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Final

Technical Memorandum
Supplemental Surface Water Sampling and Risk Management of Metals in Soil and Groundwater
Site 29—Lee Pond

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Acronyms and Abbreviations

AWQC	Ambient Water Quality Criteria
bgs	Below Ground Surface
BTAG	Biological Technical Assistance Group
CTE	central tendency exposure
DDT	Dichlorodiphenyltrichloroethane
DO	dissolved oxygen
ECOC	Ecological Chemicals of Concern
ERA	Ecological Risk Assessment
ERP	Environmental Restoration Program
FS	Feasibility Study
ft	feet
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	hazard quotient
µg/L	Micrograms per Liter
mg/L	Milligrams per Liter
NFA	No Further Action
NTU	Nephelometric Turbidity Units
ORP	oxidation/reduction potential
PCB	Polychlorinated Biphenyl
ppt	Parts per Thousand
RBC	risk based concentration
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
SSA	Site Screening Area
SSP	Site Screening Process
SVOC	Semivolatile Organic Compound
SW	Surface Water
TDS	Total Dissolved Solids
TM	Technical Memorandum
TOC	Total Organic Carbon
USEPA	United States Environmental Protection Agency

VOC	Volatile Organic Compound
WPNSTA	Naval Weapons Station

1. Introduction

This Technical Memorandum (TM) describes follow-up investigation and data evaluation for Site 29, Lee Pond, Naval Weapons Station (WPNSTA) Yorktown, completed subsequent to the *Final Round I Remedial Investigation Report, Sites 27, 28, 29, and 30, Naval Weapons Station Yorktown, Yorktown, Virginia* (Baker, 2005). Although risks identified during the Remedial Investigation (RI) were minimal, additional surface water data collection and evaluation were recommended and risk management for soil and groundwater were considered prior to proceeding with no further action (NFA) under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for Site 29 Lee Pond. The supplemental investigation documented in this TM involved collection of additional surface water analytical data to reduce uncertainties regarding the potential for aluminum, iron, and zinc to impact lower trophic level aquatic communities present in Lee Pond and to fill an identified data gap associated with the potential for aluminum, iron, and zinc to migrate to downgradient areas. This TM also provides risk management justification for metals in groundwater and soil on the basis of the flexibilities included in *Statement to Tier I Teams* issued by the Tier II Partnering Team in December 2004 (**Attachment 1**). On the basis of this additional data and evaluation of existing data, the TM provides justification for completion of an NFA Proposed Plan and Record of Decision (ROD) for this site.

2. Site Background

2.1 Site Setting

Site 29 [formerly Site Screening Area (SSA) 20] is a 4.1 acre freshwater pond (Lee Pond) located in the east-central portion of WPNSTA Yorktown (**Figure 1**). Site 29 Lee Pond is not a source of pollutants or hazardous substances. CERCLA Sites 9 and 19 are located immediately east of the pond and the pond receives groundwater discharge and surface water runoff from these sites. Site 18, SSA 22, and SSA 8 are also in the Lee Pond watershed, however, these sites have been closed with NFA under CERCLA as they pose no unacceptable risk to human health and the environment from unlimited use and unrestricted exposure.

The topography at the site slopes steeply toward the pond on the north, east, south, and southwest. Lee Road serves as the northwest boundary of the Pond (**Figure 2**). Topography slopes toward an unnamed tributary to the Eastern Branch of Felgates Creek northwest of Bollman Road. Topographic highs are to the southeast of the pond, and topographic lows are to the northwest (**Figure 3**).

In general, groundwater flows radially toward Lee Pond on the north, east, south, and southwest sides of the pond. The pond is also recharged by two surface water drainages, one coming from the east (Site 9) and another coming from the south. Water discharges from the pond through an engineered channel which runs northwest under Lee Road and into the tributary to the Eastern Branch of Felgates Creek. The flow of water through this channel is controlled by an inlet structure to maintain the water level in the pond for waterfowl. Consequently, the water level in the pond is elevated over the groundwater table in the

northwest portion of the pond. In this area, there is likely a slight surface water contribution to groundwater when the inlet structure is closed.

Habitat surrounding the pond consists of mixed pine-hardwood woodland on the southern edge, dominated by loblolly pine (*Pinus taeda*), red maple (*Acer rubrum*), and red oak (*Quercus falcata*). Associated species include Virginia pine (*Pinus virginiana*) and yellow poplar (*Liriodendron tulipifera*). The relatively open canopy supports a diverse understory, consisting of American holly (*Ilex opaca*), sweet gum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), and bayberry (*Myrica cerifera*) along the pond's edges. A deep litter layer supporting ferns and Virginia creeper (*Parthenocissus quinquifo*) characterizes the ground surface in the wooded areas. Freshwater sedges (*Carex spp.*) and emergent forbs are present in the drainage swales entering the pond and along the pond edges in low-lying areas. Iron staining of surface waters and the sediment surface is evident, but appears to be naturally occurring. A cattail (*Typha angustifolia*) stand is present along the eastern finger of Lee Pond, along Bollman Road (**Figure 2**). Roads border the pond to the north, east, and west (Baker, 2005).

Lee Pond supports rooted and unrooted aquatic vegetation, aquatic insects, fish (minnows, largemouth bass, bluegill, black crappie), amphibians and reptiles, a diverse aquatic bird population (including Canada geese, mallards, great blue herons, and belted kingfishers), and mammals (such as muskrat, raccoon, and deer) (Baker, 2005).

Migration of contaminants beyond Site 29 to either downgradient aquatic habitats or surrounding surface soils is unlikely given the depositional nature of the pond environment (Baker, 2005). Remedial actions at all known CERCLA site source areas (described in detail in Section 2.1.2) to Lee Pond have been completed, as has an evaluation of the most proximate downgradient area (Site 16/SSA 16).

2.2 Other IR Sites in the Lee Pond Watershed

2.2.1 Site 9

Site 9 consists of a drainage area approximately 500 to 600 feet (ft) long, which empties into a ditch that runs east to west, away from Building 10, crossing under Bollman Road through a culvert emptying into Lee Pond (**Figure 1**). Explosives-contaminated wastewater and organic solvents may have been discharged from Building 10 and the associated drainage from Ammunition Loading Plant No. 1 into the Site 9 drainage area during plant operations, which reportedly ended in the mid-1970s. In September 1994, a removal action was conducted to address debris and contaminated soils and sediments at the lower end of the Site 9 drainage way before it crosses Bollman Road (IT, 1995a). A ROD for soil, surface water, and sediment was signed in March 1998 (Baker, 1998) and documented a decision for NFA.

2.2.2 Site 19

Site 19 consists of the soils beneath and surrounding a 500-ft long conveyor shed formerly used (from the 1940s to the 1970s) to transport explosives from Building 10 to Building 98. Site 19 is located west of Building 10 and 300 ft south of Site 9 (**Figure 2**). Removal of an undocumented quantity of soil from beneath the conveyor shed and the surrounding area was conducted between 1973 and 1974. A ROD for soil was signed in March 1998 to mitigate the potential for direct contact with explosives in soils by human receptors, to prevent ecological exposures to

aluminum in soil, and to eliminate the potential migration of these contaminants to other environmental media (Baker, 1998). The remedy was initiated in April 1998. The conveyor shed was dismantled, the soils underneath the conveyor shed were excavated to a depth of at least 4 ft, and excavated soils were placed in a biocell at Site 22 for biological treatment (OHM, 2000). Following treatment, these soils were placed at Site 22 in the area surrounding the biocell. Aluminum-contaminated soils were also excavated from around Building 527, disposed of in the conveyor shed excavation trench, and covered with clean fill. The site was restored with topsoil and vegetated. Land use controls prohibiting residential development of Site 19 and disturbance of the soil cover are in place.

2.2.3 Site 18

Site 29 may also receive stormwater runoff from Site 18. Site 29 is located approximately 0.75 miles downgradient from Site 18, a 0.25-mile long drainage ditch located north of Building 476 (**Figure 1**). From the 1940s to the 1960s, Site 18 received discharges containing battery acid waste, consisting of hydrochloric acid or calcium hydroxide and dissolved metals such as lead, cadmium, nickel, and antimony. Battery acid waste no longer discharges from Building 476 into the ditch. No unacceptable human health or ecological risks were identified from exposure to soil, groundwater, surface water or sediment at Site 18 (Baker, 2004).An NFA ROD for all media was signed in September 2005.

2.2.4 SSA 22

SSA 22 (sandblast grit pile) may drain to a tributary of Lee Pond and is approximately 4,000 ft southeast of the pond (**Figure 1**). The sandblast grit area was adjacent to Building 530, which operated from 1945 until the early- to mid-1980s. Bomb fins and wings, inert bomb casings, and various other inert ordnance items were grit blasted in a blasting booth inside Building 530, and outside at the northern end of the building. A remedial action, consisting of the removal of lead-contaminated soil and sandblast grit from 6 inches to 2 ft below grade, was conducted in 1998 (OHM, 2001). An NFA Decision Summary for soil was signed in May 2004.

2.3 Previous Investigations of Lee Pond

In 1993, a Focused Biological Sampling and Preliminary Risk Evaluation investigation was performed at Lee Pond (Baker and Weston, 1993). Surface water, sediment (from an unreported depth), and fish tissue (whole body and fillet) samples were collected. These data were used to evaluate the potential human health risks in Lee Pond. An ecological risk evaluation was not conducted.

A Site Screening Process (SSP) evaluation (Baker, 2001) was conducted to evaluate the need for additional investigation of Lee Pond. Soil, groundwater, surface water, and sediment data were collected in 1997 to support human health and ecological risk screening. All media were evaluated with respect to Risk Based Concentrations (RBCs) during the human health risk screening. Potential risks to human health were identified for soil and groundwater primarily due to concentrations of metals in these media. During the ecological screening maximum concentrations in surface water and sediment were compared with Region III Biological Technical Assistance Group (BTAG) screening values or other available values from the literature. Ecological Chemicals of Concern (ECOCs) were identified for both surface water and

sediment during this evaluation. Aluminum, iron, and 4,4'-dichlorodiphenyltrichloro-ethane (DDT) were the primary ECOCs identified in surface water. Pesticides and metals were the primary ECOCs identified in sediment. The SSP report recommended that an RI be conducted based upon the results of the risk screening evaluations.

In 2000, additional soil, groundwater, surface water, and sediment data were collected to support an RI. This investigation is documented in *Final Round One Remedial Investigation Report for Sites 27, 28, 29, and 30, Naval Weapons Station Yorktown, Yorktown, Virginia* (Baker, 2005). The human health risk assessment (HHRA) completed as part of the RI included soil and groundwater data collected as part of previous investigations of Sites 9 and 19 , in addition to data from samples collected on the northwest and west sides of Lee Pond. The risk assessment identified unacceptable risks to future residential receptors associated with arsenic, iron, and manganese in groundwater and arsenic, iron, manganese, thallium, and vanadium in surface soil.

An ecological risk assessment (ERA), through Step 3A of the ERA process, was also conducted for Site 29 as part of the RI (Baker, 2005). Both terrestrial and aquatic pathways were considered complete at Site 29. Surface water data were used to assess the potential impact of chemical concentrations on drinking water resources for terrestrial upper trophic level receptors. No other complete exposure pathways were identified for terrestrial receptors. Direct contact/ uptake by aquatic biota from surface water and sediment, and trophic transfer to aquatic upper trophic level receptors, were identified as complete exposure pathways in Lee Pond. Surface water, bottom water, surface sediment (0 to 4 inches below ground surface [bgs]), and subsurface sediment (4 to 8 inches bgs) data were used to assess potential ecological risks. Deep (8 to 12 inches bgs) subsurface sediment samples, collected by the United States Environmental Protection Agency (USEPA) in 1998 (three samples) and by Baker in 2000 (12 samples) in Lee Pond (see Section 2.2.1), were not included in the exposure estimate because sediments at these depths do not represent an exposure point for ecological receptors (Baker, 2005). Groundwater data were also not evaluated as groundwater does not present a direct exposure point for ecological receptors at the site, and because an adequate surface water and sediment data sets were available from Lee Pond (receiving waters).

No unacceptable risks were identified for lower trophic level aquatic receptors utilizing Site 29 habitats (Lee Pond and its tributaries) based upon exposures to bottom water or to sediment (at surface depths [0 to 4 inches bgs] and at a subsurface depth [4 to 8 inches bgs]), and the Step 3A ERA recommended no further evaluation for these media. In addition, no unacceptable risks were identified, and no further evaluation was recommended, for upper trophic level terrestrial and aquatic receptors utilizing Lee Pond (**Table 1**). These recommendations have been accepted by the USEPA and Virginia Department of Environmental Quality (VDEQ) through approval and acceptance of the final RI report.

Evaluation of deep (8 to 12 inch) subsurface sediment and concern for the potential of storms to re-suspend sediments from these deeper depths into the water column (**see Attachment 2**) is not warranted because Lee Pond is a depositional environment that is relatively well-sheltered by surrounding forested habitats. The likelihood of significant re-suspension of sediments from deeper depths is thus relatively low. Should this occur, the subsurface samples from 4 to 8 inches should be sufficient to evaluate this possible occurrence; no risk was found for sediments at this depth in the Step 3A ERA. A qualitative review of the 8- to 12-inch sediment data, as reported in the Round One RI appendices, indicates that detected constituent concentrations

were generally similar (i.e., within the range of detected concentrations) to constituent concentrations at 4- to 8-inch and/or 0- to 4-inch depth strata and/or were less than the sediment screening values used in the Step 3A ERA. Thus, in the unlikely event that significant sediment re-suspension does occur in Lee Pond from deeper depths, it should not result in any unacceptable risk to ecological receptors.

