.5 | 26 | |
| CW-8 | 26 | 2.5 | 21 | |
| CW-10 | 30 | 2 | 22.5 | |
| CW-11 | 9 | 2 | 5.5 | |
| B-1 | 49 | 4 | 44 | |
| OSR-1 | 13.3 | 2.5 | 8.3 | |
| MW-1 | 20 | 2 | 15 | |
| MW-2 | 17 | 2 | 12 | |
| MW-5 | 20 | 2 | 15 | |
| MW-6 | 17 | 2 | 10.5 | |
| CWF-1 | 8.3 | 2 | 5.8 | |
| CWF-2 | 26.6 | 2 | 21.6 | |

| Well No. | Well Depth (ft) | Well Diam. (in) | Middle of Screen Depth (ft) | Observations/Remarks |
|---|---|---|---|---|
| ✓ CWF-3 | 37.8 | 2 | 32.8 | |
| ✓ CWF-4 | 54.6 | 2 | 49.6 | |
| ✓ CWF-5 | 5.3 | 2 | 3.05 | |
| ✓ CWF-6 | 6.1 | 2 | 3.6 | |
| ✓✓ CWF-7 | 30 | 2 | 25 | |

Volume of water in well (VW)

1.5" diameter well (0.0917 x LWC) ____________________ (gal)
2.0" diameter well (0.163 x LWC) ____________________ (gal)
2.5" diameter well (0.254 x LWC) ____________________ (gal)
4.0" diameter well (0.652 x LWC) ____________________ (gal)
0.62" micro-well (0.0157 x LWC) ____________________ (gal)

## Figure 1.
## Typical Detail of Observation Well

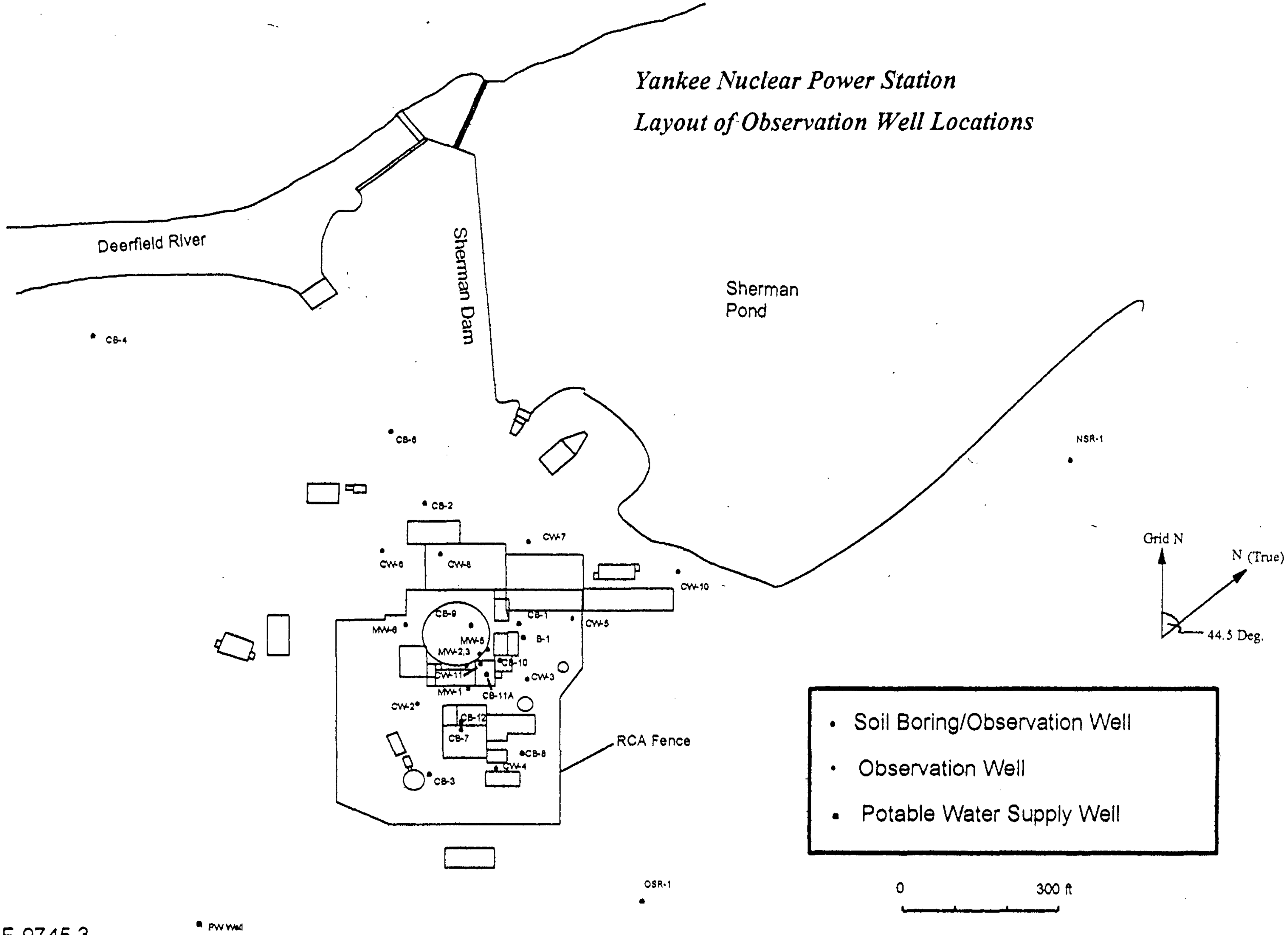


Date of installation:
Contractor:

Figure 2

*Yankee Nuclear Power Station*

*Layout of Observation Well Locations*



Sample Location____________________ Well Designation________________

Sampling Team____________________ Date__________Time__________

Sherman Pond Level________________

Measuring Point______________ Diameter of Well__________(in)

Well Depth (from measuring point) (D) ________________(ft)

Depth to water (DTW) ________________(ft)

Length of water column (LWC) ________________(ft) (LWC=D-DTW)

Volume of water in well (VW) ________________gal

Volume of purge (VTP) (VTP = VW x 3) ________________(gal)

**NOTE**: See DPF-9745.1 for well conversion factors to calculate volume of water in well (VW).

Color____________________ Odor____________________

Total volume purged________________ Duration of purging________________

Purging method________________ Did well go dry?________________

Weather conditions________________

Time of measurements________________

pH____________ (pH units) Conductivity________________(µS/cm)

Temperature________________(°C) TDS____________________(ppm)

File # __________

| Time: (min) | DTW: (feet) | Comments: | Temp (°C) | Cond (uS/cm) | DO (mg/L) | pH (std units) | ORP mV | Turb NTU |
|---|---|---|---|---|---|---|---|---|
|  |  |  | +/- 3% | +/- 3% | +/- 10% | +/- 0.1 unit | +/- 10 mV | +/- 10% |
| 0:00 |  |  |  |  |  |  |  |  |
| 5:00 |  |  |  |  |  |  |  |  |
| 10:00 |  |  |  |  |  |  |  |  |
| 15:00 |  |  |  |  |  |  |  |  |
| 20:00 |  |  |  |  |  |  |  |  |
| 25:00 |  |  |  |  |  |  |  |  |
| 30:00 |  |  |  |  |  |  |  |  |
| 35:00 |  |  |  |  |  |  |  |  |
| 40:00 |  |  |  |  |  |  |  |  |
| 45:00 |  |  |  |  |  |  |  |  |
| 50:00 |  |  |  |  |  |  |  |  |

| Time: (min) | DTW: (feet) | Comments: | Temp (°C) | Cond (uS/cm) | DO (mg/L) | pH (std units) | ORP mV | Turb NTU |
|---|---|---|---|---|---|---|---|---|
| | | | +/-<br>3% | +/-<br>3% | +/-<br>10% | +/-<br>0.1 unit | +/-<br>10 mV | +/-<br>10% |
| 55:00 | | | | | | | | |
| 60:00 | | | | | | | | |
| 65:00 | | | | | | | | |
| 70:00 | | | | | | | | |
| 75:00 | | | | | | | | |
| 80:00 | | | | | | | | |
| 85:00 | | | | | | | | |
| 90:00 | | | | | | | | |
| 95:00 | | | | | | | | |
| 100:00 | | | | | | | | |

Sampling Time:

Samples Collected: Analysis Requested: Preservative: Holding Time: Lab:

# ATTACHMENT A

## SAMPLING WITH A BAILER

### DISCUSSION

This attachment is used when sampling ground water wells using a Bailer, which may disturb accumulated sediment in the well. If a less turbid sample is desired, Attachment B "Low Flow" sampling may be used.

### PRECAUTIONS

1. Unless sample analysis history indicates otherwise, samples from each well should be handled as if contaminated with radionuclides and hazardous constituents. Such handling is necessary to protect the health and safety of the sampler. Relevant measures to prevent cross contamination of other samples should always be used.

2. Although the known concentrations of radionuclides in groundwater of some wells are very low, samplers should exercise prudent precautions whenever a potential exists of coming into contact with ground water (i.e., during well purging and collection of samples).

3. To ensure sample integrity, samplers must exercise extreme care to prevent contaminants from being inadvertently introduced into sampling containers. This will require the sampler to wear new latex or nitrile gloves while collecting samples, and never touch the inside surface of sample containers or caps. If caps fall on the ground during sampling, a new sample container or cap must be used.

4. To prevent radiological contamination of a sample ensure that a new or a designated apparatus is used for the addition of preservatives. A designated apparatus is one restricted for use with environmental samples only.

### EQUIPMENT AND MATERIALS

The following equipment and materials are needed for water level monitoring:

- Electronic water level meter
- Procedure form for documenting data and comments
- Clean cloth or paper towels
- Key(s) for any locked well covers
- Polyethylene sheet
- One gallon of deionized or distilled water

The following equipment and materials may be needed for water sampling:

- Sampling procedure
- Bailer
- String or Rope
- Several gallons of deionized or distilled water
- Peristaltic pump
- Electric drill with peristaltic pump attachment
- Portable generator
- Procedure forms for documenting data and comments, DPF-9745.1
- Sample containers
- Preservatives
- Buckets or drums to hold the purged ground water
- Cooler with ice for storing samples
- Leather work gloves
- Latex gloves
- Sharpie
- Garbage bag for trash

## PROCEDURE

A. Sherman Pond Level Determination (only for use at YNPS)

The level of Sherman Pond shall be obtained from Harriman Station whenever water level measurements are taken independently, or are associated with sampling. This information is obtained by contacting the operator at Harriman Station at (802) 423-5437. For consistency, the reading requested shall be the 0800 hours reading for the day the water level measurements are obtained, and entered onto DPF-9745.4. Data may be obtained as an elevation or as a measure of "feet above the crest (of the spillway)." Spillway crest elevation is 1103.7 feet (USGS).

B. Measurement of Ground Water Depth

1. Observe the area surrounding the well, and the well itself, and note if any unusual condition exists, such as ground staining from possible oil or gasoline spills, or damage to the well. If an unusual condition exists, do not proceed further with that well. Indicate the condition in the observations section of DPF-9745.4 and notify the assigned site personnel. Assigned Site Personnel means Safety Oversight personnel or designee.

2. Open the well cover and uncap the PVC pipe taking care not to introduce any foreign material into the well. Place the cap on a polyethylene sheet.

3. Turn the electric water level meter on (placing the end of the probe in clean water will ensure the sound indicator is working).

4. Slowly lower the probe into the well and continue lowering until the sound indicates that contact with the water has been achieved.

5. Repeat raising and lowering the probe via the cable using slight movements while listening to the indicator until the water level surface in the well can be determined to the nearest 0.1 feet. The measurement is taken at the notch filed on the top of the casing/road box or PVC pipe as recorded.

6. Record the ground water depth on DPF-9745.4, and the time the measurement was obtained.

7. Withdraw the cable from the well and wipe down the cable and probe using a clean cloth. Wash and rinse the probe and length of cable that came into contact with the groundwater with deionized water. Place a new latex glove or aluminum foil over the probe to prevent it from becoming contaminated.

8. If sampling is not to be conducted, close and lock the well when a lock is present.

C. Purging the ground water to prepare for sample collection

**NOTE**: The collection of groundwater samples requires that three well volumes of ground water be removed prior to sampling to ensure that samples are representative of the ground water aquifer. A well volume is defined as that amount of standing ground water in the PVC well in addition to the amount of water within the sand-packed annulus surrounding the PVC well. DPF-9745.1 provides depths and diameters for all wells which will be used on DPF-9745.4 to calculate purge volumes. The following steps describe the process for purging observation wells.

1. Spread a clean, unused polyethylene sheet on the ground and retain the Bailer, string, electronic water level meter, and sample bottles on the sheet during sampling. If the generator is being used for well volume purging, ensure that the generator, and any oil or gasoline do not come into contact with any of the sampling equipment or plastic sheeting. Place the generator downwind at least 20 feet away during operation.

2. Measure the ground water level as described in Section A or Section B of this procedure, and record on DPF-9745.4. Using DPF-9745.4, calculate the required purge volume and record.

3. The well may be purged using a Bailer or electric pump. If a Bailer is used, ensure the Bailer is dedicated or has been decontaminated prior to use, and that new string has been attached. If a pump is used, ensure that new hose, or hose dedicated to that well, is used.

4. Purge the volume of ground water from the well as indicated on DPF-9745.4, collecting the purge water in a 55 gallon drum or other suitable container.

5. If the well pumps dry, and does not recharge in a reasonable amount of time (about 15 minutes), do not attempt to achieve the calculated purge volume. Sampling may commence on the second withdrawal of ground water, i.e., pump the well dry at least once prior to collecting samples.

6. Record the actual volume of ground water purged from the well, the duration of purging, the purging method, and note if the well went dry on DPF-9745.4.

7. Record the color and odor if any on DPF-9745.4.

8. If purge water is not immediately disposed of, label the purge water drum or container with the date, well number, and the words "Observation Well Purge Water." The purge water must be disposed of as directed by the Radiation Protection or Plant Chemistry Department.

**NOTE**: Purge water from wells inside the RCA will be disposed by pouring down an approved radioactive liquid drain. However, the disposal method for purge water should be based on prior characterization results of radiological and nonradiological contaminants.

D. Collection of ground water samples

**NOTE**: Samples must be obtained using new or clean (decontaminated using the steps in Section E of this procedure) Bailer or tubing. The sampler must be wearing latex or nitrile gloves that must be changed between wells.

**NOTE**: Not all wells may require collection. Sampling needs will be determined by the Site Characterization Supervisor.

1. Select the sample containers to be filled. Only one container should be uncapped and filled at a time.

**NOTE**: Information regarding typical sample containers, volumes and preservatives are provided in Appendix A of DP-8120. However, specific information should be obtained from the laboratory performing the analyses prior to sample collection.

2. Lower the Bailer into the well and allow it to fill. Withdraw the Bailer by the string, coiling the string on the plastic, or maintaining in the hand so it does not come into contact with the ground.

**NOTE**: If the Bailer was used to purge the well, additional decontamination is not required prior to collection of the sample.

3. When the Bailer has been retrieved, empty the Bailer such that the contents enter the sample container. Special handling procedures may be required depending upon the analysis. Continue filling the Bailer and emptying the contents into the sample containers following the procedures below until the desired volume is achieved.

a. Samples collected for Volatile Organic Compounds (VOC) Analysis

Samples collected for volatile organic compounds analysis must be devoid of all air including bubbles, and the sample must not be aerated during sample collection. In addition, the preservative must be in the VOC container prior to sampling. Slowly fill the container from a steady flow of water from the Bailer. To ensure that no bubbles are present in the sample container, fill the container until a meniscus is present then cap the jar and turn it upside down. Lightly tap the jar on your hand to dislodge any bubbles. If any bubbles are observed, open the jar, dislodge air bubbles by adding small amounts of well water until all air is eliminated.

b. Samples collected for radiological and nonradiological metals analysis

Separate sample containers are collected for radiological and nonradiological metals analysis. Radiological and nonradiological samples are collected in a glass or plastic container and acidified prior to shipment to the lab.

c. Samples for other analysis

Samples may also be collected for other analysis such as semi-volatiles, herbicides, cyanide, etc. The sampler must follow the specific procedures prescribed by the analytical laboratory. Samples for tritium and $^{14}$C are collected in a separate container from the other radionuclides and is not acidified.

4. Label each sample container with the well number, sampler's initials, date and time of sample collection, analysis requested, preservatives, if any, and the project name.

5. For samples collected for site characterization and Final Status Survey purposes, follow DP-8123 by entering the data onto the Chain-of-Custody form DPF-8123.1 and place the sample container into the sample carrier. The Chain-of-Custody form must stay with the sample. Logbook documentation should be provided for samples collected for information or screening purposes.

**NOTE**: Some samples may require storing at 4 to 6 degrees Celsius. If this is the case, refrigerate and/or use a cooler with ice packs for sample storage and shipment.

6. When all the samples for the well have been collected, place the cap back onto the well, and close and lock the road box, when applicable.

7. At the end of the sampling period, bring the samples to the designated storage location and place a custody seal over each sample container with initial and date and store at 4°C if applicable. Relinquish the samples via the Chain-of-Custody form. Indicate the samples collected at each well on DPF-9745.4.

8. A copy of the Chain-of-Custody form DPF-8123.1, and any other QA samples are included in the shipment of samples to the analytical laboratory.

9. Ship appropriate samples in a cooler with sufficient ice to maintain the samples at 4°C.

E. Decontamination of the sampling equipment.

1. While wearing latex or nitrile gloves, perform the following decontamination steps for the Bailer:

    a. Remove any string from the top fitting and discard. Remove the top and bottom Nalgene fittings and place them into a bucket filled with clean water.

    b. Place the Bailer in a bucket containing deionized or distilled water, and scrub the inside and outside of the Bailer with a long test tube brush . After thoroughly cleaning the inside and outside of the Bailer, pour clean deionized or distilled water over and through the Bailer for a complete rinsing, collecting the rinse water in a bucket.

    c. Using a brush, clean the bottom and top fittings thoroughly, finishing with a rinse of clean deionized or distilled water, and place the fittings back onto the Bailer.

    d. If the Bailer is not intended for immediate use after decontaminating, wrap the Bailer in new aluminum foil or bags to prevent it from getting contaminated, and store for future use.

    e. Dispose of the decontamination water in the well's purge water drum, and remove and dispose of the latex gloves.

F. For nonradiological samples only, when all the samples have been collected using a common Bailer (i.e., all wells to be sampled have been completed) rinsate samples of the Bailer must be obtained to demonstrate the efficacy of the decontamination method. This is accomplished by performing the following:

    a. Using the Bailer that has been decontaminated, remove the top fitting and fill the Bailer with deionized water.

    b. Pour the water from the Bailer into sample containers similar to those that were collected for ground water analysis, representing the same suite of contaminants.

    c. Label and manage the rinsate samples the same as the ground water samples, with the exception that they are labeled as "Bailer Rinsate" samples in place of "Well No."

## FINAL CONDITIONS

1. Well covers have been secured.

2. Trash has been properly disposed.

3. Ground water sampling field log has been completed.

4. Equipment has been deconed and ready for reuse.

5. Samples are sealed and secured in accordance with DP-8123, Sample Security and Chain of Custody procedure.

# ATTACHMENT B

## LOW FLOW SAMPLING

### DISCUSSION

This Attachment is used when sampling ground water wells using Low Flow sampling. When water turbidity is not a concern, Attachment A using a Bailer may be employed.

### PRECAUTIONS

1. Unless sample analysis history indicates otherwise, samples from each well should be handled as if contaminated with radionuclides and hazardous constituents. Such handling is necessary to protect the health and safety of the sampler. Relevant measures to prevent cross contamination of other samples should always be used.

2. Although the known concentrations of radionuclides in groundwater of some wells are very low, samplers should exercise prudent precautions whenever a potential exists of coming into contact with ground water (i.e., during well purging and collection of samples).

3. To ensure sample integrity, samplers must exercise extreme care to prevent contaminants from being inadvertently introduced into sampling containers. This will require the sampler to wear new latex or nitrile gloves while collecting samples, and never touch the inside surface of sample containers or caps. If caps fall on the ground during sampling, a new sample container or cap must be used.

4. To prevent radiological contamination of a sample ensure that a new or a designated apparatus is used for the addition of preservatives. A designated apparatus is one restricted for use with environmental samples only.

### EQUIPMENT AND MATERIALS

- Adjustable-rate, low-flow, peristaltic pump (for water depth less than 28 feet)
- Adjustable-rate, low-flow, submersible or bladder pump (for water depth greater than 28 feet)
- Silicone tubing for peristaltic pump
- Teflon tubing, if dedicated to the well
- Polyethylene tubing, if one-time sampling
- Polyethylene sheeting
- In-line, flow-through cell equipped with pH, ORP, dissolved oxygen (DO), specific conductivity and temperature electrodes (YSI 600 XL)
- Calibration solutions for pH, conductivity and ORP
- LaMotte 2020 Turbidimeter and 10 NTU calibration standard
- "T" fitting for collecting turbidity samples
- Electronic water-level indicator or equivalent (marked in 0.01-foot increments)
- Logbook and sampling forms
- Sampling gloves
- Well and site keys
- Groundwater sampling procedure, DP-9745
- Site plan showing well locations
- Chain-of-custody documentation, DP-8123
- Glassware
- Coolers and ice
- Decon materials
- PPE Equipment
- Graduated cylinder
- Stop watch
- Five-gallon buckets
- Funnel
- Power inverter or gas powered generator
- Extension cord
- Ziplock bags

## PROCEDURE

### A. Sherman Pond Level Determination (only for use at YNPS)

The level of Sherman Pond shall be obtained from Harriman Station whenever water level measurements are taken independently, or are associated with sampling. This information is obtained by contacting the operator at Harriman Station at (802) 423-5437. For consistency, the reading requested shall be the 0800 hours reading for the day the water level measurements are obtained, and entered onto DPF-9745.4. Data may be obtained as an elevation or as a measure of "feet above the crest (of the spillway)." Spillway crest elevation is 1103.7 feet (USGS).

### B. Measurement of Ground Water Depth

1. Observe the area surrounding the well, and the well itself, and note if any unusual condition exists, such as ground staining from possible oil or gasoline spills, or damage to the well. If an unusual condition exists, do not proceed further with that well. Indicate the condition in the observations section of DPF-9745.4 and notify the assigned site personnel. Assigned Site Personnel means Safety Oversight personnel or designee.

2. Open the well cover and uncap the PVC pipe taking care not to introduce any foreign material into the well. Place the cap on a polyethylene sheet.

3. Turn the electric water level meter on (placing the end of the probe in clean water will ensure the sound indicator is working).

4. Measure the depth to water with an electronic water-level device from the top of the casing and record the measurement in the logbook and on the sampling form DPF-9745.4. Refer to Attachment A Section B4-B6 for level measurement instructions. Obtained well depth from DPF-9745.1 and record on sampling form DPF-9745.4.

5. Calibrate dissolved oxygen sensor to the barometric pressure on the day of sampling. Recalibrate the dissolved oxygen sensor to reflect any changes in barometric pressure during the sampling day (i.e., weather fronts).

6. Set up YSI 650MDS to data log field parameters during the low-flow pumping. Create a file name to match the well ID, record the filename on sampling form DPF-9745.4.

7. Attach and secure the tubing to the low-flow pump. Slowly and carefully lower the pump into the well. It is imperative that disturbance of water in the well casing be minimized. This will ensure a minimal time for equilibration prior to continuing the sampling process.

8. The pump or tubing intake should be set at approximately the middle of the screen by pre-measuring the length of tubing to the desired length. Refer to DPF-9745.1 for well screen information. Start purging the well at the lowest possible rate. Avoid surging. Observe air bubbles displaced from the discharge tube to assess progress of steady pumping until water arrives at the surface. Record the start time on sampling form DPF-9745.4.

**NOTE:** For sampling bedrock wells with an open borehole and a known water-bearing fracture, place pump or tubing intake at the depth of the fracture of interest. Avoid placing the pump intake less than 2 feet above the bottom of the well as this may cause mobilization of sediment present in the bottom of the well. Start purging the well at the lowest possible rate. Avoid surging. Observe air bubbles displaced from the discharge tube to assess progress of steady pumping until water arrives at the surface. Record the start time on sampling form DPF-9745.4.

9. The water level in the well should be monitored during purging, and ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well. (The water level should stabilize for the specific purge rate.) There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water on the low-flow sampling form. Purge rates should, if needed, be decreased to the minimum capabilities of the pump to avoid affecting well drawdown. The well should not be purged dry. If the recharge rate of the well is so low that the well purges dry, the sample should be collected two hours after purging and after enough water has recharged the well to fill the necessary sample bottles.

10. During well purging, use the flow-through cell to monitor the field parameters every 3 to 5 minutes. Collect turbidity samples through the "T" fitting upstream of the flow cell every 3 to 5 minutes and record on the low-flow sampling form. Record the field parameters on the low-flow sampling form in addition to using the YSI 650MDS data logging capabilities. Record the water level every 3 to 5 minutes. Record any odors and visual observations (i.e., water color) on the low flow form. The color should represent the final color of the water sampled and not the initial water pumped during purging. If the field parameters fail to stabilize within two hours, contact the supervisor for further instructions.

11. A sample will be collected when either of the criteria (A or B or C) listed below occur:

    a. Stabilization is achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

       Temperature (+/- 3%);
       Specific conductance (+/- 3%);
       pH (+/- 0.1 unit);
       Turbidity (+/- 10% for values greater than 10 NTU);
       Dissolved Oxygen (10%);
       ORP/Eh (+/- 10 millivolts).

    b. Three well volumes have been purged regardless if the meter readings have stabilized.

    c. If the well purges dry in a low permeable formation, allow two hours to pass for the well to recharge enough water to fill the necessary sample bottles.

12. Prior to sampling, disconnect the discharge tubing from the turbidity "T" valve. Water samples should not be collected downstream from the flow-through cell. Continue pumping while flow-through cell is disconnected.

13. The sampling flow rate should not exceed 250 ml/min. If the well was purged at a higher rate, pump lines are to be cleared using a flow rate less than 250 ml/min prior to sample collection for VOCs.

14. Once the field parameters have stabilized, collect the samples directly from the end of the discharge tube. The order of sample collection is:

    a. volatile organic compounds (VOCs),
    b. volatile gases (methane, ethene, ethane),
    c. semivolatile organic compounds (SVOCs),
    d. TPH,
    e. Metals (see item 15), and
    f. general groundwater parameters.

15. If final sample turbidity for sample is >10 NTUs, mark the sample container and Chain of Custody sheets for this sample to be filtered prior to analysis by the laboratory. A separate sample should be shipped (i.e., a duplicate) which should not be filtered.

16. Duplicate and split samples should be collected within series (i.e., VOC sample-VOC duplicate; VOC sample-VOC split sample).

17. All sample bottles should be filled by allowing the water from the discharge tube to flow gently down the inside of the bottle with minimal turbulence. Cap each bottle as it is filled. Immediately place sample in a cooler. Record sample completion time on the low flow sampling form and chain-of-custody form DPF-8321.1.

18. The pump assembly should be carefully removed from the well. The tubing should be dedicated and remain in the well or stored in a bag and properly labeled.

19. Measure and record the depth to the bottom of the well and note any evidence of sediment accumulation in the well.

20. Close and lock the well.

**Decontamination Procedures**

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well.

For non-peristaltic pump use, due to the fact that the tubing is dedicated to the well, the pump will be pulled from the well and the tubing removed. The pump will be disassembled and the disposable bladder removed. The pump body will then be scrubbed thoroughly with mixture of de-ionized water and a low phosphate, laboratory grade detergent (i.e., Alconox). The pump will then be double rinsed with de-ionized water.

The water level meter will be decontaminated and silicone tubing replaced at each well. All parts of the equipment coming in contact with groundwater will be decontaminated by scrubbing thoroughly with mixture of de-ionized water and a low phosphate, laboratory grade detergent (i.e., Alconox). The parts will then be double rinsed with de-ionized water.

## FINAL CONDITIONS

1. Well covers have been secured.
2. Trash has been properly disposed.
3. Ground water sampling field log has been completed.
4. Equipment has been deconed and ready for reuse.
5. Samples are sealed and secured in accordance with DP-8123, Sample Security and Chain of Custody procedure.

# *DP-8123 Sample Security and Chain of Custody*

Proc. No. DP-8123
Rev. No. 9
Issue Date 04/2003
Review Date 05/2007

# SAMPLE SECURITY AND CHAIN OF CUSTODY

## SCOPE

This procedure addresses sample security and chain of custody for samples collected under the procedures cited in References 1 - 7. This includes collecting radiological or non-radiological samples, site characterization samples, as well as other site samples. The sample security portion applies to all such samples. The chain of custody portions apply only to samples that are analyzed off-site.

## ENCLOSURES

DP-8123 - Pgs. 1-6
DPF-8123.1 - Rev. 7

## REFERENCES

1. DP-8120, "Collection of Site Characterization and Site Release Samples"
2. DP-8121, "In-Plant Radiological Surveys to Support the Characterization Program"
3. DP-8122, "Subsurface Soil Sampling and Monitoring Well Installation"
4. DP-8124, "Collection of Pond Sediment Samples for Site Characterization"
5. DP-9725, "Potable Water Quality Monitoring"
6. DP-9745, "Ground Water Level Measurement and Sample Collection in Observation Wells"
7. DP-8813, "Sample Receipt and Preparation"

## DISCUSSION

To ensure the integrity of a sample and the defensibility of its analytical results, its chain of custody should be documented. For samples analyzed off-site, this is done with the chain of custody form. For samples analyzed at the YNPS site, this is done by logging samples in and out of each on-site facility (see DP-8813). Where a sample is tracked first on one system (e.g., the Sample Log), then on another (e.g., chain of custody form), the sample's custody should be traceable, without any gaps, across both systems.

Also important is to ensure the integrity of the sample's security. Proper security will prevent or minimize sample loss, tampering and inadvertent mishandling.

## PROCEDURE

A. Initiation of Chain of Custody Form

1. A Chain of Custody Form (DPF-8123.1) shall be initiated by the sample collector for all site characterization and other site samples that are analyzed offsite. Multiple samples may be included on a single form.
2. The sample collector shall initiate the Chain of Custody Form (DPF-8123.1) at the time of collection. Radiological samples that have been tracked in accordance with DP-8813 [7] may have their Chain of Custody Form initiated just prior to shipment off-site.

3. The sample collector shall fill out DPF-8123.1, and sign and date the form, using the guidance found in Appendix A. Ensure that the information entered on the sample container is the same as that entered on DPF-8123.1.

4. Note the chain of custody form number (found at the top of DPF-8123.1,) in the Field Log Book (if one is used).

5. Once a Chain of Custody Form has been initiated, the original copy of the form shall stay with the sample(s), at least until such time as described in Step B.3.

6. When an additional chain of custody form is to be initiated for a sample that is already on a chain of custody form (e.g., the sample has been split and each aliquot is to be sent to a different analytical laboratory), a notation shall be made in the "Comment" column on each form cross-referencing the two form numbers.

B. Transfer of Sample Custody

<u>NOTE</u>: Relinquishing custody of a sample is not required when the sample is transferred among members within any laboratory or count room, or between Chemistry, HP, or Environmental sample collectors and the site countroom or laboratory analysis.

1. When the sample collector turns the sample over to another individual (e.g., the Safety Oversight Department staff or the YNPS Sample Prep Trailer), that individual shall sign the first "Received by" block, including the date and time of receipt.

2. Each time the sample(s) changes custody, the relinquishing party and the receiving party shall sign and date the form within the next available location.

3. The analytical laboratory shall be instructed to return the white page of the completed Chain of Custody Form (DPF-8123.1) to the contact name on the form along with the analytical results.

4. The completed DPF-8123.1 shall be reviewed and filed by the contact person or his/her designee as part of the data package.

C. Use of Commercial Couriers

1. Just prior to turnover to a commercial courier, relinquish the samples by date and time of shipment and signature on DPF-8123.1.

2. Note in the "Sample Shipped Via" location on DPF-8123.1 the courier utilized if applicable and the Bill of Lading number which is printed at the top of each air bill in bold black numbers.

   <u>NOTE</u>: A "Received By" signature is not required until receipt by the analytical lab.

3. Remove and retain the rear-most carbon copy of DPF-8123.1.

4. Seal the original DPF-8123.1 in the container along with the samples.

5. When the original signed DPF-8123.1 returns from the analytical lab, attach the air bill and file with sample results.

6. The completed DPF-8123.1, with air bill and rear most carbon copy shall be reviewed and filed by the contact person or his/her designee as part of the data package.

D. On-Site Sample Security

1. Following sample collection, the sample collector shall do one of the following, in accordance with the transfer of custody requirements in this procedure:

   - Deliver the sample(s) to an on-site facility (e.g., sample preparation lab or count room);
   - Deliver the sample(s) to an off-site lab (either directly or by turning over to a courier);
   - Store the sample(s) in a secure manner (see below) until the sample(s) is delivered to the on-site sample preparation facility or count room, or until the sample(s) is sent to an off-site laboratory.

2. At any time following field collection, samples must be stored in a secure manner, which shall include one or more of the following:

   - Direct physical control or under direct visual observation by an individual;
   - Storage in a locked container, locked cabinet (e.g., refrigerator),or individual locked transport box (e.g. for concrete cores).
   - Storage in a locked room or building having limited access (e.g., the YNPS Sample Prep Trailer);
   - Tamper evident seal on the sample container. A single tamper evident seal may be used on a single container (e.g., cooler) containing multiple samples.

   <u>NOTE</u>: Smear samples shall be considered secure when loaded on a planchet rack in the Radiation Protection count room. (Tamper evident seals shall not be applied to planchet racks.) All samples shall be considered secure while on a detector in the Radiation Protection or Chemistry count room.

## <u>FINAL CONDITIONS</u>

1. Original chain of custody forms (DPF-8123.1) have been completed and filed for all samples as identified in this procedure's "Scope". Ensure completed DPF-8123.1 is transferred to the applicable data package. Commercial courier receipts or bills of lading, if applicable, are also filed.

2. Samples that are on-site are stored in a secure manner.

## APPENDIX A

## FILLING OUT CHAIN OF CUSTODY FORMS

### SCOPE

This appendix describes in detail the proper completion of the Chain of Custody Form (DPF-8123.1). The actual use of the form is described in the body of this procedure (DP-8123).

### PROCEDURE

NOTE: All entries shall be made in black ink.

NOTE: Some entries on DPF-8123.1 may not apply to a particular sample. In such cases, an entry of "NA" (i.e., "Not Applicable") is acceptable.

NOTE: Multiple samples may be included on a single Chain of Custody form (DPF-8123.1). Multiple samples may be shipped in a single container with the only tamper evident seal(s) being on the outside of the container.

NOTE: Each chain of custody form has a unique number pre-printed in the upper right hand corner.

A. Fill out the following header information:

1. Project Name - For YNPS purposes, designate YNPS and project type. (Example for Site Characterization "YNPS S.C.")

2. YAEC Contact Name & Phone - Generally the lead or cognizant person. Use at least the first initial and full last name (e.g., "J. Smith, 413-424-XXXX").

3. Analytical Lab - The name of the analytical laboratory, with city and state. (For the Framatome/ANP Environmental Laboratory, Framatome ANP Environmental Lab may be entered (without the city and state).

4. Requested Testing Completion Date - Date to be provided by the lead or cognizant person. If standard turn around times (e.g., two weeks) have been established with outside lab, this may be left blank.

B. For each sample container, fill out each column on form DPF-8123.1. The columns include:

1. Sample Designation - Transcribe the unique sample identification number appearing on the sample container label in the space provided.

2. Date and Time - Transcribe the date (mm/dd/yyyy) and time (hhmm) the sample was collected as it appears on the container label.

3. Media Code - Enter the Media Type code from Table 1

4. Sample Type Code - Enter the Sample Type code from Table 1.

5. Container Size and Type Code - Enter the Container Size, along with the Container Type from Table 1.

   For example: a) a sample for metals analysis collected in an 8-ounce plastic container will be identified as "8 oz P"; b) a sample for radiological analysis collected in a 12"x18" ziplock plastic bag will be identified as "12x18 BP".

6. Analyses Requested - Enter the type of analyses to be performed on each sample. Use as many spaces as needed to indicate all requested analyses for a given sample.

7. Comment, Preservation - Enter any comments as necessary in this section including the preservation method used.

   For example, if the preservation method was acidification, identify the method in this section such as "Acidified pH<2, Nitric Acid," or "Acidified pH<2, HCl." If any sample requires cooling to 4 degrees centigrade, identify the preservation method as "Ice or 4°C".

8. Notes: Enter any other information felt to be pertinent to the collection or custody of the sample(s).

9. Signature Blocks -

   a. Complete the signature blocks as instructed in steps A and B of this procedure.

   b. In situations where a chain of custody form is initiated for an existing sample (For example, see step A.6. of the procedure), the first two signature blocks (#1 and #2) may be left blank.

10. Samples Shipped Via - Check off the method of shipment. If a commercial courier, enter the bill of lading number.

11. Lab Use Only -

**NOTE**: Instruction should be provided to the offsite analytical laboratory in the proper completion of the Laboratory "Lab Use Only" shaded section.

   a. Comments - made by the laboratory pertinent to the receipt and condition of samples.

   b. Lab Sample ID. - A unique laboratory tracking number.

   c. Internal Container Temp - Obtain on receipt the internal temperature of the sample container.

   **NOTE**: Instructions should be provided not to obtain temperature from sample media to avoid contamination. A separate temperature blank will be provided in each shipment.

   d. Custody Sealed - Note presence or absence of custody seals.

   e. Custody Seal Intact - Note integrity of custody seals.

## TABLE 1

### Sample Codes for the Chain of Custody Form (DPF-8123.1)

| Media | Code |
|---|---|
| ground water | WG |
| surface water | WF |
| river water | WR |
| estuary water | WE |
| sea water | WS |
| effluent water | EW |
| soil | TS |
| sediment | SE |
| asphalt | AS |
| vegetation | TG |
| concrete | CT |
| smear | SM |
| other | (specify) |

| Sample Type | Code |
|---|---|
| grab | G |
| composite | C |
| core | CR |
| duplicate | D |
| split | S |
| field blank | FB |
| rinsate blank | RB |
| matrix spike | MS |
| matrix spike duplicate | MSD |
| other | (specify) |

| Container Type | Code |
|---|---|
| bag, plastic | BP |
| bag, cloth | BC |
| plastic | P |
| glass | G |
| amber glass | A |
| vial | V |
| steel can | SC |
| other | (specify) |

Yankee Atomic Electric Company
49 Yankee Road, Rowe, MA 01367
413-424-5261

# Chain of Custody Record

№

Project Name:

YAEC Contact Name & Phone:

Analytical Lab (Name, City, State):

Requested Testing Completion Date:

Lab Use Only

Comments:

| Sample Designation | Date | Time | Media Code | Sample Type Code | Container Size & Type Code | Analyses Requested | | | | | | Comment, Preservation | Lab Sample ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

NOTES:

| | | | |
|---|---|---|---|
| 1) Sampled By | Date/Time | 2) Received By | Date/Time |
| 3) Relinquished By | Date/Time | 4) Received By | Date/Time |
| 5) Relinquished By | Date/Time | 6) Received By | Date/Time |
| 7) Relinquished By | Date/Time | 8) Received By | Date/Time |

Samples Shipped Via:

☐ Fed Ex
☐ UPS
☐ Hand
☐ Other ____________

____________________
Bill of Lading #

Internal Container Temp.: ____ Deg. C

Custody Sealed?
Y ☐ N ☐

Custody Seal Intact?
Y ☐ N ☐

DPF-8123.1
Rev. 7

Adams Specialty & Printing C
(413) 743-9101

# AP-8601 Ground and Well Water Monitoring Program For The Yankee Nuclear Power Station Site

Proc. No. AP-8601
Rev. No. Original
Issue Date 06/2003
Review Date 06/2008

# GROUND AND WELL WATER MONITORING PROGRAM FOR THE YANKEE NUCLEAR POWER STATION SITE

## SCOPE

This procedure outlines the overall program for the collection of radiological ground and well water samples to support decommissioning activities at the Yankee Nuclear Power Station (YNPS) site. The procedures, which support this document, implement the sampling, analysis, quality and record keeping procedures for the program are listed in the Reference Section.

## ENCLOSURES

AP-8601 - Pgs. 1-8
Attachment A - Pgs. 1-2
Attachment B - Pg. 1
Attachment C - Pg. 1
APF-8601.1 - Pg. 1

## REFERENCES

1. DP-9745, "Ground Water Level Measurement and Sample Collection in Observation Wells"
2. AP-9601, "Yankee Nuclear Power Station Site Characterization and Site Release Quality Assurance Program Plan (QAPP) for sample Data Quality"
3. DP-8602, "Ground Water Monitoring Well Drilling and Completion"
4. DP-8603, "Radiochemical Data Quality Assessment"
5. 10CFR20 Subpart E, "Radiological criteria for Licensing Termination"

## DISCUSSION

10CFR20 Subpart E requires that the total annual dose from site activities in the future be less than 25 mrem/yr from the sum of all potential uptake pathways. Analysis of the site groundwater through the use of monitoring and observation wells will help characterize the final condition of that medium. It is important that a standard set of protocols be established so that the Data Quality Objectives (DQO) will be met for all sampling and analysis activities.

The License Termination Project (LTP) Team has discussed extensively the suite of radionuclides that are important to the monitoring process at the plant site. They have decided upon the radionuclides identified in Attachments A and B, based on the probability of their (measurable) presence and potential dose consequence.

