Attachment XI

WORK PLAN
PHASE 2 ECOLOGICAL RISK ASSESSMENT
RED WATER PONDS
FORMER PLUM BROOK ORDNANCE WORKS
SANDUSKY, OHIO

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IT Project Number 807053
Control Copy No. 12

Revision 1.0

August 2000

(This work plan must be used in conjunction with the PBOW SAP, 1996)

Table of Contents

Page

List of Tables iii

List of Figures iii

List of Acronyms iv

1.0 Introduction 1-1

2.0 Project Overview 2-1

2.1 Ecological Risk Assessment Conclusions 2-2

2.2 Baseline Risk Assessment Recommendations 2-3

3.0 Problem Formulation 3-1

4.0 Study Design 4-1

4.1 Risk Assessment 4-1

4.1.1 Assessment Endpoints 4-1

4.1.2 Exposure Pathways 4-1

4.1.3 Measurement Endpoints 4-2

4.1.4 Uncertainties and Assumptions 4-2

4.2 Sampling and Analysis Plan 4-3

4.2.1 Data Needs 4-4

4.2.1.1 Soil Sampling for Earthworm COPEC Uptake Estimates 4-4

4.2.1.2 Fish Sampling for COPEC Uptake Estimates Based on Tissue . 4-5

4.2.1.3 Sediment Sampling for COPEC Uptake Estimates 4-6

4.2.1.4 Sediment Sampling for COPEC Sediment Toxicity 4-8

4.2.1.5 Surface Water Sampling for COPEC Surface Water Toxicity ... 4-8

4.2.1.6 Background Sampling 4-9

4.2.2 Analytical Procedures 4-9

4.2.3 Sampling Techniques 4-11

4.2.3.1 Surface Soil Sampling 4-11

4.2.3.2 Surface Water Sampling 4-11

4.2.3.3 Sediment Sampling 4-12

4.2.3.4 Fish Tissue Sampling 4-13

4.2.3.5 Sample Designation 4-14

Table of Contents (continued)

Page

4.2.4 Quality Assurance/Quality Control 4-14

4.2.5 Land Surveying 4-16

4.2.6 Decontamination Procedures 4-16

4.2.7 Sample Preservation, Packing, and Shipping 4-17

4.2.8 Investigation-Derived Waste Management Plan 4-18

5.0 Field Verification 5-1

6.0 Site Investigation and Analysis 6-1

7.0 Risk Characterization Report 7-1

8.0 Risk Management 8-1

9.0 References 9-1

Appendix A – Recommended Laboratory Spiking Protocol

Appendix B – Verification Site Visit Memo, dated July 18, 2000

Appendix C – Bioassay Test Details

- (Summary of Test Conditions for the Fathead Minnow, *Pimephales promelas*, Larval Survival and Growth Toxicity Tests
- Summary of Test Conditions for Daphnid, *Ceriodaphnia dubia*, Survival and Reproduction Toxicity Tests
- Summary of Test Conditions for Amphipod, *Hyalella azteca*, Survival and Growth Toxicity Tests
- Summary of Test Conditions for Oligochaete, *Lumbriculus variegatus*, Bioaccumulation Tests
- Summary of Test Conditions for Earthworm, *Eisenia fetida*, Bioaccumulation Tests.

List of Tables

Table	Title	Follows Tab
1	Assessment and Measurement Endpoints and Exposure Delineation	
2	Test Methods, Containers, Preservatives, and Holding Times	
3	Pentolite Road Red Water Pond Samples	
4	West Area Red Water Pond Samples	
5	Background Samples	

List of Figures

Figure	Title	Follows Tab
1	Simplified Terrestrial Food Web Conceptual Site Model	
2	Simplified Aquatic Food Web Conceptual Site Model	
3	Pentolite Road RWP Soil Sample Locations	
4	West Area RWP Soil Sample Locations	
5	Pentolite Road RWP Fish Sample Locations	
6	West Area RWP Fish Sample Locations	
7	Pentolite Road RWP Sediment Sample Locations	
8	West Area RWP Sediment Sample Locations	
9	Pentolite Road RWP Surface Water Sample Locations	
10	West Area RWP Surface Water Sample Locations	
11	Pentolite Road RWP Background Soil Sample Locations	

List of Acronyms

AR/COC	Analysis Request/Chain of Custody
ASTM	American Society for Testing and Materials
COPEC	constituents of potential ecological concern
DNB	dinitrobenzene
DNT	dinitrotoluene
DOD	Department of Defense
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
GRC	John Glenn Research Center at Lewis Field
HI	hazard index
HQ	hazard quotient
IDW	investigation-derived waste
IT	IT Corporation
mg/L	milligrams per Liter
NASA	National Aeronautics and Space Administration
PAH	polynuclear aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PBS	Plum Brook Station
PRRWP	Pentolite Road Red Water Ponds
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RWP	Red Water Ponds
SAP	sampling and analysis plan
SMDP	scientific management decision point
SRT	Standard Reference Toxicant
TNT	trinitrotoluene
USACE	United States Army Corps of Engineers
WARWP	West Area Red Water Ponds

1.0 Introduction

This Work Plan is for the proposed Phase 2 ecological risk assessment (ERA) at the former Plum Brook Ordnance Works (PBOW) near Sandusky, Ohio. The U. S. Army Corps of Engineers (USACE) retained IT Corporation (IT) to conduct this investigation under Contract Number DACA62-00-D-002, Delivery Order Number 002. The goal of this project is to produce a supplement to the Phase I (screening-level) ERA (IT, 1999) with additional site-specific information to determine if revised estimated ecological hazards to potentially exposed receptors are acceptable to risk managers.

As an attachment to the site-wide sampling and analysis plan (SAP) (IT, 1996a), this site-specific work plan has been prepared for fieldwork to be carried out in support of the ecological risk assessment at the West Area Redwater Pond (WARWP) and the Pentolite Road Redwater Pond (PRRWP). This Work Plan must be used in conjunction with the site-wide SAP (IT, 1996a) and Quality Assurance Project Plan (QAPP) (IT, 1996b) to ensure that work performed at the subject sites will be of quality required to satisfy the overall and site-specific project objectives. A site-specific safety and health plan has also been prepared separately for this investigation and must be used in conjunction with the site-wide safety and health plan (IT, 1996c).

Two sites within the Red Water Ponds (RWP) areas are the focus of this ERA: the WARWP and the PRRWP. It should be noted that although the 8-step process presented in the Ecological Risk Assessment Guidance for Superfund (ERAGS) (EPA, 1997) is generally followed in this Work Plan, ERAGS was not the primary guidance document used for the preparation of the Phase I ERA, therefore, there are some differences between ERAGS and the Phase I ERA. The Phase I ERA was based primarily on the Tri-Service Procedural Guidelines for Ecological Risk Assessments (Wentsel, et al., 1996).

2.0 Project Overview

Chemical contamination related to former Department of Defense (DOD) activities has been documented at the former PBOW located near Sandusky, Ohio. The PBOW was operated from 1941 to 1945 as a manufacturing plant for trinitrotoluene (TNT), dinitrotoluene (DNT), and pentolite. Some of the areas used by the DOD were decontaminated in the 1950s and 1960s in accordance with DOD standards at that time; other areas have been decommissioned, but not decontaminated. The site is currently owned by the National Aeronautics and Space Administration (NASA) and is operated as the Plum Brook Station (PBS) of the John Glenn Research Center at Lewis Field (GRC). The NASA GRC is located in Cleveland, Ohio.

The environmental impact of the past DOD operations at the PBOW site is being evaluated by the U.S. Army under the Defense Environmental Restoration Program, Formerly Used Defense Sites funding. This work is being pursued and technically overseen by the USACE, Nashville District (CELRN, formerly CEORN).

Since 1983, a number of environmental investigations and remediations have been conducted and documented within the PBOW site. The contractors performing these activities were retained by various government agencies. Results from environmental investigations that have occurred at PBOW in the last eight years are presented in the following documents:

- Science Applications International Corporation, 1991 Preliminary Assessment;
- H+GCL, 1992 Investigation;
- MK Corporation, 1993 Site Inspection;
- Dames & Moore, 1995 Site Wide Groundwater Investigation;
- IT Corporation, 1996 G-8 Burning Ground Investigation;
- IT Corporation, 1996 Site Investigation and Groundwater Investigation;
- IT Corporation, 1997 Investigation;
- IT Corporation, 1999 Summary Report Site-Wide Groundwater Investigation (1997-1998);
- IT Corporation, 1999 Risk Assessment and Direct Push Investigation of the Red Water Ponds Areas.

2.1 Ecological Risk Assessment Conclusions

In 1999, both a human health risk assessment and screening level ERA were performed using both historical and recent analytical data collected from both RWP areas at the PBOW. Results of the screening level ERA were used in developing this Work Plan and are briefly discussed below.

Potential impacts to terrestrial plants were evaluated by comparing source term concentrations of constituents of potential ecological concern (COPEC) calculated for soil at the RWP areas with available benchmark concentrations. None of the available benchmark concentration values were exceeded by source term concentrations at either area.

Potential impacts to aquatic biota were evaluated by comparing surface water and sediment COPEC concentrations at the RWP areas with available benchmarks for the protection of aquatic life. Concentrations of aluminum, iron, lead, manganese, and vanadium measured in surface water at the WARWP exceeded acceptable benchmarks to protect aquatic biota. Upon further analysis, aluminum, lead, and iron were found to be more significant COPECs than manganese and vanadium. The COPEC concentration data for sediments at the WARWP exceeded toxicity benchmarks for arsenic, copper, and iron designed to protect aquatic biota. It should be noted that these sediment COPEC concentrations only exceeded the most conservative toxicity benchmarks for the protection of aquatic biota, and did not exceed less conservative benchmarks.

Surface water COPEC concentrations of aluminum, iron, and manganese at the PRRWP also exceeded some of the benchmark concentrations. The PRRWP elevated iron concentrations appeared to be more significant than less elevated aluminum and manganese concentrations. No sediment benchmarks were exceeded at PRRWP.

Potential risks to terrestrial and aquatic wildlife at the RWPs were evaluated by calculating hazard quotients (HQs) for all COPECs and exposure pathways for each receptor of concern. The HQs were then summed to obtain a hazard index (HI). The summed HQ calculated for each receptor was compared with DOD guidelines (Wentsel, et al., 1996). According to these guidelines, the higher the HQ the greater the risk posed by site related contaminants. If the HQ is less than 1, then there is no probable risk. If the HQ is between 1 and 10 then there is a very low potential for ecological effects. If the HQ is between 10 and 100, then significant potential for ecological effects exists. If the HQ is above 100, then very significant potential for ecological effects is present due to site contamination.

For the WARWP, summed HQs for terrestrial receptors were 28 for the deer mouse; 9.1 for the cottontail rabbit; 96 for the shrew; 452 for the marsh wren; 38 for the raccoon; 8.3 for the white-tailed deer; and 0.0062 for the red-tailed hawk. Summed HQs for aquatic receptors were 724 for the great blue heron and 665 for the raccoon. Since the raccoon is exposed to both terrestrial and aquatic media, summed HQs were presented for both environments.

For the PRRWP, summed HQs for terrestrial receptors were 4.1 for the deer mouse; 2.7 for the cottontail rabbit; 15 for the shrew; 412 for the marsh wren; 6.1 for the raccoon; 1.8 for the white-tailed deer; and 0.0018 for the red-tailed hawk. Summed HQs for aquatic receptors were 126 for the great blue heron and 38 for the raccoon. Again, since the raccoon is exposed to both terrestrial and aquatic media, summed HQs were presented for both environments.

Hazard drivers (i.e., those chemical constituents contributing the most to the elevated total HIs) were as follows, by media:

- Soil: nitroaromatics (DNT compounds), polynuclear aromatic hydrocarbons (PAH), and antimony;
- Surface Water: aluminum, magnesium, lead, and iron; and
- Sediment: nitroaromatics (DNT compounds), the PAH carbazole, and the inorganics aluminum, iron, magnesium, phosphorus, potassium, calcium.

2.2 Baseline Risk Assessment Recommendations

The following recommendations were made as a result of findings of the Phase I ERA (IT, 1999):

- Establish additional background concentrations for metals for surface water and sediment;
- Conduct earthworm bioassays to estimate uptake and bioavailability of organic chemicals from surface soil;
- Conduct fish uptake study to estimate bioaccumulation and bioavailability of metals from surface water; and
- Conduct a literature search to obtain a more accurate avian toxicity benchmark (i.e., no observable adverse effects level for the nitroaromatic 4-amino-2,6-DNT.

3.0 Problem Formulation

Step 3 of the eight-step process initiates the ERA problem-formulation phase (Environmental Protection Agency (EPA), 1997). The problem formulation provided herein is of sufficient quality for stakeholders to determine and agree on scientific management decision point (SMDP) 3, that is composed of the conceptual site model, assessment endpoints, exposure pathways, and risk hypotheses.

As discussed in Section 2.1, hazard indices significantly above 1 (e.g., up to 724) were estimated for representative ecological receptors using the hazard quotient method in the Phase I ERA (IT, 1999) (equivalent to steps 1 and 2 of the ERAGS eight-step process). Section 2.1 also summarized potential surface water and sediment hazards to aquatic biota as a result of RWP media COPEC concentrations exceeding surface water and sediment criteria for the protection of aquatic life. The Phase 1 ERA (IT, 1999) presents conceptual site models for terrestrial and aquatic receptors, assessment endpoints, exposure pathways, and risk hypotheses for the RWP sites, and these are generally adopted for the Phase 2 ERA, as discussed in following subsections.

The Phase 1 screening assessment null hypotheses were as follows:

- The potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of **viable habitat** for potential ecological receptors.
- The potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of **potential ecological receptors.**
- The potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of **potential exposure pathways.**
- The potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of **potential chemical stressors.**

If one or more of these null hypotheses was accepted, a predictive assessment would not have been triggered. However, as determined in the Phase 1 ERA, all four null hypotheses were rejected and a predictive screening assessment was triggered and completed, resulting in estimates of potentially unacceptable ecological hazard from exposure of representative ecological receptors to COPECs in environmental media. This finding initiated the currently proposed Phase 2 ERA. Thus, assessment and measurement endpoints are discussed below.

The protection of ecological resources, such as habitats and species of plants and animals, is a principal motivation for conducting ERAs. Key aspects of ecological protection are presented as policy goals. These are general goals established by legislation or agency policy that are based on societal concern for the protection of certain environmental resources. To determine whether these protection goals are met at the site, assessment and measurement endpoints have been formulated to define the specific ecological values to be protected and to define the degree to which each may be protected.

Given the diversity of the biological world and the multiple values placed on it by society, there is no universally applicable list of assessment endpoints. Suggested criteria that may be considered in selecting assessment endpoints suitable for a specific ecological risk assessment are: (1) ecological relevance, (2) susceptibility to the contaminant(s), (3) accessibility to prediction and/or measurement, and (4) definable in clear, operational terms (Suter, 1993). Selected assessment endpoints should reflect environmental values that are protected by law, are critical resources, or have relevance to ecological functions that may be impaired. Both the entity and attribute should be identified for each selected assessment endpoint.

Assessment endpoints are inferred from effects to one or more measurement endpoints. The measurement endpoint is a measurable response to a stressor that is related to the valued attribute of the chosen assessment endpoint. It serves as a surrogate attribute of the ecological entity of interest (or of a closely related ecological entity) that can be used to draw a predictive conclusion about the potential for effects to the assessment endpoint. Information collected during previous site reconnaissance (IT, 1999) was used to assist in the selection of assessment and measurement endpoints. These endpoints, formal expressions of the environmental values to be protected (Suter, 1993), were used to focus the goals of the Phase 1 ERA, and are revised and presented in Table 1 for application to the Phase 2 ERA.

The primary differences between the Phase 1 and Phase 2 ERA problem formulations and assessment/measurement endpoint selections are the following:

- The first three hypotheses (presented previously) have already been answered and do not need to be reassessed; i.e., viable habitat, ecological receptors, and exposure pathways do exist at the RWP sites.

- Measurement endpoints will rely on revised HQs that are based on more site-specific uptake factors (using laboratory bioaccumulation studies) and not literature values;

- Reference toxicity values will be based on more realistic and appropriate toxicity benchmarks (particularly for nitroaromatic effects on avian receptors); and

- Direct surface water and sediment toxicity to aquatic receptors will be based on laboratory toxicity tests, rather than a simple comparison of media chemical concentrations to available criteria for the protection of aquatic life.

In conclusion, the assessed problem at the PBOW RWPs is that estimated ecological hazards are unacceptable based on the Phase 1 conservative assumptions, and further ecological assessment is required to obtain more site-specific and chemical-specific data to refine the estimated ecological hazards. This will be accomplished using the study design presented in Chapter 4.0 to address the problem formulation stated herein.

4.0 Study Design

The study design is Step 4 of the eight-step process and finalizes the measurement endpoints, completing the conceptual model begun in Step 3 (Chapter 3.0). The study design is comprised of two sections: the risk assessment (Chapter 4.1) and the sampling and analysis plan (Section 4.2).

4.1 Risk Assessment

The Phase 2 ERA will refine ecological hazards at the two RWP sites by using appropriate assessment endpoints, exposure pathways, and measurement endpoints, and by critically evaluating uncertainties and assumptions used in the risk assessment process.

4.1.1 Assessment Endpoints

Assessment endpoints were discussed in Section 3.0 and are presented in Table 1. As stated previously, assessment endpoints are inferred from effects to one or more measurement endpoints.

4.1.2 Exposure Pathways

Exposure pathways consist of four primary components: source and mechanism of contaminant release, transport medium, potential receptors, and exposure route. A chemical may also be transferred between several intermediate media before reaching a potential receptor. All of these components will be addressed in the ERA. The exposure pathways considered for the representative terrestrial and aquatic receptors at the RWP sites are presented in Figures 1 and 2.

Exposure to different categories of environmental media will be addressed in the ERA, as discussed in the following subsections (note: some of these pathways were adequately addressed in the Phase 1 ERA and will not be reassessed; see Table 1 for information on which measurement endpoints will be reassessed in the Phase II ERA).

Soil Exposure Pathway. Soil exposure pathways are potentially important for terrestrial plants and animals at the site. For non-burrowing animal exposure, soil samples obtained from a depth of 0 to 1 foot are generally considered, as this would be the point of exposure. Note: The agency-approved work plan for the Phase 1 ERA defined surface soil as 0 to 1 foot, however, due to depth compositing of 0 to 2 feet and 0 to 3 feet in the historic data set, all soils from the 0 to 3 foot depth interval were considered as surface soil for the ERA. For burrowing animals such as the shrew, soil samples obtained from a depth of 0 to 6 feet are considered.

For deep-rooted plant exposure, soil samples taken from 0 to 6 feet are considered because most feeder roots are located within this depth. Thus, the white-tailed deer was assumed to ingest leaves of trees translocating COPECs from subsoils.

Sediment Exposure Pathway. Sediment consists of materials precipitated or settled out of suspension in surface water. Potential contaminant sources for sediment include buried or stored waste, and contaminated surface water, groundwater, and soil. The release mechanisms include surface water runoff, groundwater discharge, and airborne deposition. Potential receptors of chemicals in contaminated sediment include aquatic flora and fauna. Direct exposure routes for impacted sediment include direct contact and incidental ingestion. Indirect exposure pathways from sediment include consumption of bioaccumulated contaminants by consumers in the food chain.

Surface Water Exposure Pathway. Surface water represents a potential transport medium for COPECs. Potential sources for contaminated surface water include: buried or stored waste, stored or spilled fuel, contaminated soil and groundwater, and deposition of airborne contaminants. The release mechanisms include surface runoff, leaching, and groundwater seepage. Potential receptors of contaminated surface water include terrestrial and aquatic fauna and aquatic flora. Exposure routes for contaminated surface water include ingestion by terrestrial fauna, and uptake and absorption by aquatic flora and fauna. Consumption of bioaccumulated constituents constitutes a potential indirect exposure pathway for faunal receptors. Chemical bioavailability of some metals and other chemicals is controlled by water hardness, pH, and total suspended solids.

4.1.3 Measurement Endpoints

Measurement endpoints were discussed in Section 3.0 and are presented in Table 1. The measurement endpoint is a measurable response to a stressor that is related to the valued attribute of the chosen assessment endpoint.

4.1.4 Uncertainties and Assumptions

There are many uncertainties inherent in the risk assessment process, as well as assumptions that are made given the lack of site-specific information. It is important to note that the results of ERAs are influenced to some degree by both variability and uncertainty. In theory, investigators might reduce variability by increasing sample size of the media or species sampled. Alternatively, uncertainty within the risk analysis can be reduced by using species-specific and

direct field measurements, toxicity testing of site-specific media, and field studies using site-specific receptor species). Detailed media, prey, and receptor field studies are costly; thus, the Phase 1 ERA was conducted to limit the use of these resource-intensive activities. Since Phase 1 assessment criteria were developed based on conservative assumptions, the results of the screening-level ERA err on the side of conservatism

A number of factors contribute to the overall variability and uncertainty inherent in ecological risk assessments. Variability is due primarily to measurement error; laboratory media analyses and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data to actual ecological conditions at the site. Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, all toxicity information derived from toxicity testing, field studies, or observation will have uncertainties associated with them. Calculating an estimated value based on a large number of assumptions is often the only alternative to the accurate (but costly) method of direct field or laboratory observation, measurement, or testing.

An uncertainty analysis was presented in the Phase 1 ERA (Table 6-31 of IT, 1999). Listed in this uncertainty analysis table were some of the major assumptions applied in the ERA, including: the direction of bias resulting from each assumption (i.e., if the uncertainty resulted in an overestimate or underestimate of risk); the likely magnitude of impact; and, if possible, a description of recommendations for minimizing the identified uncertainties if a Phase 2 ERA was to be completed. Some of these recommendations have been taken into consideration in preparation of this Work Plan.

The uncertainty analysis prepared for the Phase 2 ERA will identify and, if possible, quantify the uncertainty in the problem formulation, exposure and effects assessment, and risk characterization phases. Major assumptions used in the ERA process will also be presented.