For surface water, aluminum, iron, and zinc were identified in the Step 3A ERA as having the potential to adversely impact aquatic lower trophic level communities (e.g., fish) present in Lee Pond based upon total metal analyses (filtered [dissolved] samples were not collected) (**Table 1**). However, the ERA indicated that there was a large amount of uncertainty associated with this conclusion. Given this uncertainty, and the lack of dissolved surface water data (which better represent the bioavailable fraction of metals in surface water), additional sampling of Lee Pond surface water was recommended, as was surface water sampling in the unnamed tributary west of Lee Pond to fill an identified data gap associated with the potential for aluminum, iron, and zinc migration to downgradient areas.

2.4 Additional Ecological Risk Evaluation for Surface Water and Sediment

The information presented below, based on existing and newly-collected surface water analytical data reduces uncertainties regarding the potential for aluminum, iron, and zinc to impact lower trophic level aquatic communities present in Lee Pond and to describe the potential for aluminum, iron, and zinc to migrate to downgradient areas.

2.4.1 Available Analytical Data

Analytical data have been collected at Site 29 (Lee Pond) as part of a number of previous sampling activities in 1997, 1998, and 2000, with some historical data also available from 1993 and 1995. This section provides an overview of these data; more details are available in the RI report (Baker, 2005). The data collected in 1997, 1998, and 2000 for surface water, bottom water, and sediment were used in the ERA included in the RI report (Baker, 2005). Neither historical data nor data for surface soils (lack of exposure pathways) or groundwater [since surface water and sediment samples were available from the receiving water body (Lee Pond)] were included. This data review and analysis focuses on surface water data collected during previous investigations and data collected as part of the November 2006 supplemental investigation (in November 2006).

Previously Collected Data

In 1993, a Focused Biological Sampling and Preliminary Risk Evaluation investigation was performed at Lee Pond (Baker and Weston, 1993). Surface water, sediment (from an unreported depth), and fish tissue (bluegill, black crappie, and largemouth bass) samples were collected and analyzed for semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), inorganics, and/or total organic carbon (TOC). Only groundwater samples were collected in October 1995 as part of the Round Two RI for Sites 9 and 19.

Additional historical samples associated with Sites 9 and 19 were used to address potential inputs to Lee Pond and include surface water and sediment samples collected in 1997. Two

surface water and surface/subsurface sediment samples were collected from the swale draining from Sites 9 and 19 into the pond. All samples were analyzed for volatile organic compounds (VOCs), SVOCs, pesticides/PCBs, explosives, metals, and cyanide.

Fifteen surface water and surface sediment (0 to 4 inches bgs) samples, and 14 subsurface sediment samples (4 to 8 inches bgs) were collected from Lee Pond in September 1997 as part of the SSP evaluation (Baker, 2001). Bottom water samples were also collected at three of the surface water locations, at depths ranging from 3.5 to 5 ft below the water surface (at the bottom of the water column). Two additional surface water and sediment samples were collected from the tributary draining into Lee Pond from Site 18. All water and sediment samples were analyzed for VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and explosives.

Sampling activities were also conducted by the USEPA in September 1998. Three surface (0 to 4 inches bgs) and three deep subsurface (8 to 12 inches bgs) sediment samples designated D31, D32, and D33 were collected during this investigation. Samples D32 and D33 were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives, metals, and cyanide, while sample D31 was analyzed for the same parameter list except for pesticides and PCBs.

In May 2000, 12 deep (8 to 12 inches bgs) subsurface sediment locations were sampled for a planned Feasibility Study (FS) for Site 29, presumably to determine the vertical distribution of constituents. These samples were analyzed for VOCs, SVOCs, explosives, metals, and cyanide. Deep subsurface sediment samples were not included in the exposure estimate for Lee Pond aquatic receptors in the RI as sediments at these depths do not represent an exposure point for ecological receptors.

Background data from the WPNSTA base-wide background investigations were also available. The background data set included surface water and sediment collected from reference ponds located within the York River watershed at relatively undisturbed locations, including York River State Park and neighboring Camp Peary.

November 2006 Supplemental Investigation

The primary purposes of the supplemental investigation at Site 29 were to reduce uncertainties regarding the potential for aluminum, iron, and zinc in pond surface water to adversely impact aquatic lower trophic level communities present in Lee Pond and to fill the data gap associated with the potential for aluminum, iron, and zinc to migrate to downgradient areas. The specific objectives of the Site 29 supplemental investigation were to:

- Provide additional data to characterize concentrations of aluminum, iron, and zinc in the surface waters of Lee Pond to reduce uncertainties regarding the potential for adverse impacts to aquatic lower trophic level communities (e.g., aquatic plants, invertebrates, fish, and frogs).
- Provide additional data to characterize the distribution of aluminum, iron, and zinc in the surface waters of the unnamed tributary west of Lee Pond to evaluate the potential for migration to downgradient areas.

The sampling design was outlined in the final Step 4 project plans for Sites 28 and 29 (Baker, 2006). A total of 12 surface water samples were collected as part of the Site 29 supplemental investigation. Six of the samples were collected from the pond itself, three were collected from upgradient tributaries that feed into the pond, and three were collected from the tributary

northwest of the pond, which flows (downgradient) toward Felgates Creek (**Figure 3**). The final project plans were accepted by the Tier 1 Partnering Team and only specified the collection and evaluation of the additional surface water samples addressed in this TM.

The surface water samples were collected in November 2006 using a low-flow peristaltic pump. All samples were analyzed for total and dissolved aluminum, iron, and zinc, as well as total calcium, total magnesium, and water hardness. Field parameters, including water temperature, pH, conductivity, salinity, oxidation-reduction potential (ORP), total dissolved solids (TDS), and dissolved oxygen (DO) were measured at each of the sampling locations (**Table 2**).

2.4.2 Supplemental Sampling of Surface Water Results and Evaluation

This section presents the results of the supplemental investigation sampling of Site 29 surface water. The resulting data are also evaluated in terms of the potential for unacceptable risk to aquatic receptors and the potential for significant transport from Lee Pond to downgradient areas.

The water column parameter measurements (**Table 2**) indicate a slight salinity gradient, with salinities highest in the two upgradient tributaries (2.2 to 2.4 parts per thousand [ppt]), moderating towards the northern portion of Lee Pond, and lowest in the downgradient tributary (1.6 to 1.7 ppt). The salinity measurements indicate that the water is slightly brackish (1 ppt is generally considered the cutoff for freshwater; USEPA, 1996). The pH is slightly basic (7.21 to 7.86). DO was low at two locations (SW-01 and SW-08) although this will not significantly influence the evaluation. TDS was fairly uniform throughout the system. The water was somewhat turbid, with readings ranging from 15 to 50 nephelometric turbidity units (NTU) (Table 2).

Analytical data for the November 2006 surface water samples are summarized in **Table 3**; the raw analytical data are provided in **Attachment 3**. Zinc was not detected in any of the surface water samples (total or dissolved). Aluminum was detected in 12 of 12 unfiltered (total) samples and in 9 of 12 filtered (dissolved) samples. Iron was detected in 12 of 12 unfiltered samples and in 5 of 12 filtered samples (**Table 3**). Calcium and magnesium, which were measured because zinc toxicity is mediated by water hardness, were detected in all 12 total samples. Water hardness was also directly measured; the water in the system is moderately hard (average hardness of 178 milligrams/liter [mg/L]) which will tend to reduce the bioavailability of zinc (although zinc was not detected in any sample).

Total and dissolved concentrations in surface water are compared with the current chronic freshwater ambient water quality criteria (AWQC) for the protection of aquatic life (USEPA, 2006) in **Table 4**. The AWQC for zinc was adjusted using the mean measured water hardness value of 178 mg/L.

Aluminum exceeded its AWQC value in 11 of 12 unfiltered samples but did not exceed in any of the filtered samples. Iron exceeded its AWQC value in 1 of 12 unfiltered samples but did not exceed in any of the filtered samples (Table 4).

USEPA (1996) indicates that the dissolved metal fraction should be preferentially used to the total metal fraction in surface water evaluations because dissolved metal concentrations best represent the bioavailable fraction. High levels of suspended solids and sediment-adsorbed metals, which could be present in unfiltered samples, could result in overstating bioavailable

surface water concentrations and thus potential exposures and risks. All of the 2006 surface water samples were turbid to varying degrees (**Table 2**). Thus, the filtered (dissolved) samples better represent potential aquatic exposures. There were no exceedances based upon the dissolved sample data, indicating that there is no unacceptable risk to aquatic receptors from surface water exposures.

While total aluminum exceeded in 11 of 12 unfiltered samples, aluminum is substantially less toxic at higher pH and hardness (USEPA, 2006). The pH of Lee Pond and its tributaries (7.2 to almost 8.0) and hardness (average hardness of 178 mg/L) are higher than in the studies used to develop the AWQC value. In addition, field data indicate that many high quality waters in the U.S. contain more than 87 µg/L (the chronic AWQC), when either total recoverable or dissolved is measured (USEPA, 2006). This suggests that the AWQC for aluminum is very conservative, particularly for a system like Lee Pond that has relatively high pH and hardness. In addition, the species used to develop and test the AWQC (striped bass and brook trout) are not relevant fish species for this assessment based upon the habitats present in Lee Pond.

Total iron in surface water exceeded screening values in only 1 of 12 samples. Iron precipitates, if present, would be included in the surface sediment samples collected previously. However, the Step 3A ERA, which evaluated surface sediments and therefore the effects from any iron precipitates, concluded that there is no unacceptable risk related to iron in this medium.

The lack of exceedances in the downgradient samples indicates that these metals are not being transported downstream at ecologically significant concentrations under current conditions. While the results for total aluminum and total iron are higher at Location 1 (the most upstream sample on the southern tributary), Location 2, along the same upstream tributary as Location 1 but about 200 ft downstream, had much lower total concentrations (eight times lower for aluminum and six times lower for iron) relative to Location 1. It appears unlikely that an upstream source is present that would impact Location 1 but not Location 2 since they were sampled on the same day (about 20 minutes apart). The sample from Location 1 likely contained a higher amount of sediment than the other samples (note that the water at all of the sampling locations was somewhat turbid; see Table 2), although Location 1 was not notably more turbid than the other samples. However, these turbidity readings were taken from the water column at the sampling location and not from the sample itself. The large decrease in concentration between the total and the dissolved samples at Location 1 (the filtered sample was non-detect for aluminum and approximately 25 times lower for iron), however, supports the explanation of turbidity impacts. There were no other notable spatial trends in the data that would indicate a source area within Lee Pond or an active transport pathway from an upstream source.

It should be noted that maximum and mean total aluminum concentrations from the 2006 data set (1,040 and 395 micrograms/liter [µg/L], respectively) were similar to the concentrations from the 2005 ERA (1,160 and 256 µg/L, respectively); the dissolved fraction was not measured in the previously-collected samples. Maximum and mean total iron concentrations were also similar in 2006 (3,990 and 952 µg/L, respectively) relative to the 2005 ERA concentrations (4,370 and 1,634 µg/L, respectively). Total zinc, however, was lower in 2006 (non-detect) relative to the 2005 data set, which had one relatively high detection (404 µg/L). The inclusion of the dissolved fraction in the 2006 sampling reduced the uncertainty of the exposure estimates from the 2005 ERA by better accounting for potential bioavailability. The relative uniformity in the total concentrations between the 1997 samples (used in the RI) and the 2006 samples suggests that the system is fairly stable.

3. Considerations for Risk Management of Metals in Groundwater and Soil

In addition to the data gaps associated with metals in surface water, potential human health risks were identified during the RI associated with metals in soil and groundwater. Arsenic, iron, and manganese in groundwater and arsenic, iron, manganese, thallium, and vanadium in surface soil were identified as contributing to potential risk. The potential risk identified for these metals warrants risk management consideration consistent with the flexibilities included in the December 2004 *Statement to Tier I Teams* (**Attachment 1**). Specifically, the flexibilities that apply to this site comprise acceptable risk range thresholds, background concentrations, the lack of a soil or groundwater plume, and aquifer classification status.

3.1 Consideration for Risk Management of Metals in Soil

Surface soil samples were collected at seven locations in the vicinity of Lee Pond. (**Figure 4**) Potential risks associated with these soils are acceptable on the basis of the lines of evidence presented herein.

3.1.1 Human Health Risks Associated with Site 29 Soil

Human health risk tables from the Round One RI for residential soil receptors are included as **Attachment 4**. A cumulative non-cancer hazard index (HI) of 1.2 was identified for the future child resident for ingestion of surface soil under the reasonable maximum exposure (RME) scenario. HIs for other human receptors including the future adult resident were below unity (USEPA's acceptable threshold for non-cancer hazards). The child resident HI of 1.2 was a result of individual hazard quotient (HQ) values for arsenic (0.18), iron (0.37), manganese (0.061), thallium (0.38), and vanadium (0.17). None of the individual HQs are greater than 1.0. Of these metals, only arsenic and thallium have the potential to affect the same target organ (skin and vascular system); however, the sum of the HQs for arsenic and thallium is less than 0.56, below USEPA's acceptable threshold. The cumulative central tendency exposure (CTE) HI for the future child resident is 0.21, within the acceptable risk range. Additionally, RME and CTE cancer risks to the future child resident are within the USEPA's acceptable risk range (between 10^{-4} and 10^{-6}). The future child resident scenario is the most conservative exposure scenario for these metals. Because there are no cumulative target organ effects greater than 1.0, risks and hazards from soils at Site 29 are acceptable.