## PRECAUTIONS

Changes to this procedure and its referenced implementation procedures must be made in accordance with the LTP. Any changes which alter the sample collection, sample analysis or data analysis, must be evaluated prior to changing these procedures to establish a connection to historical data (see Enclosure APF- 8601.1).

## EQUIPMENT AND MATERIALS

N/A

## PROCEDURE

A. Roles and Responsibilities

1. Program Oversight.

   a. The YNPS Safety Oversight Manager/RPM [SOM] will have overall responsibility for program oversight, including:

      - Approval of budget expenditures
      - Designation of appropriate personnel qualified to review data and propose program changes.
      - Approval of Sampling events.
      - Approval of vendor selection for sampling and analytical services.
      - Final approval of program changes

2. Sample Collection Scheduling.

   a. The YNPS Assistant Safety Oversight Manager (ASOM) shall be responsible for coordinating the sampling events.

   b. The ASOM will schedule all sampling events with the contractor selected for this task.

   c. A list of the wells to be sampled shall be first approved by the ASOM and then communicated, in writing, to the vendor. This shall be part of the sampling package documentation.

3. Program Changes

Changes to programs or procedures shall be initiated by the designee of the YNPS SOM, and approved by the SOM. Changes may result from the following conditions as well as others:

- Significant changes in radioactivity levels of the wells
- Appearance of new radionuclides in the monitoring program.
- Significant physical changes to the site geology or site contour.

It is also significant to note that <u>deselection</u> of wells or radionuclides should be part of the monitoring process. If sufficient historical data indicates that certain wells or radionuclides indicate less than quantifiable radioactivity, they may be deselected using APF-8601.1.

4. Sample Collection Activities

The ASOM shall designate YNPS site personnel to have direct oversight of:

a. The sampling events and any necessary escort functions for contract personnel.

b. Proper packaging, preservation, labeling, and shipment of the samples to the contract laboratory.

c. Return of all chain of custody forms and verification that all samples were received intact.

The ASOM shall also coordinate with the Site Environmental Supervisor:

a. All non-radiological analyses required by sampling procedures

b. Verify purge time requirements or immediate analysis required prior to the samples being shipped to the analytical contract laboratory.

c. Disposal of all wastewater and chemicals associated with the sampling events.

5. Data Validation and Verification

a. The ASOM shall designate a qualified individual to perform these functions. A qualified person is defined as one who has at least 5 years experience in radiochemistry or radiation protection, and has a bachelors degree in a related scientific field.

b. Procedure DP-8603 shall be used for documentation of the verification and validation activities of all parameters related to radiological sample analysis.

c. The verification and validation activities shall be independent of those activities performed by the contract laboratory for sample analysis.

6. Report Generation

a. The ASOM shall have the responsibility for generation of any report that will be subject to regulatory review.

b. Final approval of the report will be the responsibility of the Safety Oversight Manager.

B. Schedule for Sampling and Analysis

1. The routine sampling and analysis frequency will be as specified in Attachment A for each of the wells.

2. Analysis of radiochemical samples should be performed as soon as practicable after sampling, but within three weeks of the sampling event.

3. If evaluation of data trends identifies unexpected changes (as described in B.4) selected monitoring wells may be resampled. Resampling and analysis shall occur as soon as practical after discovery of the need to resample.

4. It is anticipated that radioactivity levels in the monitoring wells will decrease over time. However, the following data changes may indicate an unexpected change in groundwater conditions.

- A sample location normally showing < MDC activity shows activity level significantly greater than the MDC. Significantly is identified as >3 MDC for the time of analysis.
- A sample location showing a steady downward trend shows a sudden increase or decrease in the projected value by greater than 20%. Projected values may be determined by best-fit extrapolation of the existing curve shape.

Such changes may require program changes to the sampling and analysis frequency for the affected well and any down gradient wells. This evaluation is recorded on APF-8601.1, and approved by the SOM.

5. Samples which are lost, or "analytical blunders" to sole samples, should be replaced with a new sample, taken as close in time to the subject sample, if possible.

6. The initial data set for the purposes of this program shall be the first one following program approval. However, the results of the initial data set should be compared to the site historical data prior to making any changes to the sampling or analysis schedules.

C. Data Quality Objectives

1. When required, samples shall be analyzed for radionuclides to the MDC values noted in Attachment B.

2. Values for duplicate results >10 times the MDC shall be within

   - 15% of each other for tritium,
   - 20% for gamma and $^{90}$Sr, and
   - 30% for gross alpha, TRUs and beta only emitters (except $^{90}$Sr).

3. Values for duplicate results between 1 and 10 times the MDC shall be within

   - 30% of each other for tritium,
   - 25% for gamma and $^{90}$Sr, and
   - 60% for gross alpha, TRUs and beta only emitters (except $^{90}$Sr).

4. Sample counts less than the critical levels (critical level = 1.645 x counts $_{\text{background}}$) are considered non-detectable, and there are no requirements on agreement of duplicate samples.

5. One laboratory QC, one duplicate and one sample spike shall be run with each batch of samples for tritium, $^{60}$Co, $^{90}$Sr, one TRU and $^{241}$Pu. The maximum batch size is 20 samples.

6. One equipment rinsate sample ("equipment blank"), one blind duplicate sample and one matrix spike sample shall be collected in the field and analyzed with each investigatory sample batch for tritium, $^{60}$Co, $^{90}$Sr, one TRU and $^{137}$Cs. The maximum batch size is 20 samples.

7. Laboratory spike samples should have a radionuclide concentration added, which is 8-15 times the laboratory MDC for that analyte (except $^{55}$Fe and $^{14}$C which shall be spiked to 5-10 times the MDC in Attachment B).

8. Recoveries for spikes shall be in agreement as per C.2.

9. Five percent (5%) of the data calculations (exclusive of QC data) shall be independently verified by a qualified individual. The data to be independently verified shall be selected at random and any calculations/information retained with the data package.

D. Analytical Laboratory Requirements

1. Quality Assurance Program (QAP)

The contract analytical laboratory shall have a QAP that meets the requirements of USNRC Regulatory Guide 4.15-1979, and ANSI/ASQC E4-1994, for all aspects of the work that they perform for the YNPS Groundwater Monitoring Program.

2. Procedures

Analytical procedures shall be written using the guidance of an accepted standards organization such as ASTM, ANSI, ISO, etc., or a recognized reference such as MARSSIM or MARLAP.

Examples of such standards are:

| | |
|---|---|
| 40 CFR Ch. I, Part 141.25 | Analytical Methods for Radioactivity |
| EML Procedures Manual(formerly HASL-300) | Environmental Measurements Laboratory Procedures Manual, 28th Edition, February 1997 |
| EPA 520/5-84-006, 1984 | Eastern Environmental Radiation Facility Radiochemistry Procedures Manual |
| EPA-600/4-80-032, 1980 | Prescribed Procedures for Measurement of Radioactivity in Drinking Water, |
| EPA R4-73-014, 1973 | Procedures for Radiochemical Analysis of Nuclear Reactor Aqueous Solutions, |
| EMSL-LV-0539-17, 1979 | Radiochemical Analytical Procedures for Analysis of Environmental Samples, |

E. Training Requirements

1. Personnel performing sampling shall have been trained in accordance with the procedure in force at the time of training. The training shall included.

2. Personnel shall have been deemed qualified for procedural use, following successful procedure use by an evaluator (usually previously qualified personnel or a designee of the SOM).

3. Qualification may occur by the following processes:

   a. Through the training process

   b. Documented historical experience of at least three years using the procedures involved or equivalent.

   c. Development of the procedure as the subject matter expert (SME).

   d. Documented training from another organization using equivalent procedures.

4. All personnel involved in the monitoring program shall review approved procedure changes prior to their using the procedures.

5. All vendor personnel performing analysis or sampling with the monitoring program procedures shall be qualified in accordance with the vendors QAP.

6. All training shall be appropriately documented in retrievable records maintained by the vendor or onsite in accordance with approved procedures.

F. Documentation Package Requirements for Sampling and Analysis

1. Each sampling event will normally take samples for multiple wells.

2. Each sampling event will include the following forms, at a minimum:

   - Attachment A – One copy of the page in force at the date of sampling.

   - DPF-9745.1 – One copy indicating which wells were sampled and any observations.

   - DPF-9745.2 –One copy of this form (typical well detail).

   - DPF-9745.3 –One copy of this form (observation well locations).

   - Form DPF-9745.4, "Ground Water Sampling Field Log" will be completed for each well. Attached to this form will be a data sheet from the laboratory, which includes the measurements made for each sample parameter and values for the blank, QC and any splits, spikes, or duplicates identified for that sampling event.

   - Original Chain of Custody Forms that have accompanied the samples to the analytical laboratory.

3. In the event that a sample is lost or not analyzed appropriately, or any of the conditions described in A.3 above have occurred, the data package will also include the appropriate number of copies of APF-8601.1 from this procedure.

4. The Analytical Laboratory report shall include as a minimum:
   - The values of all radionuclides stated in pCi/L
   - The total propagated uncertainty (TPU) of the individual results in pCi/L

- The MDC for each analyte
- The value of the QC and its target value for the batches reported
- The value of the Blank for each of the analyses
- The values for spike samples shall be reported, with a recovery percentage
- Any irregularities in sample processing
- Reproductions of the data sheets, which show sample count times, sample mass, carrier or tracer mass, and yield.

## Attachment A

## Frequency for Well Sampling and Analysis at YNPS

Note: Use DP-9745 Att. B to perform low-flow sampling. DP-9745 contains the non-radiological parameters that must be established prior to sampling.

| Well | Frequency | Analytical Parameter Suites |
|---|---|---|
| CB-1 | Quarterly | A, B, C, D |
| CB-2 | Quarterly | A, B, C, D |
| CB-3 | Semi-Annually | B |
| CB-4 | Quarterly | A, B, C, D |
| CB-5 | Semi-Annually | B |
| CB-6 | Quarterly | A, B, C, D |
| CB-7 | Semi-Annually | A, B |
| CB-8 | Semi-Annually | B |
| CB-9 | Quarterly | A, B, C, D |
| CB-10 | Quarterly | A, B, C, D |
| CB-11A | Quarterly | A, B, C, D |
| CB-12 | Quarterly | A, B |
| CW-2 | Semi-Annually | B |
| CW-3 | Quarterly | A, B |
| CW-4 | Semi-Annually | B |
| CW-5 | Quarterly | A, B |
| CW-6 | Quarterly | A, B, C, D |
| CW-7 | Quarterly | A, B |
| CW-8 | Quarterly | A, B |
| CW-10 | Semi-Annually | B |
| CW-11 | Quarterly | A, B, C, D |

| Well | Frequency | Minimum Analytical Parameter Suites |
|---|---|---|
| B-1 | Quarterly | A, B, C, D |
| OSR-1 | Semi-Annually | B |
| MW-1 | Quarterly | A, B, C, D |
| MW-2 | Quarterly | A, B, C, D |
| MW-5 | Quarterly | A, B, C, D |
| MW-6 | Quarterly | A, B, C, D |
| CWF-1 | Quarterly | B |
| CWF-2 | Quarterly | B |
| CWF-3 | Quarterly | B |
| CWF-4 | Quarterly | B |
| CWF-5 | Quarterly | B |
| CWF-6 | Quarterly | B |
| CWF-7 | Quarterly | B |
| Sherman Spring | Quarterly | B |
| MW-100 | Quarterly | A, B, C, D |
| MW-101 | Quarterly | A, B, C, D |
| MW-102 | Quarterly | A, B, C, D |
| MW-103 | Quarterly | A, B, C, D |
| MW-104 b | Semi-annually | B |
| MW-105 B | Quarterly | A, B, C, D |

106 A, B

Analytical Parameter Suites:

A. Gamma (including: $^{60}$Co, $^{134/137}$Cs, $^{54}$Mn, $^{94}$Nb, $^{125}$Sb, $^{152/154/155}$Eu, $^{108m}$Ag).

B. Tritium, Gross Alpha/Beta

C $^{14}$C, $^{55}$Fe, $^{63}$Ni, $^{90}$Sr

D. $^{241}$Am, $^{238}$Pu, $^{240/239}$Pu, $^{241}$Pu, $^{243/244}$Cm,

## Attachment B

## Required MDC values for Radiological Analytes

**Note:** All values represent small fractions of the EPA Drinking Water MCLs.

| Analyte | $^{3}H$ | $^{63}Ni$ | $^{60}Co$ | $^{55}Fe$ and $^{59}Ni$ | $^{137}Cs$ | All Other Gamma Emitters[1] | TRU[2] | Gross Beta | Gross Alpha | $^{90}Sr$ | $^{14}C$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MDC pCi/L | 500 | 25 | 50 | 200 | 10 | 25 | 5 | 5 | 5 | 5 | 200 |

1. This includes $^{54}Mn$, $^{94}Nb$, $^{125}Sb$, $^{152/154/155}Eu$, $^{108m}Ag$, $^{134}Cs$. The value of 25 pCi/L is for each radionuclide.

2. This includes $^{241}Am$, $^{238}Pu$, $^{240/239}Pu$, $^{241}Pu$, $^{243/244}Cm$

## Attachment C

## Justification for Procedure Change

**Note**: Above and beyond the requirements of AP-0001 the following guidance must be followed to ensure any change made to this procedure does not affect the DQO, Sample Integrity, Sample Validity, Reproducibility of Sampling, or Data obtained.

I. Procedure Number___________ Procedural Step(s) Changed___________

Date Required ___________

II. Identify the type of procedure change being made:

☐ Administrative change (no technical details of procedure have changed)

☐ Change of Analytical Method

☐ Change of Procedural Steps

☐ Change of Detection Limits

☐ Other: Describe______________________________________

III. Description of Change

________________________________________________________
________________________________________________________
________________________________________________________
________________________________________________________
________________________________________________________

IV. Does the Change Negatively Effect:

| | | |
|---|---|---|
| • The DQOs | YES | NO |
| • The Sample Integrity or Validity | YES | NO |
| • The Reproducibility of Sampling or Data | YES | NO |

If any of the answers above is "YES", write a justification for the change, and have an independent technical review performed before processing the change through the existing change program.

If all answers above are "NO", process the change through the existing change program.

V. Approval

Safety Oversight Manager _________________ Date___________________

# Groundwater Resample and Reanalysis Report

Date____________ Analyst____________________

Sample Identification______________ Analyte(s)__________________

The following incident(s) has occurred:

☐ The identified sample has been lost.

☐ The identified sample did not have __________ analysis performed.

☐ The value of ________ exceeded 20% of the projected value of the analyte from the historical trend.

☐ The value of ___________ has exceeded 3 times the MDC, and the previous sample had been < MDC.

☐ Other(Explain)______________________________________________________________

____________________________________________________________________________

The following remedial action(s) are recommended:

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Remedial Actions Approved:

YNPS Assistant Safety Oversight Manager ______________________________Date_________
Actions Completed:

Analyst_____________________________________________________ Date/ Time__________

# *Water Level Measurements*

# SECTION 5.1
# WATER-LEVEL MEASUREMENTS

## TABLE OF CONTENTS

| Section | Title | Page No. |
|---|---|---|
| 5.1-1 | PURPOSE | 1 |
| 5.1-2 | GENERAL CONSIDERATIONS | 1 |
| 5.1-2.1 | Measuring Point | 1 |
| 5.1-2.2 | Records | 2 |
| 5.1-3 | INSTRUMENTS | 2 |
| 5.1-3.1 | Weighted Tape (Plunker) | 2 |
| 5.1-3.2 | Chalked Tape | 3 |
| 5.1-3.3 | Electrical Tapes | 4 |
| 5.1-3.4 | Transducer | 5 |
| 5.1-3.5 | Acoustic Well Probe | 6 |
| 5.1-3.6 | Continuous Water-level Chart Recorder | 6 |
| 5.1-3.7 | Interface Probes | 7 |
| 5.1-4 | METHODOLOGY FOR MEASURING WATER LEVELS | 8 |
| 5.1-5 | PROBLEMS AND POSSIBLE SOLUTIONS | 9 |
| 5.1-5.1 | Cross-contamination | 9 |
| 5.1-5.2 | Water/Floating-fluids | 10 |
| 5.1-5.3 | Flowing Artesian Conditions | 10 |
| 5.1-5.4 | Cyclic External Factors Affecting Water Levels | 10 |
| 5.1-5.5 | Non-Cyclic External Factors Affecting Water Levels | 11 |
| 5.1-5.6 | Dropping Something in a Well | 11 |
| ADDITIONAL REFERENCES | | 12 |

## LIST OF FIGURES

Figure Title Page No.

5.1-1 Example of a Water-level Record Sheet . . . . .14

# 5.1 WATER LEVEL MEASUREMENTS

## 5.1-1 PURPOSE

Accurate water-level measurements are essential data in any hydrogeologic investigation. Water-level measurements are taken to determine the elevation of the potentiometric surface in a monitoring well, observation well or piezometer at a particular point in time. Single-event measurements, multiple-time measurements, or continuous-time measurements may be taken. Water-level data can be used to determine the following:

- Water levels prior to water quality sampling
- Horizontal and vertical ground water gradients
- Aquifer characteristics from measurements during slug and pump tests
- Aquifer response to rainfall, barometric and tidal influences
- Aquifer response to pumping or other outside influences
- Direction of ground water flow under pumping and non-pumping conditions
- Local and regional changes in ground water levels

## 5.1-2 GENERAL CONSIDERATIONS

### 5.1-2.1 Measuring Point

A measuring point for all water-level measurements must be established and consistently maintained as a reference point on a monitoring well. The reference point should be stable and have a professionally surveyed elevation. The top of the well casing (riser) should always be used as the permanent reference point. The top of the riser is preferred over the top of protective casing because the protective casing is more susceptible to movement through settling, heaving, or displacement by impact. The reference points for both the top of riser and protective casing should be indicated with a permanent mark or notch to ensure consistent measurements. Reference points must be related to Mean Sea Level (see Section 5.5) to ensure correlation between sites.

In addition to measuring the depth to water from the top of the well riser, it is recommended that one measure the difference between the top of riser and top of the protective casing. If changes are noted with time, it is an indication that one of the reference points have moved. If there has been considerable activity (such as construction or filling) or a change is detected in the distance between the riser and protective casing reference marks, a re-survey is the only sure way of knowing that the elevations are still accurate.

### 5.1-2.2 Records

Manual water-level measurements should be recorded on a water-level data sheet similar to that shown on Figure 5.1-1. The unique well number, date, time, and depth to water should be recorded for each measurement. Measurements should be recorded in feet and tenths and hundredths of a foot, not inches and fractions.

The form should be drafted so that there is room for both permanent and temporary data. Permanent data include such items as unique well identification number, geographical coordinates, site address, location of measuring point, surveyed elevation of the measuring point, depth to the bottom of the well, type of well screen, length of screened interval, presence or absence of contamination, inside diameter of the well screen and riser, and hydraulic conductivity of the formation opposite the well screen. Temporary data include observations about the condition of the well, such as, volatile organic analyzer (VOA) readings, the measurement of the depth of the water level in the well, the elevation of the water level (MSL), the type of measuring device used, the data and time the readings were taken, and the name of the person taking the measurements. In addition, recording the difference in elevation between the top of riser and protective casing is recommended to verify that the reference marks are stable.

## 5.1-3 INSTRUMENTS

### 5.1-3.1 Weighted Tape (Plunker)

A plunker usually consists of a small weighted metal cylinder with a concave undersurface. When this concave surface hits the water, it produces a "plopping" sound. By lowering the plunker in the well with a gentle up-and-down motion, the water surface can be determined. Usually the plunker is attached to a 100-foot steel or fiberglass measuring tape. A direct reading of the depth to water can be obtained if the tape has been shortened a distance equal to the length of the plunker.

If a permanent adjustment has not been made to the tape, it is not possible to obtain a direct measurement of the water level. With an unadjusted tape a compensating calculation must be made each time, to add the distance between the tape and the end of the plunker to the depth measured directly from the tape. The accuracy of this method is approximately 0.05-0.1 foot. If a steel tape is used, the weight of the plunker should be adjusted to offset the weight of a long tape.

Advantages

- Simple to operate.
- Simple and inexpensive to construct; can be dedicated to a well.
- Generally unaffected by most ground water contaminants.

- With tape modification it provides a direct reading of depth to water.

Disadvantages

- Not suitable for deep measurements (i.e., over 100 feet).
- Not suitable when ambient noise levels are high (e.g., pumps or drill rigs operating nearby).
- Not suitable if the well contains dampening substances (e.g., high percentage of sediments or viscous liquids).
- Unadjusted tape is a potential source of error.
- Very difficult to hear "plop" when the top of water is in the screened section.
- Not suitable for determining thickness of floating fluid.
- Fiberglass tapes may stretch, providing inconsistent readings.
- Unless treaded with teflon the fiberglass tape may stick to casing.

### 5.1-3.2 Chalked Tape

This method is not recommended in wells that are also being used for water quality sampling due to the fact that the chalk may introduce impurities into the well.

A steel or fiberglass tape coated with chalk with a small diameter weight attached to the end can be used to obtain water-level measurements in a well. The lower 3 to 4 feet of the tape is rubbed with chalk, and the tape is lowered into the well until the lower part is submerged and an even foot mark is at the measuring point on the well. The length of the wetted section of the chalked tape is subtracted from the total tape measurement to obtain the depth to water. The accuracy of the chalked tape device is on the order of 0.05 foot.

Chemically sensitive chalks or coatings can be used to determine the presence and thickness of fluids other than water, such as gasoline. These substances can be spread on a coated steel tape and the depth and thickness of the substances can be determined from the color change on the tape.

Advantages

- Simple, easy to operate.
- Not subject to mechanical or electrical failure.

Disadvantages

- Dripping water and condensation can result in erroneous readings.
- Chalk may introduce unacceptable impurities into the water.
- Requires subtracting the wetted length for total measurement - not a direct reading method.

## 5.1-3.3 Electrical Tapes

Electrical water-level tapes are based on the principle that once the probe (consisting of two unconnected wires located on the end of the tape) is immersed, an electrical circuit is completed and a buzzer and/or a light is activated. Electrical water-level tapes are usually marked in one- to five-foot intervals. Therefore, the intermediate distance must be measured with a ruler to determine the actual depth to water. A few instruments recently introduced and commercially available are fully marked, allowing for a direct measurement in feet or meters. Accuracy of this method is approximately 0.05 feet.

Advantages

- Small diameter (¼- to ½-inch) cable and probe is capable of measurements in small diameter piezometers.
- Relatively simple to operate.
- Multiple readings during slug and pump tests are possible without removing tape from the well.
- The individual tape length is the only depth limitation.
- Background noise is not a problem.

Disadvantages

- Dripping water or condensation on the sides of the well riser can result in erroneous readings.
- The tape may become kinked and will not hang straight in a well, producing inaccurate readings.
- If the tape requires a manual measurement between markings, it is subject to error; it may not be suitable where fast measurements are required.
- The instrument is subject to electrical malfunction (e.g., dead batteries or cable breaks); also, one-foot markings may shift, resulting in inaccurate readings.
- Not suitable for wells with PCBs or other di-electric fluids.

### 5.1-3.4 Transducer

A pressure-sensitive transducer can be used to measure water levels in a well. Transducers displace water when they are lowered into a well. One must be sure to allow adequate time for the water level to equilibrate. The pressure transducer produces an electrical signal (voltage or amps) proportional to the height of the water column above the transducer. The pressure is recorded in pounds per square inch (psi) which can then be converted to feet of water. A display meter, data logger, recorder, or similar instrument must be used to interpret the transducer signal. The output may be displayed on a meter, recorded on a chart, or fed directly into computer memory for later data reduction. Transducers are particularly suitable for slug tests or pump tests where frequent, rapid readings or long-term measurements are desirable. The accuracy of the water-level measurements depends on the type of data logging instrument used, and the psi range of the transducer (e.g., 10, 25, or 50 psi). Accuracy, usually 0.1 percent of full scales, ranges from 0.01 to 0.2 feet for most common transducer ranges. The data generated is referenced to the elevation (i.e., depth below a reference mark) of the transducer. The position (i.e., depth or elevation of the transducer) must be calculated for each well or testing event.

Advantages

- Continuous and rapid readings possible.
- Can operate remotely for long periods of time.
- Can provide for direct access to the data on a computer.
- Length of the individual transducer cable and the transducer pressure range is the only depth limitation.

Disadvantages

- Equipment is expensive.
- Operation is moderately complex and sophisticated.
- Subject to electronic failure or data transmission loss.
- Some instruments are not weatherproof and require special protection from inclement weather.
- Subject to reduced accuracy if not checked regularly and calibrated properly.
- May not be resistant to certain chemicals.
- Voltage must be held constant.
- Will give inaccurate readings if not vented to compensate for barometric pressure changes.

- o Use over long periods must account for changes in atmospheric pressure.
- o Probe constants are determined for water, which has a specific gravity of 1.0. False readings may be obtained or compensating adjustments must be made for substances with a specific gravity less than or greater than 1.
- o If a data logger is dedicated to a particular well, it may be conspicuous and encourage vandalism.

### 5.1-3.5 Acoustic Well Probe

Acoustic well probes operate on the same theory as sonar or similar sonic depth-finding devices. Acoustic well probes use ultrasonic sensors or transducers to transmit a signal and record the amount of time it takes for the reflected signal to return to the sensor. This information can then be translated into depth to water. Accuracy reportedly ranges from 0.5 to 1.0 feet for different models commercially available. This level of accuracy may be unacceptable for many projects.

#### Advantages

- o Probes do not contact liquid; therefore, they are particularly suitable for highly contaminated environments, or highly viscous contaminants.
- o Eliminates the potential for cross-contamination between wells.

#### Disadvantages

- o Equipment is expensive, relatively new and untested.
- o Operation is moderately complex and sophisticated.
- o Accuracy may be influenced by temperature changes.
- o Accuracy may not be adequate for many applications.

### 5.1-3.6 Continuous Water-level Chart Recorder

A continuous chart recorder can be used to record water levels over periods of time ranging from 4 hours to 32 days. Typically, the recorder consists of a float mechanism attached to a drum chart recorder. The relative level of the float is recorded on the chart for the time period specified. The final chart is a plot of relative water levels versus time.

Recently, quartz clocks have replaced the original key-wound clocks in these recorders, increasing the reliability of the instrument. Continuous chart recorders were originally designed for surface water monitoring, such as stream gaging, but they have been adapted to ground water monitoring by the use of small-diameter floats. More sophisticated systems are capable of translating the data into digital information and transmitting the data to a distant receptor.

Advantages

- Provides almost continuous water-level record.
- Accurate from 0.01 to 0.05 feet.
- Relatively simple to operate.
- Recognized as a well-proven method used by USGS.

Disadvantages

- Subject to mechanical problems, particularly in cold weather.
- Requires box or compartment attached to well.
- Floats and cable move with water-level fluctuations, and may become stuck or lodged in well.
- It is subject to extraneous interference from vibrations caused by trains, earth tides, etc.
- Large water-level fluctuations may be difficult to interpret, particularly near pumping wells due to overlapping impacts on water-levels.
- The recorder is conspicuous, and may be vandalized. It needs a protective cover.

### 5.1-3.7 Interface Probes

Interface probes consist of a small probe attached to the end of a coated tape that includes an optical liquid sensor and an electrical conductivity probe to differentiate between water and non-polar liquids (i.e., hydrocarbons). The probe transmits a signal up the tape to the reel, where an audible alarm emits a tone: a continuous tone for hydrocarbons and an oscillating tone for water. A direct reading of the depth of free product and of the water level can be made from the tape. The interface probe can also be used to measure water levels where floating hydrocarbons do not occur. The accuracy of this method is approximately 0.05 feet. It is advisable to cross-check the measured hydrocarbon thickness by retrieving a sample of the product and observing its thickness in a clear bailer.

Advantages

- Permits measurement of the depth and thickness of separate phase liquids, as well as water levels.

- Useful for water-level measurements alone.

- Direct reading possible.

Disadvantages

- Battery-operated and subject to possible electrical malfunctions.

- If the signal or light is not on the reel, but on the probe, it may be difficult to hear the tone or see the light.

- Probe diameter is 1¼ inches; may be too large for some piezometers; could become lodged in riser.

- Probe may be affected by decontamination solutions.

- For high viscosity fluids (i.e., No. 6 fuel oil), accurate readings may be difficult to obtain.

- Difficult to decontaminate.

## 5.1-4 METHODOLOGY FOR MEASURING WATER LEVELS

Water level measurements are so important in interpreting site hydrogeology that a clear, consise, well-ordered methodology is imperative. The following checklist is offered to ensure consistant and accurate data.

1. Prior to going into the field, check the measuring equipment to be sure that it is working properly and that it is in good repair. Also, prior to undertaking field work, the equipment should be decontaminated. Carry extra equipment and batteries to eliminate lost time in the event of equipment loss or malfunction.

2. Prior to entering the field, fill out the field forms with the permanent well data, such as well number, depth to the bottom of the well, and elevation of the permanent measuring point. Bring a current site map showing the location and identification numbers of all wells.

   When collecting measurements, it is useful to bring along previous water-level data. Comparison of the current measurement to previous measurements can help identify anomalous readings or misread well numbers.

3. Unlock the padlock in the hasp. Remove the protective cap from the well. Check that the I.D. number on the cap is the same as the one entered on the permanent record. Record any unusual sounds, odors, staining, damage, or other observations in the "Remarks" column. Be alert for evidence of vandalism or tampering.

- Well risers should be vented during installation by drilling a small hole into the casing below the depth of the seated cap (see Section 4.3). This will permit air and gas to escape during water level fluctuations. If a popping or sucking sound is heard when the cap is removed, the well is probably not vented properly. If the well is not adequately vented, the water level may take a while to stabilize once the cap is removed, especially in low permeability materials.

- If the well has been completed in contaminated ground water, appropriate health and safety protection and procedures must be utilized (see Section 2.3). Generally an OVA is used to monitor for volatile organics immediately upon opening the well.

4. First check for the measuring point. Holding the instrument at this point obtain a water-level reading with the measuring device. Record the actual reading obtained from the instrument - do not correct or convert data in your head. Repeat the measurement again to confirm the reading. Under ideal conditions the measurements would be taken using two different kinds of instruments. The reported depth would be the average of these two readings. Remember to record the time of the measurement.

5. Measure and record the difference in elevation between the reference marks on the top of well riser and protective casing.

6. Measure and record the depth to the bottom of the well.

7. Remove the instrument from the well. If the well is located at a site where contamination is suspected or known to be present, the measuring instrument must be completely decontaminated before taking another measurement in another well (see Section 6.5).

8. Replace cap and secure the well.

9. Once the measurements are complete, translate the water level depth readings into elevations (NGVD).

## 5.1-5 PROBLEMS AND POSSIBLE SOLUTIONS

### 5.1-5.1 Cross-contamination

Where contaminated groundwater exists, care must be taken to avoid cross-contamination of wells caused by contaminated water-level measuring instruments. Adequate decontamination procedures or dedicated instruments should be used to avoid this problem. It is advisable to start with the cleanest wells and work progressively to the more contaminated wells. Use historical data to determine this order.

## 5.1-5.2 Water/Floating Fluids

If immiscible fluids with a specific gravity that is less than 1 are encountered in a monitoring well, special procedures may be required to obtain a free product/water-level measurement. Instruments, such as an interface probe, are available that will measure the water/product levels. In the case of highly contaminated ground water or non-aqueous phase liquids, special dedicated instruments may be required for water level measurements. Where immiscible, floating fluids are encountered, measurements of both fluid levels should be recorded during each measuring event. Without correction water level contour maps prepared on the basis of a 2-phase liquid surface will always contain some unavoidable errors.

## 5.1-5.3 Flowing Artesian Wells

In order to obtain accurate measurements in flowing artesian wells, the water level must be stabilized. This is generally accomplished by adding an additional section of riser pipe onto the well to stabilize the flow so as to permit the measurement of a water surface below the top of the added riser or by using a pressure gauge. If additional riser pipe is added, a new measuring point for the well must be established, documented, and reported. Water pressure gauges can be adapted to fit over the top of the riser and measure the artesian pressure at the well head. The elevation or height above ground can be calculated from the pounds per square inch (psi) reading of the instrument. If flowing artesian conditions are anticipated, wells can be constructed to allow for the necessary riser additions or the use of a pressure gauge. If artesian conditions are anticipated, the surveyor conducting the original survey should be asked to establish a permanent reference datum which can be used as a reference point for future changes.

Measurement of water levels in flowing artesian wells may be impossible to obtain if the water column freezes above the ground.

## 5.1-5.4 Cyclic External Factors Affecting Water Levels

Water levels may be influenced by any combination of pumping, barometric and tidal influences. In general, tidal and pumping influences produce the most extreme deviations from undisturbed conditions. If tidal influences are a possibility at a site, ideally it is advisable to monitor the water levels in selected wells for a full 28-day tidal cycle to determine the significance of this factor. This can be roughly approximated by taking just two measurements: one at high tide and one at low tide in the middle of a 28-day tidal cycle. Nearby pumping wells can also significantly alter natural water-level elevations. If interfering pumping conditions are encountered, water levels should be measured during periods of pumping and non-pumping conditions when the water level has stabilized. A continuous water-level recorder is preferred for this type of monitoring. If anomalous measurements are obtained or pumping is occurring, these factors need to be evaluated. All water level measurements should include the time that the measurement was obtained. Use of the military or 24-hour time designation will eliminate the possibility of confusing A.M. with P.M. readings.

### 5.1-5.5 Non-cyclic External Factors Affecting Water Levels

Trenches in which underground utilities such as water, gas, sewer, and transmission pipelines are laid, disturb the natural permeability of the soil, increasing its hydraulic conductivity. At times ground water infiltrates directly into underground vaults and pipes. Taken collectively these features may represent line sinks or sources - places where ground water will tend to discharge or recharge preferentially. If a site has a large number of monitoring wells closely spaced together, the effects of these will be readily apparent on a map of the potentiometric surface. If the density of the wells is less, the water levels may produce anomalous readings that defy interpretation.

### 5.1-5.6 Dropping Something into a Well

Caution should be taken to avoid dropping objects into a well. Pencils, keys, eyeglasses, and other loose objects easily drop into wells, but are not so easily retrieved. All measuring instruments should be connected to something larger than the diameter of the well riser to avoid dropping these down a well. Measuring instruments should have a diameter small enough so that they fall freely in the well. This will avoid lodging the device in the riser, thereby obstructing further measurements or sampling. All measuring tapes or cables should be in good repair, free from breaks or splits that could result in separation of a cable within a well. Fishhooks and string may sometimes successfully retrieve lost items. Extreme care must be taken when taking water-level measurements in pumping wells to prevent entanglement of the measuring instrument on downhole equipment.

## ADDITIONAL REFERENCES

Barcelona, M.J., et al., 1983, A guide to the selection of materials for monitoring well construction and groundwater sampling: Urbana, Illinois, Illinois Water Survey, 78 p.

___________, 1985, Practical guide for groundwater sampling: Urbana, Illinois, Illinois Water Survey, ISWS Contract 374, 93 p.

Driscoll, F., 1986, Groundwater and wells: St. Paul, Minnesota, Johnson Div., 1089 p.

Heath, R.C., Basic ground water hydrology: USGS Water Supply Paper 2220, 84 p.

## SECTION 5.1
## WATER-LEVEL MEASUREMENTS

### LIST OF FIGURES

| Figure | Title | Page No. |
|---|---|---|
| 5.1-1 | Example of a Water-level Record Sheet . . . . . | 14 |

# Water Level Measurements

Project Number ________ Project Location ______________________________ Date ____________

Measuring Instrument ____________________ Field Person ______________________________

| Well Number | Elevation Top of Well Riser (M. S. L.) | Distance Between Top of Well Riser and Rim of Protective Casing | | Depth to Water from Top of Well Riser | Elevation Water Level (M.S.L.) | Time |
|---|---|---|---|---|---|---|
| | | (Last) | (Today) | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Figure 5.1-1

**Source: MADEP**

Example of a Water-level Record Sheet.

# *Groundwater Sample Collection from Wells Having Pump Systems in Place*

## Ground-Water Sample Collection from Wells Having Pump Systems in Place

STANDARD OPERATING PROCEDURE

**Revision: 3/9/87**

1.0 This Standard Operating Procedure (SOP) is concerned with the collection of valid and representative samples of ground-water from wells having pumps in place.

2.0 Background information about the well must be obtained from the owner or driller. The information is to include:

- location of well
- depth
- size
- well casing material
- gravel or bedrock subsurface

3.0 Examine the water system (pump, holding tank and plumbing) and find a faucet for sampling as close to well as possible. The sampling location should ALWAYS be prior to any water treatment system and the faucet should NOT have any aerator or hose attached to it during sampling.

4.0 Record the sampling points.

5.0 Run water with faucet open for five minutes or continue until temperature and conductivity stabilize. Record initial and final temperature and conductivity values.

Note: For convenience a hose attached to an outside sillcock may be used to flush water from the system, but sampling should be from the faucet.

6.0 Collect samples directly into sample(s) containers. Preserve according to program methodology requirements.

At times it is not possible to gain access into a home during the sampling period. Samples may than be taken from sillcock if permission to sample has been obtained and someone has ascertained that the water is not being treated prior to sampling point.

# *Multi-Parameter Water Quality Monitoring*

# 600XL

## Multi-Parameter
## Water Quality Monitor

## Instruction Manual

**Property of:**

***US Environmental***
***Rental Corp.***

***50 Sun St.***
**Waltham, MA 02453**

**(888) 550-8100**

YSI Incorporated
1725 Brannum Lane
Yellow Springs, OH 45387
(800) 765-4974 (513) 767-7241
Fax (513) 767-9353

YSI

®

# TABLE OF CONTENTS

Page

SECTION 1 INTRODUCTION

1.1 DESCRIPTION 1-1
1.2 GENERAL SPECIFICATIONS 1-2
1.3 SENSOR SPECIFICATIONS 1-3
1.4 HOW TO USE THIS MANUAL 1-5

SECTION 2 GETTING STARTED

2.1 UNPACKING 2-1
2.2 SYSTEM CONFIGURATION 2-1
2.3 SONDE SETUP 2-5
2.4 SOFTWARE INSTALLATION 2-10
2.5 PC6000 SOFTWARE SETUP 2-12
2.6 SONDE SOFTWARE SETUP 2-14

SECTION 3 BASIC OPERATION

3.1 CALIBRATION TIPS 3-1
3.2 CALIBRATION PROCEDURES 3-1
3.3 TAKING READINGS 3-6
3.4 CAPTURING DATA 3-7

SECTION 4 SONDE MENU

4.1 RUN 4-1
4.2 CALIBRATE 4-3
4.3 SYSTEM 4-6
4.4 REPORT 4-8
4.5 SENSOR 4-10
4.6 ADVANCED 4-10

SECTION 5 PC6000 SOFTWARE

5.1 INTRODUCTION 5-1
5.2 INSTALLING THE PC6000 SOFTWARE 5-1
5.3 THE SONDE MENU 5-3
5.4 THE FILE MENU 5-3
5.5 THE SETUP MENU 5-17
5.6 DATA CAPTURE/REAL-TIME SETUP 5-20
5.7 ADVANCED SETUP 5-22

Page

**SECTION 6 PRINCIPLES OF OPERATION**
6.1 CONDUCTIVITY 6-1
6.2 SALINITY 6-2
6.3 OXIDATION REDUCTION POTENTIAL (ORP) 6-2
6.4 pH 6-3
6.5 DEPTH 6-4
6.6 TEMPERATURE 6-6
6.7 DISSOLVED OXYGEN 6-6

**SECTION 7 MAINTENANCE**
7.1 SONDE MAINTENANCE 7-1
7.2 PROBE MAINTENANCE 7-2
7.3 GENERAL MAINTENANCE NOTE 7-5

**SECTION 8 TROUBLESHOOTING**
SOFTWARE PROBLEMS 8-2
SONDE COMMUNICATION PROBLEMS 8-3
SENSOR PERFORMANCE PROBLEMS 8-4

**SECTION 9 COMMUNICATION**
9.1 OVERVIEW 9-1
9.2 HARDWARE INTERFACE 9-1
9.3 RS-232 INTERFACE 9-2
9.4 SDI-12 INTERFACE 9-2

**APPENDIX A HEALTH AND SAFETY**

**APPENDIX B REQUIRED NOTICE**

**APPENDIX C WARRANTY AND SERVICE INFORMATION**

**APPENDIX D ACCESSORIES AND REAGENTS**

**APPENDIX E APPLICATION NOTE**

**APPENDIX F SOLUBILITY AND PRESSURE/ALTITUDE TABLES**

**APPENDIX G SENSOR AND SONDE STORAGE RECOMMENDATIONS**

# 1. INTRODUCTION

## 1.1 DESCRIPTION

The 600XL Environmental Monitoring System is a multiparameter, water quality measurement, and data collection system. It is intended for use in research, assessment, and regulatory compliance applications.

Measurement parameters include:

- Dissolved Oxygen
- Conductivity
- Specific Conductance
- Salinity
- Total Dissolved Solids
- Resistivity
- Temperature
- pH
- ORP
- Depth
- Level

The YSI Model 600XL is similar in appearance and performance to the original YSI Model 600 series, but is characterized by three significant enhancements. First, the Model 600XL offers field replaceable sensors. Second, the instrument can be configured with a factory-installed depth sensor module. Third, the unit is now available with an ORP sensor. Like the original Model 600, the 600XL has significant similarities to the YSI Model 6000 series, but also differs from that larger instrument in several ways. First, the Model 600XL does not have internal battery capability, and therefore must be powered from an external power source such as an AC adapter, battery pack, or terminal device. Second, the Model 600XL has no internal logging capability, and therefore the Model 600XL must be used with a terminal, data logger, data collection platform, or computer. Finally, several sensors, such as turbidity, nitrate, and ammonium, which are available on the Model 6000, cannot be used with the 600XL.