4.2 Sampling and Analysis Plan

The sampling and analysis plan presents the data needs (Section 4.2.1), analytical procedures (Section 4.2.2), sampling techniques (Section 4.2.3), and quality assurance/quality control (Section 4.2.4), land surveying (Section 4.2.5), decontamination procedures (Section 4.2.6), sample preservation, packing, and shipping (Section 4.2.7), and investigation derived waste management plan (Section 4.2.8). IT will have an experienced ecologist in the field during sampling activities to coordinate activities.

4.2.1 Data Needs

Data needs for the Phase 2 ERA include the following, and are discussed in more detail below:

- Chemical analytical testing results from site media,
- Laboratory toxicity testing results from site media,
- Laboratory biological uptake study results from site media,
- Chemical body burden analytical testing results from site fish tissue, and
- Chemical analytical testing results from site background media.

Throughout the following subsections in Section 4.2.1, "hotspot area" is defined as the historical sample locations where the concentrations of the COPECs contributing the most to the ecological hazard are the greatest.

4.2.1.1 Soil Sampling for Earthworm COPEC Uptake Estimates

Discrete surface soil samples will be collected from identified RWP area hotspots and sent to the selected bioassay laboratory. The bioassay lab will hold the samples until chemical analytical results are available from the analytical laboratory. Once given the go-ahead by IT, the bioassay lab will introduce earthworms to the impacted soil. The earthworms will be allowed to bioaccumulate COPECs as they burrow and feed over an extended time period, and at the end of the study these invertebrates will be sacrificed and tissue COPEC concentrations will be determined. These analytical results will be utilized, in conjunction with paired surface soil COPEC data, to calculate site-specific invertebrate bioaccumulation factors for use in the Phase 2 ERA. Note: soil COPEC earthworm toxicity data may also be obtained from the study, although this type of information is not essential to the Phase 2 ERA.

PRRWP. The PRRWP COPECs in invertebrates are nitroaromatics (IT, 1999). IT will collect five (5) surface soil samples for the uptake study. These samples will be split, with sample volume sent to the bioassay laboratory and to the analytical laboratory for the analysis of nitroaromatic constituents. The sample locations (Figure 3) are all situated at the potential hotspot area, so as to maximize the potential for usable uptake study results. It should be noted that the nitroaromatics of concern (4-amino-2,6-DNT and, to a much lesser extent, 1,3-dinitrobenzene [1,3-DNB]) were very infrequently detected in surface soils. The nitroaromatic 4-amino-2,6-DNT was only detected in one out of 50 surface soil samples, and 1,3-DNB was only detected in six out of 50 surface soil samples. This finding suggests that there is a distinct possibility that these two critical nitroaromatics may not be detected in the surface soil samples to be collected and site-specific bioaccumulation factors will not be able to be calculated. An alternative approach may be to have the bioassay laboratory spike the soil samples with known

concentrations of these two nitroaromatic compounds, if it is determined these nitroaromatics are nondetect in the sample matrix. A spiking protocol is presented in Appendix A, and the reader should review Appendix B (Verification Site Visit Memo dated 7/18/00) for additional discussion of spiking.

WARP. The WARWP COPECs in invertebrates are nitroaromatics and PAHs (IT, 1999). IT will collect five (5) surface soil samples for the uptake study. These samples will be split, with sample volume sent to the bioassay laboratory and to the analytical laboratory for the analysis of nitroaromatic and PAH constituents. The sample locations (Figure 4) are all situated at the potential hotspot area, so as to maximize the potential for usable uptake study results. The relative number of samples was related to the ERA results. For example, at the WARWP, the soil HI was 450 for the marsh wren (mostly due to 4-amino-2,6-DNT) and the soil HI was 91 for the shrew (mostly due to PAHs). The pathway of concern for both receptors was invertebrate uptake of chemicals from soil, followed by ingestion by the wildlife receptor. Since most of the hazard (i.e., 83%) was attributed to the wren and thus to 4-amino-2,6-DNT, most of the samples for earthworm uptake (i.e., 4 out of 5 or 80%) were situated at the known 4-amino-2,6-DNT hotspot (near sample location DP16) (Figure 4). The other location with one uptake sample (near sample location DP13) was based on the fact that this location was the known PAH hotspot. Similar logic was used for positioning all of the proposed field samples.

It should be noted that the COPECs (4-amino-2,6-DNT and PAHs) were very infrequently detected in surface soils. The nitroaromatic 4-amino-2,6-DNT was only detected in one out of 40 surface soil samples, and PAHs were only detected in one out of 10 surface soil samples. This finding suggests that there is a distinct possibility that these critical COPECs may not be detected in the surface soil samples to be collected and site-specific bioaccumulation factors will not be able to be calculated. An alternative approach may be to have the bioassay laboratory spike the soil samples with known concentrations of the nitroaromatic and PAHs compounds of concern, if it is determined these compounds are nondetect in the sample matrix. A spiking protocol is presented in Appendix A, and the reader should review Appendix B (Verification Site Visit Memo dated 7/18/00) for additional discussion of spiking.

4.2.1.2 Fish Sampling for COPEC Uptake Estimates Based on Tissue

Appropriate fish samples are planned to be collected from the two RWP sites, including water column feeders such as sunfish and bottom feeders such as catfish. Similar fish species will be composited into individual samples, resulting in ten fish samples from PRRWP and ten fish samples from WARWP (with a goal of fifty percent water-column-species and fifty percent

benthic- or bottom-species from each site). Fish total length and weight will be recorded prior to compositing. The fish tissue samples will be whole fish, to best represent the diet of piscivorous (fish-eating) predators such as the great blue heron. The goal of each fish composite sample will be to represent a similar fish size and age group. The fish samples will be frozen and sent on dry ice (or sent on blue ice if fish samples can be frozen prior to shipment) to the analytical laboratory for metals analysis, as inorganic COPECs were the hazard drivers estimated in fish (IT, 1999). Concurrent unfiltered water column samples will be collected and sent to the analytical laboratory, in order to obtained paired fish/surface water data from which to estimate uptake factors (i.e., surface water to fish tissue bioaccumulation factors) for subsequent use in the Phase 2 ERA.

PRRWP. A shallow stream located at the bottom of a deep ravine runs adjacent to the PRRWP and is filled with emergent vegetation. Another stream flows along Pentolite Road north of the site, and may receive drainage from the site via an old discharge pipe (IT, 1999). No fish were observed in these shallow flowages during previous site visits, and it is unlikely fish samples can be collected at this location. However, fish collection will be attempted, using minnow traps, aquatic dipnets, or other appropriate fish collection devices. The recommended fish and surface water sample locations (Figure 5) are situated at the potential hotspot area, so as to maximize the potential for usable uptake study results. Metals of concern in potential fish at PRRWP are iron and aluminum. Fish and surface water samples will be collected and sent to the analytical laboratory. Note: if fish cannot be collected, no associated surface water samples will be collected for the uptake study. An absence of fish may be used in the revised ERA to decide that the fish uptake/great blue heron fish ingestion exposure pathway is incomplete at PRRWP.

WARWP. A large open water pond and a smaller pond covered with emergent aquatic vegetation are located at the WARWP. The recommended fish and surface water sample locations (Figure 6) are situated at the potential hotspot area, so as to maximize the potential for usable uptake study results. Fish collection techniques will likely involve electroshocking for water-column sunfish and the use of gill nets for bottom-dwelling catfish. Metals of concern in fish at WARWP are iron, lead, aluminum, and magnesium. Fish and surface water samples will be collected and sent to the analytical laboratory.

4.2.1.3 Sediment Sampling for COPEC Uptake Estimates

Discrete sediment samples will be collected from identified RWP area hotspots for invertebrate uptake studies, and sent to the selected bioassay laboratory. The bioassay laboratory will hold the samples until the chemical analytical results are available from the analytical laboratory, and

then, when given the go-ahead by IT, will introduce sediment invertebrates (using the invertebrate species *Lumbriculus variegatus*) to the impacted sediment. The invertebrates will be allowed to bioaccumulate COPECs as they burrow and feed over an extended time period, and at the end of the study these invertebrates will be sacrificed and tissue COPEC concentrations will be determined. These analytical results will be utilized, in conjunction with paired sediment COPEC data, to calculate site-specific bioaccumulation factors for use in the Phase 2 ERA.

PRRWP. The PRRWP COPECs in aquatic invertebrates are the PAH carbazole and the inorganic potassium (IT, 1999). IT will collect five (5) sediment samples for the uptake study. These samples will be split, with sample volume sent to the bioassay laboratory and to the analytical laboratory for the analysis of SVOCs and inorganics. The sample locations (Figure 7) are all situated at the potential hotspot area, so as to maximize the potential for usable uptake study results. It should be noted that the sediment COPECs were only detected in one out of two samples in previous studies (IT, 1999). This finding suggests that there is a possibility that these two critical COPECs may not be detected in the sediment samples to be collected and site-specific bioaccumulation factors will not be able to be calculated. An alternative approach may be to have the bioassay laboratory spike the sediment samples with known concentrations of these two COPECs. A spiking protocol is presented in Appendix A, and the reader should review Appendix B (Verification Site Visit Memo dated 7/18/00) for additional discussion of spiking.

WARWP. The WARWP COPECs in invertebrates are the nitroaromatic 2-A-4,6-DNT and the inorganics aluminum, calcium, and phosphorus (IT, 1999). IT will collect five (5) sediment samples for the uptake study. These samples will be split, with sample volume sent to the bioassay laboratory and to the analytical laboratory for the analysis of nitroaromatics and inorganics. The sample locations (Figure 8) are all situated at the potential hotspot area, so as to maximize the potential for usable uptake study results. It should be noted that 2-amino-4,6-DNT was very infrequently detected in sediments in previous studies (IT, 1999). The nitroaromatic 2-amino-4,6-DNT was only detected in one out of 13 sediment samples. This finding suggests that there is a distinct possibility that the critical nitroaromatic COPEC may not be detected in the sediment samples to be collected and site-specific bioaccumulation factors will not be able to be calculated. An alternative approach may be to have the bioassay laboratory spike the sediment samples with known concentrations of this nitroaromatic compounds of concern. A spiking protocol is presented in Appendix A, and the reader should review Appendix B (Verification Site Visit Memo dated 7/18/00) for additional discussion of spiking.

4.2.1.4 Sediment Sampling for COPEC Sediment Toxicity

Discrete sediment samples will be collected from the WARWP for invertebrate toxicity studies (using the invertebrate species *Hyalella azteca*) and sent to the selected bioassay laboratory where sediment toxicity bioassays will be performed. Note: the proposed hotspot location is different from the hotspot area selected for the invertebrate uptake studies. It should also be noted that for the PRRWP area, sediment toxicity was not predicted (IT, 1999), therefore, no sediment toxicity tests using sediment from PRRWP are planned. The WARWP sediment toxicity results will be utilized in the Phase 2 ERA, in conjunction with paired sediment COPEC concentration data, to determine whether or not sediment is potentially toxic to sediment-dwelling organisms at WARWP.

WARWP. The WARWP COPECs for sediment invertebrate toxicity are arsenic, copper, and iron (IT, 1999). IT will collect five (5) sediment samples for the toxicity study. These samples will be split, with sample volume sent to the bioassay laboratory and to the analytical laboratory for the analysis of inorganics. The sample locations (Figure 8) are situated at both potential hotspot and non-hotspot areas, so as to maximize the potential for usable toxicity study results (i.e., a concentration gradient is planned that will allow a better determination of potential sediment toxicity). The upstream reference sample location will be selected, if possible, to match the substrate type (e.g., sediment grain size) of the impacted downstream areas.

4.2.1.5 Surface Water Sampling for COPEC Surface Water Toxicity

Discrete surface water grab samples will be collected from the RWP areas for fish (*Pimephales promelas*) and cladoceran (*Ceriodaphnia dubia*) toxicity studies and sent to the selected bioassay laboratory where surface water toxicity bioassays will be performed. Note: these hotspot locations are different from the hotspot areas selected for the fish uptake studies. The surface water toxicity results will be utilized in the Phase 2 ERA, in conjunction with paired surface water COPEC concentration data, to determine whether or not surface water is potentially toxic to water-column-dwelling organisms at PRRWP and WARWP.

PRRWP. The PRRWP COPECs for surface water toxicity are aluminum, iron and manganese (IT, 1999). IT will collect five (5) surface water samples for the toxicity study. These samples will be split, with sample volume sent to the bioassay laboratory and to the analytical laboratory for the analysis of inorganics. The sample locations (Figure 9) are situated at both potential hotspot and non-hotspot areas, so as to maximize the potential for usable toxicity study results

(i.e., a concentration gradient is planned that will allow a better determination of potential surface water toxicity).

WARWP. The WARWP COPECs for surface water toxicity are aluminum, iron, lead, manganese, and vanadium (IT, 1999). IT will collect five (5) surface water samples for the toxicity study. These samples will be split, with sample volume sent to the bioassay laboratory and to the analytical laboratory for the analysis of inorganics. The sample locations (Figure 10) are situated at both potential hotspot and non-hotspot areas, so as to maximize the potential for usable toxicity study results (i.e., a concentration gradient is planned that will allow a better determination of potential surface water toxicity).

4.2.1.6 Background Sampling

To assess whether inorganic concentrations in surface water and sediment are related to background, six (6) additional background surface water and sediment samples will be collected to supplement the Phase 1 ERA. Background surface water and sediment samples will be collected at locations hydraulically upgradient from the RWP sites and analyzed for the 18 target metals as listed in Table 2 (3 surface water samples and 3 sediment samples near PRRWP and 3 surface water samples and 3 sediment samples near WARWP) (Figures 7-10). For the surface water samples, total (unfiltered) metal samples will be collected.

In addition, to assess whether inorganic and/or PAH concentrations in surface soil are related to background, anthropogenic or non-RWP activities, six (6) background surface soil samples will be collected to supplement the Phase 1 ERA (3 samples near PRRWP and 3 samples near WARWP. It should be noted that only PAHs will be considered to be anthropogenic related. Background soil sample locations were selected during the field verification task (Section 5.0) (Figures 4 and 11) (Appendix B) , as site-specific factors must be taken into account.

4.2.2 Analytical Procedures

Three general types of sample analyses will be performed on samples collected under this SAP: chemical analysis, toxicity testing, and bioaccumulation testing. The analytical program has been designed to acquire sufficient and defensible data to support the ERA. Laboratory QC procedures and data quality requirements are specified in and referenced to appropriate sections of the QAPP (IT, 1996b).

Soil, surface water, tissue, and sediment samples will be selectively analyzed by an off-site contract laboratory for nitroaromatics, semivolatile organic compounds, PAHs, and/or (TAL)

metals. Table 2 summarizes the analytical parameters required and associated laboratory methodologies to be utilized during this investigation, with additional details on Tables 3, 4, and 5. In addition, bioassay tests will be used to determine surface water and sediment toxicity and bioaccumulation.

The following laboratory bioassay tests will be used, described in detail in Weber, et al. (1989), EPA (2000), American Society for Testing and Materials (ASTM) (1997) and Linder, et al. (1992). Details on the bioassay tests are presented in Appendix C.

- Chronic freshwater toxicity tests will measure both lethal and sublethal effects over the life cycle or partial life cycle of the fathead minnow and the water flea. The minnow *Pimephales promelas* larval survival and growth test will use a static-renewal design and lasts for seven days, tracking the survival of test organisms and their increase in weight. The water flea *Ceriodaphnia dubia* survival and reproduction test will estimate chronic toxicity of surface water samples. This test uses static-renewal design and lasts for seven days, monitoring both the survival of test organisms and the number of offspring they produce (Weber, et al., 1989). In addition to the standard laboratory control, a hardness control will be used where the laboratory water will be adjusted to match the hardness of the test water. Note: surface water at PRRWP has a hardness of 284-488 mg/L, and surface water at WARWP has a hardness of 372-592 milligrams per Liter (mg/L) (IT, 1999).

- Chronic freshwater sediment toxicity tests will measure toxicity to *Hyalella azteca*, an amphipod that swims in the water and burrows in the sediment surface. A 10-day test will be used that evaluates survival and growth of the test organism (EPA, 2000). A static surface water renewal design will be employed, using laboratory water adjusted to match the hardness of site surface water. Note: surface water at PRRWP has a hardness of 284-488 mg/L, and surface water at WARWP has a hardness of 372-592 mg/L (IT, 1999). These waters are thus categorized as "very hard" as they are within or above the range 280 to 320 mg/L.

- Bioaccumulation tests for freshwater sediment will use *Lumbriculus variegatus*, an oligochaete aquatic worm that burrows in the sediment surface. A 28-day test will be used that will allow the benthic invertebrate sufficient time to bioaccumulate COPEC concentrations (EPA, 2000). A static surface water renewal design will be employed, using laboratory water adjusted to match the hardness of site surface water, as discussed above. After the duration of the test, the test organisms will be sacrificed for chemical analysis.

- Bioaccumulation tests for upland surface soils will use *Eisenia foetida*, a terrestrial lumbricid earthworm that burrows in soils. A 28-day test will be used that will allow the invertebrate sufficient time to bioaccumulate COPEC concentrations

(Linder, et al., 1992; ASTM, 1997). After the duration of the test, the test organisms will be sacrificed for chemical analysis.

4.2.3 Sampling Techniques

The following sampling methods and operational procedures have been developed to ensure that the data acquired through field sampling will meet data quality objectives. All media samples collected by IT field personnel will be documented through the use of Sample Collection Logs and Analysis Request/Chain of Custody Record forms, (Figure 6-2 of the SAP [IT, 1996a]) following field custody procedures specified in Section 5.1 of the QAPP (IT, 1996b). Any changes from the work plans will be recorded in chronological order in the variance log shown in Figure 9-1 of the SAP (IT, 1996a).

4.2.3.1 Surface Soil Sampling

Surface soil samples collected for analysis will be analyzed for nitroaromatics, metals, and PAHs. Surface soil samples will also be collected for uptake (bioaccumulation) studies using earthworms. The locations for the surface soil samples are shown on Figures 3 and 4, and for PRRWP background soil, on Figure 11. The soil will be sampled with a stainless-steel hand auger, trowel, or similar device, between 0 and 1 foot bgs from the four corners and at the center of a one-foot square placed over the sample location. Each of these four to six subsamples of soil will be homogenized together in a stainless-steel bowl, then transferred to the appropriate sample jars, labeled with the appropriate information, and placed in a Ziploc™ bag. The sample will then be placed in a cooler containing bagged ice in order to maintain a temperature of 4 degrees Celsius.

4.2.3.2 Surface Water Sampling

The locations for the surface water samples are shown on Figures 9 and 10. The equipment required for surface water sampling includes a stainless-steel pitcher, a 100-foot measuring tape, proper sampling containers, and any required health and safety devices.

The following procedure will be followed for the collection of surface water samples:

- Refer to the health and safety plan before proceeding with sampling.
- Surface water shall be collected first, prior to any sediment or fish sampling. If possible, sampling will occur when flowing water is present (if not a pond sample location).

- Surface water sampling shall occur from downstream to upstream (if not a pond sample location) with semivolatile organic compounds being collected first followed by explosives and then metals.

- Two persons will perform the sampling. For stream sampling locations, one person will carefully adopt an optimal sampling position and remain in that position until all sampling at that locality is completed in order to minimize the agitation of the sediment and water. The other person will be positioned within arms length of the sampler to aid in field measurements, filling of sample bottles, and to fill out sample collection logs. For pond sampling, collection will occur from a boat. Life vests will be used by all persons in boats.

- At each sampling location, a decontaminated stainless-steel pitcher will be triple rinsed with water from the creek or pond. Alternatively, the sample bottles may be directly immersed in the surface water body, unless split samples are required. At end of sampling, field parameters including oxidation reduction potential, pH, specific conductance, temperature, and dissolved oxygen will be measured and recorded in sample collection logs.

- Surface water sample locations will be flagged and shown in the collection log for use during land survey.

- Excess surface water will be disposed of at the point of collection in the surface water body.

4.2.3.3 Sediment Sampling

The locations for the sediment samples are shown on Figures 7 and 8. The equipment required for sediment sampling includes an Ekman dredge, hand auger or similar device, stainless-steel bowls, wood stakes, hammer, a 100-foot tape, proper sample containers, and any required health and safety device.

The following procedure will be followed for the collection of sediment samples:

- Refer to the health and safety plan before proceeding with sampling.

- The collection of sediment samples shall be conducted using a decontaminated Ekman dredge, hand auger or similar device. In flowing water (if not a pond sample location), the sample shall be taken at the location upstream of the sampling personnel.

- Sediment sampling should occur in areas of low flow with sediment consisting of fine sand or smaller grain size (if not a pond sampling location).

- Lower the sample collection devise through the water column to the surface water/sediment interface. If using an Ekman dredge or similar device, the dredge should be allowed to free-fall to ensure that the dredge penetrates the sediment to allow collection of sufficient sample volume. Activate the release mechanism for the dredge to allow the sample to be collected.

- For hand augers, the auger is pushed into the sediment; however, it should be noted that augers will not retain the sediment sample if the overlying water column is greater than one or two feet.

- Retrieve the sediment and place the entire sample in a decontaminated, stainless steel bowl. Remove debris (wood, roots, and gravel).

- Thoroughly homogenize the sample in the bowl using a decontaminated stainless steel spoon.

- Fill the sample containers with sediment from the bowl. Sample containers will be labeled and placed on ice in a cooler. When all required samples are collected, the sampling location will be staked and flagged for use in land survey.

- Discard any remaining sediment at the point of collection

4.2.3.4 Fish Tissue Sampling

Appropriate fish samples are planned to be collected from the two RWP sites, including water column feeders such a sunfish and bottom feeders such as catfish. The locations for the fish tissue samples are shown on Figures 5 and 6. The fish tissue samples will be whole fish, to best represent the diet of piscivorous (fish-eating) predators such as the great blue heron. The goal of each fish composite sample will be to represent a similar fish size and age group. Fish will be collected using electroshocking, minnow traps, gillnets, seines and /or aquatic dipnets, depending on site conditions. Fish will be wrapped in extra heavy duty aluminum foil, with spines on fish sheared to minimize punctures in the aluminum foil packaging. As long-term storage of fish in aluminum foil is not planned, metals contamination of the fish is not expected (EPA, 1995). A sample label with information regarding species identification, length, and weight and time and date of collection will be taped to the outside of the aluminum foil containing the fish. The foil package will be placed into a waterproof plastic bag. Once packaged, the samples will be packed on dry ice (or blue ice if already frozen) and transported to the analytical laboratory by overnight courier. Chain of custody forms will be completed for all samples collected and accompany the samples to the laboratory. IT Field Activity Daily Logs (FADLs) will be used to record all essential information for each sample collected. Included will be descriptions of conditions

within the surface water bodies, weather, species of fish included in the samples, and length and weight of fish.

