Appendix G

Phase 1 Ecological Assessment Report

Contents

	Page
List of Figures	**G-v**
List of Tables	**G-v**
Acronyms and Abbreviations	**G-vi**
Executive Summary	**G-1**
Introduction	**G-4**
Objectives	G-4
General Approach	G-4
Site Characterization	**G-6**
Site Background and History	G-6
Field Reconnaissance Surveys	G-6
East Swale	G-7
East Fenced Area	G-7
South Ditch	G-9
Offsite Creek Area	G-11
Selection of Areas for Ecological Assessment	G-13
Selection of Potential Chemicals of Interest	G-15
Forms of Potential Chemicals of Interest	G-15
Distribution of Potential Chemicals of Interest	G-15
Selection of Chemicals of Interest	G-15
Identification of Potential Ecological Receptors	G-16
Cattail	G-18
Muskrat	G-18
Northern Short-Tailed Shrew	G-19
White-Footed Mouse	G-20
Raccoon	G-21
Coyote	G-22
Dark-Eyed Junco	G-22
American Robin	G-23

American Kestrel G-23
Wood Duck G-24

Areas of Interest G-24

Known or Suspected Effects of Lead G-25

Toxicity and Bioaccumulation Assessment G-26

Transport and Fate of Lead G-26
Geochemistry of Lead G-26
Solubility of Lead G-27

Bioavailability of Lead G-28
Bioavailability to Plants G-28
Bioavailability to Animals G-28

Toxicity and Bioaccumulation G-29

Preliminary Ecological Assessment G-31

Conceptual Site Model For Ecological Receptors G-31
Soil/Sediment G-32
Groundwater G-32
Surface Water G-32
Air G-32
Food G-33

Potential for Adverse Population Effects G-33
Cattail G-34
Muskrat G-34
Northern Short-Tailed Shrew G-34
White-Footed Mouse G-35
Raccoon G-36
Coyote G-36
American Robin G-37
Dark-Eyed Junco G-37
American Kestrel G-38
Wood Duck G-38

Ecological Screening Of Soil Lead Concentrations G-39

Sediment Bioassays G-44

Evaluation of the Need for a Phase II Ecological Risk Assessment G-45

Attachment G1 Toxicity Evaluation of Sediment with *Hyalella azteca*
Attachment G2 Toxicity Evaluation of Sediment with *Chironomus tentans*

List of Figures

Figure G-1. Ecological conceptual site model for the EFA and OCA of the Thomson Consumer Electronics site, Circleville, Ohio

List of Tables

Table G-1. Vertebrate species identified in the Offsite Creek Area

Table G-2. Plant species identified in the Offsite Creek Area on September 26, 1992

Table G-3. Potential ecological receptors for the East Fenced Area and Offsite Creek Area

Table G-4. Summary statistics of lead concentrations in the upper creek, deltaic, and downstream overbank areas

Table G-5. Food web risk evaluation for small mammal receptors in the upper creek area based on 95 percent UCL on arithmetic mean soil lead concentration

Table G-6. Food web risk evaluation for small mammal receptors in the deltaic area and downstream overbank areas based on 95 percent UCL on arithmetic mean soil lead concentration

Table G-7. Food web risk evaluation for shrews in the upper creek, deltaic, and downstream overbank areas based on 95 percent UCL on arithmetic mean soil lead concentrations and earthworm uptake regression equation from Sample et al (1998)

Table G-8. Food web risk evaluation for shrews in the upper creek, deltaic, and downstream overbank areas based on arithmetic mean soil lead concentrations and earthworm uptake regression equation from Sample et al (1998)

Table G-9. Summary of sample analytical results for supplemental sediment bioassay investigation

Acronyms and Abbreviations

BAF	bioaccumulation factor
CEC	cation exchange capacity
EFA	East Fenced Area
EHWD	Earnhart Hill Water District
gpd	gal per day
LOAEL	lowest-observed-adverse-effect-level
NOEL	no-observed-adverse-effect-level
NPDES	National Pollutant Discharge Elimination System
OCA	Offsite Creek Area
OEPA	Ohio Environmental Protection Agency
PCoI	potential chemical of interest
Phase I EA	Phase I environmental assessment
PTI	PTI Environmental Services
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation and feasibility study
the Site	Thomson Consumer Electronics facility
TOC	total organic carbon
TPH	total petroleum hydrocarbon
TRV	toxicity reference value
WWTP	wastewater treatment plant

Executive Summary

Exponent (then PTI Environmental Services or PTI) conducted a Phase I ecological assessment (Phase I EA) of the Thomson Consumer Electronics facility (the Site) in Circleville, Ohio. The Phase I EA was completed to evaluate habitat quality and potential ecological receptors at the Site and the Offsite Creek Area (OCA), to evaluate toxicity of lead in sediments to benthic invertebrates, and to determine whether a Phase II EA (baseline ecological assessment) is warranted. This assessment was based on a qualitative evaluation of habitat conditions, quantitative sampling of biota, evaluation of potential ecological receptors in onsite and offsite areas of interest, identification of potential chemicals of interest (PCoIs), assessment of the bioavailability of the PCoIs, sediment toxicity bioassays, and evaluation of potential exposure pathways.

Initial surveys for the Phase I EA were completed in 1992, after which the preliminary Phase I EA document was submitted as an appendix to the remedial investigation and feasibility study (RI/FS) work plan (PTI 1995). During August and October 1997, the Site and offsite areas of interest to the remedial investigation were revisited. The objective of the 1997 Site surveys was to reexamine more current conditions and review the conclusions of the 1995 preliminary Phase I EA in light of these conditions and additional data collected during the remedial investigation. Finally, in 2007, supplemental sediment sampling was performed within the OCA as part of sediment bioassay investigations. Those investigations involved the collection of surficial sediment samples (0- to 6-in.) from 28 locations previously sampled during the remedial investigation in an attempt to collect samples representative of the following concentration ranges for use in the sediment bioassays: 40 to 400 ppm, 400 to 800 ppm, and greater than 800 ppm. This document considers the data collected during previous surveys and remedial investigation sampling events (including supplemental sampling completed in 2003 and 2007), and presents the final conclusions of the Phase I EA.

Areas of interest at the Site and in downstream areas possibly influenced by the transport of PCoIs from the Site were primarily evaluated with regard to the quality and extent of habitat. A list of ecological receptors potentially occurring in onsite and offsite areas of interest was developed. PCoIs in environmental media were identified based on historical and remedial investigation sampling data and incorporated into the evaluation of exposure pathways to determine whether they would result in significant chemical exposure to the ecological receptors.

The conclusion of this Phase I EA is that lead is the only CoI and the East Fenced Area (EFA) and OCA are the only habitats where potential exposure of ecological receptors to Site-related chemicals may occur. Factors influencing the evaluation of potential risk to receptors were: habitat quality, size of the potentially affected habitat relative to the use area of a receptor, proportion of a receptor population affected, potential for complete exposure pathways to exist, toxicity of lead to the receptor, and bioavailability of lead. For the following reasons, it was concluded that potential ecological risks associated with lead from the Site on the EFA and OCA are not significant and do not warrant a Phase II EA:

- The quality and extent of habitat in the EFA are limited. The EFA is a small (i.e., about 5 acres), idle, mid-successional grassland habitat. While the area may support some receptors, it is unlikely to support any significant populations of receptors of interest.

- Food webs in the EFA are not expected to be significantly affected by lead concentrations in surface soils. Smaller wildlife receptors (i.e., northern short-tailed shrew, white-footed mouse, dark-eyed junco, American robin) in the EFA are expected to be primarily granivorous, frugivorous, and insectivorous. Plant parts such as seeds and fruits are not expected to readily take up lead. For insectivorous species, foraging will typically be on aboveground, mobile insects; foraging on subsurface invertebrates (e.g., earthworms) is expected to be uncommon except for the northern short-tailed shrew.

- The offsite creek is considered poor-quality habitat. The terrestrial habitat of the OCA is typical of transitional cover in mixed development properties. The Ohio Environmental Protection Agency (OEPA) has designated the offsite creek (i.e., an extension of the South Ditch referred to as the RCA Tributary) as a "limited resource water" (OAC 3745-1-09). OEPA has determined that the aquatic habitat is of poor quality and conditions are expected to remain poor because regular channel maintenance (e.g., removal of beaver dams and periodic dredging) is needed to sustain drainage of the adjacent agricultural field. This evaluation by the State is supported by observations during the 1997 Site reconnaissance that found poor habitat for receptor populations in the OCA. The OCA is subjected to additional stressors from sources unrelated to the Site, including storm water runoff from commercial and residential areas, agricultural runoff, and sewage treatment plant effluent.

- The entire OCA is less than 12 acres, and areas with substantially elevated lead concentrations in the deltaic area and affected channel portion of the upper creek are approximately 20 percent (2 acres) of this area. Thus, the frequency and duration of the exposure of receptors to lead will be minimal in the OCA.

- Most habitats in the OCA are subjected to annual flooding. Although terrestrial receptors may occupy habitats in this area, residence time and exposure are reduced as a result of periodic inundation of habitats.

- The chemical mobility of lead is low and lead mobility is generally restricted to physical transport mechanisms. The sorption capacity of soil and sediments for lead is high because of the presence of iron and manganese hydrous oxides and sulfides, clays, and organic matter, which collectively bind lead.

- The bioavailability of lead to receptor species in soil, surface water, and sediments of the OCA is expected to be low because of the low solubility of

forms of the lead and the presence of cations in soil that would control dissolution of lead minerals in the gastrointestinal tract.

- The size of affected habitat in both the EFA and OCA is small relative to the home ranges of ecological receptors, in particular predators and large herbivores. Because these individuals will spend only a portion of their time in the affected areas, the frequency, magnitude, and duration of potential exposure are likely to be low.

- Food web models developed using species-specific screening criteria and conservative exposure assumptions regarding lead bioavailability and bioaccumulation indicate that soil lead concentrations in the OCA do not represent a significant population-level risk to ecological receptors. However, a limited number of individual organisms of receptors with small home ranges restricted to the deltaic area, such as short-tailed shrews or white-footed mice, could potentially be affected by lead concentrations as food web exposure models indicate hazard quotients above unity.

- The absence of stressed vegetation noted in both the EFA and the OCA during field reconnaissance surveys provides a qualitative line-of-evidence to suggest that elevated lead concentrations in soil and sediments in these habitats are not phytotoxic, although Site-specific phytotoxicity data are not available. In addition, the bioavailability of lead in soils to plants, and hence to plant-eating mammals, is expected to be low because lead does not readily translocate to plants.

- Toxicity testing indicates that lead concentrations up to 3,180 mg/kg in sediment have no adverse effects on growth or survival of two invertebrate species, *Hyalella azteca* and *Chironomus tentans*.

Introduction

This Phase I ecological assessment (Phase I EA) was conducted to evaluate the likelihood of adverse ecological effects associated with potential chemicals of interest (PCoIs) at the Thomson Consumer Electronics facility (the Site).

Objectives

This Phase I EA was conducted on the Site and in offsite ecological habitats potentially influenced by transport of PCoIs from the Site. The objective of the assessment was to evaluate potential adverse effects of PCoIs on selected populations of plants and animals, to determine whether PCoIs in environmental media may pose a significant risk to ecological receptors to the extent that a Phase II EA is warranted. The Phase I EA evaluated the quality and extent of ecological habitats, the potential occurrence of ecological receptor species, potential exposure pathways, and toxicity of lead in sediments of the OCA.

General Approach

The approach of this Phase I EA is consistent with the format outlined in Attachment A (Generic Statement of Work) of the January 19, 1994, Administrative Order on Consent (OEPA 1994). This chapter is organized into the following sections: Site characterization, toxicity assessment, and preliminary ecological assessment.

The Phase I EA is primarily based on qualitative and quantitative field surveys conducted during 1992 and 1997, and previous historical and remedial investigation sampling efforts. The assessment is supplemented by a review of the natural history literature for central Ohio. Additional information, including the following, was also considered:

- Life history information for potential ecological receptors
- Home range of the receptors in relation to the size of area(s) with elevated concentrations of PCoIs.
- Use designations of specific habitats (OAC 3745-1-09)
- Location of PCoIs in environmental media
- Toxicity of PCoIs.

The following field surveys were conducted during the Phase I EA:

- Site survey and collection of aquatic macroinvertebrates from the South Ditch and Offsite Creek Area (OCA) by PTI Environmental Services (PTI) personnel on March 10–11, 1992

- Floral and faunal survey of the OCA by PTI personnel from May 19–21, 1992
- Floral survey of the OCA on September 26, 1992, by Dr. Michael Vincent, botanist at Miami University
- Site survey of the East Swale, East Fenced Area (EFA), and South Ditch by PTI personnel from August 17–18, 1997
- Site survey of the OCA by PTI personnel on October 15, 1997.

A conceptual site model was developed incorporating information from all available data sources (Figure G-1). This includes the Site surveys in 1992 and 1997, a floral survey of the OCA by Dr. Michael Vincent (Vincent 1992, pers. comm.), and PCoI data generated during historical and remedial investigation sampling events (PTI 1995). These data are used to identify potential exposure pathways to receptor species. The exposure assessment is based on Site-specific concentration data for PCoIs in environmental media and considers the expected bioavailability of PCoIs at the Site. The identification of receptors and exposure pathways is used to develop a qualitative assessment of the potential for adverse effects on selected receptor species. In addition to the exposure factors listed above, the Phase I EA considers the likelihood that significant populations of the receptors will occur in the affected habitats (i.e., the potential density of receptors in affected areas).

Site Characterization

Site Background and History

A complete description of the Thomson facility and former operations is presented in the remedial investigation and feasibility study (RI/FS) work plan (PTI 1995) and in Sections 1 and 3 of this report. The descriptions include the facility layout, manufacturing processes, waste management practices, geology and hydrology, and a summary of relevant Site investigations.

Field Reconnaissance Surveys

During three field surveys conducted in 1992, species of birds, small mammals, benthic macroinvertebrates, and terrestrial vegetation occurring on the Site were identified through field observations and/or qualitative sampling efforts. Additional surveys were conducted in August and October 1997 to evaluate current conditions, note any significant changes in habitat, and review the conclusions of the preliminary Phase I EA made following the 1992 surveys.

The first field survey was conducted on March 10 and 11, 1992, by PTI personnel. Areas evaluated in the field survey included the South Ditch and the OCA. Three survey stations were placed in the South Ditch to collect benthic macroinvertebrates and to record observations of vegetation and wildlife in the vicinity of the sampling stations. Two of the three stations in the South Ditch and a station located in the spur ditch (i.e., draining the cropfield adjacent to the South Ditch) all contained aquatic macroinvertebrates (e.g., molluscs).

In addition, two survey stations were placed in the offsite creek channel of the OCA. A limited assemblage of crustaceans and other macroinvertebrates were identified at the station located in the vicinity of the remnant beaver pond. The station placed downstream of the treatment plant outfall from the Earnhart Hill Water District (EHWD) yielded only large, red chironomid larvae, which are characteristic of sewage-contaminated or organically enriched sediments in streams.

A second ecological survey was performed at the Site on May 19–21, 1992, by PTI personnel. The focus of this survey was to conduct a general floral and faunal survey of the Site and the marsh habitat on the OCA. Vertebrate species identified from the OCA during this survey are listed in Table G-1.

A third ecological survey in 1992 (September 26, 1992) was a formal plant survey by Dr. Michael Vincent, a botanist from Miami University of Ohio. The objective of the survey was to confirm the presence of any rare, threatened, or endangered plants in the OCA. Dr. Vincent identified 120 species during the survey (Table G-2); none of the species are considered rare, endangered, or threatened in Ohio.

On August 17 and 18, 1997, an ecological habitat survey of the East Swale, EFA, and South Ditch was conducted by PTI. The survey occurred during a week when major storm fronts passed through the central Ohio area. Water levels in the South Ditch were elevated above

normal conditions (Davis 1997, pers. comm.; Mack 1997, pers. comm.). Severe flooding in the Scioto River watershed resulted in the OCA being submerged beneath approximately 8 to 10 ft of water; thus, no survey of the OCA was conducted at this time.

The final habitat survey was conducted on October 15, 1997. The survey focused on terrestrial habitats immediately southeast of the EFA and both terrestrial and aquatic habitats in the OCA. Results of the 1992 and 1997 surveys are discussed further in the following sections.

East Swale

The East Swale is a shallow intermittent drainage ditch about 600 ft in length, located immediately east of the main plant site. Historically, the East Swale functioned in the collection of storm water runoff from the Site. Prior to 1990, this storm water was discharged directly from the East Swale into the South Ditch. From 1990 until plant closure, storm water runoff was diverted from the East Swale to the wastewater treatment plant (WWTP) where the runoff was treated prior to discharge into the South Ditch. Thus, storm water runoff collected by the East Swale was regulated under a National Pollutant Discharge Elimination System (NPDES) permit.

The swale is typically dry and vegetated with terrestrial grasses, forbs, and a few willows (*Salix* sp.) No substantial riparian habitat occurs in or adjacent to the swale and the East Swale was dry (typical condition for the swale) during both the August and October Site surveys in 1997. The total areal extent probably does not exceed 0.3 acres. The East Swale is adjacent to a portion of the facility where cullet and raw materials were formerly handled. Woodchuck burrows were common throughout the swale, although most burrow entrances were inactive and no groundhogs were observed in 1997. The proximity of the East Swale to the constant industrial activity at this portion of the facility, the history of past disturbance, and small size and lack of suitable habitat support the conclusions that the East Swale is poor-quality wildlife habitat. This area is not considered further in this Phase I EA.

East Fenced Area

The EFA, located immediately to the east of the main plant, is an idle, mid-successional grassland habitat of approximately 5 acres. The area is enclosed by an 8-ft chainlink security fence. During the 1970s, glass polishing and grinding fines were pumped from lagoons to three "sludge pits" in the central portion of what is now the EFA. The sludge pits were covered in October 1980 with approximately 2 ft of soil. Since that time, the vegetation community of the EFA has developed into a relatively diverse mixture of grasses, wildflowers, and weedy herbaceous species typical of successional habitats or "oldfields" in the region. Teasel (*Dipsacus* sp.) covers a significant portion of the EFA. A few saplings and young trees are present, mostly cottonwood (*Populus deltoides*) and maple (*Acer* sp.)

Eastern cottontails (*Sylvilagus floridanus*) and woodchucks (i.e., groundhogs) (*Marmota monax*) have previously been reported excavating soil and sludge material during burrowing activities. Numerous inactive burrow systems were observed on the EFA during the Site survey in August 1997, but no rabbits, groundhogs, or active burrow systems were observed. Both the

woodchuck and eastern cottontail may occur onsite, based on the presence of burrows and scat. However, the significant exposure pathways (i.e., food ingestion and incidental soil ingestion) for both woodchuck and rabbits are covered by the selection of the white-footed mouse (*Peromyscus leucopus*), which is a more conservative choice for receptor. Both woodchuck and rabbits are vegetarian, consuming aboveground vegetative plant parts and roots. As plants do not readily accumulate lead (Marten and Hammond 1966; Zimdahl and Arvik 1973; Karamanos et al. 1976; Lindsay and Bookhout 1978; Chambers and Sidle 1991; PTI 1996), food ingestion is not considered to be a major exposure pathway for these species. Although the white-footed mouse also consumes vegetation, terrestrial insects can also be a major component of the diet. As terrestrial insects may bioaccumulate PCoIs more than vegetative plant parts, the white-footed mouse is considered the more conservative choice for an ecological receptor. Also, white-footed mice are prey for higher trophic level receptors (i.e., the coyote, raccoon, and American kestrel), whereas woodchucks and rabbits are less commonly found in the diet of larger predators that may occur on the EFA or OCA (e.g., Sherrod 1978; Mumford and Whitaker 1982).

The most likely mammalian receptor species on the EFA is the white-footed mouse or the deer mouse (*Peromyscus maniculatus*). These species are widespread in habitats across Ohio and are typical of wooded and grassland habitats, respectively. Both species would be considered permanent residents and are assessed to be present. Access to the EFA by larger-bodied terrestrial animals is limited by the chainlink fence surrounding the EFA. From a landscape perspective, small mammals on the EFA are relatively isolated from populations in similar oldfield habitats of the area by agricultural fields to the north and south, the vacant, unvegetated location of the former Thomson facility to the west, and the South Ditch, railroad grade, and wooded habitat to the east.

Avian receptors that may occur on the EFA during the breeding season include such species as the field sparrow (*Spizella pusilla*), vesper sparrow (*Pooecetes gramineus*), and song sparrow (*Melospiza melodia*). These species of birds are predominantly granivorous and frugivorous. While some of these species forage opportunistically on insects, they typically glean insects from vegetation or forage on relatively mobile above ground insects (e.g., grasshoppers, caterpillars, moths, butterflies, beetles) rather than probing for subsurface insects such as earthworms. Ingestion of PCoIs in food items by these avian receptors is unlikely to be a significant exposure pathway as these food items are not expected to substantially accumulate lead. As mentioned previously, plants do not readily take up lead and most of the insects feed on vegetation, minimizing or eliminating any substantial contact with the surface soil.

The receptor species that occur on the EFA likely do not maintain substantial populations as the areal extent of the habitat is small and the EFA is relatively isolated from similar habitats in the landscape. For example, Mumford and Whitaker (1982) estimate the home range of a deer mouse at 0.5 to 1.5 acres, suggesting the number of *Peromyscus* on the EFA may not exceed 3 to 10 individuals, assuming exclusive home ranges. Best (1977) reports an average territory size of 1.9 acres for field sparrows during the breeding season, varying from 0.7 to 4 acres. Based on these territory estimates, the EFA may only support two or three breeding pairs of field sparrows. Best (1977) also notes that the larger home ranges reported are typically associated with song sparrows nesting in more open grassland habitats.

Winter residents on the EFA may include such species as the American tree sparrow (*Spizella arborea*), chipping sparrow (*Spizella passerina*), white-throated sparrow (*Zonotrichia albicollis*), and dark-eyed junco (*Junco hyemalis*). Winter residents are expected to have low exposures as the ground is frozen and typically covered with snow during this season. The winter diet of these species is almost exclusively seeds, fruits, and tree buds, which are not known to bioaccumulate metals to any significant extent (Lindsay and Bookhout 1978; Chambers and Sidle 1991; PTI 1996). Thus, food ingestion of PCoIs is unlikely to be a significant exposure pathway for winter residents.

The habitat to the east and south of the EFA totals about 3 acres in size. About half the habitat is second growth maples (*Acer* sp.) and cottonwood (*Populus deltoides*) and the remainder of the habitat is dense berry thickets (i.e., *Rubus* sp.) and mid-successional grasses and forbs. Ground structure (i.e., rocks, fallen tree trunks and limbs) in both habitat types is uncommon and within the woods, understory vegetation is sparse. The mammalian receptor most likely to occur in this area is the white-footed mouse, which is expected to be a resident species.

Based on the habitat types present, avian receptors may include such bird species as the eastern towhee (*Pipilo erythrophthalmus*), brown thrasher (*Toxostoma rufum*), wood thrush (*Hylocichla mustelina*), gray catbird (*Dumetella carolinensis*), red-eyed vireo (*Vireo olivaceus*), and northern cardinal (*Cardinalis cardinalis*). Several of these species are present only during the breeding season and thus potential exposure only occurs during part of the year. Resident species would include the eastern towhee and northern cardinal.

Most of these avian receptors are omnivores, foraging on seeds, fruits, and berries during winter and on terrestrial insects during the summer months (i.e., the breeding season). Those species that forage seasonally on terrestrial invertebrates typically glean insects from vegetation or forage on aboveground insects such as grasshoppers, caterpillar larvae, cicadas, and spiders. Some species may forage on ground beetles and the wood thrush also forages on earthworms. However, these habitats are small in areal extent and the birds are territorial; thus, it is unlikely that any significant population of these birds would be found in these areas during the breeding season. Considering the diet of these species, exposure is expected to be low. Seeds and fruits typically have low metals concentrations, as do the more mobile terrestrial insects (e.g., grasshoppers) (PTI 1996).