The Model 600XL is ideal for profiling and monitoring water conditions in industrial and waste water effluents, lakes, rivers, wetlands, estuaries, coastal waters, and monitoring wells. It can be left unattended for weeks at a time with measurement parameters sampled at your setup interval and data transmitted to your computer or logging device. The Model 600XL can be used 200 feet below the water's surface or in as little as a few inches of water. The fast sensor response of the Model 600XL makes it ideal for vertical profiling. Its very small size allows it to fit down 2 inch diameter monitoring wells.

The Model 600XL is equipped with YSI's patented Rapid Pulse Dissolved Oxygen Sensor which exhibits low stirring dependence, and therefore provides accurate results without an expensive and bulky stirrer. Because stirring is not required, external battery life is extended. In addition because of the nature of the technology, sensor drift caused by passive fouling is minimized.

The Model 600XL communicates with an ASCII terminal or a computer with a terminal emulation program. Use of the 600XL with our 610 D and 610 DM display/loggers provides an ideal system for profiling or spot sampling.

Every Model 600XL comes with IBM-compatible PC based software for simple and convenient setup and data handling. Reports and plots are automatically generated and their presentation easily customized. Data is easily exported to any spreadsheet program for more sophisticated data processing.

The RS-232C and SDI-12 interfaces provide maximum versatility for system networking and real time data collection. Several Model 600XL units are easily installed as a network, providing valuable water quality data at a variety of locations. For real time results, the Model 600XL can interface to radio telemetry systems, satellite, modem and cellular phone data collection platforms.

The Model 600XL is available with an economical built-in cable of various lengths, or with a sonde-mounted connector. Optional interface cables in several lengths are available for interfacing with a computer or terminal. These cables are waterproof at the sonde end and can be used in the lab or field.

See Appendix D for a complete list of accessories and calibration reagents.

## 1.2 GENERAL SPECIFICATIONS

See also Section 1.3 Sensor Specifications.

**Operating Environment**
Medium: fresh, sea, or polluted water
Temperature: -5 to +45 °C
Depth: 0 to 200 (61 meters)

**Storage Temperature:** -40 to +60 °C

**Material:** PVC, Stainless Steel

**Dimensions and weight with a 50 foot integral cable.**
Diameter: 1.6 inches (4.06 cm)
Length: 14 inches (35.56 cm)
Weight: 4.9 pounds (2.22 kg)

**Dimensions with depth sensor bulkhead installed and no attached cable.**
Diameter: 1.6 inches (4.06 cm)
Length: 20.75 inches (52.7 cm)
Weight: 1.75 pounds (0.8 kg)

**Computer Interface**
RS-232C
SDI-12

**Software**
IBM PC compatible computer, 3 1/2 or 5 1/4 inch, high or low density floppy disk drive.
Minimum RAM requirement: 256 K bytes
Optional graphic adapter for plotting

Ecowatch for Windows (optional)

IBM PC compatible computer with 3 1/2 inch disk drive and with a 386 processor (or better) running Windows version 3.1 (or later).
Minimum RAM requirement: 4 megabytes

**Power**
External 12 VDC (8 to 13.8 VDC)

## 1.3 SENSOR SPECIFICATIONS

The following are typical performance specifications for each sensor.

**Depth - Medium**
Sensor Type...........Stainless steel strain gauge
Range......................0 to 200 ft (61 m)
Accuracy................+/- 0.4 ft (0.12 m)
Resolution.............0.001 ft (0.001 m)

**Depth - Shallow**
Sensor Type..............Stainless steel strain gauge
Range.........................0-30 ft (9.1 m)
Accuracy ................ +/- 0.06 ft (0.018 m)
Resolution................ 0.001 ft (0.001 m)

**Level**
Sensor Type..............Stainless steel strain gauge
Range.........................0-30 ft (9.1 m)
Accuracy, 0-10ft ..... +/- 0.06 ft (0.018 m)
Accuracy, 10-30ft ... +/- 0.03 ft (0.009 m)
Resolution................0.001 ft (0.001 m)

**Temperature**
Sensor Type..........Thermistor
Range.....................-5 to 45 °C
Accuracy................+/- 0.15 °C (optional configuration at +/- 0.05 °C)
Resolution.............0.01 °C

**Dissolved Oxygen, % saturation**
Sensor Type..........Rapid Pulse - Clark type, polarographic
Range.....................0 to 200 % air saturation
Accuracy................+/- 2 % air saturation
Resolution.............0.1 % air saturation

**Dissolved Oxygen, mg/L** (Calculated from % air saturation, temperature and salinity)
Sensor Type.......... Rapid Pulse - Clark type polarographic
Range.....................0 to 20 mg/L
Accuracy................+/- 0.2 mg/L
Resolution.............0.01 mg/L

**Conductivity***
Sensor Type..........4 electrode cell
Range.....................0 to 100 mS/cm
Accuracy................+/- 0.5% of reading + 0.001 mS/cm
Resolution.............0.01 mS/cm or 1 uS/cm

**Salinity**
Sensor Type..........Calculated from conductivity and temperature
Range.....................0 to 70 ppt
Accuracy................+/- 1.0% of reading or 0.1 ppt, whichever is greater
Resolution.............0.01 ppt

**pH**
Sensor Type..........Glass combination electrode
Range.....................2 to 14 units
Accuracy................+/- 0.2 units
Resolution.............0.01 units

**pH - Low Ionic Strength**
Sensor Type..........Glass combination electrode with open junction and low impedance glass
Range.....................2 to 14 units
Accuracy................+/- 0.2 units
Resolution.............0.01 units

---

* Report outputs of specific conductance (conductivity corrected to 25 C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (Ed 1989).

ORP
Sensor type............ Platinum ring
Range......................-999 to 999 mv
Accuracy.................+/-20 mv
Resolution...............0.1 mv

## 1.4 HOW TO USE THIS MANUAL

This manual provides information for operating and maintaining the Model 600XL Environmental Monitoring System. Sections 1 through 3 provide an overview of setup, calibration, and operational procedures. These first three chapters should provide enough information for you to understand the basic capabilities of the 600XL system and begin sampling. Sections 4 through 9 provide a more detailed explanation of system operations, software, principles of operation, maintenance, and performance troubleshooting. Appendices A-G provide information about health and safety, warranty, accessories, and options.

NOTE: Because of the many features and applications of this versatile product, some sections of this manual may not apply to the specific system you have purchased.

This manual is organized to let you quickly understand and operate the 600XL system. However, it cannot be stressed too strongly that informed and safe operation is more than just knowing which buttons to push. An understanding of the principles of operation, calibration techniques, and system setup is necessary to obtain accurate and meaningful results.

Regular maintenance is required to keep the 600XL functioning properly. Precautions regarding the handling of reagents are also essential for the safety of system operators (see Appendix A for health and safety information).

The early parts of this manual will teach you how to get the 600XL system running. Additional topics are included to help you understand the science it employs, how to use it most effectively and safely, and how to keep it operating correctly.

The 600XL can be purchased with external battery or power supply capability. Additionally, all probes, cables and accessories can be ordered as options or ordered together as a system.

If you have any questions about this product or its application, please contact our customer service department or authorized dealer for assistance. See Appendix C for contact information.

This Page Intentionally Left Blank

# 2. GETTING STARTED

This section is designed to quickly familiarize you with the hardware and software components of the 600XL sonde and its accessories. You will then proceed to sensor installations, cable connections, software installation and finally basic communication with the 600XL Sonde. Diagrams, menu flow charts and basic written instructions will guide you through basic hardware and software setup. For the first time user, we encourage the use a personal computer with PC6000 software during this initial setup procedure.

By the end of Section 2 you will have...
- ☐ Installed sensors in your sonde
- ☐ Installed PC6000 software in your PC
- ☐ Established communication between the sonde software and PC software
- ☐ Enabled appropriate sensors
- ☐ Assigned appropriate report parameters and units

Successful completion of the above list is essential for you to continue on to Section 3 which focuses on performing calibrations and making measurements.

## 2.1 UNPACKING

Remove the instrument from the shipping container. Be careful not to discard any parts or supplies. Check off all items on the packing list and inspect all assemblies and components for damage. If any parts are damaged or missing, contact your representative immediately. If you do not know from which dealer your 600XL was purchased, refer to Appendix C for contact information.

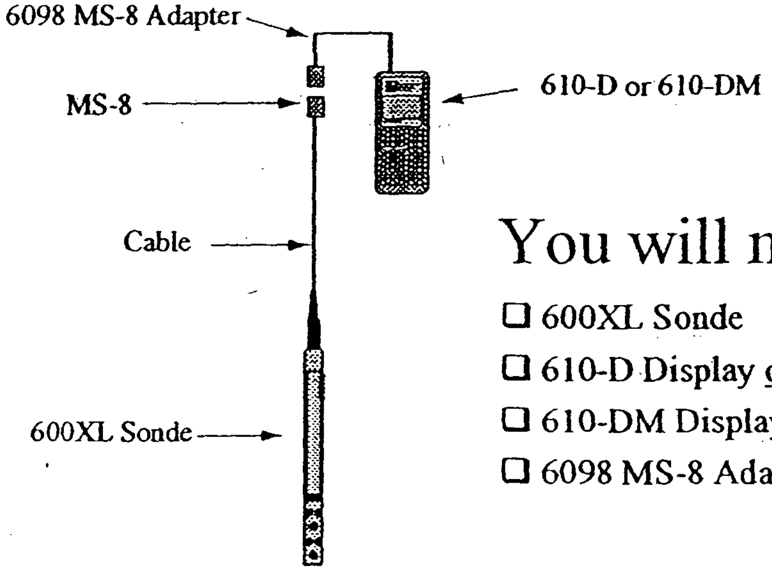
**NOTE**: Reagents for the 600XL are not packaged in the same carton as the instrument. These materials must be ordered separately and will arrive in a separate package.

## 2.2 SYSTEM CONFIGURATION

There are a number of ways in which you may configure the 600XL Sonde with various computers, terminals, and data collection devices. You should think about your particular application needs and then make certain that you have all of the components you need to make your system work. Below is a list of possible configurations that may be of interest to you. Each is depicted in diagrams on the next 3 pages.

- ☐ 600XL Sonde to Lab Computer
- ☐ 600XL Sonde to Data Collection Platform
- ☐ 600XL Sonde to Portable Computer
- ☐ 600XL Sonde to YSI 610 Display/Logger
- ☐ 600XL Sonde to YSI 610 with Portable Power
- ☐ Uploading Data from YSI 610 to Lab Computer

# 600 XL Sonde to 610 Display/Logger

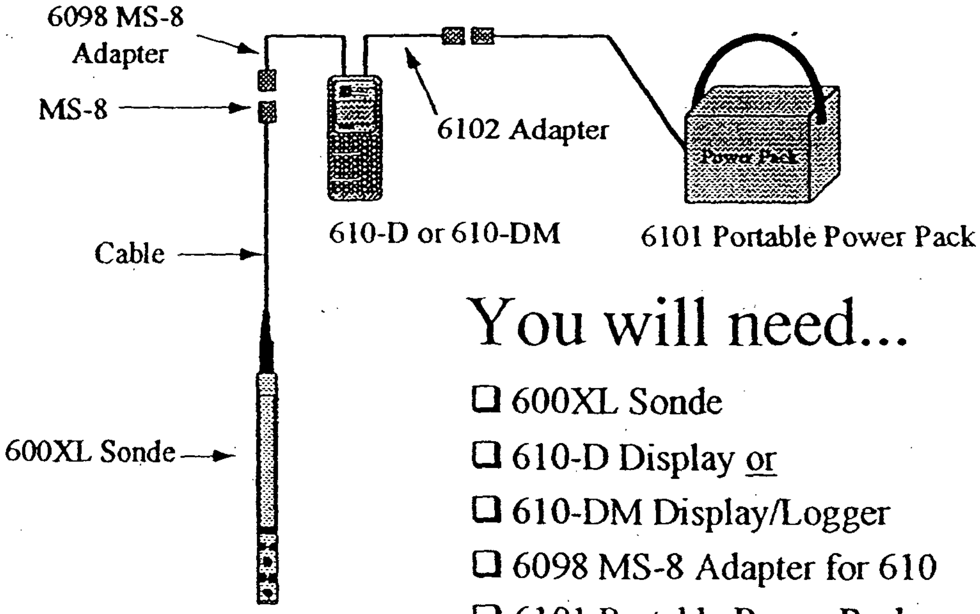


## You will need...

- ☐ 600XL Sonde
- ☐ 610-D Display or
- ☐ 610-DM Display/Logger
- ☐ 6098 MS-8 Adapter for 610

YSI 610's operate on rechargeable batteries.
Each 610 comes with a 110 VAC Wall Socket Charger Unit.

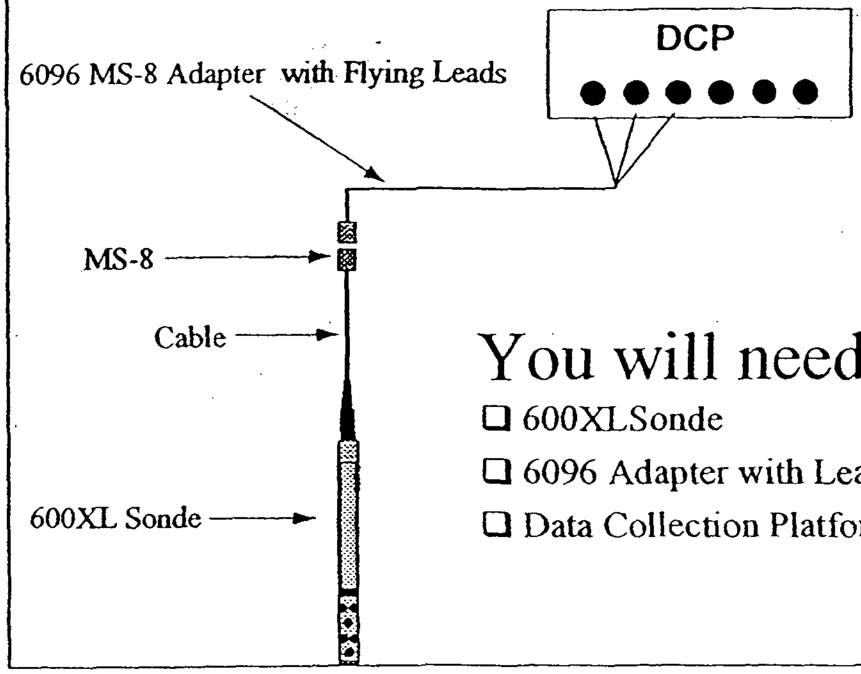
# 600XL Sonde to 610 with Portable Power



## You will need...

- ☐ 600XL Sonde
- ☐ 610-D Display or
- ☐ 610-DM Display/Logger
- ☐ 6098 MS-8 Adapter for 610
- ☐ 6101 Portable Power Pack
- ☐ 6102 Power Pack Adapter

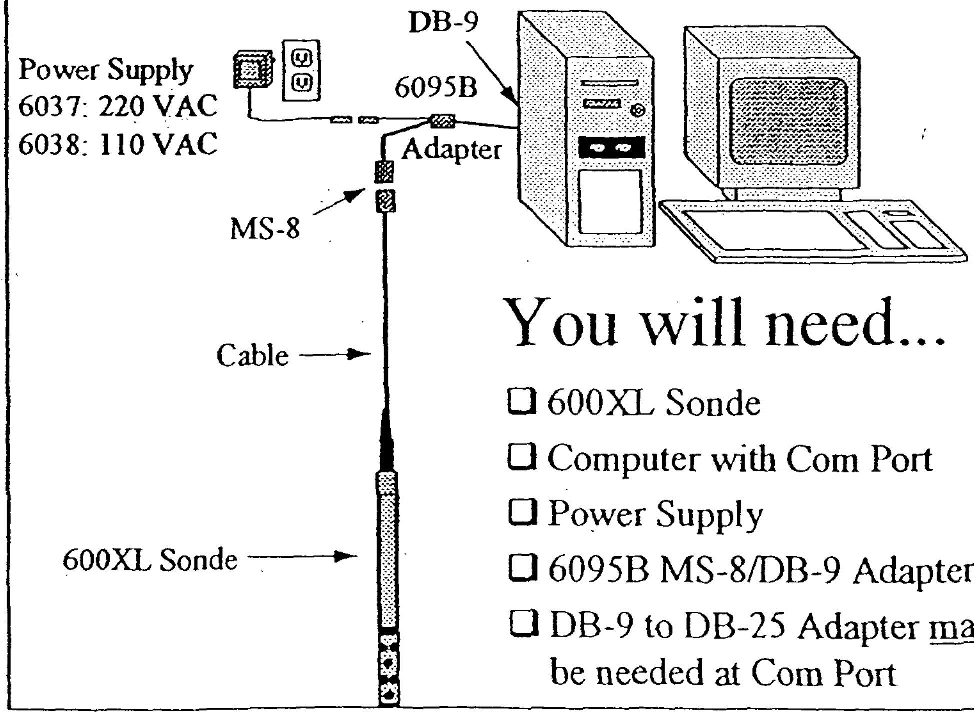
## 600XL Sonde to Data Collection Platform



### You will need...

- ☐ 600XLSonde
- ☐ 6096 Adapter with Leads
- ☐ Data Collection Platform

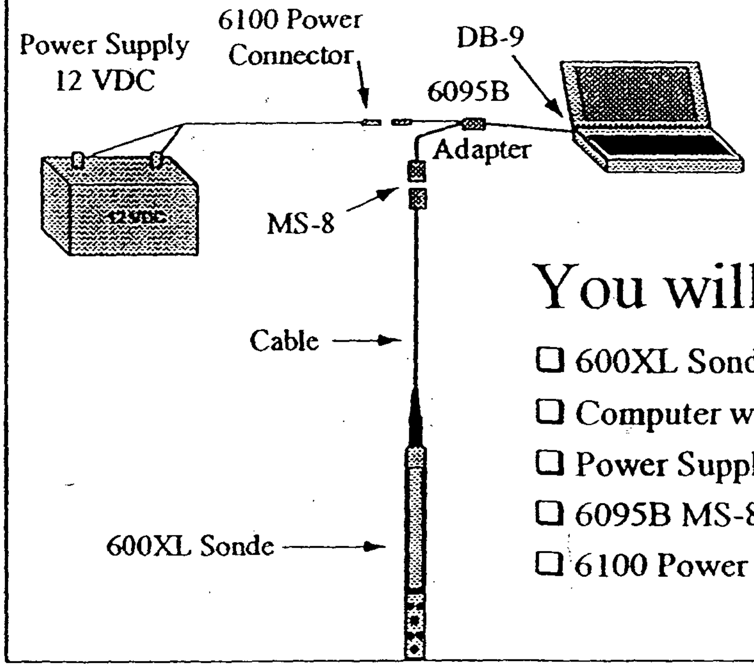
## 600XL Sonde to Lab Computer



### You will need...

- ☐ 600XL Sonde
- ☐ Computer with Com Port
- ☐ Power Supply
- ☐ 6095B MS-8/DB-9 Adapter
- ☐ DB-9 to DB-25 Adapter <u>may</u> be needed at Com Port

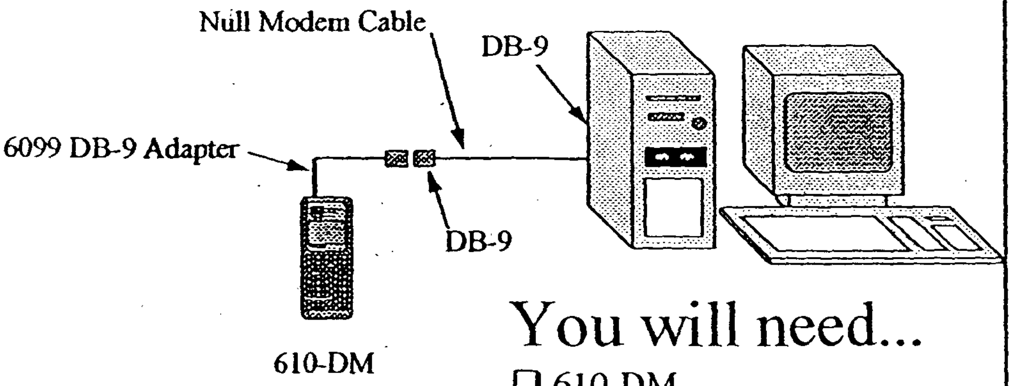
# 600XL Sonde to Portable Computer



## You will need...

☐ 600XL Sonde
☐ Computer with Com Port
☐ Power Supply (12 VDC)
☐ 6095B MS-8/DB-9 Adapter
☐ 6100 Power Connector

# Uploading 610 Data to Lab Computer

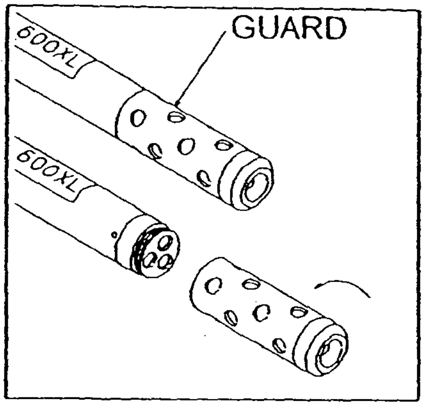


## You will need...

☐ 610-DM
☐ 6099 DB-9 Adapter
☐ Null Modem Cable
☐ DB-9 to DB-25 Adapter <u>may</u> be needed at Com Port

## 2.3 SONDE SETUP

### SENSORS

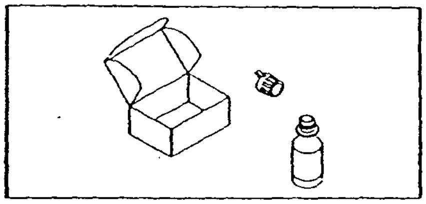


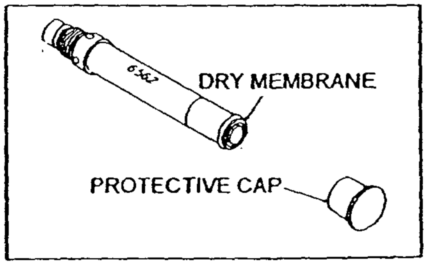
1. Remove the Model 600XL probe guard by hand.

2. NOTE: Step 2 is for the preparation of the 6562 dissolved oxygen probe only. To install other probes, proceed to step 3.

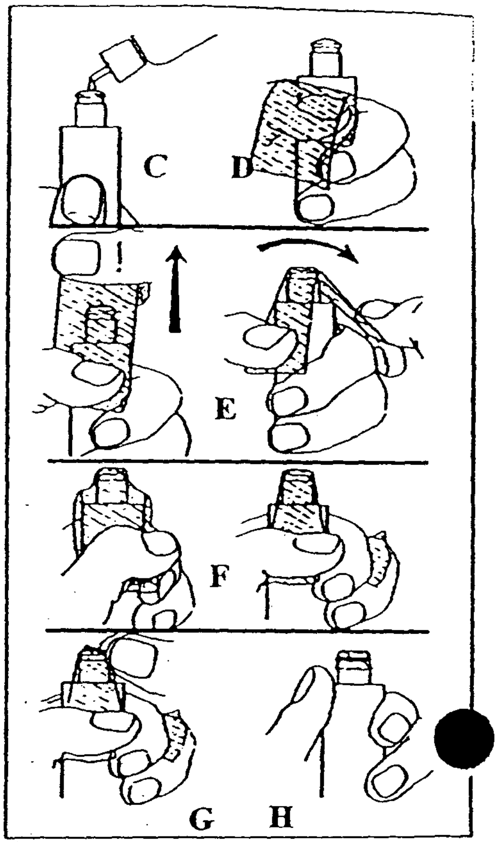
   A. Open the membrane kit and prepare electrolyte. Dissolve the KCl in the dropper bottle by filling it to the neck with distilled water and shaking until the solid is fully dissolved. After dissolution is complete, wait 10-15 minutes unit the solution is free of bubbles.

   B. Remove protective cap and the dry membrane from the 600XL dissolved oxygen probe. NOTE: The dissolved oxygen probe is shipped with a protective dry membrane on the sensor tip. It is very important not to scratch or contaminate the sensor tip. Handle the new probe with care. Avoid touching or hitting of the sensor tip.





C. Hold the probe in a vertical position and apply a few drops of KCl solution to the tip. The fluid should completely fill the small moat around the electrodes and form a meniscus on the tip of the sensor. Be sure no air bubbles are stuck to the face of the sensor. If necessary, shake off the electrolyte and start over.



D. Secure a membrane between your left thumb and the probe body. Always handle the membrane with care, touching it at the ends only.

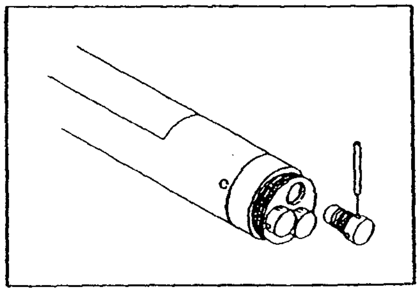
E. With the thumb and forefinger of your right hand, grasp the free end of the membrane. With one continuous motion, gently stretch it up, over, and down the other side of the sensor. The membrane should conform to the face of the sensor.

F. Secure the end of the membrane under the forefinger of your left hand.

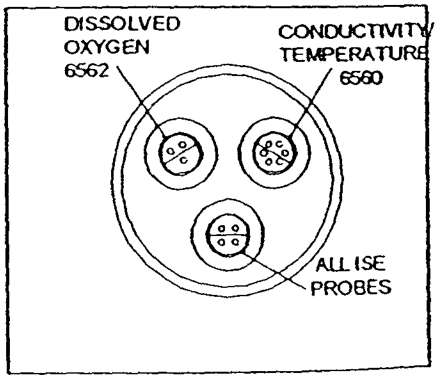
G. Roll the O-ring over the end of the probe, being careful not to touch the membrane surface with your fingers. There should be no wrinkles or trapped air bubbles. Small wrinkles may be removed by lightly tugging on the edges of the membrane. If bubbles are present, remove the membrane and repeat steps C-G.

H. Trim off any excess membrane with a sharp knife or scissors. Make sure the temperature sensor is not covered by excess membrane. Being careful not to get water in the connector, rinse off the excess KCl solution.

NOTE: Some users find it more convenient to mount the sensor vertically in a vise with rubber jaws while applying the electrolyte and membrane.

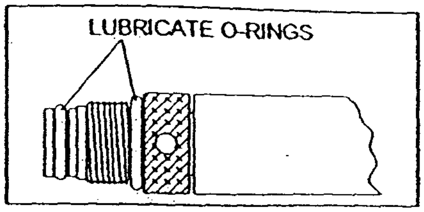


3. Using the probe installation tool supplied in the 6570 maintenance kit, remove the port plugs and locate the port with the connector corresponding to the probe you wish to install.



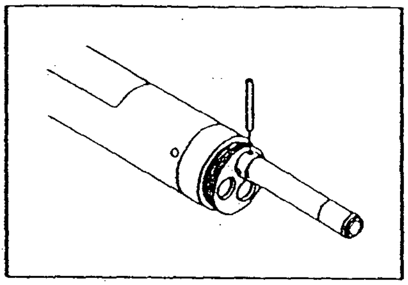
Note: 6562 Dissolved oxygen probe = 3-pin connector
6560 Conductivity/Temperature = 6-pin connector
6561 pH probe = 4 pin connector
6563 ORP probe = 4 pin connector
6565 Combination pH/ORP probe = 4 pin connector
6564 LIS pH probe = 4 pin connector
6567 combination LIS pH/ORP probe = 4 pin connector

4. Apply a thin coat of O-ring lubricant (supplied in the YSI 6570 maintenance kit) to the O-rings on the connector side of the probe.

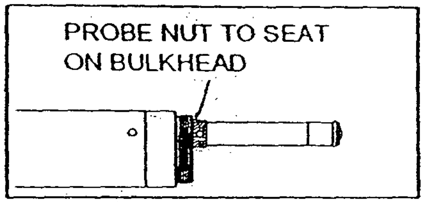


5. NOTE: Before installing probe into sonde, be sure probe port is free of moisture.

Insert the probe into the correct port and gently rotate the probe until the two connectors align.

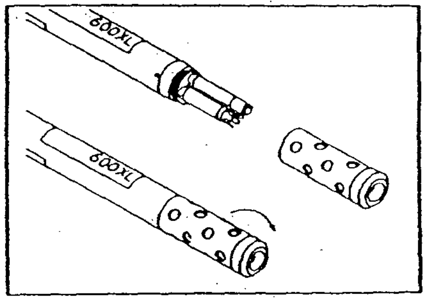


6. With connectors aligned, screw down the probe nut using the probe installation tool. **CAUTION**: Use care not to cross thread the probe nut. Seat nut on face of bulkhead. Do not over tighten.



7..Repeat steps 3-6 for all remaining probes.

8. Replace the 600XL probe guard.



## CABLES

Sondes equipped with level sensors use vented cables. See the next section for details.

Some versions of the Model 600XL have permanently attached cables. If your 600XL has a cable which is non-detachable (no stainless steel connector), parts of this section will not be relevant.

To attach a cable to the 600XL, remove the waterproof cap from the sonde connector and set it aside carefully for later reassembly. Now connect your YSI PC interface cable to the sonde connector. A built-in "key" will ensure proper pin alignment; rotate the cable gently until the "key" engages and then tighten the connectors together by rotating clockwise.

The other end of the cable is a military-style 8-pin connector. This connector plugs directly into the 610 D and 610 DM display/loggers. Most other applications will require the use of an adapter. For example, to connect the 600XL to a computer, use a YSI 6095 MS8 to DB-9 adapter.

## VENTED LEVEL

The vented level option eliminates errors due to changes in barometric pressure. This is accomplished by using a special sensor that has been vented to the outside atmosphere by way of a tube that runs up through the sonde and cable. Therefore the tube must remain open and vented to the outside atmosphere to function. All storage caps must be removed and no foreign matter can block the openings. Never expose the sonde or the cable to the atmosphere for more than a few minutes without an active desiccant system in place. This prevents moisture from entering the vent tube.

Special field cables and integral cables are used for 600XL vented level. These cables have a vent tube that runs up the middle of the cable. If you have purchased a sonde that requires a field cable, then your sonde has a stainless steel connector on the top of it. In the center of this connector is the vent hole. When the cable is removed from the sonde, seal the sonde with the pressure cap provided with the sonde, to keep it clean and dry. The field cable should also be stored in a sealed plastic bag with some desiccant to keep it dry.

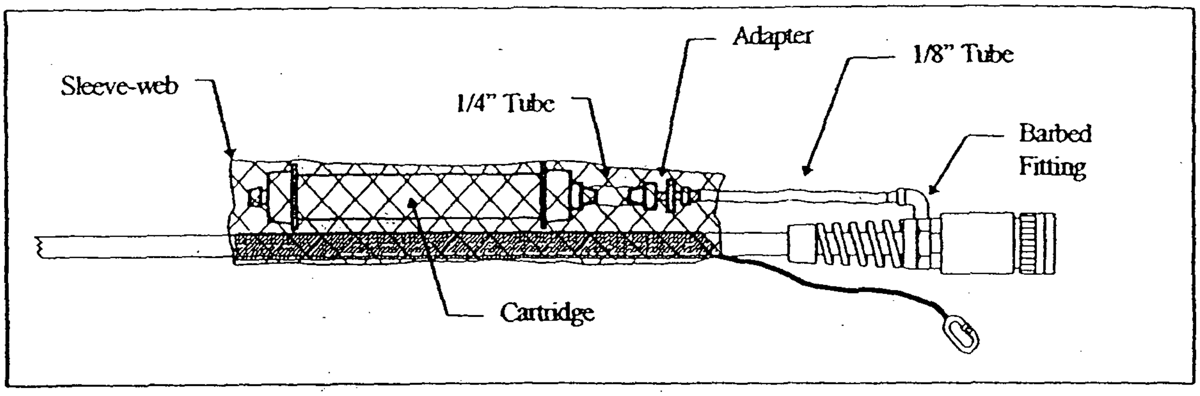
At the instrument end of every cable is a barbed fitting. This is to provide an attachment for a desiccant system. One of the two desiccant systems should always be attached to the sonde while exposed to the atmosphere to prevent moisture buildup in the vent tube. Plugs are provided with the sonde to seal the integral cable from the atmosphere when the desiccant system is removed for servicing. When dry and active, the desiccant is a distinct blue color. When exhausted it turns to a rose red or pink color. The desiccant can be regenerated in an oven. See Section 7, Maintenance, for the proper procedure.

Avoid bending the cables sharply to prevent the vent tube from kinking.

Two desiccant systems are available, a cartridge kit and a canister kit. Either will keep moisture from entering the vent tube. The desiccant cartridge kit mounts right to the cable and is intended for shorter term applications. The desiccant canister contains a larger amount of desiccant and is intended for long term deployment. The desiccant canister kit contains mounting brackets for mounting the canister to a nearby structure. The length of time that the desiccant remains active depends on several factors including heat and humidity.

When using vented level, you must enter altitude and latitude. From the sonde Main Menu, select Advanced, then Sensor. Enter the altitude in feet and the latitude in degrees of the measurement site. These values need to be accurate within 500 feet and 1 degree, respectively. See section 4.6 for more details.

## INSTALLING THE CARTRIDGE KIT



1. Place the short length of 1/4"tubing onto the 1/4"side of the 1/8"to 1/4"adapter fitting. Seat firmly.

2. Place the length of 1/8"tubing onto the 1/8"side of the adapter fitting. Seat firmly.

3. Remove one of the plugs from the end of the desiccant cartridge and place the open end of the short length of 1/4"tubing onto the open end of the desiccant cartridge. Seat firmly.

4. Remove the plug from the barbed fitting on the end of the cable and place the open end of the 1/8"tubing onto the cable fitting. Seat firmly.

5. Slide the sleeve-web over the end of the cable and the bail. Work the sleeve-web down the cable and over the cartridge taking care not to unplug the hose that connects the cartridge to the cable.

Optional: Using one of the tie-wraps, secure the hose to the cable taking care not to close off the hose.

The vent end of the cartridge should remain plugged until the sonde is ready for use. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

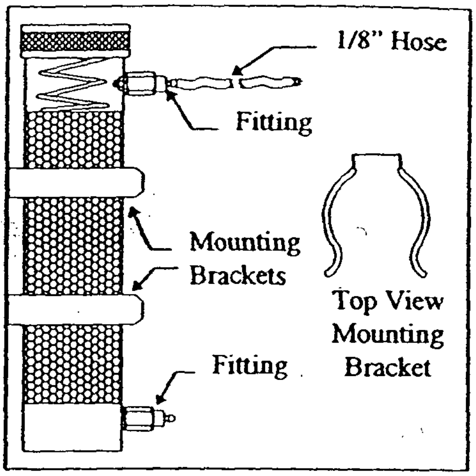
## INSTALLING THE CANISTER KIT

1. Remove the 1/8"NPT plugs from the stainless steel fittings on the canister.

2. Install the 1/8"NPT to 1/8"hose fittings into the stainless steel fittings located on the side of the desiccant canister. CAUTION: Do not over-tighten!

3. Place the plugs over the fittings on the canister until you are ready to use the canister.

4. Using suitable screws fasten the canister mounting brackets to an appropriate support structure. The spacing between the brackets must accommodate the length of the canister. The canister must be located within a few feet of the cable end.



5. Remove the plug from the top fitting of the canister. Remove the plug from the barbed fitting on the end of the cable. Using the tubing provided in the kit, connect the canister to the fitting on the end of the cable. Remember to remove the remaining plug from the canister when ready to begin sampling. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

## POWER

Some type of external power supply is required to power the 600XL sonde. For laboratory setup and calibration with the sonde interfaced to a computer, the YSI 6038 (110 VAC) or 6037 (220 VAC) is ideal. Most adapters include a short pigtail for power that plugs into the power supply. After attaching the three pin connector on the power supply to the pigtail, simply plug the power supply into the appropriate outlet. If you have purchased a 610-series display/logger for use with your 600XL, attachment of the cable to the 610 will allow your sonde to be powered from the batteries in the display/logger or from the 610 power supply if its batteries are not fully charged.

## 2.4 SOFTWARE INSTALLATION

PC6000 software is provided with the 600XL and is found on a floppy disk in the back of this instruction manual. Use this software with an IBM-compatible PC with at least 256KB of RAM and DOS 3.0 or later. If your system is not IBM-compatible, use any terminal emulation program with your computer.

Insert the disk into your floppy disk drive. At the C:\ prompt, type the letter of the drive in which the program disk was inserted followed by a colon, then press Enter.

**Example:** A: [Enter]

To install PC6000 software execute the following command from the DOS prompt:
INSTALL *<destination>*
where destination is the drive and directory in which you want the PC6000 files to be installed.

For example, the command: **INSTALL C:\PC6000** will install the PC6000 software to the C: drive and \PC6000 directory.

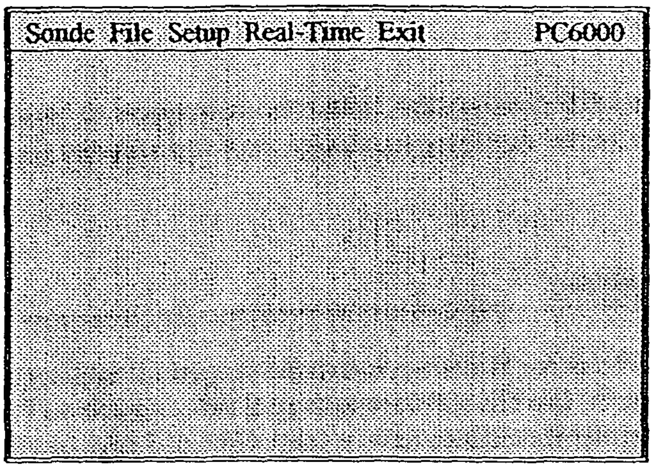
If you are using a two floppy disk drive system, follow the instructions in Section 5.2. After installing the software, remove the disk from the floppy drive and keep the original disk in a safe place.

## ECOWATCH FOR WINDOWS

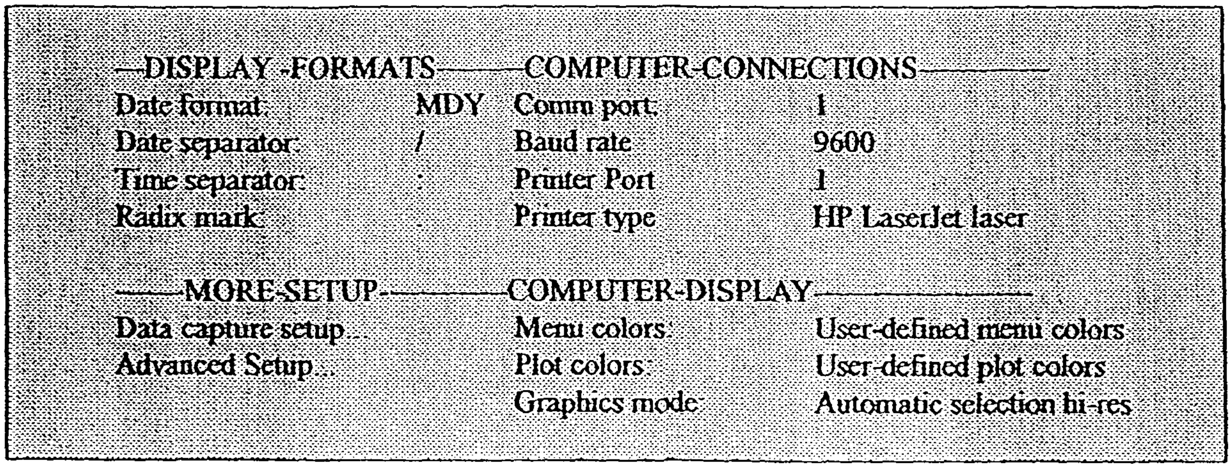
If you have purchased EcoWatch for Windows, install the program from the Program Manager menu of your Windows system. Use this software with an IBM-compatible PC with a 386 (or better) processor. The computer should also have at least 4MB of RAM and Windows Version 3.1 or later. First close any Windows applications which are currently running. After inserting the EcoWatch floppy disk in your disk drive, access the File command from the top menu bar of the Program Manager window. Click on Run and type "a:\setup.exe" at the prompt. Press Enter or click on "OK" and the display will indicate that EcoWatch is proceeding with a setup routine. After the setup is complete, you will be prompted to confirm that all applications have been closed and choose the hard drive location where EcoWatch will be installed. After answering these questions, the installation of EcoWatch will take place automatically. Use Help to learn about the program.

## 2.5 PC6000 SOFTWARE SETUP

To start the software, make your current drive C:\PC6000 (or another directory where you have installed PC6000). Type **PC6000** and press Enter. The PC6000 software will load. The PC6000 menu bar will appear at the top of the computer screen:



Use the arrow keys to move the cursor and highlight menu options. Press Enter to select a highlighted option. Press Esc to cancel an entry. To start, highlight Setup then press Enter. Check the default setup values.



```
—DISPLAY-FORMATS————COMPUTER-CONNECTIONS————
Date format:          MDY  Comm port:        1
Date separator:        /   Baud rate         9600
Time separator:        :   Printer Port      1
Radix mark:            .   Printer type      HP LaserJet laser

——MORE-SETUP————————COMPUTER-DISPLAY——————————
Data capture setup...      Menu colors:      User-defined menu colors
Advanced Setup...          Plot colors:      User-defined plot colors
                           Graphics mode:    Automatic selection hi-res
```

**Comm port:**

Select this option to enter the number of the Comm port (1 or 2) to which the 600XL is connected. Be sure to press Enter to confirm a new entry. If the default setting is correct there is no need to change it.

