Final
August 2012

Proposed Plan for Reservoir No. 2 Burning Ground

Former Plum Brook Ordnance Works Sandusky, Ohio

FUDS Project No. G05OH001812

US Army Corps of Engineers

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Final
Proposed Plan
Reservoir No. 2 Burning Ground
Plum Brook Ordnance Works, Sandusky, Ohio
DERP-FUDS Project Number G05OH001812

Issued By U.S. Army Corps of Engineers
Huntington District

Prepared by Shaw Environmental, Inc.

August 2012

U.S. Army Corps of Engineers Announces Proposed Plan

This Proposed Plan identifies the Preferred Alternative for the cleanup of contaminated soil associated with the former Reservoir No. 2 Burning Ground (R2BG) of the former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio (Figure 1), and presents the rationale for this preference. The Preferred Alternative for the R2BG soils, as well as the other alternatives described herein, addresses the human health risks associated with potential soil exposure pathways. This Proposed Plan also presents a recommendation that no further action is necessary to protect human health and the environment with respect to groundwater underlying R2BG.

U.S. Army environmental investigations and remediation at PBOW are administered under the Defense Environmental Restoration Program-Formerly Used Defense Sites (DERP-FUDS) as required for such sites by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The U.S. Secretary of Defense delegated authority to the U.S. Army Corps of Engineers (USACE) to administer the DERP-FUDS program.

The Proposed Plan is a document issued by the USACE Huntington District, the lead agency for environmental response actions at the PBOW, to fulfill public participation requirements.

DATES TO REMEMBER

Comment Period
August 14 through September 18, 2012

Public Meeting
7 p.m. August 14, 2012, at Firelands Library
BGSU Foundation Hall
One University Drive

Comments can be directed to:

U.S. Army Corps of Engineers,
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The Preferred Alternative may be modified based on any new information or comments received during this designated public comment period. Therefore, the public is encouraged to review and comment on all information presented in the Proposed Plan or Administrative Record file. Proposed Plan was prepared in partnership with the Ohio Environmental Protection Agency (OEPA). As the lead agency, the USACE is charged with planning and implementing environmental investigations and remedial actions at PBOW associated with past U.S. Department of Defense (DoD) activities. The USACE Nashville District is acting as the contracting office for environmental investigations at PBOW and provides technical review. The USACE Huntington District is acting as the contracting and oversight office for remedial actions. The OEPA provides regulatory review, comment, and oversight.

This Proposed Plan is issued to accomplish the following:

- Provide basic background information about the site
- Describe all remedial options considered
- Identify the Preferred Alternative for soil associated with R2BG and explain reasons for the preference
- Solicit public review and comment on all alternatives
- Provide information on how the public can be involved in the remedy selection process.

The USACE, after consulting with the OEPA, will select a final remedy for R2BG soil after the public has had an opportunity to comment on this Proposed Plan and all comments received have been reviewed and considered. The comment period for the Proposed Plan is from August 14 through September 18, 2012, and the public meeting will be held at 7 p.m. on August 14 , 2012, at the Firelands Library, Firelands Campus of Bowling Green State University (BGSU), Huron, Ohio. The remedy selected for R2BG soil will be documented in a Decision Document.

The USACE is issuing this Proposed Plan for public comment as part of its public participation responsibilities consistent with Sections 117(a) and 113(k)(2)(B) of the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) of 1980, as amended by SARA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) under CERCLA Part 300.430(f)(2)&(3).

This Proposed Plan summarizes information presented in greater detail in documents contained in the Administrative Record (AR) file for R2BG. Background documents for R2BG are listed on Page 4 and can be found in the AR file. These background documents are referenced within

this Proposed Plan and are the basis of most of the information summarized herein. The USACE and the OEPA encourage the public to review these documents and the entire AR file to gain a more comprehensive understanding of R2BG and the associated site activities. The AR file, which contains information upon which the selection of the response action will be based, is maintained at the Huntington District Office, 502 Eighth Street, Huntington, West Virginia, 25701. The AR file can be viewed online at the USACE Huntington District Web site:
http://lrh-apps.usace.army.mil/fuds/index.asp
The local Public Repository of the AR file is:

Firelands Library – BGSU
Foundation Hall
One University Drive
Huron, Ohio
Phone: 419-433-5560
Library hours vary throughout the year. Call for current hours. The AR file is maintained on compact disks; ask librarian at front desk for assistance.

Site Background

PBOW Description and History. PBOW is located approximately 4 miles south of Sandusky, Ohio, and 59 miles west of Cleveland (Figure 1). Although located primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is in general bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. The area surrounding PBOW is mostly agricultural and residential (IT Corporation, 2001).

The PBOW facility was built on property totaling 9,009 acres in early 1941 as a manufacturing plant for 2,4,6-trinitotoluene (TNT), 2,4-dinitrotoluene (DNT), and pentolite (International Consultants Inc., 1995). Production of explosives at PBOW began in December 1941 and continued until 1945. It is estimated that more than 1 billion pounds of nitroaromatic explosives were manufactured during the 4-year operating period. The three explosive manufacturing areas were designated TNT Area A (TNTA), TNT Area B (TNTB), and TNT Area C (TNTC). Twelve process lines were used in the manufacture of TNT: four lines at TNTA, three lines at TNTB, and five lines at TNTC. The PBOW facility also included infrastructure such as power plants and waste water treatment plants.

Primary Background Documents for the Reservoir No. 2 Burning Ground

Dames and Moore, Inc., 1997, ***TNT Areas Site Investigation, Final Report, Plum Brook Ordnance Works, Sandusky, Ohio,*** April.

International Consultants Inc., 1995, ***Site Management Plan, Plum Brook Ordnance Works, Sandusky, Ohio,*** September.

IT Corporation, 2001, ***TNT Areas A and C Remedial Investigation, Volume 1, Report of Findings, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio***, November.

IT Corporation, 1997, ***Site Investigations of the Reservoir No. 2 Burning Ground, Additional Burning Ground, Waste Disposal Plant No. 2, and Power House No. 2 Ash Pit***, Former Plum Brook Ordnance Works, Sandusky, Ohio, December.

Jacobs Engineering Group, Inc. (Jacobs), 2010a, ***Revised Final Baseline Human Health Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio***, February.

Jacobs Engineering Group, Inc. (Jacobs), 2010b, ***Revised Final Screening Level Ecological Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio***, February, as updated by October 3, 2011 replacement pages.

Jacobs Engineering Group, Inc. (Jacobs), 2006, ***Final Site Characterization Report, Remedial Investigation Part 1 at Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio***, January.

Science Applications International Corporation, 1991, ***Plum Brook Station Preliminary Assessment,*** June.

Shaw Environmental and Infrastructure, 2011, ***Feasibility Study, Reservoir No. 2 Burning Ground***, Final, Former Plum Brook Ordnance Works, October.

After plant operations ceased, the manufacturing lines were decontaminated by the War Department in late 1945. During decontamination, all structures, equipment, and manufacturing debris were either removed and salvaged or removed and burned. After decontamination, the property was initially transferred to the Ordnance Department, then to the War Assets Administration after it was certified as decontaminated by the U.S. Army. In 1949, PBOW was transferred to the General Services Administration (GSA). In 1955, the GSA completed further decontamination within the TNT manufacturing areas. This effort within the TNT manufacturing areas included removal of contaminated surface and subsurface soil around the buildings and removal of the wooden and ceramic waste disposal lines containing TNT. Thousands of pounds of TNT were discovered in catch basins; this TNT was removed and burned at the burning grounds.

Two property use agreements were entered into by the National Advisory Committee of Aeronautics, the predecessor of the National Aeronautics and Space Administration (NASA), and the Army in 1956 and 1958, respectively. On March 15, 1963, NASA obtained accountability and custody for the remaining PBOW property, approximately 6,030 acres that had been under the accountability and custody of the Department of the Army. NASA performed further decontamination efforts in the TNT Areas during 1964. The NASA decontamination process included removing contaminated surface soil above the drain tiles, flumes, etc.; destruction of all buildings by fire; then removal of all soil, debris, sumps, and above-grade portions of concrete foundations. Portions of the concrete foundations located below grade were left buried, and some that had been previously slightly above grade were likewise buried. All materials, including the soil in those areas, were flashed with a flame thrower to destroy the residual explosives. The decontamination process was reported also to have included the burning of nitroaromatic-filled sewer lines that were excavated (Dames & Moore, Inc., 1997). The TNT Areas were then rough-graded.

NASA has operated and maintained PBOW since 1963, and the facility is currently the NASA Glenn Research Center, Plum Brook Station. NASA operates the former PBOW property as a space research facility in support of their John H. Glenn Research Center at Lewis Field, Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the site are presently on standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. The Perkins Township Board of Education acquired 46 acres of the excess acreage and uses this area as a bus transportation area. The GSA retains ownership of the remaining excess acreage and currently has a use agreement with the Ohio National Guard for 604 acres of this land. NASA presently controls approximately 6,400 acres. The details of land transactions are listed in the site management plan (International Consultants Inc., 1995).

It is not known when the R2BG site was first used for burning; however, a 1950 aerial photograph clearly shows the site to be in existence, and there is documentation showing ongoing operations up to 1962 (Jacobs Engineering Group, Inc. [Jacobs], 2006). Site restoration was performed in 1963, when the area was cleared of debris and the ground restored to proper grade. At some point after 1963, the R2BG site was used temporarily as a baseball field by NASA.

Soil, groundwater, and sediment have been investigated to determine whether activities associated with former DoD activities have adversely affected R2BG environmental media. Nitroaromatic compounds (i.e., explosives), polychlorinated biphenyls (PCB), polychlorinated dibenzodioxins/furans [PCDD/F], and lead are generally the contaminants in impacted R2BG soil that that are associated with past DoD activities. The presence of these contaminants in R2BG soil has resulted from production wastes and contaminated materials being brought to R2BG for burning as a former means of disposal.

Site Characteristics

R2BG is located in the northwestern portion of PBOW, approximately 400 feet south of Reservoir No. 2 between Ransom Road and Campbell Road (Figures 2 and 3). The site was used as a burning ground for production process wastes. No buildings or other man-made features are currently present or are known to have existed at R2BG. The site comprises approximately 4 acres. The former burn area portion of R2BG, identified by a burn layer, is approximately 17,000 square feet or 0.4 acre. Although its depth and thickness varies slightly, the burn layer is typically about 1 foot thick and approximately 1 foot below the surface.

Vegetation at R2BG is currently composed of open old field and shrub thickets in the northeastern part of the site along the R2BG access road. The burn area is within this old field and shrub area. The remainder of R2BG to the west and south is forest. Soil at R2BG consists of clay or silty clay with a fairly continuous layer of silt and clayey silt near the surface. The clay content of this silt layer varies with location and with depth and is generally marked by gradational changes downward from silt to clay.

The only surface water feature within the R2BG site is a drainage ditch that runs east to west and forms the north edge of the site. The drainage ditch is located 200 to 300 feet north of the former burn area and drains to the west across the site, then northwest to Pipe Creek. A less pronounced drainage ditch runs south to north along the eastern side of the service road and discharges into the main drainage ditch north of the site. These ditches are wet-weather conveyances and contain water only during substantial precipitation events.

Groundwater at R2BG includes both shallow overburden and the Delaware Limestone bedrock aquifers. Overburden groundwater flow direction is seasonally dependent with flow to the east during the dry season. During the wet season, groundwater has a radial flow pattern away from R2BG, varying from southeast to north. Bedrock groundwater flows from the site in a southeastern direction. The bedrock aquifer at R2BG has very low potential for contaminant transport, based on the low porosity observed from the rock cores and the extremely low permeability observed during monitoring well development and groundwater sampling. It is noted that because of extremely low groundwater recharge, full well development could not be performed at any of the wells.

A Preliminary Assessment that included the R2BG was completed in 1991 (Science Applications International Corporation, 1991). A subsequent site investigation was conducted in 1996 to collect and analyze R2BG soils and to conduct a geophysical survey (IT Corporation, 1997) During the site investigation, 16 subsurface soil samples and 8 surface soil samples were collected from eight soil borings. Because the analytical results of several samples exceeded screening criteria for nitroaromatics explosives, metals, PCBs, and polycyclic aromatic hydrocarbons (PAH), a remedial investigation (RI) was performed during 2004 and 2005 (Jacobs, 2006). The RI included surface soil, subsurface soil, bedrock groundwater, and sediment. The sediment samples were collected from adjacent drainage ditches in which no surface water was present. Thus, no aquatic habitat is present, but this sediment represents soil materials resulting from deposition and erosion associated with precipitation events.

RI activities were performed in 2004 and 2005, during which a total of 65 surface (0 to 1 foot below ground surface [bgs]) and subsurface soil samples were collected from within and outside of the burn area for analysis of the full R2BG analytical suite (volatile organic compounds, PAHs, PCBs, nitroaromatics, metals, PCDD/F, and lead). In 2004 and 2005, trenching was also performed to delineate the boundary of the burn area by collecting discrete samples of the burn layer material. Preliminary excavations were performed prior to investigation activities to define the approximate burn area boundary. Six confirmatory trenches were excavated to define the burn area. Fifteen soil samples were collected during trenching: 10 from the burn layer material, 3 from the soil beneath the burn layer, and 2 from the soil outside of the burn layer. A total of 26 soil borings were completed for characterization of the overburden along with collection of 26 surface soil samples and 24 subsurface soil samples. The subsurface soil samples were collected from the depth intervals of 3 to 5 and 8 feet and to 10 feet bgs.

In the fall of 2010, additional surface soil sampling was performed in support of the feasibility study (FS) to delineate contamination outside of the burn area. The results of these delineation samples were used to fill in data gaps identified based on the results of the 2006 RI (Jacobs, 2006). These include a total of 26 samples (including duplicates) from 22 previously sampled site investigation and RI locations that were collected and analyzed again in 2010 for PCDD/Fs only, as well as 16 samples (including duplicates) from 12 new locations that were analyzed for a full suite of chemicals, including PCDD/Fs, nitroaromatics, PCBs, and semivolatiles.

In addition to soil samples, three bedrock wells were installed in 2004 for determination of bedrock aquifer depth and gradient. Groundwater samples were collected also to evaluate any impacts from the burning ground activity. Due to slow recharge and limited water volume, the wells could not be developed or purged, and groundwater had to be sampled via bailer. Only one round of groundwater samples was collected because of limited water yield. These samples were highly turbid (101 to 1,910 nepholometric units). No monitoring wells were installed in the overburden because of a lack of sufficient permeable material.

Sediment samples were collected in 2004 from the drainage ditch north of the site. As mentioned previously, the ditch is a wet-weather conveyance and does not typically contain water. Because no surface water was present during the RI sampling event, no surface water samples were collected.

The soil at the R2BG was evaluated separately for soil inside and outside of the burn area. The maximum detected concentrations of the chemicals of concern (COC) for soil samples collected within the burn area (surface and subsurface soil) and those collected from outside of the burn area (surface soil only) are presented below. COCs, described further in the Summary of Potential Site Risks section, are defined as any site-related chemical that contributes significantly to an exposure pathway with an unacceptable risk or hazard. Note that PCDD/Fs are evaluated in terms of 2,3,7,8-tetrachloro-p-dibenzodioxin toxicity equivalency (TCDD TEQ). The maximum detected concentration of each COC is presented in the list below, and the locations of these concentrations are provided in parentheses.