The EFA potentially affords a limited amount of natural habitat for some mammalian and avian receptors. As future site usage for the developed portion of the Site adjacent to the EFA will remain consistent with current use (i.e., commercial/industrial), it is unlikely that extent or quality of natural habitat or receptors present on the EFA will differ substantially in future from current conditions, as described above. The EFA will be discussed further in subsequent portions of this Phase I EA.

South Ditch

The South Ditch is an industrial wastewater drainage channel that flows along the southern portion of the Site. The channel is straight with no meanders; the surface of the channel ranges from less than 3 ft to 9 ft below the level of the top of the ditch bank. During 1992, a small riparian zone was noted along the banks of the South Ditch, in addition to a narrow buffer zone

between the South Ditch and the surrounding agricultural fields. However, current management practices have removed all the vegetation from the embankments and nearly all the emergent vascular plants from the South Ditch channel. These management practices include herbicide spraying and mowing of the herbaceous and woody vegetation (Kinnamon 1997, pers. comm.). The patches of cattails observed along the South Ditch in 1992 were absent in 1997. Emergent aquatic vegetation, primarily rush, was found only in small isolated patches. Most of the upstream channel was covered with dense mats of submerged aquatic plants and algae, with only 1 to 3 in. of standing water. Submerged vegetation is less common further downstream as stream flow increases.

Muskrat burrows identified in 1992 were not present in 1997. Numerous groundhog burrow systems were noted near the tops of the embankments along the South Ditch in 1997. All were inactive and many were collapsing. Collapse of the burrow systems appeared related to the removal of the ground cover by spraying and mowing, which has also increased bank erosion into the stream channel.

In general, both wildlife and wildlife habitat were sparse along the South Ditch. Frogs were fairly common along the upper reaches of the South Ditch, typically found in the terrestrial habitat along the embankments within 1 to 6 ft of the channel. The ants and adult midges observed in the "shoreline" grasses during 1992 were not present, likely the result of the current vegetation control practices on the South Ditch. An employee of the Thomson facility reported a turtle in the South Ditch in 1992; however, no turtles were observed during either Site survey in 1997. The shallowness of the channel and the lack of habitat structure (i.e., no downed tree limbs, branches, or rocks) suggest turtles would not be expected be occur in this habitat. PTI personnel noted minnows in the South Ditch during the 1992 Site surveys; however, none were observed in 1997. A small group of fish, possibly a cyprinid species, was observed in a pool during the 1997 survey, where the storm water outfall from the facility enters the South Ditch. These were the only fish observed in the South Ditch.

At the time of plant operation, the major sources of water for the South Ditch were the NPDES permitted outfalls from the facility's WWTP and shallow groundwater recharge to the ditch. This WWTP was in operation from the early 1980s (see Section 1.2.2, *Wastewater Treatment*). During the operating period of the facility, its (relocated) Outfall 001 discharged about 1 million gal per day (gpd) of treated effluent under a revised NPDES permit. Two outfalls located upstream on the South Ditch (i.e., Outfalls 002 and 003) discharged a combined flow rate of approximately 800 gpd. Surface water in the South Ditch should not pose an ecological risk to receptor populations that may occur. This conclusion is supported by surface water sampling results discussed previously in this report. With the cessation of Thomson's industrial activities at the Site, the NPDES discharge to the South Ditch could be reduced or terminated, depending on future re-development plans for the property. Reduced discharges would result in a lower water level in the ditch, with a corresponding overall decrease in quality of the ditch habitat from the conditions described above.

In summary, the habitat quality in and adjacent to the South Ditch was considered poor in 1992 and, based on observations made during the 1997 Site surveys, habitat is still considered poor quality for wildlife due to its structure and management practices. Habitat quality in the South

Ditch is not considered likely to improve under anticipated future use scenarios. The South Ditch is not considered further in this Phase I EA.

Offsite Creek Area

The OCA includes the downstream and offsite extension of the South Ditch channel (i.e., downstream of U.S. Route 23). The OCA begins on the west side of the U.S. Route 23 overpass and continues approximately 4,000 ft downstream to the Scioto River. General habitat features of the OCA are presented on Figure 4-6. These features include the offsite creek, the farm ditch, a triangular-shaped habitat area referred to as the "deltaic area" (see Section 4), and associated overbank areas. The deltaic area is less than 2 acres in extent and historically received sediment deposition from the offsite creek and sediment deposition during major flood events on the Scioto River. Overbank areas (Figure 4-6) are depositional areas associated with the channels adjacent to the offsite creek and the farm ditch (i.e., areas principally downstream of the deltaic area).

From the culvert beneath U.S. Route 23, the offsite creek meanders in an incised channel through a steeply banked, wooded area to a culvert beneath a railroad grade. This section of the drainage upstream of the railroad culvert is currently referred to as the upper creek portion of the OCA. Beyond the railroad grade, the offsite creek continues flowing in a well-defined channel for approximately 150 ft. At this point the stream gradient decreases and the channel bifurcates into multiple small, narrow, incised channels flowing through the deltaic area. These channels flow in both a northwest and southwest direction. The northwest-flowing channels pass through a cut in the farm ditch about 400 ft north of the deltaic area. Channels flowing southwest through the deltaic area pass through a second cut in the farm ditch embankment approximately 600 ft to the south of the deltaic area. The channels flowing to the south also receive runoff from the Logan Elm residential area. In addition, surface flow from the surrounding wooded embankments of the OCA flow through several trash disposal areas (below the EHWD water treatment plant).

The farm ditch receives runoff from the agricultural field west of the OCA (planted to corn in 1992, soybeans in 1997) and storm water runoff from residential and commercial properties at the south end of Circleville (i.e., north of the OCA). The current farm ditch was formed in 1979 to the north and west of an older abandoned channel to improve drainage of the farm field. The farm ditch is periodically dredged by the landowner to maintain flow, with the excavated material placed largely on the eastern side of the ditch, creating a small levee that generally restricts flow within the ditch extending through the OCA to the Scioto River.

One objective of the remedial investigation sampling was to evaluate whether any of the more recent modifications to the farm ditch (e.g., from the maintenance activities described above), or other physical processes occurring along the farm ditch, had significantly changed the distribution or transport of lead-bearing particulates since the early sampling at the OCA. As noted above, the farm ditch has been dredged routinely in the past for maintenance purposes, and was subject to additional modifications by the offsite farmer, most recently to construct a large dike and floodgate near the confluence of the farm ditch with the Scioto River in an area downstream from the affected soils/sediments at the OCA (Figure 4-5). While these most recent

modifications were new developments since the work plan was prepared, these modifications were completed prior to the remedial investigation sampling activities and results presented in this report. As described in Section 4.6.2 of the report, sampling within and along the ditch transects has shown that lead concentrations in this area are very similar where sampled upstream and downstream from the deltaic region below the railroad tracks where particulates with higher lead concentrations have settled. Also as described in Section 4.6.3 for the surface water sampling, both dissolved and total lead concentrations in the ditch water are well below Ohio water quality standards for the protection of aquatic organisms. These data collectively indicate that the routine maintenance activities by the farmer are not of concern and they have not significantly affected the transport of lead-bearing particulates downstream to the Scioto River.

The OCA has historically been influenced by beaver activity, where beavers periodically constructed dams on the farm ditch. However, the local farmer presently removes all beaver structures to maintain adequate drainage from his field. The 1992 field surveys reported that the beaver dam had been removed prior to the May 1992 surveys and there was no evidence during the 1997 Site survey, or subsequent field investigation activities, that beavers returned to the area.

Removal of the beaver dam prior to the 1992 field surveys has resulted in a general drying of portions of the marsh area and a change in the both the habitat conditions and vegetation community. During the 1992 Site surveys, the deltaic area was characterized by wet, black, fine-textured sediments supporting a vegetation community of wet meadow grasses and cattails (*Typha* spp.). PTI ecologists noted that the area between the north and south branches and the farm drainage ditch previously described as a cattail marsh (PTI 1995) had dried up considerably to a wet meadow following removal of the beaver dam. During the 1997 Site surveys, soils were found to be damp to dry, lacking the fine, black texture described previously for the cattail area. No standing water was found in this area except in the numerous small, narrow, and incised (8 to 14 in.) channels that bisect the deltaic area. Current conditions no longer include discharges of non-contact cooling water from the Thomson facility. However, the area remains a heavily vegetated wetland area that receives surface water drainage from the surrounding area and conveys that drainage to the Scioto River. It is also subject to intermittent inundation associated with various precipitation events. No cattail or wet meadow community is present; instead, the vegetation has been replaced by a monotypic stand of sedges. While it is likely that the soils/sediments contain the resources (i.e., seedbank) necessary to reestablish the cattail community; this is unlikely to occur unless beavers recolonize the area and soils of the deltaic area become more frequently inundated. Thus, the ecological fate of the cattail community on the OCA is determined by physical factors (i.e., the presence or absence of beaver) rather than chemical factors.

The aquatic ecosystem of the OCA was not originally included in the Phase I EA for several reasons. The Ohio Environmental Protection Agency (OEPA) has designated the offsite creek (also referred to as the "RCA Tributary") as a "limited resource water" (OAC 3745-1-09). By this designation, OEPA has determined that the aquatic habitat in the offsite creek and farm ditch is poor and will remain in poor condition, due in part to the periodic need to dredge the farm channel to maintain drainage of the field and runoff from upstream urban areas. This designation also reflects the fact that the offsite creek and farm ditch receive discharges from

multiple sources unrelated to the Site including storm water runoff from commercial and residential areas, agricultural runoff, and sewage treatment plant effluent. However, in the interim between initial drafting of the ERA and present, OEPA has standardized ERA procedures (OEPA 2003) to use for site evaluations and provided guidance on acceptable methods for evaluating aquatic ecosystems. One accepted method is the evaluation of sediments by use of bioassays. In consideration of the new ERA guidance and because the Respondents do not control the future land use of the OCA, OEPA requested that toxicity of sediments be evaluated by bioassays to provide another line of evidence for evaluating the OCA. The procedures for, and results of, the bioassays are described in detail later in this appendix.

The offsite creek and farm ditch were also used for the transport of NPDES-permitted discharge from the Thomson facility and the EHWD sewage treatment plant. When operating, the Thomson facility was permitted to discharge 1.08 million gpd of treated effluent with lead concentrations up to 116 μg/L daily maximum and 58 μg/L 30-day average. The RCA Tributary and farm ditch also receive storm water runoff from residential and commercial areas of the City of Circleville and from the Logan Elm Village residential area located south of the Thomson plant, as mentioned above.

A diversity of plants, birds, and mammals have been observed in the OCA by employees of the EHWD sewage treatment plant during past years. Personnel have observed white-tailed deer (*Odocoileus virginianus*), beaver, woodchuck, muskrat, and coyote in the OCA. Twenty-three species of birds were noted during the May 19–21, 1992, field surveys by PTI and 120 plant species were identified in the OCA by Dr. Michael Vincent. In 1992, a remnant beaver pond, which has since been removed, supported a limited assemblage of benthic macroinvertebrates.

The OCA riparian corridor is largely surrounded by undeveloped lands, particularly the region to the west of the railroad tracks where the offsite creek drainage drops abruptly to the floodplain of the Scioto River. The terraced upland area west of Highway 23 and north and south of the offsite creek consists of undeveloped fields and some commercially developed lands. The westernmost upland area north of the offsite creek also includes some lands proposed for future residential development, although such development may be restricted due to the limited access points available to cross the railroad tracks in this area. West of the railroad tracks to the south, the OCA is bordered by undeveloped lands owned by the EHWD. With the exception of a small water treatment plant and associated infrastructure (accessible only from the south), this area consists of open fields and partially forested areas on rolling terraced uplands approximately 40–50 ft above the OCA corridor. A steep embankment separates these terraced uplands from the OCA along its southern border. North of this area, the OCA is bordered by extensive agricultural fields in the low-lying floodplain between the Scioto River (to west and north) and the terraced uplands north of the offsite creek described above.

Selection of Areas for Ecological Assessment

Based on the data collected and field observations during the Site reconnaissance surveys, the EFA and OCA are the focus of this Phase I EA. These two areas are the largest landscape blocks of natural habitat associated with the Site. The EFA is a xeric mid-successional upland

dominated by grasses and forbs. The OCA is composed of three distinct habitat types: hardwood forest, creek/ditch channels, and the deltaic area. The upper creek, deltaic area and portions of the offsite creek and overbank areas are the only potentially affected habitats at the OCA based on elevated lead concentrations identified during historical and remedial investigation sampling data. The remainder of the Phase I EA of the OCA will focus only on the upper creek, deltaic area, and selected overbank areas.

The OCA is subjected to several types of periodic or seasonal physical disturbances (i.e., stressors) that are unrelated to the Site. These stressors include the following:

- Frequent flooding of significant portions of the OCA from the Scioto River (largely backwater/eddy effect)
- Routine maintenance of the farm ditch (e.g., removal of any flow-inhibiting debris)
- Storm water runoff from residential and commercial areas
- Agricultural runoff into the farm drainage ditch
- Outfall from the sewage treatment facility
- Historical (and possibly current) dumping of solid waste (i.e., trash) in the hardwood forest habitat of the OCA.

The exposure of aquatic organisms in the OCA channels is not considered in this Phase I EA. The primary reasons for excluding aquatic habitats are the "limited resource water designation" by OEPA (discussed previously), lack of any significant fisheries, and the physical barrier to upstream fish movement. Specifically, the landowner of the agricultural field has constructed a large earthen flood-control embankment across the farm ditch about 300 ft upstream of the Scioto River. The construction of the embankment includes a culvert connecting the upstream and downstream portions of the farm ditch, with the downstream end of the culvert raised about 2 ft above the water level (as observed in October 1997). The downstream end of the culvert is also partially sealed by a steel door (i.e., flood gate) hinged to close as the water in the Scioto River backs up into the ditch. This barrier appears effective in preventing any potential upstream movement of fish except during major flood events when the entire area may become inundated from river flooding.

In addition, the aquatic habitat in some locations is severely disturbed. For example, the segment of the farm ditch near the EHWD sewage treatment plant outfall has been modified and currently has steep bare-soil banks and a straightened channel. The only macroinvertebrates found in sieved sediment from this portion of the farm ditch were large, red chironomid larvae, which are characteristic of sewage-contaminated or organically enriched sediments. In other portions of the farm ditch, biological surveys revealed an assemblage of species that included crayfish (Crustacea: Decapoda), scuds (Crustacea: Amphipoda), sow-bugs (Crustacea: Isopoda), midge fly larvae (Diptera: Chironomidae), crane fly larvae (Diptera: Tipulidae), snails (Mollusca, *Physa* sp., *Gyraulus* sp.), leech (Annelida: Hirudinea), and nematode worms

(Nematoda). Sediment toxicity bioassays, discussed later in this appendix, provide information that can be used to evaluate the potential for adverse effects to benthic invertebrates.

Selection of Potential Chemicals of Interest

The list of PCoIs considered during the Phase I EA was determined by reviewing historical and current information regarding raw materials and process chemicals used in the manufacturing process and sampling results from environmental investigations at the Site. The selection of PCoIs was initially conducted and presented in the work plan (PTI 1995) and subsequently reviewed during development of this remedial investigation report. No PCoIs were added to the previously developed list for the areas of interest (i.e., EFA and OCA). The list of PCoIs for the areas of interest includes antimony, arsenic, barium, chromium, lead, nickel, hydrogen fluoride (fluoride), and total petroleum hydrocarbons (as TPH).

Forms of Potential Chemicals of Interest

All of the PCoIs except TPH occur either in vitrified form (i.e., encapsulated within a glass matrix) or associated with particulates by precipitation of insoluble forms or by adsorption to iron and aluminum oxides, clays, and organic material. As described previously in Section 5 (*Transport and Fate of PCoIs*), migration of the PCoIs is limited to sediment transport of particulates.

The nonvitrified forms of PCoIs will interact with surrounding media to varying degrees based on their physical and chemical properties and the geochemical characteristics of the environmental media. However, the properties of the environmental media indicate that the nonvitrified PCoIs are strongly bound in Site soil particles and organic matter and that their mobility is also generally limited to physical transport as particulates. This characterization is strongly supported by existing sampling data for the Site, which show strong immobilization of PCoIs in shallow soil and sediment and limited or no effect on groundwater concentration for the PCoIs (Section 5). The environmental chemistry of the PCoIs is presented in considerable detail in the work plan (PTI 1995).

Distribution of Potential Chemicals of Interest

The nature and extent of PCoIs in Site media are presented in Section 4, *Nature and Extent of Contamination*, and the transport and fate of the PCoIs are discussed in Section 5, *Transport and Fate of PCoIs*.

Selection of Chemicals of Interest

Based on the Site history and operations, historical and remedial investigation sampling results, analyses regarding the transport and fate of PCoIs, and prior remedial investigation scoping discussions with OEPA, lead remains the proposed CoI for subsequent ecological considerations at the EFA and OCA. Based on these data and the specific Site conditions and factors

controlling potential exposures to ecological receptors, the other PCoIs are expected to contribute insignificantly to risk estimates in these areas.

For the EFA, substantially elevated PCoIs appear restricted to the glass fines (sludges) at depth beneath the soil cover. Thus, potential exposure by receptors to these sludges is minimized or eliminated. Based on sample results from surrounding soils, lead is the only PCoI which appears moderately elevated above background levels. This is consistent with all historical and remedial investigation data where the other PCoIs are found at substantial concentrations only where lead is significantly elevated. Sampling results and transport and fate discussions presented in this document and in Sections 4 and 5 of the report also demonstrate that the PCoIs in the sludges, including lead, are not migrating in the subsurface and affecting surrounding media or other potential ecological receptors in the vicinity; this conclusion also applies to the OCA where sampling results indicate that further migration from the primary affected area is not occurring to any significant degree. Receptors could potentially be exposed to lead present in surface soils. The limited areal extent of the EFA will, however, limit the use of the area by receptors, as it is small relative to their home ranges. For wide-ranging species, such as the upper trophic level terrestrial receptors, the fence surrounding the EFA also restricts their use of the area. The area may provide habitat for some small mammal species typically associated with oldfield habitats, but because only a few individual home ranges could potentially be contained within the EFA, the likelihood of population-level effects is minimal.

For the OCA, lead is the predominant PCoI found at substantially elevated concentrations and lead has been the focus of remedial investigation sampling to evaluate potential impacts from the former facility operations. This is in part due to the predominance of lead detections, and the many other potential sources contributing metals to the OCA, including runoff from roadways, railway and residential and commercial developments, as well as sewage treatment discharges and localized garbage dumping in portions of the OCA. As described previously in this remedial investigation report, the locations where lead is substantially elevated are generally well defined and are limited in area compared to the size of the OCA and the home range of most potential ecological receptors. For wider-ranging, upper trophic level species, the habitat is small relative to the areas they use. Therefore, exposure is not likely to be significant, as individuals will spend, at most, only a small portion of their foraging time within this habitat. The deltaic area is also frequently inundated due to flooding from the Scioto River, which alters the overall habitat quality, limits the time when the habitat can be occupied by receptors, and reduces any viable populations of receptors potentially exposed. This is particularly important with regard to those receptors with small home ranges (e.g., small mammals), as it minimizes exposure of individuals, and thus, the likelihood of adverse population-level effects. Based on field surveys conducted, this area at the OCA does not show signs of other stresses that might be considered chemically related. Based on all available information, ecological considerations focused on lead are believed to be appropriate in relation to the former operations and discharges from the Thomson facility.

Identification of Potential Ecological Receptors

Ecological receptors identified in the EFA and the OCA are presented in Table G-3 An initial list of possible receptors was developed from data collected during 1992 Site investigations

(Tables G-1 and G-2) and a review of the literature on species distributions in Ohio. This list was reviewed and revised based on habitat observations made during the 1997 Site surveys. From this initial list of possible ecological receptors, 10 species were selected to represent the most relevant exposure pathways likely to occur in the EFA and OCA.

Plant species present at the OCA are listed in Table G-2. Significant factors considered during the selection of ecological receptors include the following:

- Importance to the ecological community (e.g., abundance, biomass, key prey or predator species)
- Regulatory status (e.g., threatened or endangered species, state or federal)
- Home range size relative to extent of areas with elevated lead concentrations
- Relevance to beneficial human use (e.g., aesthetic viewing, recreational hunting or trapping).

Several receptors that are potentially ecologically important were considered in the preliminary assessment completed following the 1992 Site surveys. For this final assessment, these same receptors were re-evaluated with the addition of a new terrestrial receptor, the white-footed mouse (*Peromyscus leucopus*). The receptors, and their corresponding trophic levels, are as follows:

- Primary producer (cattail, *Typha* spp.)
- Aquatic mammalian herbivore (muskrat, *Ondatra zibethicus*)
- Small mammalian predator (northern short-tailed shrew, *Blarina brevicauda*)
- Small mammalian omnivore (white-footed mouse)
- Large mammalian omnivore (raccoon, *Procyon lotor*)
- Large mammalian predator (coyote, *Canis latrans*)
- State endangered songbird (dark-eyed junco, *Junco hyemalis*)
- Avian omnivore (American robin, *Turdus migratorius*)
- Avian predator (American kestrel, *Falco sparverius*)
- Omnivorous waterfowl (wood duck, *Aix sponsa*).

According to data received from the Ohio Department of Natural Resources, Division of Wildlife, only one species classified as endangered by the state has been identified within a 10-mile radius of the Site. This species is the dark-eyed junco (*Junco hyemalis*). There are no federally-listed threatened or endangered species identified in the area.

No recreational fisheries or significant hunting areas exist at the OCA. Although limited deer hunting may occur at the OCA, deer were not included as ecological receptors because of the limited potential for exposure through their food supply and their large home range size. Hesselton and Hesselton (1982) report high deer densities of nine deer per 247 acres, or 1 deer for every 27 acres. Deer are herbivores that consume aboveground vegetation and mast, and frequently forage on agricultural crops such as corn and soybeans. As discussed in later sections of this document, terrestrial and riparian plants do not readily take up lead and elevated CoI concentrations are not expected in the agricultural fields. Thus, the potential for exposure of deer to lead through this pathway is considered insignificant.

The plant and animal species considered potential ecological receptors for the EFA and OCA, and the rationale for their selection, are discussed below.

Cattail

Cattail is an aquatic vascular plant characteristic of many freshwater wetlands, in particular pond and marsh habitats in the midwestern United States. The cattail was initially selected as a potential ecological receptor as cattail has historically been present in portions of the deltaic area of the OCA and is an important food resource for muskrats. Stands of cattails may also provide cover to various waterfowl and wading birds. Cattail stands attenuate the effects of floods and produce organic matter that functions to adsorb chemicals associated with agricultural (e.g., pesticides, fertilizers) and storm water runoff.

Muskrat

The muskrat is ubiquitous throughout North America and can be found in many types of aquatic habitats, including areas of still or slow-running water with shoreline vegetation, ponds, lakes, and marsh habitats (Willner et al. 1980). The species is often characteristic of wetland habitats with permanent water (Willner et al. 1980; Perry 1982; Proulx and Gilbert 1983). Historically, muskrats have been present in the OCA. Personnel at the EHWD sewage treatment plant have reported muskrat trapping below the facility and old dens occur along the farm ditch embankment.