**Baud rate:**

Select this option to check the baud rate. If the baud rate is not set to 9600, set it to 9600. To set the baud rate, highlight it and press Enter. A list of possible baud rates will appear. Select 9600 from the list and press Enter. NOTE: The Model 600XL default baud rate is 9600.

**Printer port:**

Select this option to specify the parallel port (LPT1, LPT2 or LPT3) to which your printer is connected. If no printer is connected select LPT1. Press Enter after making your selection.

**Printer type:**

Select this option to select the type of printer connected to your computer system. From the list, choose the selection that best describes your printer. If your printer is not on the list, refer to your printer's instruction manual to determine what type of printer your printer emulates. Press Enter after making your selection.

**Menu colors:**

Select this option to choose a color scheme for the PC6000 menus. As you move the cursor between color schemes, the screen changes to display your selection. Press Enter to confirm a selection.

**Plot colors:**

Select this option to choose a color scheme for the PC6000 plots. As you move the cursor between color schemes, the screen changes to display your selection. Press Enter to confirm a selection. The other setup functions are described in Section 5.5, but usually are not necessary for a quick start into 600XL operations. Press Esc to exit the setup menu. The cursor will return to the menu bar.

## 2.6 SONDE SOFTWARE SETUP

There are two sets of software at work within the 600XL system. One is resident in your PC (called PC6000) and was provided on floppy disk with this instruction manual. The other software is resident in the sonde itself. When you select **Sonde** from the PC6000 top-line menu or EcoWatch for Windows, the PC based software begins direct communication with the sonde-based software via standard VT100 terminal emulation.

Using the arrow keys, highlight and select **Sonde** from the menu bar. Press Enter, a message will appear indicating connection to the sonde, followed by a # sign. As instructed, type **Menu** after the # sign and the Main sonde menu will appear.

```
------------Main--------------------
1. Run          4. Report
2. Calibrate    5. Sensor
3. System       6. Advanced

Select option (0 for previous menu)
```

When using EcoWatch for Windows, click on the sonde icon in the top menu bar, choose the proper com port, and confirm the selection.

NOTE: If you are unable to establish interaction with the sonde, make sure that the cable is properly connected, external power is applied (YSI 6038 power supply or any 12 VDC source), and that the Comm port and other software parameters are set up as described in Section 2.4 of the manual. Also see Section 8 of the manual for troubleshooting procedures.

NOTE: If your 600XL has been previously used, the Main menu (rather than the # sign) may appear when communication is established. In this case simply proceed as described below; you will not be required to type Menu.

The sonde software is menu-driven. Select a function by typing its corresponding number. It is not necessary to press Enter after a number selection. Use the 0 or Esc key to return to a previous menu.

At the Main menu, select 3. System. The System Setup menu will be displayed.

```
-----------System-setup-----------------
1. Comm setup
2. Page length=25
3. Instrument ID
4. SDI-12 address=0

Select option (0 for previous menu):
```

You will need to verify the following options:

```
1. Comm setup
```

```
---------------Comm setup---------------
1-( ) Auto  baud            5-( ) 2400 baud
2-( )  300 baud             6-( ) 4800 baud
3-( )  600 baud             7-(*)  9600 baud
4-( ) 1200 baud

Select option (0 for previous menu):
```

The default is 9600 but you may need to change it to match your host communication interface protocol. If necessary, simply type in the corresponding number one through seven. The current selection will be indicated by an asterisk.

**NOTE:** If you change the baud rate here, you must press F10 and immediately change the baud rate in PC6000 setup. If this is not done, the Model 600 will not be able to communicate with PC6000 and your system will appear to be "locked-up." See Section 4.3 for more information.

Press 0 or Esc to return to System Setup menu.

```
3. Instrument ID
```

Select this option to identify your instrument with its serial number (located on the back of the sonde) or any other name or number you wish, up to 31 characters. Then press Enter.

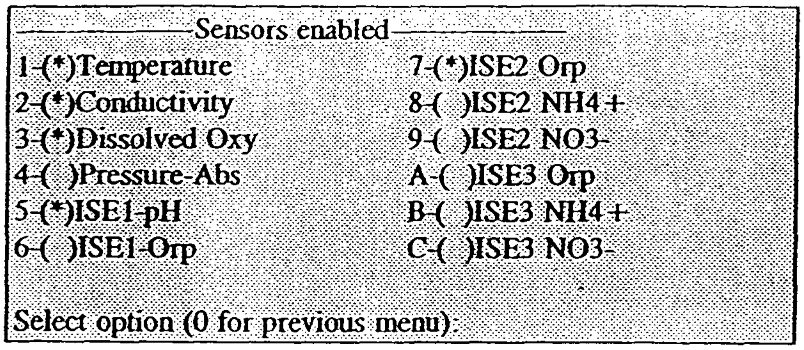
Press 0 or Esc to return to main menu.

```
------------ Main ------------
1. Run            4. Report
2. Calibrate      5. Sensor
3. System         6. Advanced

Select Option (0 for previous menu):
```

You must now enable (or activate) the sensors which have been installed in your 600XL sonde.

Select 5. Sensor

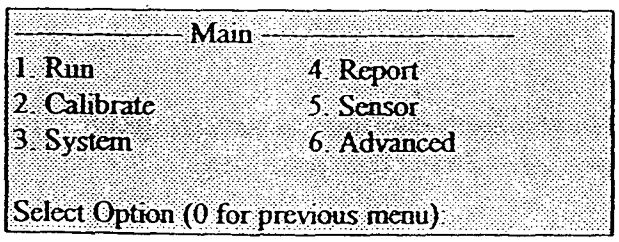


```
------------Sensors enabled------------
1-(*)Temperature         7-(*)ISE2 Orp
2-(*)Conductivity        8-( )ISE2 NH4+
3-(*)Dissolved Oxy       9-( )ISE2 NO3-
4-( )Pressure-Abs        A-( )ISE3 Orp
5-(*)ISE1-pH             B-( )ISE3 NH4+
6-( )ISE1-Orp            C-( )ISE3 NO3-

Select option (0 for previous menu):
```

Enter the corresponding number to enable the sensor(s) that are installed on the sonde. The activated selection is indicated by the asterisk. Pressure will only appear if a depth or level sensor has been installed in the factory. This selection will appear as Pressure-Abs for depth sensors, and Pressure-Gau for level sensors. Selections 8 through C are for future upgrades of the instrument only and are not currently available on your 600XL.

After all installed sensors have been enabled, press 0 or Esc to return to the Main Menu.



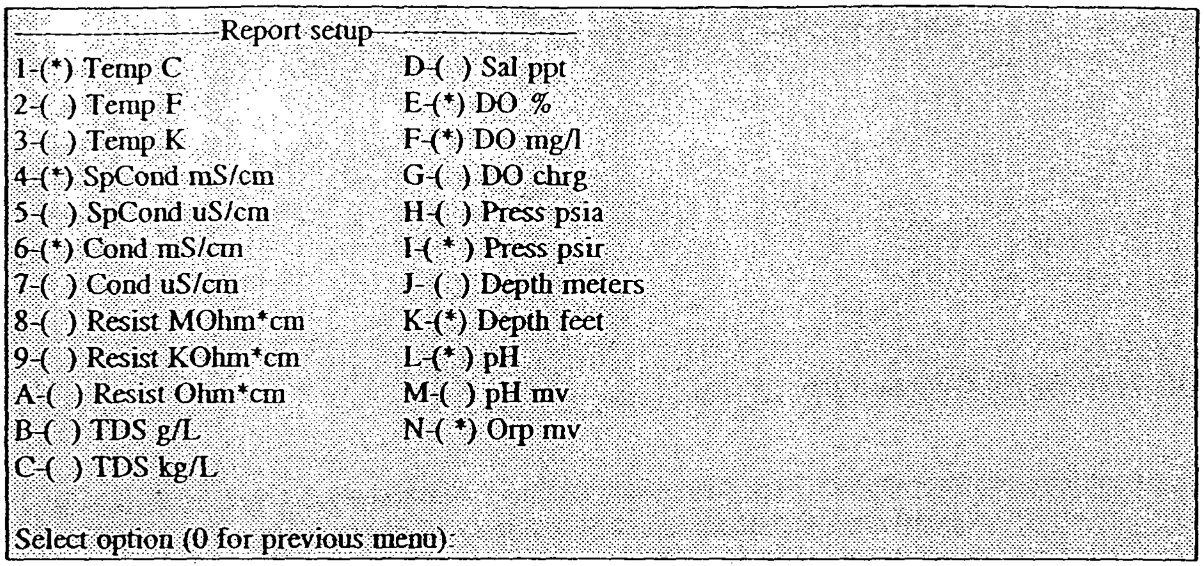
```
------------Main------------------
1. Run              4. Report
2. Calibrate        5. Sensor
3. System           6. Advanced

Select Option (0 for previous menu):
```

Even if all of your installed sensors are enabled, the measurements for that sensor may not appear on your display. In order for a specific parameter to be displayed:

1. The sensor must first be enabled (turned on).
2. That parameter must be activated in the Report section of the Main Menu.

Select **4. Report** from the Main sonde menu. The Report Setup menu will be displayed.

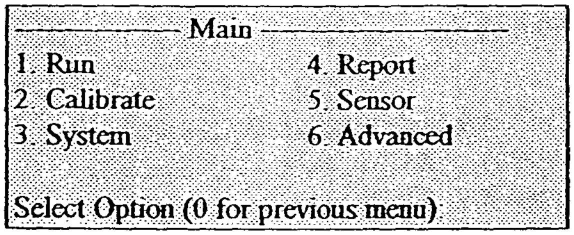


```
-----------------Report setup-----------------
1-(*) Temp C                 D-( ) Sal ppt
2-( ) Temp F                 E-(*) DO %
3-( ) Temp K                 F-(*) DO mg/l
4-(*) SpCond mS/cm           G-( ) DO chrg
5-( ) SpCond uS/cm           H-( ) Press psia
6-(*) Cond mS/cm             I-( * ) Press psir
7-( ) Cond uS/cm             J- ( ) Depth meters
8-( ) Resist MOhm*cm         K-(*) Depth feet
9-( ) Resist KOhm*cm         L-(* ) pH
A-( ) Resist Ohm*cm          M-( ) pH mv
B-( ) TDS g/L                N-( *) Orp mv
C-( ) TDS kg/L

Select option (0 for previous menu):
```

The asterisk (*) following a given number or letter indicates that parameter will appear on all output and reports. To turn a parameter on or off, type the number or letter of that parameter at the flashing cursor. Continue this process until all parameters are either on or off as you wish.

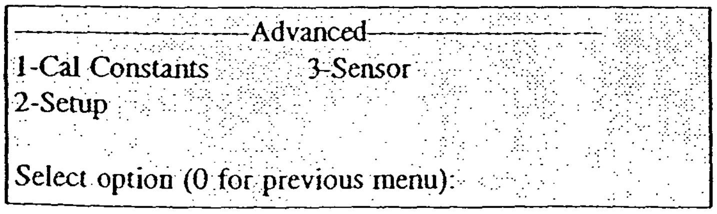
After configuring your display with the desired parameters, press 0 or Esc to return to the Main Menu.



```
-------------- Main --------------
1. Run              4. Report
2. Calibrate        5. Sensor
3. System           6. Advanced

Select Option (0 for previous menu):
```

For the final steps in the setup of your 600XL sonde software, Select 6. **Advanced** from the sonde Main menu. The following menu will be displayed:



```
----------------Advanced----------------
1-Cal Constants        3-Sensor
2-Setup

Select option (0 for previous menu):
```

Select 2. **Setup**. The following menu will be displayed:

```
------------------Advanced setup------------------
1-( * ) VT emulation
2-(   ) Power up to Menu
3-(   ) Power up to Run
4-(   ) Comma radix
5-( * ) Filter data
6-(   ) Auto sleep RS232
7-(   ) Auto sleep SDI12
8-( * ) Multi SDI12

Select option (0 for previous menu)
```

For your first studies with the 600XL, make certain that the **Advanced setup** selections (indicated "on" or "off" by the asterisk) are chosen as in the above display. It is particularly important that both of the "Auto sleep" choices are "off". When this setup is verified, press Esc or 0 to return to the Advanced menu. The basis for these choices is fully explained in Section 4.6.

Select 3.-Sensor. The following menu will be displayed.

```
------------------Advanced sensor------------------
1-TDS constant=0.65
2-Pres psi=0
3-DO temp co %/C=1.1
4-DO warm up sec=60
5-(  )Wait for DO
```

For your first studies with the 600XL, make certain that the **Advanced sensor** selections (indicated "on" or "off" by the asterisk) are chosen as in the above display. It is particularly important that "Wait for DO" is "off". When this setup is verified, press Esc or 0 to return to the Advanced menu. The basis for these choices is fully explained in Section 4.6.

Press Esc or 0 to back up to the Main menu. See Section 4 for a more detailed description of the sonde menus. The sonde software is now set up and ready to calibrate and run. Proceed to Section 3.

# 3. BASIC OPERATION

In the previous Section, you learned how to install probes and set up the PC6000, EcoWatch for Windows, and 600XL sonde software. In this Section, you will learn how to calibrate and run the Model 600XL and how to view your data on a computer display. If you choose to use your 600XL with a 610-series display/logger, refer to the operations manual for the 610 to obtain similar instructions to those provided below.

## 3.1 CALIBRATION TIPS

**WARNING:** Reagents used to calibrate and check this instrument may be hazardous to your health. Refer to Appendix A for health and safety information.

Before you begin the calibration procedures outlined below, you may find it helpful to follow some or all of these calibration tips.

1. Remove the sonde stainless steel weight on the bottom of the sonde guard by turning it counterclockwise. This allows the calibration solutions access to the probes with minimal displacement of fluid within the calibration cup. Additionally, carry-over from one solution to the next is reduced.

2. Fill a large bucket with ambient temperature water for rinsing the sonde between calibration solutions.

3. Have several clean, absorbent paper towels or cotton cloths available to dry the sonde between rinses and calibration solutions. It is important to remove as much residual liquid as possible from the sonde after each rinse. Shake the sonde to remove excess rinse water from the inside of the guard. Then dry the outside of the sonde and guard. Drying the sonde and probes in this way reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration, particularly lower conductivity calibration standards.

4. It is not necessary to remove the probe guard to rinse and dry the probes between calibration solutions. The inaccuracy resulting from simply rinsing the probe compartment and drying the outside of the sonde is minimal.

## 3.2 CALIBRATION PROCEDURES

**WARNING:** Calibration reagents may be hazardous to your health. Refer to Appendix A for health and safety information.

A calibration cup is supplied with the Model 600XL. Because the calibration cup fits over the outside of the sonde sensor guard, it is not recommended or necessary to remove the guard to calibrate the sensors. Follow the procedures below to calibrate the sensors. Only *basic* DO percent saturation, Conductivity, pH, and Depth calibration procedures are discussed in this section. Temperature does not require calibration and is, therefore, not included in the Calibrate menu. ORP calibration is required only infrequently and is discussed in Section 4.2. For more detailed calibration procedures, which can be used to enhance the accuracy of some measurements, see Section 4.2.

From the sonde Main menu select 2. Calibrate. The Calibrate menu will be displayed.

```
-----------------Calibrate---------------------
1. Conductivity          4. ISE1-pH
2. Dissolved Oxy         5. ISE2-Orp
3. Pressure-Abs

Select option (0 for previous menu):
```

Pressure only appears if a sensor has been installed at the factory. The selection will read Pressure-Abs for depth sensors and Pressure-Gau for level sensors.

Selection of any of the parameters from the Calibrate menu listing will require the user to input a numerical value and then press Enter. For example, for calibration of specific conductance, the following display will be shown during the calibration sequence.

```
Enter SpCond in mS/cm (10):
```

The number in parentheses is the default value of this parameter and will be used in the calibration if *only* Enter is pressed without typing in another value. Similar prompts will be displayed calibration of all parameters, but for some sensors, such as pH, no default values are provided. In these cases, the user must input a numerical value and then press Enter.

After the calibration value is input and Enteris pressed, a real-time display similar to the following will then appear on the screen. Note that all parameters which have been enabled will appear - not just the one being calibrated at the moment. The user should carefully observe the stabilization of the readings of the parameter which is being calibrated and, when the readings are stable for approximately 30 seconds, press Enter to implement the calibration.

```
===============================================
 Temp   SpCond   Cond      Sal
  C     mS/cm    mS/cm     ppt
-----------------------------------------------
To calibrate, press <Enter> when the readings are stable.
 23.00   10.0    10.0      15.7

Select option  (0 for previous menu)
```

**NOTE:** If an ERROR message appears, begin the calibration procedure again. Be certain that the value you enter for the calibration standard is correct. Also see Section 8, Troubleshooting for more information on error messages.

**CAUTION:** Be certain to **immerse the entire sonde** in solution standards for calibration of all parameters. Most calibrations require readings not only from the sensor being calibrated but also from the temperature sensor.

Specific start-up calibration procedures for all sensors which commonly require calibration are provided in the following paragraphs of this section. Remember that these are basic protocols designed to get the user up and running with regard to the 600XL. The more-detailed discussion of sensor calibration found in Section 4.2 should be examined prior to use of the instrument in the field.

**NOTE:** If the particular sensor listed is not installed in your sonde, proceed to the next sensor until the calibration protocol is complete.

## CONDUCTIVITY

**NOTE:** This procedure calibrates not only conductivity, but also specific conductance, salinity, and total dissolved solids.

Place approximately 300 mL of conductivity standard in a clean and dry calibration cup. The conductivity standard you choose should be within the same conductivity range as the water you are preparing to sample. However, we do not recommend using standard less than 1 mS/cm. For example:

- For fresh water choose a 1 mS/cm conductivity standard.
- For brackish water choose a 10 mS/cm conductivity standard.
- For sea water choose a 50 mS/cm conductivity standard.

**Caution:** Before proceeding insure that the sensor is as dry as possible. Ideally, rinse the conductivity sensor with a small amount of standard that can be discarded. Be certain that you avoid cross contamination of standard solutions with other solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP probes, particularly if you are employing standards of low conductivity.

Without removing the sonde guard, *carefully* immerse the probe end of the sonde into the solution. Gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell. The probe must be completely immersed past its vent hole.

Allow at least one minute for temperature equilibration before proceeding.

From the Calibrate menu, select **1. Conductivity** to access the Conductivity calibration procedure and then **1. SpCond.** to access the specific conductance calibration procedure. Enter the calibration value of the standard you are using (mS/cm at 25 C) and press Enter. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

Observe the readings under Specific Conductance or Conductivity and when they show no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to return to the Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

## pH 2-POINT

Place approximately 200 mL of pH 7 buffer in a clean calibration cup. *Carefully* immerse the probe end of the sonde into the solution.

Allow at least 1 minute for temperature equilibration before proceeding.

From the **Calibrate** menu, select **4. ISE1 pH** to access the pH calibration choices and then **2. 2-Point**. Press Enter and input the value of the buffer (7 in this case) at the prompt. Press Enter and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press Enter. The display will indicate that the calibration is accepted.

After the pH 7 calibration is complete, press Enter again, as instructed on the screen, to continue.

Rinse the sonde in water and dry the sonde before proceeding to next step.

Place approximately 200 mL of a second pH buffer solution in a clean calibration cup. The second buffer might be pH 4 if the sample is expected to be acidic or pH 10 if the sample is expected to be basic. *Carefully* immerse the probe end of the sonde into the solution.

Allow at least 1 minute for temperature equilibration before proceeding.

Press Enter and input the value of the second buffer at the prompt. Press Enter and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press Enter. After the second value calibration is complete, press Enter again, as instructed on the screen, to return to the Calibrate menu.

Rinse the sonde in water and dry the sonde.

Thoroughly rinse and dry the calibration cups for future use.

## DISSOLVED OXYGEN

Place approximately 1/8 inch of water or a wet sponge in the bottom of the calibration cup. Place the probe end of the sonde into the calibration cup. Make certain that the DO and the temperature probes are not immersed in the water. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperatures of the thermistor and the oxygen probe to equilibrate. Make certain that the calibration cup is vented to the atmosphere.

From the Calibrate menu, select 2. **Dissolved Oxy** to access the DO % calibration procedure.

Enter the current barometric pressure in mm of Hg . *Remember that barometer readings which appear in meteorological reports are generally corrected to sea level and are not useful for you calibration procedure unless they are uncorrected.*

**NOTE:** Inches of Hg x 25.4 mm/inch = mm Hg

Press Enter and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize. Observe the readings under DO % and when they show no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to return to the Calibrate menu.

Rinse the sonde in water and dry the sonde.

**NOTE:** Calibration of dissolved oxygen in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

**NOTE:** The above procedure is designed to calibrate your dissolved oxygen sensor for use in sampling applications where the sensor is being pulsed continuously in the Run mode because both "Auto sleep" and 'Wait for DO" functions have been disabled as described in Section 2. If your 600XL is to be used in a monitoring application in which data is being captured to a computer or data collection platform, "Auto sleep" and 'Wait for DO" will be activated and the calibration displays will be somewhat different. See Section 4 for details.

## DEPTH AND LEVEL

Following the DO calibration, leave the sonde in air. Make certain that the sonde is not submerged in water for this calibration.

From the Calibrate menu, select **Pressure**. Input 0.00 or some known sensor offset in feet. Press Enter and monitor the stabilization of the readings with time. When no significant change occurs for approximately 30 seconds, press Enter to confirm the calibration and zero the sensor.

After depth is zeroed, press Enter again, as instructed on the screen, to return to the Calibrate menu.

The sensors are now calibrated. Press Esc until the sonde Main menu is displayed.

## 3.3 TAKING READINGS

When you have calibrated the sensors, enabled the sensors as you prefer, and have set up the report to show the parameters you want to see, you are then ready to take readings.

Select 1. **Run** from the sonde Main menu. The following menu will be displayed:

```
------------------Run setup------------------
1-Start sampling             2-Sample interval=4

Select option (0 for previous menu):
```

Select 2. Sample interval. The following prompt will be displayed:

```
Enter sample interval:
```

Input a number which represents the number of **SECONDS** between samples. For this example, input 4 seconds, the minimum sample interval for most applications.

Next, Select 1. **Start sampling** from the Run setup menu.. A screen similar to the following will be displayed:

```
==========================================
Temp       SpCondCond         Sal     DOsat        pH
   C         mS/cm       mS/cm        ppt        %
-------------------------------------------------------
23.00       10.0        10.0          15.0      98.6      7
```

Measurements will begin to appear on the screen at the sampling interval you have defined. This data will not be stored to a file unless you instruct PC 6000 to capture this data. To create a file of the information which is displayed on your computer PC6000 system -- press F3 as instructed at the bottom of the display screen. See section 3.4 Data Capture.

## 3.4 CAPTURING DATA

### Introduction

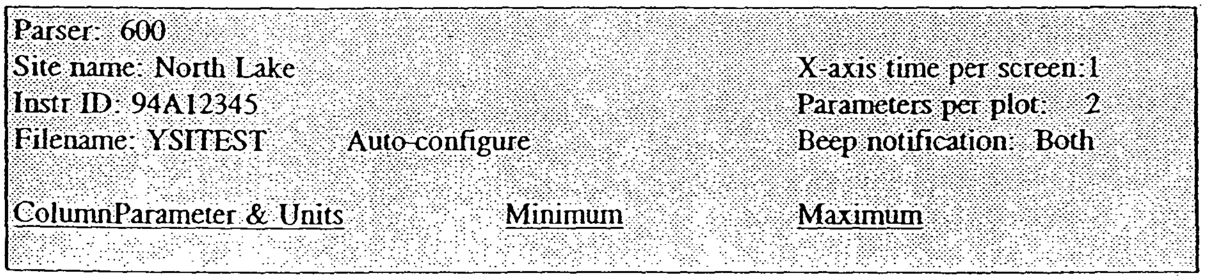
NOTE: The following section applies only to the capture of data with PC6000 software. When interacting with the 6820 via Ecowatch for Windows, consult the Help command in the top menu bar for detailed instructions.

Once you have begun to take readings, as described in section 3.3 above, you can capture that information in a data file, simply by pressing the F3 key on your computer. Once the F3 button has been pressed, the screen displaying your measurement readings will change in appearance so that it can be easily distinguished from a non data-capture screen.

PC6000 will use the date and time from your computer's internal clock to stamp each incoming data point. It is important, therefore, to make sure that the date and time are set up correctly inside your computer. Consult your computer instruction manual if you are unsure how to set the computer internal clock.

### Setting up for Data Capture

To assign a file name to your captured data, return to the PC6000 menu bar by pressing F10. Select **Setup** from the top line menu and press Enter. Select **Data Capture Setup** from the setup menu and press Enter. The Data Capture Setup menu will be displayed.



```
Parser: 600
Site name: North Lake                                      X-axis time per screen:1
Instr ID: 94A12345                                         Parameters per plot:  2
Filename: YSITEST        Auto-configure                    Beep notification: Both

ColumnParameter & Units              Minimum               Maximum
```

Use the arrow keys to highlight the **Filename**: selection. Then type in the name under which you want your data to be stored on the computer hard or floppy disk. Remember that, while you can use up to 15 characters in the name, MS-DOS will only recognize the first 8 for file designation.

Now highlight the **Auto-configure** selection and press Enter. This action makes certain that your Data Capture setup in the PC6000 software has the parameters selected as are selected in the

The following sections detail the calibration routines for all parameters under manual user control ("Auto sleep"and 'Wait for DO"deactivated). Remember that the sequence of events is very similar in the automatic calibration mode except the calibration will occur with no user input to the keyboard.

Select 2. **Calibrate** from the sonde Main menu, the Calibrate menu will be displayed. Note that only the enabled parameters will be available for calibration.

```
-----------Calibrate-----------
1-Conductivity        4-ISE1-pH
2-Dissolved Oxy       5-ISE2-Orp
3-Pressure-Abs

Select Option (0 for previous menu):
```

## 1. Conductivity

Select this option to calibrate the conductivity probe and a second menu will offer you the options of calibrating in specific conductance, conductivity, or salinity. Calibrating any one option automatically calibrates the other two. After selecting the option of choice (specific conductance is normally recommended), you will be asked to enter the value of the standard used during calibration. Be certain that the units are correct. After pressing Enter, you will be able to follow the stabilization of the readings and confirm the calibration when the readings are stable by pressing Enter as instructed on the screen. Then, as instructed, press Enter again to return to the Calibrate menu.

## 2. Dissolved Oxy

Select this option to calibrate the oxygen probe, the submenu will offer you the option of calibrating in percent saturation or mg/L. After selecting the option of choice (water-saturated air is normally recommended), you will be prompted for the next step. Calibrating either of the choices will automatically calibrate the other.

For the percent saturation mode, be certain that the sensor has been thermally equilibrated in water-saturated air and that the sensor has stabilized (about 10-15 minutes) prior to beginning the calibration routine, particularly after a membrane change. Relieve pressure in the cup if necessary. See Section 3.2 for more details. Then follow the screen prompt and enter the local barometric pressure in mm Hg, (in Hg x 25.4), press Enter, and monitor the stabilization of the DO readings. After no changes occur for approximately 30 seconds, press Enter to confirm the calibration. Then, as instructed, press Enter again to return to the Calibrate menu.

For the mg/l mode, calibration is carried out in a water sample which has a known concentration of dissolved oxygen, usually determined by a Winkler titration. For this calibration procedure, the sensor should be immersed in the water. After thermal equilibration, enter known mg/l value, press Enter, and the calibration procedure will begin with similar viewing of stabilization and confirmation of calibration as for the percent saturation mode above.

NOTE: Usually the stability of your DO sensor will allow calibration in 2-3 minutes of pulsing during the calibration protocol. However, after a membrane change, a somewhat longer period may be required (approximately 5 minutes). If you have resurfaced your DO sensor, we recommend running the probe (either in the Run or Calibrate modes) for 15-30 minutes or until good stability is realized.

### 3. Pressure -Abs

Select this option to zero the pressure sensor used for depth and level measurements (If it is a level sensor, the menu item will appear as Pressure-Gau.). The pressure sensor is factory calibrated, but it is necessary to zero the sensor. The zeroing procedure should be carried out with the sonde in air. Do not attempt to zero the depth probe when the sonde is immersed. After the pressure option is selected, enter 0.00 at the prompt, press Enter and monitor the stabilization of the readings. After no changes occur for approximately 30 seconds, press Enter to confirm the calibration. As instructed, press Enter again to return to the Calibrate menu.

In some unusual applications, an offset other than 0.00 may be desired and can be entered when prompted for a calibration value

### 4. ISE1-pH

On selecting this option, you will by given the choice of 1-point, 2-point, or 3-point calibrations.

Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. Immerse the sonde in a buffer of known pH value and press Enter. You will be prompted to type in the pH value of the solution. Press Enter again, and the screen will display real-time readings which will allow you to determine when the pH and temperature readings have stabilized. Pressing Enter will confirm the calibration. Then, as instructed, press Enter again to return to the Calibrate menu. This calibration procedure adjusts only the pH offset and leaves the slope unaltered.

Select the **2-point** option to calibrate the pH probe using only two calibration standards. In this procedure, the pH sensor is calibrated using a pH 7 buffer and *one additional* buffer. A two point calibration procedure (as opposed to a 3-point procedure) can save time if the pH of the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two point calibration with pH 7 and pH 4 buffers is appropriate. Three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.

To begin the calibration, immerse the sonde in one of the buffers, as instructed, and enter the actual pH value. Press Enter, and the screen will display real-time readings which will allow you to determine when the pH sensor has stabilized. Pressing Enter will confirm the calibration. Following the instructions on the screen, place the sonde in the second pH buffer, input the pH value, press Enter, and view the stabilization of the values on the screen in real time. After the readings have stabilized, press Enter to confirm the calibration. Then, as instructed, press Enter again to return to the Calibrate menu.

Select the **3-point** option to calibrate the pH probe using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3 point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2 point calibration, but the software will prompt you to select a third pH buffer to complete the 3 point procedure.

### 5. ISE2-Orp

Select this option to calibrate the ORP sensor. Immerse the sonde in a solution with a known oxidation reduction potential value (we recommend Zobell solution) and press Enter. You will be prompted to enter the ORP value of the solution. Press Enter, and monitor the stabilization of the ORP and temperature readings. After no changes occur for approximately 30 seconds, press Enter to confirm the calibration. Then, as instructed, press Enter again to return to the Calibrate menu.

## 4.3 SYSTEM

With this menu, the user can customize the 600XL communication protocol and display style, and enter an instrument identification number.

Select **3. System** from the sonde Main menu. The System setup menu will be displayed:

```
------------System-setup----------------
1. Comm setup
2. Page length=25
3. Instrument ID
4. SDI-12 address=0

Select option (0 for previous menu):
```

Select each item by pressing the appropriate number key and making any desired changes as described below.

### 1. Comm setup

Select **1. Comm setup** and the following menu will be displayed.

```
----------------Comm setup--------------------
1-( ) Auto  baud               5-(  ) 2400 baud
2-( )   300 baud               6-(  ) 4800 baud
3-( )   600 baud               7-(* )  9600 baud
4-( )  1200 baud

Select option (0 for previous menu):
```

The default is 9600, but you may change it to match your host communication interface protocol by typing in the corresponding number 1 to 7. The selection will be indicated by an asterisk. Auto baud may be selected with any of the choices. The Auto baud option enables the 600XL to recognize the baud rate of the received characters and adjust to it.

**NOTE:** If you change the baud rate here, you must press F10 and immediately change the baud rate in PC6000 setup. If this is not done, the Model 600XL will not be able to communicate with PC6000 and your system will appear to be "locked-up." See Section 4.5 for more information.

Press Esc or 0 to return to the System setup menu.

### 2. Page length

Depending on the type of display you are using with your Model 600XL, you may want to change the page length using the above menu option. Select **2. Page length** from the System setup menu and press Enter. This will allow you to control how many lines of data are sent to your display before a new header is shown. The smaller the page number, the fewer lines of data will be transmitted to your display between headers. The larger the page number, the more lines of data will be transmitted to your display between headers.

**NOTE:** The header itself takes 4 lines. Therefore, if the page length is set to 25, there will be 21 lines of data and one header. Any page length less than 5 will result in no header being transmitted.

### 3. Instrument ID

Its always a good idea to associate any data you are collecting with the specific sonde which performed the measurements. To record the instrument ID number (usually the instrument serial number) Select 3. **Instrument ID** from the System setup menu and press Enter. A prompt will appear which will allow you to type in the serial number of the Model 600XL you are using.

Press Esc or 0 to return to the System setup menu.

### 4. SDI-12 address= 0

The SDI-12 default address is zero (0). This feature is fully described in Chapter nine (9) and only utilized if the unit is to operate in a SDI-12 protocol network.

## 4.4 REPORT

Select 4. **Report** from the sonde Main menu to configure all reports displayed by the sonde software. You will be able to select which parameters and units of measure which are displayed during operation.

NOTE: Even if all of the sensors are turned on, the measurements for that sensor may not appear on your display. In order for a specific parameter to show up on a report:

1. The sensor must first be enabled (turned on).
2. That parameter must be activated on the Report.

Select **4. Report** from the sonde Main menu. The following menu will be displayed.

```
----------------Report setup----------------
1-(*) Temp C                D-( ) Sal ppt
2-( ) Temp F                E-(*) DO %
3-( ) Temp K                F-(*) DO mg/l
4-(*) SpCond mS/cm          G-( ) DO chrg
5-( ) SpCond uS/cm          H-( ) Press psia
6-(*) Cond mS/cm            I- ( ) Press psir
7-( ) Cond uS/cm            J- ( ) Depth meters
8-( ) Resist MOhm*cm        K-(*) Depth feet
9-( ) Resist Kohm*cm        L-(*) pH
A-( ) Resist Ohm*cm         M-( ) pH mv
B-( ) TDS g/L               N-(*) Orp mv
C-( ) TDS kg/L

Select option (0 for previous menu):
```

The asterisk (*) following a given number or letter indicates that parameter will appear on all output and reports. A blank ( ) following the number or letter indicates that parameter will not appear on any output or reports. To turn a parameter "on" or "off", type the number or letter of that parameter at the flashing cursor. Continue this process until all parameters with the desired units are either "on" or "off" as you wish.

In the above example, if the appropriate sensors have been activated in the **Sensor setup** section, the following parameters will be displayed to the computer screen or captured to a computer or data collection platform when the sonde is sampling: Temperature in degrees C, Specific Conductance in mS/cm, Conductivity in mS/cm, Dissolved oxygen in percent air saturation, Dissolved oxygen in mg/l, Depth in feet, pH, and ORP in millivolts.

NOTE: Do not attempt to memorize or associate a number or letter with a particular parameter. The numbering scheme is dynamic and changes depending on the particular sensors which have been enabled.

The following is a complete listing of the abbreviations utilized for the various parameters and units available in the Report menu.

| *Parameter* | *description* |
|---|---|
| Temp C | Temperature in degrees Celsius |
| Temp F | Temperature in degrees Fahrenheit |
| Temp K | Temperature in degrees Kelvin |
| SpCond mS/cm | Specific Conductance in milliSiemens per centimeter |
| SpCond uS/cm | Specific Conductance in microSiemens per centimeter |
| Cond mS/cm | Conductivity in milliSiemens per centimeter |
| Cond uS/cm | Conductivity in microSiemens per centimeter |
| Resist MOhm*cm | Resistivity in MegaOhms * centimeter |
| Resist Kohm*cm | Resistivity in KiloOhms * centimeter |
| Resist Ohm*cm | Resistivity in Ohms * centimeter |
| TDS g/L | Total dissolved solids in grams per liter |
| TDS kg/L | Total dissolved solids in kilograms per liter |
| Sal ppt | Salinity in parts per thousand |
| DO sat % | Dissolved oxygen in % air saturation |
| DO mg/L | Dissolved oxygen in milligrams per liter |
| DO chrg | Dissolved oxygen sensor charge |
| Press psia | Pressure in pounds per square inch absolute |
| Press psir | Pressure in pounds per square inch relative |
| Pressure psig | Pressure in pounds per square inch gauge |
| Depth meters | Water column in meters |
| Depth feet | Water column in feet |
| pH | pH in standard units |
| pH mv | millivolts associated with the pH reading |
| Orp mv | Oxidation reduction potential value in millivolts |

## 4.5 SENSOR

This section of the software allows you to Enable or Disable (turn on or off) any available sensor and, in some cases, to select the port in which your sensor is installed.

Select 5. **Sensor** and the following display will appear.

```
-------------Sensors enabled--------------
1-(*)Temperature            7-(*)ISE2 Orp
2-(*)Conductivity           8-( )ISE2 NH4+
3-(*)Dissolved Oxy          9-( )ISE2 NO3-
4-(*)Pressure-Abs           A-( )ISE3 Orp
5-(*)ISE1-pH                B-( )ISE3 NH4+
6-( )ISE1-Orp               C-( )ISE3 NO3-

Select option (0 for previous menu):
```

From this menu, simply press the number of the sensor which you desire to enable or disable. When a particular sensor is active, an asterisk will appear in the parentheses associated with the selection. In the example, the temperature, conductivity, dissolved oxygen, pressure, pH, and ORP sensors are enabled. To disable a sensor, simply press the number of the active sensor, the asterisk will disappear, and the sensor will no longer be active.

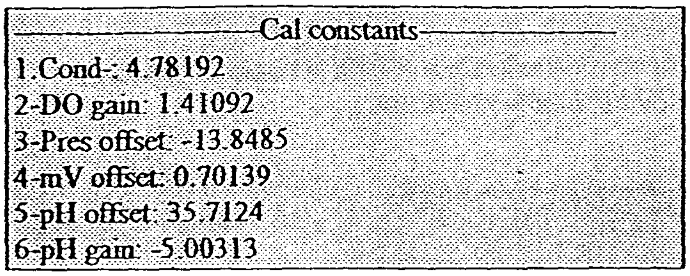
Note that an ORP sensor can be assigned to either ISE1 or ISE2 using the above selection. If the 6563 (ORP only) probe is used with the 600XL, then 6. **ISE1-Orp** should be activated. However, under the more common use of the 6565 and 6567 (pH/ORP combination) probes, it is necessary to activate 7. ISE2 in order obtain ORP readings.

NOTE: A pressure sensor will appear only if a sensor has been installed at the factory. It will appear as Pressure-Abs for depth measurements and Pressure-Gau for level measurements. Selections 8 through C are for future upgrades of the instrument only and are not currently available on your 600XL.

## 4.6 ADVANCED

Select 6. **Advanced** to display the sensor calibration constants. For a new sonde, the menu will display the factory defaults.

Select 1. **Cal constants** to display the calibration constants, as shown in the following example. Note that values only appear for enabled sensors.



```
----------------Cal constants----------------
1-Cond-: 4.78192
2-DO gain: 1.41092
3-Pres offset: -13.8485
4-mV offset: 0.70139
5-pH offset: 35.7124
6-pH gain: -5.00313
```

The following table provides the default value, operating range, and units for these calibration constants.

| | *Default* | *Operating range* | *Units* |
|---|---|---|---|
| Cond: | 5 | 2.5 to 10.0 | (traditional cond constant) |
| DO gain: | 1 | 0.5 to 2.0 | (relative to default) |
| Pres offset: | | | |
| if absolute | -14.7 | -20.7 to -8.7 | (psi) |
| if gauge: | 0.0 | -6 to 6 | (psi) |
| mv offset: | 0.0 | -100 to 100 | (mV) |
| pH offset: | 0.0 | -400 to 400 | (pH/degK) |
| pH gain: | -5.0583 | -6.07 to -4.22 | (pH/(mV*degK)) |

NOTE: To reset a calibration cell constant, access the sonde Calibrate menu. Then select the sensor and type "UNCAL" instead of the value. This action will change the calibration constants back to the factory default.

From the **Advanced** menu, select 2.Setup to display miscellaneous 600XL options. Type the appropriate number to activate/deactivate any of the displayed features.

```
------------Advanced setup------------
1-(*) VT100 emulation
2-( ) Power up to Menu
3-( ) Power up to Run
4-( ) Comma radix
5-(*) Autosleep RS232
6-( ) Autosleep SDI12
7- (*) Multi SDI12
8- ( ) Full SDI12
```

**1-(*)VT100 emulation.** Activate this option for VT100 terminal emulation. This feature allows the 600XL to send escape sequences to clear the screen which in turn results in an improved display. Usually this feature should be activated, but, if your terminal or terminal emulator shows odd characters at the beginning of each menu title, then turn this item off. With the feature off, the 600XL will send several carriage returns and line feeds to 'clear' the display. The number of <cr>'s and <lf>'s is determined by the page length setting.

**2-(*)Power up to Menu.** When this item is enabled, the 600XL will go directly to menu mode when power is applied to the 600XL. If the command line mode is not useful for your applications, then enabling this item will negate the need to type "Menu" and Enter at the # prompt to access the Main sonde menu.

**3-(*)Power up to Run.** When this item is enabled the 600XL will start sampling and output data as soon as power is applied to the 600XL. If **Power up to menu** is also enabled, the 600XL will first enter the menu mode and then the run mode where it will start sampling. If **Power up to menu** is not enabled, the 600XL will go to command line mode and then start the run function. With **Power up to Run** disabled, the 600XL will wait for your command at power up (in either command line or menu mode) as set by **Power up to Menu**.