Within the Burn Area (surface and subsurface soil)

- TCDD TEQ – 128 nanograms per kilogram (ng/kg) in surface soil (BH17); 1,186 ng/kg in subsurface soil (TR10-2)
- TNT – 3,120 milligrams per kilogram (mg/kg) in surface soil (BH18); 35,400 mg/kg in subsurface soil (TR08-1)
- 2,4-DNT – 35 mg/kg in surface soil (2BGSO02); 9,700 mg/kg in subsurface soil (TR08-1)
- 2,6-DNT – 0.98 mg/kg in surface soil (BH17); 1,400 mg/kg in subsurface soil (TR09-1)
- Aroclor 1254 – not detected in surface soil; 3.67 mg/kg in subsurface soil (TR08-1)
- Aroclor 1260 – 11.6 mg/kg in surface soil (BH17); 4.01 mg/kg in subsurface soil (TR08-1)
- Lead – 778 mg/kg in surface soil (2BGSO02); 8,220 mg/kg in subsurface soil (TR05-1D).

Outside of the Burn Area (surface soil only)

- TCDD TEQ – 956 ng/kg (BH51)
- TNT – 2,270 mg/kg (BH23)
- 2,4-DNT – 200 mg/kg (BH42)
- 2,6-DNT – 78 mg/kg (BH42)
- Aroclor 1254 – 0.149 (BH55)
- Aroclor 1260 – 44.4 mg/kg (BH23).

Note that only limited subsurface soil samples were collected outside of the Burn Area because contamination in soil outside of the Burn Area appeared to be within the upper 1 foot of the surface. Thirty subsurface soil samples (including duplicates) were collected outside of the Burn Area from depths ranging from 2 to 3 feet to 8 to 10 feet bgs. COCs were detected only in a few samples and at very low concentrations (e.g., <1 mg/kg).

None of the organic COCs identified for soil were detected in the bedrock groundwater samples. Even though the inorganic soil COC lead was detected in groundwater at a maximum concentration (17.9 micrograms per liter [µg/L]) that is marginally above the screening level (15 µg/L), the groundwater analytical data were regarded to be of poor quality and thus unsuitable for risk assessment because the wells had very low yield, could not be properly developed or purged, had to be sampled via bailer, and as a result were extremely turbid (Jacobs, 2006). It is likely that this marginal exceedance of the lead screening level resulted from the elevated concentrations of suspended solids, which are evidenced by the high turbidity of the samples. TCDD TEQ was detected in sediment at a maximum concentration (6.9 ng/kg) that only marginally exceeded the screening level (4.5 ng/kg), and lead was detected in sediment at a maximum concentration less than the screening level and consistent with background soil concentrations. No other soil COCs were detected in the sediment samples.

Scope and Role of R2BG

One of DoD’s specific goals from the Defense Planning Guidance for DERP-FUDS is to reduce risk to human health and the environment through implementation of effective, legally compliant, and cost-effective response actions. To that end, the environmental investigation of PBOW has been divided into 16 areas of concern, also referred to as DERP-FUDS projects, to address the potential concerns presented by each area associated with former DoD activities. A separate close-out document is required for each of the 16 DERP-FUDS projects. This current Proposed Plan specifically addresses the R2BG only. The status for each of the other 15 DERP-FUDS sites is also shown so that it can be seen how the current action fits into the scope of action at PBOW, including all completed, ongoing, and planned activities.

The 16 DERP-FUDS projects and their status are briefly identified in the following paragraphs. Please note that 6 of these 16 projects have been closed or have signed Decision Documents, as indicated.

Reservoir No. 2 Burning Ground. The RI began in 2004, and the site characterization report was issued in January 2006. Human health and ecological risk assessments were completed in February 2010. Further delineation sampling was performed in October 2010, and a draft FS was submitted in July 2011. The final FS was submitted in September 2011. This Proposed Plan presents the preferred alternative for remediation of contaminated soils.

TNT and Red Water Pond Areas Groundwater. A baseline human health risk assessment (BHHRA) of groundwater associated with the three former TNT Areas and two former Red Water Pond Areas was finalized in September 2006, and an FS for groundwater associated with these areas was finalized in December 2008. An addendum to the groundwater FS was finalized in July 2011. The groundwater associated with these five areas is expected to be addressed in a single Decision Document. A draft Proposed Plan was submitted in December 2011.

TNTA. A focused feasibility study (FFS) for soils and sediment was completed in 2003. A Decision Document for TNTA soils was signed on June 22, 2011, and a State of Ohio concurrence letter was received on July 20, 2011. A contract for remedial action for TNTA soils has been awarded, and remediation is planned for 2012.

TNTB. An FS for soils was completed in 2001. An Action Memorandum for a non-time-critical removal action (NTCRA) regarding soils was presented to the public on March 28, 2002. The Action Memorandum was finalized in June 2003, and the removal action was completed in December 2006. The final report of the interim soil removal action was issued in 2007. A Proposed Plan recommending no further action was presented during a July 16, 2009 public meeting. No comments were provided during the subsequent public comment period. A no-further-action Decision Document was signed on September 23, 2009, and State of Ohio concurrence letter was received on September 29, 2009. The project closeout report was signed on March 31, 2010.

TNTC. An FFS for soils and sediment was completed in 2003. A Proposed Plan was submitted in March 2009. A Decision Document was signed by DoD on December 7, 2009, and a concurrence letter, dated January 15, 2010, was received from the State of Ohio. Remedial action of TNTC soil and sediment is ongoing.

Red Water Pond Areas. An FFS for the Red Water Pond Areas soil was completed in December 2002. Remedial alternatives were developed and evaluated for Pentolite Road Red Water Pond (PRRWP) Area soil in the FFS because the human health risks associated with PRRWP Area soil were determined to be unacceptable under unrestricted land use. Because human health and ecological risks for West Area Red Water Pond (WARWP) Area soil were determined to be within acceptable levels for unrestricted land use, it was not necessary to develop remedial alternatives for the WARWP Area soil. An Action Memorandum was presented to the public in September 2002 for an NTCRA regarding PRRWP Area soil. An interim removal action at the PRRWP Area began in January 2003 under the NTCRA. During the NTCRA soil removal, the need for additional soil sampling was recognized based on the discovery of a dark layer of contaminated soil. A windrow composting action was selected to remediate this soil under the NTCRA. Composting began in 2007 and was completed in September 2008. Post-NTCRA delineation sampling was performed in spring and summer 2009. Because of residual human health risks, additional delineation sampling was completed in November 2010. A soil delineation report and risk evaluation have been prepared in support of an addendum to the FFS, which is scheduled for completion in 2012.

Acid Areas 1, 2, and 3. The site investigations of the three acid areas were completed in December 1998. An RI and risk assessments were completed for Acid Areas 2 and 3 in September 2006 and for Acid Area 1 in February 2008. These two areas are currently in the FS stage. The Acid Area 1 RI and risk assessments were completed in July 2010. Additional delineation sampling was conducted in June and July 2011. FSs are planned for Acid Area 1 and for Acid Areas 2 and 3 in 2012.

Additional Burning Grounds. A PA was performed in 1991. This project includes five burning ground areas. NASA has agreed to take full responsibility for three areas which include Taylor Road, Snake Road, and Fox Road Burning Grounds. The other two (G-8 and “Additional” Burning Grounds) require further records research review. Based on this records review, responsibility for these areas will be established.

Waste Water Treatment Plant Nos. 1 and 3. A limited site investigation was completed in July 2000. The RI report and risk assessments are scheduled for completion in 2012. These will include the associated wood-stave waste water sewer lines from TNTA and TNTB to Waste Water Treatment Plant No. 1. The former Waste Water Treatment Plant No. 3 neutral waste storage tank, which was used by NASA as the K-Site control building, is scheduled for demolition in late 2012.

Waste Water Treatment Plant No. 2. A PA performed in 1991 found a potential for contamination of soil, surface water, sediment, and groundwater with acetone, pentaerythritol, and tetraerythritol tetranitrate. A site investigation was performed in 1997. An RI/FS and risk assessments were recently funded, which include the associated TNTC to Waste Water Treatment Plant No. 2 sewer lines and the steel sewer lines. Fieldwork for the RI began in May 2011 and is expected to be completed in May 2012.

Power House Ash Pit No. 2. A PA was performed in 1991. Final site characterization and risk assessment reports were submitted in September 2010. Additional soil sampling was conducted in July 2011 for an RI and risk assessment addenda. A contract has been awarded for a Proposed Plan and Decision Document.

Ash Pits Nos. 1 and 3. A limited site investigation performed in July 2000 resulted in the recommendation that a full SI be performed. A contract for an RI was awarded in June 2008, and fieldwork began in December 2008. A site characterization report and risk assessments were submitted in 2011 for Ash Pit No. 1 and are anticipated for completion in 2012 for Ash Pit No. 3.

TNT Loading Areas. A limited site investigation was completed in July 2000. The project was closed out in September 2006 with no further action; the State of Ohio concurred.

Pentolite Area Waste Lagoon. A limited site investigation was completed. The project was closed out in September 2006 with no further action; the State of Ohio concurred.

Lower Toluene Tanks. A limited site investigation was completed in July 2000. The project was closed out in September 2006 with no further action; the State of Ohio concurred.

Garage Maintenance Area. A limited site investigation was completed for the Locomotive Building Area in July 2000 and resulted in the recommendations to proceed with further investigation. The Locomotive Building Area is in the eastern portion of the Garage Maintenance Area. A final site characterization report was submitted for the Locomotive Building Area in September 2010, and the final risk assessment reports were submitted in December 2010. Fieldwork for the Sellite Area and Unloading Area RI began in June 2011 and is expected to be completed in May 2012. An RI report and risk assessments will subsequently be prepared for these two portions of the Garage Maintenance Area.

Soil Actions on DERP-FUDS Projects. The soil actions undertaken at the PRRWP Area, TNTB, and TNTC and the proposed actions at TNTA are being implemented by the USACE under DERP-FUDS. To date, no other removal actions or response actions have been recommended.

Summary of Potential Site Risks

A BHHRA (Jacobs, 2010a) and screening level ecological risk assessment (SLERA) (Jacobs, 2010b) were performed for R2BG soil, sediment, and groundwater. No surface water was present at the time of field surveys or sampling in the adjacent ditches, and thus, no evaluation of surface water could be performed. The results of these evaluations are summarized below.

Human Health Risks. The BHHRA evaluated potential risks under the following potential human receptor scenarios (exposure pathways evaluated in parentheses):

- Future long-term indoor worker (ingestion of surface soil; ingestion of groundwater; dermal contact with groundwater)
- Current/future long-term groundskeeper (ingestion of surface soil; dermal exposure to surface soil; inhalation of particulate originating from surface soil)
- Current/future shorter-term construction worker (ingestion of surface/subsurface soil; dermal exposure to surface/subsurface soil; inhalation of particulates originating from surface/subsurface soil; ingestion of sediment; dermal contact with sediment)
- Hypothetical long-term future resident (ingestion of surface/subsurface soil; dermal exposure to surface/subsurface soil; inhalation of particulates originating from surface/subsurface soil; ingestion of sediment; dermal contact with sediment ingestion of groundwater; dermal contact with groundwater)
- Future/current hunter and child (consumers of contaminated venison; hunter ingestion of surface soil, dermal exposure to soil)
- Future/current hunter's child (consumption of venison).

Figure 4 depicts the exposure pathways evaluated for each receptor in the BHHRA.

The BHHRA identified no current human exposure to groundwater either on site or in adjacent areas off site. However, as agreed by the PBOW Project Delivery Team, it was assumed for purposes of the BHHRA that limestone bedrock groundwater underlying the R2BG Area may be developed as a source of potable water at some time in the future. Based on the groundwater investigation (Jacobs, 2006), this limestone unit would not provide an adequate quantity of groundwater, and the quality of this water would fail drinking water standards due to the presence of naturally occurring compounds that are unrelated to former site activities. Also, the bedrock groundwater wells installed at R2BG (and other areas of PBOW) emit notable amounts of naturally occurring hydrogen sulfide gas, which may result in nuisance odors and, at elevated levels, potential health concerns. Also, the presence of hydrogen sulfide gas, which has direct and indirect corrosive effects, results in the rapid deterioration of metal components of well materials, pumps, and plumbing. Therefore, groundwater from the limestone unit underlying the R2BG is regarded as nonpotable, despite the assumption made in the BHHRA that it may be developed as a drinking water source. The assumption of potability for the limestone bedrock groundwater was made in the BHHRA because the OEPA maintained that this assumption should initially be made under baseline conditions where no prior use restrictions are in place. Overburden groundwater monitoring wells were not installed because of a lack of groundwater in this unit. Therefore, the BHHRA evaluated the overburden/shale groundwater only qualitatively because of insufficient yield for groundwater sampling.

The incremental lifetime cancer risks (ILCR) that could result from a reasonable maximum exposure to potential carcinogenic (cancer-causing) chemicals detected in R2BG media (e.g., soil, groundwater, and sediment) were determined under each human receptor scenario. The ILCR is the "extra risk" that cancer will develop at some point in an exposed individual solely because of exposure to the pertinent chemicals. In this case, the ILCR is associated with chemicals in the site media that are resultant from DoD activities. This extra cancer risk does not include the baseline cancer risk statistically incurred by a member of the general population, whether or not he is exposed to the R2BG media. The ILCR from each chemical and exposure pathway (e.g., ingestion of groundwater as tap water, dermal exposure to soil, etc.) were summed to calculate the combined ILCRs to the individual receptors. The NCP states that acceptable exposure levels are generally concentrations that represent an excess upper bound lifetime cancer risk (or ILCR) to an individual between 1×10^{-6} (1 in 1,000,000) and 1×10^{-4} (1 in 10,000). The OEPA considers total ILCR values greater than 1×10^{-5} (1 in 100,000) in an environmental medium to be unacceptable. This value is the logarithmic midpoint of the NCP acceptable range; the Army recognizes the full NCP range. Please note that the baseline risk for the general U.S. population of developing cancer is approximately 40 percent (4 in 10). As an illustration, if an individual is assumed to have exactly a 40 percent chance (400,000 in 1,000,000) of developing cancer without a specific exposure, an additional exposure at an ILCR of 1×10^{-5} (1 in 100,000, or 10 in 1,000,000) would theoretically result in an overall cancer risk of 400,010 in 1,000,000.

Noncancer human health effects are evaluated differently than are cancer risks because the nature of noncancer effects generally assumes a "threshold level" below which adverse health effects are regarded as unlikely to occur at all in the (hypothetically) exposed population. As stated in the NCP, acceptable exposure levels for systemic toxicants (i.e., noncancer effects) are represented by concentration levels to which a human population may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety. Consistent with U.S. Environmental Protection Agency (USEPA) risk assessment guidance, the estimated exposure levels of DoD-related chemicals were mathematically compared to threshold-level-based chronic reference doses to derive a hazard index (HI). These chronic reference doses are acceptable lifetime exposure rates that represent the term "acceptable exposure levels" used in the NCP. Further description of the chronic reference doses and their derivation is provided in the Toxicity Assessment (Chapter 4.0) of the BHHRA. An HI value greater than 1 indicates a possible concern for potential adverse health effects; HI values equal to or less than 1 indicate that adverse health effects are unlikely for any exposed individual.