3.1.2 Soil Background Concentrations

When compared to background, the only constituent which exceeded a corresponding background concentration in surface soil was thallium. Thallium was not detected in the background dataset, but was detected at a maximum concentration of 6.4 mg/kg in surface soil. All of the samples in which thallium was detected were located across the railroad tracks from Lee Pond while no thallium was detected in samples closer to the site. Therefore, because the thallium is not believed to be related to the site and does not pose unacceptable risk as described above, risk management is warranted.

3.2 Considerations for Risk Management of Metals in Groundwater

There are four wells associated with Site 29 (A20GW01, A20GW02, A20GW03, and A20GW04). These wells are screened in the Cornwallis Cave aquifer or in wetland material adjacent to the pond (A20GW02 only). Concentrations of total and dissolved arsenic, iron, and manganese are shown on **Figure 5**. These concentrations warrant risk management on the basis of the following lines of evidence:

3.2.1 Human Health Risks Associated with Site 29 Groundwater

Potential unacceptable human health risks were identified for the future adult resident (RME cumulative HI = 4.2) and the future child resident (RME cumulative HI = 14) during the Round One RI (Baker, 2005). However, this risk assessment included groundwater data from Sites 9 and 19. Since these sites are being addressed separately, additional risk calculations were completed using only data from the Site 29 wells (A20GW01 through A20GW04). Risk tables are included as **Attachment 5**. A summary of cancer risks and non-cancer HQ values and HIs for arsenic, iron, and manganese is shown in **Table 5**.

Cumulative HIs greater than 1 are identified for the adult and child residents and a lifetime cancer risk higher than the acceptable range of 10^{-4} to 10^{-6} under the RME exposure scenario. However, arsenic, iron and manganese have the potential to affect different target organs. Arsenic may affect the skin and vascular system. Iron affects the gastrointestinal system, and manganese affects the central nervous system. The only individual HQs that exceed 1 are the arsenic HQs for both the adult and child resident under the RME scenario and the manganese HQ for the child resident under the RME scenario. There are no individual HQs which exceed 1.0 under the CTE scenario for the adult or child resident, and the cancer risk under the CTE scenario is within the acceptable risk range for the lifetime resident. Because the CTE scenario is more realistic, and there are no unacceptable risks under this scenario, concentrations of arsenic, iron, and manganese warrant risk management consideration.

3.2.2 Background Groundwater Concentrations, MCL Comparison, and Aquifer Geochemistry

Sample concentrations exceeding background concentrations and/or the maximum contaminant level (MCL) are shown on **Figure 5**. Concentrations exceeding background are limited to two sample locations (A20GW01 and A20GW02), which are located closest to the pond. Arsenic slightly exceeded the MCL in the samples from A20GW02 at total and dissolved concentrations of 40 µg/L and 14.9 µg/L, respectively. The total concentration of arsenic in the sample from A20GW01 also slightly exceeded the MCL (17.2 J µg/L). There were no other MCL exceedances. Only the total and dissolved concentrations of arsenic in the sample from A20GW02 exceeded both the MCL and background. The elevated (over background) concentrations of arsenic, iron, and manganese in the shallow groundwater samples closest to the pond are likely a result of reducing conditions created in the wetland soil adjacent to the pond. Arsenic was only detected in three surface water samples, all located on the east side of the pond near Sites 9 and 19.

Iron and manganese concentrations in surface water collected on the northwest side of the pond were also much lower than the concentrations detected in groundwater in this area. Therefore, even though the inlet structure may result in a small surface water contribution to groundwater by artificially elevating the surface water table, it does not appear that the pond is the source of metals concentrations in groundwater. However, under reducing conditions, like those generated during the degradation of organic matter in a wetland area, reduction of manganese and iron oxides may occur. Because both iron and manganese are more soluble in their reduced states, groundwater concentrations are typically higher in more anaerobic areas. Similarly, arsenic frequently sorbs to iron oxide minerals, but is released as the iron is reduced. Both A20GW01 and A20GW02 are installed very close to Lee Pond. The boring log for A20GW02 indicated that wood fragments were present in the screened interval of the well. There have been no geochemical parameters collected at Site 29 (such as nitrate, nitrite, sulfate, sulfide, or ferrous iron) to help determine the oxidation state of the aquifer. DO and ORP measurements were collected and indicated slightly oxidizing conditions. However, the groundwater samples were collected with a submersible pump which may have resulted in the introduction of air into the samples prior to field data collection. The lack of field geochemical data prevents a definitive determination as to whether reducing conditions could have resulted in the presence of arsenic and manganese, however, this is a likely scenario given that the pond itself does not appear to be the source of the arsenic and conditions are present (a wetland) that can cause this phenomenon.

3.2.3 No Discernable Plume

There is no discernable metals plume in groundwater adjacent to Lee Pond. Concentrations at the same depth intervals are comparable (**Figure 5**). The distribution of metals does not indicate that the pond is the source of these constituents in groundwater.

3.2.4 Aquifer Classification Status

It is anticipated that WPNSTA Yorktown will remain a military installation for the foreseeable future. The Cornwallis Cave aquifer is not used as a drinking water source at the base and is not anticipated to be used as a drinking water source since other sources of higher quality water are available.

According to the *Guidelines for Ground-Water Classification* (USEPA, 1986), a Class IIB Drinking Water Source is a, "potential source of drinking water and water having other beneficial uses." Site 29 may meet the USEPA's guidelines for a Class II drinking water source (TDS less than 10,000 mg/L, treatable constituent concentrations, and yield of 150 gallons/day). However, the Cornwallis Cave aquifer at Site 29 does not meet the Virginia Private Well Regulations guidelines for installation of groundwater wells for potable use. Yield from Site 29 wells is not likely to meet the Virginia Private Well Regulation guideline of a yield of 5 gallons per minute (gpm) for 10 minutes. The average hydraulic conductivity calculated during slug testing was 8.7×10^{-2} ft/day, which would likely not allow for sufficient yield.

4. Summary and Conclusions

4.1 Surface Water

Based upon the results of the dissolved surface water samples, in combination with the results of the 2005 ERA, there are no unacceptable risks for aquatic receptors in Lee Pond from current exposures. In addition, the 2006 data do not indicate that the metals evaluated are migrating to downgradient areas at significant concentrations that would result in unacceptable impacts. There were no notable spatial trends in the data that would indicate a source area within Lee Pond or an active transport pathway from an upstream source.

NFA for ecological receptors at Site 29 is justified based upon the results of the 2005 ERA (terrestrial receptors, upper trophic level aquatic receptors, bottom water, and sediment) and the results of the supplemental investigation (surface water). Remedial actions at all known CERCLA source areas to Lee Pond have been remediated, as has an evaluation of the most proximate downgradient area (Site 16/SSA 16). NFA has been recommended for each of these other sites as part of the various area-specific evaluations for all media except groundwater. Groundwater investigations are currently on-going at Sites 9 and 19.

4.2 Soil and Groundwater Risk Management

Soil and groundwater at Site 29 warrant risk management consideration because:

- There are no unacceptable risks under the more realistic CTE scenarios
- For soil, most of the site data are comparable to background and screening values
- Individual soil HQs under all exposure scenarios are acceptable
- There is no discernable contaminant source related to Lee Pond
- Elevated concentrations in groundwater are only present in the wetland area near the pond and can be explained by mobilization of metals due to the reduced conditions typical for a shallow wetland aquifer
- There is no groundwater plume related to the site, and
- The aquifer is not likely to be used as a drinking water source.

Therefore, NFA is warranted for all media at Site 29.

5. References

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Risk Management Consensus for Site 29

The Navy, in partnership with the USEPA and VDEQ, agree that, based on the lines of evidence presented in this Technical Memorandum "*Supplemental Surface Water Sampling and Risk Management of Metals in Soil and Groundwater Site 29 – Lee Pond*", NFA for soil, groundwater, and surface water are necessary at Site 29 to protect human health and the environment.

Ms. Linda Cole
NAVFAC Mid-Atlantic

Cole

Date 4/9/08

Mr. Rob Thomson
USEPA Region 3

Rob Thomson

Date 4/24/08

Mr. Wade Smith
Virginia DEQ

Wade M. Smith

Date 4/9/08

Tables

Table 1
Summary of the Chemicals of Concern (Risk Drivers) From the 2005 Ecological Risk Assessment
Site 29 - Lee Pond
Naval Weapons Station Yorktown, Yorktown, Virginia

Chemical	Sediment	Surface Water	Food Web	
			Terrestrial	Aquatic
Metals				
Aluminum (total)		X		
Iron (total)		X		
Zinc (total)		X		

1 - Shaded cells indicate hazard quotient based on reporting limits

Table 2
Water Column Physical Parameter Measurements - November 2006
Site 29 - Lee Pond
Naval Weapons Station Yorktown, Yorktown, Virginia

Station	Sample	Location	pH	Conductivity (mS/cm)	Turbidity (NTU)	Temperature (C)	Salinity (ppt)	Total Dissolved Solids (MG/L)	Oxidation Reduction Potential (MV)	Dissolved Oxygen (mg/L)
29-SW01	YS29-SW001-1106	Upstream Tributary	7.65	0.383	35	16.33	2.20	0.299	--	6.05
29-SW02	YS29-SW002-1106	Upstream Tributary	7.86	0.399	30	16.70	2.30	0.312	--	16.11
29-SW03	YS29-SW003-1106	Lee Pond	7.76	0.365	50	14.15	2.20	0.299	--	13.75
29-SW04	YS29-SW004-1106	Lee Pond	7.54	0.339	20	14.17	2.10	--	--	11.60
29-SW05	YS29-SW005-1106	Lee Pond	7.48	0.265	40	13.93	1.60	0.219	--	15.81
29-SW06	YS29-SW006-1106	Lee Pond	7.56	0.261	35	13.93	1.60	0.216	--	15.49
29-SW07	YS29-SW007-1106	Lee Pond	7.49	0.269	50	14.62	1.60	0.218	--	15.42
29-SW08	YS29-SW008-1106	Lee Pond	7.21	0.390	20	14.17	2.40	0.319	--	3.30
29-SW09	YS29-SW009-1106	Upstream Tributary	7.61	0.413	15	16.31	2.40	0.322	--	17.77
29-SW10	YS29-SW010-1106	Downgradient Tributary	7.73	0.283	25	16.37	1.60	0.220	--	15.31
29-SW11	YS29-SW011-1106	Downgradient Tributary	7.82	0.282	20	15.93	1.60	0.222	--	17.60
29-SW12	YS29-SW012-1106	Downgradient Tributary	7.80	0.287	35	16.25	1.70	0.225	--	15.43

1 - Shaded cells indicate hazard quotient based on reporting limits

Table 3
Summary Statistics - Surface Water
Site 29 - Lee Pond
Naval Weapons Station Yorktown, Yorktown, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean[1]	Standard Deviation of Mean	95% UCL (Normal)	Geometric Mean[1]	95% UCL (LN)
Total Metals (UG/L)									
Aluminum	-- - --	12 / 12	1,040	YS29-SW001-1106	395	284	542	284	1,049
Calcium	-- - --	12 / 12	85,500	YS29-SW009-1106	67,467	12,650	74,025	66,399	74,881
Iron	-- - --	12 / 12	3,990	YS29-SW001-1106	952	966	1,453	767	1,321
Magnesium	-- - --	12 / 12	2,180	YS29-SW002-1106	1,858	233	1,979	1,845	1,989
Zinc	12.5 - 37.6	0 / 12	--	--	9.82	3.63	11.7	9.30	11.9
Dissolved Metals (UG/L)									
Aluminum	9.70 - 9.70	9 / 12	34.7	YS29-SW010-1106	18.5	11.2	24.4	14.8	35.4
Iron	25.3 - 88.3	5 / 12	155	YS29-SW001-1106	73.9	54.2	102	53.9	167
Zinc	8.70 - 24.7	0 / 12	--	--	7.35	2.32	8.56	7.04	8.82
Other Parameters (MG/L)									
Hardness	-- - --	12 / 12	220	YS29-SW002-1106	178	31.9	194	175	196

1 - Shaded cells indicate hazard quotient based on reporting limits

Table 4
Screening Statistics - Surface Water
Site 29 - Lee Pond
Naval Weapons Station Yorktown, Yorktown, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Screening Value	Reference	Maximum Concentration Detected	Maximum Hazard Quotient[1]	Frequency of Exceedance	Arithmetic Mean	Mean Hazard Quotient[1]	95% UCL (Normal)	Hazard Quotient (UCL)[1]	Geometric Mean	Mean Hazard Quotient[1]
Total Metals (UG/L)													
Aluminum	-- - --	12 / 12	87.0	USEPA 2006	1,040	12.0	11 / 12	395	4.54	542	6.23	284	3.26
Calcium	-- - --	12 / 12	116,000	Suter and Tsao 1996	85,500	0.74	0 / 12	67,467	0.58	74,025	0.64	66,399	0.57
Iron	-- - --	12 / 12	1,000	USEPA 2006	3,990	3.99	1 / 12	952	0.95	1,453	1.45	767	0.77
Magnesium	-- - --	12 / 12	82,000	Suter and Tsao 1996	2,180	0.03	0 / 12	1,858	0.02	1,979	0.02	1,845	0.02
Zinc	12.5 - 37.6	0 / 12	195	USEPA 2006	--	0.19	-- / --	9.82	0.05	11.7	0.06	9.30	0.05
Dissolved Metals (UG/L)													
Aluminum	9.70 - 9.70	9 / 12	87.0	USEPA 2006	34.7	0.40	0 / 12	18.5	0.21	24.4	0.28	14.8	0.17
Iron	25.3 - 88.3	5 / 12	1,000	USEPA 2006	155	0.16	0 / 12	73.9	0.07	102	0.10	53.9	0.05
Zinc	8.70 - 24.7	0 / 12	192	USEPA 2006	--	0.13	-- / --	7.35	0.04	8.56	0.04	7.04	0.04