**4-(*)Comma radix.** When this item is enabled, the 600XL will replace decimal points with commas when printing numbers. NOTE: Regardless of this setting, SDI-12 'D' commands will still respond using a decimal point.

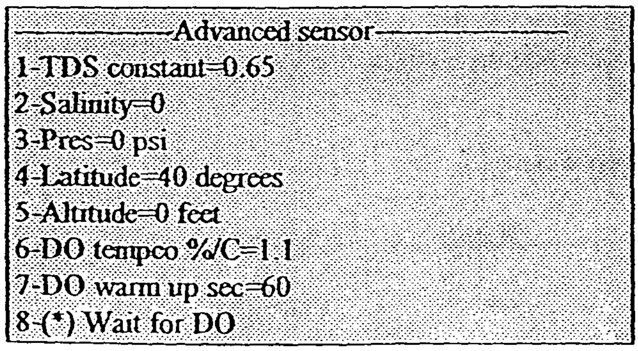
**5-(*)Auto sleep RS232.** Activation of this feature enables a power savings system when communicating with the 600XL in RS-232 mode. When enabled, power is only applied to the sensors during sampling or calibration. Additionally, if the 600XL is not sampling or calibrating, it will "sleep" after one minute with no communications. Any character sent to it when sleeping will "wake" it, although the character sent will be discarded. It takes the 600XL about 30 milliseconds to wake up. Disabling this item allows for "instant" readings. Generally, this feature should be activated for long term monitoring studies in the RS-232 communication mode.

**6-(*)Auto sleep SDI12.** Activation of this feature enables the power savings system when communicating with the 600XL in SDI-12 mode. This is basically the same as item 6 above except that it is used in communication via the SDI-12 interface. Also, the 600XL will "sleep" in about 100 milliseconds in the absence of communication, rather that waiting one minute in the Auto sleep RS-232 mode.

**7-(*) Multi SDI12.** Activation of this feature enables the 600XL sonde to respond to a global SDI-12 command, such a "start measurement" command. If multiple 600XL sondes are to be connected to an SDI-12 bus, all sondes with this feature enabled will execute the command synchronously.

**8-(*) Full SDI12.** Enabling this feature forces full SDI-12 specification in order to pass the NR Systems SDI-12 Verifier. Disabling this feature will allow the unit to be more fault tolerant and will save some power. We recommend that you leave this feature "off".

Select **3. Sensor** to display and change user-configurable constants as shown in the following display. Type the appropriate number to change to these parameters.



```
-------------Advanced sensor-------------
1-TDS constant=0.65
2-Salinity=0
3-Pres=0 psi
4-Latitude=40 degrees
5-Altitude=0 feet
6-DO tempco %/C=1.1
7-DO warm up sec=60
8-(*) Wait for DO
```

**1-TDS constant=0.65** This selection allows the user to set the constant used to calculate TDS. TDS in g/l is calculated by multiplying this constant times the specific conductance in mS/cm. This item will only appear if the conductivity sensor is enabled in the **Sensors enabled** menu.

**2-Salinity=0** This selection allows the user to input a manually-acquired value of salinity for calculating other parameters such as DO mg/L. This item is not used or displayed if the conductivity sensor is enabled in the **Sensors enabled** menu.

**3-Pres=0 psi** This selection allows the user to set a value of pressure for calculating other parameters like salinity. This item is not used or displayed if the pressure sensor is enabled in the **Sensors enabled** menu.

**4-Latitude=40 degrees** This selection applies only to depth and level measurements. Enter the latitude for the site that will be studied. A value within 1 degree is adequate.

**5-Altitude=0 feet** This selection applies only to depth and level measurements. Enter the altitude of the site that will be studied. A value within 500 feet is adequate.

**6-DO temp co=1.1%/C** This selection allows the user to input the dissolved oxygen temperature coefficient. Do not change this value unless you consult Endeco/YSI Customer Service. This item will only appear if the dissolved oxygen sensor is enabled in the **Sensors enabled** menu.

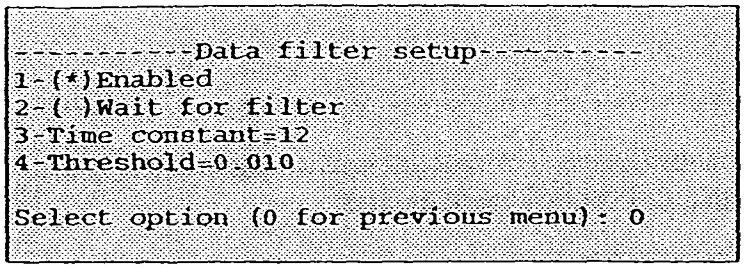
**7-DO warm up=60** This selection allows the user to set the amount of time allowed for DO warm up in seconds. Normally the default value of 60 seconds is adequate for most applications. However, there may be certain situations in which greater DO accuracy can be attained by increasing this time. Consult Endeco/YSI Customer Service if you feel that your DO warm up time is incorrect. This item will only appear if the dissolved oxygen sensor is enabled in the **Sensors enabled** menu.

**8-(*)Wait for DO** When this feature is enabled, the 600XL is forced to wait for the DO warm up time to expire before displaying any readings. Note that in SDI12 mode or while calibrating the DO sensor, the warm up time is used regardless of the activation of this item. Disabling this item allows you to see data without having to wait the DO warm up time. If you are using the 600XL with a data logger in RS232 mode and will be turning the 600XL "on" and "off" for each sample, then you may want to disable this item so that only stable DO data are recorded. This item will only appear if the dissolved oxygen sensor is enabled in the **Sensors enabled** menu.

The following is a summary of the items listed under **Sensor**:

| *item:* | *visible if:* | *default:* | *range:* |
|---|---|---|---|
| TDS constant | conductivity sensor is on | 0.65 | 0 to 1000 |
| Salinity | conductivity sensor is off | 0 | 0 to 1000 |
| Pres psi | pressure sensor is off | 0 | 0 to 1000 |
| Latitude | pressure sensor is on | 40 | -90 to 90 |
| Altitude | pressure sensor is on | 0 | -276 to 29,028 |
| DO temp co %/C | DO sensor is on | 1.1 | 0 to 10 |
| DO warm up sec | DO sensor is on | 60 | 0 to 252, in steps of 4 |
| Wait for DO | DO sensor is on | off | on or off |

From the **Advanced** menu, select **4-Data filter** to display filtering options. Type the appropriate number to activate/deactivate any of the displayed features.



```
----------Data filter setup----------
1-(*)Enabled
2-( )Wait for filter
3-Time constant=12
4-Threshold=0.010

Select option (0 for previous menu): 0
```

**1-(*) Enabled.** Activation of this item results in data filtering according to the values set in (2), (3), and (4).

**2-(*) Wait for filter.** If this feature is activated, readings will be available for output only after the unit has warmed up for a time period equal to the **Time Constant** plus an extra 4 seconds. This feature is useful, for example, if you are operating in SDI12 mode and want to average the data over a particular period of time. In such a case, you would not want the filter to be engaging and disengaging, so the value of the **Threshold** should be set to a large value like 1.

**3-Time Constant.** This value is the time constant in seconds for the digital filter. Increasing the time constant will result in greater filtering of the data, but will also slow down the response of the sensors.

**4-Threshold.** This value determines when the digital filter will engage/disengage. For example, a value of 1.0 for the threshold roughly corresponds to the following changes in sensor readings:

- ☐ Temp: 100 C
- ☐ Conductivity: Full scale for given range (100, 10, 1, or 0.1 mS/cm)
- ☐ Dissolved Oxygen: 200 percent air saturation
- ☐ pH: 10 pH

When the difference between 2 consecutive unfiltered readings drops below the threshold, the filter will engage. When the difference between 2 consecutive filtered readings rises above the threshold, the filter disengages.

When the filter is disengaged, the readings are unfiltered. When the filter engages, a "soft start" feature takes over for the first period of the time constant. During this time, the output reflects a simple average of all the readings from the time the filter engaged until the present. Once the filter has been engaged for the period of the time constant, it becomes a simple filter with a time constant equal to that set in **3-Time Constant**. Each time the filter disengages and then reengages, this process is repeated. Because of this feature, each sensor effectively has its own filter and thus one parameter may be filtered while another is not because of differences in the noise level on each of the sensors.

For general purpose sampling and monitoring use, YSI recommends settings of 0.010 for the **Threshold** and 12 for the **Time Constant.**

# 5. PC6000 SOFTWARE

**NOTE: If you have purchased Ecowatch for Windows for use with your Model 600XL, consult the Help selection in the top menu bar if you have questions on the use of this powerful Windows-based software. The following section deals with the MS-DOS-based PC6000 which is offered with all YSI logger/sampler products at no charge.**

## 5.1 Introduction

The PC6000 program is very useful in the operation of the 600XL. This PC based software can be used with any IBM-compatible computer.

PC6000 enables you to:

- Configure and deploy the sonde
- Capture data from the sonde
- Create a variety of reports and plots
- Print reports and plots
- Save reports and plots to disk
- Export data to other programs

The PC6000 program is completely menu-driven and easy to use. There are nine menus, but beginning users can generate reports and plots using only two menus.

Use the arrow keys to move the cursor and highlight menu options.
Use the Enter key to select a highlighted menu option.
Use the Esc key to return to a previous screen.

When each menu option is highlighted, a short, descriptive help line is displayed at the bottom of the screen.

## 5.2 INSTALLING THE PC6000 SOFTWARE

The PC6000 software is provided with every 600XL and is located in the back of this instruction manual. Use this software if you have an IBM-compatible PC with at least 300KB of RAM and DOS 3.0 or later. Additional RAM and the presence of a math co-processor will improve the operation of the program, but are not required.

**NOTE:** PC6000 imposes no limit on the number of lines a report can have, but after generating a report, only the last 300 to 2500 lines can be viewed, depending on available RAM.

A graphics adapter is required for operation of the plotting feature. One RS-232 port (also called a comm port or serial port) is required to communicate with the sonde and to capture data files. This port must be either com1 or com2.

If your system is not IBM-compatible, use a terminal emulation program with your computer.

On IBM compatible computer systems with a hard disk drive see section 2.3 for installation instructions:

On systems with two floppy disks proceed as follows:

If necessary, exit whatever program or shell is running.

1. Make sure your computer is at the A or A:\ prompt.

2. Make sure your DOS system disk is in drive A.

3. Place a new disk in drive B and format it: FORMAT B:

4. Place the original PC6000 software diskette in drive A.

5. Copy the software onto the new disk: COPY A:*.* B:

6. Store the original PC6000 software diskette in a cool clean place, away from magnets, video screens, electronic and electrical equipment and cords.

7. When you want to use the software, put the copy of the PC6000 software into drive B, put any data disk into drive A, and type: B:PC6000

Once PC6000 has loaded, the program disk can be removed from the disk drive. The disk must be reinserted into the drive prior to exit from the Setup menu if any changes have been made. This will allow the program to update the configuration file on the disk.

**NOTE:** If you have a non-standard video adapter and monitor (rare except on CAD work stations) you will also need to:

1.) Put your video adapter into a compatible (standard) video mode. Typically the manufacturer of the video adapter provides a program or utility to set the video mode.

2.) Type **PC6000** -V to run the program. This tells PC6000 to send video output through the computer BIOS (built-in firmware), rather than directly to video memory. This procedure slows down the video output somewhat, but guarantees compatibility.

## 5.3 THE SONDE MENU

The **Sonde** option of the PC6000 software is covered in detail in Section 4 of this manual. This option emulates a VT 100 terminal which makes a direct connection between the sonde and your PC. Selecting this option will allow you to access and setup the sonde.

## 5.4 THE FILE MENU

Choosing **File** from the PC6000 menu bar allows you to specify and customize reports and plots based on data which has been captured from the sonde. Select **File** from the menu bar, and press Enter.

---

Sonde <u>File</u> Setup Real-Time Exit YSI PC6000

---

Filename: *.dat

At this prompt, press Enter. A list of all data files in the current directory will be displayed. Select the file you wish to retrieve from the list. If only one data file exists, that file will be loaded automatically.

To retrieve files stored on another drive or directory, at the filename: prompt, type the source drive and directory and press Enter.

Example, typing A:\PC6000\ at the prompt would provide the user with a list of all files located in the directory named PC6000 and stored on a disk in the A: drive.

### 1. MODIFY File Options

Any modifications performed with these functions will allow you to customize data and format reports and plots for a selected file only. See **SETUP** in this chapter to change default values permanently.

Select the **Parameters** menu option.

---

MODIFY

---

**Parameters**

Control Info
Scaling Info

---

The **Parameters** menu will be displayed.

X-axis parameter

---

Date + Time

Y-axis parameter

---

Temperature
Specific Cond
DO
pH
ORP
Depth

Highlighting any parameter on this display will provide the following sub menu.

Add parameter here
Delete this parameter
Move parameter up
Move parameter down
Detail this parameter

You may select **ONE** parameter for the X-axis, and up to 12 parameters for the Y-axis.

Add parameter here

Select this option to add a parameter to a report or plot. A list of all available parameters which can be added will be displayed. Choose those parameters which you want to be included in reports and plots.

Delete this parameter

Select this option to delete the highlighted parameter from reports and plots.

Move parameter up
Move parameter down

Select these options to shift the highlighted parameter up or down one position. By using these options all parameters within a report and plot can be displayed in the order you prefer.

Detail this parameter

Select this option to view detailed information of a highlighted parameter. PC6000 has many built-in formulae. Each formula accepts certain inputs and produces a single output. An example of this is the formula for specific conductance, which is calculated from temperature and conductivity.

Most formula inputs must be in the input data file from the sonde, but some can be entered as constants. For example, the total dissolved solids (TDS) constant can be manually entered.

Once you have selected a parameter and pressed Enter, the following screen will be displayed:

Parameter:
Formula:
Inputs:
Compensate:

Parameter:

This line simply redisplays the parameter you have just selected.

Formula:

Select this option to view and change the formula used by PC6000 to calculate the selected parameter. This option will allow you to change formulae and input sources only in circumstances where multiple formulae or input sources exist. If formula options for the highlighted parameter exist, they will be displayed when pressing Enter while the formula is highlighted.

Inputs:

This option is reserved for future software enhancements.

Compensate:

Select this option to compensate a data file for long term sensor drift. This compensation procedure is also commonly called Post-Calibration.

**Example:** Dissolved oxygen data can be collected periodically throughout a long term deployment using a separate, freshly calibrated DO meter. This independent data can then be used to compensate the 600XL data for the small sensor drift which normally occurs over time.

**NOTE:** The setup menu options for date format, date separator, time separator, and radix separator, all apply here. The date, time, and value are separated from each other by spaces. Lines which do not match the above format are ignored.

To create a compensation file, use a word processing program or follow the procedure below. The file must be simple ASCII. In WordPerfect you use the DOS Text Out feature. In Word, save as file type Text Only (*.TXT). From DOS, proceed as follows:

1. Issue the DOS command "COPY CON DO.CMP".

2. Type all the lines in your file (make sure each line is correct before you press Enter for that line).

   An example line would look like this:

   ```
   12/31/92 23:59:59 100
   ```

3. After the last line has been typed and entered, hold **Ctrl** and press **Z**, then press **Enter**.

4. The message **1 File(s) copied** will be displayed.

**NOTE:** If only one data point is entered into the compensation file, all data after that date and time will be corrected. If more than one data point is included in the compensation file, data between points will be corrected linearly.

To enter the compensation filename, press **TAB** while the highlight cursor is on compensate. The highlight cursor will move to the right. Enter the path and file name.

**Example:** C:\DO.CMP **Enter.**

When you enter a compensation filename, the program performs a test load of that compensation file. A summary is displayed so you can verify the file structure. The summary includes how many lines were accepted, rejected, or blank; the total number of lines, and the earliest and latest date.

If you compensate a constant used in calculating one parameter, you must also compensate the same constant if you use it to calculate other parameters. A total of 1000 compensation points is allowed for any single report or plot.

**Appendix F** of this manual is an application note which will be very helpful as you prepare for data collection to be used to compensate 600XL data.

Select **Control Info** from the Modify menu. The Control Info menu will be displayed

---

MODIFY

Parameters
Control Info
Scaling Info

---

The **Control Info** menu allows you to report or plot an entire file, or any portion of a file. Other options on the Control Info menu allow you to average several data points together and set up reports and plots to display data in the format you choose.

Enter title line

First sample was at:
Enter start time:
Enter stop time:
Last sample was at:

Logging interval was:
Enter averaging interval:

X-axis time per screen:

Cross-parameter style:
Cross-parameter groups:

Parameters per plot:

Enter title line

Select this option to assign a title which will appear on all reports and plots.

```
First sample was at:
Enter start time:
Enter stop time:
Last sample was at:
```

Select these options to view start and stop times of the file, and specify portions of the file to report or plot. The first and last line of this block of information indicates the actual start and stop time of the current file. You can identify any segment of time from within a file to report and plot data. For example, if the duration of the deployment was five days, but you wish to see a report and plot for only day three, simply enter the start and stop dates and times associated with day three. Even though all five days of data are retained, reports and plots will show only day three.

```
Logging interval was:
Enter averaging interval:
```

This option shows the sampling interval which was in effect throughout the deployment. You may choose to average several data points together for reporting and plotting. For example, if the 600XL readings were captured every 900 seconds (15 minutes) during the deployment, you might want the reports and plots to average four of these readings together so that the information can be reported or plotted on an hourly basis. To do this, define an averaging interval of 3600 seconds.

```
X-axis time per screen:
```

Select this option to specify the time interval on the X-axis. This line is only applicable when Date + Time have been defined for the X-axis (see **Parameters** above). You can define the width of a given plot screen in minutes by changing the number of minutes in this option.

```
Cross-parameter style:
```

Select this option to choose one of four plot styles. This option is only applicable if a parameter other than Date + Time is selected for the X-axis (see **Parameters** above).

An averaged plot (AVG) assumes a correlation between the X-axis parameter and the Y axis parameters. The averaged plot divides the X axis into 100 equal-sized memory bins. Each sample is tallied into the appropriate memory bin based on its X-axis value. When finished, the average value for each Y-axis parameter in each memory bin is displayed.

A sequential plot (SEQ), plots each point successively as it comes from the data file. A sequential plot provides more detail on the data than an averaged plot, but can appear rather messy.

The increase (INC) and decrease (DEC) plots are types of sequential plots. An increasing plot only displays points when the X-axis values are increasing. A decreasing plot only displays points when the X-axis values are decreasing. The increasing and decreasing sequential plots are especially useful if you are profiling and display depth on the X axis. Thus the plot shows only the time in which the sonde is being lowered or raised.

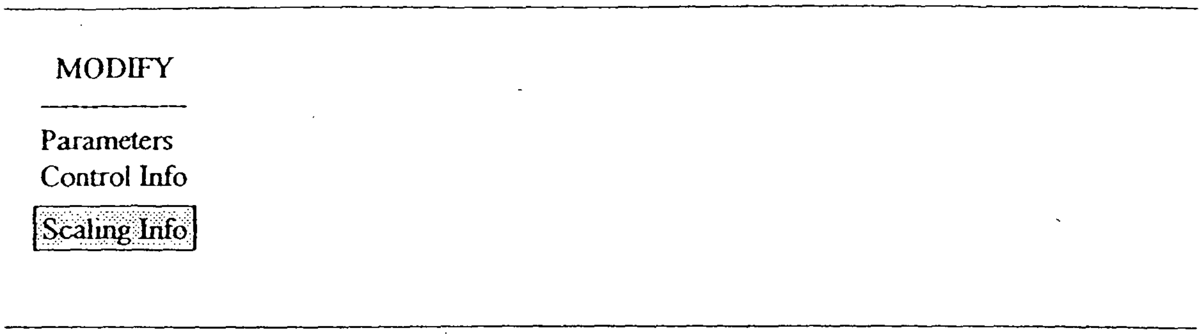
Cross-parameter bins: 100 (maximum xxxx)

Select this option to set up the number of bins which will appear on the X-axis. This feature only applies to reports and averaged plots (see above) with a parameter other than Date + Time on the X axis. Changing this value modifies the number of bins into which the X-axis is divided. The smaller the number of bins, the wider and more general is the plotted information. The maximum number of allowable bins varies with the capability of your computer system, and is displayed in parentheses.

Parameters per plot:

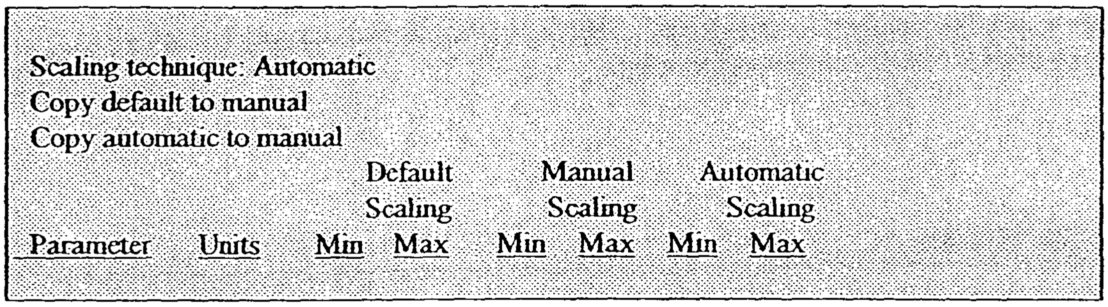
Select this option to setup the number of parameters which will be plotted together. If you choose 1, there will be an individual X and Y axis displayed for each selected parameter. Select any number of parameters per plot, (from 1 to 4) which provides your data with the best plot presentation.

Select the Scaling **Info** menu option



MODIFY

Parameters
Control Info
Scaling Info



```
Scaling technique: Automatic
Copy default to manual
Copy automatic to manual
                              Default        Manual        Automatic
                              Scaling        Scaling        Scaling
Parameter    Units       Min    Max    Min    Max    Min    Max
```

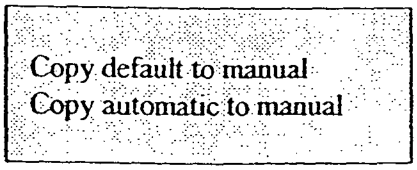
There are three scaling options.

Default scaling offers fixed limits. These limits correspond to the range of each parameter as defined by the sensor specifications, so your plot will always fit within these limits.

Manual scaling allows you to enter custom limits for each parameter.

Automatic scaling. The computer scans the data file and determines its limits, then displays those limits on the plot.

**NOTE:** When entering a scaling technique, you need only type the first letter of the desired technique and press Enter. PC6000 will fill in the rest.



Copy default to manual
Copy automatic to manual

Select these options to provide a quick way to copy from either the default or automatic limits columns to the manual scaling column. Once data has been copied into the manual scaling column, it can be modified. After copying is complete, any previous manual limits you may have defined will be lost.

### Default scaling

This column shows the default scaling limits. These limits cannot be changed.

### Manual scaling

This column shows the manual scaling limits which you can modify.

### Automatic scaling

This column shows the automatic scaling limits. These limits can not be changed, but are updated each time an automatically scaled plot is generated.

## 2. VIEW File Options

All of the View options allow you to view file data on the screen.

---

VIEW

Header
Report
Plot
Statistics

---

Select the **Header** menu option to display complete information about the sonde, probes, and configuration of the current file.

VIEW

Header
Report
Plot
Statistics

Select the **Report** menu option to display a complete list of all readings (as defined by the settings in the **Modify** portion of the menu) from the current file to the screen. As the report is scrolled onto the screen, it can be paused at any time by pressing any key. Once the entire report has been displayed, use the arrow keys, the page up and page down keys, or the home and end keys to move to any location within the report. If your computer system has limited RAM, early data points within a report may become unavailable for viewing. To redisplay unavailable data points, simply redisplay the report from the beginning.

VIEW

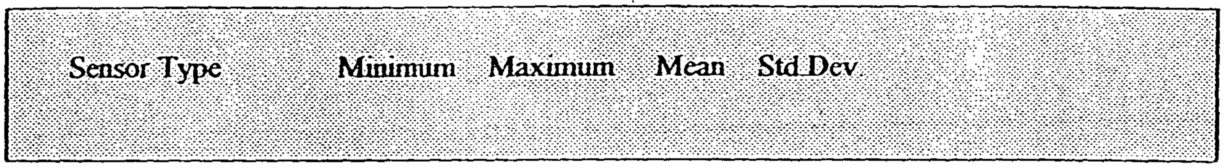
Header
Report
Plot
Statistics

Select the **Plot** menu option to display a plot of the current data file to the screen. The plot can be customized, see **Parameters and Control Info** above. A plot can be abandoned at any time by pressing Esc, or paused by striking any other key. If a plot is too large to fit on one screen, it will automatically move to a new screen.

VIEW

Header
Report
Plot
Statistics

Select the **Statistics** menu option to view statistics of a data file, or portion of a data file. As with reports and plots, the displayed statistics are affected by the choices you have made in the **Parameters**, and the **Control info** menus described previously. To view statistics for a portion of a file enter the start and stop times in **Control Info**. Statistics are only available after a report or plot is run.

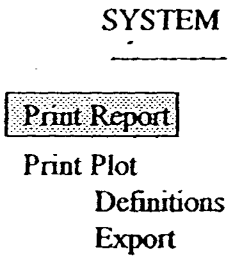


| Sensor Type | Minimum | Maximum | Mean | Std Dev |
|---|---|---|---|---|

To print a copy of the statistics screen, press the F2 key.

## 3. SYSTEM File Options

**SYSTEM** menu options allow you to print the report and plot, or export data to some other software program. The specific setup format of the report or plot can also be frozen for future access.



Select the **Print Report** option to send your report to the printer. After you select this option, a prompt will appear on the screen asking if your printer is ready. Press Enter to proceed with the print operation. If more than 8 parameters are to be printed, PC6000 will assume you have a wide-carriage printer. If your printer is not wide-carriage, set your printer to compress mode before printing (see your printer's manual for instructions).

**Note:** The printer port option (in the setup menu) specifies the computer port to which the report will be sent.

---

SYSTEM

Print Report
Print Plot
Definitions
Export

---

Select the **Print Plot** option to send your plot to the printer. After you select this option, a prompt will appear on the screen asking if your printer is ready. Press Enter to proceed with the print operation. Printing takes place after the plot is completely drawn on the screen.

**Note:** The printer port option (in the setup menu) specifies the computer port to which the report will be sent.

---

SYSTEM

Print Report
Print Plot
Definitions
Export

---

Select the **Definitions** option to create and save different report or plot configurations from the same data file. Each different file will contain all options and setup information you have defined in the modify menus. See the **MODIFY** options earlier in this section. After you have selected **Definitions** from the SYSTEM menu, the following menu will be displayed.

```
Active definition:
Select an action:   Select a definition
                     Create new definition
                     Rename active definition
                     Delete active definition
                     Clear active definition
```

**Active definition:**

Select this option to display the name of the current active definition.

**Select a definition:**

Select this option to retrieve an old definition.

**Create new definition:**

Select this option to create a new report and plot format which you will specify by variation of the current format <u>after</u> the new format has been named. For example, if you want to report and plot only dissolved oxygen readings in mg/L for your study instead of all parameters, first create a new definition at the prompt by typing "DO" (or any other designation of your choice). Then exit the definition menu by pressing Esc. Scroll to the Parameters menu and eliminate all parameters except DO, mg/L. This data presentation can then be reported, plotted, or exported, but more importantly, if you return to this data file at a later time, the "DO" definition can always be selected to provide this same data format since it has been saved under its own designation.

*Remember: Always name the new definition in the "create new designation" option <u>prior</u> to making changes which will define the new format.*

**Rename active definition:**

Select this option to change the name of the active definition.

**Delete active definition:**

Select this option to remove the active definition from the file.

Clear active definition

Select this option to reset the active definition to default values. Thus all customization features you previously set up are reset to default values.

---

SYSTEM

Print Report
Print Plot
Definitions
Export

---

Select the **Export** menu option to export a data file to another program. After selecting the Export option you will be asked to name the file to be exported. The default name is the same as the current data file with the extension PRN or CDF, depending on the export format selected. Export formats are selected in the Advanced Setup menu; see Section 5.5. After the file has been exported to disk, it can be retrieved using any program you choose. This feature is especially useful when exporting to a database or a spreadsheet program. Follow the importing instructions outlined in the destination program to retrieve the export file you have created:

## 5.5 THE SETUP MENU

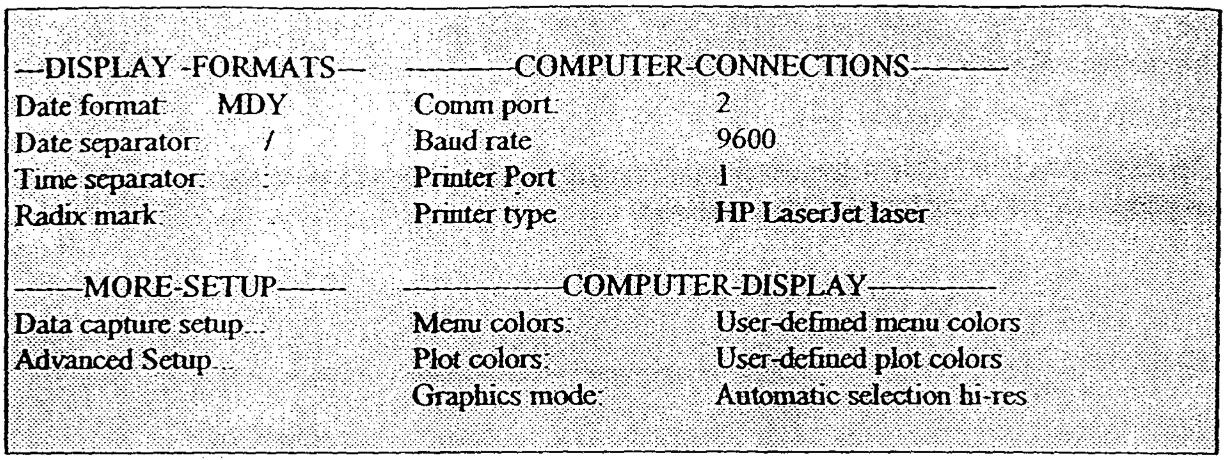
Choosing the Setup option from the menu bar allows you to configure the PC program to your specifications. Highlight **Setup**, from the menu bar and press Enter.

---

Sonde File Setup Real-Time Exit YSI PC6000

---

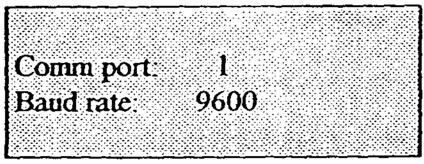
The setup menu will be displayed:



```
—DISPLAY-FORMATS—        ————COMPUTER-CONNECTIONS————
Date format:   MDY       Comm port:          2
Date separator:  /       Baud rate:          9600
Time separator:  :       Printer Port        1
Radix mark:      .       Printer type        HP LaserJet laser

———MORE-SETUP———         —————COMPUTER-DISPLAY—————
Data capture setup...    Menu colors:        User-defined menu colors
Advanced Setup...        Plot colors:        User-defined plot colors
                         Graphics mode:      Automatic selection hi-res
```

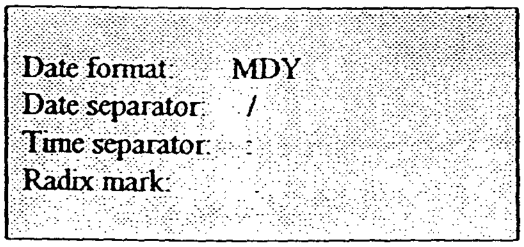
Other than the Comm port and Printer port options, the default values are adequate to perform virtually every function of the 600XL.



```
Comm port:    1
Baud rate:  9600
```

Select these options if it is necessary to change the default communications setup. These options must be properly set before attempting to communicate with the software inside the sonde. See Section 4.5. If you have difficulty communicating with the sonde, change the comm port and try again. PC6000 allows only Comm port 1 or 2.

The baud rate can be changed by highlighting it and pressing Enter. Select from a list of possible baud rates which will be displayed. The baud rate you select here **must match** the baud rate set in the sonde (which defaults to 9600). See Section 4.5.



```
Date format:     MDY
Date separator:   /
Time separator:   :
Radix mark:       .
```

Select any of these options to change them from their default. Users may specify any order of day (D), month (M), and year (Y) by selecting **Date format**.. The other options are used primarily outside of the US where other characters are sometimes used to separate numbers in dates, times, or decimals.

Printer port: 1
Printer type: HP LaserJet laser

Select these options to tell PC6000 about your computer system's printer and how it is connected. If you have difficulty printing, specify a different printer port here (1, 2, or 3) and try again. Select the **Printer type:** option to provide a list of printers which are supported by PC6000. Select a printer that best describes your system's printer. If you have difficulty printing, try a different selection here. It may also be necessary to consult the printer instruction manual to determine what type of printer your printer emulates.

**NOTE:** The printer type option only affects plot output and has no effect on report printing.

Menu colors
Plot colors
Graphic Mode

Select these options to tell PC6000 what type of monitor your computer has, and change the colors of both menus and plots as they are displayed on the screen. These color selections have no effect on the printed output of reports and plots. If none of the color schemes are to your liking, you can setup a User Defined color scheme. See Section 5.7.

From the list provided, choose a graphics mode which best matches your video adapter and monitor. If you have difficulty, consult your video adapter's instruction manual.

Data Capture Setup

See section 5.6 for a detailed explanation of this menu.

Advanced Setup

See Section 5.7 for a detailed explanation of this menu.

## 5.6 DATA CAPTURE / REAL-TIME SETUP

Once the Real-time mode has been properly set up, you will be able to view the data in real-time as it is taken in the Discrete Sample mode by the sonde. Each reading is displayed at the bottom of the real-time screen, and plots are updated with the arrival of each data point. In addition, the data will be automatically stored to the disk drive (hard or floppy) which you select. The setup process is not difficult, but you should follow the instructions in the following section *exactly* to be sure of successful operation in this mode.

**STEP 1**. Access the Sonde from the PC6000 menu bar and **Start sampling**. Make certain that the parameters which you want to view in real time and are displayed correctly. Adjust these parameters, if necessary, via the **Report Setup** menu of the Sonde software. Once the proper parameters are displayed to the screen, exit the Sonde menu structure by pressing **F10** and return to the menu bar of the PC6000 software.

**STEP 2**: Select Setup from the PC6000 menu bar, and then **Data capture setup**, pressing Enter after each entry. Access the **Parser** of this menu with the arrow keys and make certain that it is set to 600. If not, type 600 at the prompt, and press Enter. Next access the **Site Name** portion of the menu and enter any appropriate name. This name is provided for identifying purposes only. It is displayed on the File Header Menu, and it appears on the Real-Time plot screen and Real-Time plot printout. Now access the **Filename** portion of the menu and enter the name of the file under which you wish your data to be stored, and press Enter. Now access the **Auto-configure** entry of the menu, and press Enter. There will be a 5-10 second delay while the PC6000 software examines the sonde software to determine the parameters which you have decided to view in real-time. When the process is complete, the these parameters will appear in the list in the lower portion of the **Data capture setup** menu.

**STEP 3**: Set up the display which will be viewed in real-time. First, set the **X-axis time per screen** in minutes. Next, set the **Parameters per plot** which can be a value from 1 to 4. Finally, set the **Beep notification** to indicate the acquisition of either good data, bad data, or all data (both). Bad data is defined as that which, when arriving from the sonde, contains errors in the communication protocol and is rarely observed. If you prefer, you can eliminate the beep function completely by selecting off. Be sure to press Enter after each entry.

**STEP 4**: Set the scaling for each of the parameters in the lower right portion of the menu. There is no automatic scaling in this mode, so you should select the manual scaling ranges which will result in meaningful display of your data. These selections will become easier with experience. Use the Tab key to move from **Minimum** to **Maximum** and the arrow keys to move vertically when carrying out this operation. Be sure to press Enter after each scaling entry.

**STEP 5**: After entering scaling factors, exit to the PC6000 menu bar by pressing Esc twice. Then access the **Sonde** portion of the PC6000 menu and press Enter. Type "Menu" at the # prompt and press Enter. Select the **Run** menu, and begin sampling at the sample interval which is suitable for you study. *While the discrete sample mode is still operative, exit. to the PC6000 menu bar by pressing* F10 *(do not press* Esc *or the sampling will be terminated).*

**STEP 6**: From the PC6000 menu bar, select **Real-Time** and press Enter. The **Discrete Sample** data from the sonde will be plotted on the display and will be logged to disk automatically under your designated file name.

## COMMON CAUSES OF ERRORS IN REAL-TIME MODE:

1. The "Parser" is not set to "600". Set the Parser to "600"

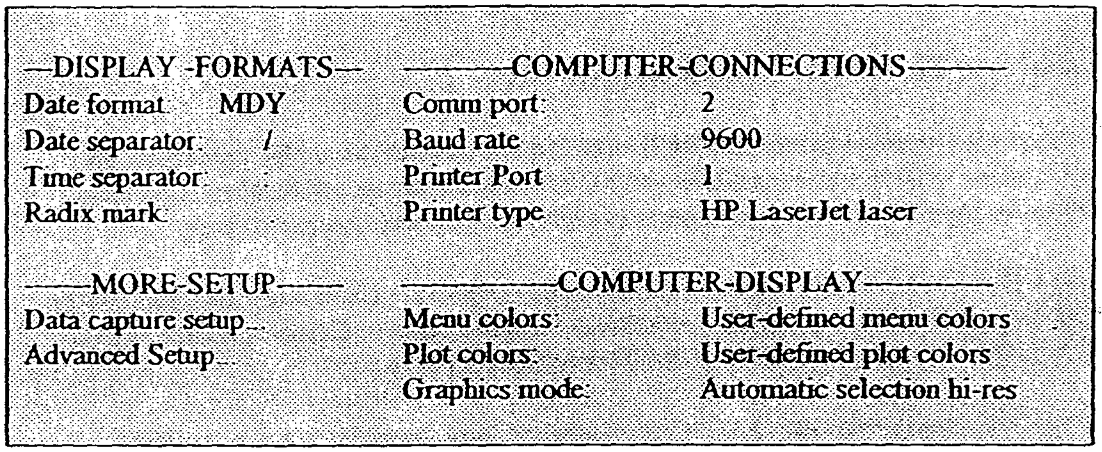
2. You have selected more parameters in the **Sonde Report Setup** than can be viewed on the computer screen. Remove time and date and/or other less important parameters in the Report Setup Menu so that all selected parameters are visible in **Discrete Sample** display.

3. The name which you entered for your data file already exists on your storage disk, but the file format for the initial study is different from the current file format. Change the name of the data file or delete the existing data file of this name from your disk.

4. You exited the **Discrete Sample** mode of the sonde software using Esc rather than F10. Return to the Sonde menu and select **Run**. Restart the **Start sampling** mode and exit with F10 to the PC6000 menu bar. Choose **Real-Time** and press Enter.

## 5.7 ADVANCED SETUP

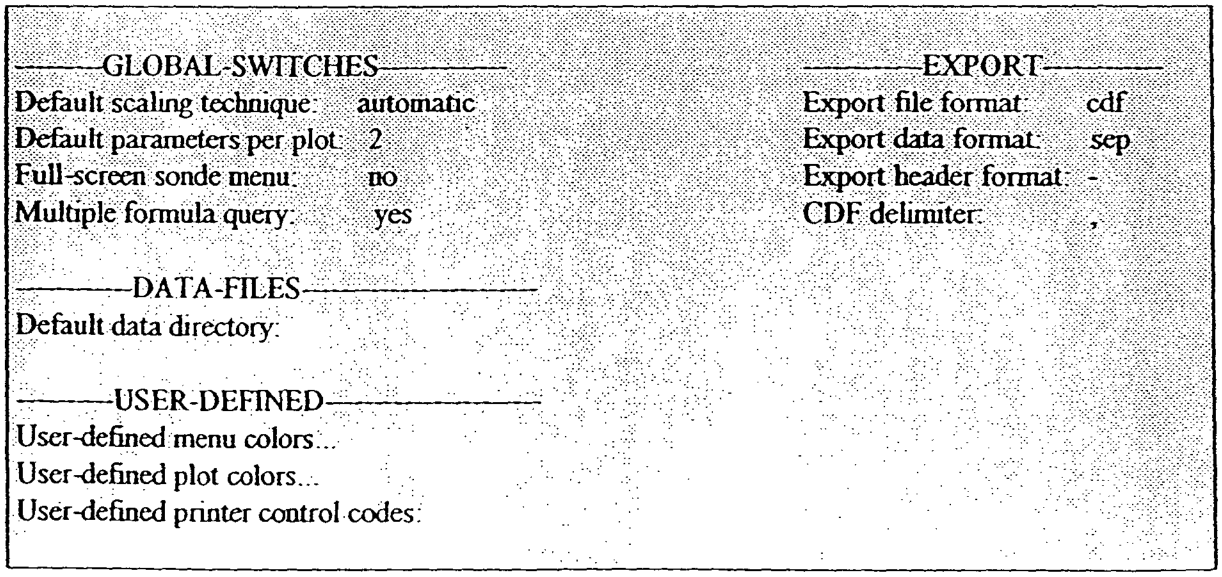
From the PC6000 menu bar, select **Setup**. The setup menu will be displayed.



```
—DISPLAY-FORMATS—        ————COMPUTER-CONNECTIONS————
Date format:  MDY        Comm port:          2
Date separator:  /       Baud rate:          9600
Time separator:  :       Printer Port        1
Radix mark:              Printer type        HP LaserJet laser

———MORE-SETUP———         —————COMPUTER-DISPLAY—————
Data capture setup...    Menu colors:        User-defined menu colors
Advanced Setup...        Plot colors:        User-defined plot colors
                         Graphics mode:      Automatic selection hi-res
```

Select this option to display the following menu.



```
————GLOBAL-SWITCHES————                          —————EXPORT—————
Default scaling technique:   automatic           Export file format:     cdf
Default parameters per plot: 2                   Export data format:     sep
Full-screen sonde menu:      no                  Export header format:   -
Multiple formula query:      yes                 CDF delimiter:          ,

—————DATA-FILES——————
Default data directory:

————USER-DEFINED—————
User-defined menu colors...
User-defined plot colors...
User-defined printer control codes:
```

It is important to remember that the default values assigned to these options will be correct for most operations. These options are provided for the advanced user who has special requirements of PC6000.