The overall ILCR and HI values for each environmental medium and each receptor are summarized in Table 1, as are the total HI and ILCR values across all environmental media. The results of separate risk evaluations are presented for inside of and outside of the Burn Area. The following conclusions are drawn from the BHHRA results and uncertainty evaluations.

Inside of the Burn Area

- The surface soil HI values associated with groundskeeper (HI=12), indoor worker (HI=6), construction worker (HI=33), and resident (HI=140) exceed the acceptable threshold value of 1. Over 99 percent of the noncancer hazard for each receptor is associated with TNT, which is clearly associated with past DoD-related practices at PBOW. The surface soil ILCR for the groundskeeper (8×10^{-5}), indoor worker (4×10^{-5}), and resident (3×10^{-4}) exceed the OEPA ILCR goal of 1×10^{-5}, and the ILCR for the resident exceeds the NCP acceptable risk range of 1×10^{-6} to 1×10^{-4}.

- With respect to surface soil exposure, neither the ILCR for the construction worker (8×10^{-6}) nor the ILCR for either the hunter (6×10^{-6}) or hunter's child (5×10^{-10}) exceeded the PBOW cancer risk goal of 1×10^{-5}. Likewise, the HI of the hunter (0.7) and hunter's child (0.0002) exposed via surface soil pathways were both less than the PBOW HI goal of 1. Thus, no unacceptable cancer risks or noncancer hazards are calculated for the hunter or hunter's child exposed via surface soil pathways.

- The subsurface soil HI values associated with the two receptors evaluated for subsurface soil exposure, the construction worker (HI=154) and resident (HI=651), exceed the acceptable threshold value of 1. Over 99 percent of the noncancer hazard for each receptor is associated with TNT, which is associated with past DoD-related practices at PBOW. The subsurface soil ILCR for the construction worker (5×10^{-5}) and resident (4×10^{-3}) exceed the OEPA ILCR goal of 1×10^{-5}, and the ILCR for the resident exceeds the NCP acceptable risk range of 1×10^{-6} to 1×10^{-4}. Over 70 percent of each ILCR value is associated with TNT, and virtually all of the remainder of each value is associated with the following chemicals that are related to past site practices: DNTs, TCDD TEQ, and Aroclor 1260.

- Assuming exposure to bedrock groundwater, the cancer risk and noncancer hazards to both receptors evaluated (indoor worker [ILCR=2E-3; HI=16] and resident [ILCR=7E-3; HI=106]) would exceed the NCP acceptable risk range of 1×10^{-6} to 1×10^{-4} or the HI threshold value of 1, respectively. Because of naturally poor groundwater quality, the bedrock groundwater underlying R2BG is not suitable for potable use. Also, because of inadequate yield, the bedrock monitoring wells could not be appropriately developed. The noncancer hazard associated with groundwater is due to naturally occurring petroleum-related compounds and inorganics, mostly benzene and arsenic. Similarly, 100 percent of the cancer risks are associated with arsenic and the petroleum-related compounds benzene and benzo(a)pyrene. None of the six organic soil COCs were detected in the groundwater. As described in the Site Characteristics section, the presence of the inorganic COC, lead, in bedrock groundwater is likely related to the poor sample quality resulting from a lack of groundwater in the limestone, rather than to former site activities.

Outside of the Burn Area

- The surface soil HI values associated the construction worker (HI=3) and resident (HI=15) exceed the acceptable threshold value of 1. The surface soil ILCR values for both the groundskeeper (ILCR=3×10^{-5}) and the resident (1×10^{-4}) exceed the OEPA ILCR goal of 1×10^{-5}, but not the NCP risk management range. Over 95 percent of the noncancer hazard for each receptor is associated with TNT, which is associated with past DoD-related practices at PBOW. Approximately 98 percent of the ILCR value is associated with TNT, DNTs, and Aroclor 1260, all of which are regarded as being related to past DoD-related practices at PBOW.

- With respect to surface soil exposure, neither the ILCR for the construction worker (2×10^{-6}) nor the ILCR for either the indoor worker (1×10^{-5}), hunter (3×10^{-6}, or hunter's child (4×10^{-10}) exceeded the PBOW cancer risk goal of 1×10^{-5}. Likewise, the HI for the groundskeeper (HI=1), indoor worker (HI=0.6), hunter (0.07), and hunter's child (0.0002) exposed via surface soil pathways were each less than or equal to the PBOW HI goal of 1, indicating that adverse noncancer health effects are unlike for these receptors.

- The subsurface soil HI values associated with the resident (HI=5) exceeds the acceptable threshold value of 1. Over 99 percent of this noncancer hazard is associated with TNT, which is associated with past DoD-related practices at PBOW. The ILCR for the resident (8×10^{-5}) exceeds the OEPA ILCR goal of 1×10^{-5},but is within the NCP acceptable risk range of 1×10^{-6} to 1×10^{-4}. Over 70 percent of this ILCR value is associated with TNT, and virtually all of the remainder of this value is associated with the following chemicals that are related to past site practices: DNTs, TCDD TEQ, and Aroclor 1260. The HI (1) and ILCR (1×10^{-6}) for the construction worker, the only other receptor evaluated for exposure to subsurface soil, do not exceed the PBOW HI and ILCR goals.

- No noncarcinogenic chemicals of potential concern were identified in R2BG sediment. The ILCR values associated with sediment were less than the OEPA goal of 1×10^{-5} in both receptors evaluated for sediment exposure, the construction worker (2×10^{-7}) and resident (4×10^{-6}).

- The evaluation of exposure to groundwater outside of the burn area is assumed to be the same as inside the burn area. As described previously, none of the seven soil COCs were detected in the groundwater, indicating that the groundwater has not been impacted by past site activities. Please note that both of the R2BG monitoring wells that could be sampled were located outside of the burn area.

In summary, predicted levels of exposure to site-related chemicals in surface soil and subsurface soil inside the burn area would result in unacceptable cancer risk levels and/or noncancer hazards for the groundskeeper (surface soil), indoor worker (surface soil), construction worker (surface/subsurface soil), and resident (surface/subsurface soil). Exposure to surface soil outside of the burn area would result in an unacceptable noncancer hazard for the construction worker and on-site resident, and a cancer risk level for the resident and groundskeeper that would exceed the OEPA goal of 1×10^{-5}, but not the NCP acceptable risk range of 1×10^{-6} to 1×10^{-4}. Both cancer and noncancer risks to the hunter and hunter's child would not exceed acceptable levels in surface soil either inside or outside of the burn area. Sediment would not pose any unacceptable human health risks or hazards.

Risks associated with the ingestion of R2BG groundwater resulted in unacceptable human health risks to both receptors evaluated, the indoor worker and the resident. The BHHRA results were used to identify seven COCs for soil. These are chemicals identified as contributing significantly to risk as defined in the BHHRA. However, as stated, the bedrock groundwater underlying R2BG is not regarded as potable because of naturally occurring petroleum hydrocarbons, elevated levels of hydrogen sulfide gas, and insufficient water yield such that one monitoring well was dry and the other two could not be developed or purged. Therefore, the data from these wells must be regarded as highly suspect and are not regarded as appropriate for quantitative evaluation such as risk assessment (Jacobs, 2006).

Because unacceptable site-related risks/hazards were identified in surface and subsurface soil based on the results of the BHHRA, the BHHRA was used to identify COCs. COCs are defined as any site-related, DoD-related contaminant that contributes significantly to an exposure pathway with an unacceptable risk or hazard. For PBOW, a significant contribution to unacceptable risk is a chemical-specific cancer risk of greater than 1×10^{-6}; for noncancer hazards, a significant contribution to significant risk is a chemical-specific HI of greater than 0.1. Based on the BHHRA, the COCs for R2BG soil inside the burn area are the following seven analytes:

- TCDD TEQ
- 2,4-DNT
- 2,6-DNT
- TNT
- Aroclor 1254
- Aroclor 1260
- Lead.

Ecological Risks. A SLERA was performed as part of the RI for R2BG (Jacobs, 2010b). The SLERA is composed of the following steps main parts:

- Problem formulation
- Exposure characterization
- Ecological effects characterization
- Risk characterization.

The problem formulation provides an ecological description of the site and identifies the chemicals of potential ecological concern (COPEC) that are evaluated in the SLERA. The exposure characterization provides an estimate of the nature, extent, and magnitude of potential exposure. The ecological effects characterization identifies toxicity reference values for the COPECs in the various environmental media, and the risk characterization provides a qualitative and semiquantitative evaluation of ecological risks.

R2BG is composed of upland old fields, early shrub thicket, and successional woodlands. There are no surface water bodies on or adjacent to R2BG, but a drainage ditch runs east to west, just north of R2BG. No water is typically present in this ditch and none was present at the time of sampling. Thus, no substantial aquatic habitat is present in the vicinity of R2BG, and sediment in this ditch was qualitatively determined as not representing significant ecological hazards.

Mammalian, avian, and herptilian wildlife species have been identified at PBOW, some of which would be expected and/or have been observed at R2BG. Although several threatened and endangered animal and plant species have been reported within a 2-mile radius of PBOW, none were observed at R2BG during the site ecological survey (Jacobs, 2010b).

The SLERA focuses on the potential exposure to species or ecological components that are the most likely to be affected, given the toxicological and mobility characteristics of the COPECs, and on those COPECs that would most likely produce the greatest effects in the on-site ecosystem.

Site biota are organized into major functional groups. The following seven receptor species were selected to evaluate the potential terrestrial effects for R2BG soil COPECs.

- Deer mouse (*Peromyscus maniculatus*) (small omnivorous mammal)
- Short-tailed shrew (*Blarina brevicauda*) (small insectivorous mammal)
- Eastern cottontail rabbit (*Sylvilagus floridanus*) (medium-sized herbivorous mammal)
- Marsh wren (*Cistothorus palustris*) (small insectivorous bird)
- White-tailed deer (*Odocoileus virginianus*) (large herbivorous mammal)
- Raccoon (*Procyon lotor*) (medium-sized omnivorous mammal)
- Red-tailed hawk (*Buteo jamaicensis*) (large carnivorous bird).

Potential impacts to terrestrial plants and macroinvertebrates were considered qualitatively in the risk characterization. Ecological receptors were evaluated for exposure to soil from the surface to a depth of 5 feet bgs. For inside the burn area, this should encompass the entire burn layer, which varies in thickness and depth but was typically found at a depth of approximately 1 foot bgs and is typically about 1 foot thick. The terrestrial food web diagram for the above receptors is provided as Figure 5.

Measurement endpoints for the SLERA are based on toxicity values from the available literature and not on statistical or arithmetic summaries of actual field or laboratory observations or measurements. The assessment endpoints for R2BG are stated as "the protection of long-term survival and reproductive capabilities for terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, and benthic invertebrates."

Ecological routes of exposure for biota may be direct (e.g., ingestion of soil; plants absorbing contaminants from soil) or indirect via the consumption of contaminated organisms. Media-to-tissue transfer factors and food-chain multiplier values were used to model indirect exposure via ingestion of contaminated biota.

The ecological effects characterization includes the selection of benchmark values and the development of reference toxicity values. These values focus on the growth, survival, and reproduction of species and/or populations and provide a reference point for the comparison of toxicological effects upon exposure to a contaminant.

The risk characterization integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects of COPECs present at a site, based on qualitative and quantitative approaches. The weight-of-evidence risk characterization results, in conjunction with the uncertainties described in the SLERA, are summarized by the following statements.

- Impacts to terrestrial plants appear to be insubstantial.
- Several ecological hazard quotient (EHQ) values associated with soil inside the burn area were elevated for terrestrial receptors, especially with respect to 2,4-DNT (mouse EHQ=19,000), TNT (mouse EHQ=4,200), and 2,6-DNT (mouse EHQ=660) (Table 2).
- Several EHQ values associated with soil outside the burn area were elevated for terrestrial receptors, but these values were orders of magnitude less than those associated with soil inside the burn area. The highest EHQ values for outside-the-burn-area soil are for TNT (wren EHQ=420), 2,4-DNT (mouse EHQ=59), and 2,6-DNT (mouse EHQ=23) (Table 2).

The SLERA concluded that a remedial action based specifically on ecological concerns is not warranted, as no threatened or endangered species are present, and that a remedial action based on human health effects will also address ecological concerns. The three major chemicals driving ecological hazards, TNT, 2,4-DNT, and 2,6-DNT, were also identified as COCs to be remediated based on the BHHRA.

Delineation Sample Human Health Risk Calculations. As discussed in the Site Characteristics section of this Proposed Plan, delineation samples were collected outside of the burn area during 2010 in support of the FS. Specifically, these samples were collected to better delineate the extent of contamination outside of the burn area, especially with respect to TCDD TEQ. These samples were collected subsequent to completion of the BHHRA and SLERA; thus, the results of the delineation samples are not included in the risk assessment reports.

Although no formal risk assessment was performed on these samples, human health risk assessment calculations were used in the FS based on the results of these and the previously collected samples as a tool to aid in delineating the extent of contamination of the COCs, which were identified based on the BHHRA. Sample-specific ILCR and HI values were estimated using risk-based delineation levels as described in the FS. These resulting values were compared to the

OEPA ILCR (ILCR≤1 × 10^{-5}) and HI (HI≤1) goals. The following were observed from the sample-specific HI and ILCR results:

- Only 4 samples exceeded the HI goal, whereas 20 samples exceeded the OEPA ILCR goal. Each of the samples which exceeded the HI goal also exceeded the ILCR goal.
- Four samples exceeded NCP acceptable cancer risk range of 1 × 10^{-6} to 1 × 10^{-4}, and two of these were not analyzed for PCDD/Fs.
- Of the 20 samples that exceeded the acceptable risk range, 8 were not analyzed for PCDD/Fs.

Because cancer risk goal exceedances were more prevalent than the exceedances of noncancer hazards, it was sufficient to use only the sample-by-sample ILCR results to describe the use of risk assessment calculations to aid in contamination delineation. These sample-specific ILCR values are shown on Figure 6. Please note that not all samples were analyzed for PCDD/Fs because these analyses are much more expensive than those used for the other COCs. Therefore, some of the ILCR values for samples not analyzed for PCDD/Fs may be substantially underestimated. It is emphasized that these ILCR values are not intended to represent a risk estimate for any specific locations, but rather they were used collectively as a tool, as described in the FS, to aid in delineating contamination.

Remedial Action Objective

The following remedial action objective (RAO) was developed in the FS for R2BG soil:

- Prevention of human exposure via any exposure route (ingestion, inhalation, or dermal contact) to site soil containing the COCs at concentrations that exceed R2BG remedial goals (RG).

The R2BG RGs, presented in Table 3, were derived in the FS for the COCs assuming unrestricted future land use. This assumption is appropriate because the area surrounding the former PBOW facility is rural and residential and if/when the property is excessed, the land will likely become residential. Please note that because no unacceptable site-related risks are associated with R2BG groundwater, no RAO for groundwater is developed.

In general, an RG may be based on an applicable or relevant and appropriate requirement (ARAR) or human health or ecological risks/hazards. Because no ARARs are pertinent to any of the COCs at the concentrations present, the RG for each R2BG COC is primarily risk based. The

RG for lead (400 mg/kg) was based on the TBC criterion USEPA (1998) residential soil screening level, which is derived from acceptable risk-based levels as indicated in the BHHRA. The risk-based level of 1 mg/kg is selected as the RG for PCBs because it is protective.