The home range size of a muskrat is relatively small. U.S. EPA (1993) reports that the average home range size varies from 0.41 to 1 acres. However, muskrats need open water when foraging to provide critical escape routes (Proulx and Gilbert 1983; Lacki et al. 1990) and individuals generally forage within a small (i.e., 5 to 10 m) radius of their lodge or den (Willner et al. 1980). Home range size depends on the areal extent and configuration of the water body in which the animals live. Animals occurring in the center of a marsh typically use a circular home range. Muskrats occupying a shoreline often use a narrow area, at times extending several hundred feet into deeper water (Schwartz and Schwartz 1981). During the breeding season when most animals establish territories, the maximum concentration of muskrats is approximately two pairs per acre. Muskrats are generally nocturnal although during late spring and early summer they are active during the day as well.

Although muskrats consume a variety of plant species in small quantities, they typically concentrate on only one or two plant species (Lacki et al. 1990). In marshy areas of Missouri, the diet consists of cattail (rootstalks and stems), bulrush, and lotus seeds. They also consume terrestrial vegetation such as white clover, corn, and bluegrass. In Ozark streams, muskrats have been known to eat freshwater clams. They also consume small amounts of snails, crayfish, frogs, reptiles, young birds, and muskrat carrion (Schwartz and Schwartz 1981).

Muskrats are prey items for larger mammalian and avian predators. Gates (1972) reports muskrats in the diet of red-tailed hawks (*Buteo jamaicensis*) in Wisconsin and Jackson (1961) and Kurta (1995) report muskrats in the diet of coyotes.

Muskrats were initially selected as a receptor species because they are the only aquatic mammalian herbivore that feeds on aquatic vegetation in close association with sediments. The primary exposure route of muskrats to lead is through feeding on cattails (i.e., tubers and inner core of stalks) and the secondary exposure pathways is the incidental ingestion of sediments (e.g., during foraging and den construction).

Northern Short-Tailed Shrew

The northern short-tailed shrew is found throughout the midwestern United States, typically inhabiting riparian areas with overstory vegetation, but avoiding grassy areas with minimal cover. The species is commonly found occupying the same habitats as the white-footed mouse (*Peromyscus leucopus*). Northern short-tailed shrews may be locally abundant in optimal habitat conditions, which are typically wet soils in mature forest with a thick ground litter and rotted logs and stumps. The species is often absent from other habitat types such as farm fields, pastures, and brushy and weedy fields (Mumford and Whittaker 1982). Northern short-tailed shrews utilize runways of other mammals but will also dig their own tunnels, often beneath rotting logs or rocks (Jackson 1961).

The diet of the northern short-tailed shrew consists primarily of insects, insect larvae, snails, mammals, birds, salamanders, earthworms, and crayfish (Gottschang 1981). Although earthworms are a common diet item, published information on food habitats indicates that earthworms rarely comprise more than 40 percent of the diet (Hamilton 1941; Whitaker and Ferraro 1963; not seen; as cited in U.S. EPA 1993). The diet shifts according to seasonal or periodic availability of food items. For example, Hahus and Smith (1990) report northern short-tailed shrews to shift their foraging to cicadas during a periodic (i.e., 17-year) emergence. Short-tailed shrews generally confine their activities to areas of approximately 1 acre and live in densities of 6–8 shrews per acre (Gottschang 1981).

Northern short-tailed shrews are relatively short-lived. Getz (1989) reports that only 1.2 to 2.3 percent of the shrew population survives beyond 6 months of age. In a 13-year study of northern short-tailed shrews in grassland and pasture habitats of Illinois, northern short-tailed shrews were documented to undergo annual cycles of abundance; at times, local populations may all but disappear (Getz 1989). Similar annual fluctuations in populations of the northern short-tailed shrew have been reported by Buckner (1966), Smith et al. (1974), Grant (1976), and Yahner (1983). The reason for the population cycles is not yet understood.

The northern short-tailed shrew was initially chosen as an ecological receptor species because its diet consists primarily of terrestrial invertebrates that may potentially accumulate PCoIs. Northern short-tailed shrews are closely associated with the surface soil horizon, constructing and utilizing shallow burrows beneath rocks and logs, and occupying tunnels and burrow systems constructed by other animals such as rabbits and woodchucks. Although the northern short-tailed shrew is a prey item of several higher-trophic-level species (e.g., raptors), shrews are usually a minor component of these diets (Sherrod 1978). Northern short-tailed shrews comprise only a very minor portion of the diet of the American kestrel (Sherrod 1978).

The primary exposure route for the northern short-tailed shrew is the food ingestion pathway, with incidental soil ingestion a secondary exposure pathway. The inhalation and dermal contact pathways are not considered significant. The water ingestion pathway also is considered insignificant as the species does not rely on the availability of free water.

White-Footed Mouse

The white-footed mouse is likely to be the most common small mammal in the Circleville area. The species occupies a wide variety of habitat types, generally being most abundant in wooded habitats with understory structure (i.e., fallen logs, rock outcrops) and less common in open grassland habitats (Lackey et al. 1985). White-footed mice are agile climbers that utilize habitat resources in three dimensions, climbing shrubs and fallen trees and often nesting in tree cavities (Myton 1974; M'Closkey 1975; Graves et al. 1988).

The home range size of white-footed mice is variable, influenced by such factors as food supply, age of the individual, and population density (Stickel 1968). Home range size also varies by season, with the smallest home ranges maintained during the winter months (Lackey et al. 1985). Estimates of the average home range of a white-footed mouse vary from 0.25 acres as reported by Madison (1977) and Lackey et al. (1985) to estimates of 3.11 acres for males and 2.2 acres for females (Mineau and Madison 1977).

Population abundance of white-footed mice can be highly variable. Kaufman et al. (1995) demonstrated nearly an order of magnitude change within and between years in a population of white-footed mice inhabiting a gallery forest in Kansas. White-footed mice generally do not live more than 1 year. Schug et al. (1991) reported that only 2.3 percent of the population survives more than 345 days.

White-footed mice are opportunistic omnivores. The annual diet consists primarily of seeds, with aboveground terrestrial invertebrates and berries being of secondary importance. Diet composition generally reflects the seasonal availability of food items (Brown 1964; Mumford and Whitaker 1982). In hardwood forests of Missouri, Brown (1964) reports that seeds comprise 57 to 74 percent of the diet (by volume) of white-footed mice. Madison (1977) found white-footed mice apparently caching nuts, seeds, and the shell fragments of hickory and cherry in day nests. Hahus and Smith (1990) report that white-footed mice opportunistically shifted their diet from predominantly seeds to cicadas during a periodical (i.e., 17-year) emergence.

White-footed mice are prey items for many other vertebrates, including the Virginia opossum (*Dedelphis virginiana*), weasels (*Mustela* spp.), striped skunk (*Mephitis mephitis*), domestic cats

(*Felis catus*) and dogs (*Canis domesticus*), barn owls (*Tyto alba*) and screech owls (*Otus asio*). Sherrod (1978) reports small numbers of white-footed mice in the diet of the American kestrel.

The white-footed mouse has been added as a potential ecological receptor as it is the species most likely to occur on both the EFA and OCA and the prey item from these areas most likely to be consumed by higher level predators (e.g., coyote, American kestrel). The primary route of exposure for the white-footed mouse on both the EFA and OCA is the food ingestion pathway, with incidental ingestion of soils a secondary pathway. The inhalation and dermal contact pathways are not considered significant. The water ingestion pathway also is considered insignificant as the species does not rely on the availability of free water.

Raccoon

The raccoon is widely distributed throughout North America in wooded areas bordering aquatic habitat and is commonly identified as an urban wildlife species. Raccoons typically use relatively small areas within a larger home range, shifting their short-term movements among these smaller areas in response to local factors such as food availability (Johnson 1970). Estimates in the literature of home range size and raccoon density vary considerably and are strongly dependent on habitat quality and extent. For example, on a 2,000-acre wildlife area in Indiana composed of shallow marshes interspersed with wooded ridges and uplands, Lehman (1977) reported an average home range of 50 acres and a density of one raccoon per 1 to 7 acres. On a second study area with permanent water and croplands, floodplain, and timbered areas interspersed, Lehman (1976) reported an average home range of 200 acres and a density of one raccoon per 15 to 45 acres. Gottschang (1981) found that in rural areas, raccoon densities may approach one raccoon for every 30 to 40 acres. Family units (adult females and young) have an average home range of 0.75 mi^2 (360 acres) (Schwartz and Schwartz 1981).

Raccoons are generally nocturnal, but will occasionally come out during the day. The species has an omnivorous diet consisting of both plant and animal foods, in addition to foraging on carrion and garbage (i.e., from local shops and restaurants adjacent to the OCA). The vegetative portion of the diet consists of fruits, nuts, grasses, leaves, seeds, and sedges. Animal matter includes crayfish, clams, fish, insects, amphibians, reptiles, earthworms, eggs (i.e., bird, reptile, amphibian), and small mammals. Adult raccoons are generally at the top of the food chain, but young raccoons may be preyed upon by great horned owls (*Bubo viriginianus*), bobcats (*Lynx rufus*), and coyotes (Schwartz and Schwartz 1981).

Raccoons were selected as a receptor species because of their potential for use of the EFA and OCA as a travel corridor between the agricultural fields near the Site and riparian areas along the Scioto River. The primary exposure route is the food ingestion pathway, secondarily the incidental ingestion of soils and sediment. The inhalation, dermal, and water ingestion pathways are not considered significant. Raccoon use of the OCA has been documented by the observation of tracks.

Coyote

The status of the coyote in Ohio is not well established (Gottschang 1981). Historical sightings of coyote have occurred in the vicinity of the OCA; however, no signs of coyote were observed in either the 1992 or 1997 surveys. Suitable habitat requirements for this species include large areas of mixed farmland and woods.

Coyotes maintain large home ranges and consume a variety of food items. Schwartz and Schwartz (1981) report that coyotes maintain an average home range of 1,900 to 2,500 acres while feeding pups and 16,000 to 22,400 acres at other times of the year. Coyotes dig shallow dens or often enlarge burrows of woodchuck, skunk, or fox during the breeding season (Jackson 1961).

Coyotes are opportunistic omnivores, consuming domestic livestock and fowl, small mammals, rabbits, opossum, small birds, fruits (e.g., persimmon), and agricultural crops such as corn (Schwartz and Schwartz 1981). Of the small mammal species consumed, stomach analyses reported in Mumford and Whitaker (1982) suggest voles (*Microtus* spp.) are the most common prey, although *Peromyscus* spp. also are consumed.

Coyotes were initially selected as a receptor species occupying the top of the mammalian ecological food web. The primary exposure route for the coyote is the food ingestion pathway; the incidental ingestion of soils is secondary. The inhalation, dermal, and water ingestion pathways are not considered significant.

Dark-Eyed Junco

The dark-eyed junco has the widest distribution of all juncos and is commonly seen across much of the United States and Canada, although the species is listed as endangered in Ohio. In the Circleville area, the dark-eyed junco is only a winter resident with breeding documented only in the extreme eastern portion of Ohio where minimal overlap of summer and winter ranges occurs (Martin et al. 1961; Robbins et al. 1983; Terres 1991; Kaufman 1996).

In winter, the dark-eyed junco migrates southward in small flocks that feed in edges of woods, weedy fields and old pastures, hedges, and along roadsides (Terres 1991). The dark-eyed junco forages mostly on the ground and eats seeds and insects. During the winter about 76 percent of the diet of dark-eyed juncos is weed seeds and other vegetation (e.g., berries). Seeds from ragweed and bristlegrass make up 10 to 25 percent of the diet while seeds of crabgrass and dropseed comprise 5 to 10 percent of the diet.

The dark-eyed junco was initially selected as a receptor species because it is an endangered species in Ohio and was observed on the OCA during a Site survey in 1992 (PTI 1995). The primary exposure route is the food ingestion pathway; the incidental sediment ingestion pathway is secondary. Inhalation, dermal exposure, and water ingestion are not considered significant exposure pathways for this Site.

American Robin

The American robin is the largest member of the thrush family in North America. Its distribution range is from northern North America to Mexico and it lives along forest borders, hedges, orchards, and in gardens (Terres 1991). The American robin is a year-round resident in Ohio.

The American robin is omnivorous, with terrestrial invertebrates (e.g., earthworms, grasshoppers, beetles, caterpillars, snails, spiders) and fruits (e.g., wild berries) being the most common types of food items consumed (Terres 1991). Kaufman (1996) estimates that up to 60 percent of the annual diet of the American robin may be fruits. The type of food eaten (e.g. fruit, invertebrates) also depends on numerous factors including the quality and extent of the habitat, time of day, age class of the bird, and season of the year. Juveniles consume more fruit because of undeveloped foraging skills (Wheelwright 1986). The American robin prefers foraging in open, grassy habitats. In particular, landscaped habitats and areas where vegetation is low increase the foraging activities by this species. For example, mowing has been shown to increase the foraging activities of American robins (Eiserer 1980).

The American robin was initially selected as a receptor species because it has been observed at the OCA and has a potential for exposure to lead through the food ingestion pathway. Diet items that may result in the uptake of lead include the consumption of soil-dwelling invertebrates (e.g., earthworms) and incidental soil ingestion during foraging on subsurface organisms. The pathways of inhalation and dermal contact are not considered significant. The water ingestion pathway also is considered insignificant as the species does not rely on the availability of free water.

American Kestrel

The American kestrel is a small, predatory falcon characteristic of open areas (e.g., grasslands, idle fields). American kestrels are listed as permanent residents in Ohio. However, Mills (1976b) points out that there is confusion regarding the term "permanent resident." Based on his winter studies of the American kestrel in the Circleville, Ohio area, the author found that the population was heterogeneous and changed frequently, with little "permanency" (Mills 1976b).

American kestrels feed primarily on large insects such as grasshoppers, crickets, cicadas, beetles, dragonflies, and moths (Kaufman 1996). American kestrels also consume small birds (e.g., sparrows, blackbirds, finches, warblers) and small mammals (e.g., deer mice, harvest mice, meadow voles) characteristic of grassland habitats (Sherrod 1978). As reported in a compilation of raptor diets by Sherrod (1978), invertebrates comprise 32 percent to more than 98 percent of the diet of the American kestrel with most studies reporting values near the high end of the range. The lowest percentage reported (32 percent) was from a study in Pennsylvania where 54 percent of the diet was small mammals; however, nearly all the small mammals in the diet were voles (*Microtus* spp.).

The American kestrel maintains large home ranges that typically have only minimal overlap. In a study of territoriality among a winter population of American kestrels, Mills (1976b) calculated an average territory of 380 acres, with the largest territory being 1,118 acres. This

study was conducted about 11 miles south of Circleville, Ohio. As noted by Mills (1976b), this estimate of an average home range is substantially smaller than winter ranges in Illinois reported by Enderson (1960) of 1,118 acres and the winter ranges in Michigan of 2,378 acres reported by Craighead and Craighead (1956).

The American kestrel was initially selected as a receptor species because it is common in Ohio and is an upper trophic level species characteristic of open grassland habitats. The primary route of exposure for the American kestrel is the food ingestion pathway; the incidental soil ingestion pathway is secondary. The inhalation and dermal contact pathways are not considered significant. The water ingestion pathway also is considered insignificant as the species does not rely on the availability of free water. The American kestrel is expected to occur only in the EFA; the wooded and riparian habitats of the OCA are not the types of habitats used by American kestrels.

Wood Duck

The wood duck is a medium-sized, dabbling freshwater duck. Its distribution range is from southern Canada to Texas and extends from the Atlantic to the Pacific coasts. The species occupies open woodlands around forested lakes, swamps, wooded river bottoms, and along the banks of wooded ponds (Terres 1991). Wood ducks feed in wild rice marshes and in sluggish streams and ponds filled with aquatic plants and insects. A primary food item of the wood duck is mast, especially from oak trees. Wood ducks typically nest in tree hollows or cavities in swamps or along woodland streams. Thus, a potential for exposure of ducklings to lead at the OCA exists. However, no evidence of nesting activity was observed during any of the surveys in 1992 or 1997.

The wood duck was initially selected as a receptor species because it represents omnivorous water birds and was observed at the OCA during a Site visit in 1992. This species may potentially be exposed to lead through the ingestion of food items (e.g., aquatic invertebrates) and secondarily through the incidental sediment ingestion pathway. The pathways of inhalation and dermal contact are not considered significant for wood ducks. The water ingestion pathway also is considered insignificant as the species does not rely on the availability of free water and surface water is not an exposure pathway of interest on the OCA.

Areas of Interest

The areas of interest are the EFA and the OCA. These are the only areas of natural habitat that potentially support populations of receptors of interest. Overbank sediments of the OCA are the primary exposure media for receptor species. Ingestion of in-channel sediments is also a potential route of exposure to the muskrat. Exposure points are related to the distribution of elevated concentrations of lead as discussed below.

Known or Suspected Effects of Lead

There is no evidence to suggest that lead in the EFA and OCA has caused wildlife mortality. There are no known reports of wildlife mortalities from this area.

In a study of background metals concentrations in Ohio soils conducted for OEPA, Cox and Colvin (1995) report that the 95-percent upper confidence limit of the mean for lead in nonindustrial background soil concentrations was 44.9 mg/kg and, for industrial background concentrations, was 2,400 mg/kg. In the EFA, the range of concentrations in surface soils (0-to-6-in. horizon) is 16 to 49 mg/kg. Concentrations are below or within an order of magnitude of nonindustrial background concentrations, and substantially below industrial background concentrations. Thus, concentrations of lead on the EFA are not elevated beyond background concentrations to levels suggesting a risk to receptors. Maximum lead concentrations in the OCA range up to 15,800 mg/kg in the deltaic area (Table 4-24), which is substantially higher than both non-industrial and industrial background concentrations.

A review of current and available literature suggests that soluble lead can be toxic to biota. However, the solubility of lead at the Site is low, as discussed in the following section (*Toxicity and Bioaccumulation Assessment*). Therefore, toxic effects from lead are not expected.

Toxicity and Bioaccumulation Assessment

Processes influencing the transport and fate of lead have a significant effect on the potential for exposure, bioaccumulation, and toxicity. The transport and fate of lead and other PCoIs is presented in Section 5 of this report, in addition to a discussion of lead geochemistry, solubility, and bioavailability. An overview of the relevant issues of lead transport and fate is provided in the following section and the section is concluded with a discussion of lead bioaccumulation and toxicity.

Transport and Fate of Lead

Based on the physical and chemical properties of lead, as well as the Site mineralogy, geochemistry, and media sampling results to date, particulate transport is the primary mechanism for lead migration in the environment. Concentrations of dissolved lead in surface water are below the detection limit (3 μg/L). The sediment investigation documented that any dissolved lead will be immobilized by adsorption to surface sediments. Vitrified forms of lead (i.e., glass particles) are essentially insoluble and, therefore, expected to be nontoxic. Vitrified lead forms account for about 17 percent of lead in the OCA soils/sediments (Section 4). The primary forms of nonvitrified lead observed in OCA soils/sediments are iron-lead oxide, manganese-lead oxide, lead phosphate, and barium-lead sulfate in the surface and lead sulfide in the deeper soils/sediments. Therefore, the primary forms in which lead occurs at the Site are expected to have low bioavailability and therefore little or no toxicity. The geochemistry of lead at the Site is discussed further below.

Geochemistry of Lead

Lead is highly immobile in soils and sediments (Dragun 1988). The distribution of lead in soil and sediments is controlled by both precipitation/dissolution and adsorption/desorption reactions. The nonvitrified forms of lead in Site soils and sediments would occur as lead precipitates (e.g., lead phosphate, lead carbonate, lead sulfate, and lead sulfide) and as the divalent cation (Pb^{+2}) adsorbed to soil and organic matter. In calcareous soils, such as those in the EFA, lead carbonate ($PbCO_3$), with a solubility of 1.1 mg/L (CRC 1976), is expected to control lead solubility (EPRI 1984). This interpretation is supported by microprobe analysis of a sludge sample from the EFA, which showed that lead that was not bound in the glassy matrix was present as $PbCO_3$ (PTI 1995). In the sediments of the East Swale, South Ditch, and OCA, lead mineral precipitates include lead sulfide, iron-lead oxide, manganese -lead oxide, lead phosphate, and barium-lead sulfate, all of which are stable in the sediment environment and will produce limited soluble lead.

Iron and manganese oxides and sulfides are strong specific adsorbents for lead, especially in sediments high in organic content (Gadde and Laitinen 1974). Based on the concentration of iron in the South Ditch sediments (1.8 percent by weight), lead could be effectively immobilized by iron oxides alone (Davis and Galloway 1993). Finally, the soil property that most often correlates with lead adsorption is cation exchange capacity (CEC) (Zimdahl and Skogerboe

1977). The CEC is a measure of the concentration of cationic metals that a given volume of sediment can bind and immobilize. The OCA sediments have high organic CEC, resulting in a high capacity to immobilize lead (see Section 5 and Table 5-3).

The buried sludges at the EFA contain solids (glass fines) removed from the settling ponds and placed in the EFA. A single analysis of this material by electron microprobe indicated that the EFA sludges contain much of their lead mass as lead entrained in glass particles (polishing fines), with the remainder present as lead carbonate ($PbCO_3$). This analysis and results were described in the work plan (PTI 1995). Exposure of ecological receptors to lead from the materials buried in the EFA will be limited, due to the fact that lead is largely present encapsulated within glass particles and is buried below the ground surface, reducing or eliminating the potential for exposure.

In summary, lead that may dissolve at the OCA will either precipitate or be strongly adsorbed onto organic matter and iron oxides in the OCA sediments. Therefore, lead mobility is limited, and lead is not expected to leach into surface water or groundwater at significant concentrations. This is supported by surface water and groundwater sampling results discussed previously in the remedial investigation (see Sections 4 and 5).

Solubility of Lead

Although solubility and bioavailability are two distinct processes, the bioavailability of a chemical depends in part on the soluble form. For example, if a metal is not precipitated as, or complexed within, a mineral, that metal will be available for uptake and potential bioaccumulation into an organism. The availability of the dissolved form of a metal depends on the sorption capacity of the sediment and soil.

The sorption capacity of the EFA and OCA soils and sediments is high due to the presence of iron and manganese hydrous oxides and sulfides, clays, and organic matter. Because organic carbon is a major factor in attenuating lead in soils and sediments (Zimdahl and Skogerboe 1977), the OCA sediments, which have elevated total organic carbon (TOC) values, have a high capacity to immobilize lead as demonstrated by the CEC values. This indicates that the OCA sediments have the capacity to immobilize much more lead than is currently present (see Section 5 and Table 5-3).

The low solubility of the forms of lead at the Site is confirmed by the results from years of Resource Conservation and Recovery Act (RCRA) groundwater monitoring (PTI 1995) and remedial investigation sampling of groundwater at the EFA discussed previously in this report. These groundwater monitoring results demonstrate that even under the worst possible conditions (i.e., placement of lead-containing slurry in unlined areas located in permeable soils) the effect on groundwater is negligible. The available surface water data also confirm that the dominant transport mechanism for lead is as particles and not in the dissolved phase. These data confirm the very low solubilities of the forms of lead at the EFA and OCA.

Bioavailability of Lead

Bioavailability to Plants

Lead has low bioavailability for plants, and uptake is typically low. Plants have no specialized mechanism for assimilating lead from the soil because lead is not an essential trace element for plants. Lead uptake by plants appears to be a passive process. Soluble lead is taken up by roots until exchange sites in the root system are equilibrated with the solution concentration (Zimdahl and Arvik 1973). Because the solubility of lead at the OCA is very low, uptake by roots is expected to be minimal.