NOTE: Most changes in the Advanced Setup Menu require the user to press Enter after the parameter is altered.

### Full-screen sonde menu: Y

Select this option to specify whether terminal emulation should use the entire PC screen, or should take place within the usual border drawn by the PC software.

### Export date format: FORM

Select this option to choose from a variety of date formats for the exported data.

**FORM** (formatted):

MM/DD/YY and HH:MM:SS.

**SEP** (separated):

6 numeric values (m,d,y,h,m,s).

**COMB** (combination):

YYYYMMDD and a string of the form HH:MM:SS.

**JUL** (Julian):

A ten-digit integral number of seconds past midnight March 1, 1984. **NUM** (numeric):

A fixed point number of the form DDDDDD.TTTTTT where DDDDDD is the number of days past December 31 1899, and where TTTTTT is the fractional part of the day which has elapsed (.750000 is 6 PM).

**REL** (relative):

A fixed point number of the form HHHH.HHHH giving the number of hours elapsed since the first sample in the file.

NOTE: The export date format only applies to CDF and SDF export files. The date and time formats displayed on the PC6000 screen are determined in the SETUP menu.

### Export header format: -

Select this option to specify what header lines (if any) should be included at the top of CDF and SDF export files. The header can contain up to three lines.

(-): No header lines.

P: One header line, containing the name of each Parameter.

U: One header line, containing the name of each Unit.

T: One header line, containing the name of the report Title.

### Multiple formula query: N

Select this option to change the characteristics of a derived parameter. This option should be set to N for no, except for advanced users.

### User-Defined menu colors

Select this option to customize the menu colors of PC6000. Changing the colors using this option will permanently modify the color scheme of **User Defined Colors** in the **Setup** menu.

To use this feature, select a menu item to be changed from the lists provided. Find the box which has the same title as the item you selected. Watch the box as you press enter repeatedly to scroll through the various color options. Stop scrolling when the desired color is displayed and press Esc.
Continue this process until all colors are as you prefer.

### User-Defined plot colors

Select this option to modify the plot colors of PC6000. As detailed in the User-defined menu colors section above, select a plot item to be changed from the list provided and press Enter. Watch the sample plot as you repeatedly press Enter. Press Esc when the item color you prefer is displayed. Repeat this process until all plot colors are as you prefer.

### Default Data Directory:

Select this option to specify the drive and directory to which you want all PC6000 files to be stored. Type the drive and directory to which you wish all PC6000 data files to be stored when captured from the sonde.

**Example:** Typing C:\PC6000 would save all data files to the C:\ drive and to a directory called PC6000.

### User-defined printer control codes:

Select this option to manually enter special printer commands. Consult your printer's instruction manual for the specific commands compatible with your printer.

### Export file format: PRN

Select this option to setup a format if you wish to export data to another program; see Section 5.4. The correct format to specify is determined by the software to which you want to export data. Consult the manual of the destination software to determine the compatible format.

The three export format choices PC6000 allows are:

### Printer format (PRN):

Select this option to export data in exactly the same format as it would be sent to a printer. All page headings, column headings, and formfeeds are present in the export file.

### Comma & " " delimited format (CDF):

Select this option to export data in a format which encases all strings of data in double quotes, and separates each option on each line with a comma (or other delimiter character). There will be no spaces on any line unless they are inside a string.

**Example:** "12/31/92","23:59:59",123.45,12.3,123

### Space delimited format (SDF):

Select this option to export data in a format with fixed-column fields, which can be string or numeric. Strings and dates are left-adjusted in their field, numbers are right-adjusted. Strings are not encased in quotes. Lines are fixed width, and columns are apparent when viewing the file. Field widths are as follows: title is 80 characters; parameter names and units are 8 characters each; numbers are 8 digits including the radix separator and decimal digits; formatted dates are two 8 character strings separated by 1 space; separated dates are six 3-digit values; combined dates are an 8-digit number and an 8 character string separated by 1 space; Julian dates are 10 digits; numeric dates are 13 digits; relative dates are 9 digits.

**Example:** 12/31/92 23:59:59 123.45 12.3 123

Default scaling technique: Automatic
Default parameters per plot: 2

Select these options to modify the default values for reports and plots. These options are described in detail in the MODIFY portion of Section 5.4. The Setup menu determines what the default scaling technique and parameters per plot should be for each new data file. To modify these options for all future reports and plots change the values here. To modify these options only for a current file, see Section 5.4.

# 6. PRINCIPLES OF OPERATION

## 6.1 CONDUCTIVITY

The 600XL utilizes a cell with four pure nickel electrodes for the measurement of solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milli-Siemens (millimhos). To convert this value to a conductivity value in milliSiemens per cm (mS/cm), the conductance is multiplied by the cell constant which has units of reciprocal cm ($cm^{-1}$). The cell constant for the 600XL conductivity cell is 5.0/cm ± 4%. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed; see Section 3.2. Solutions with conductivities of 1.00, 10.0, 50.0, and 100.0 mS/cm, which have been prepared in accordance with recommendation 56-1981 of the Organization International De Metrologie Legale (OIML) are available from Endeco/YSI. The instrument output is in mS/cm for both conductivity and specific conductance. The multiplication of cell constant times conductance is carried out automatically by the software.

### CALIBRATION AND EFFECT OF TEMPERATURE

The conductivity of solutions of ionic species is highly dependent on temperature, varying as much as 3% for each change of one degree Celsius (temperature coefficient = 3%/C). In addition, the temperature coefficient itself varies with the nature of the ionic species present.

Because the exact composition of a natural media is usually not known, it is best to report a conductivity at a particular temperature, e.g. 20.2 mS/cm at 14 C. However, in many cases, it is also useful to compensate for the temperature dependence in order to determine at a glance if gross changes are occurring in the ionic content of the medium over time. For this reason, the 600XL software also allows the user to output conductivity data in either raw or temperature compensated form. If Conductivity is selected, values of conductivity which are *NOT* compensated for temperature are output to the report. If Specific Conductance is selected, the 600XL uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25 C. The calculation is carried out as in equation (1) below, using a temperature coefficient of 1.91%/C (TC = 0.0191):

$$\text{Specific Conductance (25 C)} = \frac{\text{Conductivity}}{1 + TC * (T - 25)}$$

As noted above, unless the solution being measured consists of pure KCl in water, this temperature compensated value will be somewhat inaccurate, but the equation with a value of TC = 0.0191 will provide a close approximation for seawater and for solutions of many common salts such as NaCl and $NH_4Cl$.

### MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) When filling the calibration cups prior to performing the calibration procedures, make certain that the level of calibrant buffers is high enough in the calibration/storage cup to cover the entire conductivity cell (approximately 300 mL). Gently agitate the sonde to remove any bubbles in the conductivity cell.

(2) Rinse the sensors with deionized water between changes of calibration solutions.

(3) During calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The readings after calibration are only as good as the calibration itself.

(4) Perform sensor calibration at a temperature as close to 25°C as possible. This will minimize any temperature compensation error.

## 6.2 SALINITY

Salinity is determined automatically from the 600XL conductivity readings according to algorithms found in *Standard Methods for the Examination of Water and Wastewater (ed. 1989)*. The use of the Practical Salinity Scale results in values which are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 C. However, the unitless salinity values are very close to those determined by the previously used method where the mass of dissolved salts in a given mass of water (parts per thousand) was reported. Hence, the designation "ppt" is reported by the instrument to provide a more conventional output.

## 6.3 OXIDATION REDUCTION POTENTIAL (ORP)

The 600XL determines the Oxidation Reduction Potential (ORP) of the media by measuring the difference in potential between an electrode which is relatively chemically inert and a reference electrode. To measure ORP with the 600XL, a combination pH/ORP probe must be in place in the sonde bulkhead and ORP must be accessed via the ISE2 channel of the sonde. The ORP sensor consists of a platinum ring found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor which utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature

### CALIBRATION AND EFFECT OF TEMPERATURE

Calibration is usually not required for the ORP sensor of the 600XL. However, older probes which have been deployed extensively may show some deviation from the theoretical ORP value. This deviation is usually due to a change in the concentration of the KCl in the reference electrode gel. To determine whether the sensor is functioning correctly, place the ORP probe in 3682 Zobell solution and monitor the millivolt reading. If the probe is functioning within specifications, the ORP reading should be within the range of 221-241 at normal ambient temperature. If the reading is outside of this range, the probe can be calibrated to the correct value (231 mV at 25°C) using the calibration procedure outlined in Section 4.2.

ORP readings for the same solution can vary up to 100 mv depending on the temperature. However, no standard compensation algorithms exist for this parameter. Be sure to take this factor into account when reporting ORP values.. For Zobell solution, consult the following chart:

| TEMPERATURE, CELSIUS | ZOBELL SOLUTION VALUE, MV |
|---|---|
| | |
| -5 | 270 |
| 0 | 263.5 |
| 5 | 257 |
| 10 | 250.5 |
| 15 | 244 |
| 20 | 237.5 |
| 25 | 231 |
| 30 | 224.5 |
| 35 | 218 |
| 40 | 211.5 |
| 45 | 205 |
| 50 | 198.5 |

## 6.4 pH

The 600XL employs a field replaceable pH electrode for the determination of hydrogen ion concentration. The probe is a combination electrode consisting of a proton selective glass reservoir filled with buffer at approximately pH 7 and a Ag/AgCl reference electrode which utilizes gelled electrolyte. A silver wire coated with AgCl is immersed in the buffer reservoir. Protons ($H^+$ ions) on both sides of the glass (media and buffer reservoir) selectively interact with the glass, setting up a potential gradient across the glass membrane. Since the hydrogen ion concentration in the internal buffer solution is invariant, this potential difference, determined relative to the Ag/AgCl reference electrode, is proportional to the pH of the media.

The 6561 pH sensor available for the 600XL should provide long life, good response time, and accurate readings in most environmental waters. For waters of very low conductivity, however, the 6564 low ionic strength pH probe may provide better results. The 6564 features a low impedance glass membrane and a lower impedance junction reference junction than the 6561. While the 6564 will produce good data in freshwater of higher conductivity, it is likely to have a shorter lifetime than the 6561 due to the loss of gel through the reference junction over time.

## CALIBRATION AND EFFECT OF TEMPERATURE

The software of the 600XL calculates pH from the established linear relationship between pH and the millivolt output as defined by a variation of the Nernst equation:

$$E = E_o + \frac{2.3RT}{nF} * pH$$

where E = millivolts output

Eo = a constant associated with the reference electrode
T = temperature of measurement in degrees Kelvin
R, n, and F are invariant constants

Thus, in simplified y = mx + b form, it is (mv output) = (slope)x(pH) + (intercept). In order to quantify this simple relationship, the instrument must be calibrated properly using commercially available buffers of known pH values. In this procedure, the millivolt values for two standard buffer solutions are experimentally established and used by the 600XL software to calculate the slope and intercept of the plot of millivolts vs. pH. Once this calibration procedure has been carried out, the millivolt output of the probe in any media can readily be converted by the 600XL software into a pH value, *as long as the calibration and the reading are carried out at the same temperature*. This last qualifier is almost never met in actual environmental measurements since temperatures can vary several degrees during a deployment simply from a diurnal cycle. Thus, a mechanism must be in place to compensate for temperature or, in other words, to accurately convert the slope and intercept of the plot of pH vs. millivolts established at $T_c$ (temperature of calibration) into a slope and intercept at $T_m$ (temperature of measurement). Fortunately, the Nernst equation provides a basis for this conversion.

According to the Nernst equation as shown above, the slope of the plot of pH vs. millivolts is *directly proportional* to the absolute temperature in degrees Kelvin. Thus, if the slope of the plot is experimentally determined to be 59 mv/pH unit at 298 K (25 C), then the slope of the plot at 313 K (40 C) must be (313/298) * 59 = 62 mv/pH unit. At 283 K (10 C), the slope is calculated to be 56 mv/pH unit ((283/298) * 59). Determination of the slope of pH vs. mv plots at temperatures different from $T_c$ is thus relatively simple. In order to establish the intercept of the new plot, the point where plots of pH vs. mv at different temperatures intersect (the isopotential point) must be known. Using standard pH determination protocol, the 600XL software assigns the isopotential point as the mv reading at pH 7 and then calculates the intercept using this assumption. Once the slope and intercept to the plot of pH vs. mv are assigned at the new temperature, the calculation of pH under the new temperature conditions is straightforward, and is automatically carried out by the sonde software.

## MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) When filling the calibration cup prior to performing the calibration procedure, make certain that the level of calibrant buffers is high enough in the calibration/storage cup to cover the pH probe and temperature sensor of the 6561 probe (approximately 200 mL).

(2) Rinse the sensors with deionized water between changes of calibration buffer solutions.

(3) During pH calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The pH readings after calibration are only as good as the calibration itself.

(4) Clean and store the probe according to the manufacturer's instructions.

## 6.5 DEPTH AND LEVEL

The 600XL can be equipped with either depth or level sensors. In fact, both sensors measure depth, but by convention, level refers to vented measurements and depth refers to non-vented measurements. Both measurements use a differential strain gauge transducer to measure pressure with one side of the transducer exposed to the water.

For depth measurements, the other side of the transducer is exposed to a vacuum. The transducer measures the pressure of the water column plus the atmospheric pressure above the water. Depth must be calculated from the pressure exerted by the water column alone; therefore, when depth is calibrated in air, the software records the atmospheric pressure and subtracts it from all subsequent measurements. This method of compensating for atmospheric pressure introduces a small error. Because the software uses the atmospheric pressure at the time of calibration, changes in atmospheric pressure between calibrations appear as changes in depth. The error is equal to 0.045 feet for every 1 mm Hg change in atmospheric pressure. In sampling applications, frequent calibrations eliminate the error. Considering typical changes in barometer during long term monitoring, errors of ± 0.6 feet (0.2m) would be common. In applications where this error is significant, we recommend using a level sensor in place of the depth sensor.

As with depth measurements, level uses a differential transducer with one side exposed to the water. However, the other side of the transducer is vented to atmosphere. In this case, the transducer measures only the pressure exerted by the water column. Atmospheric pressure is ignored and changes in atmospheric pressure do not affect the reading at all.

The voltage output of the transducer is directly proportional to the pressure. The 600XL software converts this voltage to a depth reading in feet or meters via calibration parameters which are factory installed. Readings are automatically compensated for the density of the environmental medium which is estimated from the measured salinity.

### CALIBRATION AND EFFECT OF TEMPERATURE

The depth sensor must be zeroed prior to deployment to account for atmospheric pressure. This procedure is carried out by following the calibration menu instructions with the sonde in air only (do not submerge). The temperature dependence of the sensor is automatically taken into account by the sonde software based on input from factory calibration.

### MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) Be certain that the sonde is not immersed in water during the calibration procedure.

(2) Remember that the depth sensors for the 600XL are not vented. In practical terms, this means that changes in barometric pressure after the sensor is calibrated will appear as changes in depth. This effect is significant, particularly for the 0-30 ft option of the depth probe. For example, a change of 1 mm of Hg in barometric pressure will change the apparent depth by approximately 0.04 ft (0.012 m). For the level sensor which is vented, this error is eliminated.

## 6.6 TEMPERATURE

The 600XL utilizes a thermistor of sintered metallic oxide which changes predictably in resistance with temperature variation. The algorithm for conversion of resistance to temperature is built in to the 600XL software, and accurate temperature readings in degrees Celsius, Kelvin, or Fahrenheit are provided automatically. No calibration or maintenance of the temperature sensor is required.

## 6.7 DISSOLVED OXYGEN

The 600XL employs the patented YSI Rapid Pulse system for the measurement of dissolved oxygen (DO). Use of this technology provides major advantages for the *monitoring* of DO without significantly compromising the accuracy of *sampling* applications. Standard electrochemical detectors of DO are highly flow dependent and therefore require external stirring of the medium being evaluated. The operation of this mechanical stirrer consumes most of the power associated with the DO determination and severely limits the length of remote deployment unless an external battery source is utilized. The Rapid Pulse system needs no external stirring, allowing the 600XL to accurately monitor DO for up to 90 days. In addition, because of the nature of the technology, some effects of fouling of the sensor are minimized.

The Rapid Pulse system utilizes a Clark-type sensor which is not radically different from other membrane-covered, steady-state dissolved oxygen probes. The system still measures the current associated with the reduction of oxygen which diffuses through a teflon membrane, and this current is still proportional to the partial pressure (not the concentration) of oxygen in the solution being evaluated. The membrane isolates the electrodes necessary for this reduction from the external media, encloses the thin layer of electrolyte required for current flow, and prevents other non-gaseous, electrochemically active species from interfering with the measurement. However, as the user will note from examination of the 6561 probe, the sensor consists of three electrodes (a cathode, anode, and reference electrode) while steady state Clark probes usually have only two electrodes (a cathode and a combined anode-reference electrode). In addition, the geometry of the sensor is novel, consisting of a thin linear gold cathode placed between two silver rectangles which serve as anode and reference electrodes. These sensor changes were required to implement the new Rapid Pulse method for DO measurement as described in the following section.

## METHOD OF OPERATION

Standard Clark dissolved oxygen sensors which are marketed by YSI and other manufacturers are continuously polarized at a voltage sufficiently negative to cause oxygen (which diffuses through the teflon membrane) to be reduced to hydroxide ion at the cathode and silver metal to be oxidized to silver chloride at the anode. The current associated with this process is proportional to the oxygen present in the solution outside the membrane. However, as this electrochemical reaction proceeds, oxygen is consumed (or depleted) in the medium, resulting in a decrease in measured current (and apparent oxygen content) if the external solution is not stirred rapidly. To minimize this oxygen depletion, the probe electrodes in the YSI Rapid Pulse system are rapidly and reproducibly polarized (on) and depolarized (off) during a measurement sequence. The Rapid Pulse system thus measures the charge or coulombs (current summed over a specific time period) associated with the reduction of oxygen during a carefully controlled time interval. The coulombs due to charging of the cathode (capacitance), but not to reduction of oxygen, are subtracted during integration after the cathode has been turned off. The net charge, like the steady state current in a standard system, is proportional to the oxygen partial pressure in the medium. Because oxygen is only being reduced 1/100th of the total measurement time, even if the probe is pulsed in this manner continuously, oxygen consumption outside the membrane is kept to a minimum, and the stirring dependence of the system is greatly reduced.

One key to the practicality of Rapid Pulse oxygen system is the fact that the on time is very short. This allows the off time to also be relatively short and still maintain the off to on ratio of 100 which is necessary to obtain relatively flow independent measurements. The second important aspect of the Rapid Pulse technology is the integration (summing of the current) over the total pulse (on and off). Because the charging current of the electrodes is subtracted in this process, the net signal is due only to the reduction of oxygen. From a practical point of view, this means that when there is zero oxygen partial pressure outside the membrane, the Rapid Pulse signal will also be zero; this in turn allows the system to be calibrated with a single medium (air or water) of known oxygen pressure.

## CALIBRATION AND EFFECT OF TEMPERATURE

The 600XL Rapid Pulse system is calibrated using the same basic methods employed for steady state oxygen sensors. However, the software which controls the calibration protocol is somewhat different depending on whether the unit will be used in sampling or deployment studies. For sampling studies using either a 610 display unit or a laptop computer, the Rapid Pulse system is allowed to run continuously when the Run mode is activated by turning off "Wait for DO" and "Autosleep" as detailed in Section 4. Under these software conditions, the user views the DO readings in real time and confirms the calibration manually after the readings have stabilized.

For studies in which the 600XL is deployed and readings are saved to a computer or data collection platform less frequently (5-60 minutes), it is best to activate "Wait for DO" and input an appropriate warm up time for the system. Usually 60 seconds is adequate for this parameter, but in some cases, larger values may result in more accurate results. In addition, for deployment studies, "Autosleep" should be activated. With these software entries in place, the user will input the calibration value (concentration or barometric pressure), and the unit will automatically calibrate after the selected warm up time.

The description below is designed around sampling applications with "Wait for DO" and "Autosleep" deactivated.

The two general calibration methods possible with the 600XL are "DO mg/l" and "DO %". The former method is designed for calibration in solution while the latter utilizes water-saturated air as the medium. Since the percent saturation (DO %) and concentration (DO mg/l) values are related by well-known algorithms, calibration by either method results in correct outputs in both units.

If the mg/L method is selected from the 600XL **Calibrate** menu, the oxygen concentration of an aqueous solution is determined either by:

1.) Winkler titration
2.) Aerating the solution and assuming that it is saturated, or
3.) Measurement with another instrument.

If this calibration method is employed, place the sonde into this known-value solution, input the value (in mg/l) into the 600XL software, and then, after the reading has stabilized (2-15 minutes, depending on whether the probe has been serviced recently), confirm the calibration according to the instructions.

If the Percent Saturation method is selected, the sonde is simply placed in a calibration cup which contains a small quantity of water or a damp sponge. ***The probe sensor should not be in the water for this calibration procedure.*** The barometric pressure is entered into the 600XL software and then, after the readings have stabilized (5-15 minutes, depending on whether the probe has been serviced recently), the calibration is confirmed according to the instructions.

NOTE: Remember that calibration will occur automatically if the unit is set up properly for deployment ("Wait for DO" and "Autosleep" activated).

The DO readings of steady state oxygen systems are greatly affected by temperature (approximately 3% per degree Celsius) due to the effect of temperature on the diffusion of oxygen through the membrane. The Rapid Pulse system exhibits a greatly reduced effect of temperature (approximately 1% per degree Celsius), but this factor still must be accounted for if DO readings acquired at temperatures different from that at calibration are to be accurate. This compensation is automatically carried out by the sonde software.

In addition, the relationship between the measured partial pressure of oxygen (percent saturation) and the solubility of oxygen in mg/L is very temperature dependent. For example, air saturated water (100 percent saturated) at 20 C contains 9.09 mg/L, but only 7.65 mg/L at 30 C. Both of these temperature related factors are compensated for by the 600XL software after instrument calibration. The temperature compensation for the percent saturation reading is empirically derived, while the conversion from percent saturation and temperature to a solubility in mg/L is carried out using formulae available in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* See Appendix F for dissolved oxygen solubility tables as a function of salinity and temperature.

## FLOW DEPENDENCE

As noted above, oxygen readings acquired using the Rapid Pulse technology are much less affected by sample flow than steady state probes. However, there is a finite stirring dependence exhibited by the Rapid Pulse system if measurements are taken when the probe is being pulsed continuously. Our tests indicate that, under these sampling conditions, observed dissolved oxygen readings can be 2-3 percent lower than the true readings in very still water. Minimal agitation of the water removes this effect.

This small flow dependence of the sensor is greatly reduced in longer term monitoring deployments where the sampling interval is longer, e.g. 15 minutes. Under these conditions, the sensor is pulsed for only approximately 60 seconds every 15 minutes, and normal diffusion of oxygen in the medium re-establishes the oxygen which has been depleted in the previous warm-up/read sequence.

## MEASUREMENT AND CALIBRATION PRECAUTIONS

**(1)** If water-saturated air is used as the calibrating medium, make certain that *both the DO reading and the temperature* have stabilized (10-15 minutes) before starting the calibration sequence. A wet thermistor can indicate artificially low temperature readings due to evaporation and this situation will result in poor temperature compensation and inaccurate readings.

**(2)** Insure that the calibration cup being used is vented or pressure released.

**(3)** Keep the probe moist when not in use, either by immersing in water or by placing a damp sponge in the calibration vessel. If the membrane appears to be damaged or has dried out, be sure to replace it prior to calibration and deployment.

**(4)** Always calibrate the Rapid Pulse system at a temperature as close as possible to that of the sample being measured. If possible, immerse the calibration chamber (which contains either a small amount of water or a wet sponge) into the body of water which is later to be measured. ***Do not allow the sample water to seep into the calibration chamber.*** Monitor the readings; after thermal equilibrium has been established, proceed with the calibration.

**(5)** Before you install a new membrane, make sure that the O-ring groove and the probe tip are clean and smooth. If the KCl electrolyte solution leaks from the probe surface during monitoring studies, the readings are likely to be less accurate in a shorter period of time.

This Page Intentionally Left Blank

# 7. MAINTENANCE

A Model 6570 Maintenance Kit is available for use with the 600XL. The kit includes several items which will be helpful or necessary in performing the proper routine maintenance on the 600XL. The kit includes two types of O-rings (for probes and cable connector), a probe installation and replacement tool, 2 cleaning brushes for the conductivity sensor, O-ring lubricant, and a syringe for cleaning the depth port.

The Model 6570 Maintenance Kit can be ordered from any authorized YSI dealer, or directly from YSI. See Appendix D for details.

## 7.1 SONDE MAINTENANCE

When caring for the 600XL sonde, it is important to remember that the sonde is sealed at the factory, and there is never a need to gain access to the interior circuitry of the sonde; in fact, to do so would void the manufacturer's warranty.

### SONDE STORAGE

Since the introduction of the YSI Environmental Monitoring Systems (EMS) product line several years ago, YSI has learned a great deal about storage protocols which will maximize the lifetime of our sensors. This knowledge has come from our own extensive in-house testing programs as well as from feedback from a large number of customers and sales representatives. Just prior to the release of the 6820 in May 1996, we have summarized these storage recommendations in a separate document which is included in this manual as Appendix G.

These current storage guidelines are, in some cases, slightly different from those provided in our previous manuals on the YSI Models 6000UPG, 600, and 600XL. We believe that the previous storage recommendations were good, but that the procedures described in the current version are better. No doubt these recommendations will continue to be refined slightly as we introduce new sensors and gain additional information from testing. Please refer to Appendix G for detailed instructions for sensor storage. Note that the appendix deals with instruments other than the 600XL -- be sure to refer specifically to the instructions for the instrument which you have purchased.

Proper storage of the 600XL sonde between periods of usage will not only extend the life of the sensors, but will also ensure that the unit will be ready to use as quickly as possible in your next application

Sondes with level sensors have a tube that vents the pressure transducer to atmosphere. It is imperative that the air in the tube remain dry at all times. Sondes with integral cables should be stored with the desiccant in place and the vented end of the desiccant sealed. Sondes with connectors should be stored with the connector cap firmly in place. Do not disconnect the cable without putting the cap on immediately. Vented cables should be stored with their caps on in a bag with desiccant.

### SONDE PROBE PORTS

Whenever a probe is installed, removed, or replaced, it is extremely important that the entire sonde and all probes be thoroughly dried prior to the removal of the probe or the probe port plug. This will prevent water from entering the port. Once the probe or plug has been removed, examine the connector inside the sonde probe port. If any moisture is present, use compressed air to completely dry the connector. If the connector is corroded, return the sonde to your dealer or directly to YSI's Product Service Department (see Appendix C for details). When reinstalling a probe or port plug, lightly grease the O-ring with lubricant supplied in the 6570 Maintenance Kit.

### CABLE CONNECTOR PORT

The cable connector port at the top of the sonde should be covered at all times. While communicating with the sonde, a cable should be installed and tightened in place. This will assure that a proper connection is being made and prevent moisture and contaminants from entering.

When a communications cable is not connected to the cable connector port, the pressure cap supplied with the instrument should be securely tightened in place.

If moisture has entered the connector, dry the connector completely with compressed air, a clean cloth, or paper towel. Apply a very thin coat of lubricant from the 6570 Maintenance Kit to the O-ring inside the connector cap before each installation.

## 7.2 PROBE MAINTENANCE

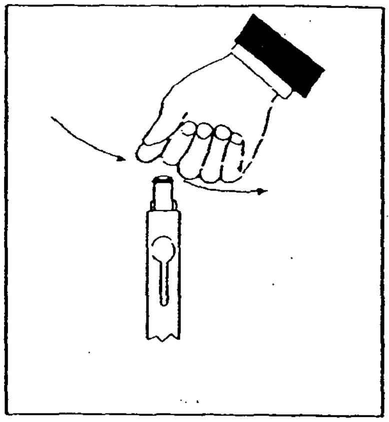
Once the probes have been properly installed, regular cleaning and oxygen probe membrane changes are required.

### 6562 DO PROBES

For best results, it is recommended that the KCl solution and the teflon membrane at the tip of the 6562 probe be changed prior to each sonde deployment and at least once every 30 days during the use of the 600XL in sampling studies. In addition, the KCl solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible on the membrane or the O-ring; and (c) if the probe shows unstable readings or other malfunction. See Section 2.2 for instructions on changing the membrane.

After removing the used membrane from the tip of the 6562 probe, examine the electrodes at the tip of the probe.

If either or both of the silver electrodes are black in color, the probe should be resurfaced using the sanding disks which are provided in the 6035 reconditioning kit. Following the instructions supplied with the kit, first dry the probe tip completely with lens cleaning tissue. Next, hold the probe in a vertical position, place one of the sanding disks under your thumb, and stroke the probe face in a direction parallel to the gold electrode. The motion is similar to that used in striking a match. Usually 10-15 strokes of the sanding disk is sufficient to remove black deposits on the silver electrodes, but, in extreme cases, more sanding may be required to regenerated the original silver surface.



After the sanding procedure is complete, repeatedly rinse the probe face with clean water and wipe with lens cleaning tissue to remove any grit left by the sanding disk. After cleaning, thoroughly rinse the entire tip of the probe with distilled or deionized water and install a new membrane. See Section 2.2.

NOTE: Be sure to: (1) Use *only* the sanding disks provided in the 6035 maintenance kit in the resurfacing operation and (2) Sand in a direction parallel to the gold electrode. *Not adhering to either of these instructions can seriously damage the electrodes.*

NOTE: If this procedure is unsuccessful, as indicated by improper probe performance, it may be necessary to return the probe to an authorized dealer service center. See Appendix C for contact information.

## 6560 CONDUCTIVITY/TEMPERATURE PROBES

The openings which allow fluid access to the conductivity electrodes must also be cleaned regularly. The small cleaning brush included in the 6570 Maintenance Kit is ideal for this purpose. Dip the brush in clean water and insert it into each hole 15-20 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent with the brush. After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

NOTE: If this procedure is unsuccessful, or if probe performance is impaired, it may be necessary to return the probe to an authorized dealer service center See Appendix C for contact information.

The temperature portion of the probe requires no maintenance.

## 6561 pH, 6564 LOW IONIC STRENGTH, 6563 ORP PROBES, AND 6565/6567 COMBINATION pH-ORP PROBES

Cleaning is required whenever deposits or contaminants appear on these glass probes. Remove the probe from the sonde. Use clean water and a clean cloth to remove all foreign material from the glass probe. Carefully remove any material which may be blocking the circular reference electrode junction of the sensor.

Dry the sonde port and probe connector with compressed air and apply a very thin coat of O-ring lubricant to all O-rings before re-installation.

## DEPTH SENSORS

The depth sensors are factory installed options which are located between the bulkhead and the sonde tube. On the side of the sonde, there is a circular cap with two small holes that protects the depth sensor. The cap cannot be removed, but a syringe is supplied in the maintenance kit to aid cleaning the pressure port. Fill the syringe with clean water, press the syringe against one of the holes and gently force water into the pressure port. Ensure that the water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

CAUTION: Never try to remove the circular pressure port cap.

## LEVEL SENSORS

For level sensors follow all the maintenance procedures given for depth sensors. In addition, ensure that the desiccant always remains active. Active desiccant is a distinctive blue color. When it can absorb no more moisture it is a rose red or pink color. For either the cartridge or the canister, the end that is vented to atmosphere will begin to change color first. As long as the desiccant closest to the sonde is blue, no maintenance is required. Local conditions will dictate how long the desiccant will last. In humid environments, the desiccant may need to be changed or regenerated well before it is completely exhausted to ensure that it lasts the entire deployment.

You may regenerate the desiccant, replace the desiccant in the cartridge or canister, or replace the entire cartridge or canister.

To regenerate the desiccant remove it from the unit and spread it evenly, one granule deep, on a suitable tray. Heat for about one hour at about 200 degrees C (about 400 degrees F). The desiccant should then be cooled in a suitable, tight container before refilling the unit. The felt filters should also be dried at about 100 degrees C (about 200 degrees F) for about 30 minutes before assembly.

Desiccant granules are sold separately. Both the cartridge and canister can easily be opened, emptied and refilled.

To replace a cartridge or canister, see Section 2.

**CAUTION:** It is important to keep the tube in vented sondes and cables dry. They are supplied with caps for closing the volume when not in use. Keep the caps on until just before calibration and deployment. For storage, replace the caps.

## 7.3 GENERAL MAINTENANCE NOTE

In the event that the 600XL continues to exhibit some problem that you can not correct by following the Maintenance procedures outlined within this section, call your authorized service center. See Appendix C for contact information.

**REMEMBER: DO NOT ATTEMPT TO GAIN ACCESS TO THE INTERNAL CIRCUITRY OF THE SONDE.**

This Page Intentionally Left Blank

# 8. TROUBLESHOOTING

The following tables should be helpful in identifying the cause of the most common difficulties which may occur while operating the 600XL. The column titled **Symptom** details the type of difficulty you might experience. The column titled **Possible cause** details the conditions which might cause the stated symptom. The column titled **Action** provides simple steps which can be followed to correct for the "possible cause" and cure the "symptom" being experienced. The column titled **Ref** is the reference section and subsection in the manual where you may find additional information.

Symptoms have been categorized into four general areas.

- PC6000 Software
- Sonde communication
- Sensor Performance
- Calibration Error Messages

If you need assistance for which the following tables are not immediately helpful, please contact your authorized dealer, Endeco/YSI, YSI Ltd.,or YSI Ohio. See Appendix C for specific contact information.

## CALIBRATION ERRORS

Calibration Error messages are not included in the following tables. There are only three error messages which you may enounter, and only two of these are related to sensor performance.

**High DO Charge**: This message indicates a malfunction in the DO sensor which is generally due to the roughness of the electrodes on the surface of the probe face. The charge associated with the DO sensor must be in the range 25 to 75 or the error message will appear when calibration is attempted. If this error message is encountered, remove the DO probe from the sonde and resurface it according to the instructions in Section 7. After resurfacing the probe, activate the DO charge parameter in the **Report** setup section of the sonde software and confirm that the value is within the acceptable range. After resurfacing, allow the sensor to pulse in the **Run** mode for at least 5 minutes during which time it may be expected to drop in value if the sensor is still functional. If resurfacing according to the instructions in Section 7 do not result in a lowering of the charge, contact Endeco/YSI customer service for advice.

**Out of Range**: This message indicates that the output of the sensor being calibrated does not conform to the normal range for this parameter. This problem could be due to either a malfunctioning sensor or to a calibration solution which is out of specification. If this error message is encountered, first assure that your pH buffers, ORP calibrant, or conductivity standards have not been contaminated and that your DO sensor is in air (DO % Cal) or in a solution of known dissolved oxygen concentration (DO mg/l). Also be certain that you have entered the correct value for the calibration solution. If the calibration error message continues to occur, contact Endeco/YSI customer service to determine whether the sensor in question needs to be replaced.

**Illegal Entry**: This message simply indicates that your keyboard input does not conform to the accepted format for this parameter. For example, you may have entered the "letter O" instead of "zero" for a calibration value. Return to the desired parameter in the Calibrate menu and repeat the calibration entry, being certain to enter only numbers.

Consult the following three tables if you encounter problems with software, communication protocol, or sensor malfunctions other than calibration errors.

## PC6000 SOFTWARE PROBLEMS

| SYMPTOMS | POSSIBLE CAUSE | ACTIONS | REF |
|---|---|---|---|
| PC6000 software operates but no data is displayed | Data capture not setup | Move cursor (key board arrows only) to data capture setup | 5.4 |
|  | Will not auto configure. | Enter parser, site name , ID | 5.6 |
|  | After auto configure, no data arrives | Return to sonde menu and start sonde | 4.1 |
| PC6000 displays data, no files found. | Data directory path not recognized | Move cursor to PC6000 Advanced setup and establish a directory | 5.2 |
|  | Data files not readable | Export file as PRN, CDF, SDF | 5.7 |
| Expected parameters are not displayed on reports or plots | Parameters not added to Y-axis list | Add parameter | 5.4 |
|  | Sensor disabled | Check sensor setup instructions | 4.7 |
| Unable to print reports or plots | Printer port improperly configured | Try a screen print out to the printer (print scrn) |  |
|  | Printer port improperly set | Check setup | 5.7 |
|  | Printer type improperly selected | Check setup | 5.7 |
|  | Print cable improperly connected | Check connections at both ends |  |
| Video screen of PC is not readable | Incorrect menu color option has been selected | Select appropriate menu parameter | 2.4 |
|  | Incorrect graphic mode | Select compatible graphic mode | 5.5 |
|  |  |  |  |
| When selecting "sonde" from PC6000 top line, sonde menu not shown | Prompt # appears in place of menu | Type "menu" and press (enter) |  |
|  | Communication problem | See communication |  |
|  |  |  |  |

## SONDE COMMUNICATION PROBLEMS

| SYMPTOM | POSSIBLE CAUSE | ACTION | REF |
|---|---|---|---|
| Can not communicate with sonde | Sonde not powered | Check 12 vdc source | 5.5 |
| | Cable connection is loose | Check both ends of cable; secure connectors | |
| | Damaged connectors | Check pins at both ends, insure they are straight, dry and clean. | |
| | Comm port not selected | Change to other comm port, other peripheral on the same port (Internal mouse se). Try other PC, 610 hand held terminal or dumb term | |
| Scrambled data | Unmatched baud rate between host and sonde | Match the baud rate | 2.4<br>4.5 |
| | Host is too slow | Use faster computer | |
| | Interface cable failure | Check cable for damage. If necessary, return for service | |
| | Internal failure | Return sonde for service | C |
| | | | |

## SENSOR PERFORMANCE PROBLEMS

| SYMPTOMS | POSSIBLE CAUSE | ACTION | REF |
|---|---|---|---|
| Dissolved Oxygen reading unstable or inaccurate | Probe not properly calibrated | Follow DO cal procedures | 3.1 |
| | Membrane not properly installed or may be punctured | Follow 6562 setup procedure | 2.2 |
| | DO probe electrodes require cleaning | Follow DO cleaning procedure use 6035 maint. kit | 7.2 |
| | Water in probe connector | Dry connector; reinstall probe | 2.2 |
| | Algae or other contaminant clinging to DO probe | Rinse DO probe with clean water | |
| | Barometric pressure entry is incorrect | Repeat DO cal procedure | 3.1 |
| | Cal at extreme temperature | Recal at (or near) sample temperature | |
| | DO Charge too high >75<br>1. Anodes polarized (tarnished)<br>2. Probe left on continuously | Enable DO charge parameter in the Sonde report menu. Run 600, if charge is over 75, recondition probe with 6035 maint. kit<br>Follow DO cleaning procedure | 4.1<br>7.2 |
| | DO Charge too low <25 Insufficient electrolyte. | Replace electrolyte and membrane. | |
| | DO probe has been damaged | Replace 6562 probe | 2.2 |
| | Internal failure | Return sonde for service | C |
| pH, ORP, unstable or inaccurate. Error messages appear during calibration. | Probe requires cleaning, Temperature thermistor not in pH solution at time of cal. | Follow probe cleaning procedure | 7.2 |
| | Probe requires calibration | Follow cal procedures | 3.1 |
| | Probe has been damaged. Check for gel at base of probe | Replace pH or ORP probe.. | E |
| | Water in probe connector | Dry connector; reinstall probe | E |
| | Calibration solutions out of spec or contaminated with other solution | Use new calibration solutions | |
| | ORP fails Zobell check | Repeat test. Check possible causes above. | 6.3 |
| | Internal failure | Return sonde for service | C |
| Depth unstable or inaccurate | Depth sensor has not been zeroed | Follow depth zero procedure | 3.1 |
| | Depth sensor access hole is obstructed | Follow depth cleaning procedure | 7.2 |
| | Depth sensor has been damaged | Return sonde for service | C |
| | Internal failure | Return sonde for service | C |

| | | | |
|---|---|---|---|
| Conductivity unstable or inaccurate. Error messages appear during calibration. | Conductivity improperly calibrated. | Follow cal procedure | 3.1 |
| | Conductivity probe requires cleaning | Follow cleaning procedure | 7.2 |
| | Water drop attached to temperature sensor | Dry temperature sensor | |
| | Conductivity probe damaged | Replace probe | 2.2 |
| | Calibration solution out of spec or contaminated | Use new calibration solution | 3.2 |
| | Calibration value too far from sample value | Cal at or near expected value | 3.2 |
| | Internal failure | Return sonde for service | C |
| | Calibration solution or sample does not cover entire sensor. | Immerse sensor fully. | 3.1 |
| Installed probe has no reading | The sensor has been disabled | Enable sensor | 4.7 |
| | Water in probe connector | Dry connector; reinstall probe | 2.2 |
| | Probe has been damaged | Replace the 6560 probe | 2.2 |
| | Report output improperly set up | Set up report output | 4.6 |
| | Internal failure | Return sonde for service. | C |
| Temperature, unstable or inaccurate | Check thermistor sheath for damage. | Dry connector; reinstall probe | |
| | Probe has been damaged | Replace the 6560 probe | 2.2 |

This Page Intentionally Left Blank

# 9. COMMUNICATION

This chapter describes the communication protocols that the Model 600XL uses to communicate with the host system. Section 1 gives a brief overview of the communication ability of the Model 600XL. The remaining sections describe available hardware and software features.