The risk-based RGs were designed based on site-specific concentrations such that the cumulative cancer risk (i.e., ILCR) associated with residential exposure to the soil would not result in a cumulative cancer risk that exceeds the target cancer goal of 1×10^{-5} or the target cumulative noncancer hazard of 1. The OEPA has maintained an ILCR of 1×10^{-5} as a target cancer risk goal for all PBOW sites, which is consistent with OEPA policy. Though USACE is bound by the CERCLA/NCP range of 1×10^{-6} to 1×10^{-4}, the OEPA target goal of 1×10^{-5} is the logarithmic midpoint of the CERCLA/NCP risk range, and as such, can be used to initially set remediation goals subject to possible modification in accordance with appropriate risk considerations. The noncancer RGs were derived so that the sum of the noncancer effects of those chemicals that affect the same target organ does not exceed the target HI goal of 1.

The RGs will be used statistically during excavation and confirmation sampling as part of a risk-based approach to aid in determining whether additional soil removal is required. This will involve the averaging of samples from each excavation and comparing the analytical results to the respective RGs. The exceedance of an RG level in an individual discrete sample will be acceptable for an area of an excavation as long as the overall excavation site does not exceed the RG. Also, for Remedial Alternatives 3 and 4 (described below), which may include on-site placement of treated materials, an exceedance of an RG level in an individual discrete sample would be acceptable for a given batch of treated soil as long as the overall batch did not exceed the RGs.

RAOs based specifically on ecological risk were not recommended for soil because of considerable uncertainties associated with toxicity, no observation of vegetative stress at R2BG, and absence of any threatened and endangered species. Also, the major risk-driving chemicals for terrestrial ecological risks in soil are predominant with respect to human health risks. Therefore, through following remediation which attains human health-based RG concentrations, estimated potential ecological hazard estimates will be greatly reduced.

Summary of the Remedial Alternatives

The following four remedial alternatives were developed and evaluated in the FS for contaminated soil at R2BG:

- ***Alternative 1:*** No action
- ***Alternative 2:*** Excavation and Off-Site Treatment/Disposal
- ***Alternative 3:*** Excavation, Windrow Composting, Chemical Stabilization, and On-Site and Off-Site Disposal
- ***Alternative 4:*** Excavation, Alkaline Hydrolysis, Chemical Stabilization, and On-Site and Off-Site Disposal.

Each of the three action-based alternatives (Alternatives 2 through 4) would require the excavation of an estimated 7,395 cubic yards of contaminated soil from the locations shown on Figure 7. This includes an estimated 5,056 cubic yards within the burn area (0 to 8 feet deep) and 2,339 cubic yards in areas outside of the burn area (0 to 2 feet deep). Based on existing soil data from R2BG, 100 percent of the soil volume may be classified as a characteristic hazardous waste due to anticipated 2,4-DNT and/or lead concentrations. Unless the excavated soil is first treated to render it nonhazardous, this material must be disposed of in a Resource Conservation and Recovery Act (RCRA) hazardous waste treatment, storage, and disposal facility (TSDF). It is estimated that a total of 7,395 cubic yards are hazardous with respect to either lead and 2,4-DNT. This includes 3,793 cubic yards that are hazardous only with respect to leachable 2,4-DNT, 1,300 cubic yards that are hazardous only with respect to leachable lead, and 2,303 cubic yards that are hazardous with respect to both 2,4-DNT and lead.

Alternatives 3 and 4 employ treatment technologies, whereas Alternative 2 includes only off-site disposal. The treatment technologies associated with Alternatives 3 and 4 address 2,4-DNT and lead but are not designed to treat PCBs or PCDD/Fs. PCBs and PCDD/Fs adsorb strongly to soil and are effectively treated only by thermal technologies such as incineration, which are not cost effective for on-site treatment. Therefore, soils with PCB and/or TCDD TEQ concentrations that exceed the respective RGs are disposed of off site in all three action-based alternatives. If the soil contaminated with PCBs or PCDD/Fs is also a hazardous waste because it fails the TCLP test for lead and/or 2,4-DNT, then prior to disposal, the soil would be treated for nitroaromatics and the lead in the soil would be stabilized under alternatives 3 and 4. Whether it is sent off site for disposal at a nonhazardous waste landfill or a hazardous waste landfill, the stabilized soil must comply with the land disposal restrictions (LDR) including treatment for any underlying hazardous constituents before placement into any land disposal unit. The lead-stabilized soil is not suitable for on-site backfill because the residual risk associated with the reduced bioavailability of lead in soil cannot be adequately quantified and cannot be regarded as acceptable for human health unless the total lead concentration of the stabilized soil is less than the lead RG.

If during remediation any of the soil is determined to be nonhazardous based on toxicity characteristic leaching procedure (TCLP) testing, the material may be disposed of at a nonhazardous waste landfill under Alternatives 2 through 4. Alternatively, this material may be placed on site under Alternatives 3 and 4 if the RGs are met. Any nonhazardous disposal facility must be approved in advance by the USEPA as appropriate facilities to receive CERCLA waste (40 Code of Federal Regulations 300.440); the OEPA will also be consulted.

Based on the current data, contamination is estimated to extend to a total depth of 8 feet below the surface in the burn area and to a depth of 2 feet outside the burn area. The extent of soil excavation needed to attain the RAO will be confirmed in the field by sampling and analysis of the excavation sidewalls and comparing the sample results to the RGs. Additional soil excavation may be required laterally if indicated by a comparison of the confirmation samples to the RGs. Outside the burn area, it is possible that soil removal to a depth greater than the planned 2 feet may be required in some areas based on sampling and analysis of the excavation floor. Additional removal of soil to a greater depth is not anticipated within the burn area because the planned excavation to 8 feet is expected to extend to the water table. Characterization of the excavated soil as hazardous or nonhazardous waste will be confirmed by analysis using TCLP prior to disposal.

Alternative 1 – No Action

A no-action alternative is carried forward as a baseline for comparison. Under this alternative, no remedial action or monitoring would be conducted for contaminated soil at the site. This alternative fails to meet the RAO for soil at the site.

The following estimated costs and durations are associated with Alternative 1:

Capital Cost: $0 K
Total Operation and Maintenance Costs: $0 K
Present Worth Cost: $0 K
Time to Implement: 0 Months
Time to Achieve RAO: (would not be met in the foreseeable future).

Alternative 2 – Excavation and Off-Site Disposal

This alternative includes excavation of the contaminated soil from the areas depicted on Figure 7, TCLP testing, segregation of soil that is hazardous due to elevated levels of 2,4-DNTand/or lead (if applicable based on TCLP results), off-site treatment/disposal of hazardous soil at a RCRA TSDF, and (if applicable based on TCLP results) off-site disposal of nonhazardous soil at a nonhazardous solid waste landfill. PCBs will be excavated and disposed of off site at a nonhazardous waste landfill, as long as the criteria for the other contaminants meet the criteria for nonhazardous disposal.

The following estimated costs and durations are associated with Alternative 2:

Capital Cost: $4.7M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $3.5M
Time to Implement: 25 Months
Time to Achieve RAO: 25 Months.

Alternative 3 – Excavation, Windrow Composting, Chemical Stabilization, and On-Site and Off-Site Disposal

This alternative includes excavation of the contaminated soil (Figure 7), TCLP testing, segregation of the hazardous lead-contaminated soil, segregation and windrow composting of hazardous 2,4-DNT-contaminated soil, segregation of soils containing PCBs or TCDD TEQ at concentrations exceeding the RGs, chemical stabilization of the lead-contaminated soil, and off-site disposal of the treated material at a nonhazardous solid waste landfill and/or placement of the treated material on site. Any soils found to be nonhazardous prior to treatment based on TCLP and PCB results will be disposed of off site at a nonhazardous waste landfill. A simplified decision flow chart for this alternative is depicted on Figure 8.

Soils within the remediation area (Figure 7) at a depth of 0 to 2 feet have elevated lead, PCB, and/or TCDD TEQ concentrations. The soil with elevated lead concentrations will require stabilization. The lead-stabilized soil is not suitable for on-site backfill because the residual risk associated with the reduced bioavailability of lead in soil cannot be adequately quantified. Additionally, composting does not effectively remediate PCDD/Fs and PCBs. Therefore, it is assumed that soil excavated from the top 2 feet within the entire remedial area will require off-site disposal after composting and/or lead stabilization as described in the following paragraphs. Soils excavated from within the burn area at a depth of 2 to 8 feet do not appear to have elevated lead, PCB, or PCDD/F concentrations and may be appropriate for on-site placement after composting.

The excavated soil would be hauled to an outdoor staging area and characterized as hazardous or nonhazardous using the results of the TCLP test and analyses for the COCs. Soil that passes the TCLP test will be hauled to the Erie County Landfill or other nonhazardous solid waste landfill that is approved to accept the soil. Note that if any soil contains PCBs at 50 mg/kg or greater, it will be hauled to a TSCA-approved, RCRA Subtitle C hazardous waste landfill,, regardless of whether the soil fails for a RCRA hazardous waste characteristic or analytical results for the other COCs.

Soil that initially fails the TCLP test for 2,4-DNT will be composted until the TCLP criterion for 2,4-DNT is met. Composting will be performed at the existing outdoor area specifically designed for the treatment (both stabilization and composting) of contaminated soil. During composting, the contaminated soil will be blended with amendments, such as straw and manure, turned occasionally with a windrow compost turner, and kept moist. The nitroaromatic compounds are biodegraded and transformed into less toxic and less mobile compounds through a series of sequential aerobic and anaerobic treatments, which are facilitated by mixing the soil with the amendments and periodic turning of the compost.

After composting, soil that fails the TCLP test for lead will be treated with a chemical (e.g., Maectite®) to immobilize the lead within the soil matrix. After treatment, TCLP testing will be used to confirm that the stabilized material is nonhazardous for lead. This stabilization treatment will be performed in the same area as the composting. TCLP testing will be used to confirm at what point the stabilized soil is nonhazardous for lead. Soils that have been stabilized with respect to lead will be disposed of at a nonhazardous solid waste landfill. Likewise, soils that have PCBs or TCDD TEQ at concentrations that exceed the respective RGs will be disposed of at a nonhazardous solid waste landfill. All excavated soil that was hazardous at the time it was excavated will be treated to comply with the LDRs for all underlying hazardous constituents before land disposal.

Composted material may be disposed of on site under the following criteria: 1) the TCLP criterion for 2,4-DNT is met; 2) the material did not require stabilization for lead; 3) PCB and TCDD TEQ concentrations meet the RGs; and 4) the LDR ATS are met. Note that because the finished composted material has been blended with organic amendments and is less dense than the native soil, it is not suitable as a base for construction, but may be desirable for landscaping purposes.

The following estimated costs and durations are associated with Alternative 3:

Capital Cost: $3.8M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $3.8M
Time to Implement: 34 Months
Time to Achieve RAO: 34 Months.

Alternative 4 – Excavation, Alkaline Hydrolysis, Chemical Stabilization, and Off-Site and On-Site Disposal

This alternative includes excavation of the contaminated soil (Figure 7), TCLP testing, segregation and stabilization of the hazardous lead-contaminated soil, segregation and alkaline hydrolysis of hazardous 2,4-DNT-contaminated soil, segregation of soils containing PCBs or TCDD TEQ at concentrations exceeding the RGs, chemical stabilization of the lead-contaminated soil, and off-site disposal of the treated material at a nonhazardous solid waste landfill and/or placement of the treated material on site. Any soils found to be nonhazardous prior to treatment based on TCLP and PCB results will be disposed of off site at a nonhazardous waste landfill. A simplified decision flow chart for this alternative is depicted on Figure 8.

Soils within the remediation area at a depth of 0 to 2 feet shown on Figure 7 have elevated lead, PCB, and/or TCDD TEQ concentrations. The soil with elevated lead concentrations will require stabilization. The lead-stabilized soil is not suitable for on-site backfill because the residual risk associated with the reduced bioavailability of lead in soil cannot be adequately quantified. Additionally, alkaline hydrolysis treatment technology does not effectively remediate PCDD/Fs and PCBs. Therefore, it is assumed that soil excavated from the top 2 feet within the entire remedial area will require off-site disposal after alkaline hydrolysis treatment and/or lead stabilization as described in the following paragraphs. Soils excavated from within the burn area at a depth of 2 to 8 feet do not appear to have elevated lead, PCB, or TCDD/F concentrations and may be appropriate for on-site placement after alkaline hydrolysis.

The excavated soil will be hauled to an outdoor staging area and characterized as hazardous or nonhazardous using the results of the TCLP test and analyses for the COCs. Soils that pass the TCLP test as nonhazardous and have PCB concentrations less than 50 mg/kg will be hauled to the Erie County Landfill or other nonhazardous solid waste landfill that can accept the soil. Note that if any soil contains PCBs at 50 mg/kg or greater, it will be hauled to a TSCA-approved, RCRA Subtitle C hazardous waste landfill, regardless of whether the soil fails for a RCRA hazardous waste characteristic or analytical results for the other COCs.

Soils that initially fail the TCLP testing for 2,4-DNT will be treated with an alkaline chemical mixture (e.g., caustic soda) at the existing area designed for treatment, until the TCLP criterion for 2,4-DNT is met. Chemicals will be mixed into the soil using an excavator, wheel loader, or compost turner. The nitroaromatics are chemically reacted to less toxic compounds. Alkaline hydrolysis treatment of this soil will continue until the 2,4-DNT TCLP criterion is met. If RGs are also met, the alkaline-treated material will be placed on site; if RGs are not met, then this material will be disposed of off site. Addition of the alkaline chemicals to the contaminated soil will result in the pH of this material being raised, at least temporarily. Therefore, addition of a neutralization agent (e.g., ferrous sulfate) may be required to lower the pH for disposal on site or for acceptance by a landfill if disposed of off site. Placement of soil back on site as subsurface soil will be acceptable at a pH value below 12.5 and when the alkaline hydrolysis process is no longer providing a benefit.

Soil that fails the TCLP for lead will be treated with a reagent (e.g., Maectite) to immobilize the lead within the soil matrix. This stabilization treatment will be performed in the same area as the alkaline hydrolysis treatment. TCLP testing will be used to confirm at what point the stabilized soil is nonhazardous for lead. Soils that have been stabilized with respect to lead will be disposed of at a nonhazardous solid waste landfill. Likewise, soils that have PCBs or TCDD TEQ at concentrations that exceed the respective RGs will be disposed of at a nonhazardous solid waste landfill. All excavated soil that was hazardous at the time it was excavated will be treated to comply with the LDRs for all underlying hazardous constituents before land disposal.

It is possible that treatment with the alkaline agent (caustic soda) will irreversibly bind the lead to soil, even after neutralization. If this is the case, chemical addition to alkaline hydrolysis-treated soil may not be required to neutralize the soil pH for on-site placement. It is noted that alkaline hydrolysis-treated soil at a non-PBOW site was not chemically neutralized, and the soil pH at this site dropped to near neutral over a period of 3 months while staged on site.

Materials treated with alkaline hydrolysis may be disposed of on site under the following criteria: 1) the TCLP criterion for 2,4-DNT is met; 2) the material did not require stabilization for lead; 3) PCB and TCDD TEQ concentrations meet the RGs; and 4) the LDR ATS are met.