1 - Shaded cells indicate hazard quotient based on reporting limits

TABLE 5
Summary of Cancer Risks and Non-cancer HQ Values and HIs for Arsenic, Iron, and Manganese

	RME HQ	CTE HQ	RME Cancer Risk	CTE Cancer Risk
Future Adult Resident				
Arsenic	1.4	0.29	NA	NA
Iron	0.38	0.082	NA	NA
Manganese	0.63	0.15	NA	NA
Cumulative Adult HI	*2.4*	*0.52*	*NA*	*NA*
Future Child Resident				
Arsenic	3.2	0.98	NA	NA
Iron	0.89	0.27	NA	NA
Manganese	1.3	0.5	NA	NA
Cumulative Child HI	*5.4*	*1.8*	*NA*	*NA*
Future Child through Adult Resident				
Arsenic	NA	NA	$4.1x10^{-4}$	$6.1x10^{-5}$
Iron	NA	NA	NA	NA
Manganese	NA	NA	NA	NA
Cumulative Adult HI	*NA*	*NA*	$4.1x10^{-4}$	$6.1x10^{-5}$

Figures

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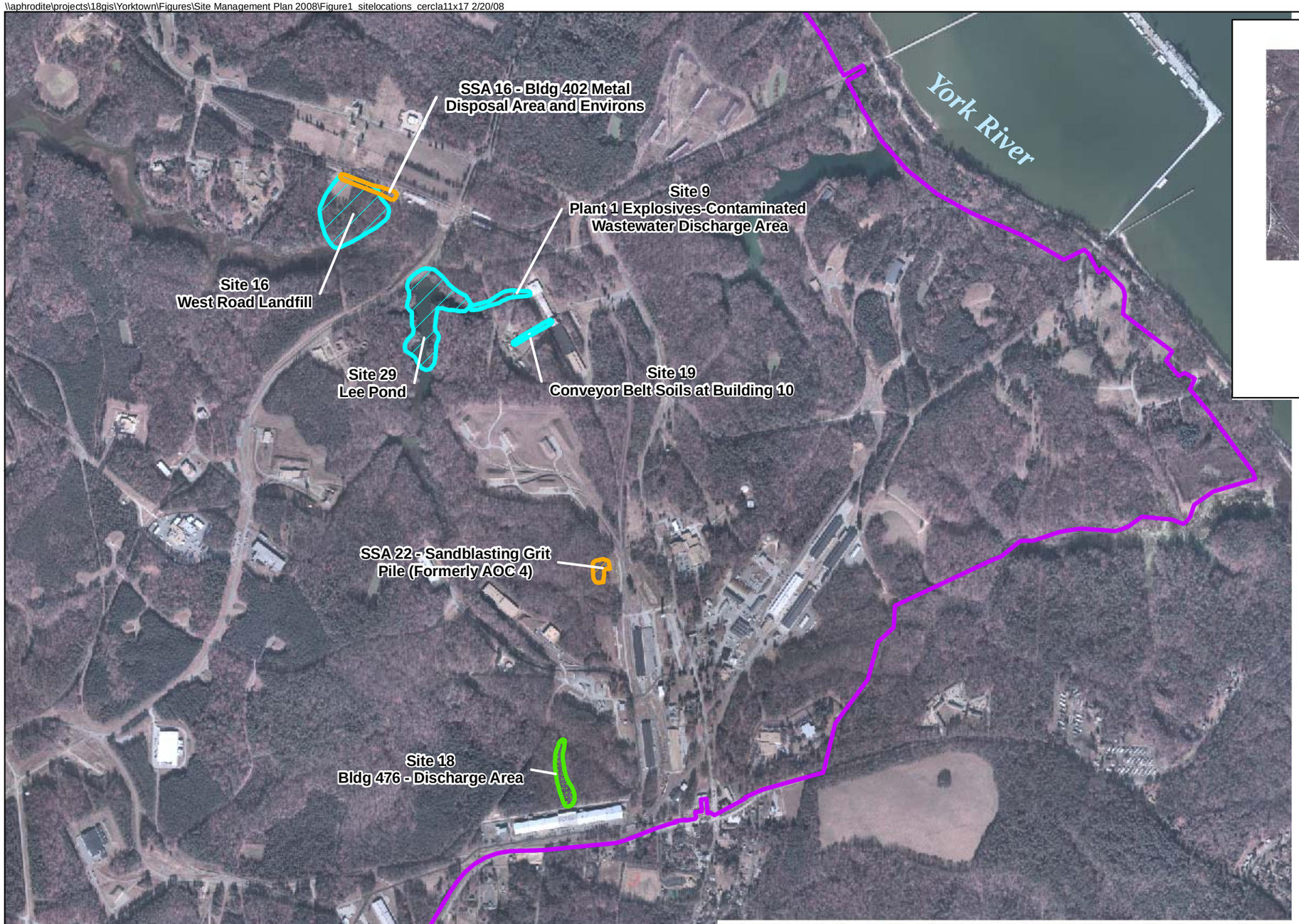

Legend

- Active RI/FS Sites (one or more media)
- Action SSP SSAs (one or more media)
- No Further Action RI/FS Sites and SSP SSAs

N
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S

0 1,200 2,400 Feet

Figure 1
Site/SSA Locations
Site 29 - Lee Pond
WPNSTA Yorktown
Yorktown, Virginia

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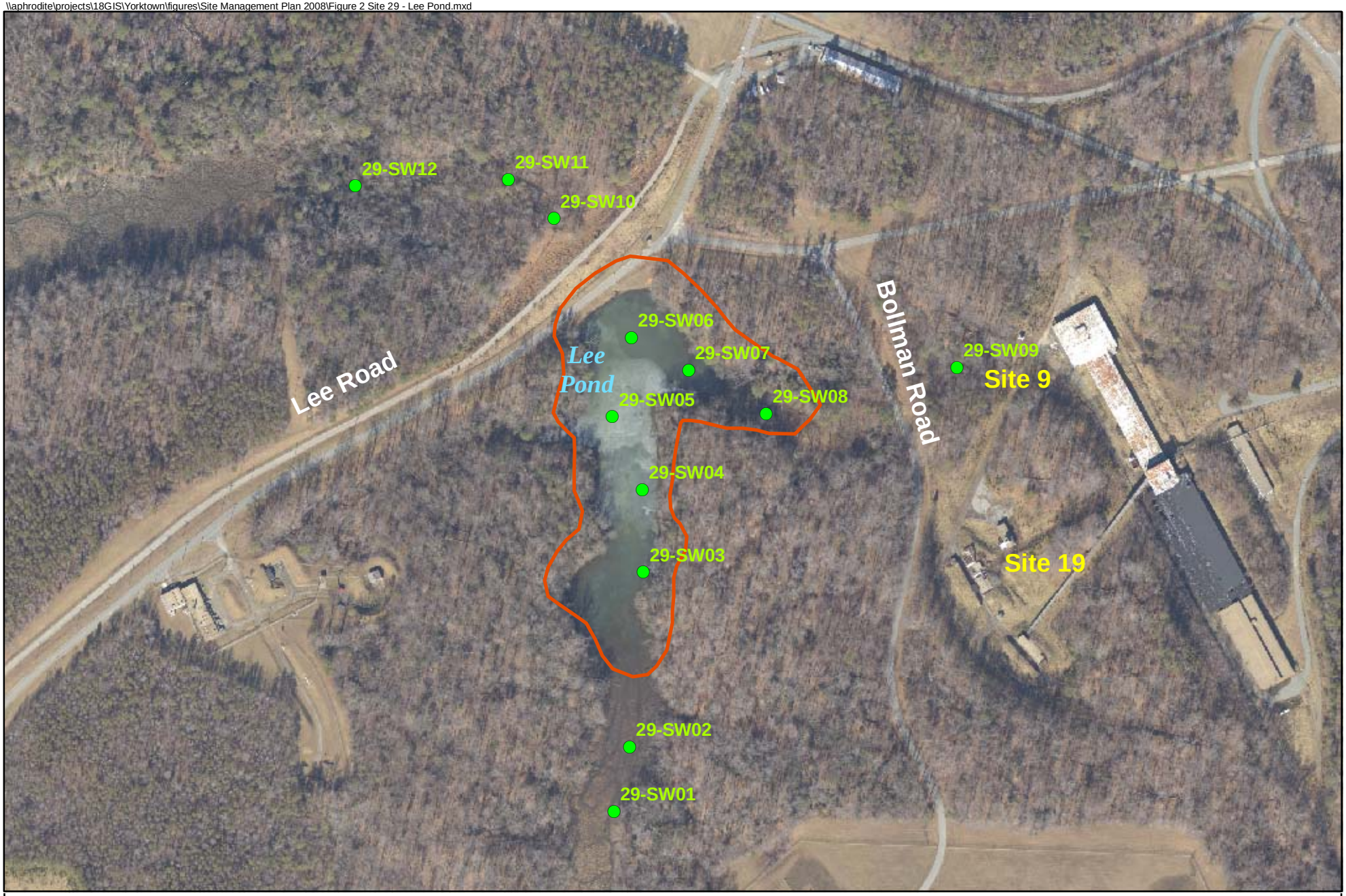

LEGEND

- 2006 Surface Water Sampling Locations
- Site Boundary

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Feet

Figure 2
Site 29 - Lee Pond
Naval Weopons Station Yorktown
Yorktown, Virginia

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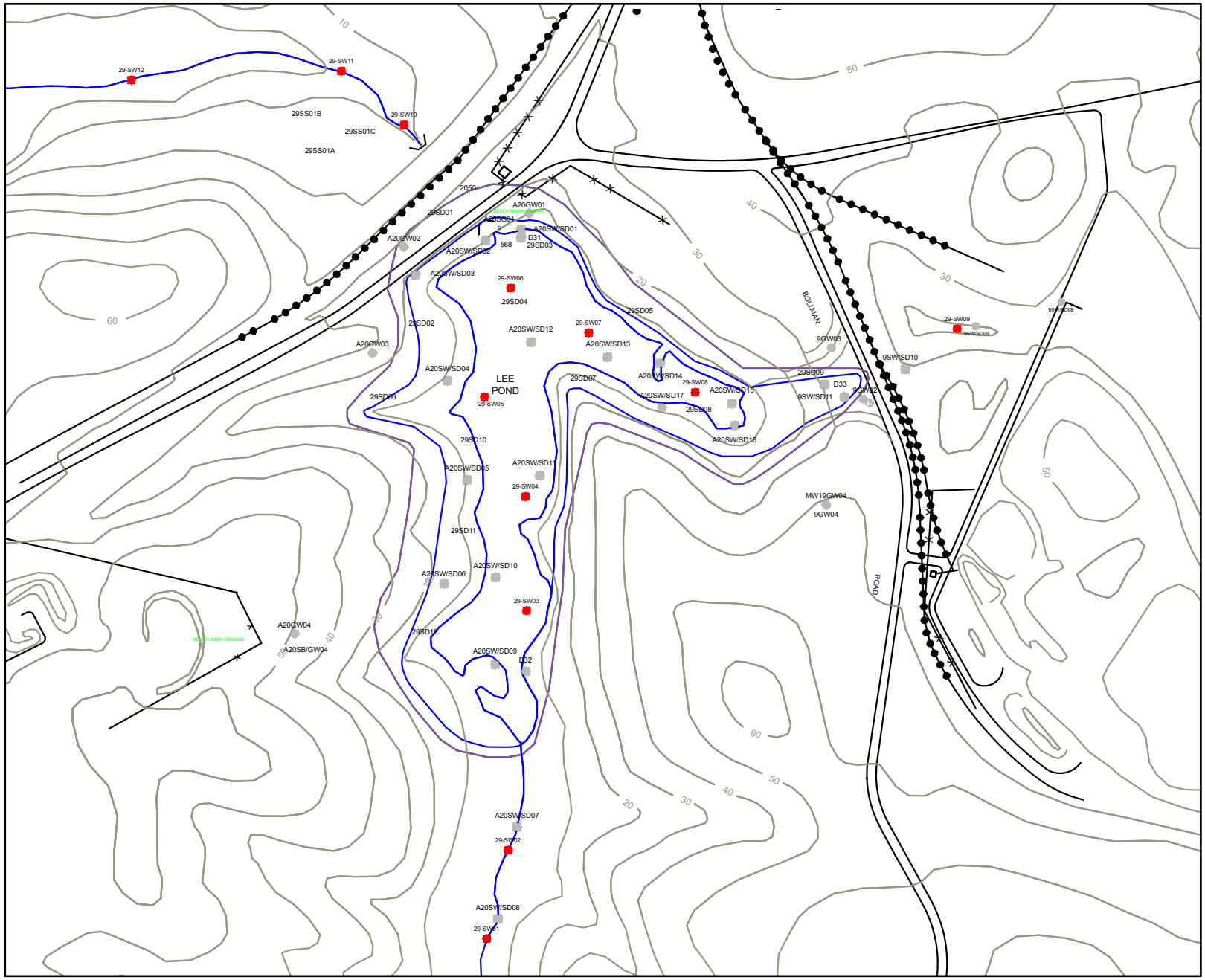