4.2.3.5 Sample Designation

The sample numbering system to be used during this investigation will conform to the USACE-Nashville District's numbering convention. Specifically, each sample will be assigned a unique sample identification number that describes where the sample was collected. Each number consists of a group of letters and numbers, separated by hyphens. The numbering system to be used for the ERA is described as follows:

Project Code	Year	Sample Type[a]	Site Identification[b]	Location Number	Sample Number	Sample Depth (ft)
PBOW	2000	XX	PRWP	XXXXX	XXXXX	XX-XX

[a]Sample types:
- BI – Biological sample, fish whole body
- ER - Equipment rinsate sample
- FB - Field blank
- FD - Field duplicate sample
- FS - Field split sample
- MD - Matrix spike duplicate sample
- MS - Matrix spike sample
- SS – Surface soil sample
- SD - Sediment sample
- SW - Surface water sample

[b]Site Identification:
- PRWP – Pentolite Road RWP
- WRWP – West Area RWP

PBOW-0-SO-PRWP-SS001-10340-00-01 signifies that this soil sample was collected from a depth of 0 to 1 feet at soil sampling location SS001 in PRWP (Pentolite Road Red Water Pond) with a sample number of 10340. The sample identification number will be recorded by the IT field geologist in the field activity daily log, boring log, and/or sample collection log, as appropriate, as shown respectively in Figures 4-1, 4-11, and 4-16 of the SAP (IT, 1996a).

4.2.4 Quality Assurance/Quality Control

The data quality objectives process followed during the planning stages of the ERA evaluated data requirements needed to support the decision-making process and selected the best action to satisfy these requirements. Incorporated components of the data quality objective process, described in the EPA publication 9355.9-01 *Data Quality Objectives Process for Superfund* (EPA, 1993), are discussed in detail in Section 3.3 of the SAP. Determining factors for procedures necessary to satisfy investigative objectives and to establish the basis of future actions at PBOW are presented in Figure 3-2 of the SAP (IT, 1996a).

Soil, surface water, fish tissue, and sediment samples will be collected and analyzed to meet the objectives of the ERA. Quality assurance/quality control (QA/QC) samples will be collected for all sample types as depicted on Tables 3, 4, and 5. All samples will be analyzed by EPA-approved methods and will comply with EPA definitive data requirements. In addition to meeting the quality needs of the ERA, data analyzed at this level of quality are appropriate for all phases of the characterization and risk assessment. Laboratory requirements of precision, accuracy, and completeness for confirmation samples generated during the ERA are provided in Chapter 12.0 of the QAPP (IT, 1996b).

As stated earlier, all samples collected by IT field personnel will be documented through the use of Sample Collection Logs and Analysis Request/Chain of Custody Record forms (Figure 6-2 of the SAP [IT, 1996a]) following field custody procedures specified in Section 5.1 of the QAPP (IT, 1996b). Any changes from the work plans will be recorded in chronological order in the variance log shown in Figure 9-1 of the SAP (IT, 1996a).

Soil, Surface Water and Sediment. Soil, surface water, and sediment samples will be collected and analyzed to meet the objectives of the ERA. QA/QC samples will be collected for all sample types as shown in Tables 3, 4, and 5 of this work plan. All samples will be analyzed by EPA-approved methods and will comply with EPA definitive data requirements. Laboratory requirements of precision, accuracy, and completeness for confirmation samples generated during the investigation are provided in Chapter 12.0 of the QAPP (IT, 1996b).

Fish Tissue. Fish tissue samples will be collected and analyzed to meet the objectives of the ERA. A QA/QC sample will be analyzed by conducting a duplicate analysis of the fish tissue after homogenization by the laboratory as shown in Tables 3 and 4 of this work plan. All samples will be analyzed by EPA-approved methods and will comply with EPA definitive data requirements. Laboratory requirements of precision, accuracy, and completeness for confirmation samples generated during the investigation are provided in Chapter 12.0 of the QAPP (IT, 1996b).

Toxicity Testing. QA/QC procedures will include control bioassay toxicity tests. For the toxicity tests to be considered valid, test organism survival of at least 80% is required in the controls. Toxicity will be defined based on comparisons to the control samples. Samples will be considered toxic if a given test endpoint (survival or weight) is statistically different ($p<0.05$) from the control sample or from the reference site (if available), and at least 20% lower than mean test organism response in the control samples. This approach is consistent with statistical

evaluation procedures recommended by EPA. Organisms to be used for testing should be positively identified by a qualified expert and be of similar age and life stage. Only organisms that behave normally, appear healthy and feed normally in culture will be used. The quality and general health of test organisms will be verified through positive and negative control tests. Positive control tests, or Standard Reference Toxicant (SRT) tests, provide documentation that tests organisms are responding to a SRT as expected and are not more or less tolerant. This is documented through control charts for the organism and SRT. Negative controls or laboratory control sediments provides a measure of non-chemical related stress to which organisms may be subjected during the course of the testing. Unacceptable mortality indicates that test organisms are being adversely affected by something other than the contaminants being tested. For tests to be considered valid, control organisms must achieve at least 80% survival.

4.2.5 Land Surveying

Following completion of sampling activities, IT will secure the services of an Ohio-registered professional land surveyor. The professional land surveyor will determine the coordinates and elevations of confirmation soil borings and surface water/sediment samples. The horizontal coordinates will be to the closest 0.1 foot and referenced to the State Plane Coordinate System. Vertical coordinates (ground elevation and well riser, if applicable) will be to the nearest 0.01 foot and referenced to the 1929 National Geodetic Vertical Datum. If the 1929 Datum is not readily available, the existing local vertical datum will be used. All survey data will be tabulated. Loop closure for survey accuracy shall be within the horizontal and vertical limits given above. Once sample survey information is available, it will be entered on the boring logs (Figure 4-11 of the SAP).

Critical reference points, landmarks, and sample locations will be plotted on appropriate map figures with a scale large enough to show their locations relative to other structures at the site.

4.2.6 Decontamination Procedures

Decontamination requirements and procedures are specified in detail in Chapter 5.0 of the SAP (IT, 1996a) and will be followed during the ERA investigation at the Redwater Ponds Area. IT field coordinator must contact PBS for access to a potable water source for decontamination use. The following summarizes decontamination procedures for equipment before site entry, between samples, and before site departure:

- Wash and scrub using a brush with nonphosphate detergent

- Rinse with potable water
- Rinse with ASTM Type II water
- Rinse with isopropanol
- Final rinse with ASTM Type II water; the volume of water used will be at least five times greater than the volume of isopropanol used
- Air dry
- Wrap in aluminum foil.

4.2.7 Sample Preservation, Packing, and Shipping

Sample containers and caps will be new, certified as precleaned containers from I-CHEM, made of materials recommended by the EPA in Title 40, Code of Federal Regulations, Part 136 and SW-846 (3rd Edition). General sample containers and preservatives/preservation methods are summarized in Table 5-1 of the QAPP (IT, 1996b), and are provided in Table 2 for the current scope of work. Sample containers will be supplied and shipped to the job site by the designated primary laboratory.

Each sample container will be bagged before placement in the cooler. Sample holding times will be calculated from the date the sample is collected, not the date that it is received by the laboratory.

Samples for chemical analysis will be preserved as prescribed in the QAPP (IT, 1996b) and placed in coolers as soon as possible after collection. The samples will be packed so as to minimize the possibility of container breakage by using Vermiculite or styrofoam peanuts to fill void spaces in the cooler. Samples for chemical analysis will be cooled as promptly as feasible to a temperature of approximately 4 degrees Celsius and maintained at that temperature by means of bagged ice from the time the shipping carton is sealed using tape and custody tape until it is received at the laboratory. Fish tissue samples will be placed in a cooler with dry ice (or with blue ice if frozen) prior to shipment. Coolers will be shipped to the laboratory by a next-day-delivery service. Notifica-tion of shipment, including air bill number, will be telephoned or faxed to the laboratory the day of sample shipment. If this is not possible, the laboratory will be notified the following morning.

Completed AR/COC records will be secured and included with each shipment of coolers to the following laboratories (or equivalent):

For Bioaccumulation and/or Toxicity Samples:
EA Engineering, Science, and Technology, Inc.
15 Loveton Circle
Sparks, Maryland 21152
Attention: Mr. Wayne McCullod

For Primary Chemical Analytical Samples:
Severn Trent Laboratory, Inc.
19 Loveton Circle
Sparks, Maryland 21152

For Field Split (QA/QC) Chemical Analytical Samples:
GPL, Inc.
202 Perry Parkway
Gaithersburg, Maryland 20877
Attention: Mr. Bill Locke

4.2.8 Investigation-Derived Waste Management Plan

Anticipated investigation-derived waste (IDW) during field activities includes decontamination fluid and disposable personal protective equipment. Detailed procedures of IDW management is provided in Chapter 8.0 of the SAP (IT, 1996a). The following is a brief summary of the procedures for handling IDW.

Residual surface soil will be used as backfill or spread out on the surface at the point of origin. Excess surface water and sediment will be disposed of at the point of origin. Therefore, no IDW will be generated during surface soil, surface water, or sediment sampling. Limited quantities of decontamination fluid, including wash water, nonphosphate soapy water, and final rinse water will be kept in plastic tubs during the decontamination process, and will be placed in 55-gallon drums upon completion of field sampling. Decontamination fluid containing small quantities of solvents such as isopropanol will be collected in metal pans for evaporation. IDW drums will be labeled to indicate project name, date collected, and contents, and stored on pallets in the staging area located east of the Building 9201 on Pentolite Road.

5.0 Field Verification

Field verification is Step 5 of the eight-step process. IT will provide an ecological risk professional to the project to verify if methods and sampling efforts as described in Section 4.0 of this ERA Work Plan are actually feasible at the RWP sites. For example, is there enough surface water available at each site for sample collection and to provide fish habitat. IT assumes that this field effort will take one (1) full day plus travel time to PBOW to determine feasibility. To expedite the process, IT will set up in advance a conference call time with CELRN, PBS and Ohio Environmental Protection Agency to offer verbal descriptions of field verification, ideally while the ecologist is still at PBOW. At the time of this field conference call, the stakeholders will decide on whether or not the Work Plan should be executed as written, or should be revised to address specific field verification findings. The locations for background soil sampling (Section 4.0) will also be discussed. After the conference call, IT will prepare a memorandum for the record. Site conditions and feasibility of the proposed approach will be documented in this memo to be sent to CELRN, PBS and Ohio Environmental Protection Agency, with subsequent revision of the ERA Work Plan as necessary. The memo will confirm the Work Plan sampling design, or if the Work Plan cannot be confirmed, the memo will suggest alternatives to the plan, as discussed in the field conference call.

At the conclusion of ERA Step 5, there is a SMDP. IT assumes that the proposed field conference call will fulfill SMDP 5 (EPA, 1997). IT assumes that the Field Verification Memorandum for the record is sufficient documentation for this ERA Step.

It should be noted that this ERA Work Plan is a living document, due to potential changes in field conditions. This document may be amended on an "as needed" basis to address changing circumstances as they are encountered (e.g., after the field verification task or at any time new information is discovered that has a bearing on the ERA process).

6.0 Site Investigation and Analysis

The site investigation and analysis is Step 6 of the eight-step process. IT will conduct the Phase 2 ERA site investigation at both the PRRWP and WARWP areas following the study design presented in Chapter 4.0, taking into consideration any findings of the field verification task (Chapter 5.0). The site investigation and analysis will be performed to address the hypotheses presented in Table 1. Uptake studies at the selected bioassay laboratory will be conducted in accordance with the outcome of the abiotic chemical analytical results. For example, if COPECs are not detected in collected site media, spiking of media with known concentrations of COPECs will be considered so that usable data may be obtained from the uptake studies, in order to calculate site-specific bioaccumulation factors. If spiking is required, soil and/or sediment will be allowed to equilibrate for at least 48 hours prior to running the uptake study. Nominal soil or sediment concentrations will be calculated by the laboratory based on the spiking protocol used. Holding times for soil and sediment (for uptake studies) are 45 days, thus sufficient time will be available to obtain results of the abiotic chemical analyses.

All analytical results will be 100 percent reviewed by an independent party separate from the primary analytical lab used for this project. IT will follow the criteria outlined in the Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses (EPA, 1988) and EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA 1994). Sampling locations will be sufficient to verify a concentration gradient for the toxicity tests. Toxicity tests will have at least one control run by the laboratory for each sample grouping (e.g., one control for daphnids, one control for minnows, and one control for *Hyalella*). Adequate survival in the control will be required to confirm the validity of the toxicity test. Upon completion of all the field sampling, sample locations will be surveyed by a licensed Ohio State surveyor.

7.0 Risk Characterization Report

The risk characterization report is Step 7 of the eight-step process. IT will prepare a supplemental risk characterization report (Phase 2 ERA), to supplement the Phase 1 ERA (IT, 1999), in accordance with the approach defined in Step 7 of the ERA Process (EPA, 1997). The report will document the results of the Phase 2 risk characterization. The report will also contain a refined evaluation of site surface water, sediment, and soil background COPEC concentrations, as limited background data were available for the Phase I ERA. Ecological hazards will be revised (from the Phase 1 ERA) using more realistic exposure parameters and site-specific information obtained during the ERA field investigations (Chapter 6.0). It should be noted that no field community assessment studies or population impact studies have been proposed as part of this Phase 2 ERA, as these types of studies were deemed unnecessary at this time.

As part of the risk characterization report, IT will also perform a literature search for a more appropriate avian toxicity benchmark no-observed-adverse-effect level for the amino-DNT compounds. New toxicity information found regarding the amino-DNTs will be presented in a toxicological profile, and used in the revised risk characterization. Documentation of all data manipulations, data screening, exposure equations, and exposure parameters will be provided or referenced in the risk characterization report. The estimated receptor hazards for each media for each assessment endpoint will be documented. A discussion of the likelihood of ecological risk, and pertinent factors that may effect risk will also be provided. IT will also provide discussions of uncertainties in various steps of the ERA process, and how the uncertainties effect the outcome of risk characterization. Information in the ERA report will be utilized to support a Management Decision Memo for risk managers (Chapter 8.0).

8.0 Risk Management

Risk management is Step 8 of the eight-step process. The goal of risk management is to provide sufficient information to the risk managers to proceed with management decisions, regarding the RWP sites.

After the ERA is completed and approved, IT will draft a brief memo for each RWP site. The memo will provide a list of ecological remedial goal options for the COPECs. IT will provide scientific judgement as to whether a potential remedial alternative would be more detrimental to the environment than leaving chemical-impacted media onsite. For example, dredging impacted sediment or filling in the existing pond in the West Area may adversely affect the ecosystem more than the no-action alternative. This type of information will be presented to aid risk management decisions.

9.0 References

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TABLES

Table 1

Assessment and Measurement Endpoints and Exposure Delineation
Plum Brook Ordnance Works, Sandusky, Ohio

Assessment Goal	Assessment Endpoint	Null Hypothesis (H_o)	Selected Receptor and Exposure Routes	Measurement Endpoint
Protection of terrestrial ecosystem structure and function.	Protection of long-term survival and reproductive capabilities for soil invertebrates.	The presence of site contaminants within surficial soils will have no adverse effect on survival and reproductive capabilities of terrestrial invertebrates.	Terrestrial invertebrates ingestion of soil and direct exposure to soil	Comparison of soil concentration to soil critical effect values (CEV). **Already done in Phase 1 ERA**
	Protection of long-term survival and reproductive capabilities for herbivorous mammals.	The presence of site contaminants within surface and subsurface soils, surface water, and vegetation will have no adverse effect on survival and reproductive capabilities of herbivorous mammals.	Eastern cottontail (*Sylvilagus floridanus*) white-tailed deer (*Odocoileus virginianus*) ingestion of plants, water, and incidental soil	Comparison of total daily dose to species-specific toxicity endpoint values (TEV). **Already done in Phase 1 ERA and hazards acceptable.**
	Protection of long-term survival and reproductive capabilities for omnivorous mammals.	The presence of site contaminants within surface soils, surface water, terrestrial invertebrates and vegetation will have no adverse effect on survival and reproductive capabilities of omnivorous mammals.	Raccoon (*Procyon lotor*) ingestion of terrestrial plants, and invertebrates, small mammals, water and incidental soil	Comparison of total daily dose to species-specific toxicity endpoint values (TEV). **Will be revised in Phase 2 ERA.**
	Protection of long-term survival and reproductive capabilities for omnivorous mammals.	The presence of site contaminants within surficial soils, surface water, terrestrial invertebrates, and vegetation will have no adverse effect on survival and reproductive capabilities of omnivorous mammals.	Deer mouse (*Peromyscus maniculatus*) ingestion of terrestrial invertebrates, plants, water, and incidental soil	Comparison of total daily dose to species-specific TEVs. **Will be revised in Phase 2 ERA.**

Table 1

Assessment and Measurement Endpoints and Exposure Delineation
Plum Brook Ordnance Works, Sandusky, Ohio

Assessment Goal	Assessment Endpoint	Null Hypothesis (H_o)	Selected Receptor and Exposure Routes	Measurement Endpoint
Protection of terrestrial ecosystem structure and function.	Protection of long-term survival and reproductive capabilities for carnivorous birds.	The presence of site contaminants within surficial soils, surface water, small mammals, and birds will have no adverse effect on survival and reproductive capabilities of carnivorous birds.	red-tailed hawk (*Buteo jamacencis*) ingestion of small mammals, birds, water, incidental soil	Comparison of total daily dose to species-specific TEVs. **Already done in Phase 1 ERA and hazards acceptable.**
	Protection of long-term survival and reproductive capabilities for small insectivorous mammals.	The presence of site contaminants within surficial soils, surface water, and terrestrial invertebrates will have no adverse effect on survival and reproductive capabilities of insectivorous mammals.	short-tailed shrew (*Blarnia brevicauda*) ingestion of terrestrial invertebrates, water, and incidental soil	Comparison of total daily dose to species-specific TEVs. **Will be revised in Phase 2 ERA.**
	Protection of long-term survival and reproductive capabilities for insectivorous birds.	The presence of site contaminants within surficial soils, surface water, and terrestrial invertebrates will have no adverse effect on survival and reproductive capabilities of insectivorous birds.	marsh wren (*Cistorthorus palustris*) ingestion of terrestrial invertebrates, water, and incidental soil	Comparison of total daily dose to species-specific TEVs. **Will be revised in Phase 2 ERA.**

Table 1

Assessment and Measurement Endpoints and Exposure Delineation
Plum Brook Ordnance Works, Sandusky, Ohio

Assessment Goal	Assessment Endpoint	Null Hypothesis (H_o)	Selected Receptor and Exposure Routes	Measurement Endpoint
Protection of aquatic ecosystem structure and function.	Protection of long-term survival and reproductive capabilities for benthic invertebrates.	The presence of site contaminants within sediments and surface water will have no adverse effect on survival and reproductive capabilities of benthic invertebrates.	Benthic invertebrates ingestion of sediment and direct exposure to surface water	**Survival and growth of *Hyalella azteca* in site-specific sediment bioassays.**
	Protection of long-term survival and reproductive capabilities for aquatic vertebrates (fin fish).	The presence of site contaminants within surface water, benthic invertebrates, and plants will have no adverse effect on survival and reproductive capabilities of aquatic vertebrates.	aquatic vertebrates ingestion of benthic invertebrates, plants, and direct exposure to water	**Survival and growth of fathead minnows and survival and reproduction of cladocerans in site-specific surface water bioassays.**
	Protection of long-term survival and reproductive capabilities for semi-aquatic omnivorous mammals (also considered in the terrestrial assessment).	The presence of site contaminants within surface water, sediments, aquatic invertebrates, and fish have no adverse effect on survival and reproductive capabilities of aquatic mammals.	raccoon (*Procyon lotor*) ingestion of aquatic invertebrates, fish, water and incidental sediment	Comparison of total daily dose to species-specific TEVs. **Will be revised in Phase 2 ERA.**
	Protection of long-term survival and reproductive capabilities for piscivorous birds.	The presence of site contaminants within aquatic vertebrates and benthic invertebrates will have no adverse effect on survival and reproductive capabilities of piscivorous birds.	great blue heron (*Ardea herodias*) ingestion of aquatic vertebrates, benthic invertebrates, water, and incidental sediment	Comparison of total daily dose to species-specific TEVs. **Will be revised in Phase 2 ERA.**

Table 2

Test Methods, Containers, Preservatives, and Holding Times
Ecological Risk Assessment at Red Water Ponds Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Parameter	Test Method	Sample Container	Preservation Requirements	Holding Time [b]
Surface Water	Metals	6010B/365.1	1 L HDPE	Cool to 4°C, HNO3 to pH <2	6 months (28 days for Hg)
	Toxicity	Weber (1989)[a]	11.4 L HDPE	Cool to 4°C	36 - 72 hours
Sediment	Metals	6010B/365.1	4 oz CWM glass with Teflon-lined lid	Cool to 4°C	6 months (28 days for Hg)
	Nitroaromatics	8330	4 oz CWM glass with Teflon-lined lid	Cool to 4°C	Extraction 14 days/analysis 40 days
	Semivolatiles	8270C	4 oz CWM glass with Teflon-lined lid	Cool to 4°C	Extraction 14 days/analysis 40 days
	Tot. Org. Carbon				
	Toxicity	USEPA (2000)[a]	3.8 L HDPE	Cool to 4°C	two weeks
	Bioaccumulation	USEPA (2000)[a]	11.4 L HDPE	Cool to 4°C	45 days
Soil	Metals	6010B/365.1	4 oz CWM glass with Teflon-lined lid	Cool to 4°C	6 months (28 days for Hg)
	Nitroaromatics	8330	4 oz CWM glass with Teflon-lined lid	Cool to 4°C	Extraction 14 days/analysis 40 days
	PAHs	8310	4 oz CWM glass with Teflon-lined lid	Cool to 4°C	Extraction 14 days/analysis 40 days
	Bioaccumulation	Linder (1992)[a]	11.4 L HDPE	Cool to 4°C	45 days
Fish	Lipids				
	Metals	6010B/365.1	200 g frozen in foil	Frozen	45 days
Aquatic Invertebrates [c]	Metals	6010B/365.1		Frozen	45 days
	Lipids				
(Lumbriculus)	Nitroaromatics	8330	To be selected by the bioassay	Frozen	45 days
	Semivolatiles	8270C	laboratory, as appropriate, for	Frozen	45 days
Terrestrial Invertebrates [d]	Nitroaromatics	8330	transport to the analytical laboratory.	Frozen	45 days
	Lipids				
(earthworms)	PAHs	8310		Frozen	45 days

[a] See Section 9.0 for complete reference.
[b] Holding times are from time of sampling.
[c] Aquatic invertebrate Lumbriculus tissue to be analyzed as follows:
* Metals: Pentolite Road sediment uptake samples, West Area sediment uptake samples
* Nitroaromatics: West Area sediment uptake samples
* SVOCs: Pentolite Road sediment uptake samples
[d] Terrestrial invertebrate earthworm tissue to be analyzed as follows:
* Nitroaromatics: Pentolite Road soil uptake samples, West Area soil uptake samples
* PAHs: West Area soil uptake samples
CWM - clear, wide-mouth jar.
HDPE - High density polyethylene.
PAH - Polynuclear aromatic hydrocarbon
Note: See Tables 3, 4, and 5 for details on specific chemical parameters per matrix, by area, and sample purpose.