The alkaline hydrolysis treatment may result in raising the pH of the soil, at least temporarily (e.g., months). Therefore, this remediated material can be used as backfill, but not as surface soil. Please note that it is anticipated that only the soil currently at a depth of 2 to 8 feet, all within the burn area, may be placed back on site, and that this subsurface soil may not be an adequate growth medium for plants even if it is neither contaminated nor remediated.

The following estimated costs and durations are associated with Alternative 4:

Capital Cost: $2.8M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $2.8M
Time to Implement: 31 Months
Time to Achieve RAO: 31 *Months.*

As discussed previously, if chemical addition is not required for pH neutralization, a further cost savings may be realized.

Evaluation of the Alternatives

Each of the remedial alternatives for R2BG soil was evaluated with respect to the following nine criteria, as required by the NCP at 40 Code of Federal Regulations 300.430 (e)(9)(iii). Criteria 1 and 2 are the threshold criteria, which must be met; criteria 3 through 7 are the primary balancing criteria; and criteria 8 and 9 are the modifying criteria.

Threshold Criteria

1. Overall Protectiveness of Human Health and the Environment
2. Compliance with ARARs

Primary Balancing Criteria

3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost

Modifying Criteria

8. State Support/Agency Acceptance
9. Community Acceptance.

The threshold criteria are requirements that a remedial alternative must meet to be eligible for selection. The five primary balancing criteria are used to determine the trade-offs between alternatives. The modifying criteria are public and state acceptance. Although the public and the State of Ohio have had opportunity for input throughout the R2BG RI/FS process and have previously accepted these technologies for other PBOW sites, these criteria are not finalized until conclusion of the public comment period on the R2BG Proposed Plan.

Threshold Criteria. Each of the three action-based alternatives (i.e., Alternatives 2 through 4) meet the threshold criteria for protection of human health and the environment and compliance with ARARs. These ARARs (Appendix A) include the Federal Land Disposal Restrictions and the Special Federal Provision for Cleanup—Staging Piles. Alternative 1, no action, does not meet the threshold criterion for protection of human health and the environment. Thus, Alternative 1 is not regarded as viable for R2BG and is not further discussed in this evaluation of alternatives.

Primary Balancing Criteria. Alternatives 2 through 4 are equally effective in the long term because the contaminated soil would be treated and/or taken off site. Alternatives 3 and 4 would meet the preference for treatment technologies that result in a reduction in toxicity, mobility, or volume. Alternative 2 relies only on off-site disposal and assumes that based on existing data, all materials would be treated at a RCRA/TSCA TSDF to comply with the LDR requirements prior to disposal.

Each of the three action-based alternatives could be performed in 34 months or less upon commencement of field remediation activities. Alternative 2 is estimated to take the shortest duration (25 months). Alternatives 3 and 4 could be performed within similar time frames (34 and 31 months, respectively). Alternatives 2 through 4 can all be carried out safely without appreciable risk to remediation workers, NASA employees, or nearby residents. Although Alternative 4 requires the handling of hazardous chemicals (e.g., caustic soda) whereas the other alternatives do not, proper adherence to the safety and health plan that would be developed specifically for the selected alternative allows for safe implementation of each alternative.

Alternatives 2 through 4 represent proven technological approaches and each is regarded as implementable. Windrow composting, the primary technology of Alternative 3, has been used successfully at the PBOW TNTB and PRRWP Area sites. Chemical stabilization of lead, included in Alternatives 3 and 4, has also been used at various PBOW sites. Alternative 2 is implementable, because it is simply off-site disposal/treatment. The effectiveness of alkaline hydrolysis, which is the primary technology for Alternative 4, has been demonstrated on even high concentrations of TNT (>99 percent destruction) and DNTs (~97 percent destruction for 2,4-DNT). Alkaline hydrolysis has been used for contaminated soil from TNT Area C.

Once treatment of nitroaromatic-contaminated soil is complete using composting under Alternative 3, the composted material is not a suitable base for construction, but it may be used for landscaping purposes and as a soil amendment with respect to plant growth. Under Alternative 4, the alkaline-treated soil cannot be used as a growth medium for plants, but it is suitable as a construction base as subsurface soil.

Costs of the three action-based alternatives are as follows, from least to most expensive:

- Alternative 4 – $2.8M
- Alternative 2 – $3.5M
- Alternative 3 – $3.8M.

In addition, it is possible that Alternative 4 will not require neutralization for on-site placement of the remediated soil which is planned to be placed on site below the surface. This would result in greater cost savings. Also, a stabilizing agent may not be required for lead under Alternative 4 because the alkalizing agent should precipitate the lead out as stable lead hydroxide. These possibilities represent additional potential cost savings under this alternative that are not reflected in the above estimate for Alternative 4.

Modifying Criteria. The two modifying criteria, state acceptance and public acceptance, are not fully evaluated until the Responsiveness Summary of the Decision Document is complete. The evaluation in the Responsiveness Summary is based on state comment on the Proposed Plan, state comment during the public meeting and comment period, and public comment during the public meeting and public comment period.

It is noted that each of the technologies represented by the three action-based alternatives have been presented to the State of Ohio and public in the past. Neither the State of Ohio nor the public has expressed concern over any of these technologies. Composting, alkaline hydrolysis, and stabilization have been presented to the State of Ohio and public and in the past. Each of these technologies has been employed at different PBOW sites after approval by the public and state. Also, the Preferred Alternative for TNTA soils presented during a November 30, 2009 public meeting for the TNTA Proposed Plan included all three of these treatment technologies. No objections were expressed by the public or the State of Ohio to any of the technologies presented, either during the meeting or during the public comment period for TNTA. However, it is emphasized that evaluation of the modifying criteria for the preferred alternative for R2BG will be completed in the Responsiveness Summary of the R2BG Decision Document, based on public and state input provided specifically during the R2BG public meeting and public comment period.

Summary of the Preferred Alternative

Soil. Alternative 4: Excavation, Alkaline Hydrolysis, Chemical Stabilization, and Off-Site Disposal/On-Site Disposal, is selected as the preferred remedial alternative for R2BG soil.

Alternative 4 is recommended over Alternative 1 because Alternative 1 does not meet the threshold criterion of protecting human health and the environment.

Alternative 4 is recommended over Alternative 2 because it utilizes on-site treatment to satisfy the statutory preference for alternatives that reduce the toxicity, mobility, or volume of contamination through treatment. Alternative 2 does not utilize on-site treatment. Both alternatives provide equal protection for human health and the environment.

Alternatives 2, 3, and 4 provide equal protection for human health and the environment. However, Alternative 4 ($2.8M) is recommended over Alternatives 2 ($3.5M) and 3 ($3.8M) because it would cost less to implement.

Alternative 4 is the most cost-effective alternative based on an evaluation of the five primary balancing criteria used in the FS process. The USACE expects Alternative 4 to satisfy the following statutory requirements of CERCLA Section 121(b): (1) be protective of human health and the environment; (2) comply with ARARs (Appendix A); (3) be cost effective; (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (5) satisfy the preference for treatment as a principal element or explain why the preference for treatment will not be met. The Preferred Alternative is subject to change after the public comment period as the result of input by the State of Ohio or the public. This change would be reflected in the R2BG Decision Document, and the comment(s) providing the basis for such change would be recorded in the Responsiveness Summary of the Decision Document.

Groundwater. No action is the preferred alternative for groundwater based on the following rationale:

- The bedrock water underlying R2BG is regarded as nonpotable due to the presence of naturally occurring petroleum hydrocarbons. It is also noted that R2BG groundwater also appears to be of insufficient yield for potable use, regardless of quality.
- Naturally occurring petroleum hydrocarbons have been observed at depth from the cores of numerous PBOW bedrock wells, including R2BG-BEDGW-002 (37.75 to 39.0 feet bgs; 67.0 to 71.5 feet bgs) (Jacobs, 2006). Additionally, many of the monitoring wells across PBOW emit elevated levels of hydrogen sulfide gas, which renders these wells unusable.
- Bedrock groundwater monitoring wells underlying R2BG produced very little water. One of the wells was dry and the other two could not be developed or

purged. These circumstances indicate insufficient water yield for a potable supply, even if the water were of potable quality.

- Because of the dry conditions, the bedrock groundwater samples had to be collected using the bailer method. The low yields described in the previous bullet coupled with the collection method resulted in groundwater samples that were of highly suspect quality due to turbidity and correspondingly elevated total suspended solids and metals content.

- None of the organic COCs found in R2BG soil were detected in groundwater. This indicates that the contaminants present in R2BG soil have not affected the groundwater. Although lead was detected in R2BG groundwater, its presence is likely associated with suspended particulates resulting from the sample quality described in the previous bullet.

- No unacceptable site-related health risks are associated with hypothetical groundwater use. The BHHRA results for a hypothetical bedrock groundwater user show that 100 percent of the noncancer hazard is associated with naturally occurring petroleum hydrocarbons. Similarly, 100 percent of the groundwater cancer risks in the BHHRA were associated with naturally occurring petroleum hydrocarbons and non-site-related arsenic.

- The overburden groundwater underlying R2BG produced insufficient yield or sampling. Therefore, the overburden groundwater is of insufficient yield for use.

Community Participation

A level of community relations activities that is consistent with CERCLA, SARA, and the NCP is required for DERP-FUDS projects. The objective of the community relations program at PBOW is to provide a mechanism for the communication and exchange of information among Army agencies, government agencies, and residents of local communities and those adjacent to Plum Brook downgradient from PBOW. In January 1997, a Restoration Advisory Board composed of local citizens with varying backgrounds, along with members from the USACE, NASA, and the OEPA, was established to promote a two-way dialog to keep local citizens informed about site progress and to allow them the opportunity to provide input to DERP-FUDS project decisions. The USACE and Restoration Advisory Board follow the community relations plan, which was developed in 1999 and is updated each year.

In compliance with CERCLA (Section 113), the USACE has developed the AR file to provide documentation as to how and why decisions specific to the remediation of the site are made. The AR file contains these final documents as well as all others for the PBOW site. Currently, these final documents are located in the AR file at the USACE Huntington District Office (Huntington, West Virginia) and at the Public Repository located at the BGSU Firelands Library (Huron, Ohio). All documents are available for public viewing at the Firelands Library, at the USACE Huntington District Office, and at the following Web site: http://lrh-apps.usace.army.mil/fuds/index.asp

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References *(in addition to the list of R2BG documents provided on Page 4)*

U.S. Environmental Protection Agency (USEPA), 1998, "Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities," memorandum from T. Fields, Jr., Acting Assistant Administrator, August, OSWER Directive 9200.4-27P.

U.S. Environmental Protection Agency (USEPA), 1990, ***National Oil and Hazardous Substances Pollution Contingency Plan***, 40 CFR Part 300.430.

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

Common acronyms and abbreviations used in this Proposed Plan are defined below:

AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
ATS	Alternative Treatment Standards (under LDR)
bgs	below ground surface
BGSU	Bowling Green State University
BHHRA	baseline human health risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (also referred to as “Superfund”)
COC	chemical of concern
COPEC	chemical of potential ecological concern
DERP-FUDS	Defense Environmental Restoration Program-Formerly Used Defense Sites
DNT	dinitrotoluene
DoD	U.S. Department of Defense
EHQ	ecological hazard quotient
FFS	focused feasibility study
FS	feasibility study
GSA	General Services Administration
HI	hazard index
ILCR	incremental lifetime cancer risk
Jacobs	Jacobs Engineering Group, Inc.
LDR	Land Disposal Restriction
mg/kg	milligram per kilogram
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/kg	nanograms per kilogram
NTCRA	non-time-critical removal action
OEPA	Ohio Environmental Protection Agency
PA	preliminary assessment
PAH	polycyclic aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
PCDD/F	polychlorinated dibenzodioxins/furans
PRRWP	Pentolite Road Red Water Pond
R2BG	Reservoir No. 2 Burning Ground
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RG	remedial goal
RI	remedial investigation
SARA	Superfund Amendments and Reauthorization Act of 1986
SLERA	screening level ecological risk assessment
TBC	to be considered
TCDD TEQ	2,3,7,8-tetrachloro-p-dibenzodioxin toxicity equivalency

ACRONYMS AND ABBREVIATIONS (continued)

TCLP	toxicity characteristic leaching procedure
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WARWP	West Area Red Water Pond

TABLES

Table 1

Summary of Total Hazard Index and Total Cancer Risk from Chemicals of Potential Concern[a]
Reservoir No. 2 Burning Ground Feasibility Study
Plum Brook Ordnance Works, Sandusky, Ohio

	Groundskeeper		Indoor Worker		Adult Hunter		Construction Worker		On-Site Resident[b]	
Contaminant Source	Total HI[c]	Total ILCR[d]	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR
Inside the Burn Area										
Surface Soil	***12***	*8.0E-05*	***6.0***	*3.9E-05*	0.67	6.0E-06	***33***	4.6E-06	***140***	***3.4E-04***
Subsurface Soil	NA[e]	NA	NA	NA	NA	NA	***154***	*5.0E-05*	***651***	***3.6E-03***
Groundwater[f]	NA	NA	***16***	***2.1E-03***	NA	NA	NA	NA	***106***	***7.4E-03***
Total across all media Inside the Burn Area [g]	***12***	*8.E-05*	***22***	***2.E-03***	0.7	6.E-06	***154***	*5.E-05*	***757***	***1.E-02***
Outside the Burn Area										
Surface Soil	1.2	*2.6E-05*	0.6	1.3E-05	0.07	2.3E-06	***3.4***	1.5E-06	***14.5***	*1.0E-04*
Subsurface Soil	NA	NA	NA	NA	NA	NA	1.3	1.1E-06	***5.3***	*8.3E-05*
Sediment	NA	NA	NA	NA	NA	NA	NA	1.9E-07	NA	3.5E-06
Groundwater	NA	NA	***16***	***2.1E-03***	NA	NA	NA	NA	***106***	***7.4E-03***
Total across all media Outside the Burn Area [g]	1	*3.E-05*	***16***	***2.E-03***	0.07	2.E-06	***3***	2.E-06	***121***	***7.E-03***

[a]The values shown are based on information contained in the text, tables, and appendices of the BHHRA (Jacobs, 2010).

[b]The BHHRA includes both a childhood and adult resident exposure scenarios. For noncancer effects, the HI value (see footnote c) for childhood exposure is shown for Total HI because it is higher (more health protective) than the adult value from the BHHRA. The Total ILCR (see footnote d) is the summed ILCR values for both child and adult scenarios which, unlike noncancer HI values, are regarded as additive throughout the lifetime of an individual.

[c]The hazard index (HI) is a measure of noncancer hazard for an exposed individual.

[d]The incremental lifetime cancer risk (ILCR) is the estimated extra cancer risk which an individual encounters based on exposure to a site.

[e]NA = Not applicable.

[f]No wells were installed inside the Burn Area. Pertinent Inidivuals inside the Burn Area are assumed to be exposed to the same groundwater as those outside of the Burn Area.

[g]For soil exposure, either surface soil or subsurface soil exposure was assumed in this sum, whichever would lead to a higher Total HI and Total ILCR. Summed totals are rounded to one significant figure.