## 9.1 OVERVIEW

The Model 600XL communicates via a serial port that can be configured as either a SDI-12, or a 3 or 5-wired RS-232 interface. The normal mode of operation for the 600XL is RS232, with the following configurations:

| | |
|---|---|
| Baud rate: | 300, 600, 1200, 2400, 4800, 9600 |
| Data Bit: | 8 |
| Parity: | None |
| Handshake: | None |

For further detail into the 600XL's RS232 and SDI-12 implementations, see sections 9.3 and 9.4 respectively.

With these configurations, the Model 600XL is capable of interfacing to a variety of devices from a "dumb" terminal to numerous data collection platforms.

## 9.2 HARDWARE INTERFACE

Connection from the Model 600XL to the host computer is provided through a 9-pin, waterproof, female connector to the standard DB-9 female RS-232 connector. The Model 600XL PC interface cable is wired for direct connection to a DTE device. The table on the next page defines the interface circuits. The signals and their directions are defined with respect to the Model 600XL.

| Wire Color | Pin Description | 6095 Adapter DB-9 | 6095 Adapter MS-4 | All Field Cables MS-8 |
|---|---|---|---|---|
| Yellow | RS232 TX | 2 | — | C |
| Orange | RS232 RX | 3 | — | D |
| Green | Alarm | — | — | E |
| Grey | RTS | — | — | G |
| Blue | CTS | — | — | H |
| Red | + 12V DC | 9 | A | A |
| Black | GND | 5 | C | B |
| Purple | SDI-12 | — | B | F |
| Bare | Shield | — | — | B |

## 9.3 RS-232 INTERFACE

The 600XL has an advanced baud rate-seeking feature which allows the instrument to automatically adjust to the terminal baud rate. If the 600XL is set to a baud rate of 4800 and a 9600 baud terminal is attached to it, after a few carriage returns are entered, the 600XL will recognize the communication mismatch and attempt to change its own internal baud rate to match the terminals.

## 9.4 SDI-12 INTERFACE

SDI-12 is an industry standard serial digital interface bus. The bus was designed to allow compatibility between data collection devices and sensors of various manufacturers. The description below applies specifically to the Model 600XL implementation of SDI-12 interface. For complete SDI-12 technical specifications please contact:

Campbell Scientific, Inc.
P.O. Box 551
Logan, Utah 84321 USA
(801) 753-2342

SDI-12 is a single master multi-drop bus and command protocol. As many as 10 sensors can be connected to the bus at a time. Each sensor is preassigned a unique address from 0 to 9. Each Model 600XL is factory-set to address 0. The address can be changed in the System menu, see Section 4.5.

Running the 600XL in SDI-12 mode requires it to be connected to a SDI-12 master device. An example of such as device is the YSI 1240 RF node or units from Campbell Scientific or Handar Instruments. These instruments provide the commands neccessary to communicate with the 600XL in SDI-12 mode. In addition, the 600XL also supports the following commands which are entered from the command line, at the '#' prompt:

SDIADDR[=a]

Set the Model 600XL SDI-12 address to 'a'. The address range for 'a' is from 0 to 9. If 'a' is not specified, the Model 600XL will display the current SDI-12 address.

SDI12

This command activates SDI-12 mode. This is the only mode in which the Model 600XL will respond to any SDI-12 command. To exit to command line, hit any key from the terminal connected to the RS-232 port. The Model 600XL provides a confirmation before exiting.

The Model 600XL implements the basic SDI-12 command set. Below are the descriptions of each command and their responses.

The following notations are used:

| | |
|---|---|
| • **a** | Model 600XL SDI-12 address (ASCII '0' to '9') |
| • **[CR]** | Carriage return (ASCII 13) |
| • **[LF]** | Line feed (ASCII 10) |
| • **Master** | Any SDI-12 compatible data collection device |

| | | |
|---|---|---|
| Master: | aM! | Initiate a measurement |
| Model 600XL: | atttn[CR][LF] | |

ttt - Maximum time in seconds the Model 600XL will take to complete the measurement.

n - Number of data that will be available when the measurement is completed. This number is the same as the number of output parameters set in the **Report** menu, see section 4.6. If the number of parameters set is greater than 9, it is truncated to 9.

After finishing the measurement, the Model 600XL will usually send a service request "a[CR][LF]" to the bus master. The bus master can then retrieve the measurement result by "D0" to "D9" commands (see below). If the Model 600XL does not send a service request within the specified maximum time, the measurement is canceled. The bus master can then send a "V" command (see below) to obtain the specific error code or restart with another "M" command.

Master: al! Send identification.

Model 600XL: allccccccccmmmmmmvvvxxx...xxx[CR][LF]

l - 2 character SDI-12 level number. For version 1.00 of the EMS600 software, this field is "10".

c - 8 character manufacturer identification. This field always contains "YSIIWQSG" (YSI Inc., Water Quality Systems Group).

m - 6 character model number. This field always contains "EMS600" (Environmental Monitoring System Model 600XL).

v - 3 character version number. This field holds the 600XL's software version number ("100" for version 1.00).

x - 0 to 13 characters identify active measurement parameters. These parameters are available through "D0" to "D9" commands followed by an "M" command. Each parameter is coded as a single character as follow.

'1'- N/A
'2'- N/A
'3'- Temperature
'4'- Specific conductance
'5'- Conductivity
'6'- Resistivity
'7'- Total dissolved solid (TDS)
'8'- Salinity
'9'- DO %
'A'- DO mg/L
'B'- ISE1
'C'- ISE2
'D'- Depth
'E'- N/A
'F'- N/A
'G'- DO charge
'H'- N/A
'I'- Pressure
'J'-N/A

Master: aD0! to aD9! Retrieve measurement/verifying data

Model 600XL: a<values>[CR][LF]

<values>- 33 characters or less. This field holds one or more values resulted from a measurement or verifying sequence. A value contains between 1 to 7 digits with an optional radix mark (period '.' or comma ','). Each value must be preceded by its sign (either '+' or '-' ) since the sign is also used to delimit multiple values.

If the number of values returned by the "D0" command is less than the number specified in the previous response to "M" or "V" commands, the rest of the data can be retrieved by using "D1" to "D9" commands. The "D" commands are non-destructive. Thus if the same "D" command is issued multiple times before the next "M" or "V" command, it will return the same data. If the response to the "D0" command is "a[CR][LF]" then either no "M" or "V" command was received before the first "D" command or the "M" or "V" command was canceled.

**Example:** Here is an example SDI-12 transaction. Here SDI-12 master will issue an Identify command followed by a Measure command. The 600XL is configured with a report output of Temperature, Specific conductance, DO %, DO mg/L, pH (ISE1), ORP (ISE2), and Depth, a DO warmup time of 60 seconds, and an SDI-12 address of 1.

Master: 1I!

Model 600XL: 110YSIIWQSGEM60010349ABCD[CR][LF]

The bus master asked for identification and the Model 600XL returned data showing the following.

SDI-12 level: 1.0
Manufacturer: YSIIWQSG
Model: EM600(XL)
Version: 1.00
Sensor output: Temperature, Specific conductance, DO %, DO mg/L, pH, ORP, Depth

Master: 1M!

Model 600XL: 10617[CR][LF]

The bus master sent a measurement command. The Model 600XL will take a maximum of 60 seconds to finish the measurement. Upon completion, it will have 7 sensor data availabl...(after about 61 seconds)...

Model 600XL: 1[CR][LF]

Master: 1D0!

Model 600XL: 1+17.5+12.05+98.7+8.25+6.45[CR][LF]

Master: 1D1!

Model 600XL: 1-325+10[CR][LF]

After finishing the measurement, the Model 600XL sent a service request to indicate completion. The bus master then sent the "D0" command to retrieve the data. There were 5 data returned. Since 7 readings should be available, the master continued with "D1" commands and received the remaining data. The responses from "D0" and "D1" commands are

| | |
|---|---|
| Temperature: | 17.5 |
| Specific conductance: | 12.05 |
| DO %: | 98.7 |
| DO mg/L: | 8.25 |
| pH (ISE1): | 6.45 |
| ORP (ISE2): | -325 |
| Depth: | 10 |

# APPENDIX A

# HEALTH AND SAFETY

**YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, 3169**

INGREDIENTS:

- Iodine
- Potassium Chloride
- Water

**WARNING: INHALATION MAY BE FATAL.**

**CAUTION: AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY EVOLVE TOXIC FUMES IN FIRE.**

Harmful by ingestion and inhalation. Skin or eye contact may cause irritation. Has a corrosive effect on the gastro-intestinal tract, causing abdominal pain, vomiting, and diarrhea. Hypersensitivity may cause conjunctivitis, bronchitis, skin rashes etc. Evidence of reproductive effects.

**FIRST AID:**

INHALATION: Remove victim from exposure area. Keep victim warm and at rest. In severe cases seek medical attention.

SKIN CONTACT: Remove contaminated clothing immediately. Wash affected area thoroughly with large amounts of water. In severe cases seek medical attention.

EYE CONTACT: Wash eyes immediately with large amounts of water, (approx. 10 minutes). Seek medical attention immediately.

INGESTION: Wash out mouth thoroughly with large amounts of water and give plenty of water to drink. Seek medical attention immediately.

## YSI pH 4.00, 7.00, and 10.00 Buffer Solutions: 3821, 3822, 3823

pH 4 INGREDIENTS:
- Potassium Hydrogen Phthalate
- Formaldehyde
- Water

pH 7 INGREDIENTS:
- Sodium Phosphate, Dibasic
- Potassium Phosphate, Monobasic
- Water

pH 10 INGREDIENTS:
- Potassium Borate, Tetra
- Potassium Carbonate
- Potassium Hydroxide
- Sodium (di) Ethylenediamine Tetraacetate
- Water

**CAUTION - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

**FIRST AID:**

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

## YSI Zobell Solution: 3682

INGREDIENTS:
- Potassium Chloride
- Potassium Ferrocyanide Trihydrate
- Potassium Ferricyanide

**CAUTION - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by inhalation, ingestion, or skin absorption. Causes eye and skin irritation. Material is irritating to mucous membranes and upper respiratory tract. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities can cause weakness, gastrointestinal irritation and circulatory disturbances.

**FIRST AID:**

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

This Page Intentionally Left Blank

# APPENDIX B

# REQUIRED NOTICE

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the computer with respect to the receiver
- Move the computer away from the receiver
- Plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No.0004-000-00345-4.

This Page Intentionally Left Blank

# APPENDIX C

# WARRANTY AND SERVICE INFORMATION

The 600XL sonde is warranted for two years against defects in workmanship and materials when used for its intended purposes and maintained according to instructions. All cables are warranted for one year. The depth, dissolved oxygen, temperature/conductivity, pH, ORP, and pH/ORP combination probes are warranted for one year. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. This warranty is limited to repair or replacement at Endeco/YSI's option.

## If service is required...

### In the USA contact YSI, Yellow Springs, OH.

| | |
|---|---|
| Telephone: | (513) 767 7241<br>(800) 765 4974 (Toll Free in USA) |
| Fax: | (513) 767 9353 |

### In the United Kingdom, contact YSI Limited, Farnborough, Hampshire, England.

| | |
|---|---|
| Telephone: | 44 1252 51 47 11 |
| Fax: | 44 1252 51 18 55 |

### Other parts of the World, contact YSI Incorporated, Yellow Springs, OH, USA.

| | |
|---|---|
| Telephone: | 513 767 7241 |
| Fax: | 513 767 9353 |

This Page Intentionally Left Blank

# APPENDIX D

# ACCESSORIES AND REAGENTS

## The following components come standard with the purchase of any 600XL Environmental Monitoring System:

- 600XL Sonde
- PC6000 Software
- Instruction Manual
- Calibration/Transport Cup
- 6570 Maintenance Kit
- 6560 Conductivity/Temperature Probe

## The following components are sold separately:

### Probes

- 6560: Conductivity/Temperature Probe Replacement Kit
- 6561: Standard pH Probe Replacement Kit
- 6562: Rapid Pulse DO Probe Replacement Kit
- 6563: ORP Probe Replacement Kit
- 6564: Low Ionic Strength pH Probe Replacement Kit
- 6565: Standard Combination pH/ORP Probe Replacement Kit
- 6567: Low Ionic Strength Combination pH/ORP Probe Replacement Kit

**Optional Accessories**

- 6035: Probe Reconditioning Kit for 6562 Probe
- 062655: Carrying case for 600XL
- 6038: 12 VDC power supply with 110 VAC input
- 6037: 12 VDC Power Supply with 220 VAC input
- 6100: External Power Connector, attaches to 6095 Field Cable
- 690: Sonde Weight for 600XL (24 oz., 3"long)
- 691: Sonde Weight for 600XL (51 oz., 6"long)
- 693: Mooring Clamp for 600XL
- 694: Transport Cup Kit for 600XL
- 6570: Maintenance Kit for 600XL
- 5775 Membrane Kit
- 6108 Desiccant Cartridge Kit
- 6109 Desiccant Canister Kit
- 065802 Replacement Desiccant

**Conductivity Reagents**

- 3161: Calibrator Solution, 1,000 umhos/cm (quart)
- 3163: Calibrator Solution, 10,000 umhos/cm (quart)
- 3165: Calibrator Solution, 100,000 umhos/cm (quart)
- 3167: Calibrator Solution, 1,000 umhos/cm (8 ea, pint)
- 3168: Calibrator Solution, 10,000 umhos/cm (8 ea, pint)
- 3169: Calibrator Solution, 100,000 umhos/cm (8 ea, pint)

## pH Reagents

- 3821: pH 4 Buffer (liter)
- 3822: pH 7 Buffer (liter)
- 3823: pH 10 Buffer (liter)

## ORP Reagents

- 3682: Zobell Solution (125 ml)

## Cables

- 6093 Field Cable, 100 ft (30 m)
- 6092 Field Cable, 50 ft (15 m)
- 6091 Field Cable, 25 ft (7.5 m)
- 6090 Field Cable, 8 ft (2.4 m)
- 6191 Field Cable, Vented, 25 ft (7.5 m)
- 6192 Field Cable, Vented, 50 ft (15 m)
- 6067B Low Cost Calibration Cable, Dry use only; 10 ft (3m)
- SP6093-L Special field cables available in 25 ft (7.6 m) increments; Maximum 1000 ft (305 m)
- 6098B Field Cable to 610-D/610-DM adapter
- 6096 Field Cable to Flying Lead (wire) adapter, 15 ft (5m)
- 6095B Field Cable to Female DB-9 (PC Serial with Power Connector)
- 6099: 610 to Female DB-9 (PC Serial)
- 6100 External Power Connector, attaches to 6095 Field Cable (6ft)
- 6102: 610 to Portable Power Pack Adapter

- 6103 MS-8 Dust Cover (caps connector when not in use)

**Displays, Loggers, and Accessories**

- 610-D Handheld Field Display with Accessories
- 610-DM: 610-D with 128K of memory
- 610-DM: 610-D with 512K of memory
- 614 Ultraclamp, C-clamp Mount for 610
- 615 Leather Carrying Case for 610
- 616 Cigarette lighter adapter (powers and charges 610s)
- 617 Replacement Battery Pack for 610
- 6099: 610 to Female DB-9 (PC serial)
- 6097 Blank port plug for 610
- 6104 Replacement Charger Jack for 610
- 6042 Battery Charger for 610

**Logger/Telemetry**

- 1240: SDI-12 Logger for interfacing as many as 10 6-series devices. Can also serve as RF telemetry platform (RF radio, battery, interface cable, junction box not included)
- 1240B1: 7 amp hour, lead acid 12 VDC rechargeable battery
- 1240B2: 20 amp hour, alkaline 6 VDC battery (2 required)
- 1240AC: 110 VAC charger/transformer assembly, charges 1240B1
- 1240SO: 1240 Solar Panel Assembly, includes panel, mount, cable
- 1240SE: 1240 Serial data interface cable, connects 1240 to PC

- 1240JU: 1240/6 series Junction Box, provides input of multiple SDI-12 devices (standard configuration is for 5 devices)

Note: For RF radio frequency telemetry system applications, contact Endeco/YSI Customer Support @ 1-800-363-3269

**Software**

- PC6000: MS-DOS compatible communication, upload, plotting
- 610SOFT: Software upgrade for Model 610 D/DM
- 6000SOFT: Software upgrade for Model 6000
- EW-DOS Ecowatch for MS-DOS Applications
- EW-WIN Ecowatch for Windows (Use EW-WIN for 6 Series Applications)

This Page Intentionally Left Blank

# APPENDIX E
# APPLICATION NOTE

## SENSOR DRIFT COMPENSATION WITH THE 600XL

The following application note is designed to facilitate the use of the sensor drift software included in the PC6000 package by providing the user with a specific example. The use of this function is generalized in Section 5.4 of the 600XL manual.

### Situation

After laboratory calibration, a user deployed their 600XL in a readily-accessible stream on 10/14/92 with the instrument set to capture data to memory at 15 minute intervals. The study was named SRUN7. The instrument was left in place for approximately 2 weeks and during this time period, the user visited the site 3 times, took a water sample in a sealed bottle, and, on returning to the laboratory, measured the dissolved oxygen and pH with recently-calibrated instruments. The user also collected a water sample when the instrument was retrieved (10/26/92) and measured dissolved oxygen and pH in the laboratory. The following records were kept.

**Laboratory Measurements**

| Date | Time | DO (mg/L) | pH |
|---|---|---|---|
| 10/17/92 | 8:00 | 5.40 | 7.62 |
| 10/29/92 | 8:00 | 7.50 | 7.63 |
| 10/23/92 | 10:00 | 7.30 | 7.58 |
| 10/26/92 | 8:15 | 6.32 | 7.60 |

The user now has everything required to compensate the DO and pH readings for field drift:

- The data file captured by the computer or data collection platform.
- The correct DO and pH readings at various times during the study based on grab samples of water which were analyzed with recently-calibrated laboratory instruments.
- PC6000 software for retrieval and manipulation of the data from the sonde memory.

**Compensation Procedure**

(1) For this example, make certain that the data file is present in a subdirectory of the hard drive (C:\PC6000).

(2) "Exit" from PC6000 software using the top menu bar. The "C:\PC6000" prompt should be displayed.

(3) The user must now write compensation files which contain the above data points and which will be accessed automatically by the PC6000 software. If the "C:\PC6000" prompt is displayed, the files will be located in the same subdirectory as the SRUN7.DAT data file. *A compensation file for each parameter (DO and pH, in this example) must be written.* Since the overall filename is SRUN7.DAT, the DO compensation file will be called SRUN7DO.CMP and the pH compensation file will be called SRUN7PH.CMP. Note that for accurate record keeping, the compensation file name should somehow be related to the name of the overall study. For example, it will become extremely confusing if all dissolved oxygen compensation files are named "DO.CMP" as shown in the brief example in the manual.

(4) To compose the DO compensation file, type the following at the "C:\PC6000" prompt:

```
C:\PC6000COPY CON SRUN7DO.CMP -- (Return)
10/17/92  8:00:00 5.40 (Return)
10/20/92  8:00:00 7.50 (Return)
10/23/92  10:00:00 7.30 (Return)
10/26/92  8:15:00 6.32 (Return)
Control Z (Return)
```

The screen will display "1 File Copied" if all is correct and the file SRUN7DO.CMP will now be in the "PC6000" subdirectory of the C drive. Note that the data must be entered in exactly the above format: (1) The time must contain a designation for seconds even if the user does not know this value exactly; an entry of XX:XX:00 is suggested for all time inputs and (2) there must be a space between the date, time, and parameter value entries.

(5) To compose the pH compensation file, type the following at the "C:\PC6000" prompt:

```
C:\PC6000COPY CON SRUN7PH.CMP -- (Return)
10/17/92  8:00:00 7.62 (Return)
10/20/92  8:00:00 7.63 (Return)
10/23/92  10:00:00 7.58 (Return)
10/26/92  8:15:00 7.60 (Return)
Control Z (Return)
```

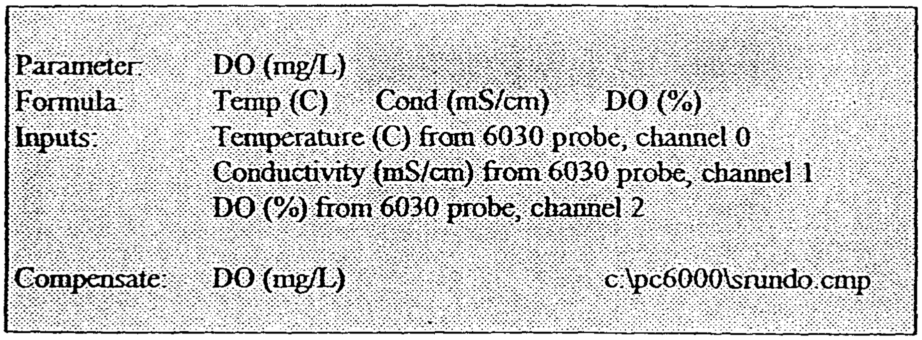
The screen will display "1 File Copied" if all is correct and the file SRUN7PH.CMP will now be in the "PC6000" subdirectory of the C drive.

(6) After writing the DO and pH compensation files to the C:\PC6000 directory, type "PC6000" at the "C:\PC6000" prompt to re-enter the PC6000 software package. Just as would be done for no compensation, prepare the plot and report output format desired by manipulation of the "Parameters", the "Control Information", and the "Scaling Information".

(7) After the format is finalized, re-enter the "Parameters" section of the software. Place the cursor on the "DO (mg/l)" entry, hit "Return", and then select the "Detail this parameter" option within the window.

(8) Move the cursor to the "Compensate" entry and hit "Return". Move the cursor to the "DO, mg/l" entry and hit "Return" to activate the compensation of this parameter.

(9) Hit the "Tab" key once to move the cursor to the right portion of the screen and then enter the location and designation of the DO compensation file in this bar. In this case, the entry is: **C:\PC6000\SRUN7DO.CMP**. Hit "Return" and the screen should appear as follows if the procedure has been followed:



```
Parameter:    DO (mg/L)
Formula:      Temp (C)    Cond (mS/cm)     DO (%)
Inputs:       Temperature (C) from 6030 probe, channel 0
              Conductivity (mS/cm) from 6030 probe, channel 1
              DO (%) from 6030 probe, channel 2

Compensate:   DO (mg/L)                     c:\pc6000\srundo.cmp
```

(10) Carry out the same procedure for pH:
  (a) Activation of the compensation, and
  (b) Entry of the location and designation of the pH compensation file.

This Page Intentionally Left Blank

# APPENDIX F

## SOLUBILITY AND PRESSURE/ALTITUDE TABLES

### Table 1: Solubility of Oxygen in mg/l in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.

**Salinity = Measure of quantity of dissolved salts in water.**
**Chlorinity = Measure of chloride content, by mass, of water.**
**$S(^0/_{00}) = 1.80655$ x Chlorinity $(^0/_{00})$**

| Temp °C | Chlorinity:0 Salinity:0 | 5.0 ppt 9.0 ppt | 10.0 ppt 18.1 ppt | 15.0 ppt 27.1 ppt | 20.0 ppt 36.1 ppt | 25.0 ppt 45.2 ppt |
|---|---|---|---|---|---|---|
| 0.0 | 14.62 | 13.73 | 12.89 | 12.10 | 11.36 | 10.66 |
| 1.0 | 14.22 | 13.36 | 12.55 | 11.78 | 11.07 | 10.39 |
| 2.0 | 13.83 | 13.00 | 12.22 | 11.48 | 10.79 | 10.14 |
| 3.0 | 13.46 | 12.66 | 11.91 | 11.20 | 10.53 | 9.90 |
| 4.0 | 13.11 | 12.34 | 11.61 | 10.92 | 10.27 | 9.66 |
| 5.0 | 12.77 | 12.02 | 11.32 | 10.66 | 10.03 | 9.44 |
| 6.0 | 12.45 | 11.73 | 11.05 | 10.40 | 9.80 | 9.23 |
| 7.0 | 12.14 | 11.44 | 10.78 | 10.16 | 9.58 | 9.02 |
| 8.0 | 11.84 | 11.17 | 10.53 | 9.93 | 9.36 | 8.83 |
| 9.0 | 11.56 | 10.91 | 10.29 | 9.71 | 9.16 | 8.64 |
| 10.0 | 11.29 | 10.66 | 10.06 | 9.49 | 8.96 | 8.45 |
| 11.0 | 11.03 | 10.42 | 9.84 | 9.29 | 8.77 | 8.28 |
| 12.0 | 10.78 | 10.18 | 9.62 | 9.09 | 8.59 | 8.11 |
| 13.0 | 10.54 | 9.96 | 9.42 | 8.90 | 8.41 | 7.95 |
| 14.0 | 10.31 | 9.75 | 9.22 | 8.72 | 8.24 | 7.79 |
| 15.0 | 10.08 | 9.54 | 9.03 | 8.54 | 8.08 | 7.64 |
| 16.0 | 9.87 | 9.34 | 8.84 | 8.37 | 7.92 | 7.50 |
| 17.0 | 9.67 | 9.15 | 8.67 | 8.21 | 7.77 | 7.36 |
| 18.0 | 9.47 | 8.97 | 8.50 | 8.05 | 7.62 | 7.22 |

| **Temp °C** | **Chlorinity:0 Salinity:0** | **5.0 ppt 9.0 ppt** | **10.0 ppt 18.1 ppt** | **15.0 ppt 27.1 ppt** | **20.0 ppt 36.1 ppt** | **25.0 ppt 45.2 ppt** |
|---|---|---|---|---|---|---|
| 19.0 | 9.28 | 8.79 | 8.33 | 7.90 | 7.48 | 7.09 |
| 20.0 | 9.09 | 8.62 | 8.17 | 7.75 | 7.35 | 6.96 |
| 21.0 | 8.92 | 8.46 | 8.02 | 7.61 | 7.21 | 6.84 |
| 22.0 | 8.74 | 8.30 | 7.87 | 7.47 | 7.09 | 6.72 |
| 23.0 | 8.58 | 8.14 | 7.73 | 7.34 | 6.96 | 6.61 |
| 24.0 | 8.42 | 7.99 | 7.59 | 7.21 | 6.84 | 6.50 |
| 25.0 | 8.26 | 7.85 | 7.46 | 7.08 | 6.72 | 6.39 |
| 26.0 | 8.11 | 7.71 | 7.33 | 6.96 | 6.62 | 6.28 |
| 27.0 | 7.97 | 7.58 | 7.20 | 6.85 | 6.51 | 6.18 |
| 28.0 | 7.83 | 7.44 | 7.08 | 6.73 | 6.40 | 6.09 |
| 29.0 | 7.69 | 7.32 | 6.96 | 6.62 | 6.30 | 5.99 |
| 30.02 | 7.56 | 7.19 | 6.85 | 6.51 | 6.20 | 5.90 |
| 31.0 | 7.43 | 7.07 | 6.73 | 6.41 | 6.10 | 5.81 |
| 32.0 | 7.31 | 6.96 | 6.62 | 6.31 | 6.01 | 5.72 |
| 33.0 | 7.18 | 6.84 | 6.52 | 6.21 | 5.91 | 5.63 |
| 34.0 | 7.07 | 6.73 | 6.42 | 6.11 | 5.82 | 5.55 |
| 35.0 | 6.95 | 6.62 | 6.31 | 6.02 | 5.73 | 5.46 |
| 36.0 | 6.84 | 3.52 | 6.22 | 5.93 | 5.65 | 5.38 |
| 37.0 | 6.73 | 6.42 | 6.12 | 5.84 | 5.56 | 5.31 |
| 38.0 | 6.62 | 6.32 | 6.03 | 5.75 | 5.48 | 5.23 |
| 39.0 | 6.52 | 6.22 | 5.98 | 5.66 | 5.40 | 5.15 |
| 40.0 | 6.41 | 6.12 | 5.84 | 5.58 | 5.32 | 5.08 |
| 41.0 | 6.31 | 6.03 | 5.75 | 5.49 | 5.24 | 5.01 |
| 42.0 | 6.21 | 5.93 | 5.67 | 5.41 | 5.17 | 4.93 |
| 43.0 | 6.12 | 5.84 | 5.58 | 5.33 | 5.09 | 4.86 |
| 44.0 | 6.02 | 5.75 | 5.50 | 5.25 | 5.02 | 4.79 |
| 45.0 | 5.93 | 5.67 | 5.41 | 5.17 | 4.94 | 4.72 |

## Table 2: Calibration Values for Various Atmospheric Pressures and Altitudes

| PRESSURE | | | ALTITUDE | | CALIBRATION VALUE |
|---|---|---|---|---|---|
| inches Hg | mm Hg | millibars | Feet | meters | % sat |
| 30.23 | 768 | 1023 | -276 | -84 | 101 |
| 29.92 | 760 | 1013 | 0 | 0 | 100 |
| 29.61 | 752 | 1003 | 278 | 85 | 99 |
| 29.33 | 745 | 993 | 558 | 170 | 98 |
| 29.02 | 737 | 983 | 841 | 256 | 97 |
| 28.74 | 730 | 973 | 1126 | 343 | 96 |
| 28.43 | 722 | 963 | 1413 | 431 | 95 |
| 28.11 | 714 | 952 | 1703 | 519 | 94 |
| 27.83 | 707 | 942 | 1995 | 608 | 93 |
| 27.52 | 699 | 932 | 2290 | 698 | 92 |
| 27.24 | 692 | 922 | 2587 | 789 | 91 |
| 26.93 | 684 | 912 | 2887 | 880 | 90 |
| 26.61 | 676 | 902 | 3190 | 972 | 89 |
| 26.34 | 669 | 892 | 3496 | 1066 | 88 |
| 26.02 | 661 | 882 | 3804 | 1160 | 87 |
| 25.75 | 654 | 871 | 4115 | 1254 | 86 |
| 25.43 | 646 | 861 | 4430 | 1350 | 85 |
| 25.12 | 638 | 851 | 4747 | 1447 | 84 |
| 24.84 | 631 | 841 | 5067 | 1544 | 83 |
| 24.53 | 623 | 831 | 5391 | 1643 | 82 |
| 24.25 | 616 | 821 | 5717 | 1743 | 81 |
| 23.94 | 608 | 811 | 6047 | 1843 | 80 |
| 23.62 | 600 | 800 | 6381 | 1945 | 79 |
| 23.35 | 593 | 790 | 6717 | 2047 | 78 |
| 23.03 | 585 | 780 | 7058 | 2151 | 77 |
| 22.76 | 578 | 770 | 7401 | 2256 | 76 |
| 22.44 | 570 | 760 | 7749 | 2362 | 75 |
| 22.13 | 562 | 750 | 8100 | 2469 | 74 |
| 21.85 | 555 | 740 | 8455 | 2577 | 73 |
| 21.54 | 547 | 730 | 8815 | 2687 | 72 |
| 21.26 | 540 | 719 | 9178 | 2797 | 71 |
| 20.94 | 532 | 709 | 9545 | 2909 | 70 |
| 20.63 | 524 | 699 | 9917 | 3023 | 69 |
| 20.35 | 517 | 689 | 10293 | 3137 | 68 |
| 20.04 | 509 | 679 | 10673 | 3253 | 67 |
| 19.76 | 502 | 669 | 11058 | 3371 | 66 |

# Table 3. Conversion Factors

| TO CONVERT FROM | TO | EQUATION |
|---|---|---|
| Feet | Meters | Multiply by 0.3048 |
| Meters | Feet | Multiply by 3.2808399 |
| Degrees Celsius | Degrees Fahrenheit | 5/9×(°F-32) |
| Degrees Fahrenheit | Degrees Celsius | 9/5×(°C)+32 |
| Milligrams per liter (mg/l) | Parts per million (ppm) | Multiply by 1 |

## Conversion Factors for Common Units of Pressure

| | kilo Pascals | mm Hg | millibars | inches $H_20$ | PSI | inches Hg |
|---|---|---|---|---|---|---|
| **1 atm** | 101.325 | 760.000 | 1013.25 | 406.795 | 14.6960 | 29.921 |
| **1 kiloPascal** | 1.00000 | 7.50062 | 10.0000 | 4.01475 | 0.145038 | 0.2953 |
| **1 mmHg** | 0.133322 | 1.00000 | 1.33322 | 0.535257 | 0.0193368 | 0.03937 |
| **1 millibar** | 0.100000 | 0.750062 | 1.00000 | 0.401475 | 0.0145038 | 0.02953 |
| **1 inch $H_20$** | 0.249081 | 1.86826 | 2.49081 | 1.00000 | .0361 | 0.07355 |
| **1 PSI** | 6.89473 | 51.7148 | 68.9473 | 27.6807 | 1.00000 | 2.0360 |
| **1 inch Hg** | 3.38642 | 25.4002 | 33.8642 | 13.5956 | 0.49116 | 1.00000 |
| **1 hectoPascal** | 0.100000 | 0.75006 | 1.00000 | 0.401475 | 0.0145038 | 0.02953 |
| **1 cm $H_20$** | 0.09806 | 0.7355 | 9.8 x $10^{-7}$ | 0.3937 | 0.014223 | 0.02896 |

# APPENDIX G

## SENSOR AND SONDE STORAGE RECOMMENDATIONS

The multiparameter equipment associated with the EMS product line from YSI consists of a number of types of sondes which differ in size and function and which, by definition, contain a variety of sensors (or probes) in a compact arrangement where the sensors cannot be separated physically. This arrangement allows the user to concurrently (and conveniently) acquire data from all of these sensors (either in spot sampling or monitoring applications). The presence of multiple probes in the same unit sometimes results in questions as to the proper procedure for storage of the sensors which will maximize their lifetime and will minimize the time required to get the sonde in shape for a new application. This document is designed to answer most of the questions previously raised by our users with regard to two types of storage requirements:

1. Interim or short term storage between applications where the sonde is being used at a regular interval (daily, weekly, biweekly, etc.).
2. Long term storage, e.g., over-the-winter, where the sonde will not be used on a regular basis for several months.

**NOTE: In the descriptions and instructions below, it is assumed that the user has retained the vessels (bottles, boots, etc.) in which the individual sensors were stored on initial delivery. If these specific items have been misplaced or lost, they can be replaced by contacting YSI Product Service. Alternatively, the user may have similar (and equally acceptable) storage equipment on hand even though it was not part of the original YSI package. Common sense should be the guide on substitution of storage vessels.**

### RECOMMENDATIONS FOR INTERIM SONDE STORAGE

Fortunately, the recommended short term or interim storage procedure is very simple and is identical for all instruments (Models 600, 600XL, 6000UPG, and 6820).

No matter what sensors are installed in the instrument, the key is to keep them moist without actually immersing them in liquid which could cause some of them to drift or result in a shorter lifetime. For example, the reference junction of a pH sensor must be kept moist to minimize its response time during usage, but continued immersion in pure water may compromise the function of the glass sensor and/or result in long term leaching of the reference junction. With this in mind, YSI recommends that short term storage of all multiparameter instruments be done **by placing approximately 0.5 inch of water in the calibration and/or storage vessel which was supplied with the instrument and placing the sonde with all probes in place in the vessel.** The use of a moist sponge as a source of humidity is also acceptable, as long as its presence does not compromise the attachment of the storage vessel to the sonde. **The storage vessel should be sealed to prevent evaporation.**

The key for interim storage is to use a minimal amount of water so that the air in chamber remains at 100 percent humidity, but the water level is low enough so that none of the sensors are actually immersed. Any type of water can be used in this protocol: Distilled, deionized, or tap. If storage water is inadvertently lost during field sampling studies, environmental water can be used to provide the humidity.

Sondes with level sensors have a tube that vents the pressure transducer to atmosphere. It is imperative that the air in the tube remain dry at all times. Sondes with integral cables should be stored with the desiccant in place and the vented end of the desiccant system sealed. Sondes with connectors should be stored with the connector cap firmly in place. Do not disconnect the cable without putting the cap on immediately. Vented cables should be stored with their caps on, in a bag with desiccant.

Thus, interim multiparameter storage is easy. Simply remember the following key points:

☐ Use enough water to provide humidity, but not enough to cover the probe surfaces.

☐ Make sure the storage vessel is sealed to minimize evaporation.

☐ Check the vessel periodically to make certain that water is still present.

☐ For sondes with level sensors, keep the tube sealed and dry.

## GENERAL RECOMMENDATIONS FOR LONG TERM STORAGE

The following are long term storage recommendations listed by instrument type which will be applicable for sondes with typical sensor configurations:

**6000UPG** – Remove all sensors except the combination DO/Conductivity/Temperature probe from the sonde and store according to the instructions found in the following section on individual sensors. Cover the empty ports with the provided plugs. Leave the DO sensor with electrolyte and a membrane in place. Place approximately 400 mL of deionized, distilled, or tap water in the calibration/storage vessel, insert the sonde into the vessel, and seal to minimize evaporation

**600XL** – Remove the pH or pH ORP probe from the sonde and store according to the instructions found in the following section on individual sensors. Cover the empty port with the provided plug. Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Place approximately 300 mL of deionized, distilled, or tap water in the calibration/storage vessel, insert the sonde into the vessel, and seal with the cap/O-ring to minimize evaporation.

**6820** -- Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Remove all other probes from the sonde and store according to the instructions found in the following section on individual sensors. Cover the empty ports with the provided plugs. Place approximately 300 mL of deionized, distilled, or tap water in the calibration/storage vessel, insert the sonde into the vessel, and tighten the threaded cup to attain a good seal and minimize evaporation.

**600 (with Replaceable Reference Electrode Module)** -- Instruments of this design were generally sold after January, 1996 and can be identified by the presence of 4 probes (temperature, dissolved oxygen, pH reference, and pH glass) in the bulkhead. Remove the reference module, store it as described below, and plug the open port with the insert which was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Place approximately 300 mL of tap water in the storage vessel, insert the sonde, and seal the vessel with the cap and O-ring. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor which must remain in the sonde.**

**600 (with Combination pH Sensor)** -- Instruments of this design were generally sold prior to January, 1996 and can be identified by the presence of only 3 probes (temperature, dissolved oxygen, pH) in the bulkhead Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar (2 M) in potassium chloride (KCl) to a level which completely covers the dissolved oxygen and pH probes. See the following section for instructions on preparation of the KCl storage solution. Seal the vessel with the cap and O-ring.

## RECOMMENDATIONS FOR LONG TERM STORAGE OF INDIVIDUAL SENSORS

The following sections provide additional details on the storage of individual sensors associated with instruments in the EMS product line from YSI.

### TEMPERATURE

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with thermistor probe are not corrosive (for example, chlorine bleach).

## CONDUCTIVITY

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with thermistor probe are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to long term storage.

## DISSOLVED OXYGEN

Rapid Pulse dissolved oxygen sensors should always be stored with a membrane and electrolyte in place and in such a way that the drying out of the electrolyte on the probe face is minimized. For long term storage, the medium should be water rather than the moist air used in interim storage. The long term storage protocol is also dependent on the instrument under consideration.

For the 6000UPG, the 600XL, and the 6820, two long term storage methods are equally acceptable.

☐ Remove all probes other than dissolved oxygen, conductivity, and temperature from the sonde and seal the vacant ports with the provided plugs. Leave the electrolyte and membrane in place on the dissolved oxygen sensor. Fill the provided storage vessel with water (tap, deionized, or distilled are equally acceptable) and insert the sonde. Make certain the water level is high enough to completely cover the DO sensor. Seal the vessel to prevent evaporation of the water. At the end of the storage time, remove the existing membrane and remembrane the probe using new electrolyte.

☐ Remove the dissolved oxygen sensor from the sonde leaving the electrolyte and membrane in place. Store the probes in water (tap, deionized, or distilled are equally acceptable) in a beaker, flask, or other vessel of the user's choice. <u>Be sure not to damage the membrane or the probe tip when placing the probe on the bottom of the vessel</u>. If possible cover the vessel with parafilm or plastic wrap to minimize evaporation of the water during the long term storage. Monitor the water level in the storage vessel periodically and replenish if loss due to evaporation occurs. At the end of the storage time, remove the existing membrane and remembrane the probe using new electrolyte.

Because the dissolved oxygen probe associated with the Model 600 cannot be removed from the sonde by the user, a slightly different long term storage protocol is required:

☐ For 600 systems equipped with a replaceable reference electrode module, remove the reference module, store it as described below, and plug the open port with the insert which was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar (2 M) in potassium chloride (KCl), insert the sonde, and seal the vessel with the cap and O-ring. This solution can be prepared by dissolving 74.6 g of KCl in 500 mL (approximately 1 pint) of water or 37.3 g of KCl in 250 mL (approximately 0.5 pint) of water. The water should be distilled or deionized. If KCl solution is unavailable, it is acceptable to store the dissolved oxygen and pH glass sensors in tap water. **However, do not use deionized or distilled water in this case, as it may**

**damage the pH glass sensor which must remain in the sonde.** At the end of the storage time, remove the existing membrane and remembrane the probe using new electrolyte.