Legend

- Supplemental
- Previous

Figure 3
Location of Previous and Supplemental Investigation
Surface Water/Sediment Samples
Site 29 - Lee Pond
Naval Weapons Station Yorktown
Yorktown, Virginia

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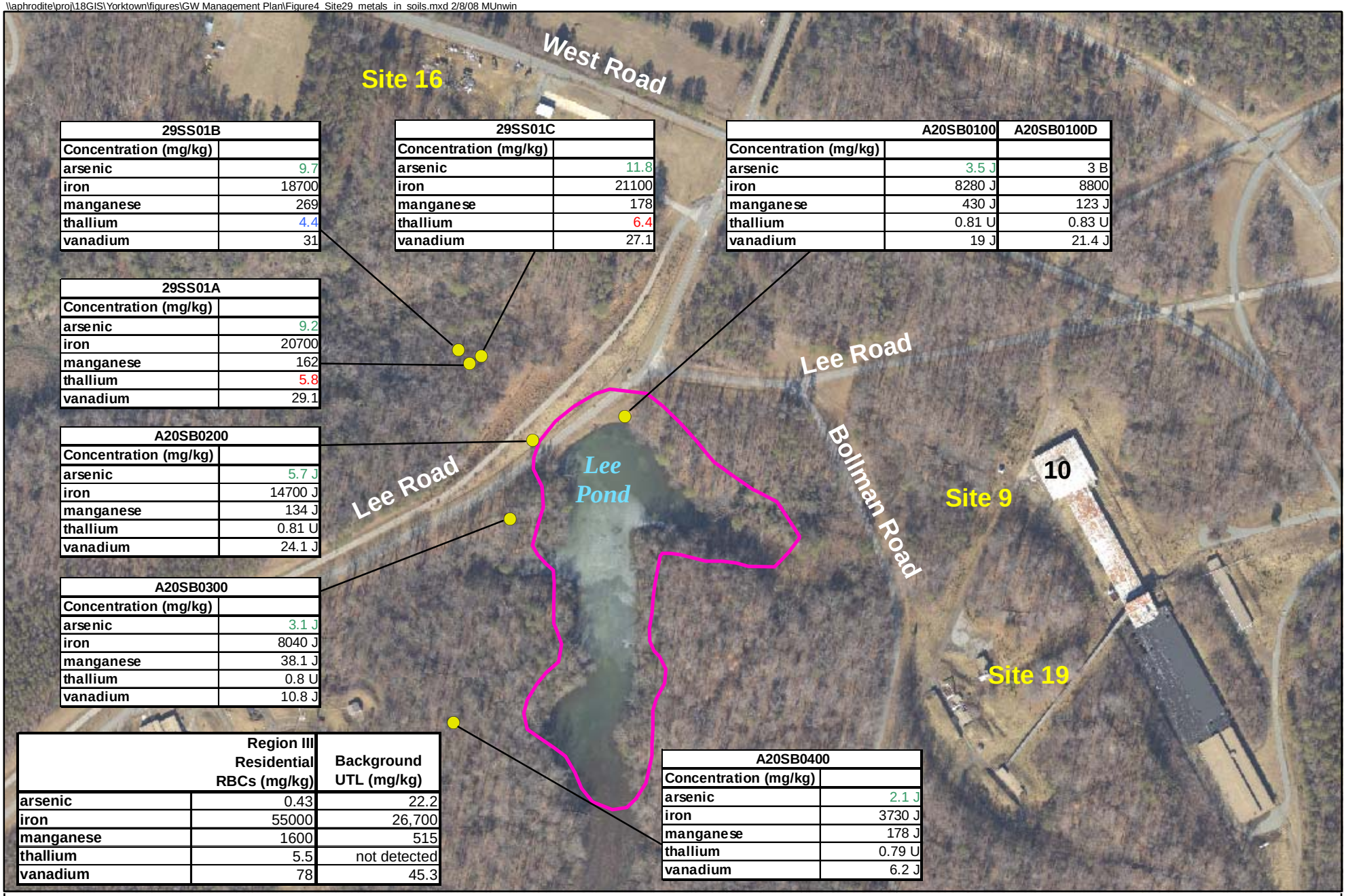

29SS01B	
Concentration (mg/kg)	
arsenic	9.7
iron	18700
manganese	269
thallium	4.4
vanadium	31

29SS01C	
Concentration (mg/kg)	
arsenic	11.8
iron	21100
manganese	178
thallium	6.4
vanadium	27.1

	A20SB0100	A20SB0100D
Concentration (mg/kg)		
arsenic	3.5 J	3 B
iron	8280 J	8800
manganese	430 J	123 J
thallium	0.81 U	0.83 U
vanadium	19 J	21.4 J

29SS01A	
Concentration (mg/kg)	
arsenic	9.2
iron	20700
manganese	162
thallium	5.8
vanadium	29.1

A20SB0200	
Concentration (mg/kg)	
arsenic	5.7 J
iron	14700 J
manganese	134 J
thallium	0.81 U
vanadium	24.1 J

A20SB0300	
Concentration (mg/kg)	
arsenic	3.1 J
iron	8040 J
manganese	38.1 J
thallium	0.8 U
vanadium	10.8 J

	Region III Residential RBCs (mg/kg)	Background UTL (mg/kg)
arsenic	0.43	22.2
iron	55000	26,700
manganese	1600	515
thallium	5.5	not detected
vanadium	78	45.3

A20SB0400	
Concentration (mg/kg)	
arsenic	2.1 J
iron	3730 J
manganese	178 J
thallium	0.79 U
vanadium	6.2 J

LEGEND

Soil Sample Locations

Study Area Boundary

green text = exceeds residential RBC
blue text = exceeds background
purple text = exceeds background and residential RBC

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0 175 350
Feet

Figure 4
Concentrations of Metals in Soils
Site 29, Lee Pond
Naval Weapons Station Yorktown
Yorktown, Virginia

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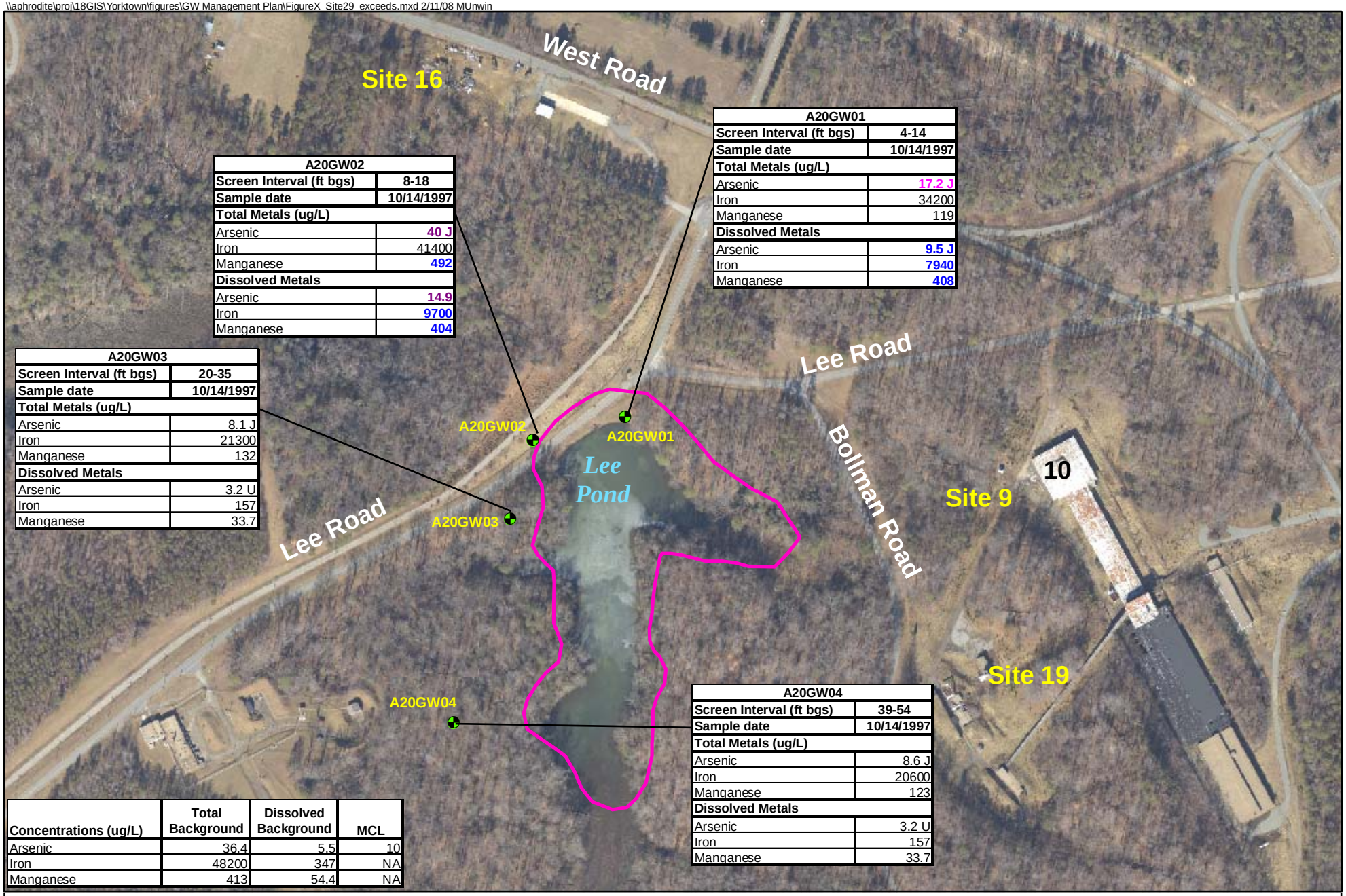

A20GW02	
Screen Interval (ft bgs)	**8-18**
Sample date	**10/14/1997**
Total Metals (ug/L)	
Arsenic	40 J
Iron	41400
Manganese	492
Dissolved Metals	
Arsenic	14.9
Iron	9700
Manganese	404

A20GW01	
Screen Interval (ft bgs)	**4-14**
Sample date	**10/14/1997**
Total Metals (ug/L)	
Arsenic	17.2 J
Iron	34200
Manganese	119
Dissolved Metals	
Arsenic	9.5 J
Iron	7940
Manganese	408

A20GW03	
Screen Interval (ft bgs)	**20-35**
Sample date	**10/14/1997**
Total Metals (ug/L)	
Arsenic	8.1 J
Iron	21300
Manganese	132
Dissolved Metals	
Arsenic	3.2 U
Iron	157
Manganese	33.7

A20GW04	
Screen Interval (ft bgs)	**39-54**
Sample date	**10/14/1997**
Total Metals (ug/L)	
Arsenic	8.6 J
Iron	20600
Manganese	123
Dissolved Metals	
Arsenic	3.2 U
Iron	157
Manganese	33.7

Concentrations (ug/L)	Total Background	Dissolved Background	MCL
Arsenic	36.4	5.5	10
Iron	48200	347	NA
Manganese	413	54.4	NA

LEGEND

Cornwallis-Cave Monitoring Wells

Study Area Boundary

purple text = exceeds background and MCL
pink text = exceeds MCL
blue text = exceeds background

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0 175 350
Feet

Figure 5
Concentrations of Metals in Groundwater
Site 29, Lee Pond
Naval Weapons Station Yorktown
Yorktown, Virginia

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Attachment 1
Statement to Tier 1 Teams

Statement to Tier 1 Teams December 6, 2004

In cases where teams may be working to assess beneficial use, groundwater potability and/or cleanup goals, there are flexibilities in the process that can be used by each team to develop a strategy in accordance with CERCLA, the NCP and site specific conditions to reach a mutually agreeable solution. It is our expectation that the appropriate technical experts will be brought in to participate in discussions early on to help identify which flexibilities may be appropriate to explore. These flexibilities can be used as part of the overall site assessment process to create lines of evidence that serve as documentation for beneficial use, ground water potability, and/or cleanup goals. The teams will determine the specific site appropriate flexibilities that should be used (number and type) that form the lines of evidence.

Flexibilities may include but are not limited to:

- Background: In many cases, inorganics may be attributable to background conditions. A background assessment can prove to be invaluable to determining whether or not a contaminant is site-related.

- Risk-Range: There is flexibility in determining whether an action needs to be taken as long as the site-related cancer risk falls within EPA's acceptable risk-range (1×10^{-6} to 1×10^{-4} and Hazard Index of 1).

- Source removal/containment & monitoring: Another option to explore if there is not a current user. If the contamination in the groundwater is representative of what is being found in the soils, soil removal and monitoring may be warranted to determine if source removal alone will result in a reduction of contaminant levels in the groundwater.

- Timeframes: Depending on the current use of the groundwater the amount of time needed to reach cleanup goals may be flexible. For example, if groundwater is not currently being used as a drinking water source, and it is not expected to be used as such in the near future, cleanup technologies that may take longer to achieve cleanup goals could be considered. Monitored Natural Attenuation (MNA) is an example. MNA may be used in certain situations when: the processes will allow ARARs to be met in a timeframe comparable to a more active remedy. (NCP Preamble, 55 Fed. Reg. 8734). Additional EPA Guidance is available: *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, 1999. This guidance clarifies that MNA may be used when there is a low potential for plume migration, and when sources have been controlled.