The 18 Key Metals of Concern for Analysis are as follows:

Aluminum	Lead
Antimony	Magnesium
Arsenic	Manganese
Barium	Nickel
Calcium	Phosphorus
Chromium	Potassium
Cobalt	Sodium
Copper	Vanadium
Iron	Zinc

Table 3

Pentolite Road Red Water Pond Samples
Ecological Risk Assessment at Red Water Ponds Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Purpose	Sample Identification[a]	QA/QC Samples		
			Field Duplicate	Field Split	MS/MSD
Soil	Earthworm COPEC Uptake Estimates (for nitroaromatics)	PBOW-00-SS-PRWP-SO001-AC0001-0000	x	x	x
		PBOW-00-SS-PRWP-SO002-AC0002-0000			
		PBOW-00-SS-PRWP-SO003-AC0003-0000			
		PBOW-00-SS-PRWP-SO004-AC0004-0000			
		PBOW-00-SS-PRWP-SO005-AC0005-0000			
Surface Water	Fish COPEC Uptake Estimates (for metals)	PBOW-00-SW-PRWP-SW001-AC2001-0000	x	x	x
		PBOW-00-SW-PRWP-SW002-AC2002-0000			
		PBOW-00-SW-PRWP-SW003-AC2003-0000			
		PBOW-00-SW-PRWP-SW004-AC2004-0000			
		PBOW-00-SW-PRWP-SW005-AC2005-0000			
	Surface Water Toxicity (for metals)	PBOW-00-SW-PRWP-SW006-AC2006-0000			
		PBOW-00-SW-PRWP-SW007-AC2007-0000			
		PBOW-00-SW-PRWP-SW008-AC2008-0000			
		PBOW-00-SW-PRWP-SW009-AC2009-0000			
		PBOW-00-SW-PRWP-SW010-AC2010-0000			
Fish	Fish COPEC Uptake Estimates (for metals)	PBOW-00-BI-PRWP-BI001-AC4001-0000	Lab Dup		x
		PBOW-00-BI-PRWP-BI002-AC4002-0000			
		PBOW-00-BI-PRWP-BI003-AC4003-0000			
		PBOW-00-BI-PRWP-BI004-AC4004-0000			
		PBOW-00-BI-PRWP-BI005-AC4005-0000			
		PBOW-00-BI-PRWP-BI006-AC4006-0000			
		PBOW-00-BI-PRWP-BI007-AC4007-0000			
		PBOW-00-BI-PRWP-BI008-AC4008-0000			
		PBOW-00-BI-PRWP-BI009-AC4009-0000			
		PBOW-00-BI-PRWP-BI010-AC4010-0000			

Table 3

Pentolite Road Red Water Pond Samples
Ecological Risk Assessment at Red Water Ponds Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Purpose	Sample Identification[a]	QA/QC Samples		
			Field Duplicate	Field Split	MS/MSD
Sediment	Invertebrate COPEC Uptake Estimates (for metals and SVOCs)	PBOW-00-SD-PRWP-SD001-AC1001-0000			
		PBOW-00-SD-PRWP-SD002-AC1002-0000			
		PBOW-00-SD-PRWP-SD003-AC1003-0000			
		PBOW-00-SD-PRWP-SD004-AC1004-0000			
		PBOW-00-SD-PRWP-SD005-AC1005-0000			
Earthworms (tissue from biassay lab)	Invertebrate COPEC Uptake Estimates (for nitroaromatics)	PBOW-00-BI-PRWP-BI011-AC4011-0000			
		PBOW-00-BI-PRWP-BI012-AC4012-0000			
		PBOW-00-BI-PRWP-BI013-AC4013-0000			
		PBOW-00-BI-PRWP-BI014-AC4014-0000			
		PBOW-00-BI-PRWP-BI015-AC4015-0000			
Aquatic Worms (tissue from biassay lab)	Invertebrate COPEC Uptake Estimates (for metals and SVOCs)	PBOW-00-BI-PRWP-BI016-AC4016-0000			
		PBOW-00-BI-PRWP-BI017-AC4017-0000			
		PBOW-00-BI-PRWP-BI018-AC4018-0000			
		PBOW-00-BI-PRWP-BI019-AC4019-0000			
		PBOW-00-BI-PRWP-BI020-AC4020-0000			

MS/MSD - Matrix spike/matrix spike duplicate.
QA/QC - Quality assurance/quality control.

[a] Surface water samples for fish COPEC uptake estimates and fish samples will be co-located. Note: two different fish species to be collected from each surface water/fish sample location.

Table 4

West Area Red Water Pond Samples
Ecological Risk Assessment at Red Water Ponds Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Purpose	Sample Identification[a]	QA/QC Samples		
			Field Duplicate	Field Split	MS/MSD
Soil	Earthworm COPEC Uptake Estimates (for nitroaromatics and PAHs)	PBOW-00-SS-WRWP-SO001-AD0001-0000			
		PBOW-00-SS-WRWP-SO002-AD0002-0000			
		PBOW-00-SS-WRWP-SO003-AD0003-0000			
		PBOW-00-SS-WRWP-SO004-AD0004-0000			
		PBOW-00-SS-WRWP-SO005-AD0005-0000			
Surface Water	Fish COPEC Uptake Estimates (for metals)	PBOW-00-SW-WRWP-SW001-AD2001-0000	x	x	x
		PBOW-00-SW-WRWP-SW002-AD2002-0000			
		PBOW-00-SW-WRWP-SW003-AD2003-0000			
		PBOW-00-SW-WRWP-SW004-AD2004-0000			
		PBOW-00-SW-WRWP-SW005-AD2005-0000			
	Surface Water Toxicity (for metals)	PBOW-00-SW-WRWP-SW006-AD2006-0000			
		PBOW-00-SW-WRWP-SW007-AD2007-0000			
		PBOW-00-SW-WRWP-SW008-AD2008-0000			
		PBOW-00-SW-WRWP-SW009-AD2009-0000			
		PBOW-00-SW-WRWP-SW010-AD2010-0000			
Fish	Fish COPEC Uptake Estimates (for metals)	PBOW-00-BI-WRWP-BI001-AD4001-0000	Lab Dup		x
		PBOW-00-BI-WRWP-BI002-AD4002-0000			
		PBOW-00-BI-WRWP-BI003-AD4003-0000			
		PBOW-00-BI-WRWP-BI004-AD4004-0000			
		PBOW-00-BI-WRWP-BI005-AD4005-0000			
		PBOW-00-BI-WRWP-BI006-AD4006-0000			
		PBOW-00-BI-WRWP-BI007-AD4007-0000			
		PBOW-00-BI-WRWP-BI008-AD4008-0000			
		PBOW-00-BI-WRWP-BI009-AD4009-0000			
		PBOW-00-BI-WRWP-BI010-AD4010-0000			

Table 4

West Area Red Water Pond Samples
Ecological Risk Assessment at Red Water Ponds Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Purpose	Sample Identification[a]	QA/QC Samples		
			Field Duplicate	Field Split	MS/MSD
Sediment	Invertebrate COPEC Uptake Estimates (for nitroaromatics and metals)	PBOW-00-SD-WRWP-SD001-AD1001-0000	X	X	X
		PBOW-00-SD-WRWP-SD002-AD1002-0000			
		PBOW-00-SD-WRWP-SD003-AD1003-0000			
		PBOW-00-SD-WRWP-SD004-AD1004-0000			
		PBOW-00-SD-WRWP-SD005-AD1005-0000			
	Sediment Toxicity (for metals)	PBOW-00-SD-WRWP-SD006-AD1006-0000			
		PBOW-00-SD-WRWP-SD007-AD1007-0000			
		PBOW-00-SD-WRWP-SD008-AD1008-0000			
		PBOW-00-SD-WRWP-SD009-AD1009-0000			
		PBOW-00-SD-WRWP-SD010-AD1010-0000			
Earthworms (tissue from biassay lab)	Invertebrate COPEC Uptake Estimates (for PAHs and nitroaromatics)	PBOW-00-BI-WRWP-BI011-AD4011-0000			
		PBOW-00-BI-WRWP-BI012-AD4012-0000			
		PBOW-00-BI-WRWP-BI013-AD4013-0000			
		PBOW-00-BI-WRWP-BI014-AD4014-0000			
		PBOW-00-BI-WRWP-BI015-AD4015-0000			
Aquatic Worms (tissue from biassay lab)	Invertebrate COPEC Uptake Estimates (for metals and nitroaromatics)	PBOW-00-BI-WRWP-BI016-AD4016-0000			
		PBOW-00-BI-WRWP-BI017-AD4017-0000			
		PBOW-00-BI-WRWP-BI018-AD4018-0000			
		PBOW-00-BI-WRWP-BI019-AD4019-0000			
		PBOW-00-BI-WRWP-BI020-AD4020-0000			

MS/MSD - Matrix spike/matrix spike duplicate.
QA/QC - Quality assurance/quality control.

[a] Surface water samples for fish COPEC uptake estimates and fish samples will be co-located. Note: two different fish species to be collected from each surface water/fish sample location.

Table 5

Background Samples
Ecological Risk Assessment at Red Water Ponds Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Purpose	Sample Identification[a]	QA/QC Samples		
			Field Duplicate	Field Split	MS/MSD
Soil	Background (for metals and PAHs)	PBOW-00-SS-BCG-SO001-AE0001-0000	X	X	X
		PBOW-00-SS-BCG-SO002-AE0002-0000			
		PBOW-00-SS-BCG-SO003-AE0003-0000			
		PBOW-00-SS-BCG-SO004-AE0004-0000			
		PBOW-00-SS-BCG-SO005-AE0005-0000			
		PBOW-00-SS-BCG-SO006-AE0006-0000			
Surface Water	Background (for metals)	PBOW-00-SW-BCG-SW001-AE2001-0000			
		PBOW-00-SW-BCG-SW002-AE2002-0000			
		PBOW-00-SW-BCG-SW003-AE2003-0000			
		PBOW-00-SW-BCG-SW004-AE2004-0000			
		PBOW-00-SW-BCG-SW005-AE2005-0000			
		PBOW-00-SW-BCG-SW006-AE2006-0000			
Sediment	Background (for metals)	PBOW-00-SD-BCG-SD001-AE1001-0000			
		PBOW-00-SD-BCG-SD002-AE1002-0000			
		PBOW-00-SD-BCG-SD003-AE1003-0000			
		PBOW-00-SD-BCG-SD004-AE1004-0000			
		PBOW-00-SD-BCG-SD005-AE1005-0000			
		PBOW-00-SD-BCG-SD006-AE1006-0000			

[a] Surface water and sediment samples are co-located (i.e., SW001 and SD001 are from the same location).

MS/MSD - Matrix spike/matrix spike duplicate.
QA/QC - Quality assurance/quality control.

FIGURES

Figure 1

Simplified Terrestrial Food Web Conceptual Site Model (CSM)
Plum Brook Ordnance Works, Ohio

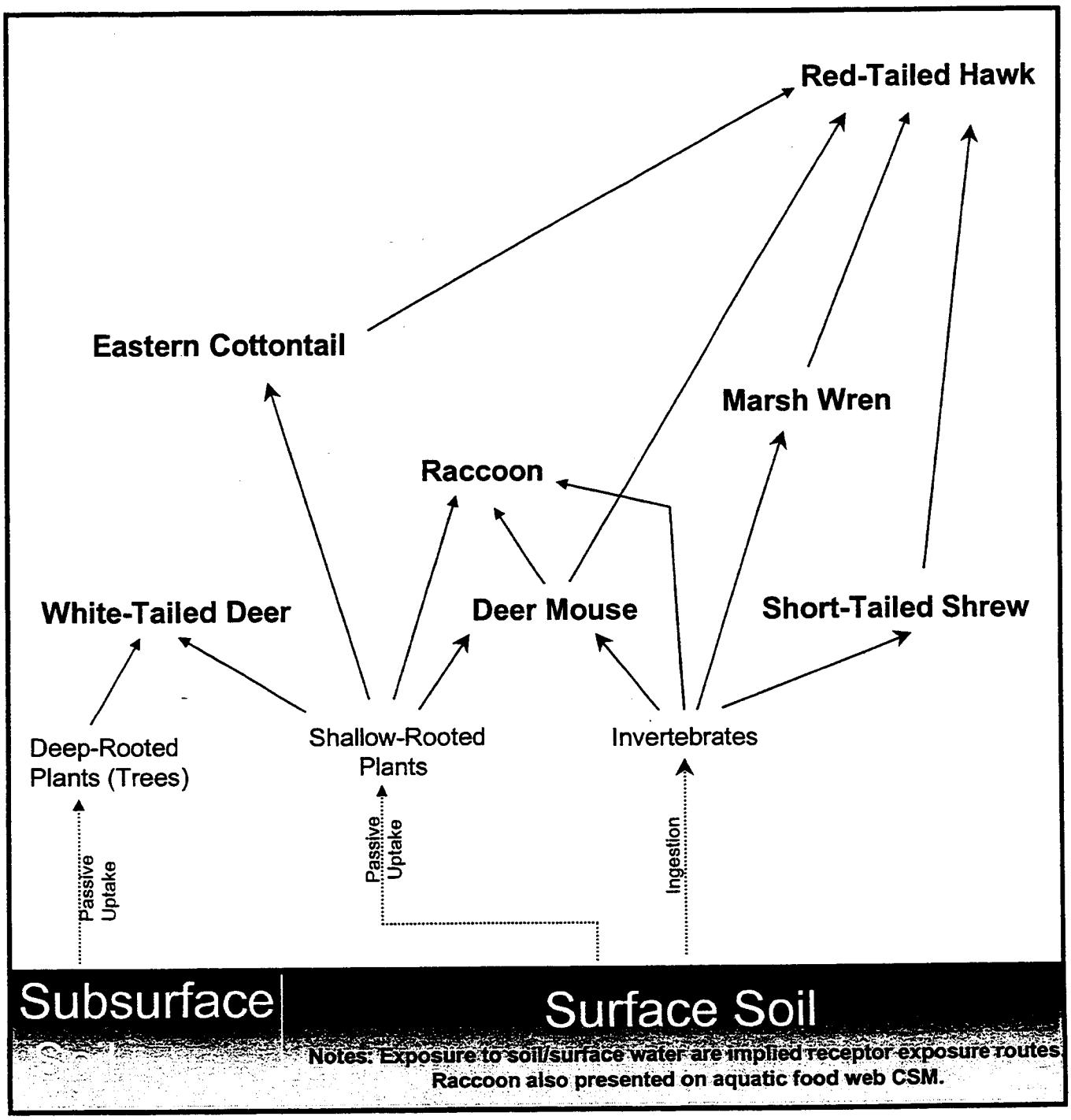
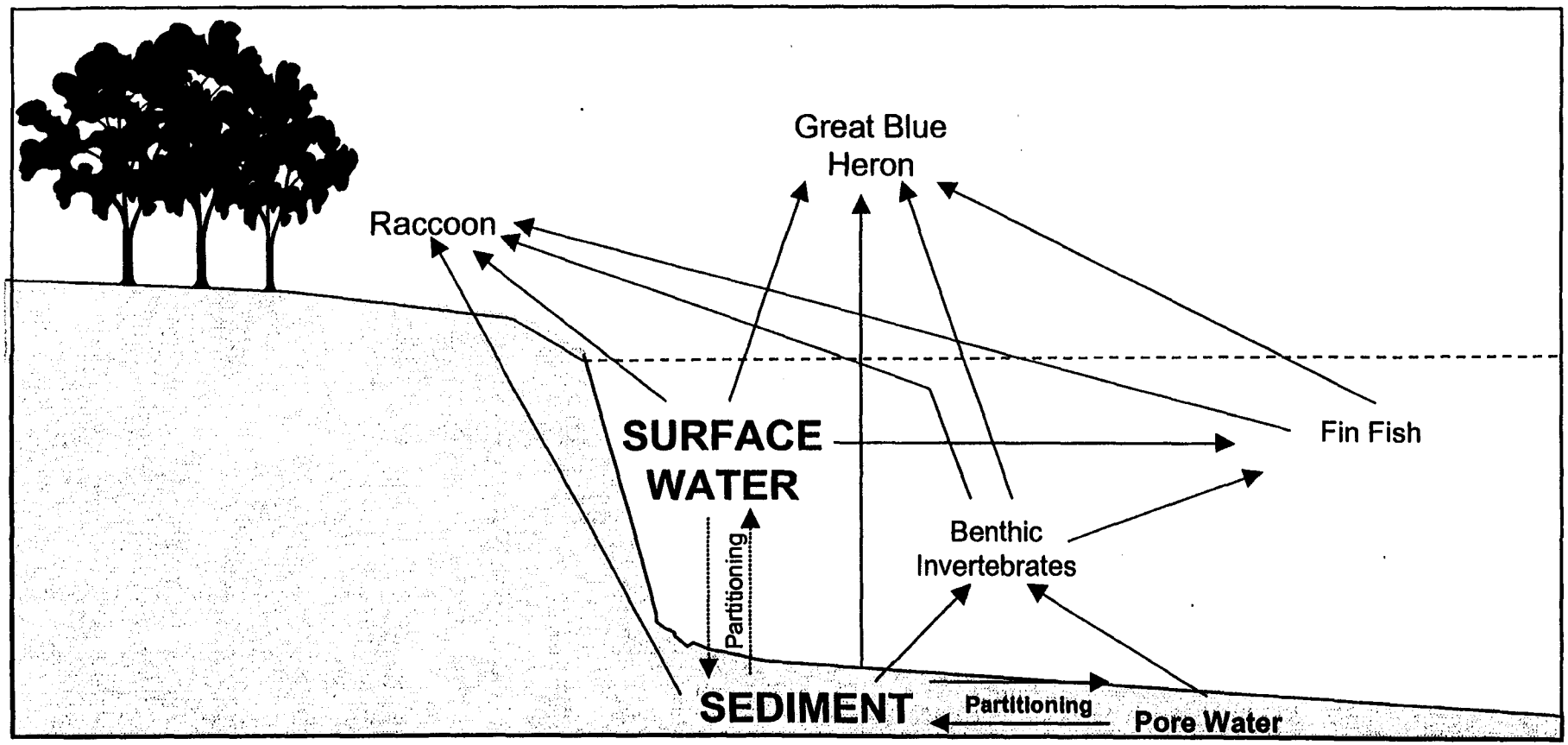
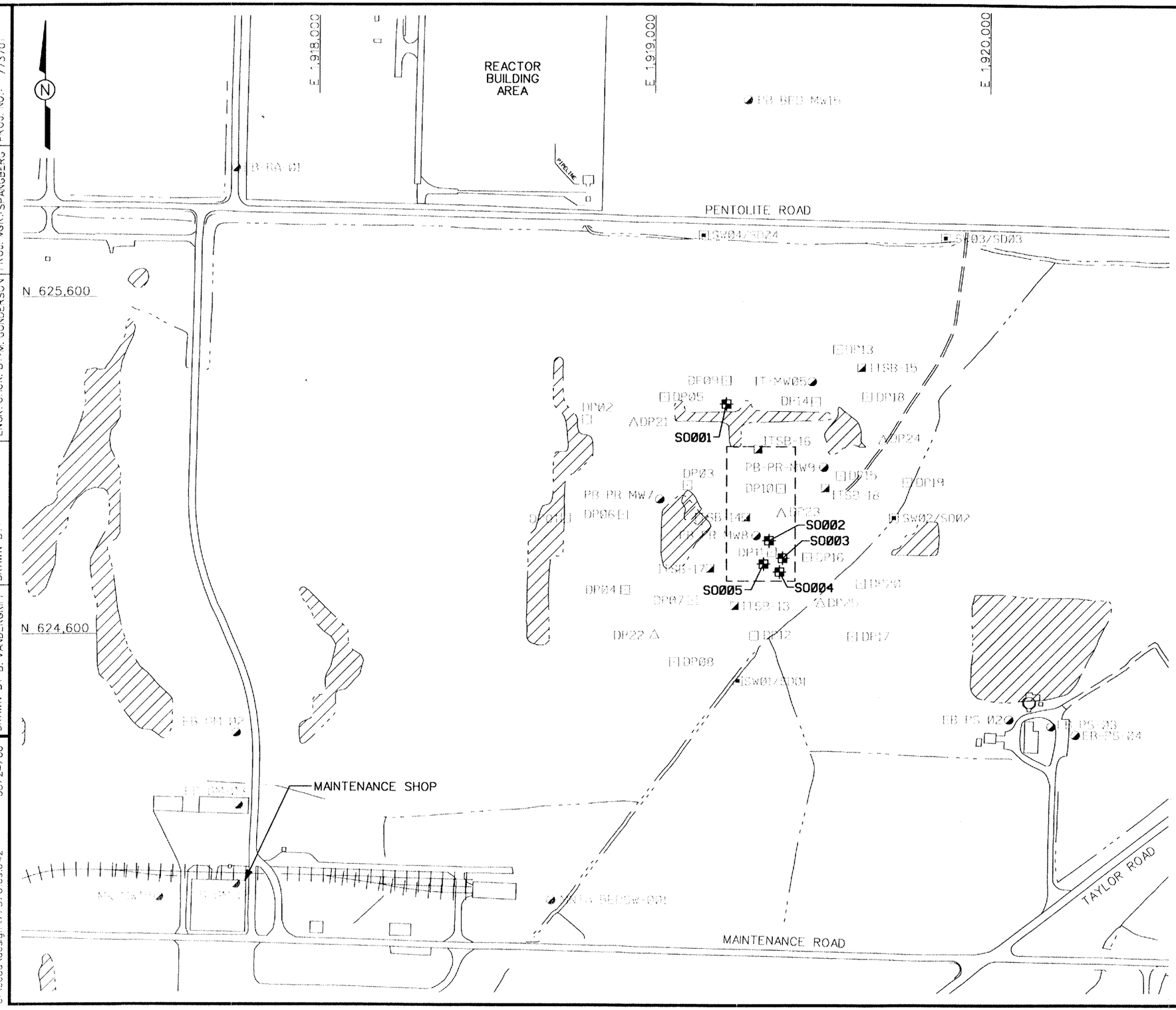


Figure 2

Simplified Aquatic Food Web Conceptual Site Model (CSM)
Plum Brook Ordnance Works, Ohio



Note: Raccoon also presented on terrestrial food web CSM.