Notes:

1. HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2. ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable.
3. The NCP identifies ILCR values less than 1E-6 (1 in 1,000,000) as negligible, and ILCR values of 1E-6 (1 in 1,000,000) through 1E-4 (1 in 10,000) are within the NCP acceptable range; It is noted that the average lifetime cancer risk of the general U.S. population is approximately 40,000 in 100,000.
4. *Italics* (non-bolded) apply only to cancer risks and indicate that the value exceeds the the 1E-5 value that is regarded as acceptable by the OEPA.
5. ***Bold intalics*** indicates that the noncancer hazard is unacceptable, or that the cancer risk value exceeds the NCP acceptable range (1E-6 to 1E-4).
6. A child venison consumer was also evaluated for the R2BG. Cancer risks (less than 1E-6) and potential noncancer hazards (less than 0.1) for this receptor were found to be negligible.

Table 2

Summary of Screening-Level Ecological Risk Assessment
Reservoir No. 2 Burning Ground Proposed Plan
Former Plum Brook Ordnance Works
Sandusky, Ohio

Inside the Burn Area		
Risk-Driving Chemical[a]	**Minimum Ecological Hazard Quotient (receptor)[b]**	**Maximum Ecological Hazard Quotient (receptor)[c]**
2,3,7,8-Tetrachlorodibenzo-p-dioxin Toxicity Equivalency	0.006 (deer)	92 (shrew)
2,4-Dinitrotoluene	35 (hawk)	19,000 (mouse)
2,6-Dinitrotoluene	1 (hawk)	660 (mouse)
2,4,6-Trinitrotoluene	5 (deer)	4,200 (wren)
Acenaphthene	0.002 (deer)	280 (shrew)
Naphthalene	0.004 (deer)	64 (shrew)

Outside the Burn Area		
Risk-Driving Chemical[a]	**Minimum Ecological Hazard Quotient (receptor)[b]**	**Maximum Ecological Hazard Quotient (receptor)[c]**
2,4-Dinitrotoluene	0.1 (hawk)	59 (mouse)
2,6-Dinitrotoluene	0.02 (hawk)	23 (mouse)
2,4,6-Trinitrotoluene	0.5 (deer)	420 (wren)

[a] Chemicals shown are those which are site related and have an ecological hazard quotient greater than 10 in at least one receptor.
[b] Receptor associated with the minimum ecological hazard quotient is shown in parentheses.
[c] Receptor associated with the maximum ecological hazard quotient is shown in parentheses.

Table 3

Remedial Goals for Soil
Reservoir No. 2 Burning Grounds Proposed Plan
Former Plum Brook Ordnance Works
Sandusky, Ohio

COC	RG[a] (mg/kg)[b]	Basis of RG	HQ of RG	ILCR of RG
TCDD TEQ (ng/kg)[b]	18	cancer risk[c]	NA	4E-6
2,4,6-Trinitrotoluene	38	noncancer hazard	1	2E-6
2,4-Dinitrotoluene	1.4[d]	cancer risk[c]	0.01[e]	2E-6
2,6-Dinitrotoluene	1.4[d]	cancer risk[c]	0.02[e]	2E-6
Aroclor 1254[f]	1.0	cancer risk/noncancer hazard[g]	0.9	4.5E-6[h]
Aroclor 1260[f]	1.0	cancer risk[g]	NA	4.5E-6[h]
Lead	400	guidance/IEUBK Model[i]	NA	NA
Total HI/ILCR			**1**[j]	**1E-5** (1.45E-5)[k]

[a] The RGs were derived assuming unrestricted land use and are based on residential exposure, including all exposure pathways for the resident. Cancer-based RGs include combined childhood (6 years) and adult (24 years) exposure. Noncancer-based RGs are based on childhood exposure only, which is the most conservative assumption for noncancer effects.

[b] TCDD TEQ concentrations are in units of ng/kg.

[c] Considers cumulative cancer effects among the COCs.

[d] RG values of 2,4- and 2,6-dinitrotoluene may alternatively be added (2.8 mg/kg combined).

[e] RG derived on the basis of carcinogenicity of dinitrotoluene mixture; noncancer effects are negligible (HQ<0.1).

[f] RG based on combined Aroclor 1254 and 1260 concentrations.

[g] In additional to cancer risk and (for Aroclor 1254) noncancer hazard, this value of 1 mg/kg was selected because it was used for other Plum Brook Ordnance Works sites.

[h] ILCR for combined Aroclor 1254 and 1260 concentration of 1 mg/kg.

[i] RG is based on the EPA soil screening value for average lead concentration (USEPA, 1998). This screening level is consistent with the U.S. Environmental Protection Agency (EPA), 2010b, *Integrated Exposure Uptake Biokinetic Model for Lead in Children, Windows® version (IEUBKwin v1.1 build 11)*, February.

[j] Total HI reflects the HQ of the RG representing the highest noncancer hazard (TNT). The noncancer effects of TNT are not additive with those of the other COCs, because the other COCs have different target organs with respect to their critical effects.

[k] Value outside of parentheses is for nitroaromatics at the RG levels; value shown in parentheses is the total ILCR assuming the combined Aroclor 1254/1260 concentration is equal to the RG. This combined ILCR rounds to an ILCR of 1E-5.

COC - Chemical of concern.
HI - Hazard index; sum of HQ values.
HQ - Hazard quotient.
IEUBK - Integrated Exposure Uptake Biokinetic.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
ng/kg - Nanograms per kilogram.
RG - Remedial goal.
TBC - To be considered criterion.
TCDD TEQ - 2,3,7,8-Tetrachlorodibenzo-p-dioxin toxicity equivalency.

FIGURES

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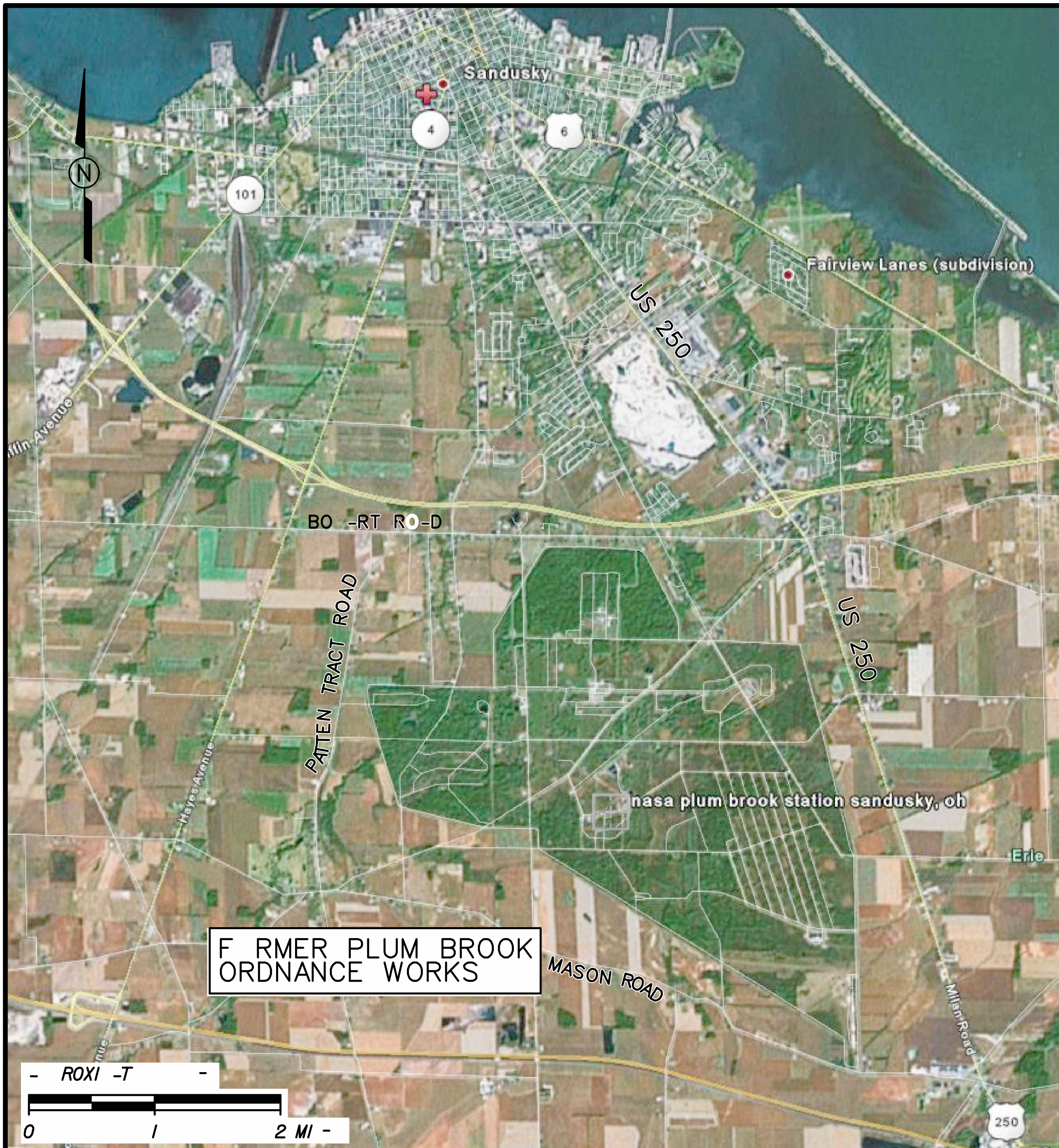

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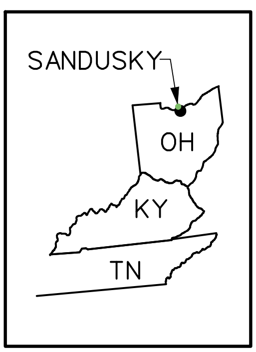
PBOW VICINITY M-P



RESERVOIR NO. 2 BURNIN -ROUND
PROPOSED PL-
F RMER PLUM BROOK ORDN- E WORK
N - PLUM BROOK ST-TION
S- DUSKY, OHIO

Shaw® a world of Solu i

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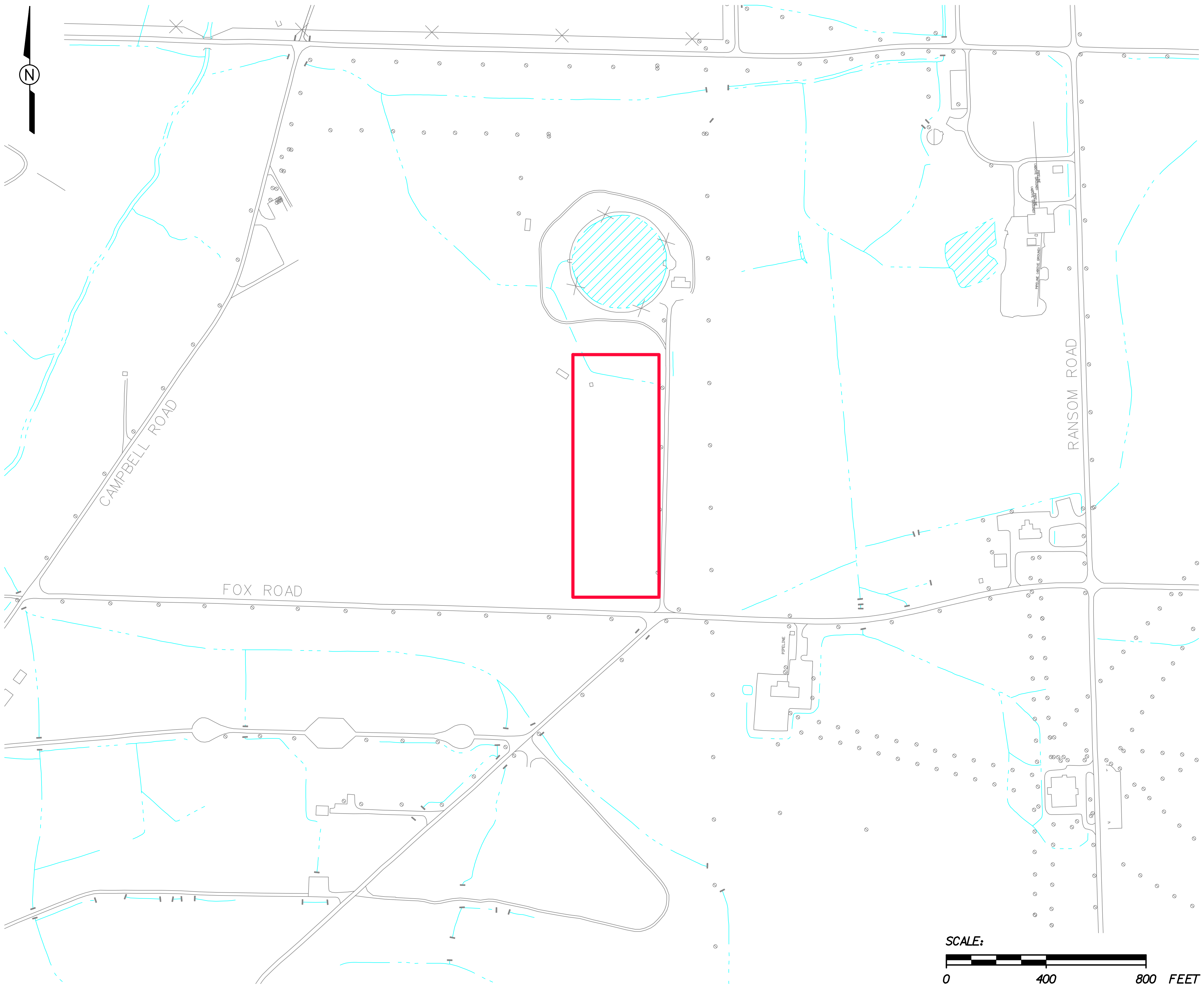

LEGEND:

- AREA OF CONCERN
- POND
- CREEK, DITCH, CONVEYANCE
- ROAD
- FENCE
- FACILITY BOUNDARY

FIGURE 2
LOCATION OF RESERVOIR NO.2 BURNING GROUND AT PBOW

RESERVOIR NO.2 BURNING GROUND PROPOSED PLAN
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® a world of Solutions™