  When evaluating remedial actions that require extended timeframes, additional factors may be considered that lend support to the Timeframe flexibility. For example, existing ground water controls, regulations, ordinances, etc., can be used to demonstrate that current restrictions are in place to manage water usage until the remedial action is complete.

- Is it a Plume? (Consistent/Contiguous): There may be instances where data from one well is driving the site-related risk. A close review of data will help determine whether there truly is a plume or not.

- Sample representativeness: It may be beneficial to review historical data to determine if proper well installation and sampling methodology occurred and verify the current conditions of the wells to ensure that sampling of the wells will generate representative samples.

- Classification: Guidance for assessing groundwater uses is provided in the Preamble to the 1990 NCP Revision (55 Fed Reg. 8666 et seq. (March 1990); recommending that EPA's 1984 "Ground-Water Protection Strategy" and 1986 "Guidelines for Ground-Water Classification" be used to assess future use of ground waters at a particular site.

- Alternate Concentration Limits (ACLs): (only when active restoration to ARARs is not practicable (from the nine criteria analysis). This is not the engineering practicability as used for TI determination.

  CERCLA Section 121(d)(2)(B)(ii) and NCP Section 300.430(e)(2)(i)(F) also allow for the use of Alternate Concentration Limits (ACLS):
  - there are known and projected points of groundwater entry into surface water
  - there are no statistically significant increases in contaminant levels downstream or at any place where contamination is expected to accumulate; and
  - enforceable measures can be taken to prevent human exposure between site and the entry points in surface water

- Technical Impracticability (TI): If from an engineering perspective, it is technically impracticable to comply with an applicable, relevant and/or appropriate requirement (ARAR) (such as meeting MCLs), a TI Waiver may be prepared. EPA's "Guidance for Evaluating the Technical Impracticability of Groundwater Restoration" can be utilized to prepare the supporting TI Waiver documentation.

Attachment 2
Response to Comments

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CH2MHILL

January 10, 2008

343901.EC.AM

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United States Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: Draft Technical Memorandum Response to Comments
Supplemental Surface Water Sampling, Site 29 – Lee Pond
Naval Weapons Station Yorktown (WPNSTA), Yorktown, Virginia
Navy Clean III Program - Contract N62470-02-D-3052
Contract Task Order 0117

Dear Mr. Thomson

This letter is in response to your comments on the subject document provided in your letter dated December 12, 2007. Comments are presented, shown in italics, followed by Navy responses in bold.

1. *Section 2.1 on page 3 states that deep (8 inches – 12 inches) subsurface sediment was not sampled given the lack of biological activity at these depths. Information should be provided in the TM to support this statement. EPA BTAG is concerned with the lack of data at depth in Lee Pond, primarily because of historical deposition from nearby sites and the potential for future storms to re-suspend sediment from this depth zone into the water column. This issue needs to be addressed.*

The Navy respectfully disagrees that data gaps exist at depth in Lee Pond. Section 2.1 of the technical memorandum is a summary of the Step 3A ERA that was included in the final Round One RI report for Site 29 and served as the basis for the follow-on evaluation contained in the technical memorandum. The Step 3 ERA did evaluate risk for subsurface sediment from 4 to 8 inches. Deep subsurface sediment samples (8 to 12 inches) were collected by USEPA in 1998 (3 samples) and by Baker in 2000 (12 samples) in Lee Pond; the data from these samples are provided in the appendices to the final Round One RI. However, the Step 3A ERA did not evaluate risk from these deep subsurface sediment (>8 inches) samples. The stated reason for not evaluating deep subsurface sediment was "....as sediments at these depths do not represent an exposure point for ecological receptors" (pages 7-68 and 7-69). The statement in the technical memorandum will be changed to use the same language as the Step 3A ERA. No unacceptable risk was found for sediment (at surface depths or at depths of 4 to 8 inches) in the Step 3A ERA, a conclusion that has been accepted by the partnering team by its acceptance of the final RI report. The subsequent final project plans, also accepted by the team, only specified the

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collection and evaluation of the additional surface water samples addressed in the technical memorandum.

Lee Pond is a depositional environment that is relatively well sheltered by surrounding forested habitats. The likelihood of significant re-suspension of sediments from deeper depths is thus relatively low. Should this occur, the subsurface samples from 4 to 8 inches should be sufficient to evaluate this possible occurrence; no risk was found for sediments at this depth in the Step 3A ERA. A qualitative review of the 8 to 12 inch sediment data, as reported in the Round One RI appendices, indicates that detected constituent concentrations were generally similar (i.e., within the range of detected concentrations) to constituent concentrations at 4 to 8 and/or 0 to 4 inches and/or were less than sediment screening values used in the Step 3A ERA. Thus, in the unlikely event that significant sediment re-suspension does occur in Lee Pond from deeper depths, it should not result in any unacceptable risk to ecological receptors.

2. *Section 2.1 on page 3 states that groundwater was not evaluated because groundwater does not represent a direct exposure point for ecological receptors and adequate surface water and sediment data are available. This statement does not address any groundwater contamination that is yet to reach the pond, where ecological exposures would occur. The section further states that groundwater will be evaluated as part of a future assessment for the study area. Deferring the evaluation of potential groundwater impacts to Lee Pond seems reasonable; however, the investigation will need to address contaminants identified in this investigation, particularly aluminum, which is known to be a site related contaminant within the watershed.*

The Navy concurs that all site-related chemicals of concern will be addressed during the groundwater assessment of CERCLA Sites 9 and 19. These sites are upgradient of Lee Pond and within the Lee Pond watershed.

3. *Section 3 presents the results of the surface water sampling. The section states that aluminum exceeded its ambient water quality criteria (AWQC) value in 11 of 12 unfiltered samples but did not exceed AWQC in any of the filtered samples. Iron exceeded its AWQC value in 1 of 12 unfiltered samples but did not exceed in any of the filtered samples. Zinc was not detected in this round of sampling. Section 4 states that based on the results of the dissolved surface water samples, in combination with the results of the 2005 ecological risk assessment, there are no unacceptable risks for aquatic receptors in Lee Pond from current exposures. This section also concludes no further action for ecological receptors at Site 29. These conclusions were based primarily on the fact that no dissolved metals exceeded AWQC values. However, for some receptors, the dissolved fraction may not consider all exposure pathways. A footnote in the 2006 AWQC tables states that in tests with the brook trout, effects increased with increasing concentration of total aluminum even though the concentration of dissolved aluminum was constant, indicating that total recoverable is a more appropriate measurement than dissolved, at least when particulate aluminum is primarily aluminum hydroxide particles. With regard to iron, if only the dissolved fraction is considered, effects from iron precipitates on aquatic organisms are not evaluated. Given these results, effects from total aluminum and iron should not be dismissed and need to be considered in the evaluation of risk to aquatic receptors.*

Effects from total aluminum and total iron were considered in the technical memorandum. However, the Navy respectfully disagrees that effects from total aluminum and total iron should be the basis for determining the risk to aquatic receptors. Please note that the footnote in the 2006 AWQC tables indicates that aluminum is

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substantially less toxic at higher pH and hardness. The pH of Lee Pond and its tributaries (7.2 to almost 8.0) and hardness (average hardness of 178 mg/L) are above those values used to study effects on brook trout. The tests with brook trout were conducted at low pH and hardness, which likely resulted in stress to the test organisms. The footnote goes on to state that EPA is aware of field data indicating that many high quality waters in the U.S. contain more than 87 µg aluminum/L (the chronic AWQC), when either total recoverable or dissolved is measured, suggesting that the AWQC for aluminum is conservative, particularly for a system like Lee Pond that has relatively high pH and hardness. Also, the brook trout is not a particularly relevant fish species for this assessment based upon the habitats present.

Iron precipitates, if present, would be included in the surface sediment samples collected previously. However, the Step 3A ERA, which evaluated surface sediments and therefore the effects from any iron precipitates, concluded that there is no unacceptable risk related to iron in this medium.

4. *Figure 2 shows the surface water sampling locations collected from Lee Pond. The sample results are presented in Attachment 1. The results show that the most upstream sample in the upstream tributary has concentrations of aluminum, iron and zinc that are higher than all downstream samples. There should be a discussion of the results from this sample, particularly as it relates to a potential source it this tributary. Additional sampling upstream may be needed to evaluate the presence of a potential source.*

The Navy concurs that the results for total aluminum and total iron are higher at Location 1 (the most upstream sample on the southern tributary), however, zinc was not detected in any sample. Location 2, along the same upstream tributary as Location 1 but about 200 feet downstream, had much lower total concentrations (eight times lower for aluminum and six times lower for iron) relative to Location 1. It appears unlikely that an upstream source is present that would impact Location 1 but not Location 2 since they were sampled on the same day (about 20 minutes apart). The Navy concluded that the sample from Location 1 likely contained a higher amount of sediment than the other samples and notes that the water at all of the sampling locations was somewhat turbid (see Table 2), although Location 1 was not notably more turbid than the other samples. However, these turbidity readings were taken from the water column at the sampling location and not from the sample itself. The large decrease in concentration between the total and the dissolved samples at Location 1 (the filtered sample was non-detect for aluminum and approximately 25 times lower for iron), however, supports the explanation of turbidity impacts. The Navy respectfully disagrees that additional sampling is warranted.

Sincerely,

CH2M HILL

Laura J. Cook
Project Manager

cc: Ms. Linda Cole/NAVFAC

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Attachment 3
Raw Analytical Data

Attachment 3
Analytical Data - Surface Water - November 2006
Site 29 - Lee Pond
Naval Weapons Station Yorktown, Yorktown, Virginia

Station ID	YS29-SW001	YS29-SW002	YS29-SW003	YS29-SW004	YS29-SW005		YS29-SW006	YS29-SW007	YS29-SW008		YS29-SW009	YS29-SW010	YS29-SW011	YS29-SW012
Sample ID	YS29-SW001-1106	YS29-SW002-1106	YS29-SW003-1106	YS29-SW004-1106	YS29-SW005-1106	YS29-SW005P-1106	YS29-SW006-1106	YS29-SW007-1106	YS29-SW008-1106	YS29-SW008P-1106	YS29-SW009-1106	YS29-SW010-1106	YS29-SW011-1106	YS29-SW012-1106
Sample Date	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06	11/01/06
Total Metals (UG/L)														
Aluminum	1,040	131 J	151 J	90.8 J	532	578	576	555	137 J	279	35.4 J	463	480	362
Calcium	80,100	84,400	79,400	73,000	55,700	55,300	54,700	55,400	71,500	70,200	85,500	56,500	57,000	56,400
Iron	3,990 J	639 J	502 J	374 J	629 J	838 J	643 J	828 J	805 J	761 J	730 J	684 J	769 J	626 J
Magnesium	1,540 J	2,180 J	2,180 J	2,030 J	1,660 J	1,670 J	1,650 J	1,690 J	2,100 J	2,100 J	2,070 J	1,700 J	1,740 J	1,750 J
Zinc	37.6 B	23.6 B	19.3 B	16.6 B	15.2 B	16.2 B	13.4 B	13.7 B	26.0 B	14.5 B	12.5 B	14.2 B	18.2 B	24.3 B
Dissolved Metals (UG/L)														
Aluminum	9.70 U	9.70 U	11.4 J	17.5 J	27.0 J	25.0 J	33.7 J	28.7 J	11.4 J	11.5 J	9.70 U	34.7 J	26.0 J	17.5 J
Iron	155 K	56.2 B	27.2 B	25.3 B	79.2 B	85.5 B	76.2 B	88.3 B	87.2 B	80.4 B	109 K	117 K	144 K	139 K
Zinc	24.7 B	16.3 B	12.6 B	12.2 B	9.70 B	7.70 B	8.70 B	16.3 B	12.3 B	16.7 B	11.2 B	11.7 B	15.7 B	20.6 B
Other Parameters (MG/L)														
Hardness	210	220	210	190	150	140	140	150	190	180	220	150	150	150

U- Analyte not detected
B- Not detected substantially above the level reported in lab or field blanks
J- Reported value is estimated
K- Reported value is estimated biased high
L- Reported value is estimated biased low
Shading represents detection

Attachment 4
Human Health Risk Tables

ADULT AND YOUNG CHILD RESIDENTS - FUTURE SCENARIO
ACCIDENTAL INGESTION OF SUBSURFACE SOIL - SITE 29 (LEE POND)
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL WEAPONS STATION YORKTOWN - YORKTOWN, VIRGINIA

CDI (mg/kg/d) = (C*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Units	Description	Adult	Young Child	
CDI	mg/kg/d	Chronic daily intake	CS	CS	(Chemical Specific)
ILCR	NA	Incremental lifetime cancer risk	CS	CS	
CSFo	1/(mg/kg/d)	Oral cancer slope factor	CS	CS	
HQ	NA	Hazard quotient	CS	CS	
RfDo	mg/kg/d	Oral reference dose	CS	CS	
C	mg/kg	Concentration of chemical in soil	CS	CS	
IR-S	mg/day	Ingestion rate of soil	100	200	
CF	kg/mg	Conversion factor	1.00E-06	1.00E-06	
FI	NA	Fraction of soil ingested from site	0.5	0.5	
EF	days/year	Exposure frequency	350	350	
ED	years	Exposure duration	24	6	
BW	kg	Body weight	70	15	
AT-C	days	Averaging time, carcinogens	25,550	25,550	
AT-N	days	Averaging time, noncarcinogens	8,760	2,190	

				Adult						Young Child					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	C (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Aluminum	9,130	NA	1.0E+00	2.1E-03	--	--	6.3E-03	6.3E-03	10.9%	5.0E-03	--	--	5.8E-02	5.8E-02	10.9%
Arsenic	3.7	1.5E+00	3.0E-04	8.7E-07	1.3E-06	100.0%	2.5E-06	8.4E-03	14.8%	2.0E-06	3.0E-06	100.0%	2.4E-05	7.9E-02	14.8%
Iron	11,500	NA	3.0E-01	2.7E-03	--	--	7.9E-03	2.6E-02	46.0%	6.3E-03	--	--	7.4E-02	2.5E-01	46.0%
Vanadium	23.6	NA	1.0E-03	5.5E-06	--	--	1.6E-05	1.6E-02	28.3%	1.3E-05	--	--	1.5E-04	1.5E-01	28.3%
				Total ILCR:	1.3E-06	100.0%	Total HI:	5.7E-02	100.0%	Total ILCR:	3.0E-06	100.0%	Total HI:	5.3E-01	100.0%

NOTES:
-- - Not applicable.
NA - Toxicity criterion not available.