While plants may accumulate lead in roots, it is not readily translocated to the stems, shoots, leaves, or seeds (Karamanos et al. 1976; Zimdahl and Arvik 1973). Marten and Hammond (1966) reported lead concentrations of 12.5 mg/kg in bromegrass (*Bromus inermis*) growing in the vicinity of a smelter on soils containing 680 mg/kg lead. Chambers and Sidle (1991) report foliar concentrations of less than 75 mg/kg dry weight in alkali muhly (*Muhlenbergia asperifolia*) growing in soil with lead concentrations exceeding 5,000 mg/kg dry weight. PTI has documented similar results of low lead uptake by native grasses and forbs at a zinc smelter site in Oklahoma (PTI 1996). In grassland habitats adjacent to the smelter site, the highest lead concentration in surface soils (458 mg/kg dry weight) was associated with concentrations in the vegetative parts (i.e., stems and leaves) of switchgrass (*Panicum virgatum*) and indiangrass (*Sorghastrum nutans*) of only 1.8 and 0.46 mg/kg dry weight, respectively. Seeds of switchgrass and indiangrass contained only 2.1 and 1.7 mg/kg dry weight, respectively. In a riparian area with the highest lead concentration on the site (485 mg/kg dry weight), vegetative plant parts of a beggar's tick (*Bidens polylepsis*) contained lead concentrations of only 1.1 mg/kg dry weight and seeds contained lead concentrations of only 0.8 mg/kg dry weight.

Submerged angiosperms, bryophytes, and algae may take up lead by passive absorption through shoot tissue from surface water (Denny 1980, 1981; Welsh and Denny 1980; Welsh and Denny 1979, as cited in Everard and Denny 1985; Rai et al. 1981, as cited in Everard and Denny 1985) rather than translocation from roots. Metal diffusion across plant membranes is also related to the anatomy and morphology of the plant. For example, cattail (*Typha* spp.) has a dense integument, which inhibits diffusion. Because lead in the OCA soils/sediments is present as mineral precipitates, bound to soil/sediment particles, or encapsulated in glass and not in the dissolved form in the water column, it is not readily available for root uptake or passive absorption. It is unlikely that lead taken up by the roots of wetland species would be translocated to other plant parts (Denny 1980; Welsh and Denny 1979, as cited in Everard and Denny 1985).

Bioavailability to Animals

While organisms may ingest lead by direct consumption of contaminated soils or by consuming contaminated prey, only a portion of the lead is bioavailable. The bioavailability of lead in soils and sediments is dependent on various factors, including:

- Form and solubility of the lead
- Grain size of the soil particles to which the lead is bound
- Particle structure or matrix of the lead
- Nutrients or other compounds ingested with the lead.

For instance, the presence of iron and/or calcium and magnesium reduces bioavailability of lead. The concentrations of these cations in soil samples analyzed from the Site (ADL 1993) have average values of 34,000, 34,000, and 10,000 mg/kg for calcium, iron, and magnesium, respectively. These concentrations of cations should result in reduced bioavailability of lead. Bioavailability of lead is also related to complexation with other minerals and to dissolution relative to residence time in the gastrointestinal tract (2 hours in rats) (Ruby et al. 1992). Based on the forms of lead and their very low solubility, the presence of cations that control dissolution, and the amount of organic matter and clay, bioavailability of lead to receptor species is expected to be low. In addition, lead present in vitrified form (about 17 percent in OCA sediments) will not be bioavailable.

Toxicity and Bioaccumulation

In the absence of site-specific empirical data, toxicity profiles in an ecological risk assessment are derived from studies in the scientific literature and government publications. Studies of lead toxicity were reviewed as part of the toxicity and bioaccumulation assessment. While these studies aid in the evaluation of potential toxicity of lead to receptor species, they are generally representative of responses of laboratory species to contaminants. In quantitative ecological risk assessments that include food web model analysis, several factors are considered when extrapolating effects of potential contaminants to wildlife. These factors include the amount of contaminant absorbed in tissues (absorption factor), the ingestion rate for each potentially contaminated dietary component, the body weight of the receptor species, and the proportion of the receptor species' home range relative to the size of the contaminated area. For instance, a small mammal such as a white-footed mouse (*Peromyscus leucopus*) consumes about 2 percent of soil in its diet (Beyer et al. 1994). Additionally, only a portion of the lead potentially consumed is absorbed by the small mammal in the wild. Studies on small mammals indicate that only a fraction of the total metals in ingested soil are absorbed in the gut (Chaney et al. 1989; Griffin et al. 1990; Foulkes 1985). Moreover, the form of the lead administered in the laboratory toxicity test is generally in a more bioavailable form or mixed in a carrier to increase solubility to elicit a response from the test animal.

Based on these distinctions, direct comparisons of onsite soil lead concentrations to toxicity values outlined in the literature should be avoided. In many cases, surrogate species that cannot be directly compared to wildlife have been used in toxicity tests to estimate effects. As discussed previously, soil and sediment at the OCA have lead present as vitrified forms, mineral precipitates, and adsorbed onto particle surfaces. Therefore, risk to receptor species is minimal compared to laboratory species, as a result of the low solubility and bioavailability of lead. Finally, the exposure frequency is considered minimal for most receptor species due to home

range size relative to the size of the contaminated area. For these reasons toxicity profiles were not compiled for receptor species at the OCA. Direct comparisons to laboratory tests are expected to be overly conservative when compared to actual bioaccumulation since the laboratory tests use very soluble forms of lead that are not found at the Site. This is particularly true for species at the OCA, given the low bioavailability of lead due to geochemical factors and minimal exposure frequency of receptors (discussed in the following section).

Conceptual Site Model For Ecological Receptors

Potential pathways and routes of exposure for ecological receptors in the OCA and EFA are summarized in this section. The conceptual site model was developed using information gathered during field surveys on habitats and species identified or expected to occur in the OCA (Figure G-1). This information was combined with data gathered during the remedial investigation and previous sampling events to predict potential exposure pathways to receptor species. Refer to the *Identification of Potential Ecological Receptors* section for further discussion of ecological receptors.

The primary exposure pathway for plants to trace metals that are essential micronutrients (e.g., copper, iron, and zinc) from soil occurs by uptake through roots. However, lead is not essential for plant growth and so uptake by the root system, and subsequent translocation of lead from the roots to aboveground plant parts (e.g., leaves, stems, fruits), is minimal. Research has shown that lead taken up by the root system is not readily translocated to aboveground plant parts (Karamanos et al. 1976; Zimdahl and Arvik 1973; Baumhardt 1970, as cited in Holl and Hampp 1975; Chambers and Sidle 1991). Marschner (1986) reports that many plant species exclude such elements as lead and copper from shoots.

Soluble lead is taken up by roots until exchange sites in the root system are equilibrated with the solution concentration (Zimdahl and Arvik 1973). Because the solubility of lead at the OCA is very low, uptake by roots is likely to be minimal and translocation from the roots to the aboveground plant parts is expected to be minimal. Therefore, incidental ingestion of lead by organisms feeding on aboveground plant parts is also considered minimal.

Direct ingestion of overbank soil/sediment is likely to be an important pathway for organisms that feed on detritus and decomposed organic matter. In addition, burrowing mammals are likely to be exposed to overbank soil/sediment by indirect ingestion of soil and feeding on plant roots. The most important exposure route for predators is likely to be ingestion of prey that have accumulated lead or the incidental ingestion of soil and/or sediments. Direct contact with lead in sediment is the most likely exposure pathway for aquatic benthic invertebrates.

Groundwater is not likely to be a pathway for receptor species because the organic content of the marsh sediments would further immobilize lead potentially leached from the sediments. The vertical profile of lead concentrations in all soil/sediment samples collected indicates that leaching and vertical migration of lead is not occurring. In addition, the elevated lead concentrations in soils and sediments of the South Ditch and OCA occur in groundwater discharge areas (see Section 3.0). Surface water is not likely to be a significant exposure route for biota because of the geochemical properties of the lead-bearing particulates and the capacity of the sediments to immobilize lead.

Soil/Sediment

A primary pathway for wildlife receptors is direct and incidental ingestion of soil or sediment during feeding, preening, and burrowing. Secondary exposure may occur through ingestion of, and dermal exposure to, interstitial water. The importance of this pathway is determined by the life histories of receptor organisms. Aquatic omnivores (e.g., some waterfowl) may be exposed primarily through incidental ingestion of sediment and ingestion of benthic macroinvertebrates. For some terrestrial species (e.g., raccoons) incidental ingestion of sediment may also be a primary pathway. *Typha* spp. may be exposed to lead by direct contact of their roots with sediment and interstitial water. The concentration of lead in interstitial water is expected to be low due to the form of lead and the geochemistry of the sediments. Direct contact with lead in sediment is the most likely exposure pathway for aquatic benthic invertebrates.

Groundwater

The OCA is a discharge zone for shallow groundwater. Groundwater is not likely to be an important exposure pathway for biota because of the geochemical properties of the materials previously discussed, and the lack of significant impact on groundwater, based on monitoring around former source areas (e.g., the former lagoons and the EFA sludge). Because the OCA is a discharge zone, any shallow groundwater potentially in contact with lead-bearing particulates would discharge to surface water.

Surface Water

Aquatic plants and animals may be exposed to lead by direct contact with surface water. However, because of the immobilization capacity of OCA sediments, leaching of lead and subsequent ingestion of lead in surface water is considered a minor pathway for biota. This conclusion is supported by surface water data collected from the OCA during 1995 and 1996. In samples collected from four stations during a low-flow event in December 1995, dissolved lead was undetected at 3.0 μg/L and total lead ranged from undetected at 3.0 μg/L to 6.3 μg/L. Both the dissolved and total lead concentrations are below the corresponding water quality criteria (30 and 37 μg/L, respectively) for the protection of aquatic life at a water hardness of 400 mg/L $CaCO_3$. Sampling at two stations in May 1996 during a high flow event did not detect dissolved lead (at a detection limit of 3.0 μg/L) at either station; total lead concentrations were less than 3.0 μg/L and 13.5 μg/L, both values below the water quality criteria[1].

Air

Lead in soils is not volatile under most natural conditions and thus is not considered an appropriate exposure pathways for this Phase I EA. The ground cover, including vegetation and litter, is relatively dense on both the EFA and OCA and most of the OCA is shaded. Therefore, fugitive dust is not considered a significant pathway.

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[1] These criteria are the values for outside the mixing zone, obtained from the Water Quality Criteria for the Ohio River Drainage Basin, 3745-1-34, effective October 31, 1997.

Food

The primary pathway for exposure of plants to lead in soil occurs by uptake through the root system with translocation and subsequent storage into vegetative and reproductive parts. As discussed earlier, lead uptake by root systems and subsequent translocation by plants is likely to be minimal and not result in significant uptake by organisms feeding on terrestrial plants. Therefore, incidental ingestion of lead by organisms feeding on aboveground plant parts is considered minimal. Incidental ingestion of soil (e.g., uptake by predators foraging on terrestrial soil biota) is a potential exposure pathway for organisms that feed on subsurface and ground-dwelling invertebrates.

Omnivores (e.g., raccoon) and predators (e.g., coyote, American kestrel) may be exposed to lead from the EFA and OCA by ingesting organisms (e.g., crustaceans and small mammals) that have accumulated lead. The importance of prey species as pathways of exposure for receptors depends on the extent that food items bioaccumulate lead, the size of the areas of interest (i.e., EFA and OCA) relative to the home range size of the receptor, and the bioavailability of lead. As discussed earlier, the contribution of aboveground vascular plant parts to total lead exposures in receptors or receptor prey items is expected to be minor. The scaling of home range size to the area of interest is discussed later in this document (see *Ecological Screening of Soil Lead Concentrations*). For larger receptors, the amount of food resources obtained from the areas of interest is expected to be minimal.

As discussed earlier, lead at the Site occurs in both vitrified and nonvitrified forms. The vitrified forms of lead are encapsulated in a silicate (i.e., glass) matrix and are considered essentially inert. Nonvitrified forms of lead display varying degrees of reactivity, but they are attenuated in Site soils and sediments by environmental and geochemical factors. For these reasons, the bioavailability of lead is considered low.

Potential for Adverse Population Effects

The risk of adverse ecological effects resulting from lead concentrations in soils of the EFA, and the overbanks, sediments, and surface waters of the OCA was evaluated based on the following factors:

- Extent and quality of habitat afforded by the EFA and OCA to resident receptor populations
- Influence of physical and chemical stressors, unrelated to the Site, on habitat quality and receptor populations
- Size of the area of interest (i.e., EFA or OCA) relative to the home range size of the receptor species
- Proximity of other suitable wildlife habitats
- Potential density of receptor populations on the EFA and OCA

- Toxicity of lead to avian and mammalian receptors
- Solubility and bioavailability of lead in relation to its concentrations at the EFA and OCA.

The toxicity assessment and the evaluation of exposure pathways were used to develop a qualitative assessment of the potential for adverse effects on ecological receptors. The assessment consider the following receptor species: cattail, muskrat, northern short-tailed shrew, white-footed mouse, raccoon, coyote, dark-eyed junco, American robin, American kestrel, and wood duck.

Cattail

Adverse effects on cattails from OCA sediments are not expected to be significant given the predicted low solubility of lead and its limited uptake by plants. The significance of the cattail habitat in the OCA is limited for three reasons. First, the cattail community, when present, occupies only a small area (i.e., less than 3 acres) of the deltaic area. Second, frequent disturbance from drainage maintenance activities removes portions of the cattail marsh. Third, the cattail marsh is not a permanent habitat type. Rather, the cattail marsh is cyclic, depending on the status of beaver in the area. The reported removal of a beaver and its associated dam in 1992 has resulted in a general drying of the habitat and replacement of the cattail community with a sedge community; no cattails were observed during the Site survey in October 1997. Thus, physical stressors appear to be the primary factor determining the extent and quality of the cattail community and those receptors associated with this habitat type.

Muskrat

Historic reports on the number of dens and trapping of muskrats from the Circleville area suggest the OCA could support a viable population of muskrats. However, no evidence of muskrat activity was found during the Site survey of 1997. The few holes in the farm ditch embankment downstream of the marsh area that may be old muskrat burrows showed no evidence of recent use. It is believed that the absence of muskrat is related to the removal of beaver from the area. Removal of beaver has led to loss of impounded water and a general drying of the habitat that has resulted in the replacement of the cattail community with a sedge community. Without a preferred food resource (i.e., cattails) and sufficient permanent water to support foraging and movements of muskrats, this species is unlikely to occur. This supports the conclusion that physical stressors dominate the deltaic area and the area cannot support a permanent muskrat population. In addition, if muskrats were present, the low bioavailability and uptake of lead by cattails is unlikely to result in any significant exposure through their diet. Thus, lead concentrations in the OCA are unlikely to pose any significant risk to muskrats.

Northern Short-Tailed Shrew

It is unlikely that the EFA supports a permanent population of the northern short-tailed shrew. The EFA is a dry (i.e., xeric) upland habitat composed primarily of grasses, forbs, and shrubs.

Xeric habitats are marginal for the northern short-tailed shrew, the species preferring more mesic (i.e., wet) habitats (Choate and Fleharty 1973; Wrigley et al. 1979). The OCA may support a population of the northern short-tailed shrew, although the population is unlikely to be large or permanent, given the periodic flooding that occurs on the OCA. One of the preferred habitat components of this species (i.e., tree stumps and fallen, rotting tree trunks and limbs) is uncommon to rare on downstream portions of the OCA. Also, observations made during the October 1997 survey indicate that some of the preferred food items of the northern short-tailed shrew (e.g., earthworms) are rare or absent from the deltaic area and habitats adjacent to the creek channel, likely a consequence of baseflow discharge in the offsite creek and flooding events.

Shrews have been shown to bioaccumulate lead (Pankakoski et al. 1993), with the most likely exposure pathway being the ingestion of earthworms. Elevated lead concentrations are found primarily in the wet deltaic area and wet western portion of the upper creek (Figure 4-7). These areas are also among the first habitats to be submerged during flood events and the last to dry out. Flooding on a seasonal or periodic basis removes both the receptor (shrew) and the food resource (earthworms) from the OCA. Exposure pathways would not reoccur until both the receptor and food resource were reestablished in habitats of the OCA. For example, the OCA may have flooded at least three times in 1997 (Betky 1997, pers. comm.). It is unlikely that northern short-tailed shrew or earthworm populations persisted for any significant length of time during 1997 in the deltaic area or the overbank habitats along the offsite creek or farm ditch due to this frequent inundation. It is likely that earthworm populations will lag behind shrew populations in reestablishing in flooded habitats because of their restricted mobility relative to a small mammal. Thus, as northern short-tailed shrews return to these habitats, their diet is likely to consist of available food resources (e.g., aboveground insects, carrion). Such shifts in the diet of northern short-tailed shrews have been documented previously (Hahus and Smith 1990). Exposure to lead from the ingestion of aboveground insects is likely to be substantially less than exposure of subsurface organisms such as earthworms.

If northern short-tailed shrews occur in the OCA, they are most likely to be found on the forested slopes of the OCA that are above flood levels, and therefore away from areas of elevated lead concentrations. The weight of evidence suggests that the frequency and duration of exposure of northern short-tailed shrew to elevated lead concentrations is minimal and not suggestive of potential population-level risk.

White-Footed Mouse

Site conditions on both the EFA and most of the OCA are not expected to pose a significant ecological risk to the white-footed mouse. It is unlikely that the small area of the EFA supports a substantial population of white-footed mice. While the vegetation community is diverse and likely provides the habitat to support a relatively abundant and diverse insect population, there is little habitat structure (e.g., mature trees, downed tree trunks) that is attractive to white-footed mice. Most of the insect population is expected to be aboveground, herbivorous insects (e.g., grasshoppers, moths, caterpillars, beetles) that are unlikely to take up and accumulate lead or have originated onsite. Thus, exposure to white-footed mice through the food ingestion pathway is expected to be minimal.

It is unlikely that the OCA sustains a resident population of the white-footed mouse except along the steep, uppermost embankments surrounding the OCA where lead concentrations are low and not of concern. Those areas closest to the stream channels, where lead concentrations are highest (principally the deltaic area and upper creek channel), are typically wet from baseflow discharges or are otherwise susceptible to seasonal flooding. Although white-footed mice can avoid the effects of flooding by climbing into the vegetation, the food resources are typically removed by flooding. In particular, the understory vegetation that produces seeds and fruits and supports invertebrate populations is removed or impaired in growth and development. Furthermore, because white-footed mice are primarily herbivorous, dietary exposure to lead is likely to be low due to the low uptake of lead by plants.

The weight of evidence suggests that environmental conditions in the OCA do not provide sufficient resources to support a resident population of white-footed mice. Those white-footed mice that disperse into the OCA following a flood event will have shorter exposures, and their large home ranges that occur from resources being less abundant will result in exposure composited over larger areas, many (if not most) with low lead concentrations in the soils.

Raccoon

Raccoons are not expected to receive a significant exposure to lead in the areas of interest. No extensive use of the EFA or OCA is expected. The EFA does not support resources typically used by raccoons. The OCA is a small habitat patch within the rural Circleville landscape and represents only a small portion of the home range area utilized by raccoons. Raccoons may use the OCA as a corridor for movement between suburban areas, agricultural fields in the Circleville area, and riparian habitats along the Scioto River. However, den sites are expected to be absent or rare in the OCA and food resources limited. Thus, it is unlikely that raccoons make significant use of the OCA or that this habitat is capable of supporting any resident individuals or populations.

Coyote

Site conditions are not expected to pose a significant risk to coyotes. Comparing the reported home range estimates with the size of the EFA or OCA indicates the habitats of concern constitute substantially less than 1 percent of the home range of a coyote. If it is assumed that a coyote uses all areas within its home range in direct proportion to the areal extent of the habitat, a coyote is expected to spend an insignificant portion (i.e., less than 1 percent) of its time on either the EFA or OCA.

It is unlikely that coyotes den on the EFA given the proximity of the EFA to the Site and the activities of Site personnel. It also is unlikely that coyotes would construct a den or occupy a burrow in a saturated or marshy environment such as the OCA. No dens were noted at either area during Site surveys.

Although coyotes feed on white-footed mice, the most common small mammal in their diet is the vole (*Microtus* spp). No significant vole population is expected to occur on the OCA based on the small area and habitat structure. In addition, voles are herbivores, consuming vegetative

plant parts (i.e., roots, tubers, green vegetation) and for the woodland vole (Microtus pinetorum), mast and seeds are consumed. Terrestrial plants and seeds do not readily take up lead and much of the lead ingested by vertebrates (e.g., *Microtus* and *Peromyscus*) is sequestered into bone (i.e., indigestible components of the coyote diet). Thus, to the extent that coyotes occur in the Circleville area and feed on voles, foraging is expected to occur primarily in offsite habitats unaffected by the Site. Exposure through this pathway is expected to be negligible.

American Robin

American robins are not expected to be resident on the EFA as there are few mature trees to provide nesting habitat. Individuals may nest in the wooded habitat immediately east of the EFA and incorporate the EFA into their foraging territories. However, the extent of the wooded habitat is less than about 1 acre in size, and thus cannot support any substantial population of this species. Further, American robins prefer to forage in more open habitats and in areas where vegetation is short, as the species hunts by sight (Kaufman 1996). The height and density of vegetation on the EFA is not expected to be attractive to American robins and thus the area is not expected to be used to any significant extent. The same is true for the non-wooded habitat immediately east of the EFA.

Use of the OCA is also expected to be minimal. Periodic flooding of the OCA removes much of the vegetation that provides habitat for terrestrial invertebrates, and effectively removes the earthworm population. While the mature tree overstory may be attractive as nesting habitat for American robins, most of the foraging may occur in offsite areas, resulting in a low potential for exposure on the OCA.

The primary exposure to lead is expected to occur during the spring and summer months when the diet of the American robin shifts to terrestrial invertebrates, including caterpillars, beetles, and earthworms (Martin et al. 1961). The dose to an individual bird depends on the extent that terrestrial insects are consumed and the extent to which the individual insects have bioaccumulated lead. Bioaccumulation in the terrestrial invertebrate population is expected to be relatively low for several reasons. Many of the insects typically consumed by the American robin are relatively mobile insects (e.g., grasshoppers, moths, butterflies, and ground beetles) that may have originated in offsite habitats. As discussed previously, periodic flooding of the OCA is believed to limit the occurrence of earthworms and also restrict development of any understory vegetation throughout much of the OCA. The absence of understory vegetation removes habitat for terrestrial insect populations. Thus, to satisfy their dietary requirements, American robins may forage outside of the OCA, thereby reducing their exposure duration and frequency in onsite habitats. In addition, the geochemical characteristics of the lead-bearing particulates (as discussed previously) indicate that lead is not in a form that will be readily incorporated into plants or invertebrates.

Dark-Eyed Junco

Exposure of dark-eyed juncos to lead is expected to be insignificant. Dark-eyed juncos are resident in the Circleville area only during winter months when the ground is frozen and often

covered by snow and terrestrial invertebrates are absent or rare. The diet is almost exclusively seeds; thus, the exposure pathways to these sources of lead are absent or of only minor importance as plants typically do not take up and transfer lead from soil into seeds. Thus, the accumulation of lead by dark-eyed juncos from the dietary exposure pathway (i.e., seed ingestion) is expected to be insignificant.

American Kestrel

Site conditions on the EFA are not expected to pose a significant risk to the American kestrel. The EFA comprises an insignificant portion of the home range of an American kestrel—approximately 1 to 2 percent based on the average winter home range reported by Mills (1976b) and less about 0.5 percent of the maximum home range. Habitat on the OCA also is considered generally unsuitable for this species. The density of the ground cover appears to limit, if not prevent, effective foraging by American kestrels on ground-dwelling organisms (e.g., voles, if present). Most of the invertebrate groups consumed by American kestrels (i.e., grasshoppers and crickets) are herbivorous and thus do not readily bioaccumulate metals like the more predaceous invertebrates (Roberts and Johnson 1978, 1979). Although kestrels have been documented to feed heavily on voles at times, it is unlikely voles occur on the EFA. Even if voles were found on the EFA, lead uptake by voles will be minimal as voles consume almost exclusively vegetative plant parts that do not readily take up lead. The American kestrel would not forage on white-footed mice as the American kestrel is diurnal and the white-footed mouse is crepuscular and nocturnal. Thus, lead concentrations in soils of the EFA are not expected to pose a significant risk to American kestrels.