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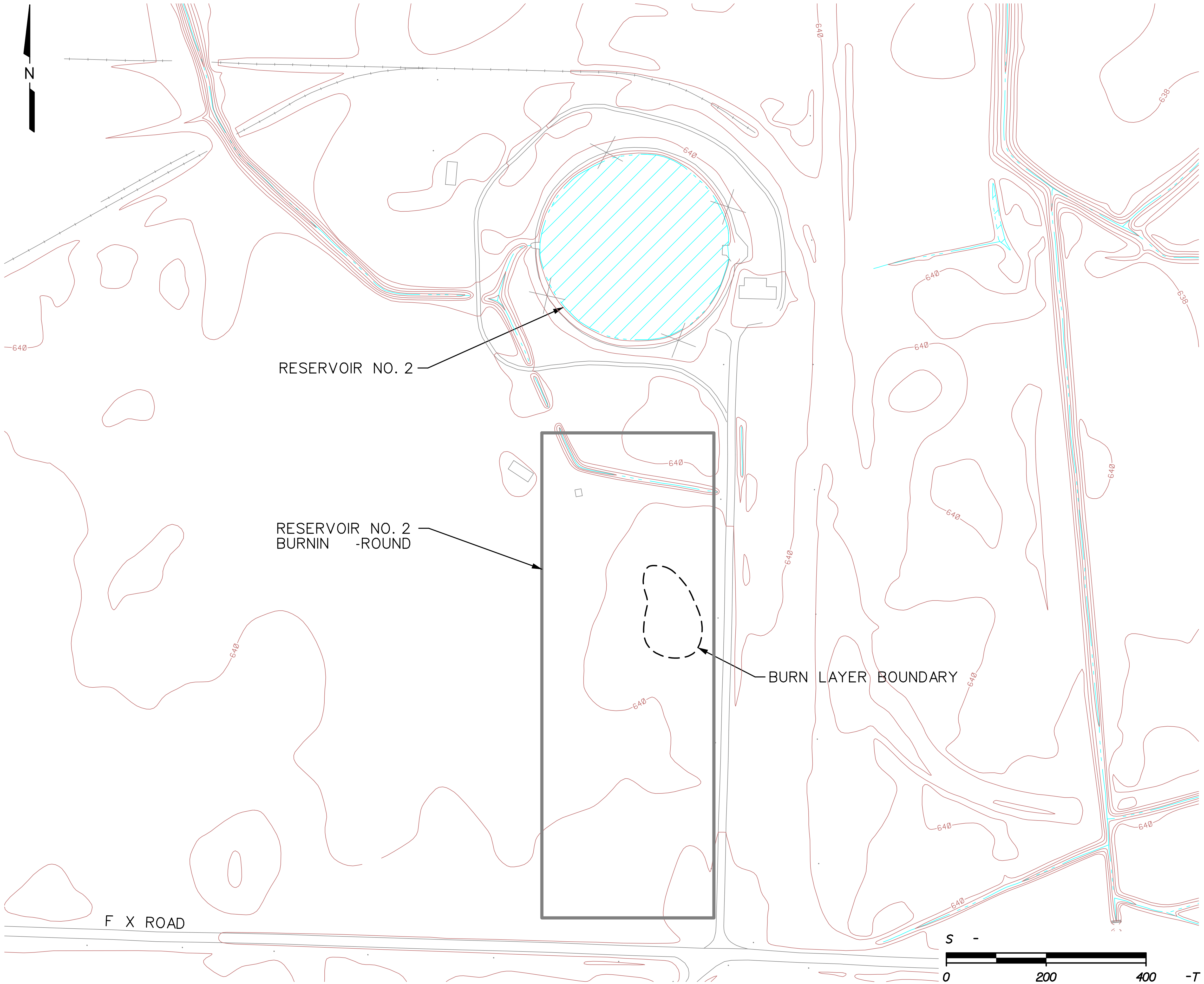

LE -END:

-RE- F ERN

TOPO -R-PHIC CONTOUR (2 FT. INTERV-

POND

CREEK, DITCH, CONVEY- E

R-ILRO-D

RO-D

BURN L-'ER BOUND-RY

FI- RE 3

-ENER- ITE FE-TURES WITH SITE TOPO -R-PHY

RESERVOIR NO. 2 BURNIN -ROUND
PROPOSED PL-
F RMER PLUM BROOK ORDN- E WORK
N - PLUM BROOK ST-TION
S- DUSKY, OHIO

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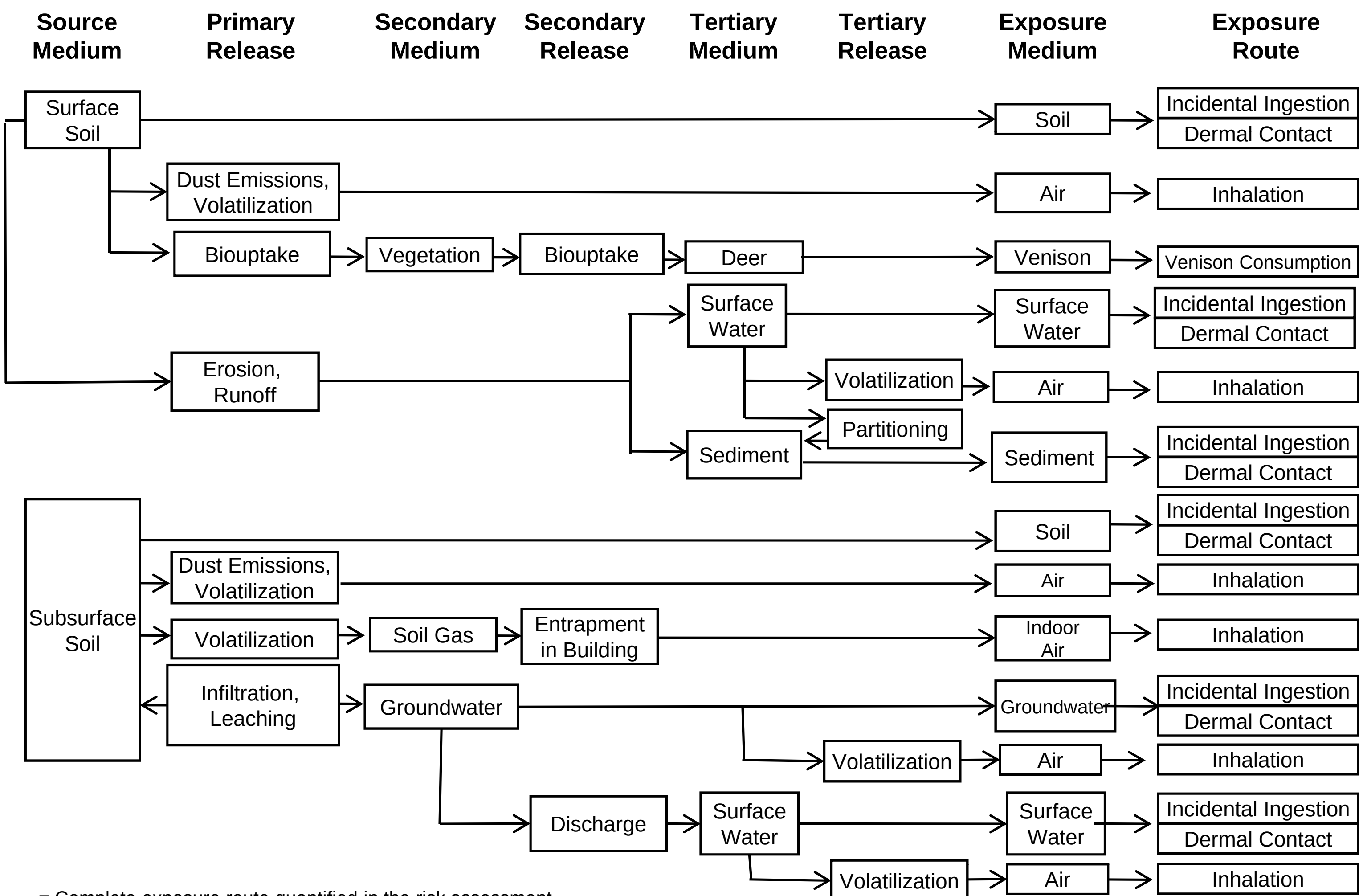
Figure 4
Human Health Conceptual Site Exposure Model
Reservoir No. 2 Burning Ground Proposed Plan
Plum Brook Ordnance Works, Sandusky, Ohio



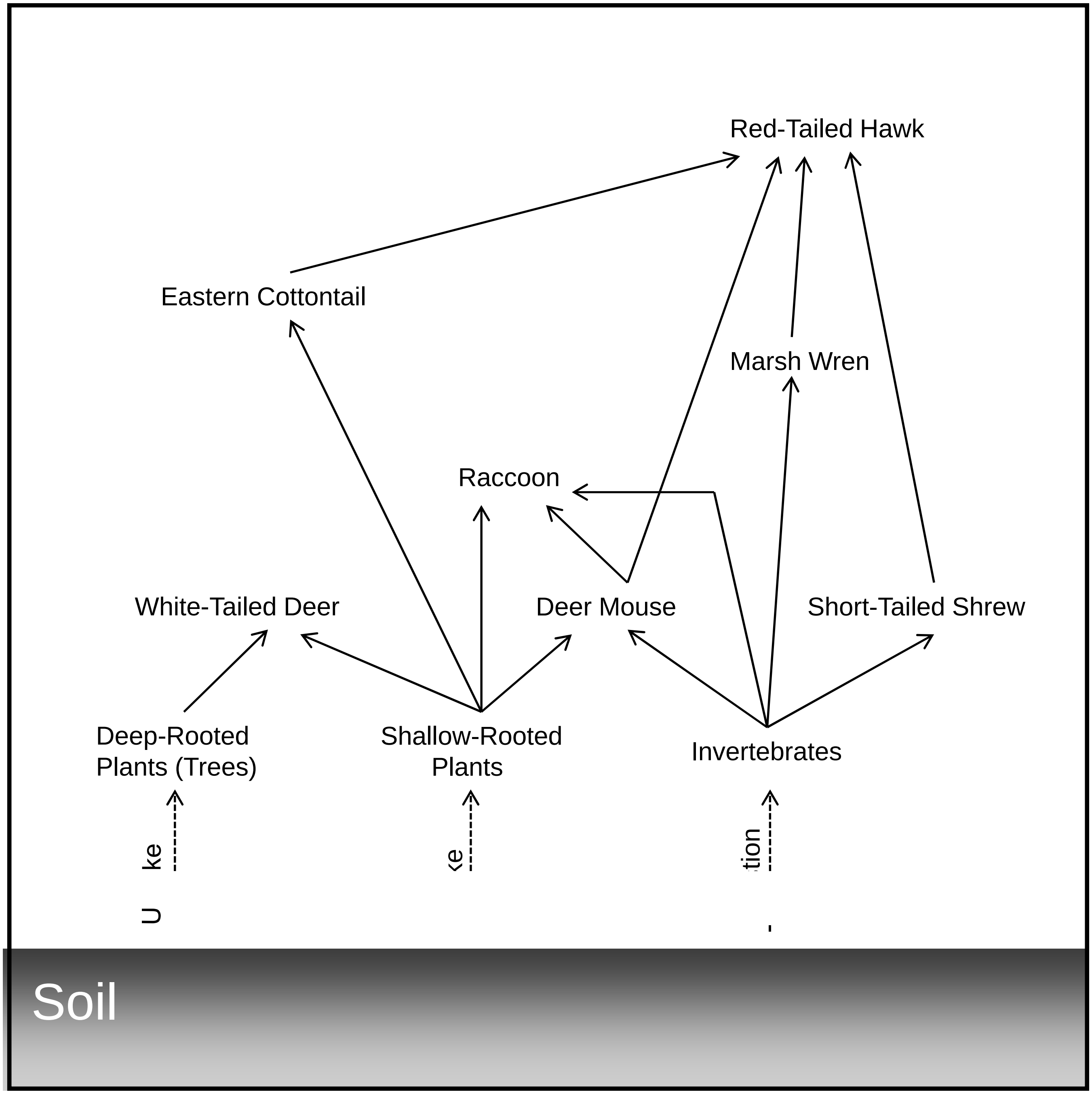
Receptor Scenarios

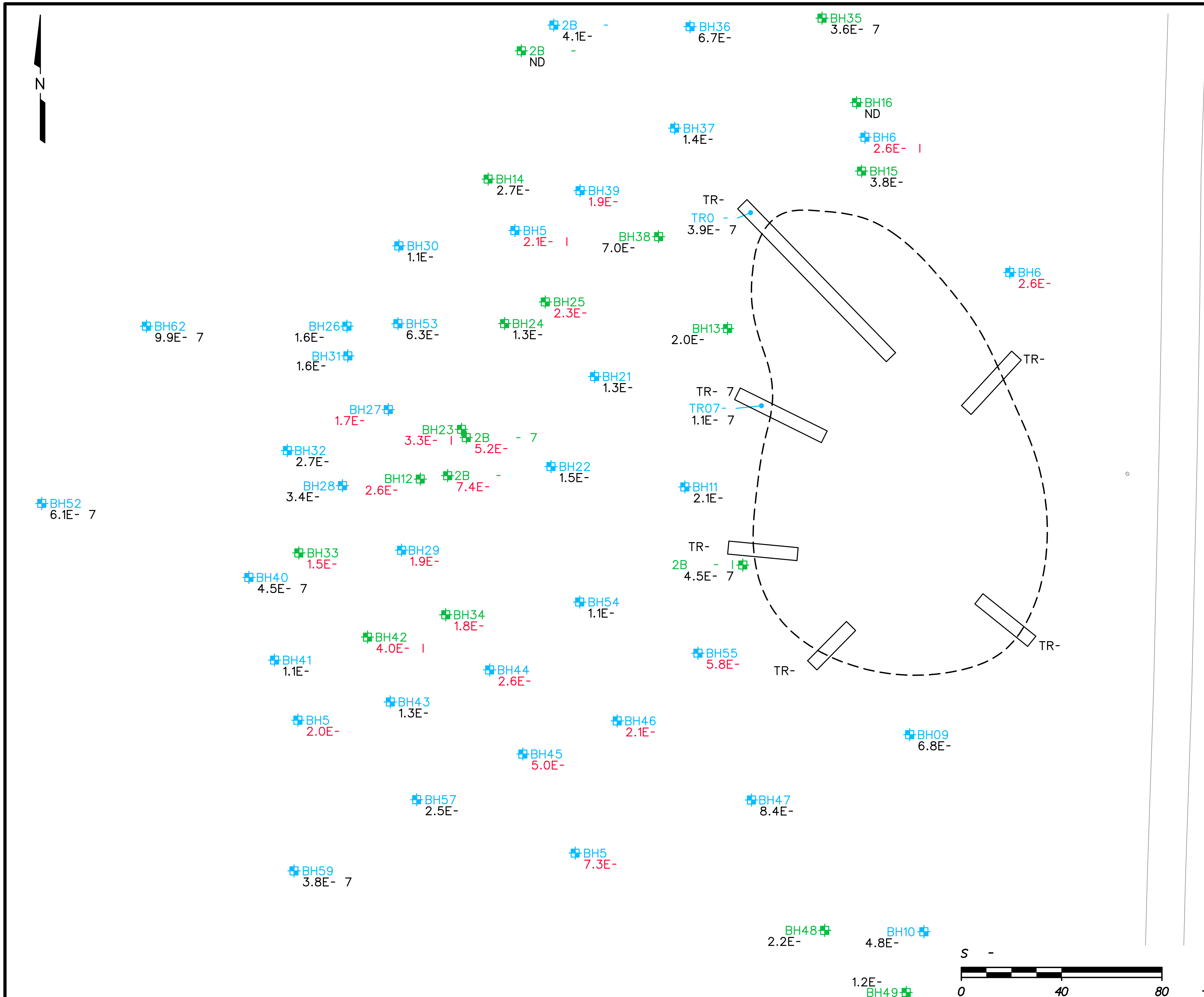
Source Medium	Exposure Medium	Exposure Route	Groundskeeper (Current/Future)	Construction Worker (Current/Future)	On-Site Resident (Future)	Indoor Worker (Future)	Hunter (Current/Future)	Hunter's Child (Current/Future)
Surface Soil	Soil	Incidental Ingestion	*	*	*	*	*	1
Surface Soil	Soil	Dermal Contact	*	*	*	2	*	1
Surface Soil	Air	Inhalation	*	*	*	2	2	1
Surface Soil	Venison	Venison Consumption	1	1	1	1	*	*
Surface Soil	Surface Water	Incidental Ingestion	3	3	3	3	3	3
Surface Soil	Surface Water	Dermal Contact	3	3	3	3	3	3
Surface Soil	Air	Inhalation	3	3	3	3	3	3
Surface Soil	Sediment	Incidental Ingestion	2	*	*	1	2	1
Surface Soil	Sediment	Dermal Contact	2	*	*	1	2	1
Subsurface Soil	Soil	Incidental Ingestion	1	*	*	1	4	1
Subsurface Soil	Soil	Dermal Contact	1	*	*	1	4	1
Subsurface Soil	Air	Inhalation	1	*	*	1	4	1
Subsurface Soil	Indoor Air	Inhalation	1	1	*	*	1	1
Subsurface Soil	Groundwater	Incidental Ingestion	1	2	*	*	1	1
Subsurface Soil	Groundwater	Dermal Contact	1	2	*	*	1	1
Subsurface Soil	Air	Inhalation	2	2	2	2	1	1
Subsurface Soil	Surface Water	Incidental Ingestion	3	3	3	3	3	3
Subsurface Soil	Surface Water	Dermal Contact	3	3	3	3	3	3
Subsurface Soil	Air	Inhalation	3	3	3	3	3	3

* = Complete exposure route quantified in the risk assessment.
1 = There is no plausible pathway for exposure to this medium.
2 = Although theoretically complete, this pathway is not quantified as explained in text.
3 = Incomplete pathway because no surface water was present in the drainage ditch during sampling event.
4 = Contact with this medium, although plausible, is not part of this receptor's normal or expected activities; therefore contact would be sporadic and is not quantified.