ADULT AND YOUNG CHILD RESIDENTS - FUTURE SCENARIC
INHALATION OF FUGITIVE DUSTS EMANATING FROM SURFACE SOIL - SITE 29 (LEE POND
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL WEAPONS STATION YORKTOWN - YORKTOWN, VIRGINIA

CDI (mg/kg/d) = (Ca*RR*ET*EF*ED)/(BW*AT
Where: Ca = C * (1/PEF)

ILCR = CDI*CSFi
HQ = CDI/RfDi

Parameter	Units	Description	Adult	Young Child	
CDI	mg/kg/d	Chronic daily intake	CS	CS	(Chemical Specific)
ILCR	NA	Incremental lifetime cancer risk	CS	CS	
CSFi	1/(mg/kg/d)	Inhalation cancer slope factor	CS	CS	
HQ	NA	Hazard quotient	CS	CS	
RfDi	mg/kg/d	Inhalation reference dose	CS	CS	
Ca	mg/m3	Concentration of chemical in air as fugitive dusts	CS	CS	
C	mg/kg	Concentration of chemical in soi	CS	CS	
PEF	m3/kg	Particulate emission factor	1.32E+09	1.32E+09	
RR	m3/hour	Respiration rate	0.83	0.35	
ET	hours/day	Exposure time	2.0	2.0	
EF	days/year	Exposure frequency	350	350	
ED	years	Exposure duration	24	6	
BW	kg	Body weight	70	15	
AT-C	days	Averaging time, carcinogens	25,550	25,550	
AT-N	days	Averaging time, noncarcinogens	8,760	2,190	

					Adult						Young Child					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	C (mg/kg)	Ca (mg/m3)	CSFi 1/(mg/kg/d)	RfDi (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	0.185	1.40E-10	NA	NA	1.1E-12	--	--	3.2E-12	--	--	5.4E-13	--	--	6.3E-12	--	--
Benzo(a)pyrene	0.17	1.29E-10	3.1E+00	NA	1.0E-12	3.1E-12	0.4%	2.9E-12	--	--	4.9E-13	1.5E-12	0.4%	5.8E-12	--	--
Benzo(b)fluoranthene	0.185	1.40E-10	NA	NA	1.1E-12	--	--	3.2E-12	--	--	5.4E-13	--	--	6.3E-12	--	--
Benzo(k)fluoranthene	0.17	1.29E-10	NA	NA	1.0E-12	--	--	2.9E-12	--	--	4.9E-13	--	--	5.8E-12	--	--
Carbazole	0.046	3.48E-11	NA	NA	2.7E-13	--	--	7.9E-13	--	--	1.3E-13	--	--	1.6E-12	--	--
Chrysene	0.187	1.41E-10	NA	NA	1.1E-12	--	--	3.2E-12	--	--	5.4E-13	--	--	6.3E-12	--	--
Indeno(1,2,3-cd)pyrene	0.11	8.33E-11	NA	NA	6.5E-13	--	--	1.9E-12	--	--	3.2E-13	--	--	3.7E-12	--	--
Arsenic	8.45	6.40E-09	1.5E+01	NA	5.0E-11	7.5E-10	99.6%	1.5E-10	--	--	2.5E-11	3.7E-10	99.6%	2.9E-10	--	--
Iron	17,469	1.32E-05	NA	NA	1.0E-07	--	--	3.0E-07	--	--	5.1E-08	--	--	5.9E-07	--	--
Manganese	192	1.45E-07	NA	1.4E-05	1.1E-09	--	--	3.3E-09	2.3E-04	100.0%	5.6E-10	--	--	6.5E-09	4.5E-04	100.0%
Thallium	4.14	3.14E-09	NA	NA	2.4E-11	--	--	7.1E-11	--	--	1.2E-11	--	--	1.4E-10	--	--
Vanadium	27.0	2.04E-08	NA	NA	1.6E-10	--	--	4.6E-10	--	--	7.8E-11	--	--	9.1E-10	--	--
					Total ILCR:	7.6E-10	100.0%	Total HI:	2.3E-04	100.0%	Total ILCR:	3.7E-10	100.0%	Total HI:	4.5E-04	100.0%

NOTES:
-- - Not applicable.
NA - Toxicity criterion not available

ADULT AND YOUNG CHILD RESIDENTS - FUTURE SCENARIC
DERMAL CONTACT WITH SURFACE SOIL - SITE 29 (LEE POND
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL WEAPONS STATION YORKTOWN - YORKTOWN, VIRGINIA

DAD (mg/kg/d) = (C*CF*AF*ABS*SA*EF*ED)/(BW*AT
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Units	Description	Adult	Young Child	
DAD	mg/kg/d	Dermally absorbed dose	CS	CS	(Chemical Specific)
ILCR	NA	Incremental lifetime cancer risk	CS	CS	
CSFd	1/(mg/kg/d)	Dermal cancer slope factor	CS	CS	
HQ	NA	Hazard quotient	CS	CS	
RfDd	mg/kg/d	Dermal reference dose	CS	CS	
C	mg/kg	Concentration of chemical in soi	CS	CS	
CF	kg/mg	Conversion factor	1.00E-06	1.00E-06	
AF	mg/cm2	Soil to skin adherence factor	0.07	0.2	
ABS	NA	Absorption fraction	CS	CS	
SA	cm2/day	Skin surface area available for contact	5,000	1,700	
EF	days/year	Exposure frequency	350	350	
ED	years	Exposure duration	24	6	
BW	kg	Body weight	70	15	
AT-C	days	Averaging time, carcinogens	25,550	25,550	
AT-N	days	Averaging time, noncarcinogens	8,760	2,190	

					Adult						Young Child					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	C (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	0.185	0.13	7.3E-01	NA	4.0E-08	2.9E-08	3.0%	1.2E-07	--	--	4.5E-08	3.3E-08	3.0%	5.2E-07	--	--
Benzo(a)pyrene	0.17	0.13	7.3E+00	NA	3.6E-08	2.7E-07	27.4%	1.1E-07	--	--	4.1E-08	3.0E-07	27.4%	4.8E-07	--	--
Benzo(b)fluoranthene	0.185	0.13	7.3E-01	NA	4.0E-08	2.9E-08	3.0%	1.2E-07	--	--	4.5E-08	3.3E-08	3.0%	5.2E-07	--	--
Benzo(k)fluoranthene	0.17	0.13	7.3E-02	NA	3.6E-08	2.7E-09	0.3%	1.1E-07	--	--	4.1E-08	3.0E-09	0.3%	4.8E-07	--	--
Carbazole	0.046	0.13	2.0E-02	NA	9.8E-09	2.0E-10	0.0%	2.9E-08	--	--	1.1E-08	2.2E-10	0.0%	1.3E-07	--	--
Chrysene	0.187	0.13	7.3E-03	NA	4.0E-08	2.9E-10	0.0%	1.2E-07	--	--	4.5E-08	3.3E-10	0.0%	5.3E-07	--	--
Indeno(1,2,3-cd)pyrene	0.11	0.13	7.3E-01	NA	2.4E-08	1.7E-08	1.8%	6.9E-08	--	--	2.7E-08	1.9E-08	1.8%	3.1E-07	--	--
Arsenic	8.45	0.03	1.5E+00	3.0E-04	4.2E-07	6.3E-07	64.6%	1.2E-06	4.1E-03	5.7%	4.7E-07	7.1E-07	64.6%	5.5E-06	1.8E-02	5.7%
Iron	17,469	0.01	NA	3.0E-01	2.9E-04	--	--	8.4E-04	2.8E-03	3.9%	3.3E-04	--	--	3.8E-03	1.3E-02	3.9%
Manganese	192	0.01	NA	8.0E-04	3.1E-06	--	--	9.2E-06	1.1E-02	16.2%	3.6E-06	--	--	4.2E-05	5.2E-02	16.2%
Thallium	4.14	0.01	NA	7.0E-05	6.8E-08	--	--	2.0E-07	2.8E-03	4.0%	7.7E-08	--	--	9.0E-07	1.3E-02	4.0%
Vanadium	27.0	0.01	NA	2.6E-05	4.4E-07	--	--	1.3E-06	5.0E-02	70.1%	5.0E-07	--	--	5.9E-06	2.3E-01	70.1%
					Total ILCR:	9.7E-07	100.0%	Total HI:	7.1E-02	100.0%	Total ILCR:	1.1E-06	100.0%	Total HI:	3.2E-01	100.0%

NOTES:
-- - Not applicable.
NA - Toxicity criterion not available

ADULT AND YOUNG CHILD RESIDENTS - FUTURE SCENARIO
ACCIDENTAL INGESTION OF SURFACE SOIL - SITE 29 (LEE POND)
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL WEAPONS STATION YORKTOWN - YORKTOWN, VIRGINIA

CDI (mg/kg/d) = (C*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Units	Description	Adult	Young Child	
CDI	mg/kg/d	Chronic daily intake	CS	CS	(Chemical Specific)
ILCR	NA	Incremental lifetime cancer risk	CS	CS	
CSFo	1/(mg/kg/d)	Oral cancer slope factor	CS	CS	
HQ	NA	Hazard quotient	CS	CS	
RfDo	mg/kg/d	Oral reference dose	CS	CS	
C	mg/kg	Concentration of chemical in soil	CS	CS	
IR-S	mg/day	Ingestion rate of soil	100	200	
CF	kg/mg	Conversion factor	1.00E-06	1.00E-06	
FI	NA	Fraction of soil ingested from site	0.5	0.5	
EF	days/year	Exposure frequency	350	350	
ED	years	Exposure duration	24	6	
BW	kg	Body weight	70	15	
AT-C	days	Averaging time, carcinogens	25,550	25,550	
AT-N	days	Averaging time, noncarcinogens	8,760	2,190	

				Adult						Young Child					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	C (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	0.185	7.3E-01	NA	4.3E-08	3.2E-08	0.9%	1.3E-07	--	--	1.0E-07	7.4E-08	0.9%	1.2E-06	--	--
Benzo(a)pyrene	0.17	7.3E+00	NA	4.0E-08	2.9E-07	8.7%	1.2E-07	--	--	9.3E-08	6.8E-07	8.7%	1.1E-06	--	--
Benzo(b)fluoranthene	0.185	7.3E-01	NA	4.3E-08	3.2E-08	0.9%	1.3E-07	--	--	1.0E-07	7.4E-08	0.9%	1.2E-06	--	--
Benzo(k)fluoranthene	0.17	7.3E-02	NA	4.0E-08	2.9E-09	0.1%	1.2E-07	--	--	9.3E-08	6.8E-09	0.1%	1.1E-06	--	--
Carbazole	0.046	2.0E-02	NA	1.1E-08	2.2E-10	0.0%	3.2E-08	--	--	2.5E-08	5.0E-10	0.0%	2.9E-07	--	--
Chrysene	0.187	7.3E-03	NA	4.4E-08	3.2E-10	0.0%	1.3E-07	--	--	1.0E-07	7.5E-10	0.0%	1.2E-06	--	--
Indeno(1,2,3-cd)pyrene	0.11	7.3E-01	NA	2.6E-08	1.9E-08	0.6%	7.5E-08	--	--	6.0E-08	4.4E-08	0.6%	7.0E-07	--	--
Arsenic	8.45	1.5E+00	3.0E-04	2.0E-06	3.0E-06	88.8%	5.8E-06	1.9E-02	15.5%	4.6E-06	6.9E-06	88.8%	5.4E-05	1.8E-01	15.5%
Iron	17,469	NA	3.0E-01	4.1E-03	--	--	1.2E-02	4.0E-02	32.0%	9.6E-03	--	--	1.1E-01	3.7E-01	32.0%
Manganese	192	NA	2.0E-02	4.5E-05	--	--	1.3E-04	6.6E-03	5.3%	1.0E-04	--	--	1.2E-03	6.1E-02	5.3%
Thallium	4.14	NA	7.0E-05	9.7E-07	--	--	2.8E-06	4.1E-02	32.5%	2.3E-06	--	--	2.6E-05	3.8E-01	32.5%
Vanadium	27.0	NA	1.0E-03	6.3E-06	--	--	1.8E-05	1.8E-02	14.8%	1.5E-05	--	--	1.7E-04	1.7E-01	14.8%
				Total ILCR:	3.4E-06	100.0%	Total HI:	1.2E-01	100.0%	Total ILCR:	7.8E-06	100.0%	Total HI:	1.2E+00	100.0%

NOTES:
-- - Not applicable.
NA - Toxicity criterion not available.