LEGEND:

	BUILDINGS
	RAILROAD
	SURFACE WATER
	SURFACE WATER DRAINAGE
	APPROXIMATE HISTORICAL LOCATION OF PONDS
	FENCE (PBOW BOUNDARY)
SO001	SOIL SAMPLE LOCATION FOR EARTHWORM UPTAKE
IT MW02	HISTORIC MONITORING WELL LOCATION
ITSB-13	HISTORIC SOIL BORING LOCATION
DP01	HISTORIC DIRECT PUSH SAMPLE LOCATION
ADP21	HISTORIC DIRECT PUSH GEOTECHNICAL LOCATION
SW01/SD01	HISTORIC SURFACE WATER/ SEDIMENT SAMPLES

NOTE:

THREE BACKGROUND SOIL SAMPLES WILL BE COLLECTED BASED ON VERIFICATION SITE VISIT. (SEE FIGURE 11)

FIGURE 3
PENTOLITE ROAD RED WATER PONDS SOIL SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: M. WESBERG
ENGR. CHCK. BY: M. GUNDERSON	PROJ. MGR.: SPANGBERG
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DATE LAST REV.:	PROJ. NO.: 77370
DRAWN BY: B. VANDERGRIFF	
DRAWN BY:	

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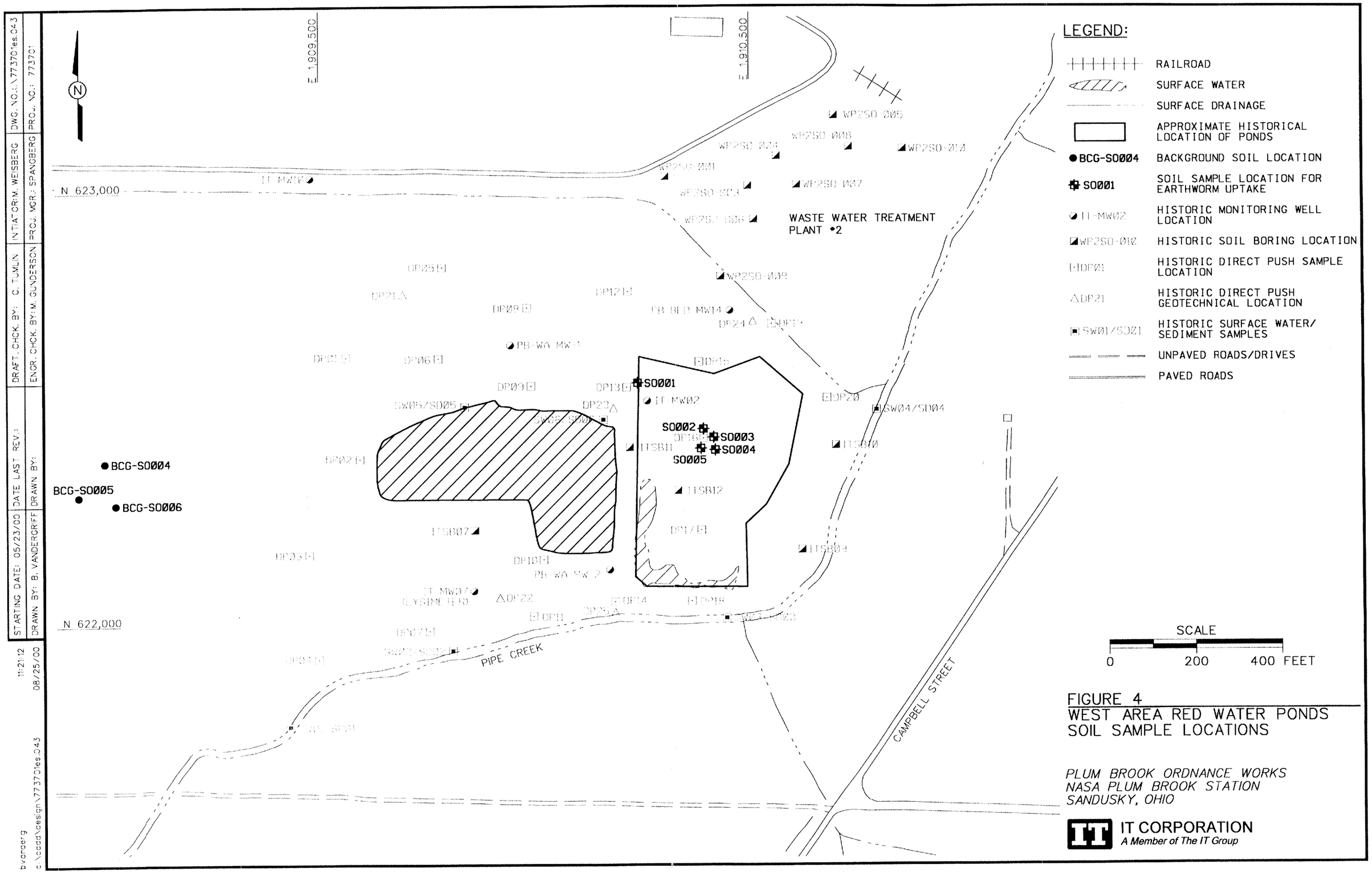

FIGURE 4
WEST AREA RED WATER PONDS
SOIL SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

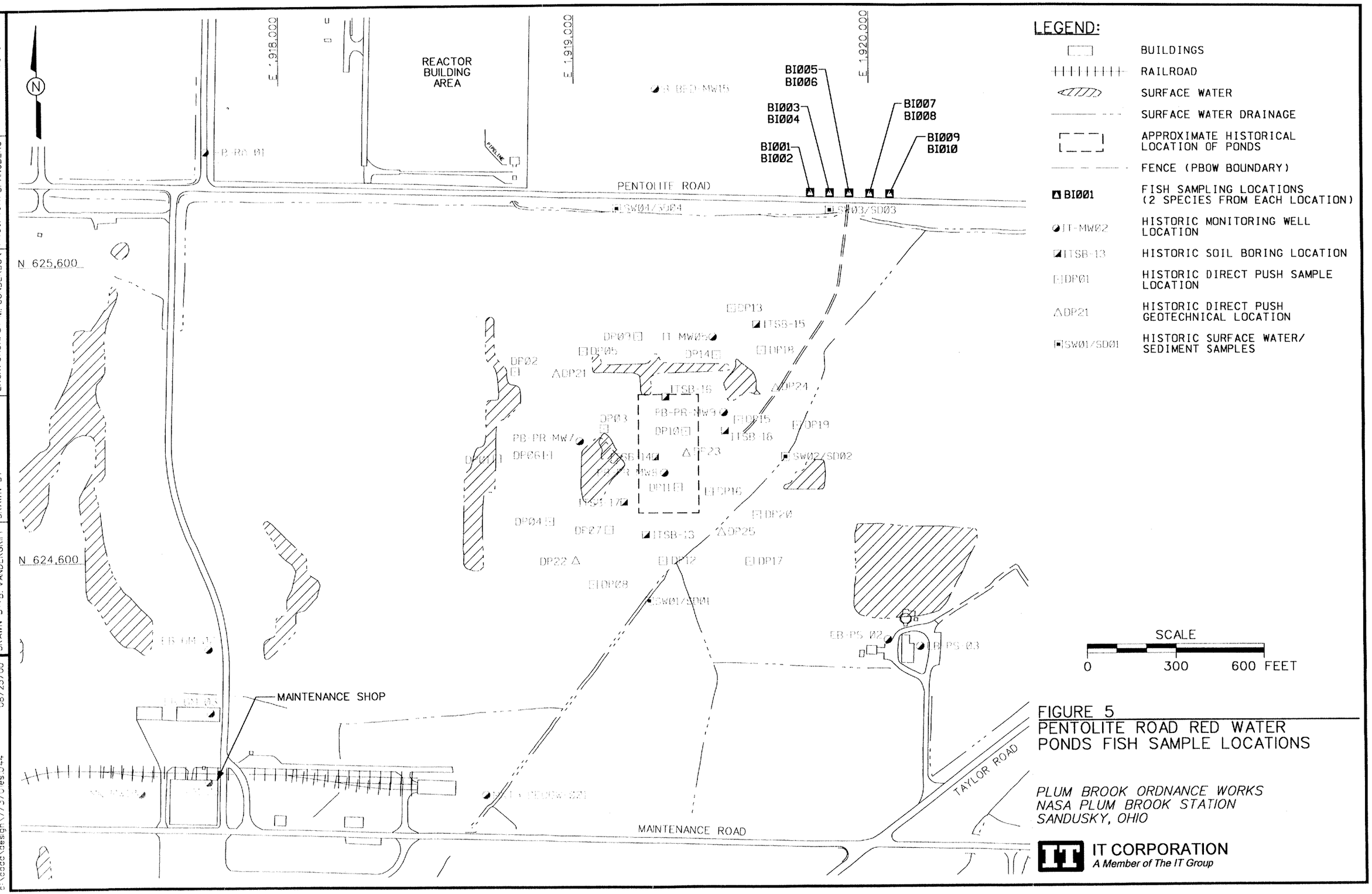

FIGURE 5
PENTOLITE ROAD RED WATER PONDS FISH SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

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		PROJ. MGR.: SPANGBERG	INITIATOR: M. WEISBERG

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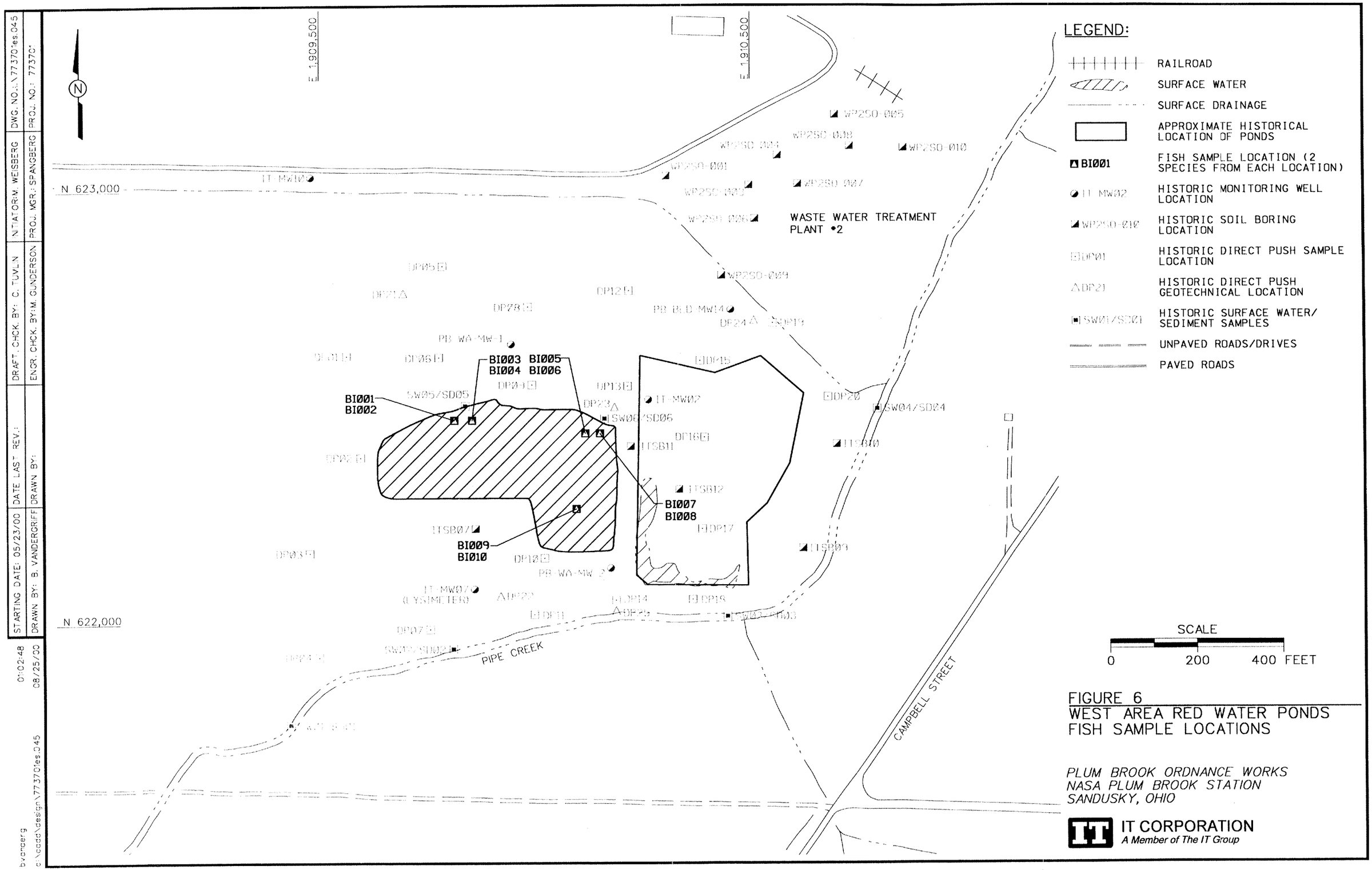

FIGURE 6
WEST AREA RED WATER PONDS
FISH SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DRAFT. CHCK. BY: C. TUVLN | INITIATOR: W. WEISBERG | DWG. NO.: \77370les.045
ENGR. CHCK. BY: M. GUNDERSON | PROJ. MGR.: SPANGBERG | PROJ. NO.: 77370
STARTING DATE: 05/23/00 | DATE LAST REV.:
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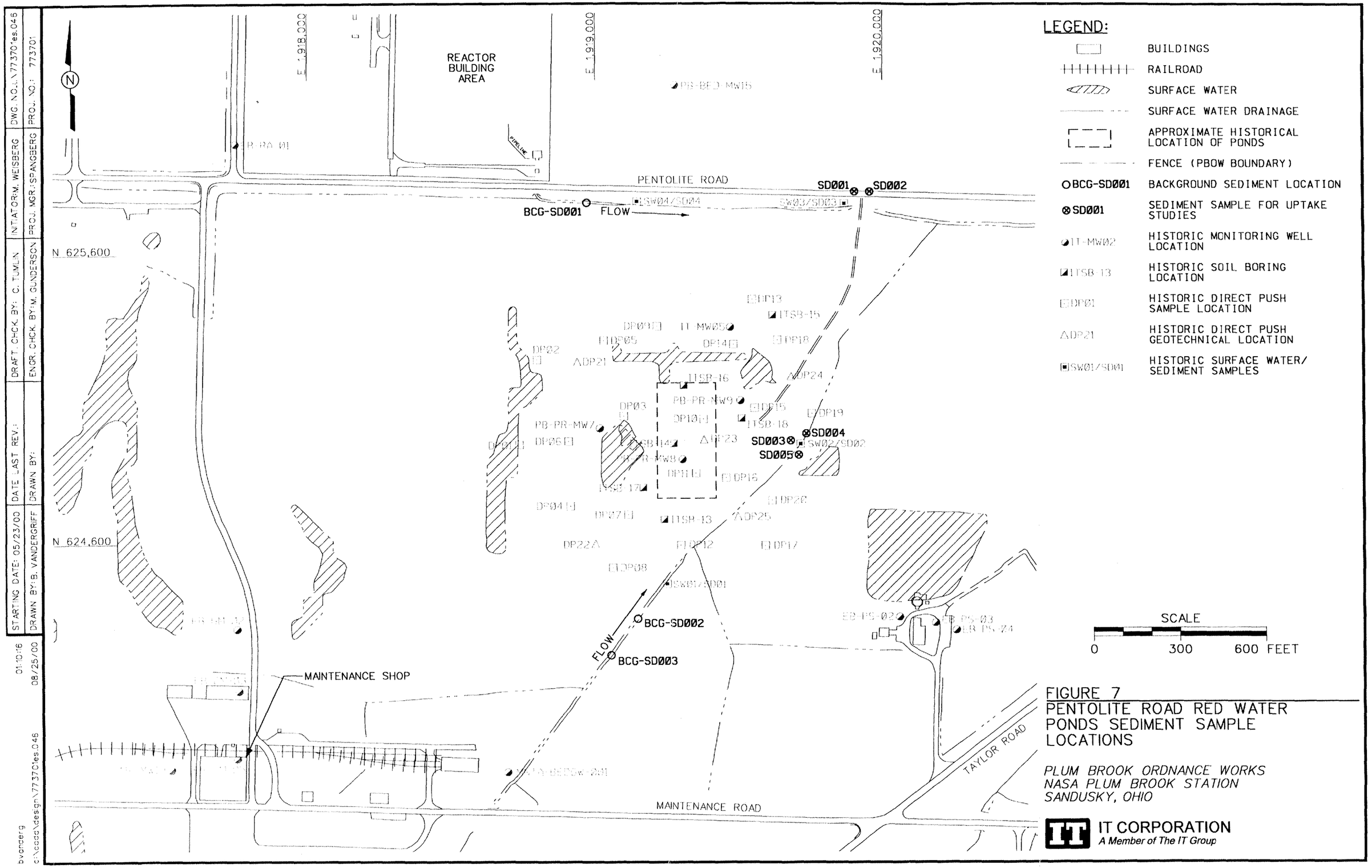