As mentioned previously, the American kestrel is a bird of open grassland habitats and is not known to utilize wooded habitats or riparian areas to any significant extent. It is considered unlikely that the OCA is used by the American kestrel and that any significant exposure would occur in this habitat.

Wood Duck

Site conditions are not expected to pose a significant risk to wood ducks. Although a wood duck was observed on the OCA in 1992, a breeding population is not expected to occur in onsite habitats. There is an absence of nesting habitat (i.e., mature trees with cavities in inundated habitat). Throughout much of the year, acorn mast and aquatic vegetation are the primary food items of wood ducks and neither is common on the OCA. Removal of the beaver dam has led to a general drying of the OCA habitat below the railroad crossing. The vegetation community has changed from a cattail-dominated to a sedge-dominated community. There is no perennial water except in the small incised creek channels that dissect the OCA and flooding of the deltaic area habitat may not occur regularly or coincide with the reproductive season of wood ducks.

In downstream areas of the OCA (i.e., adjacent to EHWD) where mature trees are found, no nesting cavities were observed. Food resources are uncommon, as there are few mast-producing trees in the OCA. Although wood ducks and other waterfowl may occasionally use lower reaches of the OCA for resting, it is doubtful that exposures would be biologically significant.

Without breeding habitat or mast as a winter food resource, it is unlikely that wood ducks spend any substantial time on the OCA.

Ecological Screening Of Soil Lead Concentrations

The previous section has indicated that risk is likely to be low for most receptors, due either to infrequent use of the EFA and OCA because of limited availability of suitable habitat and/or prey, or to likely limited uptake of lead by their food items. To provide a quantitative assessment of risk to potential receptors at the OCA, a food-web evaluation was performed for the short-tailed shrew and white-footed mouse to assess risk from potential lead exposure associated with intake of food and incidental soil ingestion. These two receptors were selected for this evaluation because they have localized home ranges, so individuals of both species could forage exclusively within the OCA. Therefore, both receptors are more likely to have higher exposure rates that other larger-bodied, wider-ranging receptors that may utilize the OCA only sporadically. This food-web model approach was prepared in consultation with OEPA following submittal of the draft remedial investigation report.

The OCA was divided into several sub-units for purposes of this screening evaluation. The railroad grade is considered a habitat barrier across which movement by individual shrews or mice is unlikely to occur with any regularity. Consequently, small mammals inhabiting areas in the upper creek portion of the OCA, upstream of the railroad grade, are likely to have different exposure scenarios than mammals that inhabit the downstream section consisting of the deltaic area and the overbank areas. Therefore, risk estimates are derived separately for these two areas.

Risks for these receptors were evaluated using simple deterministic food-web exposure models consistent with EPA's wildlife exposure guidance (U.S. EPA 1997; 61 Fed. Reg. 47552). The food-web model estimates dietary exposure as a body-weight-normalized total daily dose for each receptor species. The general structure of the food-web exposure model is described by the following equation:

$$IR_{chemical} = \frac{\sum_i (C_i \times M_i \times A_i \times F_i)}{W}$$

where:

$IR_{chemical}$ = total ingestion rate of chemical from all dietary components (mg dry weight/kg body weight-day)

C_i = concentration of the chemical in a given dietary component or inert medium (mg/kg dry weight)

M_i = rate of ingestion of dietary component or inert medium (kg dry weight/day)

A_i = relative gastrointestinal absorption efficiency for the chemical in a given dietary component or inert medium (fraction)

F_i = fraction of the daily intake of a given dietary component or inert medium derived from the Site (unitless time-use or area-use factor)

W = body weight of receptor species (kg).

The evaluation provides risk estimates (expressed as hazard quotients) using current research findings on lead toxicity, conventional risk-based assumptions for certain parameters, and reasonably conservative assumptions for other input parameters. The parameter assumptions used in the evaluation are as follows:

- Soil lead concentration: The 95-percent UCL arithmetic mean soil lead concentrations are used. Summary statistics on lead concentrations for all areas are presented in Table G-4.

- Earthworm bioaccumulation factor (BAF): Lead concentrations have not been measured in worms or other invertebrates present in the OCA. Earthworms, along with aboveground insects, can constitute a large proportion of the diet of short-tailed shrews (U.S. EPA 1993). Since lead bioaccumulation from soils is likely to be greater in worms than in ground-dwelling insects, the food-web model conservatively assumes that worms constitute 100 percent of the shrew diet. A recent study developed and validated bioaccumulation models for earthworms exposed to a variety of metals (including lead) and organic compounds in soil (Sample et al. 1998). This study developed a highly significant ($p = 0.0001$) regression equation to predict lead concentrations in worms from concentrations in soil. Sample et al. (1998) recommend that the 90th percentile BAF based on the combined model and validation sets in that study be used as the soil-to-earthworm uptake factor for conservative screening assessments. This represents a BAF of 1.52, which is used in the shrew food-web models.

- Plant BAF: White footed-mice are omnivorous, but plant components are often a major part of the diet (U.S. EPA 1993), and this species is selected as a representative small mammal receptor that potentially consumes plant material in the OCA. Lead concentrations in plants are estimated from soil concentrations by using a BAF of 0.074 calculated from a study of lead accumulation in plants from soil (Garcia et al. 1974).

- Wet-weight food concentrations: The bioaccumulation model of Sample et al. (1998) calculates dry weight lead concentrations in worms from dry lead soil concentrations. Similarly, the BAF calculated from Garcia et al. (1974) is based on a comparison of dry-weight concentrations in plants and in soil. Food ingestion rates (see next bullet) for both the shrew and mouse are estimated on a live-weight (i.e., wet-weight) basis, so the predicted lead concentrations in worms and plants need to be converted to wet-weight values to be consistent with format used to estimate the intake dose from food. To perform the conversions, it is assumed that moisture content for earthworms is 84 percent and that representative moisture content for plants

is 80 percent. Both moisture content values are derived from data reported by U.S. EPA (1993).

- Food ingestion rates: Food ingestion rates for the short-tailed shrew and white-footed mouse use values recommended by OEPA (2003). Specifically, the food ingestion rate for short-tailed shrews is 0.56 kg food consumed (wet-weight)/kg body weight-day, and the ingestion rate for white-footed mice is 0.27 kg/kg-day, based on the consumption rate for deer mice, which belong to the same taxonomic genus as white-footed mice.

- Soil ingestion rates: Soil ingestion rates are based on values recommended by OEPA (2003). The rate of incidental soil ingestion equals 6.0 percent of the daily food ingestion rate for shrews and 2.0 percent for white-footed mice (both values expressed on a dry-weight basis).

- Daily exposure from food: Daily exposure from food is calculated by multiplying the estimated wet-weight concentration of lead in food (worms or plants) by the appropriate food ingestion rate for each receptor.

- Daily exposure from soil: Daily exposure from soil is calculated by multiplying the estimated dry-weight concentration of lead in soil by the appropriate soil ingestion rate for each receptor.

- Time use factors: Within the upper creek, small mammals are more likely to forage along the banks of the incised channel than in the bottom area where the creek meanders, due to the presence of vegetative cover on the banks and soil that is not permanently wet. Similarly, in the downstream area, mammals are less likely to occur in the deltaic area than in the overbank area, as the former is prone to regular flooding that renders the area periodically uninhabitable. Therefore, in the upper creek area the assumption is that small mammals forage 90 percent of the time within the area of the creek banks and only 10 percent of the time in the creek channel. In the downstream area, mammals are assumed to forage 90 percent of the time in the overbank area and 10 percent of the time in the deltaic area. Within either area, hazard quotients are summed to determine the overall risk to small mammal receptors that potentially forage across both habitats. However, because these habitat features represent current conditions that could change in future, OEPA has requested the Respondents to also conduct a risk evaluation for scenarios where receptors spend their entire time within any one of the four areas (i.e., a time use factor of 1.0). In this case, because receptors do not forage across areas, there is no need to sum hazard quotients, and results are displayed separately for each of the four habitat areas.

- Lead bioavailability: 100 percent of the lead in soil (a portion of which is bound in an inert glassy matrix) is assumed to be bioavailable.

- Lowest-observed-adverse-effect level (LOAEL) and no-observed-adverse-effect level (NOAEL): The LOAEL and NOAEL values are derived from a

study on rats by Azar et al. (1973) that examined effects on ecologically relevant endpoints (reproductive performance) in a three-generational study. Five lead dose levels (10, 50, 100, 1,000, and 2,000 ppm) were tested. None of the lead dose levels affected the number of pregnancies, number of live births, or other reproductive indices. The two highest doses reduced offspring weights and produced kidney damage in young. Reduced offspring weight could potentially be an ecologically significant outcome in wild small mammal populations if it were to lead to reduced likelihood of survival of young. Therefore, 1,000 mg/kg lead in food (which corresponds to a TRV of 80 mg/kg-day, as calculated by Sample et al. 1996) was considered to represent the LOAEL. The NOAEL was 100 mg/kg lead in food, which corresponds to a TRV of 8 mg/kg-day.

Results of the food-web models using these assumptions are shown in Tables G-5 and G-6 for the upper creek area and downstream OCA, respectively. Models indicate that the likelihood of adverse effects on white-footed mice is minimal in both locations when they are assumed to forage across two habitat locations, as all hazard quotients are less than 1.0 based on comparison of exposure estimates to both the LOAEL- and NOAEL-based TRVs. However, if white-footed mice are assumed to forage exclusively within any one location, hazard quotients exceed 1.0 based on comparison to the NOAEL-based TRVs for the upper creek channel and deltaic areas, although hazard quotients are less than 1.0 when compared to the LOAEL-based TRVs. All hazard quotients for the upper creek overbank area and the downstream overbank area are less than 1.0 based on comparison of exposure estimates to both the LOAEL- and NOAEL-based TRVs. These results indicate a possibility of adverse effects to white-footed mice foraging exclusively in either the upper creek channel or deltaic areas. However, because exposures are less than the lowest observed effect thresholds from laboratory studies, the likelihood of effects or their potential ecological significance is uncertain.

For short-tailed shrews, hazard quotients exceed 1.0 based on comparison to the LOAEL-based TRVs, and exceed 10 based on comparison to the NOAEL-based TRVs if shrews are assumed to forage across two habitat locations. Results are comparable if shrews are assumed to forage exclusively within one habitat location, except for the downstream overbank area where the hazard quotient is below 1.0 in comparison to the LOAEL-TRV and below 10 in comparison to the NOAEL-TRV. These results indicate that possibility of adverse risk to shrews cannot be eliminated on the basis of the conservative screening models. Several sources of uncertainty may affect the risk estimates presented in this evaluation. A major source of uncertainty in the risk estimates for shrews arises from the equations used to estimate lead uptake by worms. As noted by Sample et al. (1998), empirical data indicate that lead bioaccumulation by earthworms is non-linear, and decreases as soil concentration increases, whereas point-value BAFs implicitly assume that accumulation is linear and constant across all soil concentrations. Sample et al. (1998) noted that where conservative estimates are desired, the 90th percentile BAF is recommended for lead, corresponding to a value of 1.52, as used in the food-web models presented above. However, for more general assessments, they recommend the use of log-linear regression models to estimate earthworm bioaccumulation. For lead, the appropriate regression equation is ln(earthworm) = –0.218 + 0.807*(ln[soil]), as shown in Table 12 of Sample et al. (1998). In Table G-7, food-web models are reanalyzed for the shrew in the upper creek area and

in the OCA using this equation to estimate worm lead concentrations, while retaining all other exposure and effects parameters. As shown, this results in hazard quotients less than 1.0 in both areas when based on the LOAEL TRV for shrews that potentially forage across habitat locations. Hazard quotients are also less than 1.0 for shrews foraging exclusively within one habitat location, except in the deltaic area. There the LOAEL TRV hazard quotient is 1.2. Hazard quotients based on the NOAEL TRV range up to 12, and are greater than 1.0 for all scenarios except when a shrew forages exclusively in the downstream overbank area. For purposes of the uncertainty evaluation, arithmetic mean soil concentrations can be used in place of 95-percent UCL values, as they are more representative of what a receptor is exposed to as they forage across the entire Site. In this analysis, none of the hazard quotients based on the LOAEL TRV exceed 1.0, although hazard quotients based on the NOAEL do exceed 1.0 for shrews foraging exclusively in the upper creek channel or deltaic areas, or across the deltaic area and downstream overbank area (Table G-8).

A factor that suggests that results presented in Tables G-5 and G-6 overestimate risk is that no adjustment was made to account for the bioavailability of lead in soil or in prey. The exposure estimates presented in the table assume that 100 percent of lead in soil is available for uptake by prey (earthworms and plants) and that 100 percent of the lead in prey is absorbed by the small mammal receptors that consume these prey items. Both these assumptions are very conservative and result in overestimation of exposure to lead, and hence the overestimation of risk.

An additional uncertainty regarding bioavailability is associated with the study by Azar et al. (1973) that was used to develop the TRV. In that study, animals were fed lead in the diet in the form of lead acetate. Although the bioavailability of that form of lead was not measured by the authors of the study, other investigations have shown that lead acetate is 10-15 times more bioavailable than lead bound in a soil matrix (Freeman et al. 1992, 1996). Consequently, a TRV based on lead acetate underestimates the actual toxicity threshold for small mammals at the OCA that incidentally ingest lead in soil. In other words, since lead in soil is less bioavailable than lead acetate salt, the NOAEL-based TRV for small mammals ingesting soil is likely greater than 8 mg/kg-day. Therefore, the selected TRVs are likely lower than the actual toxic effect level of lead in soil, and hence the magnitude of risk is overestimated.

Based on the most conservative screening approach, risks to herbivorous mammals, as represented by the white-footed mouse, are minimal, as LOAEL-based hazard quotients are less than 1.0 in both the upper creek and deltaic area for mice foraging either across habitat locations, or exclusively within one location. Conservative screening models indicate a potential for adverse effects on worm-eating mammals, as represented by the shrew, as hazard quotients exceed 1.0 at both locations. However, considerable uncertainty exists in this conclusion due to the probable overestimation of lead bioavailability in soil, the probable overestimation of lead uptake from soil by worms using a fixed BAF, and the probable under-estimation of the likely effect level due to the higher bioavailability of the form of lead used in the study that is the basis of the TRV. Together, all three of these factors are likely to overestimate risk to shrews. Models that use a more general estimate of earthworm bioaccumulation based on a highly significant regression equation, but that still make no adjustment for lead bioavailability, indicate that the likelihood of adverse effects is minimal, as hazard quotients based on the LOAEL TRV (the threshold above which adverse effects begin to

occur) is less than 1.0 in all cases except for shrews foraging exclusively in the deltaic area, where the hazard quotient (1.2) is slightly greater than 1.0. Furthermore, the limited spatial extent of the upper creek and deltaic areas suggests that only a few shrews would be present in those locations, and that population-level effects, if any, would be minimal. Given the uncertainties, these food-web analyses indicate that the lead in soil/sediments at the OCA and the upper creek area do not present an unacceptable population-level risk to the small mammal receptors, as represented by the white-footed mouse and short-tailed shrew, although a limited number of individual organisms of these species could potentially be affected by lead concentrations as food web exposure models indicate hazard quotients above unity. Based on these evaluations, no further ecological assessment for the OCA is recommended.

Sediment Bioassays

As discussed above, based on their new ERA guidance methods released subsequent to the initial drafting of the ERA, OEPA requested that bioassays be conducted to evaluate toxicity of sediments in the OCA to aquatic macroinvertebrates. GE submitted a work plan for the study on May 1, 2007 (Exponent 2007), which was approved by OEPA on May 3, 2007.

Potential sediment sampling locations were selected based on previously collected data with the intent to obtain samples that span the range of lead concentrations present in sediments in the OCA. Three samples were targeted for the concentration range of less than 40 ppm lead, three samples for the concentration range of 40–400 ppm lead, three samples for the concentration range 400–800 ppm lead; and three samples for concentrations greater than 800 ppm lead. All sediment samples were chemically characterized to verify target lead concentrations before selecting samples for testing in the bioassay. All samples were also analyzed for four other metals (cadmium, copper, nickel, zinc), AVS/SEM, TOC, and grain size. To ensure that sufficient samples were available for each sample range, 25 sediment samples were collected in the initial phase of sampling. However, because the first set did not include enough samples with suitable concentrations exceeding 800 ppm lead, a second sampling event was conducted to collect an additional 10 samples. Complete analytical results for all samples are provided in Table G-9. Based on a review of the lead, the following locations were selected for sediment bioassays (grouped by target concentration range from lowest to highest): T-BG-3A, T-BG-4A, and T-BG-5-OB1R; T-6A, T-OCA-2-C2L, and TOCA-20-A; OS-2, T-OCA-26-OB1R, T-OCA-34-OB1R; and C-OCA-15, C-OCA-16, and T-OCA-14-C1R.

Selected samples were assayed using two standard toxicity tests; a 28-day *Hyalella azteca* survival and growth test and a 10-day *Chironomus tentans* survival and growth test. Both tests were based on U.S. EPA (2000) guidelines. Springborn Smithers Laboratories in Wareham, Massachusetts, conducted the toxicity tests. Their final reports on the tests are included as attachments to this appendix.

As reported in the laboratory's summary report, no significant effects were seen on *Chironomus* growth or survival at any lead concentration, up to the maximum concentration tested (3,180 mg/kg). The laboratory summary report for the *Hyalella* assays reports no significant effect on *Hyalella* survival at any concentration up to the maximum tested concentration. The laboratory did detect a significant reduction in growth of *Hyalella* in sample C-OCA-15, which

had a lead concentration of 1,570 mg/kg (the second highest concentration tested). However, this effect does not appear to be a result of lead, as the sample with the highest lead concentration (T-OCA-14-C1R) had survival and growth rates that were statistically indistinguishable from the control sample, indicating a lack of a dose-response relationship. Overall, despite the one indication of reduced growth in *Hyalella*, these results indicate that lead in the OCA has no adverse effects on benthic invertebrates at concentrations up to 3,180 mg/kg.

Evaluation of the Need for a Phase II Ecological Risk Assessment

Habitats on and around the Thomson Consumer Electronics property were evaluated with regard to habitat quality and extent, potential ecological receptors, PCoIs, and exposure pathways. Conclusions of the evaluation are that:

- Only terrestrial environments are of concern
- The EFA and OCA are the only areas of interest with habitats under consideration
- Lead is the only CoI for potential ecological receptors
- The only relevant exposure routes for potential receptors are the food ingestion and incidental soil ingestion pathways.

The conclusion that environmental concentrations of lead on the EFA and OCA do not pose a significant ecological risk to receptor populations is based on the integration of several factors. These factors include the overall habitat quality and distribution of lead at the EFA and OCA, size of receptor home ranges relative to the size of the EFA and OCA, proportion of the receptor population potentially affected by exposure to lead, bioavailability of lead, toxicity of lead to the receptors, and quantitative food-web exposure models for the most highly exposed receptors. Based the following information, it is concluded that a Phase II ecological assessment is not necessary:

- Use of the EFA and OCA by receptors is limited by the physical extent of available habitat. The total area of the EFA is less than 5 acres and the area of the OCA does not exceed 12 acres, including the triangular deltaic area, upper creek, and farm ditch. Both areas of interest are small relative to the areas used by most of the receptors. Exposures will not be significant as individuals of most receptors will spend only a minor portion of their time in the affected areas of the OCA. In addition, PCoI-bearing materials at the EFA (glass polishing fines) are present generally in subsoils below an approximate 2-ft soil cover. Thus, the frequency, magnitude, and duration of potential exposure are expected to be low.
- Substantially elevated lead concentrations occur in a limited portion of the OCA. For example, elevated lead concentrations in the OCA are confined to

the channel portion of the upper creek, the deltaic area, and limited overbank deposits along the farm ditch. In total, these areas comprise approximately 2 acres.

- Physical stressors influence the physical habitat and receptors on the OCA. Periodic or seasonal flooding of the OCA, maintenance of the farm ditch, and construction of a physical barrier (i.e., flood gate) on the downstream portion of the farm ditch significantly alter the ecology of the OCA.

- The OCA receives lead and other chemicals from sources unrelated to the Thomson Site. Offsite sources include storm water runoff from commercial and residential areas, agricultural runoff from nearby farm fields, sewage treatment plant effluent from the EHWD, and sediment deposition from the Scioto River during major flood events.

- The offsite creek and farm ditch have been designated by OEPA as a "limited resource water" (OAC 3745-1-09). OEPA has determined that the aquatic habitat of the OCA is of poor quality and future conditions will remain poor because of regular channel maintenance necessary to maintain the drainage system of the adjacent agricultural field. This designation also reflects the fact that the offsite creek and farm ditch receive discharges from multiple municipal and industrial sources.

- Sorption capacity of soil and sediments for lead is expected to be high because of the presence of iron and manganese hydrous oxides and sulfides, clays, and organic matter.

- The bioavailability of lead to receptor species in soil, surface water, and sediments of the OCA is expected to be low because of the low solubility of forms of the lead and the presence of cations in soil that control dissolution in the gastrointestinal tract.

- The absence of stressed vegetation noted in both the EFA and the OCA during field reconnaissance surveys provides a qualitative line-of-evidence to suggest that elevated lead concentrations in soil and sediments in these habitats are not phytotoxic, although Site-specific phytotoxicity data are not available. In addition, the bioavailability of lead in soils to plants, and hence to plant-eating mammals, is expected to be low because lead does not readily translocate to plants.

- Food-web models developed using species-specific screening criteria and conservative exposure assumptions regarding lead bioavailability and bioaccumulation indicate that soil lead concentrations in the OCA do not represent a significant population-level risk to ecological receptors.

- Toxicity testing indicates that lead concentrations up to 3,180 mg/kg in sediment have no adverse effects on growth or survival of two invertebrate species, *Hyalella azteca* and *Chironomus tentans.*

The conclusion of this Phase I EA is that a Phase II EA or environmental baseline risk assessment is not necessary. The areas of interest comprise only a minor portion of the home ranges of the larger receptors and thus the major exposure pathway (i.e., food ingestion) is unlikely to result in any significant exposure. Food-web models analyzed for small mammals indicate that the likelihood of population-level effects for these receptors is low. Toxicity tests indicate that the likelihood of adverse effects of lead in sediments to benthic invertebrates is very low. For the EFA and OCA, the isolated media or small area affected by elevated lead concentrations, and the effect of physical stressors on the OCA environment, argue against the potential for ecological risk. In addition, a review of the current data on geochemical characteristics controlling solubility and bioavailability of lead at the OCA support the conclusion that lead in the environment of the EFA and OCA is not highly bioavailable or readily taken up and incorporated by plants and animals. Thus, it is unlikely that lead concentrations in environmental media of these onsite or offsite areas of interest pose a significant ecological risk to receptors.