Attachment 5
Risk Tables

TABLE 7.1.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Site 29, Lee Pond

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion													
				Arsenic	1.5E+01	µg/L	NA	NA	NA	NA	NA	4.1E-04	mg/kg/day	3.0E-04	mg/kg/day	1.4E+00
				Iron	9.7E+03	µg/L	NA	NA	NA	NA	NA	2.7E-01	mg/kg/day	7.0E-01	mg/kg/day	3.8E-01
				Manganese	4.1E+02	µg/L	NA	NA	NA	NA	NA	1.1E-02	mg/kg/day	2.0E-02	mg/kg/day	5.6E-01
			Exp. Route Total								NA					2.3E+00
			Dermal	Arsenic	1.5E+01	µg/L	NA	NA	NA	NA	NA	2.1E-06	mg/kg/day	3.0E-04	mg/kg/day	7.1E-03
				Iron	9.7E+03	µg/L	NA	NA	NA	NA	NA	1.4E-03	mg/kg/day	7.0E-01	mg/kg/day	2.0E-03
				Manganese	4.1E+02	µg/L	NA	NA	NA	NA	NA	5.8E-05	mg/kg/day	8.0E-04	mg/kg/day	7.3E-02
			Exp. Route Total								NA					8.2E-02
		Exposure Point Total									NA					2.4E+00
	Exposure Medium Total										NA					2.4E+00
Groundwater Total											NA					2.4E+00
										Total of Receptor Risks Across All Media	NA			Total of Receptor Hazards Across All Media		2.4E+00

Notes:
used filted data
NA = Not applicable
DAevent for exposure to groundwater while showering calculated on Table 7.1.RME Supplement A.

Table 7.1.RME Supplement A
Calculation of DAevent
Resident Adult Ground Water
Site 29, Lee Pond

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Arsenic	1.5E+01	1.0E-03	NA	NA	NA	NA	0.58	8.6E-09	1
Iron	9.7E+03	1.0E-03	NA	NA	NA	NA	0.58	5.6E-06	1
Manganese	4.1E+02	1.0E-03	NA	NA	NA	NA	0.58	2.4E-07	1

Inorganics: DAevent (mg/cm^2-event) =

Kp x CW x t_{event} x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm^2-event) =

If tevent<t*, then DAevent =

2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =

FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + 3xB^2)/(1+B)^2) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

Notes:

NA - Not applicable

Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t* - Time to reach steady-state

TABLE 7.2.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Site 29, Lee Pond

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion													
				Arsenic	1.5E+01	µg/L	NA	NA	NA	NA	NA	9.5E-04	mg/kg/day	3.0E-04	mg/kg/day	3.2E+00
				Iron	9.7E+03	µg/L	NA	NA	NA	NA	NA	6.2E-01	mg/kg/day	7.0E-01	mg/kg/day	8.9E-01
				Manganese	4.1E+02	µg/L	NA	NA	NA	NA	NA	2.6E-02	mg/kg/day	2.0E-02	mg/kg/day	1.3E+00
			Exp. Route Total								NA					5.4E+00
			Dermal													
				Arsenic	1.5E+01	µg/L	NA	NA	NA	NA	NA	6.3E-06	mg/kg/day	3.0E-04	mg/kg/day	2.1E-02
				Iron	9.7E+03	µg/L	NA	NA	NA	NA	NA	4.1E-03	mg/kg/day	7.0E-01	mg/kg/day	5.8E-03
				Manganese	4.1E+02	µg/L	NA	NA	NA	NA	NA	1.7E-04	mg/kg/day	8.0E-04	mg/kg/day	2.2E-01
			Exp. Route Total								NA					2.4E-01
		Exposure Point Total									NA					5.6E+00
	Exposure Medium Total										NA					5.6E+00
Groundwater Total											NA					5.6E+00
							Total of Receptor Risks Across All Media				NA	Total of Receptor Hazards Across All Media				5.6E+00

Notes:
used filted data
NA = Not applicable
DAevent for exposure to groundwater while showering calculated on Table 7.2.RME Supplement A.

Table 7.2.RME Supplement A
Calculation of DAevent
Resident Child Ground Water
Site 24 - NAS Patuxent River, Maryland

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Arsenic	1.5E+01	1.0E-03	NA	NA	NA	NA	1	1.5E-08	1
Iron	9.7E+03	1.0E-03	NA	NA	NA	NA	1	9.7E-06	1
Manganese	4.1E+02	1.0E-03	NA	NA	NA	NA	1	4.1E-07	1

Inorganics: DAevent (mg/cm^2-event) =

Kp x CW x t_{event} x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm^2-event) =

If tevent<t*, then DAevent =

2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =

FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + 3xB^2)/(1+B)^2) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

Notes:

NA - Not applicable

Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t* - Time to reach steady-state

TABLE 7.3.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Site 29, Lee Pond

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion													
				Arsenic	1.5E+01	µg/L	2.2E-04	mg/kg-day	1.5E+00	1/(mg/kg-day)	3.3E-04	NA	NA	NA	NA	NA
				Iron	9.7E+03	µg/L	1.4E-01	mg/kg-day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	4.1E+02	µg/L	6.1E-03	mg/kg-day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								3.3E-04					NA
			Dermal													
				Arsenic	1.5E+01	µg/L	5.4E-05	mg/kg/day	1.5E+00	1/(mg/kg-day)	8.1E-05	NA	NA	NA	NA	NA
				Iron	9.7E+03	µg/L	3.5E-02	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	4.1E+02	µg/L	1.5E-03	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								8.1E-05					NA
		Exposure Point Total									4.1E-04					NA
	Exposure Medium Total										4.1E-04					NA
Groundwater Total											4.1E-04					NA
										Total of Receptor Risks Across All Media	4.1E-04				Total of Receptor Hazards Across All Media	NA

Notes-

used filted data

NA = Not applicable

DAevent for exposure to groundwater while showering and bathing calculated on Tables 7.1.RME Supplement A and 7.2.RME Supplement A.

TABLE 7.4.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Site 29, Lee Pond

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer-Water in Excavation Trench	Dermal													
				Arsenic	1.5E+01	µg/L	4.7E-08	mg/kg-day	1.5E+00	1/(mg/kg-day)	7.1E-08	3.3E-06	mg/kg/day	3.0E-04	mg/kg/day	1.1E-02
				Iron	9.7E+03	µg/L	3.1E-05	mg/kg-day	NA	1/(mg/kg-day)	NA	2.2E-03	mg/kg/day	7.0E-01	mg/kg/day	3.1E-03
				Manganese	4.1E+02	µg/L	1.3E-06	mg/kg-day	NA	1/(mg/kg-day)	NA	9.1E-05	mg/kg/day	8.0E-04	mg/kg/day	1.1E-01
			Exp. Route Total								7.1E-08					1.3E-01
		Exposure Point Total									7.1E-08					1.3E-01
	Exposure Medium Total										7.1E-08					1.3E-01
Groundwater Total											7.1E-08					1.3E-01
Total of Receptor Risks Across All Media											7.1E-08	Total of Receptor Hazards Across All Media				1.3E-01

Notes-

used filted data

NA = Not applicable

Subchronic RfD values used when available.

DAevent for exposure to groundwater during excavation activities calculated on Table 7.4.RME Supplement A.

Table 7.4.RME Supplement A
Calculation of DAevent
Construction Worker Ground Water
Site 29, Lee Pond

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Arsenic	1.5E+01	1.0E-03	NA	NA	NA	NA	8	1.2E-07	1
Iron	9.7E+03	1.0E-03	NA	NA	NA	NA	8	7.8E-05	1
Manganese	4.1E+02	1.0E-03	NA	NA	NA	NA	8	3.3E-06	1

Inorganics: DAevent (mg/cm^2-event) =

Kp x CW x t_{event} x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm^2-event) =

If tevent<t*, then DAevent =

2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =

FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + $3xB^2$)/$(1+B)^2$) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

Notes:

NA - Not applicable

Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

TABLE 7.1.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Site 29, Lee Pond

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion													
				Arsenic	6.9E+00	µg/L	NA	NA	NA	NA	NA	8.8E-05	mg/kg/day	3.0E-04	mg/kg/day	2.9E-01
				Iron	4.5E+03	µg/L	NA	NA	NA	NA	NA	5.8E-02	mg/kg/day	7.0E-01	mg/kg/day	8.2E-02
				Manganese	2.2E+02	µg/L	NA	NA	NA	NA	NA	2.8E-03	mg/kg/day	2.0E-02	mg/kg/day	1.4E-01
			Exp. Route Total								NA					5.2E-01
			Dermal	Arsenic	6.9E+00	µg/L	NA	NA	NA	NA	NA	2.8E-07	mg/kg/day	3.0E-04	mg/kg/day	9.5E-04
				Iron	4.5E+03	µg/L	NA	NA	NA	NA	NA	1.8E-04	mg/kg/day	7.0E-01	mg/kg/day	2.6E-04
				Manganese	2.2E+02	µg/L	NA	NA	NA	NA	NA	9.1E-06	mg/kg/day	8.0E-04	mg/kg/day	1.1E-02
			Exp. Route Total								NA					1.3E-02
		Exposure Point Total									NA					5.3E-01
	Exposure Medium Total										NA					5.3E-01
Groundwater Total											NA					5.3E-01
							Total of Receptor Risks Across All Media				NA	Total of Receptor Hazards Across All Media				5.3E-01

Notes:
NA = Not applicable
DAevent for exposure to groundwater while showering calculated on Table 7.4.RME Supplement A.

Table 7.1.CTE Supplement A
Calculation of DAevent
Resident Adult Ground Water
Site 29, Lee Pond

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Arsenic	6.9E+00	1.0E-03	NA	NA	NA	NA	0.25	1.7E-09	1
Iron	4.5E+03	1.0E-03	NA	NA	NA	NA	0.25	1.1E-06	1
Manganese	2.2E+02	1.0E-03	NA	NA	NA	NA	0.25	5.5E-08	1

Inorganics: DAevent (mg/cm^2-event) =

Kp x CW x t_{event} x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm^2-event) =

If tevent<t*, then DAevent =

2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =

FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + 3xB^2)/(1+B)^2) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

Notes:

NA - Not applicable

Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t* - Time to reach steady-state

TABLE 7.2.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Site 29, Lee Pond

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion													
				Arsenic	6.9E+00	µg/L	NA	NA	NA	NA	NA	2.9E-04	mg/kg/day	3.0E-04	mg/kg/day	9.8E-01
				Iron	4.5E+03	µg/L	NA	NA	NA	NA	NA	1.9E-01	mg/kg/day	7.0E-01	mg/kg/day	2.7E-01
				Manganese	2.2E+02	µg/L	NA	NA	NA	NA	NA	9.4E-03	mg/kg/day	2.0E-02	mg/kg/day	4.7E-01
			Exp. Route Total								NA					1.7E+00
			Dermal	Arsenic	6.9E+00	µg/L	NA	NA	NA	NA	NA	6.4E-07	mg/kg/day	3.0E-04	mg/kg/day	2.1E-03
				Iron	4.5E+03	µg/L	NA	NA	NA	NA	NA	4.2E-04	mg/kg/day	7.0E-01	mg/kg/day	6.0E-04
				Manganese	2.2E+02	µg/L	NA	NA	NA	NA	NA	2.0E-05	mg/kg/day	8.0E-04	mg/kg/day	2.6E-02
			Exp. Route Total								NA					2.8E-02
		Exposure Point Total									NA					1.8E+00
	Exposure Medium Total										NA					1.8E+00
Groundwater Total											NA					1.8E+00
									Total of Receptor Risks Across All Media		NA	Total of Receptor Hazards Across All Media				1.8E+00

Notes:
NA = Not applicable
DAevent for exposure to groundwater while showering calculated on Table 7.5.RME Supplement A.

Table 7.2.CTE Supplement A
Calculation of DAevent
Resident Child Ground Water
Site 29, Lee Pond

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Arsenic	6.9E+00	1.0E-03	NA	NA	NA	NA	0.33	2.3E-09	1
Iron	4.5E+03	1.0E-03	NA	NA	NA	NA	0.33	1.5E-06	1
Manganese	2.2E+02	1.0E-03	NA	NA	NA	NA	0.33	7.3E-08	1

Inorganics: DAevent (mg/cm^2-event) =

Kp x CW x t_{event} x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm^2-event) =

If tevent<t*, then DAevent =

2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =

FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + 3xB^2)/$(1+B)^2$) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

Notes:

NA - Not applicable

Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t* - Time to reach steady-state

TABLE 7.3.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Site 29, Lee Pond

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion													
				Arsenic	6.9E+00	µg/L	3.7E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	5.5E-05	NA	NA	NA	NA	NA
				Iron	4.5E+03	µg/L	2.4E-02	mg/kg-day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	2.2E+02	µg/L	1.2E-03	mg/kg-day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								5.5E-05					NA
			Dermal													
				Arsenic	6.9E+00	µg/L	4.0E-06	mg/kg/day	1.5E+00	1/(mg/kg-day)	6.1E-06	NA	NA	NA	NA	NA
				Iron	4.5E+03	µg/L	2.6E-03	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	2.2E+02	µg/L	1.3E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								6.1E-06					NA
		Exposure Point Total									6.1E-05					NA
	Exposure Medium Total										6.1E-05					NA