Figure 5

Simplified Terrestrial Food Web Conceptual Site Model
Reservoir No. 2 Burning Ground Proposed Plan
Plum Brook Ordnance Works, Sandusky, Ohio





LE -END:

- TRENCH LOC-TION
- SOIL S- PLE LOC-TION NOT - ’ZED F R PCDD/F
- SOIL S- PLE LOC-TION - ’ZED F R F ITE INCLUDIN- PCDD/F
- TRENCH S- PLE LOC-TION - ’ZED F R PCDD/F ’
- BURN L-’ER BOUND-RY (B- ED ON J- BS 2004 TRENCHIN-

NOTES:

1. V- ES SHOWN IN RED EXCEED - PLE SPECIFIC INCREMENT- IFETIME C- ER RISK OF E- ROUNDED TO ONE SI- IFIC- T FI- RE).
2. "PCDD/F" REFERS TO POLYCHLORIN-TED DIBENZODIOXINS/F R- .

FI- RE 6

C- ER RISK V- ES F R SURΓ- E SOIL S- PLES OUTSIDE THE BURN L-’ER BOUND-RY

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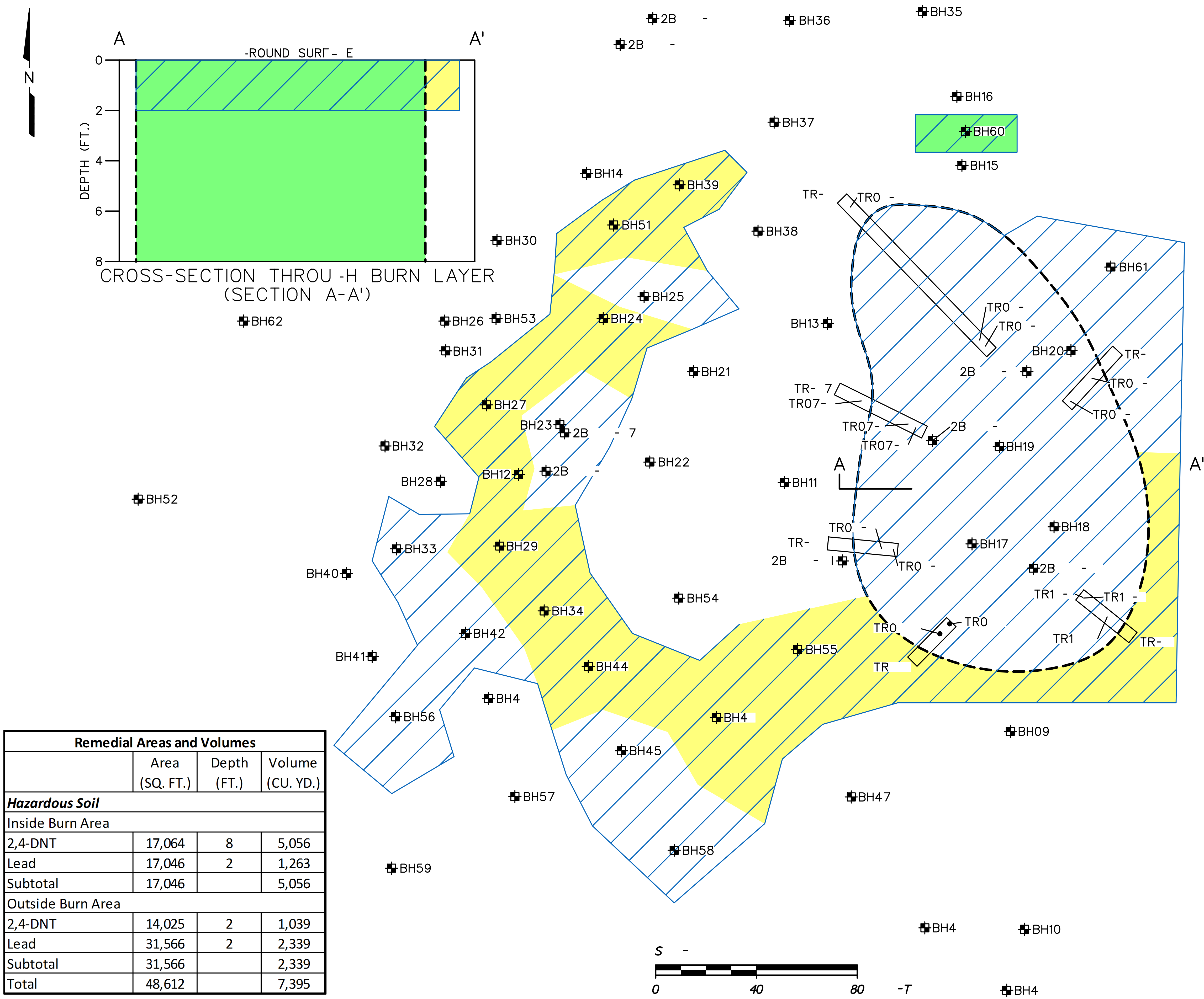

LE -END:

TRENCH LOC-TION

BURN L-ʼER BOUND-RY (B- ED ON J- BS 2004 TRENCHIN -

REMEDI -RE- - H -RDOUS F R 2,4-DNT (≤2.6 mg/kg)

REMEDI -RE- - H -RDOUS F R 2,4-DNT (>2.6 mg/kg)

REMEDI -RE- - H -RDOUS F R LE-D (>100 mg/kg) (SEE NOTES 1 - D 2)

SURΓ- E SOIL S- PLE LOC-TION

TRENCH S- PLE LOC-TION (SUBSURΓ- E)

NOTES:

1. - IL FROM 0 TO 2 FEET IS - ED H -RDOUS WITH RESPECT TO LE-D.
2. - BURN -RE- IL -T DEPTHS OF TO 8 FEET IS - ED H -RDOUS DUE TO 2,4-DNT ONLY.
3. REMEDI -RE- IRCUMSCRIBE S- PLE LOC-TIONS WITH - TOT - ER RISK >1E- .
4. DEPTH OF REMEDI- VOLUME INSIDE LIMITS OF BURN -RE- = FEET.
5. DEPTH OF REMEDI- VOLUME OUTSIDE LIMITS OF BURN -RE- = FEET.

FI - RE 7
PROPOSED REMEDI -RE- - D VOLUMES OF IL

RESERVOIR NO. 2 BURNIN -ROUND
PROPOSED PL-
F RMER PLUM BROOK ORDN- E WORK
N - PLUM BROOK ST-TION
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Remedial Areas and Volumes

	Area (SQ. FT.)	Depth (FT.)	Volume (CU. YD.)
Hazardous Soil			
Inside Burn Area			
2,4-DNT	17,064	8	5,056
Lead	17,046	2	1,263
Subtotal	17,046		5,056
Outside Burn Area			
2,4-DNT	14,025	2	1,039
Lead	31,566	2	2,339
Subtotal	31,566		2,339
Total	48,612		7,395

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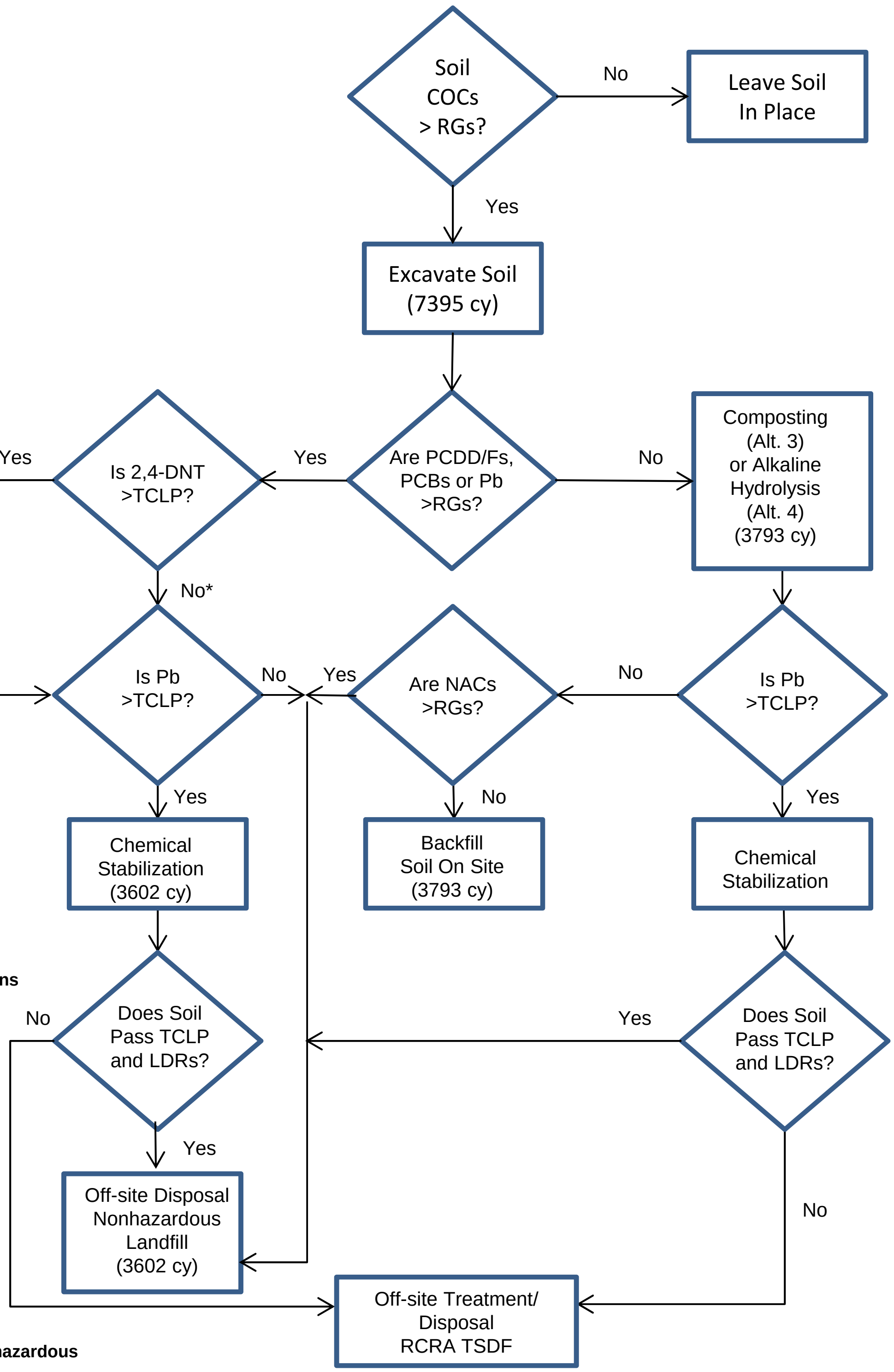
Figure 8

Simplified Decision Flow Chart for Treatment and Disposal of Soil, Alternative Nos. 3 and 4
Reservoir No. 2 Burning Ground Proposed Plan
Plum Brook Ordnance Works, Sandusky, Ohio



Legend:

COC = Chemical of concern.
cy = Cubic yards.
DNT = Dinitrotoluene.
LDR = Land disposal restriction.
NAC = Nitroaromatic explosive compound.
Pb = Lead.
PCB = Polychlorinated biphenyls.
PCDD/Fs = Polychlorinated dipenzo-p-dioxins and dibenzofurans.
RG = Remedial goal.
TCLP = Toxicity characteristic leaching procedure.
TSDF = Treatment, storage, and disposal facility.

***Volume of 1300 cy is assumed to be hazardous for lead but nonhazardous for 2,4-DDT.**

Notes:
1. **Estimated consolidated volumes are shown in parentheses. Volumes are based on assumptions explained in the text.**
2. **Soil that meets LDRs must also meet treatment standards for any underlying hazardous constituents.**

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APPENDIX A

APPLICABLE AND RELEVANT OR APPROPRIATE REQUIREMENTS FOR REMEDIAL ACTION

Appendix A

Applicable and Relevant or Appropriate Requirements for Remedial Action
Alternative 4: Excavation, Alkaline Hydrolysis, Chemical Stabilization, and Off-Site and On-Site Disposal
Reservoir No. 2 Burning Grounds Proposed Plan
Former Plum Brook Ordnance Works
Sandusky, Ohio

Authority	Medium	Requirement	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
U.S. Environmental Protection Agency	Soil	Federal Applicability of Treatment Standards (40 CFR 268.40)	Applicable	Prohibits land disposal of hazardous waste unless treatment standards are attained.	Remedial alternatives will comply with the treatment standards for contaminated soil that is placed back on site if the soil is managed outside the contiguous area of contamination.
U.S. Environmental Protection Agency	Soil	Federal Universal Treatment Standards (40 CFR 268.48)	Applicable	Specifies universal treatment standards for hazardous constituents in hazardous waste.	Remedial alternatives will comply with the treatment standards for contaminated soil that is placed back on site if the soil is managed outside the contiguous area of contamination.
U.S. Environmental Protection Agency	Soil	Federal Land Disposal Restriction Alternative Treatment Standards for Contaminated Soil (40 CFR 268.49)	Applicable	Rules specify how the universal treatment standards for hazardous waste are applied for contaminated soil that contains a hazardous waste.	Remedial alternatives will comply with the treatment standards for contaminated soil that is placed back on site if the soil is managed outside the contiguous area of contamination.
U.S. Environmental Protection Agency	Soil	Federal Special Provisions for Cleanup – Staging Piles (40 CFR 264.554)	Applicable	Rule identifies requirements for temporary storage of solid, non-flowing hazardous remediation waste that is not in a containment building.	Remedial alternatives will comply with these requirements by observing the standards and design criteria for staging piles.

CFR – Code of Federal Regulations.