☐ For 600 systems equipped with a combination pH probe (purchased prior to 1996), none of the probes are user-replaceable and a different storage technique is required. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar (2 M) in potassium chloride (KCl) to a level which completely covers the dissolved oxygen and pH probes. Seal the vessel with the cap and O-ring. At the end of the storage time, remove the existing membrane and remembrane the probe using new electrolyte.

## pH

The key to pH probe storage, either short or long term, is to make certain that the reference electrode junction does not dry out. Junctions which have been allowed to dry out due to improper storage procedures can usually be rehydrated by soaking the sensor for several hours (overnight is recommended) in a solution which is 2 molar in potassium chloride (see dissolved oxygen section above for preparation of this solution). If potassium chloride solution is not available, soaking in tap water or commercial pH buffers may restore probe function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement. It is also important to remember not to store the pH sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

The long term storage protocol is dependent on the instrument.

For Model 6000UPG, 600XL, and 6820 systems, the recommended long term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a solution which is 2 molar in potassium chloride. Make certain that the vessel is sealed to prevent evaporation of the storage solution. Electrical tape can be used to provide a removeable seal between the boot and the module body.

For Model 600 systems equipped with a replaceable reference electrode module, remove the reference module and plug the open port with the insert which was provided. Place the module in the storage vessel boot which was in place on delivery and seal the vessel with electrical tape. The vessel should contain a solution which is 2 molar in potassium chloride and should be sealed to prevent evaporation of the storage solution. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided sonde storage vessel with tap water, insert the sonde, and seal the vessel with the cap and O-ring. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor which must remain in the sonde.**

For Model 600 systems equipped with a combination pH probe (purchased prior to 1996), a different storage technique is required. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar in potassium chloride (KCl) to a level which completely covers the dissolved oxygen and pH probes, insert the sonde, and seal the vessel with the cap and O-ring.

## ORP

**Long Term Storage**: ORP is not available on the Model 600. For the Model 6000UPG, 600XL, and 6820 systems, the recommended long term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a solution which is 2 molar in potassium chloride. Make certain that the vessel is sealed to prevent evaporation of the storage solution.

## AMMONIUM AND NITRATE

The active element in these ion selective electrode sensors is a polyvinyl chloride (PVC) membrane which is impregnated with the reagent which provides specificity for either ammonium or nitrate. The useful life of this sensor can be reduced if the membrane is stored immersed in water. Thus, storage in dry air is recommended for long term storage. While dry air is slightly preferable for general storage, the short term storage of these sensors in the sonde, with the entire sensor array in moist air, will have no significant detrimental effect on the life of the membrane. Remove the sensor module (6820) or the probe (6000UPG) from the sonde and cover the vacant port with the provided plug. Place the sensor back in the storage boot which was provided, and set aside in room air.

## TURBIDITY

No special precautions are necessary for either the short or long term storage of the turbidity sensors for the Models 6000UPG and 6820. However, for long term storage, the user may wish to remove the sensor from the sonde and store it dry in air to minimize any cosmetic degradation of the probe body and to maximize the life of the wiper on the 6026.

## DEPTH/LEVEL

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with the strain gauge sensor port are not corrosive (for example, chlorine bleach).

Recommendations are identical for short-term and long-term storage.

This Page Intentionally Left Blank

LaMotte

# TURBIDIMETER

OPERATOR'S MANUAL MODEL 2008 CODE 1790

LaMOTTE

## OPERATOR'S MANUAL
# TURBIDIMETER
## MODEL 2008

## INDEX

Page

Specifications . . . . . 2

Introduction . . . . . 3

Meter Features . . . . . 4

General Operating Instructions . . . . . 6

  Standards . . . . . 6

  Techniques . . . . . 6

  Glassware . . . . . 7

Interpretation of NTU's . . . . . 8

Dilution of Samples . . . . . 9

Preparation of Turbidity-Free Water . . . . . 9

  Procedure . . . . . 9

Maintenance . . . . . 10

  Recharging Batteries . . . . . 10

  Battery Replacement . . . . . 10

  Replacing Lightbulb . . . . . 10

  Cleaning Lightbox . . . . . 10

Instrument Guarantee . . . . . 11

Limits of Liability . . . . . 11

Packaging and Delivery . . . . . 11

LaMotte Company
PO Box 329 • Chestertown • Maryland • 21620
800-344-3100 • 410-778-3100 (in MD)

11/91

## SPECIFICATIONS FOR MODEL 2008 TURBIDIMETER

### METER

*Range:* 0-19.99 and 0-199.9 NTU Full Scale

*Measurement Accuracy:* ±2% of reading or 0.05 NTU, whichever is greater.

*Display:* 0.5" Liquid Crystal Display

*Warm Up Time (to specified accuracy):* less than 15 seconds

### PHOTOMETRIC DATA

*Photodetector:* Silicon photodiode, centered at 90° to the incident light path.

*Lamp:* Tungsten, lens-end long life, operated at a color temperature of 2230°K. Distance traversed by incident light and scattered light within the sample tube is 2.5 cm.

*Lamp Life:* Approximately 10,000 hours

### CONTROL PANEL

*Range Selector:* 4-position: Charge only/Off/0-20 NTU/0-200 NTU

*Standardize:* For standardizing instrument with AMCO™ standards.

### POWER REQUIREMENTS

Operates from internal Ni-Cad rechargeable batteries (not user replaceable)

*D.C. Operation:* Requires 9V, 500 ma (nominal) source - operation is possible on any D.C. source between 9 &16 volts capable of supplying at least 300 ma.

*A.C. Operation:* Is possible via A.C. adapter (120 VAC input, 9V, 500 ma output)

### METER HOUSING

*Material:* ABS

*Dimensions:* 7 1/2"L x 5 3/8"H x 2 3/4"W

*Weight:* 2.4 lbs.

### OPTIONAL CARRYING CASE

*Material:* High Density Polyethylene Case

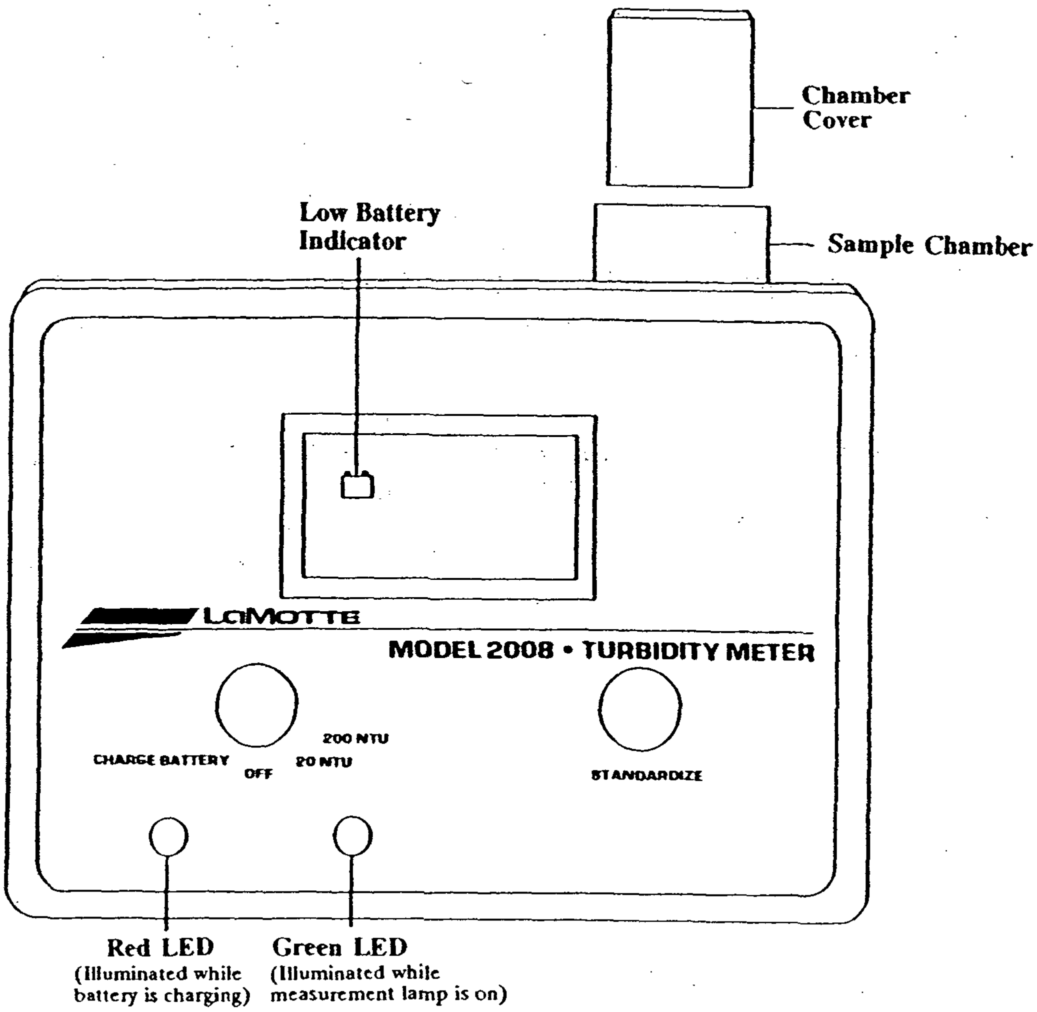
*Dimensions:* 10"L x 13 1/2"W x 6 1/8"H

*Weight:* 8 lbs.

# INTRODUCTION

The Model 2008 portable turbidimeter is acceptable for turbidity measurements reportable under either the National Primary Drinking Water Regulations (NPDWR) or the National Pollutant Discharge Elimination System (NPDES) compliance monitoring program. This instrument is suitable for testing municipal waters, food and beverage processing waters, and any aqueous solutions in which control of clarity is critical. The unit may be operated from line power via an AC adaptor or from self-contained rechargeable batteries.

The Model 2008 is a true nephelometer, measuring the amount of light scattered at right angles from a beam of light passing through the test sample. Test results are read directly in NTUs on an LCD digital readout. Two ranges make the Model 2008 a versatile instrument for testing turbidity in treated waters, natural waters and wastewaters. The turbidimeter is pre-calibrated in LaMotte laboratories, and a simple standardization is the only step required prior to testing.



## METER FEATURES

The Model 2008 is shipped complete with all the necessary glassware and apparatus to perform turbidity measurements. A four position control switch located at the left of the panel has a Charge and Off position and also serves as the range selector for the two ranges: 0-20, 0-200 NTU. The low range (0-20 NTU) is used for monitoring drinking water quality, while the high range (0-200 NTU) may be used for a wide range of monitoring applications.

The batteries in the 2008 can be recharged from a fully discharged state in approximately 4.5 hours. The red LED in the front panel indicates that the battery is being charged. It will go out when full charge is reached. There is no possibility of overcharging the batteries, and they will also charge during the measurement modes. If the red LED is extinguished before the 2008 is disconnected from the AC adapter you can be assured that the batteries are fully charged. When fully charged, the batteries are sufficient to allow 300 readings to be made. This is based on the assumption that the reading is made in 30 seconds or less. Please note that the design of the instrument has been optimized for portable use, and readings will be stable and accurate after only a few seconds. There is no need to keep the instrument on continuously, and indeed doing so is deleterious to both battery life and lamp life. The lamp is not user replaceable, so care has been taken to assure long lamp life; it is estimated at 10,000 hours. Based on 30 second readings this should allow over a million readings to be made before bulb replacement is necessary. Allowing the lamp to remain on for long periods will shorten its service life.

The green LED (See Figure 1) on the front panel will be illuminated along with the measurement lamp. Notice that this occurs only when a sample tube is fully inserted in the sample chamber. With the lamp off, the power requirements of the 2008 are quite small, so the function switch need not be returned to the off position. Simply remove the sample tube.

A small indicator will appear in a corner of the panel meter when batteries are nearly exhausted. For a while after the appearance of the indicator, the 2008 will continue to function and readings will continue to be accurate. At the end of the useful charge, the readings will become unstable; they will appear to "drift." Recharging is necessary at this point. Note that as soon as the 2008 is connected to the AC adapter it is again useable. There is no necessity to wait for the batteries to fully recharge. **Do not operate the 2008 on batteries once they have discharged beyond a useable point. If the batteries are discharged beyond this point it may not recharge properly.**

In a measurement mode, with the sample chamber capped and no sample tube in the chamber, the panel meter will indicate some small negative number. The exact value will depend on the position of the standardization control. If the instrument is operating normally and the standardization has been done properly the reading should be between -0.10 and -0.40 NTUs. Observation of this value is a convenient check on the functionability and accuracy of the 2008.

## GENERAL OPERATING INSTRUCTIONS

The accuracy and repeatability of your measurements will be a function of the condition of your standards, your technique, and the quality of the glassware.

### STANDARDS

Two standards are supplied with each 2008, and others are available. The standards are used as a reference to allow you to calibrate, or *Standardize*, the instrument. This typically would be done before a series of measurements, or on some other regular basis, as an assurance of the accuracy of your readings. The AMCO™ standards supplied have been carefully manufactured and are guaranteed to be accurate to within ±1%. Since the accuracy of your results will depend on these standards the following observations and precautions are important:

1. In an unopened bottle (as supplied) the standards will remain stable indefinitely as long as they are not exposed to excessively hot or cold environments. (Keep between 10°C and 40°C.)
2. Once the seal is broken on the standard, the stability is only guaranteed for nine months thereafter, again based on normal environmental conditions.
3. To ensure the accuracy of the standard, never transfer anything into the bottle (e.g. don't dilute, don't return standards that have been removed, don't combine with other standards, etc.)
4. Do not open the standards in dusty environments, and guard against contaminates entering the bottle while it is open.
5. When transferring the standard to a sample tube be certain that the tube is absolutely clean. A reasonable precaution is to rinse out the inside of the tube with the standard before filling the tube. This wastes a few mL of standard, but will minimize the possibility of contamination.
6. After transferring the standard, promptly cap both the sample tube and the standards bottle.

### TECHNIQUE

The handling of the sample tubes and the preparation of the sample is of utmost importance. The glassware must be clean and defect-free. Scratches and/or abrasions will permanently affect the accuracy of your readings.

A good procedure to follow is the following:

1. Use a clean container to obtain a sample of the liquid to be measured. The volume is not critical; somewhere between 50 and 500 mL is fine. Set the container aside and allow the sample time to equilibriate to ambient temperature, and also to allow any entrained gasses to escape. Keep dust or other airborne contaminates from contact with the sample.
2. When the sample has equilibriated, pour a bit of it into the sample tube as a final rinse, and again shake the excess liquid out. Now fill the sample tube to its neck (See Figure 2), taking care to pour the sample gently down the side to avoid creating any bubbles.
3. Cap the tube and, while holding the tube by the cap only, wipe the outside surface with a clean, lint-free, absorbent wipe until the tube is dry and smudge-free. Handling the tube only by its cap will avoid problems from fingerprints. Set the tube aside on a clean surface that won't contaminate or scratch the bottom of the tube.
4. Select the appropriate range on the 2008, and insert a sample tube containing an AMCO™ standard with a value close to what you suspect the sample you are measuring to be.

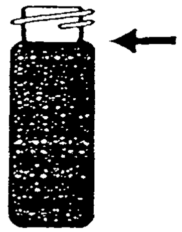


Figure 2

5. Be certain the chamber is capped, and that the tube is seated at the bottom of the chamber. The green front panel LED must be illuminated, indicating that the lamp is on. Adjust the *Standardization* control so that the display reads the known value of the chosen standard.

6. Withdraw the standard and insert the tube with the sample to be measured. Again, make sure the chamber is capped and the tube is seated on the bottom. The reading should stabilize within 15 seconds. Make a note of the reading and withdraw the tube.

7. If you wish to take repeated measurements or measure several samples in succession, it will not be necessary to readjust the *Standardization* before each reading. Once set it will remain stable for long periods. Of course, you may reinsert the standard at any time to verify the stability of the readings.

## GLASSWARE

The variability in the geometry and quality of the glassware is the predominate cause of variability in the readings that will be obtained. With a few precautions to minimize the effects of these variations, readings significantly more accurate than the specified ±2% may be obtained.

No piece of glassware is ever perfectly cylindrical (or exactly like any other). You will notice that if the tube is rotated in the chamber slightly (say in 15° increments) the reading will also vary somewhat. If the tube were always placed into the chamber with the same orientation this source of variability could be eliminated. This can be accomplished if the cap is marked in some way, perhaps with a piece of tape, and always used with the same tube. When inserting the tube with its paired cap you can observe the mark on the cap and always insert it with the same orientation. It is especially useful to do this with the tube used for the AMCO™ standards; any variability in the standardization will affect all subsequent readings.

Once the rotational variability is compensated for the residual uncertainty is a result of how well the tubes match. If absolute accuracy is necessary in your readings it is possible to calibrate the set of tubes supplied with the 2008. The procedure entails filling all the tubes with the same sample, preferably a sample with a turbidity at the upper end of the range you will normally use, and recording the readings for each tube. The value of the readings are irrelevant, but they can be used to derive a correction factor for each tube relative to any other tube. However, if monitoring trends and following small changes is more of a concern, the simple precaution of always using the same tube (in the same orientation) will effectively eliminate the ±2% uncertainty. This assumes, of course, that the tubes used for the AMCO™ standards are not switched either.

Following these precautions can allow the precision and repeatability of your readings to approach ±.01 NTU. Do not forget, however, that since the standardization procedure is based on the AMCO™ standard used, no reading can be considered to be more accurate than ±1% in an absolute sense.

# INTERPRETATION OF NTU'S

Turbidity in a liquid is a result of "suspended solid matter." The presence of "solid matter," usually of a particular nature, results in the scattering of light passing through the liquid which is perceived as a cloudiness in the liquid. Turbid liquid appears cloudy; indeed the cloudy appearance is the definition of turbidity. Turbidity is of interest because it affords an **indirect** way to evaluate the concentration of the "suspended solid matter." It is indirect in that the solids are not measured; what is measured is their interaction with light.

How a solid particle reacts with (scatters) light depends on the physical characteristics of both the particle and the light. How the scattering is quantified depends on the particular characteristics of measurement procedure or instrument. Historically there have been several different ways to measure, and thus to quantify, turbidity. All yield different results and different numbers. This is not unexpected in a world that cannot agree on a standard for so basic a quantity as distance (inches or centimeters ?).

What a NTU is and what it represents is a matter of definition. In part, since NTU is the acronym for **Nephelometric Turbidity Units** the measurement technique is defined; nephelometry is accepted as referring to the measurement of light scattering in the direction perpendicular to its propagation. The characteristics of the measuring device have been constrained (within rather generous limits) by the requirements of various standards agencies. There is also an accepted standard solution to be used as a calibrated standard. Formazin, formed by reacting hydrazine sulfate with hexamethylenetetramine, is widely used. Unfortunately it is not very stable. Using it as a calibration standard requires reformulating it every few days, which limits its usefulness outside of a laboratory environment.

The 2008 has been calibrated with (and is supplied with) a secondary standard manufactured by Advanced Polymer Systems, Inc. It is a suspension of uniformly sized plastic, "microspheres," requiring no preparation, and is stable for long periods. These AMCO® standards are different from Formazin, and so and instrument calibrated on one will necessarily not be calibrated for the other.

In any one type of instrument there is a fixed relationship between the indicated NTU with different standards. For the 2008 that relationship is:

$$\text{NTU}_{\text{Formazin}} = 1.25 \times \text{NTU}_{\text{AMCO®}} \text{ or } 0.8 \times \text{NTU}_{\text{Formazin}} = \text{NTU}_{\text{AMCO®}}$$

The one equation is just the inverse of the other, and using this relationship you can determine the NTU of any unknown in terms of either Formazin or AMCO® calibration standards. Do not expect, though, that readings made on any one type of instrument will agree with what a different type of instrument indicates. There will be a fixed and determinable relationship between them, but the numerical values need not correspond.

## DILUTION OF SAMPLES

If the sample has a turbidity reading greater than 200 NTU's, it is necessary to dilute the sample with turbidity-free deionized water to bring the reading within the range of the instrument. Turbidity-free deionized water may be prepared as described below. The following calculation is required if the sample is diluted:

$$\frac{A(B + C)}{C} = D$$

where A = NTU found in diluted sample
B = Volume of deionized dilution water used, mL
C = Sample volume taken for dilution, mL
D = NTU of original, undiluted sample

*For example:* If 10 mL of sample water is diluted with 90 mL of turbidity-free water to a total volume of 100 mL and the resulting solution measures 40 NTU, the turbidity of the original undiluted sample is:

$$\frac{40(90 + 10)}{10} = 400 \text{ NTU}$$

## PREPARATION OF TURBIDITY-FREE WATER

The preparation of turbidity-free water requires careful technique. Introduction of any foreign matter will affect the turbidity reading. A filtering device with a special membrane filter is incorporated into the procedure to prepare turbidity-free water. The filter, filter holder, and syringe must be conditioned by forcing at least two syringe loads of deionized water through the filtering mechanism to remove foreign matter from the filtering apparatus. The first and second rinses are discarded. Turbidity-free water as prepared below may be stored in the dark at room temperature in a clear glass bottle with screw cap or in a turbidity tube (Code 0273) and used as required. The storage vessels should be rinsed thoroughly with filtered deionized water. Periodically inspect the water for foreign matter in bright light.

*Note: The membrane filters are white and packaged between two blue protective disks. Handle membrane filters with extreme care.*

### PROCEDURE

1. Unscrew the top of the filter holder and place a white membrane filter on the screen inside. The filter disc should be positioned carefully so that it covers the entire surface of the screen. Replace the top of the filter holder and screw on securely.
2. Remove the plunger from the syringe, then attach the filter holder to the bottom of the syringe.
3. Pour approximately 50 mL of deionized water into the barrel of the syringe. Replace plunger into barrel and exert pressure on the plunger to slowly force the water through the filter. Collect the water in a suitable clean container.
4. Remove filter holder from syringe, then remove plunger from barrel. This step is required to prevent rupturing the membrane filter by vacuum as the plunger is removed from the barrel.

5. Replace filter holder and repeat steps 3 and 4 until the desired amount of turbidity-free water is collected. Periodically examine the membrane filter to insure no holes or cracks are evident.

6. Depending upon the nature of the unfiltered water it is possible to prepare a liter or more of turbidity-free water using a single filter. The membrane filter may be stored in the holder for an indefinite period of time and used as required.

## MAINTENANCE

No periodic maintenance is required. The most importance considerations in assuring long life and accurate readings are:

1. Keep the instrument clean and dry, especially the sample chamber. Keep the chamber capped except while inserting or removing sample tube. If the chamber needs to be cleaned the best first choice is compressed gas. Photo-supply outlets sell an "aerosol" can of clean and dry gas for cleaning lenses - this is ideal. Hold the 2008 upside down while "squirting" it so that the particles will fall out and not be forced further into the bottom of the chamber.

2. Be aware that the lamp will eventually "burn out," though its estimated service life in normal use is in excess of 10 years. It is not user serviceable because the type of lamp used is not commonly available and its placement critically effects the calibration and so it is best replaced at the LaMotte Service Laboratory where the necessary calibration equipment is available. But also note that the lamp may become unstable and/or excessively dim well before it actually fails. A good test of lamp stability is to observe the display with a clean, dry and empty sample tube in the chamber. The actual value under these conditions is unpredictable (it will probably be between 1.50 and 3.00 NTU) but it should be stable (±0.02 NTU). As long as the display is stable the lamp is useable.

3. Likewise the battery life is finite, though it is harder to estimate, since it is a function of use history and environmental conditions. As a rule, if A.C. power is available use it instead of the battery. **If the instrument is used occasionally (once a month or less) it will maximize battery life if the function switch is left in the "Charge" position with the AC adaptor plugged in.** Another useful practice is to continue using battery power only, once the instrument had been disconnected from the A.C. adaptor, until the battery low indicator is visible. Recharging from the fully discharged condition (Bat low indicator visible) to the fully charged condition (red LED extinguished) should take 4 to 5 hours. If it takes notably less than that it is a sign of diminished battery capacity. Note that the 2008 may be used with the A.C. adaptor even with totally exhausted and/or "worn out" batteries. If the battery capacity diminishes to the extent that they are no longer able to make as many measurements as you need between charging cycles return the instrument (see instructions for "Returns") for battery replacement.

*The lamp is only illuminated when the instrument is in the measurement mode and a sample tube is seated in the bottom of the chamber. Since the readings are valid within 15 seconds there is no need to allow the lamp to be illuminated any longer than necessary to take a measurement. Battery life and lamp life will both be enhanced by always removing the sample from the chamber after the measurement is recorded.*

## INSTRUMENT GUARANTEE

This instrument is guaranteed to be free from defects in material and workmanship for six months from original purchase date. If within that time the instrument is found to be defective, it will be repaired without charge - except for transportation expense.

This guarantee is void under the following circumstances: operator's negligence, improper application, and unauthorized servicing.

## LIMITS OF LIABILITY

Under no circumstances shall LaMotte Company be liable for loss of life, property, profits or other damages incurred through the use or misuse of their products.

## PACKAGING AND DELIVERY

Experienced packaging personnel at LaMotte Company assure the adequate protection against normal hazards encountered in transportation of shipments. After the product leaves the manufacturer, all responsibility for its safe delivery is assured by the transportation company. Damage claims must be filed immediately with the transportation company to receive compensation for damaged goods.

Should it be necessary to return the instrument for repair or servicing, pack instrument carefully in suitable container with adequate packing material. Attach a letter to the shipping carton describing the kind of trouble experienced. This valuable information will enable the service department to make the required repairs more efficiently.

# *Surface Water and Sediment Sample Collection*

FINAL

# Standard Operating Procedure

## *Surface Water and Sediment Sampling*

December 2001

**Environmental Resources Management**
399 Boylston Street
Boston, Massachusetts02116

# TABLE OF CONTENTS

TABLE OF CONTENTS I

1.0 PURPOSE AND SCOPE 1

2.0 RESPONSIBILITIES AND QUALIFICATIONS 2

3.0 PROCEDURES FOR COLLECTION OF SURFACE WATER SAMPLES 3

3.1 EQUIPMENT LIST 3

3.2 PROCEDURE 4

4.0 PROCEDURES FOR COLLECTION OF SEDIMENT SAMPLES 6

4.1 EQUIPMENT LIST 6

4.2 PROCEDURE 6
4.2.1 Surface Water Sampling 6
4.2.2 Sample Collection 7

5.0 SAMPLES 10

5.1 SAMPLE CONTAINERS 10
5.1.2 Sample Identification 10
5.1.3 Sample Labeling 10

5.2 SAMPLE PRESERVATION AND HANDLING 10
5.2.1 Sample Preservation 10
5.2.2 Sample Handling 11

5.3 SAMPLE TRACKING 11

5.4 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES 12
5.4.1 Trip Blanks 12
5.4.3 Matrix Spike/Matrix Spike Duplicate for Surface Water Samples 12

# 1.0 PURPOSE AND SCOPE

The purpose of this document is to define the standard operating procedure (SOP) for conducting surface water and sediment sampling. This Standard Operating Procedure (SOP) is applicable to the collection of representative aqueous samples and non-aqueous (e.g. sediment) from wetlands, streams, rivers, and surface waters.

The ultimate goal of surface water and sediment sampling is to obtain data and samples that meet acceptable standards of accuracy, precision, comparability, representativeness, and completeness. In this SOP, procedures for sample tracking, documentation, and integrity have been explained in sufficient detail to allow different sampling personnel to collect samples that are equally reliable and consistent. The following items will be discussed in detail in the procedure section of this SOP:

- Surface water dip sampling; and
- Surface water and sediment direct sampling.

Specifically, the procedures section describes the equipment, field procedures, sample containers, storage, decontamination, documentation, and field quality assurance/quality control (QA/QC) procedures necessary to conduct surface water and sediment sampling. The step-by-step procedures are described in sufficient detail to allow field personnel to obtain data of sufficient integrity and to ensure representative surface water and sediment samples are collected.

This SOP serves as a reference for project personnel and applies to all surface water and sediment samples collection by Environmental Resources Management (ERM) personnel or their subcontractors. This workplan is to be strictly followed, and any modification to the procedure shall be approved by the project manager (PM) in advance.

## 2.0 *RESPONSIBILITIES AND QUALIFICATIONS*

The PM is responsible for assigning project staff to perform surface water and sediment sampling activities and for ensuring that all project personnel follow appropriate procedures.

The project staff assigned to the collection of data, surface water and sediment samples are responsible for completing their tasks according to this SOP. All staff are responsible for reporting deviations from the procedure or nonconformance to the PM or project QA/QC officer.

Only qualified personnel shall perform this procedure. At a minimum, ERM employees qualified to perform surface water sampling and sediment sampling will be required to have:

- Read this SOP;
- Indicated to the PM that all procedures contained in this SOP are understood;
- Completed the Occupational Safety and Health Association (OSHA) 40-hour training course, and/or annual 8-hour refresher course, as appropriate; and
- Previously performed surface water and sediment sampling in a manner generally consistent with the procedures described in this SOP.

ERM employees who do not have previous experience performing surface water and sediment sampling will be trained on site by a qualified ERM employee. A qualified professional geologist or professional engineer will oversee progress of the project, results, and interpretations. The PM shall document personnel qualifications related to this procedure in the project QA files.

# 3.0 PROCEDURES FOR COLLECTION OF SURFACE WATER SAMPLES

## 3.1 EQUIPMENT LIST

Equipment needed for collection of surface water samples includes:

- Sample bottles with preservatives appropriate for the analysis to be performed;
- Sample bottle labels;
- Plastic zip-sealed bags;
- Ice or frozen ice packs;
- Cooler(s);
- Chain of custody forms;
- Field data sheets;
- Decontamination equipment (as needed);
- Maps/plot plan;
- Personal protective equipment (PPE);
- Compass (optional);
- Tape measure;
- Global Positioning System (GPS) (optional);
- Survey stakes, flags, or buoys and anchors;
- Camera and film;
- Logbook and waterproof pen;
- Approved QA project plan;
- Approved health and safety plan;
- Dip sampler (as needed); and
- Water quality meter(s) (e.g. dissolved oxygen, pH, temperature, conductivity, oxidation reduction potential)

The appropriate sampling device must be of proper composition. Samplers constructed of glass, stainless steel, PVC or PFTE (Teflon) should be used based upon the analyses to be performed. The sampling team member collecting the sample should not get too close to the edge of the water body to be sampled, where bank failure may cause them to lose their balance.

## 3.2 PROCEDURE

The following tasks should be performed prior to mobilization to the field for the surface water sampling effort:

1. Determine the extent of the sampling effort, the sampling methods to be employed, and equipment and supplies required (see quality assurance project plan (QAPP)).
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment and ensure that water quality monitors are in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, as appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan and QAPP.
6. Use stakes, flags, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. To the degree feasible, the samples should be collected at locations with less than one foot of standing water.

The following tasks should be performed during surface water sampling activities:

1. Samples should be collected in order from the most downstream location to the most upstream location.
2. Approach the surface water sampling location from the downstream side to minimize disturbance of sediment at the sampling location.
3. Measure and record water quality parameters, as defined in the Workplan, such as dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential. Record this information on the attached surface water sampling log (attached).
4. A dip sampler should be used for situations where direct access is limited and the sample is to be collected while standing on the bank. The long handle on such a device allows access from a more distant location. Sampling procedures for a dip sampler are as follows:

- Assemble the device in accordance with the manufacturer's instructions.
- Extend the device to the sample location and collect the sample from immediately below the surface of the water body.
- Retrieve the sampler and transfer the sample to the appropriate sample container.

5. Note the depth of standing water at each sampling location and record in the field book/field log.
6. The direct sampling method should be used for collection of surface water samples from the surface of the water body, such as streams, rivers, and wetlands. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants is a concern. Sampling procedures for the direct sampling method are as follows:
   - The container must be upstream of the collector.
   - Do not use pre-preserved sample bottles during sample collection.
   - Minimize disturbance of sediment during sample collection.
   - Avoid collection of surface debris.
   - Collect the sample immediately under the water surface pointing the sample container upstream.
7. Transfer the sample(s) into appropriate pre-preserved and labeled sample containers (refer to Section 5.0 for sample labeling procedures). Fill the VOC sample containers first, and then proceed to fill the other sample containers.
8. Document the sampling event in the field book as specified in the project work plans. Any encountered problems or unusual conditions should also be immediately brought to the attention of the Field Team Leader.
9. Appropriately preserve, handle, package, and ship the samples per the project work plan. The samples shall also be maintained under proper chain-of-custody procedures.

## 4.0 PROCEDURES FOR COLLECTION OF SEDIMENT SAMPLES

### 4.1 EQUIPMENT LIST

The equipment list for collection of sediment samples is the same as is required for collection of surface water samples with the exception of the following:

- Dip sampler; and
- Water quality meter(s) (e.g. dissolved oxygen, pH, temperature, conductivity, oxidation reduction potential)

In addition, the following equipment may be required for collection of sediment samples:

- Shovel; and/or
- Hand operated bucket auger.

### 4.2 PROCEDURE

Although the number and type of soil samples to be collected may vary according to the QAPP, the sequence of steps will generally follow that described in this section. If a soil sample is to be submitted for laboratory analysis, the procedures for sample labeling, handling and tracking, described in Section 4.0 of this SOP, will be followed.

### 4.2.1 *Surface Water Sampling*

The pre-mobilization activities described for surface water sampling apply to the collection of sediment samples. The following tasks should be performed during sediment sampling activities:

1. Samples should be collected in order from the most downstream location to the most upstream location.
2. Approach the sediment sampling location from the downstream side to minimize disturbance of sediment at the sampling location.
3. Sediment samples should be collected from the first twelve inches of bottom organics. To the degree feasible, the samples should be collected at locations with less than one foot of standing water.
4. In small, low-flowing streams or wetlands, or near the shore of a pond or lake, the sample container (unpreserved only), a shovel, or

hand-operated bucket auger may be used to scrape up the sediments.

5. To obtain sediments from larger streams or further from the shore of a pond or lake, a bucket auger or core sampler with the appropriate extensions should be used. A bucket auger/core sampler should be used for situations where direct access is limited or the sample is to be collected while standing on the bank. The long handle on such a device allows access from a more distant location. Sampling procedures for a bucket auger/core sampler are as follows:
    - Assemble the device in accordance with the manufacturer's instructions.
    - Extend the device to the sample location and collect the sample from the top twelve inches of bottom organics.
    - Retrieve the sampler and transfer the sample to the appropriate sample container
6. If excess water is present in the sediments, decant off excess water to the degree feasible.
7. Transfer the sample(s) into appropriate pre-preserved and labeled sample containers (see Section 3.2.3 of this SOP).
8. Note the depth of standing water at each sampling location and record in the field book/field log.
9. Document the sampling event in the field book as specified in the project work plans. Any encountered problems or unusual conditions should also be immediately brought to the attention of the Field Team Leader.
10. Appropriately preserve, handle, package, and ship the samples per the project work plan. The samples shall also be maintained under proper chain-of-custody procedures.

### 4.2.2 *Sample Collection*

Sediment samples for VOCs will be collected first, followed by samples for other analyses (SVOCs, PCBs, metals, etc.).

Upon receipt of the sample bottles from the laboratory, and prior to sampling, the field team will inspect the bottles to evaluate if the sample bottle integrity was compromised during transit. This includes, but is not limited to, checking custody seals, observing moisture, discoloration or other indications of preservative leaking from the vials. In the event that a given sample bottle has been compromised, that sample bottle will be discarded, and the laboratory will be notified of the condition. In addition, the laboratory will notify the project manager if any of the sample bottles, or coolers have been compromised during transit from the field to the laboratory.

### 4.2.2.1 *VOC Sample Collection*

Sediment samples for VOC analysis will be collected from the sediment contained within the bucket auger or core sampling using the following procedure:

1. An undisturbed sample will be collected by removing any sticks, rocks or leaves from the top or bottom of the core sampler or bucket auger and then collecting a representative sediment sample.

2. In order to minimize disturbance, a 10 cc, 25 cc, or 30 cc syringe with the end removed (or other similar sampling device) will be plunged into the sediment a minimum number of times required to collect a representative 5, 10, or 15-gram sediment sample, respectively.

3. The amount of sediment to be collected will be determined by field calibrating the syringe. The syringe will be calibrated to determine a weight-volume ratio using a portable balance on a test sample. The test syringe will be weighed prior to and after test sample collection to determine a weight-volume ratio for future sample collection. The accurate weight of the sample will be determined at the laboratory using the initial weight of the sample container prior to sample collection and the final sample container weight after receipt at the laboratory. The range of acceptable sample weight will be +/- 10% of the desired sample weight.

4. The sediment sample will be placed into five pre-weighed containers and completely submerged in the appropriate preservative in the following order:

    - Two 40 ml vials with 5 g of sediment in 5 mL of organic-free water (low level VOCs)

    - One 40 ml vial with 15 g of sediment in 15 ml of methanol (high level VOCs)

    - Two 40 ml vials with 15 g of sediment in 10 mL of organic-free water (low level VOCs with low percent solids)

    - One 4 oz jar (percent solids)

5. Samples will be frozen in the field with dry ice and stored on a 45-degree angle.

6. If split-sampling or field duplicate sampling is to be conducted, use the syringe (or other similar sampling device) to collect the other sediment samples from adjacent locations within the bucket auger or core sampling and place the soil in the appropriate sample containers at the same time as the original sample.

### 4.2.2.2 *Other Sample Collection*

Following VOC sample collection, sediment samples for other analysis will be collected.

1. Place sediment into a large, stainless steel mixing bowl that has been decontaminated.

2. Decant off any excess water.

3. Mix the sediment using a decontaminated, stainless steel spoon until it is reasonably homogeneous. Remove any rocks sticks, leaves or debris present in the sample. Transfer the composited sediment to the appropriate laboratory-provided sample jars. If split-sampling or duplicate sampling is to be conducted, transfer the composited sediment to the split-sampling/duplicate sampling jars in the same manner.

4. For sediment samples that appear to contain less than 50% solids, additional sediment will be placed into the appropriate sampling containers.

## 5.0 SAMPLES

## 5.1 SAMPLE CONTAINERS

Surface water and sediment samples for laboratory analysis will be placed in pre-preserved (as appropriate) laboratory supplied containers. The QAPP indicates the appropriate sample containers, preservatives, and holding times for each analytical parameter.

### 5.1.2 *Sample Identification*

Sample identification numbers will follow the labeling conventions discussed in the QAPP.

### 5.1.3 *Sample Labeling*

Sample containers will have a plastic or waterproof paper label attached that will be filled out using waterproof ink, or information may be recorded directly on to the sampling container. The label will contain the following information:

- Project number;
- Site/project name;
- Sample number
- Sample location;
- Sampler's name;
- Date and time the sample was collected;
- Preservatives; and
- Parameters for analysis.

## 5.2 SAMPLE PRESERVATION AND HANDLING

### 5.2.1 *Sample Preservation*

After collection, samples bottles will be placed directly into plastic bags with a zip seal and transferred immediately to a cooler with ice or frozen ice pack to maintain a temperature of approximately 2-6° C. Sediment samples for VOCs will be frozen on dry ice.

### 5.2.2 *Sample Handling*

Samples will be packaged and stored in a manner that will prevent damage to each sample container. Sample bottles will be labeled, wrapped in protective packing material, and placed right side up in a cooler for delivery to the laboratory. Sediment VOC samples will be stored at a 45-degree angle.

The samples will be delivered or shipped to the laboratory on the date of sample collection, or as soon afterwards as possible. The analysis and holding times for the various analytical parameters are listed in the QAPP.

## 5.3 *SAMPLE TRACKING*

A COC record will be filled out in the field, and will accompany every shipment of samples to the analytical laboratory. The purpose of the COC record is to document possession of a sample from the time of collection in the field to its final disposal by the laboratory.

Information to be provided on the COC record includes:

- Project name and number;
- Laboratory name, address and phone number;
- Consultant name, address and phone number;
- Sampler signatures;
- Sample number;
- Sample collection date and time;
- Analysis parameters;
- Number of containers;
- Preservatives; and
- Comments.

An example of a COC record is provided in the QAPP.

The laboratory will record the following information:

- Name of persons receiving the sample;
- Date of sample receipt; and
- Sample condition.

All corrections to the COC record will be initialed and dated by the person making the corrections. Each COC record will include signatures of the appropriate individuals indicated on the form. The originals will follow the samples to the laboratory, and copies documenting each custody change will be retained and kept on file by ERM. The COC record will be maintained until final disposition of the samples.

## 5.4 *QUALITY ASSURANCE/QUALITY CONTROL SAMPLES*

### 5.4.1 *Trip Blanks*

A trip blank is a suite of (VOA) sample bottles containing deionized water that is prepared by the laboratory. Trip blanks (aqueous) will accompany each shipment of water sample containers from the laboratory. The trip blanks will be kept with the same shipment of sample containers at all times and will be returned, unopened, to the laboratory with that shipment. Trip blanks will be used to detect any contamination or cross-contamination during handling and transportation. One trip blank set for volatile analysis is sent per cooler of samples per day.

### 5.4.3 *Matrix Spike/Matrix Spike Duplicate for Surface Water Samples*

Matrix spikes and matrix spike duplicates (MS/MSD) are prepared in the laboratory to assess precision and accuracy of an analytical method on various matrixes. An MS/MSD is generated by preparing three separate samples for analysis from the same soil sample, and then spiking the second and third samples with selected target compounds. For metals determined by ICP analysis, for example, the spike contains all the analyte metals at levels approximately five times the reporting limit. Following the addition of the spike to the MS/MSD, these two QC samples are carried through all laboratory procedures and analyzed as are the routine soil samples taken for the investigation. The QAPP documents the frequency of MS/MSD analysis per matrix and analysis.