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Figure

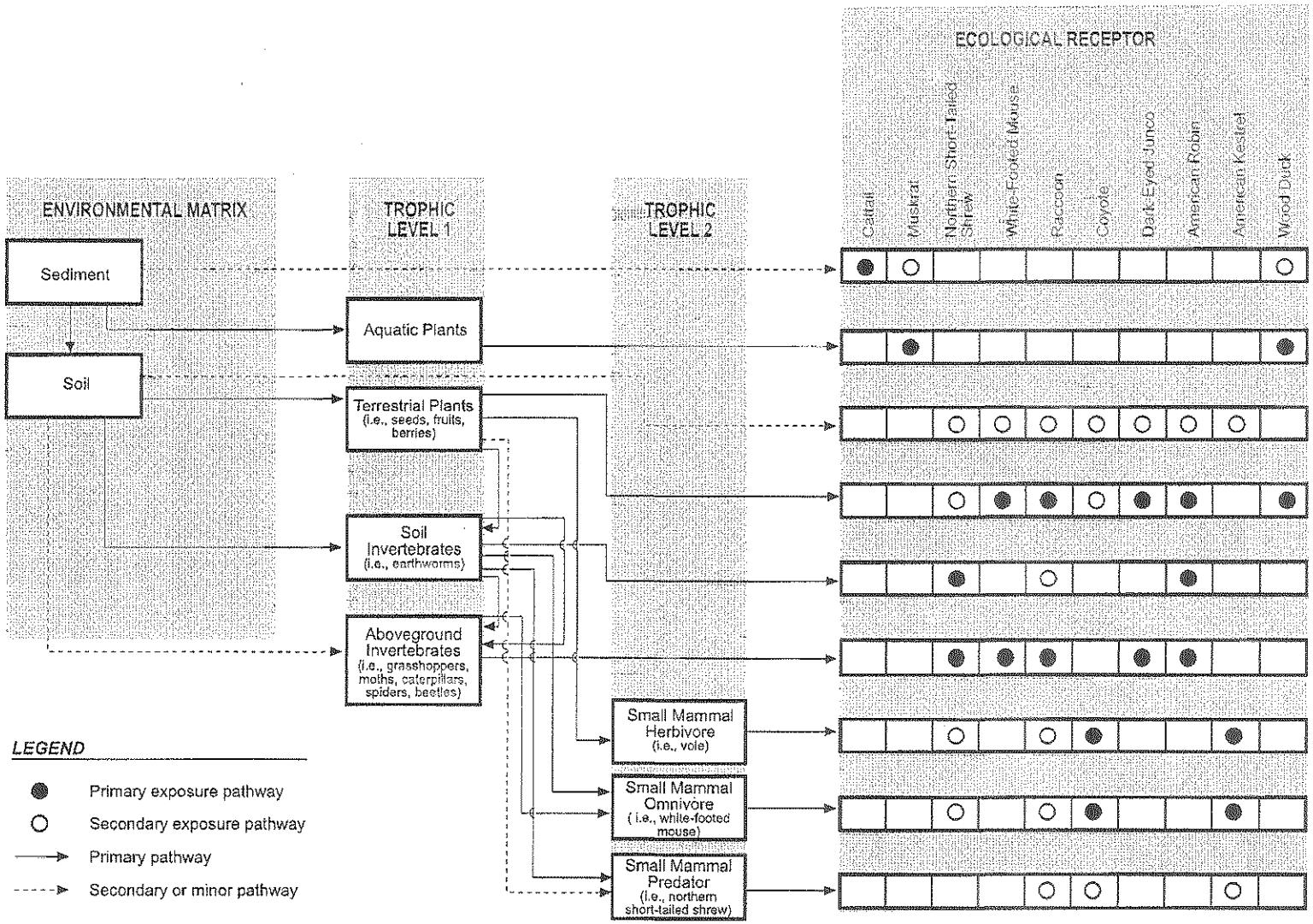

Figure G-1. Ecological conceptual site model for the EFA and OCA of the Thomson Consumer Electronics site, Circleville, Ohio.

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Tables

Table G-1. Vertebrate species identified in the Offsite Creek Area

Family	Common Name	Scientific Name
Amphibians		
Ranidae	Green frog	*Rana clamitans*
Birds		
Anatidae	Wood duck	*Aix sponsa*
Accipitridae	Red-tailed hawk	*Buteo jamaicensis*
Charadriidae	Killdeer	*Charadrius vociferus*
Columbidae	Mourning dove	*Zenaida macroura*
Alcedinidae	Belted kingfisher	*Megaceryle alcyon*
Picidae	Northern flicker	*Colaptes auratus*
	Pileated woodpecker	*Dryocopus pileatus*
Tyrannidae	Great crested flycatcher	*Myiarchus crinitus*
	Eastern wood peewee	*Contopus virens*
	Willow flycatcher	*Empidonax traillii*
Corvidae	American crow	*Corvus brachyrhynchos*
	Blue jay	*Cyanocitta cristata*
Troglodytidae	Carolina wren	*Thryothorus ludovicianus*
Paridae	Tufted titmouse	*Parus bicolor*
Muscicapidae	Wood thrush	*Hylocichla mustelina*
	American robin	*Turdus migratorius*
Mimidae	Gray catbird	*Dumetella carolinensis*
Vireonidae	Red-eyed vireo	*Vireo olivaceous*
Emberizidae	Northern cardinal	*Cardinalis cardinalis*
	Rufous-sided towhee	*Pipilo erythophthalmus*
	Song sparrow	*Melospiza melodia*
	Red-winged blackbird	*Agelaius phoeniceus*
	Dark-eyed junco	*Junco hyemalis*
Fringillidae	American goldfinch	*Carduelis tristis*
Mammals		
Sciuridae	Woodchuck	*Marmota monax*
Cervidae	White-tailed deer	*Odocoileus virginianusa*
Canidae	Coyote	*Canis latrans*
Procyonidae	Raccoon	*Procyon lotor*
Castoridae	Beaver	*Castor canadensisa*
Cricetidae	Muskrat	*Ondatra zibethicus*

[a] Presence indicated by signs; not directly observed.

Table G-2. Plant species identified in the Offsite Creek Area on September 26, 1992

Scientific Name	Scientific Name
Abutilon theophrasti	*Lycopus uniflorus*
Acer negundo	*Lysimachia nummularia*
Acer saccharum	*Menispermum canadense*
Acer saccharinum	*Mollugo verticillata*
Aesculus glabra	*Morus rubra*
Alisma subcordatum	*Morus alba*
Allium canadense	*Nepeta cataria*
Amaranthus tuberculatus	*Oxalis stricta*
Apocynum cannabinum	*Panicum capillare*
Asarum canadense	*Panicum dichotomiflorum*
Asimina triloba	*Parthenocissus quinquefolium*
Aster flexicaulis	*Physalis subglabrata*
Aster simplex	*Phytolacca americana*
Berteroa incana	*Pilea pumila*
Bidens frondosa	*Polygonum amphibium*
Bidens comosa	*Polygonum punctatum*
Bidens cernua	*Polygonum pensylvanicum*
Boehmeria cylindrica	*Polygonum hydropiperoides*
Brassica rapa	*Portulaca oleracea*
Campsis radicans	*Quercus borealis*
Capsella bursa-pastoris	*Quercus alba*
Carduus acanthoides	*Ranunculus sceleratus*
Carex grayii	*Ranunculus abortivas*
Carex plantaginea	*Rorippa sessiliflora*
Celtis occidentalis	*Rosa sp.*
Cephalanthus occidentalis	*Rosa multiflora*
Cercis canadensis	*Rudbeckia laciniata*
Chaenorrhinum minus	*Rumex verticillatus*
Chenopodium album	*Salix nigra*
Conium maculatum	*Salix exigua*
Cornus racemosa	*Saururus cernuus*
Cyperus esculentus	*Scirpus fluviatilis*
Cyperus strigosus	*Scrophularia marilandica*
Datura stramonium	*Scutellaria lateriflora*
Daucus carota	*Sedum ternatum*
Echinochloa crusgalli	*Senecio glabellus*
Eclipta prostrata	*Setaria faberii*
Eclipta alba	*Setaria viridis*
Euonymus atropurpureus	*Sicyos spp.*
Eupatorium rugosum	*Sicyos angulatus*
Euphorbia (Chamaesyce) nutaus	*Sida spinosa*
Euphorbia (Chamaesyce) serpens	*Solanum ptycanthum*
Galinsoga quadriradiata	*Solidago flexicaulis*
Galium circaezans	*Solidago canadensis*
Gavoderma lucidum	*Sorghum halepense*
Geranium carolinianum	*Stellaria media*
Geum virginianum	*Tanacetum vulgare*
Gleditsia triacanthos	*Tilia americana*
Hepatica acutiloba	*Tovara virginiana*
Impatiens pallida	*Triosteum aurantiacum*
Ipomoea hederacea	*Typha spp.*
Ipomoea pandurata	*Ulmus rubra*
Ipomoes lacunosa	*Verbesina alternifolia*
Lamium amplexicaule	*Viola spp.*
Lamium purpureum	*Viola sororia*
Laportea canadensis	*Vitis riparia*
Leersia virginica	*Vitis sp.*
Leersia oryzoides	*Xanthium strumarium*
Leucospora multifida	*Xanthoxylum americanum*
Lycopersicon esculentum	

Table G-3. Potential ecological receptors for the East Fenced Area and Offsite Creek Area

	Area of Interest	
	East Fenced Area	Offsite Creek Area
Cattail *Typha latifolia*		●
Muskrat *Ondatra zibethica*		●
Northern short-tailed shrew *Blarina brevicauda*	●	●
White-footed mouse *Peromyscus maniculatus*	●	●
Raccoon *Procyon lotor*	●	●
Coyote *Canis latrans*	●	●
Dark-eyed junco *Junco hyemalis*	●	
American robin *Turdus migratorius*	●	●
American kestrel *Falco sparverius*	●	
Wood duck *Aix sponsa*		●

Table G-4. Summary statistics of lead concentrations in the upper creek, deltaic, and downstream overbank areas

Area	No. Depths	No. Locations	Min	Max	Median	Geometric Mean	Arithmetic Mean	Stdev	Skewness	Pro-UCL Recommendation	95% UCL on Arithmetic Mean
Upper creek channel	59	59	8.6	7,820	204	263	1,084	1,746	2.143	Land's H-stat	3,339
Upper creek overbank	15	15	18	1,020	25.9	38.2	99.2	255	3.846	99% Chebyshev (Mean, Sd)	755
Deltaic area	100	97	10.2	12,100	1,100	582	2,200	2,875	1.571	99% Chebyshev (Mean, Sd)	5,105
Downstream overbank	244	244	8.4	728	70.2	76.7	127	145	2.202	Land's H-stat	144

Note: All concentrations are shown in mg/kg.

Includes all samples with >50% of depths within the 0–6 in. interval.

Multiple depth intervals at a single location were averaged prior to averaging within areas.

Table G-5. Food-web risk evaluation for small mammal receptors in the upper creek area based on 95 percent UCL on arithmetic mean soil lead concentration

Receptor/Location	95% UCL Soil Concentration (mg/kg, dw)	Estimated Worm Concentration from Bioaccumulation Model[a] (mg/kg, dw)	Plant Bioaccumulation Factor[b]	Wet Weight Concentration in Food[c] (mg/kg, ww)	Food Ingestion Rate[d] (kg/kg BW-d)	Soil Ingestion Rate[e] (kg/kg BW-d)	Daily Exposure from Food (mg/kg BW-d)	Daily Exposure from Soil (mg/kg BW-d)	Time Use Factor
Short-tailed shrew									
Upper creek channel	3,339	5,075.91		812.1	0.56	0.0054	454.8	18.0	0.1
Upper creek overbank	755	1,147.57		183.6	0.56	0.0054	102.8	4.06	0.9
Upper creek channel only	3,339	5,075.91		812.1	0.56	0.0054	454.8	18.0	1.0
Upper creek overbank only	755	1,147.57		183.6	0.56	0.0054	102.8	4.06	1.0
White-footed mouse									
Upper creek channel	3,339		0.074	49.4	0.27	0.0011	13.3	3.6	0.1
Upper creek overbank	755		0.074	11.2	0.27	0.0011	3.0	0.82	0.9
Upper creek channel only	3,339		0.074	49.4	0.27	0.0011	13.3	3.6	1.0
Upper creek overbank only	755		0.074	11.2	0.27	0.0011	3.0	0.82	1.0

Table G-5. (cont.)

Receptor/Location	Time-weighted Daily Dose from Food and Soil (mg/kg BW-d)	LOAEL[f] (mg/kg/d)	Hazard Quotient Based on LOAEL[g]	NOAEL[f] (mg/kg/d)	Hazard Quotient Based on NOAEL[g]
Short-tailed shrew					
Upper creek channel	47.28	80.0	0.59	8.0	5.9
Upper creek overbank	96.19	80.0	1.20	8.0	12.0
	Total Hazard Quotient:		**1.79**		**17.9**
Upper creek channel only	472.75	80.0	5.91	8.0	59.1
Upper creek overbank only	106.88	80.0	1.34	8.0	13.4
White-footed mouse					
Upper creek channel	1.70	80.0	0.02	8.0	0.21
Upper creek overbank	3.45	80.0	0.04	8.0	0.43
	Total Hazard Quotient:		**0.06**		**0.64**
Upper creek channel only	16.95	80.0	0.21	8.0	2.1
Upper creek overbank only	3.83	80.0	0.05	8.0	0.5

Note: Dry to wet weight conversion: (dry weight)*(1-percent moisture) = wet weight.

BW - body weight
d - day
dw - dry weight
ww - wet weight

[a] Based on 90th percentile UF (1.52) in Table 11 of Sample et al. (1998).

[b] From Garcia et al. (1974).

[c] Wet weights were converted from dry weight values that were predicted by the bioaccumulation model (earthworms) or the BAF (plants). Percent moisture of 84 percent for earthworms and 80 percent for plants were used based on data in U.S. EPA (1993).

[d] Based on OEPA recommended values.

[e] Soil ingestion rate calculated by multiplying the dry weight soil concentration by 6 percent of daily food ingestion rate for shrews or 2 percent of the daily food ingestion for white-footed mice (converted to a dry weight basis).

[f] Based on Azar et al. (1973).

[g] Hazard quotient calculated by dividing dose by LOAEL or NOAEL.

Table G-6. Food-web risk evaluation for small mammal receptors in the deltaic and downstream overbank areas based on 95 percent UCL on arithmetic mean soil lead concentrations

Receptor/ Location	95% UCL Soil Concentration (mg/kg, dw)	Estimated Worm Concentration from Bioaccumulation Model[a] (mg/kg, dw)	Plant Bioaccumulation Factor[b]	Wet Weight Concentration in Food[c] (mg/kg, ww)	Food Ingestion Rate[d] (kg/kg BW-d)	Soil Ingestion Rate[e] (kg/kg BW-d)	Daily Exposure from Food (mg/kg BW-d)	Daily Exposure from Soil (mg/kg BW-d)	Time Use Factor
Short-tailed shrew									
Deltaic area	5,105	7,759.60		1241.5	0.56	0.0054	695.3	27.4	0.1
Downstream overbank area	144	218.88		35.0	0.56	0.0054	19.6	0.77	0.9
Deltaic area only	5,105	7,759.60		1241.5	0.56	0.0054	695.3	27.4	1.0
Downstream overbank only	144	218.88		35.0	0.56	0.0054	19.6	0.77	1.0
White-footed mouse									
Deltaic area	5,105		0.074	75.6	0.27	0.0011	20.4	5.5	0.1
Downstream overbank area	144		0.074	2.1	0.27	0.0011	0.6	0.16	0.9
Deltaic area only	5,105		0.074	75.6	0.27	0.0011	20.4	5.5	1.0
Downstream overbank only	144		0.074	2.1	0.27	0.0011	0.6	0.16	1.0

Table G-6. (cont.)

Receptor/ Location	Time-weighted Daily Dose from Food and Soil (mg/kg BW-d)	LOAEL[f] (mg/kg/d)	Hazard Quotient Based on LOAEL[g]	NOAEL[f] (mg/kg/d)	Hazard Quotient Based on NOAEL[g]
Short-tailed shrew					
Deltaic area	72.27	80.0	0.90	8.0	9.0
Downstream overbank area	18.35	80.0	0.23	8.0	2.3
	Total Hazard Quotient:		**1.13**		11.3
Deltaic area only	722.70	80.0	9.0	8.0	90.3
Downstream overbank only	20.39	80.0	0.25	8.0	2.5
White-footed mouse					
Deltaic area	2.59	80.0	0.032	8.0	0.32
Downstream overbank area	0.66	80.0	0.008	8.0	0.08
	Total Hazard Quotient:		**0.04**		0.41
Deltaic area only	25.91	80.0	0.32	8.0	3.2
Downstream overbank only	0.73	80.0	0.009	8.0	0.09

Note: Dry to wet weight conversion: (dry weight)*(1-percent moisture) = wet weight.

BW - body weight
d - day
dw - dry weight
ww - wet weight

[a] Based on 90th percentile UF (1.52) in Table 11 of Sample et al. (1998).

[b] From Garcia et al. (1974).

[c] Wet weights were converted from dry weight values that were predicted by the bioaccumulation model (earthworms) or the BAF (plants). Percent moisture of 84 percent for earthworms and 80 percent for plants were used based on data in U.S. EPA (1993).

[d] Based on OEPA recommended values.

[e] Soil ingestion rate calculated by multiplying the dry weight soil concentration by 6 percent of daily food ingestion rate for shrews or 2 percent of the daily food ingestion for white-footed mice (converted to a dry weight basis).

[f] Based on Azar et al. (1973).

[g] Hazard quotient calculated by dividing dose by LOAEL or NOAEL.

Table G-7. Food-web risk evaluation for shrews in the upper creek, deltaic, and downstream overbank areas based on 95 percent UCL on arithmetic mean soil lead concentrations and earthworm uptake regression equation from Sample et al. (1998)

Receptor/Location	95% UCL Soil Concentration (mg/kg, dw)	Estimated Worm Concentration from Bioaccumulation Model[a] (mg/kg, dw)	Wet Weight Concentration in Food[b] (mg/kg, ww)	Food Ingestion Rate[c] (kg/kg BW-d)	Soil Ingestion Rate[d] (kg/kg BW-d)	Daily Exposure from Food (mg/kg BW-d)	Daily Exposure from Soil (mg/kg BW-d)	Time Use Factor
Short-tailed shrew								
Upper creek channel	3,339	560.95	89.8	0.56	0.0054	50.3	18.0	0.1
Upper creek overbank	755	168.97	27.0	0.56	0.0054	15.1	4.06	0.9
Upper creek channel only	3,339	560.95	89.8	0.56	0.0054	50.3	18.0	1.0
Upper creek overbank only	755	168.97	27.0	0.56	0.0054	15.1	4.06	1.0
Deltaic area	5,105	790.09	126.4	0.56	0.0054	70.8	27.4	0.1
Downstream overbank area	144	44.37	7.1	0.56	0.0054	4.0	0.77	0.9
Deltaic area only	5,105	790.09	126.4	0.56	0.0054	70.8	27.4	1.0
Downstream overbank only	144	44.37	7.1	0.56	0.0054	4.0	0.77	1.0

Table G-7. (cont.)

Receptor/Location	Time-weighted Daily Dose from Food and Soil (mg/kg BW-d)	LOAEL[e] (mg/kg/d)	Hazard Quotient Based on LOAEL[f]	NOAEL[e] (mg/kg/d)	Hazard Quotient Based on NOAEL[f]
Short-tailed shrew					
Upper creek channel	6.82	80.0	0.09	8.0	0.85
Upper creek overbank	17.28	80.0	0.22	8.0	2.16
	Total Hazard Quotient:		**0.30**		**3.01**
Upper creek channel only	68.21	80.0	0.85	8.0	8.5
Upper creek overbank only	19.20	80.0	0.24	8.0	2.4
Deltaic area	9.82	80.0	0.12	8.0	1.2
Downstream overbank area	4.27	80.0	0.053	8.0	0.53
	Total Hazard Quotient:		**0.18**		**1.76**
Deltaic area only	98.24	80.0	1.2	8.0	12.3
Downstream overbank only	4.75	80.0	0.059	8.0	0.59

Note: Dry to wet weight conversion: (dry weight)*(1-percent moisture) = wet weight

BW - body weight
d - day
dw - dry weight
ww - wet weight

[a] Based on relationship in Table 12 of Sample et al. (1998), where: **ln[earthworm] = -0.218 + 0.807(ln[soil])**.

[b] Wet weights were converted from dry weight values that were predicted by the bioaccumulation model Percent moisture of 84% for earthworms was used based on data in U.S. EPA (1993).

[c] Based on OEPA recommended values.

[d] Soil ingestion rate calculated by multiplying the dry weight soil concentration by 6% of daily food ingestion rate (converted to a dry weight basis).

[e] Based on Azar et al. (1973).

[f] Hazard quotient calculated by dividing dose by LOAEL or NOAEL.

Table G-8. Food-web risk evaluation for shrews in the upper creek, deltaic, and downstream overbank areas based on arithmetic mean soil lead concentrations and earthworm uptake regression equation from Sample et al. (1998)

Receptor/Location	Arithmetic Mean Soil Concentration (mg/kg, dw)	Estimated Worm Concentration from Bioaccumulation Model[a] (mg/kg, dw)	Wet Weight Concentration in Food[b] (mg/kg, ww)	Food Ingestion Rate[c] (kg/kg BW-d)	Soil Ingestion Rate[d] (kg/kg BW-d)	Daily Exposure from Food (mg/kg BW-d)	Daily Exposure from Soil (mg/kg BW-d)	Time Use Factor
Short-tailed shrew								
Upper creek channel	1,084	226.25	36.2	0.56	0.0054	20.3	5.8	0.1
Upper creek overbank	99	32.85	5.3	0.56	0.0054	2.9	0.53	0.9
Upper creek channel only	1,084	226.25	36.2	0.56	0.0054	20.3	5.8	1.0
Upper creek overbank only	99	32.85	5.3	0.56	0.0054	2.9	0.53	1.0
Deltaic area	2,200	400.55	64.1	0.56	0.0054	35.9	11.8	0.1
Downstream overbank area	127	40.10	6.4	0.56	0.0054	3.6	0.68	0.9
Deltaic area only	2,200	400.55	64.1	0.56	0.0054	35.9	11.8	1.0
Downstream overbank only	127	40.10	6.4	0.56	0.0054	3.6	0.68	1.0

Table G-8. (cont.)

Receptor/Location	Time-weighted Daily Dose from Food and Soil (mg/kg BW-d)	LOAEL[e] (mg/kg/d)	Hazard Quotient Based on LOAEL[f]	NOAEL[e] (mg/kg/d)	Hazard Quotient Based on NOAEL[f]
Short-tailed shrew					
Upper creek channel	2.61	80.0	0.033	8.0	0.33
Upper creek overbank	3.13	80.0	0.039	8.0	0.39
	Total Hazard Quotient:		**0.07**		**0.72**
Upper creek channel only	26.10	80.0	0.326	8.0	3.26
Upper creek overbank only	3.48	80.0	0.043	8.0	0.43
Deltaic area	4.77	80.0	0.060	8.0	0.60
Downstream overbank area	3.85	80.0	0.048	8.0	0.48
	Total Hazard Quotient:		**0.108**		**1.08**
Deltaic area only	47.72	80.0	0.60	8.0	5.96
Downstream overbank only	4.28	80.0	0.053	8.0	0.53

Note: Dry to wet weight conversion: (dry weight)*(1-percent moisture) = wet weight

BW - body weight
d - day
dw - dry weight
ww - wet weight

[a] Based on relationship in Table 12 of Sample et al. (1998), where: **ln[earthworm] = -0.218 + 0.807(ln[soil])**.

[b] Wet weights were converted from dry weight values that were predicted by the bioaccumulation model Percent moisture of 84% for earthworms was used based on data in U.S. EPA (1993).

[c] Based on OEPA recommended values.

[d] Soil ingestion rate calculated by multiplying the dry weight soil concentration by 6% of daily food ingestion rate (converted to a dry weight basis).

[e] Based on Azar et al. (1973).

[f] Hazard quotient calculated by dividing dose by LOAEL or NOAEL.