FIGURE 7
PENTOLITE ROAD RED WATER PONDS SEDIMENT SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

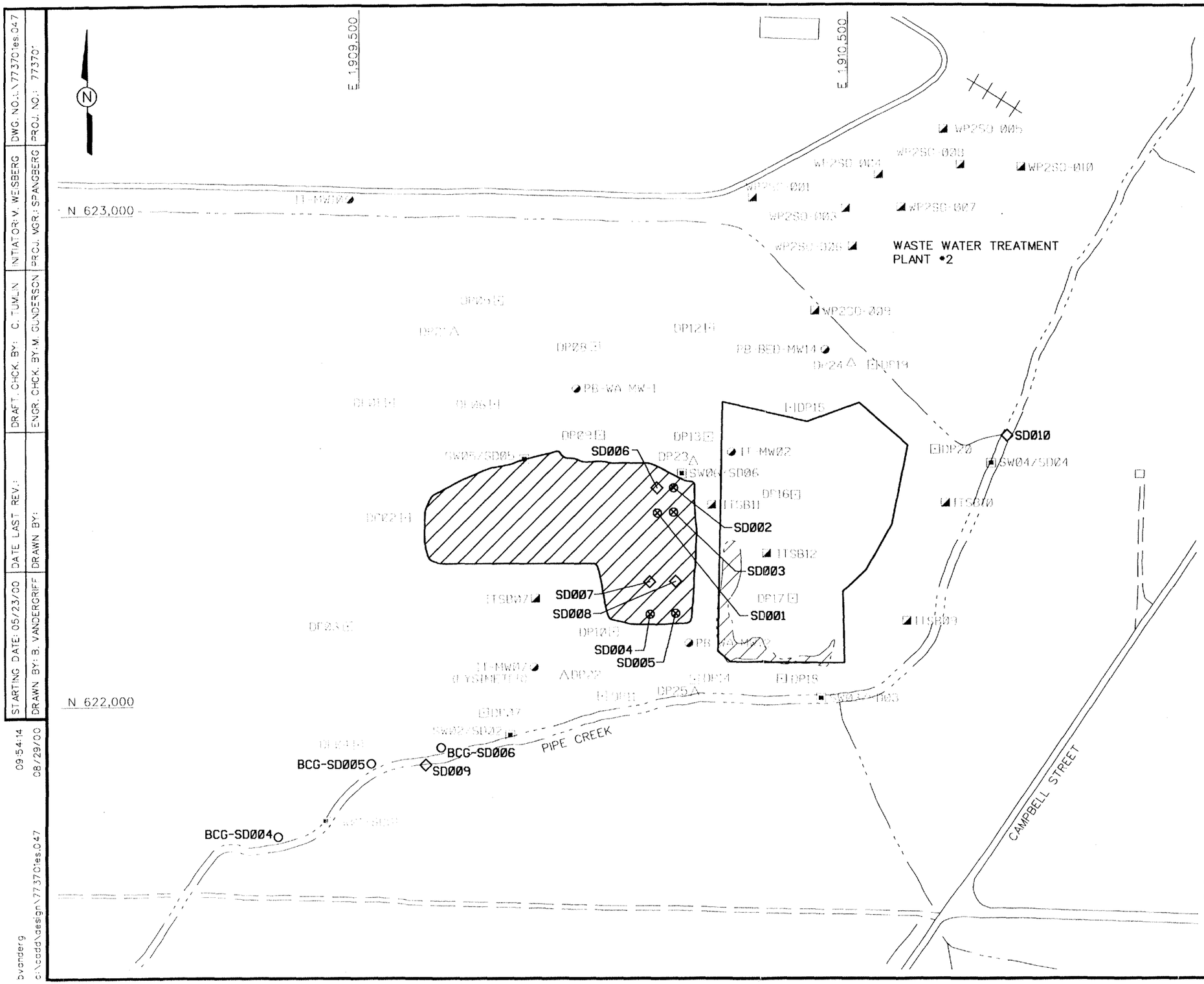

FIGURE 8
WEST AREA RED WATER PONDS
SEDIMENT SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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ENGR. CHCK. BY: M. GUNDERSON | PROJ. MGR.: SPANGBERG | PROJ. NO.: 77370
STARTING DATE: 05/23/00 | DATE LAST REV.:
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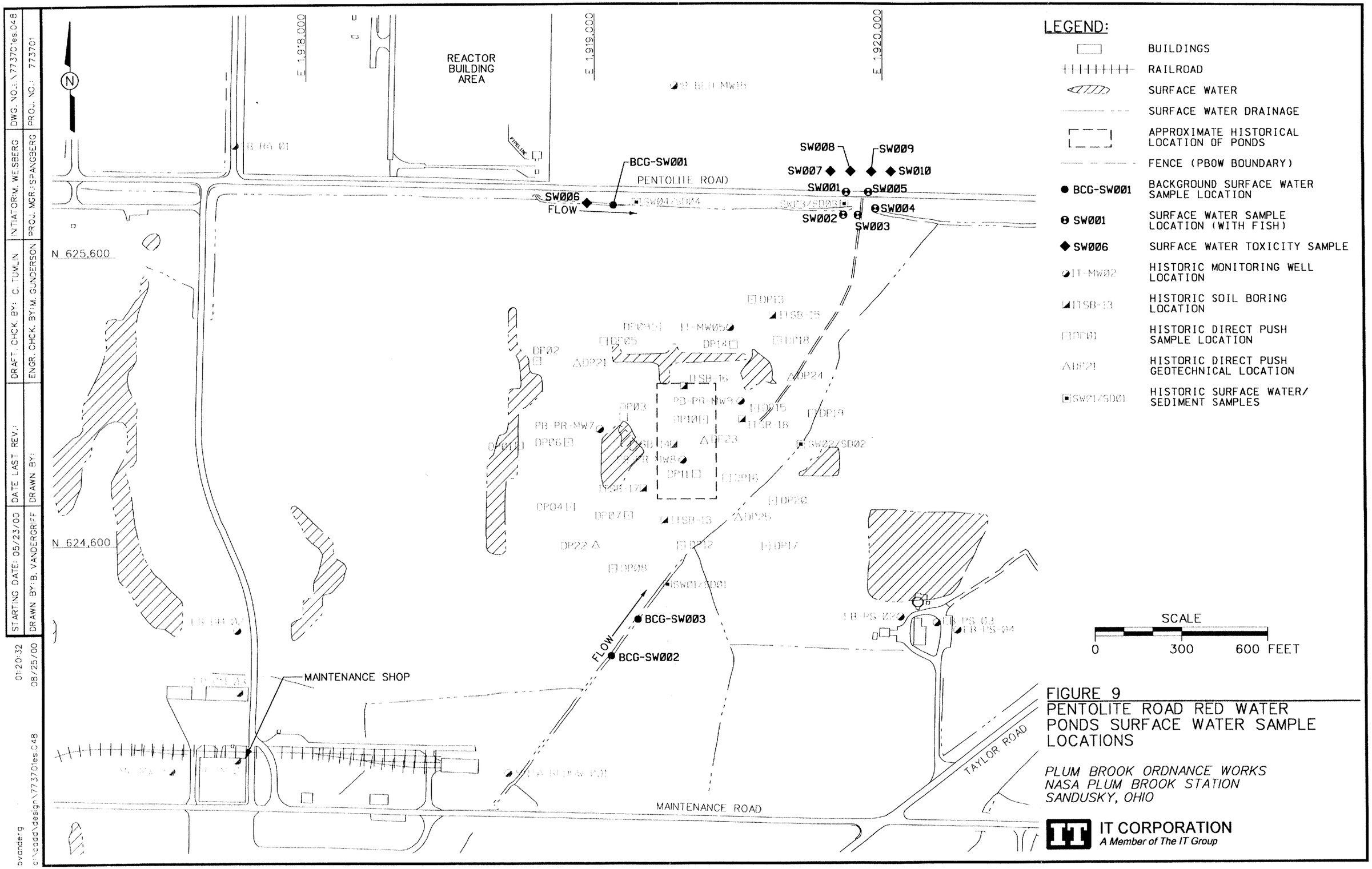

FIGURE 9
PENTOLITE ROAD RED WATER PONDS SURFACE WATER SAMPLE LOCATIONS

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PROJ. NO.: 77370
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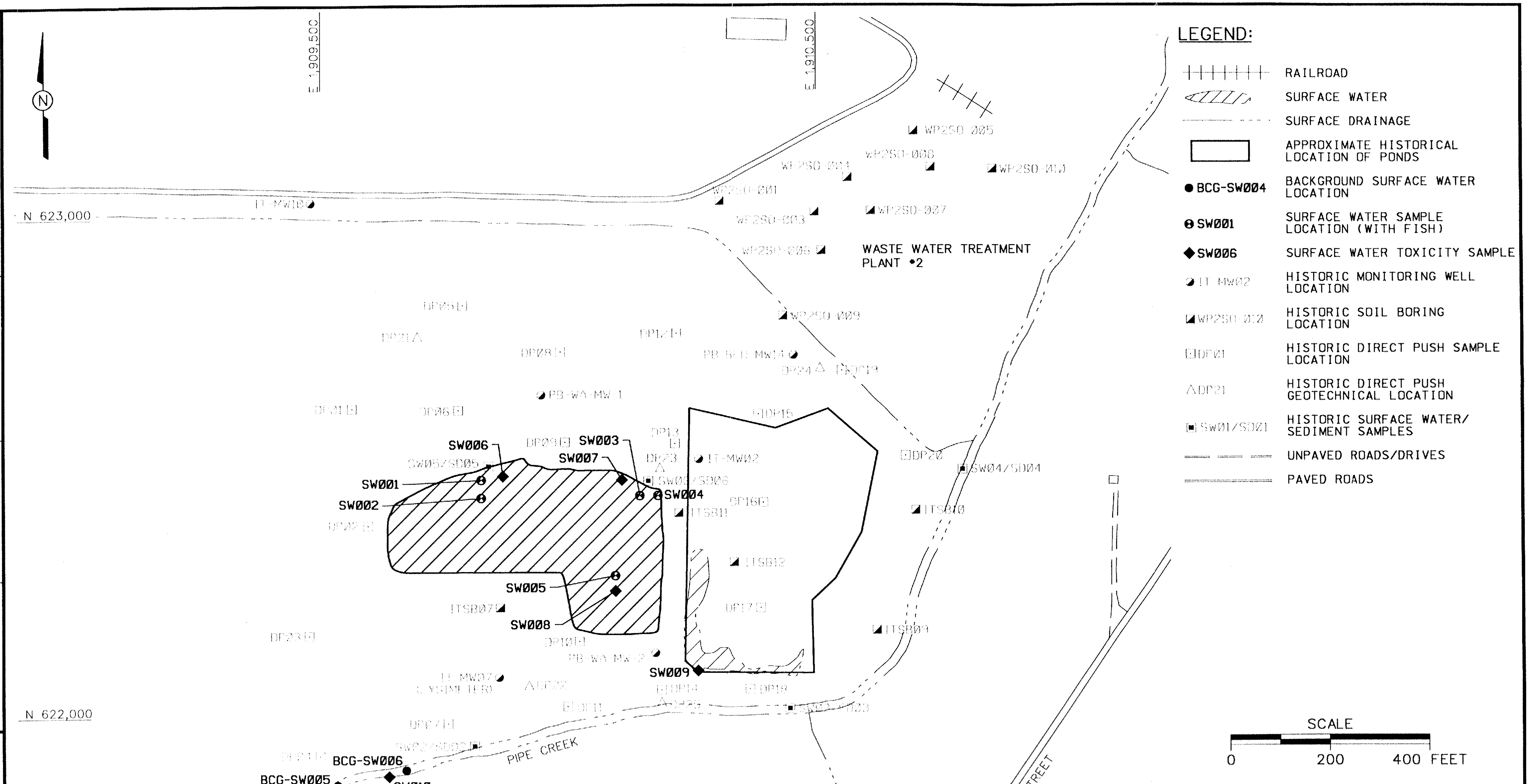

FIGURE 10
WEST AREA RED WATER PONDS SURFACE WATER SAMPLE LOCATIONS

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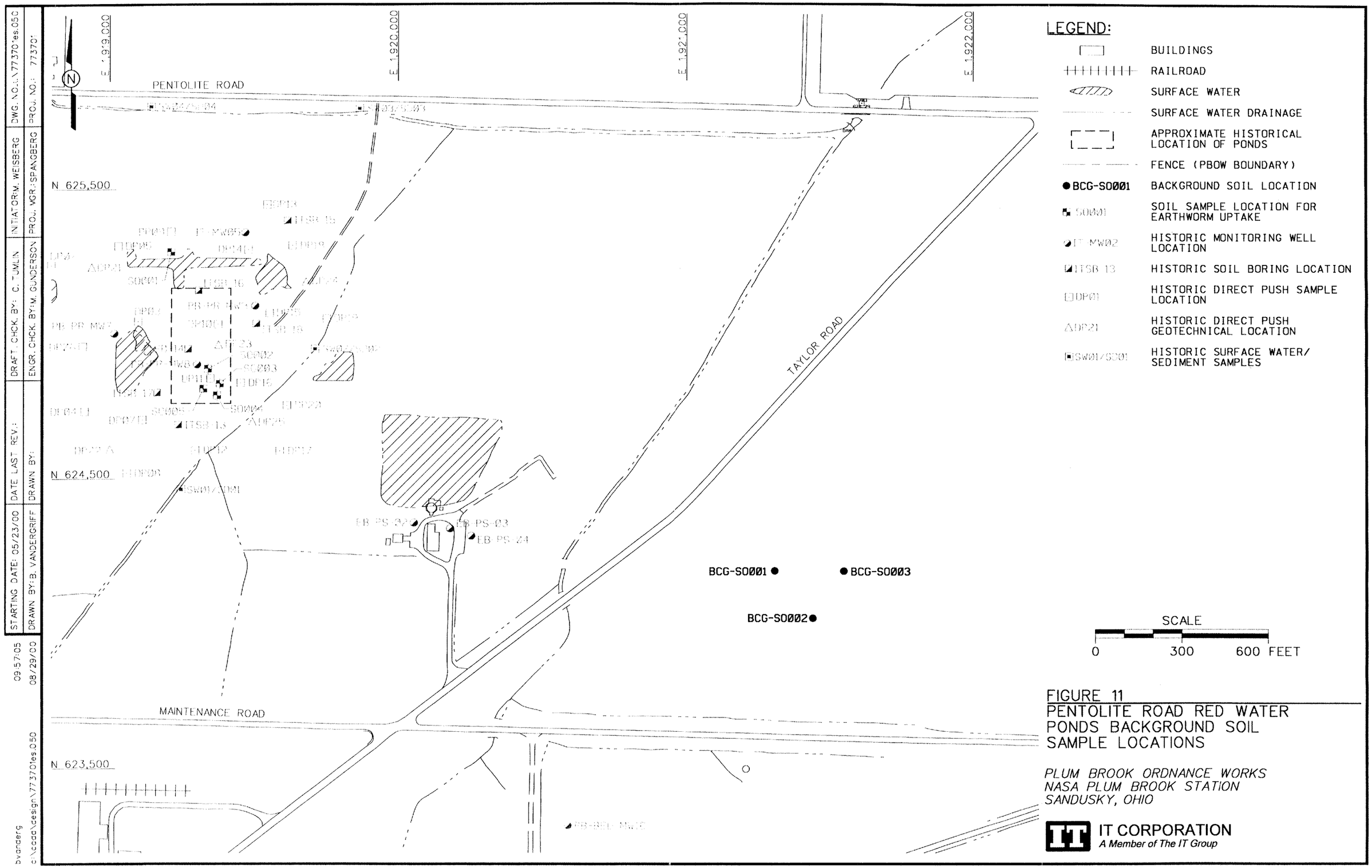

FIGURE 11
PENTOLITE ROAD RED WATER PONDS BACKGROUND SOIL SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

APPENDIX A

RECOMMENDED LABORATORY SPIKING PROTOCOL

Laboratory Spiking Procedures

Two standard methods for soil/sediment spiking may be used, as follows:

Water Soluble Compounds – If the compound is water soluble, then a water stock solution is prepared and dosed into the soil or sediment based on dry weight. The entire sample is then mixed in an industrial mechanical mixer (e.g., Hobart) constructed of stainless steel for 15 minutes. Following mixing, the soil or sediment is then allocated to the appropriate exposure vessels.

Organic or Insoluble Compounds – If the compound is an organic substance or has low water solubility and a high Kow value, then application by using a jar-rolling technique is appropriate. With this technique, the appropriate amount of compound is dissolved in approximately 25 mL of organic solvent (e.g., acetone) and then placed in a 1 gallon jar. The jar is then rolled for approximately 10 minutes to evaporate the co-solvent off and the compound is coated on the jar wall. After coating the wall, the approximate amount of sediment, based on dry weight, is added and the jar is rolled for at least 4 hours.

APPENDIX B

VERIFICATION SITE VISIT MEMO
DATED JULY 18, 2000

IT Corporation

Memo

To: Mikael Spangberg, Lannae Long

From: Mark Weisberg

CC: Michael Gunderson, Knoxville Project Files-

Date: 7/18/00

Re: Former Plum Brook Ordnance Works, Red Water Ponds, Phase 2 Ecological Risk Assessment, Verification Site Visit Conducted June 29-30, 2000

This memo provides a summary of the Field Verification Site Visit for the former Plum Brook Ordnance Works (PBOW), Red Water Ponds (RWPs), Phase 2 Ecological Risk Assessment (ERA). This memo serves as Step 5 of the eight-step ERA process being performed for the sites. IT Corporation (IT) has provided an ecological risk professional (Mr. Weisberg) to the project to verify that methods and sampling efforts as described in Section 4.0 of the ERA Work Plan (IT, 2000) are actually feasible at the RWP sites.

Meeting Attendees
Mr. Mark Weisberg – IT
Ms. Linda Ingram – USACE Nashville
Captain John Osborn – USACE Huntington
Mr. David Kessler – IT
Mr. Keith Peecook – PBS (6/29/00 only)
Mr. John Blakeman – RAB (6/30/00 only)

Not Able to Attend
Ms. Laurie Moore – OEPA
Mr. Ron Nabors – OEPA
Mr. Richard Kunath – PBS

The meeting started at approximately 10:00 AM on June 29, 2000. Calls were placed to OEPA and it was determined that Ms. Moore and Mr. Nabors would not be attending. Mr. Weisberg presented the proposed Phase 2 ERA approach to the group present and answered questions.

It was discussed what should be done if proposed soil sample locations are inundated with surface water during the actual field sampling event (an unlikely but possible situation). The group decided that wet soil could be collected as is with appropriate notations on the sample collection log. Note: if proposed surface water/sediment locations are dry, no sample(s) will be collected.

The option of having the laboratory spike soil or sediment samples with particular chemical constituents was discussed, in the event targeted chemicals of concern (COC) are not detected in these media (see Work Plan Sections 4.2.1 and 6.0). The point was raised that if COCs such as a nitroaromatics could not be found at the resampled historic hotspot, spiking the sample with target COCs could be problematic, especially if bioavailability is artificially elevated compared with *in-situ* COC bioavailability. It should be noted that this relates only to the proposed uptake studies, not to the proposed toxicity studies as the toxicity studies must be started as soon as the samples (i.e., media) are received by the bioassay laboratory, whereas the uptake studies may be started later after the chemical analytical

results from the media are available. It is recommended that spiking media at the laboratory not be performed for COCs that have a low frequency of detection (below 5 percent; such as for 4-amino-2,6-DNT) because these constituents are unlikely to remain COCs in the Phase 2 ERA Report.

Potential sampling locations for background soil were discussed. Mr. Peecook suggested that as major portions of PBS are burned semi-annually to control vegetation, and as burning may result in the production of some chemicals such as polycyclic aromatic hydrocarbons (PAHs), background locations that are within the burned areas should be selected. This recommendation was accepted by the group. As the Pentolite Road RWP is within the prescribed burning area, three background soil samples were located and staked within a similarly burned area that has no history of PBS production or operation (an open field area about 300 feet from the PBS water tower and surrounded by Taylor Road, Maintenance Road, and Columbus Avenue approximately 2,500 feet east southeast of the Pentolite Road RWP). Since the West Area RWP is not within the prescribed PBS burning area, the background soil sample locations for this site were not selected to be within a burned area. For the West Area RWP, three background soil samples were located and staked in a pristine forested area approximately 600 feet due west of the RWP.

Other proposed sample locations (as presented in the Work Plan) were discussed and the general areas in which they are located were visited. It should be noted that some of the areas had historic sample locations surveyed in and flagged by surveyors that were at the site to assist in orientation. Enough surface water was available at the proposed surface water/sediment sites for sample collection (most likely due to the wet spring) and it appeared that viable fish habitat exists. Minnows were observed in the unnamed creek flowing along Pentolite Road at the Pentolite Road RWP, and a great blue heron was seen at the open water West Area RWP. The water at the West Area RWP had significant growth of submergent aquatic macrophytes, while the Pentolite Road flowage had filamentous green algae.

On the morning of June 30, 2000 the group met Mr. John Blakeman, a member of the citizen Restoration Advisory Board (RAB). Mr. Blakeman is a biologist and knows the botany of PBS very well. He gave the group a tour of significant PBS botanical sites, and commented that the vegetative assemblage at the proposed Pentolite Road RWP background sampling locations had different species than the RWP area itself, suggesting different soil types. He recommended comparing soil types from an Eire County soil survey map to ensure similar soil types are indeed present at both locations. He agreed with the proposed background soil sample locations at the West Area RWP. Mr. Blakeman noted that more recent unpublished soil survey data may be available at the USDA Soil Service Center in Sandusky, Ohio.

Mr. Weisberg visited the USDA Soil Service Center located at 2900 Columbus Avenue at 1:30 PM June 30, 2000 to obtain any recent unpublished soil survey data, however, the office was closed with staff out in the field. A copy of the 1971 Erie County Soil Survey was picked up and reviewed by Mr. Weisberg. The proposed background soil locations for the Pentolite Road RWP and the RWP itself are both within the Arkport Galen soil association (one of the 12 main soil associations identified for Erie County). Although specific soil types within the Arkport Galen soil type differ between the two areas, it may be difficult to match the exact soil type, especially as the Pentolite Road RWP area has at least five different sub-Arkport Galen soil types. It should be noted that background soil COCs are less important than background surface water and sediment COCs, due to fewer inorganic risk drivers in the soil media. It should also be noted that the existing background soil database consists of results from 12 to 26 soil samples, therefore the collection of six additional background soil samples is a minor point.

It was discussed how exact locations of proposed sample locations would be identified in the field during the sampling event. Proposed surface water, sediment, and fish locations within open water may not be able to be flagged by surveyors (due to the water depth), and a global positioning system (GPS) might have to be used to pinpoint the desired sample locations.

Site conditions and feasibility of the proposed approach are documented herein and are being sent to CELRN, PBS and OEPA. This memo confirms the proposed Work Plan sampling design.

At the conclusion of ERA Step 5, there is a scientific management decision point (SMDP). IT had assumed that a proposed field conference call would fulfill SMDP 5. However, as OEPA did not attend the site visit, final resolution on this SMDP cannot be made at this time. IT had assumed that this Field Verification Memorandum for the record would be sufficient documentation for this ERA Step. It is now proposed that upon receipt of OEPA comments on the work plan and this memo, this memo will be revised as appropriate, and in its revised form it will serve as sufficient documentation for this ERA Step.

Action Items

- OEPA to provide comments on draft Phase 2 ERA Work Plan.
- OEPA to approve proposed background soil sampling locations.
- OEPA to comment on the recommendation in this memo that it is unnecessary for the bioassay laboratory to spike COCs in collected media (for subsequent uptake studies) if chemical analysis shows target COCs are non detect and the COC has been shown to have an historical frequency of detection of less than 5 percent.

APPENDIX C

BIOASSAY TEST RESULTS

Summary of Test Conditions for Fathead Minnow, *Pimephales promelas*, Larval Survival and Growth Toxicity Tests	
Test type	Static Renewal
Temperature	25±1°C
Light Quality	Ambient laboratory illumination
Light intensity	50-100 ft-c (ambient laboratory levels)
Photoperiod	16 hours light, 8 hours dark
Test chamber size	500 ml (minimum)
Test solution volume	250 ml (minimum)
Renewal of test solutions	Daily
Age of test organisms	Newly hatched larvae less than 24 hours old
Number of larvae per test chamber	10 (minimum)
Number of replicate chambers per sample	5
Number of larvae per sample	50 (minimum)
Feeding regime	0.15 g of newly hatched *Artemia* nauplii fed twice daily up to but not including the last 12 hours of testing
Cleaning	Siphon daily, immediately prior to test solution renewal
Parameters measured	Alkalinity, hardness, and conductivity on the sample prior to testing; D.O., pH, and temperature daily
Aeration	None, unless DO concentration falls below 4.0 mg/L. Aeration rate should not exceed 100 bubbles/minute.
Control Water	Synthetic fresh water or laboratory-grade natural fresh water matching the site-specific hardness. A laboratory control should also be used matching the hardness of the culture water
Test concentrations	Samples will be tested undiluted only. No concentrations will be used
Test duration	7 days
Test acceptability criteria	≥80% laboratory control survival; ≥0.25 mg average dry weight per surviving laboratory control organism
Sample requirements	Sample will be collected once, and used for renewals throughout test period. Sample should be used within 36 hours of collection.