Table G-9. Summary of sample analytical results for supplemental sediment bioassay investigation

Sample ID:	C-OCA-15	C-OCA-16	OS-2	T-5A	T-6A	T-BG-1-A	T-BG-2-OB1R	T-BG-3A	T-BG-4-A
Date Collected:	6/6/2007	5/16/2007	5/15/2007	5/15/2007	5/15/2007	5/16/2007	5/16/2007	5/16/2007	5/16/2007
Units									
Metals									
Lead	mg/kg	1,570	831	420	484	270	34.1	77.6	26.2	14.1
Metals-AVS									
Cadmium	µmole/g	0.0046 *B*	0.0039 *B*	0.0029 *B*	0.0037 *B*	0.0026 *B*	0.0055 *B*	0.0085 *B*	0.006 *B*	0.0022 *B*
Copper	µmole/g	1.1	0.54	0.082 *B*	0.32	0.083 *B*	0.15 *B*	0.26	0.18 *B*	0.077 *B*
Lead	µmole/g	5	2.9	0.91	6.1	0.9	0.13	0.23	0.16	0.037
Nickel	µmole/g	0.23 *B*	0.11 *B*	0.049 *B*	0.13 *B*	0.046 *B*	0.21 *B*	0.15 *B*	0.18 *B*	0.092 *B*
Zinc	µmole/g	2.7	1.5	0.49	1.2	0.6	1.1	0.88	1.2	0.23
AVS SEM										
Acid volatile sulfide	µmole/g	0.8	0.71 *U*	2	0.8	0.59 *U*	15	0.64	9.3	0.61 *U*
Percent solids	%	70.5	66.9	80.1	61.1	82.6	41	75.9	45.1	76.5
TOC										
TOC by Lloyd Kahn	mg/kg	59,000	31,700	32,700	35,000	23,800	58,300	36,200	76,300	24,900
Percent solids	%	61	68.7	80	68.3	80.1	46.8	74.1	38.3	78.4
Grain Size										
Cobbles	%	0	0	0	0	0	0	0	0	0
Gravel	%	0	0	30.3	7.4	10.5	0	0	0	22
Coarse gravel	%	0	0	0	0	0	0	0	0	0
Fine gravel	%	0	0	30.3	7.4	10.5	0	0	0	22
Sand	%	45.3	70.1	61.2	58.7	85.5	33.7	9	31.3	48.4
Coarse sand	%	0	0	18	6.9	14.7	0	0	0	11.9
Medium sand	%	2.6	22.2	19.7	23.2	48.6	16.8	6.5	11.2	19.7
Fine sand	%	42.7	47.9	23.5	28.6	22.2	16.9	2.5	20.1	16.8
Clay	%	11.2	7.1	3.1	14.2	1.5	25.9	47.5	25.1	12
Silt	%	43.5	22.8	5.4	19.7	2.5	40.4	43.5	43.6	17.6
Fines	%	54.7	29.9	8.5	33.9	4	66.3	91	68.7	29.6
Grain Size-Coefficient										
D10	Coef.	0.0042	0.0091	0.113	0.0025	0.249	0	0	0	0.0033
D15	Coef.	0.0076	0.0148	0.194	0.0054	0.306	0.0023	0	0.0016	0.0092
D30	Coef.	0.022	0.0756	0.383	0.05	0.468	0.0065	0.0013	0.0066	0.0814
D50	Coef.	0.0612	0.159	1.77	0.252	0.773	0.0179	0.0057	0.0243	0.591
D60	Coef.	0.091	0.225	3.26	0.381	1.05	0.0366	0.0132	0.0433	1.3
D85	Coef.	0.172	0.605	7.37	1.86	3.53	0.48	0.058	0.318	7.76

Table G-9. (cont.)

Sample ID:		T-BG-5-OB1R	T-BG-6-A	T-BG-7-OB1L	T-OCA-2-A	T-OCA-2-C2L	T-OCA-09-C1L	T-OCA-10-A	T-OCA-10-C1L
Date Collected:		5/16/2007	5/16/2007	5/16/2007	5/16/2007	5/16/2007	6/6/2007	5/16/2007	6/6/2007
	Units								
Metals									
Lead	mg/kg	34.5	15.9	82.1	40.0	64.4	171	201	323
Metals-AVS									
Cadmium	µmole/g	0.0052 *B*	0.0052 *B*	0.0066 *B*	0.0056 *B*	0.0073 *B*	0.0025 *B*	0.0026 *B*	0.0015 *U*
Copper	µmole/g	0.1 *B*	0.087 *B*	0.083 *B*	0.13 *B*	0.22	0.13	0.066 *B*	0.11 *B*
Lead	µmole/g	0.1	0.079	0.2	0.18	0.24	0.37	0.33	0.56
Nickel	µmole/g	0.063 *B*	0.1 *B*	0.14 *B*	0.19 *B*	0.13 *B*	0.078 *B*	0.044 *B*	0.072 *B*
Zinc	µmole/g	0.25	0.6	0.24	1	0.72	0.64	0.4	0.46
AVS SEM									
Acid volatile sulfide	µmole/g	0.58 *U*	34.9	0.7 *U*	6.7	0.65 *U*	7.9	0.56 *U*	6.8
Percent solids	%	80.9	37.6	67.4	47.6	73.6	82.2	85.5	79.4
TOC									
TOC by Lloyd Kahn	mg/kg	43,900	59,600	159,000	46,700	27,900	48,100	41,800	35,800
Percent solids	%	81	46.5	68.6	46	70.7	76.2	80.7	65.9
Grain Size									
Cobbles	%	0	0	0	0	0	0	0	0
Gravel	%	0	0	0	0	0	39.6	19.2	29
Coarse gravel	%	0	0	0	0	0	3.5	0	0.9
Fine gravel	%	0	0	0	0	0	36.1	19.2	28.1
Sand	%	30.4	69.5	39.7	28.8	5.2	46.6	70.2	51.8
Coarse sand	%	0	0	0	0	0	12.4	21.7	13
Medium sand	%	7	26.9	14.2	4.8	1.6	12.9	28.6	18
Fine sand	%	23.4	42.6	25.5	24	3.6	21.3	19.9	20.8
Clay	%	30.4	8	16.1	24.7	46.7	3	2.4	5.4
Silt	%	39.2	22.5	44.2	46.5	48.1	10.8	8.2	13.8
Fines	%	69.6	30.5	60.3	71.2	94.8	13.8	10.6	19.2
Grain Size-Coefficient									
D10	Coef.	0	0.0084	0.0025	0	0	0.0506	0.034	0.0159
D15	Coef.	0	0.0152	0.0044	0.0019	0	0.0946	0.124	0.0448
D30	Coef.	0.0047	0.0711	0.0116	0.0088	0.0013	0.297	0.411	0.249
D50	Coef.	0.0338	0.187	0.0291	0.0353	0.0058	2.43	1.29	0.874
D60	Coef.	0.0494	0.265	0.072	0.0485	0.0099	4.66	2.08	2.36
D85	Coef.	0.18	0.66	0.406	0.162	0.0413	13.2	5.82	9.52

Table G-9. (cont.)

Sample ID:	T-OCA-11-A	T-OCA-12-C1R	T-OCA-14-A	T-OCA-14-C1R	T-OCA-16-C1L	T-OCA-18-0B1L	T-OCA-20-A
Date Collected:	5/16/2007	6/6/2007	5/16/2007	6/6/2007	6/6/2007	6/6/2007	5/16/2007
Units							
Metals							
Lead	mg/kg	127 (134)	3,290	158	3,180	529	3,920	118
Metals-AVS							
Cadmium	μmole/g	0.0019 *B* (0.001 *U*)	0.0054 *B*	0.0026 *B*	0.0037 *B*	0.0052 *B*	0.0098 *B*	0.0054 *B*
Copper	μmole/g	0.071 *B* (0.0071 *U*)	0.38 *B*	0.052 *B*	1	0.92	1.8	0.21
Lead	μmole/g	0.52 (0.056)	16.3	0.47	4.8	5.2	13.2	0.39
Nickel	μmole/g	0.048 *B* (0.0048 *U*)	0.17 *B*	0.037 *B*	0.2 *B*	0.14 *B*	0.31	0.14 *B*
Zinc	μmole/g	0.51 (0.049 *B*)	1.4	0.38	2.7	2.4	4.6	0.88
AVS SEM							
Acid volatile sulfide	μmole/g	0.62 *U* (0.57 *U*)	8.8	0.56 *U*	0.98	5.9	1.3	1.1
Percent solids	%	79.4 (79.1)	54.1	87.5	61	59.8	65.3	51.5
TOC							
TOC by Lloyd Kahn	mg/kg	33,900 (47,600)	64,000	31,200	49,300	35,800	86,000	34,900
Percent solids	%	87.1 (82.6)	56.1	85	59.3	67.7	58.5	51.3
Grain Size							
Cobbles	%	0 (0)	0	0	0	0	0	0
Gravel	%	45.8 (51.3)	20.3	27.3	0	29.9	0.8	0
Coarse gravel	%	7.4 (5.7)	5	1.7	0	7.7	0	0
Fine gravel	%	38.4 (45.6)	15.3	25.6	0	22.2	0.8	0
Sand	%	51.4 (46.6)	36.2	69.3	47.5	59.6	37.4	16.1
Coarse sand	%	15.4 (14)	5.1	18.5	0	10.1	1.3	0
Medium sand	%	21.9 (20)	10.5	36.6	2.9	15.2	11.3	2.1
Fine sand	%	14.1 (12.6)	20.6	14.2	44.6	34.3	24.8	14
Clay	%	1 (0.9)	10	1.1	7.5	2.9	16.7	35.3
Silt	%	1.8 (1.2)	33.5	2.3	45	7.6	45.1	48.6
Fines	%	2.8 (2.1)	43.5	3.4	52.5	10.5	61.8	83.9
Grain Size-Coefficient							
D10	Coef.	0.287 (0.323)	0.005	0.267	0.0071	0.064	0.0022	0
D15	Coef.	0.383 (0.432)	0.0088	0.37	0.0131	0.126	0.0044	0
D30	Coef.	0.956 (1.23)	0.0281	0.732	0.0372	0.261	0.0101	0.0034
D50	Coef.	4.02 (5)	0.131	1.66	0.0686	0.556	0.0409	0.0123
D60	Coef.	5.77 (7.07)	0.301	2.62	0.102	2	0.0668	0.0284
D85	Coef.	15.1 (15.2)	8.88	8.11	0.218	12.6	0.385	0.0813

Table G-9. (cont.)

	Sample ID: Date Collected: Units	T-OCA-21-A 5/16/2007	T-OCA-21-C2L 5/16/2007	T-OCA-22-0B1R 6/6/2007	T-OCA-22-A 5/16/2007	T-OCA-24-0B1R 6/6/2007	T-OCA-26-OB1R 5/15/2007
Metals							
Lead	mg/kg	81.6 (59.2)	214	11,900	46.6	11,000	767
Metals-AVS							
Cadmium	µmole/g	0.0041 *B* (0.0054 *B*)	0.0098 *B*	0.0085 *B*	0.0048 *B*	0.0075 *B*	0.011 *B*
Copper	µmole/g	0.2 (0.21)	0.27	0.8	0.16 *B*	1.2	0.27
Lead	µmole/g	0.21 (0.23)	0.33	32.2	0.19	31.2	3.7
Nickel	µmole/g	0.19 *B* (0.19 *B*)	0.15 *B*	0.3	0.19 *B*	0.32	0.14 *B*
Zinc	µmole/g	0.95 (0.99)	0.91	3.9	0.94	4.5	1.2
AVS SEM							
Acid volatile sulfide	µmole/g	1.9 (7.8)	0.6 *U*	0.8 *U*	3.1	0.84	0.57 *U*
Percent solids	%	56.5 (48.3)	80.3	61.8	53.2	71	81.8
TOC							
TOC by Lloyd Kahn	mg/kg	42,400 (68,800)	37,200	37,700	33,300	55,400	45,000
Percent solids	%	50.1 (49.8)	79.4	53.2	44.8	64.5	80.1
Grain Size							
Cobbles	%	0 (0)	0	0	0	0	0
Gravel	%	0 (0)	0.1	0.7	0	0	6
Coarse gravel	%	0 (0)	0	0	0	0	0
Fine gravel	%	0 (0)	0.1	0.7	0	0	6
Sand	%	26 (24.2)	25.3	33.1	16.7	17.3	39.5
Coarse sand	%	0 (0)	13.9	15.9	0	0	17.6
Medium sand	%	6 (5.7)	7.2	5.2	4.2	4.2	12.3
Fine sand	%	20 (18.5)	4.2	12	12.5	13.1	9.6
Clay	%	27.1 (26.4)	30.2	30.4	30.3	21.7	18.6
Silt	%	46.9 (49.4)	44.4	35.8	53	61	35.9
Fines	%	74 (75.8)	74.6	66.2	83.3	82.7	54.5
Grain Size-Coefficient							
D10	Coef.	0 (0)	0	0.0015	0	0.0017	0.0017
D15	Coef.	0.0015 (0.0022)	0	0.0025	0	0.0029	0.0032
D30	Coef.	0.0066 (0.0065)	0.0049	0.0049	0.0049	0.0092	0.0177
D50	Coef.	0.0319 (0.03)	0.031	0.0143	0.0216	0.0371	0.0587
D60	Coef.	0.044 (0.0427)	0.0468	0.0438	0.0334	0.0451	0.235
D85	Coef.	0.159 (0.146)	1.8	2.3	0.0886	0.109	3.04

Table G-9. (cont.)

Sample ID:	T-OCA-30-OB1R	T-OCA-32-C1R	T-OCA-34-C1L	T-OCA-34-OB1R	T-OCA-51-C2L
Date Collected:	5/15/2007	5/15/2007	5/15/2007	5/15/2007	6/6/2007
Units					
Metals					
Lead	mg/kg	539	474	494	541	3,600
Metals-AVS					
Cadmium	μmole/g	0.0074 *B*	0.0058 *B*	0.0098 *B*	0.012 *B*	0.0098 *B*
Copper	μmole/g	0.28	0.11 *B*	0.38	0.4	2.4
Lead	μmole/g	1.4	1.8	1.4	1.7	15.4
Nickel	μmole/g	0.13 *B*	0.18 *B*	0.17 *B*	0.19 *B*	0.34
Zinc	μmole/g	0.98	1.6	1.4	1.5	5.1
AVS SEM						
Acid volatile sulfide	μmole/g	0.64 *U*	27.4	1.1	1.1	0.8 *U*
Percent solids	%	75.4	47.3	54.5	45.9	60.4
TOC						
TOC by Lloyd Kahn	mg/kg	40,500	56,300	47,100	67,400	66,500
Percent solids	%	74.4	41.4	55.2	44.2	56.7
Grain Size						
Cobbles	%	0	0	0	0	0
Gravel	%	0.3	0	0	0	0
Coarse gravel	%	0	0	0	0	0
Fine gravel	%	0.3	0	0	0	0
Sand	%	32.6	26.2	29.5	16	11.6
Coarse sand	%	18.3	0	0	0	1.7
Medium sand	%	7.7	2.4	3.6	3.3	4.3
Fine sand	%	6.6	23.8	25.9	12.7	5.6
Clay	%	31.3	21.6	23.4	35.8	31.1
Silt	%	35.8	52.2	47.1	48.2	57.3
Fines	%	67.1	73.8	70.5	84	88.4
Grain Size-Coefficient						
D10	Coef.	0	0.0014	0.0016	0	0
D15	Coef.	0	0.0025	0.0026	0	0.002
D30	Coef.	0.0045	0.0103	0.0074	0.0037	0.0047
D50	Coef.	0.0385	0.0411	0.0256	0.0127	0.0119
D60	Coef.	0.054	0.0521	0.0474	0.0338	0.0166
D85	Coef.	2.5	0.132	0.159	0.0826	0.067

Note: *B* - amount in preparation blank greater than method detection limit
U - undetected at detection limit shown

Attachment G1

Toxicity Evaluation of Sediment from *Hyalella azteca*

SUMMARY REPORT

Toxicity Evaluation of Sediment with
Hyalella azteca

Author

Arthur E. Putt

Study Completed On

20 August 2007

Submitted To

Exponent
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Laboratory Project ID

Springborn Smithers Study No. 13694.6118

TABLE OF CONTENTS

Page

TABLE OF CONTENTS 2

KEY STUDY PERSONNEL 3

EXECUTIVE SUMMARY 4

CONCLUSIONS 6

SUMMARY OF TEST CONDITIONS 7

Table 1. Water quality summary for the *Hyalella azteca* 28-day exposure 9

Table 2. Summary of the survival and growth of *Hyalella azteca* after a 28-day exposure. 11

REFERENCES 12

APPENDIX 1 13

APPENDIX 2 19

KEY STUDY PERSONNEL

The following Springborn Smithers personnel were responsible for the conduct of the work and reporting of the study results.

Arthur E. Putt	Study Director
Christian Picard	Biologist I
Jennifer Donovan	Biology Technician II
Kristen Follett	Biology Technician I
Michael Bradley	Assistant Biologist
Jeffrey Martin	Biologist I
Jennifer Collins	Technical Report Writer
Susan P. Shepherd	Director, Ecotoxicology

Arthur E. Putt

8/20/2007
Date

EXECUTIVE SUMMARY

The following is a summary of testing performed with the freshwater amphipod (*Hyalella azteca*) to evaluate sediment. The test sediments identified as T-OCA-2-C2L, T-BG-4-A, OS-2, T-6A, T-OCA-20-A, T-BG-3-A, C-OCA-16, T-BG-6-A, T-OCA-26-OBIR and T-OCA-34-C1L were collected on 15 May 2007 by the Study Sponsor and received at Springborn Smithers Laboratories on 16 May 2007. These sediments samples were stored refrigerated (2 to 8 °C) and wet-pressed through a 2-mm sieve on 25 May 2007. A 28-day chronic test exposing *Hyalella azteca* to these 10 test sediments was initiated on 29 May 2007 (Group #1). The test sediments identified as C-OCA-15 and T-OCA-14-C1R were collected on 6 June 2007 by the Study Sponsor and received at Springborn Smithers Laboratories on 7 June 2007. These sediment samples were stored refrigerated (2 to 8 °C) and wet-pressed through a 2-mm sieve on 18 June 2006 prior to use. A 28-day chronic test exposing *Hyalella azteca* to these two test sediments was initiated on 19 June 2007 (Group #2).

In addition, the laboratory control sediment was prepared by Springborn Smithers Laboratories on 12 April 2007 (Springborn Smithers Batch No. 041207A). The artificial sediment was prepared by mixing 6.0% peat moss, 20% kaolin clay, 37% fine sand and 37% coarse sand. Prior to use, the sediment was wet-pressed through a 2.0-mm sieve to remove large particles.

The test method used during the conduct of this study followed the "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates, 2nd Edition", Test Method 100.4 (U.S. EPA, 2000) and ASTM Guideline E 1706-04 "Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh Water Invertebrates" (ASTM, 2004). The test method followed during the conduct of this test is attached in Appendix 1.

A 96-hour reference test with *H. azteca* was initiated on 7 July 2007. Potassium chloride was the reference toxicant used. The population of organisms used to initiate the reference test was from the same population of organisms used to initiate all of test sediments. The 96-hour LC50 for

potassium chloride and *H. azteca* was calculated to be 317 mg KCl/L. Appendix 2 contains the control chart for this reference test and previously conducted reference tests. The reference test conducted on 7 July 2007 fell within the acceptable 2 standard deviation range established from the calculated LC50 values.

A summary of the day 0 and day 28 water quality characteristics of overlying water during the 28-day chronic tests with *Hyalella azteca* are presented in Table 1. Water quality remained acceptable throughout the 28-day exposure period of Group#1 and Group #2. Dissolved oxygen, pH and temperature measurements were made by inserting the measuring probe in the respective vessel and moving the probe gently to prevent agitation of the sediment or disturbing the organisms. Dissolved oxygen concentrations in all exposure vessels were ≥ 5.1 and 6.0 mg/L throughout Group #1 and Group #2, respectively, and were safely above the required concentration of 2.5 mg/L. Ammonia concentrations, measured in all samples were ≤ 0.81 and 1.4 mg/L during Group #1 and Group #2, respectively, and were safely below levels where toxicity is observed. Water temperature measured daily in exposure vessels ranged from 22 to 25 °C during Group #1 and was maintained at 23 °C during Group #2.

A summary of the *Hyalella azteca* survival and growth during both 28-day chronic tests is presented in Table 2. The mean percent laboratory control survival was 80% for Group #1 and Group #2. Mean control growth (measured as dry weight) was 0.33 and 0.36 mg per amphipod for Group #1 and Group #2, respectively. These results met the minimum performance criteria for this type of test. The results of the laboratory control organisms established that the test system and conditions were appropriate for the survival and growth of *H. azteca*. The laboratory control results were used to evaluate the toxicity potential of the test samples during this study.

At test day 28 of the exposure, the mean percent survival among amphipods exposed to sediment samples T-OCA-2-C2L, T-BG-4-A, OS-2, T-6A, T-OCA-20-A, T-BG-3-A, C-OCA-16, T-BG-6-A, T-OCA-26-OBIR and T-OCA-34-C1L was 85, 93, 63, 75, 95, 93, 96, 95, 88 and 90%, respectively, and was not statistically different from the survival observed among

laboratory control organisms (80%). The mean percent survival among amphipods exposed to sediment samples C-OCA-15 and T-OCA-14-C1R was 95 and 93%, respectively, and was not statistically different from the survival observed among laboratory control organisms (80%).

Following 28 days of exposure, the mean dry weight among amphipods exposed to sediment samples T-OCA-2-C2L, T-BG-4-A, OS-2, T-6A, T-OCA-20-A, T-BG-3-A, C-OCA-16, T-BG-6-A, T-OCA-26-OBIR and T-OCA-34-C1L was 0.31, 0.35, 0.40, 0.37, 0.32, 0.35, 0.34, 0.32, 0.32 and 0.35 mg per amphipod, respectively, and was not statistically different from the mean dry weight observed among laboratory control organisms (0.33 mg per amphipod). The mean dry weight among amphipods exposed to sediment samples C-OCA-15 and T-OCA-14-C1R was 0.28 and 0.36 mg per amphipod, respectively. Statistical analysis (Bonferroni's t-Test) determined a significant reduction in mean dry weight among amphipods exposed to sediment sample C-OCA-15 compared to mean dry weight among laboratory control organisms (0.36 mg per amphipod).

CONCLUSIONS

Results of the samples tested established that the laboratory control organism survival and growth were within the range of acceptance criteria. The survival and growth endpoints evaluated in the amphipod test are thus reliable. Sediment sample C-OCA-15 demonstrated a statistically significant reduction (22% reduction in dry weight compared to the laboratory control data) in amphipod growth compared to the laboratory control. No impact in amphipod survival was observed in this sample. All other sediment samples demonstrated consistent amphipod survival and growth compared to the laboratory control data. Therefore, the potential for growth reductions exists with test sample C-OCA-15.