Summary of Test Conditions for Daphnid, *Ceriodaphnia dubia*, Survival and Reproduction Toxicity Tests	
Test type	Static Renewal
Temperature	25±1°C
Light Quality	Ambient laboratory illumination
Light intensity	50-100 ft-c (ambient laboratory levels)
Photoperiod	16 hours light, 8 hours dark
Test chamber size	30 ml (minimum)
Test solution volume	15 ml (minimum)
Renewal of test solutions	Daily
Age of test organisms	<24 hours old and all released within an 8-hour period
Number of neonates per test chamber	1
Number of replicate chambers per sample	10
Number of neonates per sample	10
Feeding regime	0.1 ml of YCT and algal suspension per test chamber daily
Cleaning	Freshly cleaned glass beakers of new plastic cups are used daily
Parameters measured	Alkalinity, hardness, and conductivity on the sample prior to testing; D.O., pH, and temperature daily
Aeration	None
Control Water	Synthetic fresh water or laboratory-grade natural fresh water matching the site-specific hardness. A laboratory control should also be used matching the hardness of the culture water
Test concentrations	Samples will be tested undiluted only. No concentrations will be used
Test duration	Until 60% of surviving control organisms have three broods (maximum test duration 8 days)
Endpoints	Survival and reproduction
Test acceptability criteria	≥80% laboratory control survival and an average of 15 or more young per surviving female in the laboratory control. 60% of surviving laboratory control organisms must produce three broods;
Sample requirements	Sample will be collected once, and used for renewals throughout test period. Sample should be used within 36 hours of collection.

Summary of Test Conditions for Amphipod, *Hyalella azteca*, Survival and Growth Toxicity Tests	
Test type	Whole sediment with renewal of overlying water
Temperature	23±1°C
Light Quality	Wide spectrum fluorescent lights
Light intensity	~500 – 1000 lx
Photoperiod	16 hours light, 8 hours dark
Test chamber size	300 ml (minimum)
Test solution volume	100 ml sediment and 175 ml overlying water
Renewal of test solutions	2 volume additions per day
Age of test organisms	7-14 days old at the start of the test
Number of organisms per test chamber	10
Number of replicate chambers per sample	8
Number of organisms per sample	80
Feeding regime	1.5 ml of YCT suspension per test chamber daily
Cleaning	If overflow screens are clogged, gently brush the outside of the screens to clean
Parameters measured	Alkalinity, hardness, and conductivity at the beginning and end of the test; D.O., pH, and temperature daily
Aeration	None, unless DO concentration falls below 4.0 mg/L. Aeration rate should not exceed 100 bubbles/minute.
Overlying Water and Control Sediment	Synthetic fresh water or laboratory-grade natural fresh water matching the site-specific hardness and laboratory-grade sediment demonstrated to have sufficient survival and growth
Test concentrations	Samples will be tested undiluted only. No concentrations will be used
Test duration	10 days
Endpoints	Survival and growth
Test acceptability criteria	≥80% laboratory control survival
Sample requirements	Sediment sample will be collected once and not changed throughout the test period. Sample should be used within 10 days of collection.

Summary of Test Conditions for Oligochaete, *Lumbriculus variegatus*, Bioaccumulation Tests	
Test type	Whole sediment with renewal of overlying water
Temperature	23±1°C
Light Quality	Wide spectrum fluorescent lights
Light intensity	~100 – 1000 lx
Photoperiod	16 hours light, 8 hours dark
Test chamber size	4 – 6 liter aquaria with stainless steel screens or glass standpipes
Test solution volume	1 Liter or more of both sediment and overlying water (TOC dependent)
Renewal of test solutions	2 volume additions per day
Age of test organisms	Adults
Number of organisms per test chamber	Ratio of TOC in sediment to organisms dry weight should be no less than 50:1.
Number of replicate chambers per sample	5
Number of organisms per sample	See above
Feeding regime	None
Cleaning	If overflow screens are clogged, gently brush the outside of the screens to clean
Parameters measured	Alkalinity, hardness, and conductivity at the beginning and end of the test and weekly throughout; D.O., pH, and temperature daily
Aeration	None, unless DO concentration falls below 2.5 mg/L. Aeration rate should not exceed 100 bubbles/minute.
Overlying Water and Control Sediment	Synthetic fresh water or laboratory-grade natural fresh water matching the site-specific hardness and laboratory-grade sediment demonstrated to have sufficient survival and growth
Test concentrations	Samples will be tested undiluted only. No concentrations will be used
Test duration	28 days
Endpoints	Bioaccumulation
Depuration	Organisms are isolated in clean water the day prior to testing in order to purge gut contents; guts are depurated for 6 hours in clean water at the end of the test
Test acceptability criteria	None specified
Sample requirements	Sediment sample will be collected once and not changed throughout the test period. Sample should be used within 60 days of collection.

Summary of Test Conditions for Earthworm, *Eisenia fetida*, Bioaccumulation Tests	
Test type	Whole soil
Temperature	25±1°C
Light Quality	Wide spectrum fluorescent lights
Light intensity	50 – 100 foot candles
Photoperiod	Continuous light
Test chamber size	4-liter
Test solution volume	1500 g
Renewal of test solutions	None
Age of test organisms	Adults
Number of organisms per test chamber	75
Number of replicate chambers per sample	5
Number of organisms per sample	375
Feeding regime	None
Cleaning	None
Aeration	None
Control Soil	Laboratory-grade soil demonstrated to have sufficient survival and growth and to have no contamination
Test concentrations	Samples will be tested undiluted only. No concentrations will be used
Test duration	28 days
Endpoints	Bioaccumulation
Depuration	Organisms are isolated on moist paper prior to testing in order to purge gut contents; guts are depurated for 6 hours on moist paper at the end of the test
Test acceptability criteria	At least 80% survival in the control
Sample requirements	Soil sample will be collected once and not changed throughout the test period. Sample should be used within 60 days of collection.

Site-Specific Safety and Health Plan
Phase 2 Ecological Risk Assessment
Former Plum Brook Ordnance Works
Sandusky, Ohio

Prepared by:

IT Corporation
312 Directors Drive
Knoxville, Tennessee 37923

Submitted to:

Commander
U.S. Army Corps of Engineers, Nashville District
Post Office Box 1070
Nashville, Tennessee 37202-1070

IT Project No. 807112
Control Copy No. 12

August 2000
Revision 0

This Site-Specific Safety and Health Plan Attachment must be used in conjunction with the Sitewide Safety and Health Plan for Site Investigations and Groundwater Investigations at the former Plum Brook Ordnance Works, dated July 1997.

Reviews and Approvals

for M.L. Springberg 6/7/00

Project Manager
IT Corporation

Date

6/5/2000

Health and Safety Manager
IT Corporation

Date

6/7/00

Site Coordinator
IT Corporation

Date

6/7/00

Site Safety and Health Officer
IT Corporation

Date

This Site-Specific Safety and Health Plan Attachment must be used in conjunction with the Sitewide Safety and Health Plan for Site Investigations and Groundwater Investigations at the former Plum Brook Ordnance Works, dated July 1997.

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Plum Brook Project Emergency Contacts

Note: All field crews will be provided 2-way radios from the Plum Brook Communications Center. In the event of an emergency, contact the Plum Brook Communications Center by radio and they will contact and coordinate emergency response personnel.

Fire Department	(419) 627-5837
Ambulance	911
Police Department	(419) 627-5863
Providence Hospital	(419) 621-7000
National Response Center	(800) 424-8802
Poison Control Center	(800) 462-0800
Ohio EPA Emergency Spill Number	(800) 282-9378
Linda Ingram, USACE Technical Coordinator	(615) 736-7122
Mike Spangberg, IT Project Manager	(865) 690-3211
Mike Gunderson, IT Site Manager	2-way radio
Mike Henderson, IT H&S Manager	(865) 690-3211
Dr. Elaine Theriault, IT Occupational Physician	(800) 299-3674

Table of Contents

Page

List of Tables ii
List of Figures ii
1.0 Site Work Plan Summary 1
2.0 Site Characterization and Analysis 2
2.1 Anticipated Hazards 2
2.2 General Site Information 2
3.0 Personal Protective Equipment 3
4.0 Site Monitoring 6
5.0 Activity Hazard Analysis 7

List of Tables

Number	Title	Follows Page
2-1	Toxicological and Physical Properties of Chemicals	2
4-1	Action Levels	6
5-1	Activity Hazard Analysis	7

List of Figures

Figure	Title	Follows Page
1-1	Site and Hospital Location Map	1
1-2	Route From Red Water Ponds to U.S. Highway 250	1

List of Acronyms

DNT	dinitrotoluene
DOD	Department of Defense
ERA	ecological risk assessment
PBOW	Plum Brook Ordnance Works
PPE	personal protective equipment

1.0 Site Work Plan Summary

Project Objective. This site-specific safety and health plan supports the Work Plan for the proposed Phase 2 ecological risk assessment at the former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio. The goal of this project is to produce a supplement to the Phase I (screening-level) ecological risk assessment (International Technology Corporation, 1999) with additional site-specific information to determine if revised estimated ecological hazards to potentially exposed receptors are within acceptable guidelines. Two sites within the Red Water Ponds areas are the focus of this ERA; the West Area Red Water Ponds and the Pentolite Road Red Water Ponds.

The environmental impact of the past Department of Defense operations at the PBOW site is being evaluated by the U.S. Army under the Defense Environmental Restoration Program, Formerly Used Defense Sites funding. This work is being pursued and technically overseen by the U.S. Army Corps of Engineers, Nashville District (CELRN, formerly CEORN).

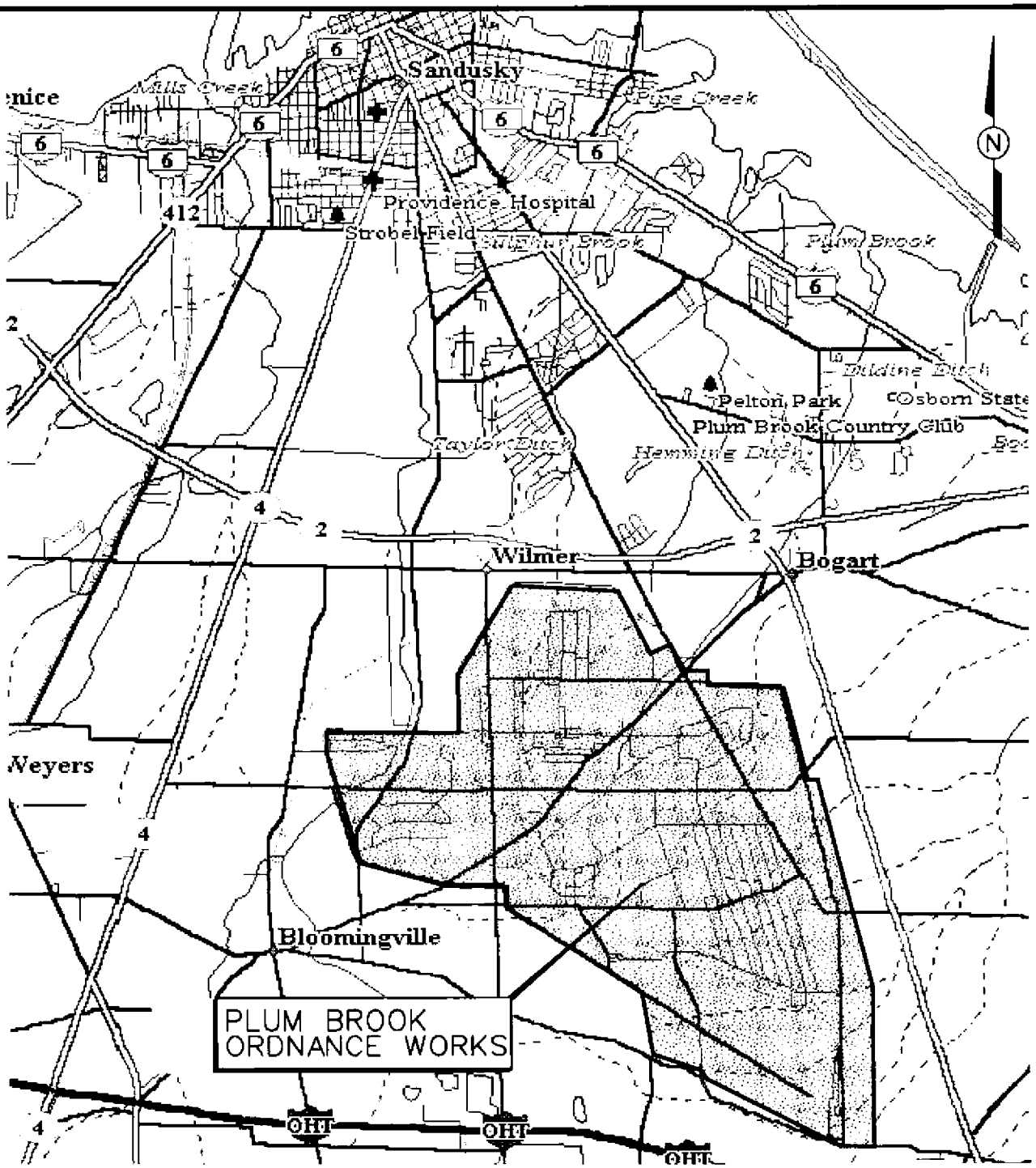
Project Tasks

- Surveying
- Soil boring and sampling
- Sediment and surface water sampling
- Fish sampling
- Decontamination of equipment (pressure washing operations)

Personnel Requirements. Up to 10 employees.

Note: All personnel on this site shall have received training, informational programs, and medical surveillance as outlined in the sitewide safety and health plan for site investigations at PBOW and be familiar with the requirements of this site-specific sitewide safety and health plan. Figure 1-1 presents PBOW and the hospital location map. Figure 1-2 shows the route from Red Water Ponds to U.S. Highway 250. The Red Water Ponds' work zones will change daily due to the large area to be sampled. Based on the sampling, sufficient work zones' boundaries will be established at least 10 feet from surface sampling locations and 30 feet from all boring locations.

Project Schedule. Summer 2000.



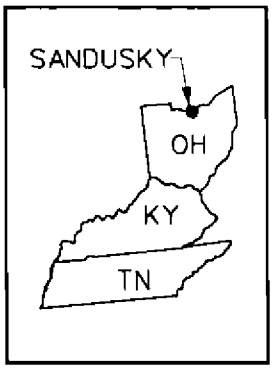


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FIGURE 1-1
SITE AND HOSPITAL
LOCATION MAP

PLUM BROOK ORDNANCE WORKS
SANDUSKY, OHIO

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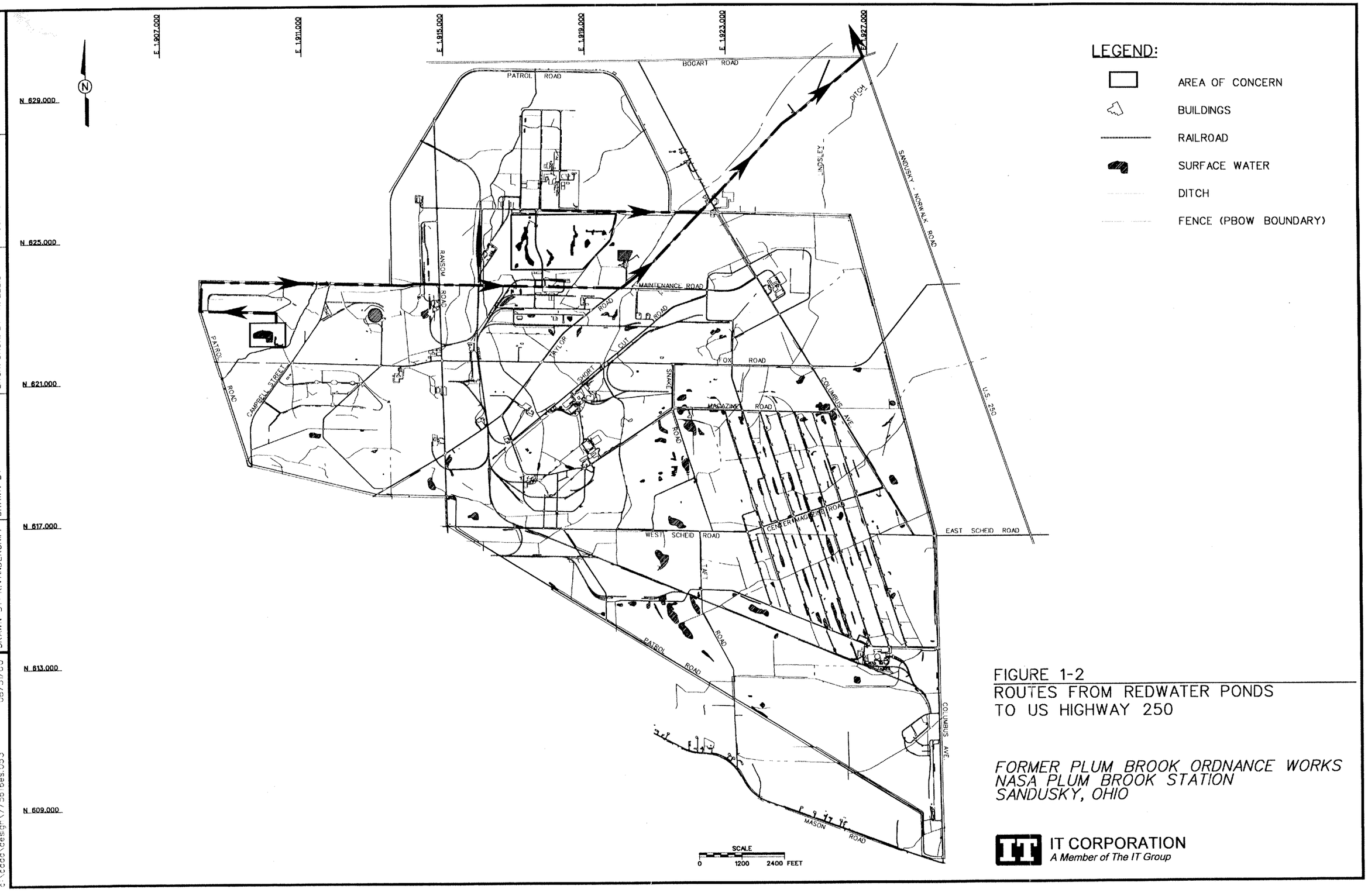

FIGURE 1-2
ROUTES FROM REDWATER PONDS
TO US HIGHWAY 250

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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2.0 Site Characterization and Analysis

2.1 Anticipated Hazards

The activity hazard analysis in Chapter 5.0 contains project-specific practices utilized to reduce or eliminate anticipated site hazards. The activity hazard analysis indicates specific chemical and physical hazards that may be present and encountered during each task from on-site operations. Below each task is a list of hazards and specific actions that will be taken to control the respective hazards. These control measures may include work practice controls, engineering controls, and/or use of appropriate personal protective equipment (PPE).

The contaminants of potential concern include antimony, arsenic, chromium, coal tar pitch volatiles, 1,3-dinitrobenzene, 2,4-dinitrotoluene (DNT), lead, and manganese. The maximum concentrations of these contaminants found in earlier investigations are as follow:

Table 2-1 contains chemicals anticipated and chemicals to be used during project activities.

2.2 General Site Information

Chemical contamination related to former Department of Defense (DOD) activities has been documented at the former PBOW located near Sandusky, Ohio. The PBOW was operated from 1941 to 1945 as a manufacturing plant for trinitrotoluene, DNT, and pentolite. Some of the areas used by the DOD were decontaminated in the 1950s and 1960s in accordance with DOD standards at that time; other areas have been decommissioned, but not decontaminated. The site is currently owned by the National Aeronautics and Space Administration and is operated as the Plum Brook Station of the John Glenn Research Center at Lewis Field. The John Glenn Research Center is located in Cleveland, Ohio.

Table 2-1

Toxicological and Physical Properties of Chemicals
Plum Brook Ordnance Works, Sandusky, Ohio

Substance [CAS]	IP[a] (eV)	Odor Threshold (ppm)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
Antimony and compounds (as Sb) [7440-36-0]	NA	NA	Inh Con Ing	Irritated nose, throat, and mouth; cough; dizziness and headache; nausea and vomiting; diarrhea and stomach cramps; insomnia; irritated skin; unable to smell properly.	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention	0.5 mg/m^3 0.5 mg/m^3	NA NA	PEL TLV	50 mg/m^3 (as Sb)
Arsenic (soluble and inorganic compounds, as As) [7740-38-2]	NA	odorless	Inh Abs Ing Con	Ulceration of nasal septum, dermatitis, gastrointestinal disturbances; respiratory irritation. Carcinogenic.	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention	0.01 mg/m^3 0.01 mg/m^3 (Ca - See 29 CFR 1910.1018)	NA NA	PEL TLV	Ca [5 mg/m^3 (as As)]
Coal-tar-pitch volatiles (benzene-soluble fraction) (polynuclear aromatic hydro-carbons [PAH]) [65996-93-2]	NA	tar NA	Inh Con	Eye sensitivity to light, eye and skin irritation; dermatitis, bronchitis. Carcinogenic.	Eye: Irrigate immediately Skin: Soap wash Breath: Respiratory support Swallow: Immediate medical attention	0.2 mg/m^3 0.2 mg/m^3 (Ca - See 29 CFR 1910.1002)	NA NA	PEL TLV	Ca [80 mg/m^3]
Chromium (as Cr) [7440-47-3]	NA	NA	Inh Ing Con	Irritation of eyes, skin, and upper respiratory system; fibrosis of lungs.	Eye: Irrigate immediately Skin: Wash flush Breath: Respiratory support Swallow: Immediate medical attention	1 mg/m^3 0.5 mg/m^3	- -	PEL TLV	250mg/m^3 (as Cr)
1,3-Dinitrobenzene [99-65-0]	10.43		Inh Abs Ing Con	Anoxia, cyanosis, visual disturbances, central blind spot of vision, bad taste, burning of mouth, dry throat, thirsty; yellowing hair, eyes, and skin; anemia, liver damage.	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention	1 mg/m^3 (skin) 1 mg/m^3 (skin) 1 mg/m^3 (skin)		PEL TLV REL	50 mg/m^3
2,4-Dinitrotoluene (DNT)	N/A	-	Inh Abs Ing	Anoxia, cyanosis, anemia, jaundice; reproductive effects. Animal carcinogen.	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support	1.5 mg/^{3} (skin) NIC-0.2 mg/m^3 (skin)	- - -	PEL TLV REL	Ca [50 mg/m^3)

Table 2-1

Toxicological and Physical Properties of Chemicals
Plum Brook Ordnance Works, Sandusky, Ohio

Substance [CAS]	IP[a] (eV)	Odor Threshold (ppm)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
			Con		Swallow: Immediate medical attention	1.5 mg/m³ (skin)			
Lead inorganic dusts & fumes (as Pb) [7439-92-1]	NA	NA	Inh Ing Con	Weakness, lassitude, insomnia; facial pallor; eye pallor, low body weight, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremors; wrist and ankle paralysis; brain damage; kidney damage; irritated eyes; hypotension.	Eye: Irrigate immediately Skin: Soap flush promptly Breath: Respiratory support Swallow: Immediate medical attention	0.05 mg/m³ 0.05 mg/m³ (NIC) (CA - See 29 CFR 1910.1025)	NA NA	PEL TLV	100 mg/m³ (as Pb)
Manganese compounds (as Mn) and fumes [7439-96-5]	NA	NA	Inh Ing	Parkinson's; asthenia, insomnia, mental confusion; metal fume fever; dry throat, cough, tight chest, dyspnea, rales, flu-like fever; low-back pain; vomiting; malaise; fatigue.	Breath: Respiratory support Swallow: Immediate medical attention	NA 0.2 mg/m³ (NIC)	C 5 mg/m³ NA	PEL TLV	500 mg/m³ (as Mn)

[a]IP = Ionization potential (electron volts).
[b]Route = Inh, Inhalation; Abs, Skin absorption; Ing, Ingestion; Con, Skin and/or eye contact.
[c]TWA = Time-weighted average. The TWA concentration for a normal work day (usually 8 or 10 hours) and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day without adverse effect.
[d]STEL = Short-term exposure limit. A 15-minute TWA exposure that should not be exceeded at any time during a work day, even if the TWA is not exceeded.
[e]PEL = Occupational Safety and Health Administration (OSHA) permissible exposure limit (29 CFR 1910.1000, Table Z).
TLV = American Conference of Governmental Industrial Hygiene (ACGIH) threshold limit value—TWA.
REL = National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit.
[f]IDLH (NIOSH)—Immediately dangerous to life or health (NIOSH). Represents the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing or irreversible health effects.
NE = No evidence could be found for the existence of an IDLH (NIOSH Pocket Guide to Chemical Hazards, Pub. No. 90-117, 1990).
C = Ceiling limit value which should not be exceeded at any time.
Ca = Carcinogen.
NA = Not applicable.
NIC = Notice of intended change (ACGIH).

3.0 Personal Protective Equipment

The work activities will begin in the following levels of protection.

Task	Initial Level of PPE
Surveying	Level D
Soil boring and sampling	Level D*
Sediment and surface water sampling	Level D*
Fish Sampling	Level D*
Decontamination of equipment	Modified Level D

*Initial level will be raised to Level C or higher if air monitoring results in the worker's breathing zone are above action levels. Note: If unusual conditions or odors are encountered and air monitoring instruments do not detect volatile organic chemicals or hydrogen sulfide, turn equipment off, evacuate the work area, and contact the Health and Safety Manager for further assistance.

A complete description of Level D, Modified Level D, and Level C follows.

Level D. The following equipment will be used for Level D protection:

- Coveralls or work clothing
- Steel-toed safety boots
- Safety glasses
- Hard hat
- Nitrile gloves (when handling potentially contaminated materials)
- Hearing protection (when working near/adjacent to operating equipment)
- U.S. Coast Guard-approved personal flotation device (where potential for drowning exists).

Modified Level D. The following equipment will be used for Modified Level D protection:

- Permeable Tyvek, Kleenguard, or its equivalent
- Polyvinyl chloride boot covers
- Nitrile gloves (outer)
- Lightweight nitrile gloves (inner)
- Steel-toed safety boots
- Safety glasses
- Hard hat
- Hearing protection (when working near/adjacent to operating equipment).

Level C. Level C protection will not be used unless air monitoring data indicate the need for upgrade; however, the equipment shall be readily available on site. The following equipment will be used for Level C protection:

- National Institute of Occupational Safety and Health-approved full face, air purifying respirators equipped with organic vapor/acid gas/P100 cartridge
- Hooded, saran-coated Tyvek, taped at gloves, boots, and respirator
- Nitrile gloves (outer)
- Lightweight nitrile gloves (inner)
- Neoprene steel-toed boots or polyvinyl chloride overbooties/steel-toed safety boots
- Hard hat
- Hearing protection (when working near/adjacent to operating equipment).

Personnel Decontamination: All personnel working in the exclusion zone wearing modified Level D PPE or higher must undergo personnel decontamination prior to entering the support zone. Wearing Level D PPE will require washing of hands after proper disposal of sampling gloves. The personnel decontamination area shall consist of the following stations:

Station 1. Personnel leaving the exclusion zone will remove the gross contamination by physical means from their outer clothing and boots (i.e., dislodging/displacement, rinsing, wiping, brushing etc.).

Station 2. Equipment for this station may include plastic-lined waste receptacle, chair, clean damp cloths or paper towels, and plastic bags. At Station 2, personnel will remove their Tyvek coveralls and gloves and deposit them in the lined waste receptacles. Personnel will wipe their respirators (if used), hard hats, and boots with clean, damp cloths and then remove those items. Those items are then hand-carried to the next station.

Station 3. Equipment for this station may include a wash basin with soap and water and a respirator sanitation station. At this station, personnel will thoroughly wash their hands and face before leaving the decontamination zone. Respirators will be sanitized and then placed in a clean, plastic Ziplock® bag.

Donning Procedures.

- Put on boots and boot covers and tape the coveralls over the boots.
- Put on gloves.
- Tape the coveralls over the gloves at the wrist.
- If Level C PPE is required, don respirator and check for secure fit.
- Put hood or head covering over the respirator.
- Put on the remaining protective equipment (i.e., hard hat, safety glasses, etc.).

4.0 Site Monitoring

The potential contaminants of concern include antimony, arsenic, chromium, coal tar pitch volatiles, 1,3-dinitrobenzene, 2,4-DNT, lead, and manganese.

Table 4-1 contains action levels for site monitoring.

Monitoring will be performed by the site safety and health officer initially for the location, then periodically during the performance of boring operations (sampling every 5- to 10-foot soil boring depth). A calibrated photoionization detector will be utilized to monitor the wells and breathing zones to determine if any organic compounds may be present that would necessitate upgrading of protection level.

No air monitoring is required for operations that do not disturb existing materials (i.e., site setup, surveying, decontamination, and miscellaneous support zone activities).

Table 4-1

Action Levels
Plum Brook Ordnance Works, Sandusky, Ohio

When in Level C PPE

Analyte	Action Level	Required Action[a,b]
Volatile organic compounds	• ≥ 25 ppm above background in BZ	Stop work, suspend work activities for 15 to 30 minutes, if readings are sustained, then upgrade to Level B personal protectivie equipment (PPE).

When in Level D/Modified D PPE

Analyte	Action Level	Required Action[a,b]
Volatile organic compounds	• ≥ 5 ppm above background in BZ	Stop activities, suspend work activities for 15 to 30 minutes; if readings are sustained, then upgrade to Level C PPE.

When in Support Zone

Analyte	Action Level	Required Action
Volatile organic compounds	• ≥ 1 ppm above background in BZ	Evacuate support zone and re-establish perimeter of EZ.

[a]Four instantaneous peaks in any 15-minute period or a sustained reading for 5 minutes in excess of the action level will trigger a response.
[b]Contact with the health and safety (H&S) manager must be made prior to continuance of work. The H&S manager may then initiate perimeter/integrated air sampling along with additional engineering controls.

No one is permitted to downgrade levels of PPE without authorization from the H&S manager.

5.0 Activity Hazard Analysis

The attached activity hazard analysis (Table 5-1) is provided for the following activities:

- Setup of equipment and general field activities
- Surveying
- Soil boring and sampling
- Fish sampling
- Sediment and surface water sampling
- Decontamination (pressure washing operations).

Table 5-1

Activity Hazard Analysis
Plum Brook Ordnance Works, Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Setup of equipment and general field activities	Slip, trip, and fall hazards	• Determine best access route before transporting equipment. • Practice good housekeeping; keep work area picked up and clean as feasible. • Continually inspect the work area for slip, trip, and fall hazards. • Look before you step; ensure safe and secure footing.
	Heavy lifting	• Use proper lifting techniques. Lifts greater than 60 pounds require assistance or mechanical equipment.
	Falling objects	• Stay alert and clear of materials suspended overhead; wear hard hat and steel-toed boots.
	Flying debris, dirt, dust, etc.	• Wear safety glasses/goggles; ensure that eye wash is in proper working condition.
	Pinch points	• Keep hands, fingers, and feet clear of moving/suspended materials and equipment. • Beware of contact points. • Stay alert at all times!
	Cuts/bruises	• Use cotton or leather work gloves for material handling.
	Bees, spiders, and snakes	• Inspect work area carefully and avoid placing hands and feet into concealed areas.
	Fire	• Fire extinguishers shall be suitably placed, distinctly marked, readily accessible, and maintained in a fully charged and operable condition.
	Hazard communication	• Label all containers as to contents and dispose of properly. • Ensure Material Safety Data Sheets (MSDS) are available for hazardous chemicals used on site.
	Noise	• Sound levels above 85 A-weighted decibels (dBA) mandates hearing protection.
	Lighting	• Adequate lighting will be provided to ensure a safe working environment.
	Cold stress	• Workers should wear insulated clothing when temperatures drop below 40°F. • Drink warm beverages on breaks. Refrain from drinking caffeinated beverages. • Remove wet clothing promptly. • Take breaks in warm areas. • Reduce work periods as necessary. • Layer work clothing.

Table 5-1

Activity Hazard Analysis
Plum Brook Ordnance Works, Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Setup of equipment and general field activities (continued)	Frostbite	• Personnel should wear inner cotton gloves and insulated socks to protect extremities from cold weather. • Take breaks in warm areas. • Remove wet gloves and socks promptly.
	Poison ivy/oak/sumac	• Avoid plant areas if possible. • Wear long sleeves and long pants. • Promptly wash clothing that has contacted poisonous plants. • Wash affected areas immediately with soap and water.
	Ticks	• Wear light-colored clothing (can see ticks better). • Mow vegetated and small brush areas. • Wear insect repellant. • Wear long sleeves and long pants. • Visually check oneself promptly and frequently after exiting the work area.
	Heat rash	• Keep the skin clean and dry. • Change perspiration-soaked clothing, as necessary. • Bathe at end of work shift or day. • Apply powder to affected area.
	Heat cramps	• Drink plenty of cool fluids even when not thirsty. • Provide cool fluid for work crews. • Move victim to shaded, cool area.
	Heat exhaustion	• Conduct physiological worker monitoring as needed (i.e., heart rate, oral temperature). • Set up work/rest periods. • Use the buddy system. • Allow workers time to acclimate. • Have ice packs available for use. • Take frequent breaks.
	Heat stroke	• Evaluate possibility of night work. • Perform physiological monitoring on workers during breaks. • Wear body cooling devices.

Table 5-1

Activity Hazard Analysis
Plum Brook Ordnance Works, Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Setup of equipment and general field activities (continued)	Contact with moving equipment/vehicles	• Work area will be barricaded/demarcated. • Equipment will be laid out in an area free of traffic flow. • Barricades shall be used on or around work areas when it is necessary to prevent the inadvertent intrusion of pedestrian traffic. • Barriers shall be used to protect workers from vehicular traffic. • Barriers shall be used to guard excavations adjacent to streets or roadways. • Flagging shall be used for the short term (less than 24 hours) to identify hazards until proper barricades or barriers are provided. • Heavy equipment shall have backup alarms.
	Forklift operations	• Use qualified and trained forklift operators. • The operator shall not exceed the load capacity rating for the forklift. • The load capacity shall be clearly visible on the forklift. • Forklift operators shall inform their supervisor of any prescribed medication that they are taking that would impair their judgement.
	Portable electric tools	• Portable electric tools which are unsafe due to faulty plugs, damaged cords, or other reason, shall be tagged (do not use) and be removed from service. • Portable electric tools and all cord and plug connected equipment shall be protected by a ground-fault circuit interrupter (GFCI) device. • Electrical tools shall be inspected daily prior to use.
	Extension cords	• Extension cords that have faulty plugs, damaged insulation, or are unsafe in any way shall be removed from service. • Cords shall be protected from damage from sharp edges, projections, pinch points (doorways), and vehicular traffic. • Cords shall be suspended with a nonconductive support (rope, plastic ties, etc.). • Cords shall be designed for hard duty. • Cords shall be inspected daily. • Cords shall be of adequate sized wire to power each device without exceeding size and distance requirements.
Setup of equipment and general field activities (continued)	Lightning strikes	• Whenever possible, halt activities and take cover. • If outdoors, stay low to the ground. • Limit the body surface area that is in contact with the ground (i.e., kneeling on one knee is better than laying on the ground). • Seek shelter in a building if possible. • Stay away from windows. • If available, crouch under a group of trees instead of one single tree. • Keep all body parts in contact with the ground as close as possible. • Remain 6 feet away from tree trunk if seeking shelter beneath tree(s). • If in a group, keep 6 feet of distance between people.
	Thunderstorms, tornadoes	• Listen to radio or TV announcements for pending weather information. • Cease field activities during thunderstorm or tornado warnings. • Seek shelter. Do not try to outrun a tornado.

Table 5-1

Activity Hazard Analysis
Plum Brook Ordnance Works, Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Surveying	Slip, trip, fall	• Provide adequate lighting in all work areas. • Whenever possible, avoid routing cords and hoses across walking pathways. • Flag or cover inconspicuous holes to protect against falls. • Work areas will be kept clean and orderly. • Garbage and trash will be disposed of daily in approved refuse containers. • Tools and accessories will be properly maintained and stored. • Work areas and floors will be kept free of dirt, grease, and slippery materials.
	Traffic accidents	• Place physical barrier (i.e., barricades, fencing) around work areas regularly occupied by pedestrians. • If working adjacent to roadways, have workers wear fluorescent orange vests. • Use warning signs or lights to alert oncoming traffic. • Assign flag person(s) if necessary to direct local traffic. • Set up temporary parking locations outside the immediate work area. • Motor vehicle operators shall obey all posted traffic signs, signals, and speed limits. • Pedestrians have the right-of-way. • Wear seat belts when vehicles are in motion.
	Wildlife hazards	• Workers should be cautious when driving through the site in order to avoid encounters with passing animals.
Soil Boring and Sampling	Overhead hazards	• Make sure no obstacles are within radius of boom. Always stay a safe distance from power lines.
	Faulty or damaged equipment being utilized to perform work	• All machinery or mechanized equipment will be inspected by a competent mechanic and be certified to be in safe operating condition. • Equipment will be inspected before being put to use and at the beginning of each shift. • Faulty/unsafe equipment will be tagged and if possible locked out. • Drill rigs shall be equipped with reverse signal alarm, backup warning lights, or the vehicle is backed up only when an observer signals it is safe to do so.
	Uneven terrain, poor ground support, inadequate clearances, contact with utilities	• Inspections or determinations of road conditions and structures shall be made in advance to ensure that clearances and load capacities are safe for the passage or placing of any machinery or equipment. • All mobile equipment and areas in which they are operated shall be adequately illuminated. • Aboveground and belowground utilities will be verified with NASA personnel, and delineated or flagged prior to staging equipment. • Whenever the equipment is parked, the parking brake shall be set. • Equipment parked on inclines will have the wheels choked. • Inspect brakes and tire pressure on drill rig before staging for work.
	Inexperienced operator	• Machinery and mechanized equipment shall be operated only by designated personnel. • Operators shall inform their supervisor(s) of any prescribed medication that they are taking that would impair their judgment.
	Jacks/outriggers	• Ensure proper footing and cribbing.

Table 5-1

Activity Hazard Analysis
Plum Brook Ordnance Works, Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
	Falling objects	• Remove unsecured tools and materials before raising or lowering the derrick. • Stay alert and clear of materials suspended overhead.
	Pinch points	• Keep feet and hands clear of moving/suspended materials and equipment. • Stay alert at all times!
	Fire	• Mechanized equipment shall be shut down prior to and during fueling operations. • Have fire extinguishers inspected and readily available.
	Fall hazards	• Personnel are not allowed to work off of machinery or use machinery as ladders. • Use fall protection when working above 6 feet.
Soil Boring and Sampling (continued)	Noise	• Hearing protection is mandatory above 85 dBA.
	Contact with rotating or reciprocating machine parts	• Use machine guards; use long-handled shovels to remove auger cuttings. • Use safe lockout procedures for maintenance work.
	Heavy lifting	• Use proper lifting techniques. Lifts greater than 60 pounds require assistance or mechanical equipment; size-up the lift.
	Slip, trip, and fall hazards	• Practice good housekeeping; keep work area picked up and clean as feasible. • Continually inspect the work area for slip, trip, and fall hazards.
	Contact with potentially contaminated materials	• Real-time air monitoring will take place. If necessary, proper personal protective clothing and equipment will be utilized. • Stop immediately at any sign of obstruction. • Do not breathe air surrounding boring unless necessary. • Upgrade to respirator if necessary. • Avoid skin contact with soil cuttings. Wear gloves. • Stay clear of moving parts of drill rig.
	Drum handling	• Be careful not to breathe air from around open drum any more than necessary. Monitor with photoionization detector/flame ionization detector (PID/FID) equipment and upgrade to respirator if necessary. • When filling a drum (with either soil or water), be careful not to make contact with the contained waste. Wear appropriate gloves. Make sure lid or bung of drum is secure. • If moving a drum unassisted, be sure to leverage properly, use proper lifting techniques, and wear safety glasses and steel-toed boots. • When using a drum dolly, make sure straps and lid catch are securely attached. Leverage properly when tilting drum. Be sure toes stay away from drum.
Sediment and Surface Water Sampling; Fish Sampling	Contact with potentially contaminated materials	• Real-time air monitoring will take place. If necessary, proper personal protective clothing and equipment will be utilized. • Stop immediately at any sign of obstruction. • Upgrade to respirator if necessary. • Avoid skin contact with contaminated materials. Wear gloves.
	Drowning	• Wear an approved personal floatation device when working on, over, or adjacent to the water • Do not stand up in the boat • Wear harness and lanyard to on shore personnel when wading in creek beds.

Table 5-1

Activity Hazard Analysis
Plum Brook Ordnance Works, Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Sediment and Surface Water Sampling; Fish Sampling, (continued)	Slip, trip, and fall hazards	• Practice good housekeeping; keep work area picked up and clean as feasible. • Continually inspect the work area for slip, trip, and fall hazards. • Wear chest waders with non-slip soles (carpet) when wading in creek beds or on slippery rocks.
	Electrical shock hazard	• Collectors using dip nets to catch stunned fish will wear rubber linemans' gauntlets or equivalent protection. • Test for leaks in waders if electrofishing using backpack unit or collecting downstream of electrofishing boat. • Electrofishing boat shall be equipped with foot safety switch that must be depressed to energize the anode. • Do not allow the anode or cathode to touch the boat or other conductive surfaces prior to placing in water for electrofishing. • Keep boots and gloves dry when handling electrofishing units (generators), controls, probes, and nets.
	Fueling Heavy lifting	• Use approved safety cans to store fuel; allow the engine to cool prior to fueling • Use proper lifting techniques. Lifts greater than 60 pounds require assistance or mechanical equipment; size-up the lift.
	Wildlife hazards	• Workers should be cautious when driving through the site in order to avoid encounters with passing animals. • Wear protective gloves and use wire cutters to snip barbs or spines from fish • Probe banks and shrubbery along creek beds to check for snakes or animals that could react violently if startled by approach.
	Lightning strikes	• Whenever possible, halt activities and take cover. • Return to shore and move away from the boat and waterway. • If outdoors, stay low to the ground. • Limit the body surface area that is in contact with the ground (i.e., kneeling on one knee is better than laying on the ground). • Seek shelter in a building if possible. • Stay away from windows. • If available, crouch under a group of trees instead of one single tree. • Keep all body parts in contact with the ground as close as possible. • Remain 6 feet away from tree trunk if seeking shelter beneath tree(s). • If in a group, keep 6 feet of distance between people.
	Thunderstorms, tornadoes	• Listen to radio or TV announcements for pending weather information. • Cease field activities during thunderstorm or tornado warnings. • Seek shelter. Do not try to outrun a tornado.
Pressure Washing Operations	Slip, trip, and fall hazards	• Good housekeeping shall be implemented. • The work area shall be kept clean as feasible. • Inspect the work area for slip, trip, and fall hazards.
	Fueling	• Only approved safety cans shall be used to store fuel. • Do not refuel equipment while it is operating or hot to touch. • Fire extinguishers shall be suitably placed, distinctly marked, readily accessible, and maintained in a fully charged and operable condition.
Pressure Washing Operations (continued)	Faulty or damaged equipment	• Equipment shall be inspected before being placed into service and at the beginning of each shift. • Preventive maintenance procedures recommended by the manufacturer shall be followed. • A lockout/tagout procedure shall be used for equipment found to be faulty or undergoing maintenance.

Table 5-1

Activity Hazard Analysis
Plum Brook Ordnance Works, Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
	High-pressure water	• Operator must wear appropriate PPE including hard hat, impact-resistant safety glasses with side shields, water-resistant clothing, metatarsal guards for feet and legs, and hearing protection (if appropriate). • One standby person shall be available within the vicinity of the pump during operation. • The work area shall be isolated and adequate barriers will be used to warn other site personnel.
	Unqualified operators	• Only qualified and trained personnel are permitted to operate machinery and mechanized equipment associated with water jet cutting and cleaning.
	Out of control equipment	• No machinery or equipment is permitted to run unattended. • Machinery or equipment will not be operated in a manner that will endanger persons or property nor will the safe operating speeds or loads be exceeded.
	Noise	• Sound levels above 85 dBA mandates hearing protection by nearby site personnel.
	Activation during repairs	• All machinery or equipment will be shut down and positive means taken to prevent its operation while repairs or manual lubrications are being done.
	Pinch points	• Keep feet and hands clear of moving/suspended materials and equipment. • Stay alert and clear of materials suspended
	Falling objects	• Hard hats are required by site personnel. • Stay alert and clear of material suspended overhead.
	Flying debris	• Impact-resistant safety glasses with side shields are required.
	Contact with potentially contaminated materials	• All site personnel will wear the appropriate PPE.