SUMMARY OF TEST CONDITIONS

28-Day Sediment Toxicity Tests with *Hyalella azteca*

DATE SAMPLES RECEIVED:	Group #1: 16 May 2007 Group #2: 7 June 2007
TEST DATES:	Group #1: 29 May to 26 June 2007 Group #2: 19 June to 17 July 2007
TEST TYPE:	Whole-sediment toxicity test with renewal of overlying water
TEMPERATURE:	Group #1: 18 to 25 °C Group #2: 22 to 25 °C
PHOTOPERIOD:	16 hours light, 8 hours dark Group #1: 37 to 51 footcandles Group #2: 32 to 52 footcandles
TEST CHAMBER SIZE:	300 mL
SEDIMENT VOLUME:	100 mL
OVERLYING WATER VOLUME:	175 mL
RENEWAL OF TEST SOLUTIONS:	2 volume additions/day
AGE OF TEST ORGANISMS:	7 to 8 days old at start of test
NUMBER OF ORGANISMS PER TEST CHAMBER:	10
NUMBER OF REPLICATE TEST CHAMBERS PER TREATMENT:	8
NUMBER ORGANISMS/SAMPLE:	80
FEEDING:	1.0 mL of YCT daily per vessel
AERATION:	None

TEST CONCENTRATION:	100% (no dilutions)
TEST DURATION:	28 days
ENDPOINTS:	Survival and growth (amphipod dry weight) following 28 days of exposure
TEST ACCEPTABILITY:	Minimum mean control survival of 80% Minimum mean control growth of 0.15 mg per amphipod

Table 1. Water quality summary for the *Hyalella azteca* 28-day exposure.

Sample Identification	Ranges			
	Dissolved Oxygen (mg/L)		pH	
	Day 0	Day 28	Day 0	Day 28
Group #1				
Laboratory Control	9.2 – 9.9	7.1 – 7.7	6.0 – 7.2	6.7 – 6.8
T-OCA-2-C2L	9.7 - 10	5.7 – 6.9	7.4 – 7.5	7.3 – 7.6
T-BG-4-A	9.8 – 9.9	6.2 – 6.9	7.6	7.7 – 7.8
OS-2	9.2 – 9.5	6.9 – 7.3	7.5 – 7.6	7.4
T-6A	9.5 – 9.6	7.2 – 7.7	7.5 – 7.7	7.3 – 7.4
T-OCA-20-A	9.6 – 9.9	5.4 – 6.4	7.4 – 7.5	7.8 – 8.1
T-BG-3-A	9.6 – 10	5.5 – 6.5	7.5	8.1 – 8.5
C-OCA-16	9.8 – 10	6.1 – 6.8	7.4 – 7.6	7.5
T-BG-6-A	9.4 - 10	5.1 – 6.2	7.4 – 7.5	7.9 – 8.1
T-OCA-26-OBIR	9.4 – 9.7	6.2 – 6.7	7.5 – 7.6	7.4 – 7.6
T-OCA-34-C1L	9.3 – 9.8	6.8 – 7.0	7.5 – 7.6	7.4
Group #2				
Laboratory Control	7.6 – 8.3	6.3 – 7.4	6.7 – 6.9	6.4 – 6.8
C-OCA-15	6.6 – 7.5	6.0 – 6.9	7.5 – 7.6	6.8 – 7.3
T-OCA-14-C1R	7.2 – 7.9	6.5 – 7.4	7.6	7.2 – 7.3

Sample Identification	Alkalinity (mg/L as $CaCO_3$)		Hardness (mg/L as $CaCO_3$)	
	Day 0	Day 28	Day 0	Day 28
Group #1				
Laboratory Control	14	18	36	36
T-OCA-2-C2L	34	58	56	92
T-BG-4-A	42	56	76	88
OS-2	34	28	72	52
T-6A	32	28	64	52
T-OCA-20-A	42	68	72	104
T-BG-3-A	38	72	72	128
C-OCA-16	38	50	64	80
T-BG-6-A	38	54	64	88
T-OCA-26-OBIR	28	70	60	104
T-OCA-34-C1L	46	44	76	72
Group #2				
Laboratory Control	20	40	22	44
C-OCA-15	32	68	36	60
T-OCA-14-C1R	36	68	36	56

Table 1. (continued) Water quality summary for the *Hyalella azteca* 28-day exposure.

Sample Identification	Ammonia as N (mg/L)	
	Day 0	Day 28
Group #1		
Laboratory Control	0.68	0.12
T-OCA-2-C2L	0.062	0.17
T-BG-4-A	0.0	0.11
OS-2	0.62	0.11
T-6A	0.81	0.16
T-OCA-20-A	0.048	≤0.10
T-BG-3-A	0.073	0.14
C-OCA-16	0.0071	0.20
T-BG-6-A	0.24	0.22
T-OCA-26-OBIR	0.52	0.29
T-OCA-34-C1L	0.24	0.12
Group #2		
Laboratory Control	1.4	≤0.10
C-OCA-15	0.61	≤0.10
T-OCA-14-C1R	≤0.10	≤0.10

Sample Identification	Conductivity (µmhos/cm)				
	Day 0	Day 7	Day 14	Day 21	Day 28
Group #1					
Laboratory Control	320	280	210	260	260
T-OCA-2-C2L	310	330	310	320	350
T-BG-4-A	330	310	330	300	360
OS-2	330	300	280	270	260
T-6A	320	300	280	270	280
T-OCA-20-A	320	310	280	300	360
T-BG-3-A	320	300	280	330	400
C-OCA-16	320	310	280	280	330
T-BG-6-A	340	350	300	300	340
T-OCA-26-OBIR	300	340	320	340	370
T-OCA-34-C1L	340	320	290	280	300
Group #2					
Laboratory Control	290	280	250	250	230
C-OCA-15	290	300	240	250	260
T-OCA-14-C1R	280	280	260	260	250

Table 2. Summary of the survival and growth of *Hyalella azteca* after a 28-day exposure.

Sample Identification	Mean Percent Survival (Standard Deviation)	Mean Dry Weight in mg/organism (Standard Deviation)
Group #1		
Laboratory Control	80 (19)	0.33 (0.03)
T-OCA-2-C2L	85 (14)	0.31 (0.09)
T-BG-4-A	93 (12)	0.35 (0.05)
OS-2	63 (38)	0.40 (0.12)
T-6A	75 (21)	0.37 (0.09)
T-OCA-20-A	95 (5)	0.32 (0.06)
T-BG-3-A	93 (7)	0.35 (0.04)
C-OCA-16	96 (5)	0.34 (0.04)
T-BG-6-A	95 (5)	0.32 (0.17)
T-OCA-26-OBIR	88 (12)	0.32 (0.10)
T-OCA-34-C1L	90 (8)	0.35 (0.05)
Group #2		
Laboratory Control	80 (15)	0.36 (0.06)
C-OCA-15	95 (8)	0.28 (0.03)[a]
T-OCA-14-C1R	93 (7)	0.33 (0.03)

[a] Growth in this sample was significantly reduced compared to the laboratory control, based on Bonferroni's t-Test.

REFERENCES

ASTM. 2004. Guideline E 1706-04 Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh Water Invertebrates Volume 11.05. ASTM 100 Barr Harbor Drive, West Conshohocken, PA.

U.S. EPA. 2000. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates, 2nd Edition. U.S. Environmental Protection Agency. Office of Research and Development. EPA/600/R-99/064.

APPENDIX 1

28-Day Toxicity Test with Freshwater Amphipod (*Hyalella azteca*) to Meet U.S. EPA Guidelines.

1.0 INTRODUCTION

The objective of this study is to determine the chronic toxicity of a contaminated sediment sample(s) to the amphipod (*Hyalella azteca*) during a 28-day exposure. Amphipods are exposed to the sediment sample to assess survival and growth on test day 28. The methods (Springborn Smithers Laboratories test method No.: SED-Ha-123) in this study plan meet those described in the document entitled "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates, Second Edition", Test Method 100.4 (U.S. EPA, 2000).

2.0 MATERIALS AND METHODS

2.1 Test System

2.1.1 Species

The freshwater invertebrate, *Hyalella azteca,* is the species used in this test. Test organisms will be 7 to 8 days old at initiation of the test. Amphipods will be obtained by removing adult amphipods from culture tanks and placing them in 9.5-liter aquaria with approximately 8 L of water, 7 to 8 days prior to test initiation. Young produced by these isolated adults will then be removed and pipetted into holding containers until test initiation. Amphipods will not be used if >5 % mortality is observed during the 48 hours prior to test initiation.

2.1.2 Source

Hyalella azteca cultures will be maintained at Springborn Smithers Laboratories. Amphipods will be cultured in 20 liter glass aquaria (containing approximately 10 L of culture water) under flow-through conditions. Water used to culture the amphipods is similar to the overlying water used during the 28-day test. Culture water will be maintained at 23 ± 1 °C.

2.1.3 Feeding

While being maintained in the culture prior to the test, adult and juvenile amphipods will be fed once daily. They will be fed a combination of Yeast, Cerophyl® and Flaked Fish food suspension (YCT) and a unicellular green algae *Ankistrodesmus falcatus*. During testing, 1.0 mL of YCT suspension will be added daily to each test vessel. If food collects on the sediment surface during testing, feeding will be suspended for one or more days.

2.1.4 Handling

Wide-bore pipets will be used to transfer the amphipods, taking care to minimize possible stress due to handling. Amphipods that are damaged or dropped during transfer will not be used.

2.2 Physical System

2.2.1 Sediment

Sediment samples should be shipped overnight to Springborn Smithers Laboratories after collection. Upon receipt at Springborn Smithers, sample containers will be inspected for leakage or damage and the sample identity recorded. If storage is required, the samples will be refrigerated at approximately 4 °C. In addition, if possible, a sediment sample will be collected from an uncontaminated location near the site of interest to be used as a reference sediment. A laboratory control sediment, prepared or collected by Springborn Smithers Laboratories, will be included in the test to evaluate performance of the test organisms and exposure system. Prior to use, each sediment sample will be sieved through a 2-mm stainless steel sieve to remove large particles. The test will be initiated within 14 days of sediment collection.

2.2.2 Test Vessels

The test vessels used in the static-renewal toxicity test will be 300-mL glass beakers which are chemically clean. Each test vessels has a 2 cm hole cut on the top portion of the vessel and is covered with 40-mesh Nitex® screen for drainage. Each vessel will contain 100 mL (approximately 2 cm layer) of sediment and 175 mL of overlying water. Test vessels will be cleaned by an appropriate method to remove residue of test substance previously used (i.e., acid to remove metals and bases; detergents and organic solvents to remove organic compounds) and rinsed several times using diluent water.

2.2.3 Overlying Water

Water from a 100-meter bedrock well is pumped to a concrete reservoir where it is supplemented on demand with untreated, unchlorinated, Town of Wareham well water. The water is characterized with a normal pH range of 6.9 to 7.7, a total hardness of 40 to 60 mg/L and a specific conductance of 110 to 160 µmhos/cm. The pH, total hardness, alkalinity, and specific conductance of this water will be monitored weekly at a central location in the laboratory to assure that these parameters are within the normal, acceptable ranges. Total hardness and alkalinity will be determined according to *Standard Methods for the Water and Wastewater*, (APHA, 1995).

The quality of the water is judged by periodic analyses of representative samples conducted to ensure the absence of potential toxicants, including pesticides, PCBs and selected toxic metals, at concentrations which may be harmful to the amphipods, as well

as the ability of amphipod cultures to survive and reproduce in the water free of stress. TOC analyses will be conducted once a month in the overlying water source.

2.3 Test Procedures:

2.3.1 Test Concentration

Eight replicates will be maintained for each sediment sample consisting of 100% whole sediment sample (no dilutions). A common reference control, conducted with eight replicates, may be used to evaluate the survival and growth potential of the test organism in a non-contaminated sediment. In addition, a laboratory control sediment, prepared or collected by Springborn Smithers Laboratories, will be used to evaluate the survival and growth potential of the test organisms. The laboratory control sediment will also be conducted with eight replicates. Ten amphipods (7 to 8 days old) per replicate (80 organisms per sediment sample or control) will be used to initiate the test.

2.3.2 Test Initiation

The day before test initiation (day -1), test sediment, reference and laboratory control sediment will be added to the replicate test vessels and the overlying water will be added. Each sediment sample will be thoroughly homogenized prior to addition to the replicate exposure vessels. The water will be added gently to prevent suspension of the sediment layer in the water column. This period allows the sediment and water to equilibrate prior to addition of the test organisms. Delivery of the overlying water will be initiated the day prior to test initiation using the automated water delivery system.

Amphipods (7 to 8 days old) will be removed from the holding vessels (see Section 2.1.1). Ten amphipods will be impartially selected and pipetted into a replicate test or control vessel. This procedure will be repeated until all vessels contain ten amphipods.

2.3.3 Renewal of Overlying Water

During the 10-day study, the overlying water will be renewed by adding two volume additions (i.e., 350 mL) per day using an intermittent delivery system in combination with a calibrated water-distribution system (Zumwalt et al., 1994). The intermittent delivery system will be calibrated to provide 1 liter of water per cycle to the water-distribution system, which subsequently provides 50 mL of water per cycle to each replicate test chamber. The water delivery system cycles 7 times per day, providing 2 volume additions every 24 hours. Delivery of two volume replacements per day is sufficient to provide consistent and acceptable water quality characteristics throughout the duration of the 28-day exposure.

2.3.4 Photoperiod

The test vessels will be located in an area illuminated to a light intensity of 30 to 100 footcandles using a combination of fluorescent bulbs. A 16-hour light, 8-hour dark photoperiod will be maintained with an automatic timer. Sudden transitions from light to dark and vice versa will be avoided.

2.3.5 Measurement of Water Quality Variables

Total hardness, alkalinity, specific conductance, and ammonia will be determined at the beginning and end of the test in the overlying water from a composite sample from all twelve replicate vessels. The composite sample will be taken from 1 to 2 cm from the sediment surface using a pipet. In addition, specific conductance will be measured weekly thereafter until test termination from a composite sample. Dissolved oxygen, pH and temperature will be measured in all replicate vessels at test initiation and test termination of the test (day 28). Dissolved oxygen and temperature will also be monitored daily in one alternating replicate during the course of the study (test days 1 to 27). In addition, temperature will be monitored continuously in the water bath using a minimum-maximum thermometer. Readings of temperature extremes will be recorded daily.

2.3.6 Dissolved Oxygen

Total dissolved oxygen will not be allowed to drop below 2.5 mg/L during the study. Aeration (with oil-free air) or increased water renewal rate will be initiated to raise and maintain the dissolved oxygen concentration at or above 2.5 mg/L.

2.3.7 Temperature

Water temperature of the test solutions will be maintained at 23 °C by conducting the study in a temperature controlled water bath at the appropriate test temperature. The mean daily temperature must be 23 ± 1 °C. The instantaneous temperature must be 23 ± 1 °C.

2.3.8 Biological Data

Daily observations of organism behavior (e.g., sublethal effects) and characteristics of sediment and overlying water will also be observed and recorded daily.

Survival and growth (dry weight) of the amphipods will be determined in each of the eight replicate exposure vessels on test day 28 by sieving the sediment to remove all surviving amphipods. The growth of surviving amphipods will be recorded by pooling all surviving amphipods from each replicate vessel and drying at 60EC for 24 hours. Pooled amphipods will be weighed on a calibrated analytical balance to the nearest 0.01 mg.

2.3.9 Test Acceptability Requirements

Mean survival and growth of the amphipods in the laboratory control must be ≥ 80% and ≥ 0.15 mg per amphipod, respectively, at test day 28.

Hardness, alkalinity and ammonia in the overlying water should not vary by more than 50% during the sediment exposure (day 0 to 28).

3.0 STATISTICAL ANALYSES

The mean survival and growth of organisms exposed in each test sediment and reference control sample will be tested for normality and homogeneity of variance. If the data set passes these two tests, then a parametric method (e.g., ANOVA 2-Sample T-test or Dunnett's Test) will be used to evaluate the results of the mean survival and growth of each test sample for significant adverse effects. If the data set fails the test for normality and homogeneity of variance, then a non-parametric method (e.g., Steel's Many-One Rank Test) will be used to determine significant adverse effects. If necessary, mean survival values will be transformed (e.g., arcsine square).

4.0 REPORTING

The raw data and the final summary report will be reviewed by the Study Director. The test results will be presented in an outline format on a per sample basis.

5.0 REFERENCES

APHA, AWWA, WPCF. 1995. Standard Methods for the Examination of Water and Wastewater. 19th Edition, Washington, D.C.

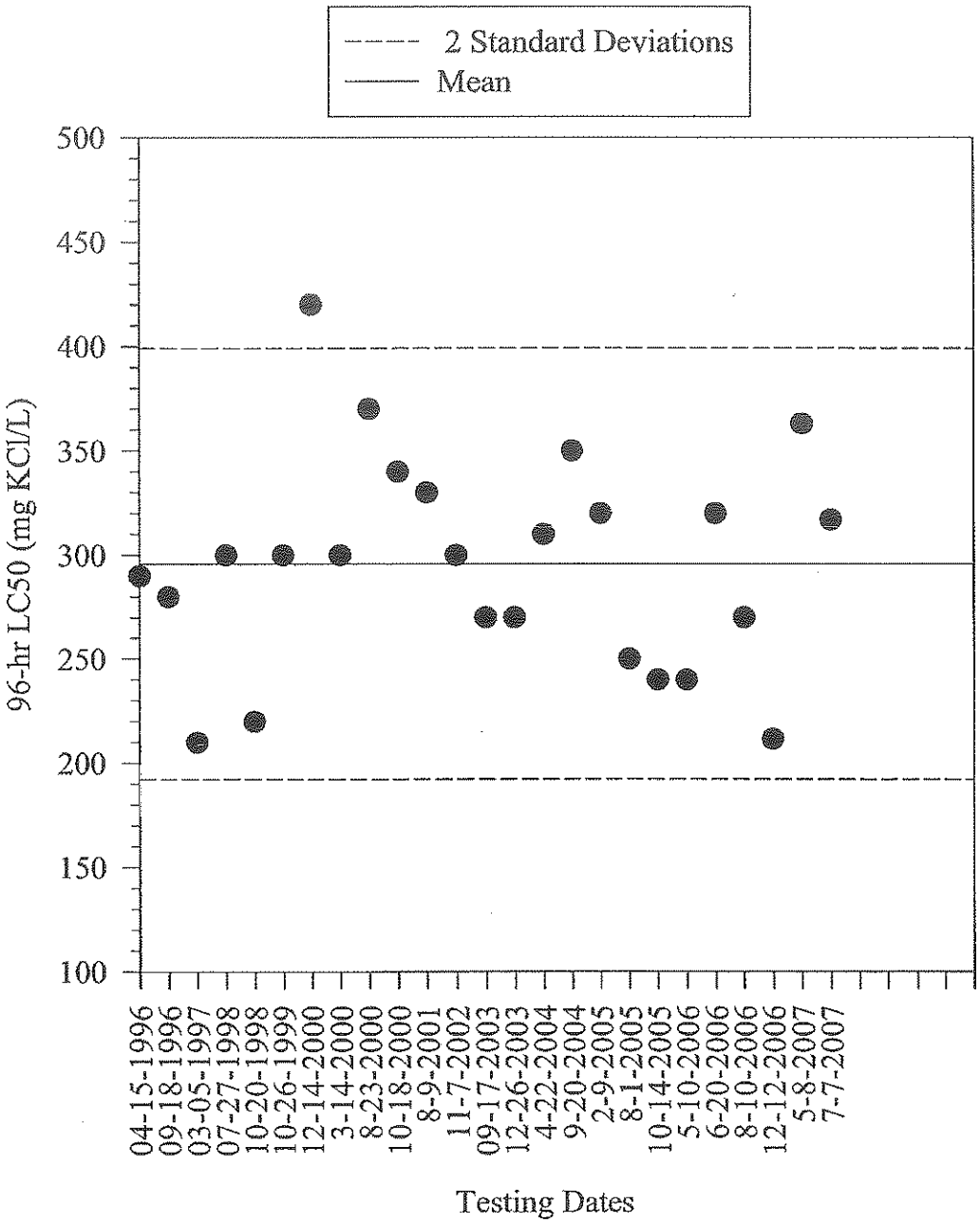
U.S. EPA. 1975. Methods for Acute Toxicity Tests with Fish, Macroinvertebrates, and Amphibians. Ecological Research Series (EPA-660/3-75-009). 61 pp.

U.S. EPA. 2000. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates. Second Edition. U.S. Environmental Protection Agency. March 2000. Office of Research and Development. EPA/600/R-99/064.

Zumwalt, D.C., F.J. Dwyer, I.E. Greer and C.G. Ingersoll. 1994. A water-renewal system that accurately delivers small volumes of water to exposure chambers. Environmental Toxicology and Chemistry. pgs. 1311-1314.

APPENDIX 2

Summary of Hyalella azteca Reference Testing with Potassium Chloride



Attachment G2

Toxicity Evaluation for Sediment with *Chironomus tentans*

SUMMARY REPORT

Toxicity Evaluation of Sediment with
Chironomus tentans

Author

Arthur E. Putt

Study Completed On

20 August 2007

Submitted To

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Winchester, MA 02155

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Laboratory Project ID

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS 2

KEY STUDY PERSONNEL 3

EXECUTIVE SUMMARY 4

CONCLUSIONS 6

SUMMARY OF TEST CONDITIONS 7

Table 1. Water quality summary for the *Chironomus tentans* 10-day exposure. 9

Table 2. Summary of the survival and growth of *Chironomus tentans* after a 10-day exposure. 10

REFERENCES 11

APPENDIX 1 12

APPENDIX 2 18

KEY STUDY PERSONNEL

The following Springborn Smithers personnel were responsible for the conduct of the work and reporting of the study results.

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8/20/2007
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EXECUTIVE SUMMARY

The following is a summary of testing performed with the freshwater amphipod (*Chironomus tentans*) to evaluate sediment. The test sediments identified as T-OCA-2-C2L, T-BG-4-A, OS-2, T-6A, T-OCA-20-A, T-BG-3-A, C-OCA-16, T-BG-6-A, T-OCA-26-OBIR and T-OCA-34-C1L were collected on 15 May 2007 by the Study Sponsor and received at Springborn Smithers Laboratories on 16 May 2007. These sediments samples were stored refrigerated (2 to 8 °C) and wet-pressed through a 2-mm sieve on 25 May 2007. A 10-day subchronic test exposing *Chironomus tentans* to these 10 test sediments was initiated on 29 May 2007 (Group #1). The test sediments identified as C-OCA-15 and T-OCA-14-C1R were collected on 6 June 2007 by the Study Sponsor and received at Springborn Smithers Laboratories on 7 June 2007. These sediment samples were stored refrigerated (2 to 8 °C) and wet-pressed through a 2-mm sieve on 18 June 2006 prior to use. A 10-day subchronic test exposing *Chironomus tentans* to these two test sediments was initiated on 19 June 2007 (Group #2).

In addition, the laboratory control sediment was prepared by Springborn Smithers Laboratories on 12 April 2007 (Springborn Smithers Batch No. 041207A). The artificial sediment was prepared by mixing 6.0% peat moss, 20% kaolin clay, 37% fine sand and 37% coarse sand. Prior to use, the sediment was wet-pressed through a 2.0-mm sieve to remove large particles.

The test method used during the conduct of this study followed the "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates, 2nd Edition", Test Method 100.2 (U.S. EPA, 1994). The test method followed during the conduct of this test is attached in Appendix 1.

A 96-hour reference test with *Chironomus tentans* was initiated on 7 July 2007. Potassium chloride was the reference toxicant used. The population of organisms used to initiate the reference test was from the same population of organisms used to initiate all of test sediments. The 96-hour LC50 for potassium chloride and *Chironomus tentans* was calculated to be 7,220 mg potassium chloride/L. Appendix 2 contains the control chart for this reference test and

previously conducted reference tests. The reference test conducted on 7 July 2007 fell within the acceptable 2 standard deviation range established from the calculated LC50 values.

A summary of the day-0 and day-10 water quality characteristics of overlying water during the 10-day subchronic test with *Chironomus tentans* is presented in Table 1. Water quality remained acceptable throughout the 10-day exposure period of Group #1 and Group #2. Dissolved oxygen, pH and temperature measurements were made by inserting the measuring probe in the respective vessel and moving the probe gently to prevent agitation of the sediment or disturbing the organisms. Dissolved oxygen concentrations in all exposure vessels were ≥ 3.8 and 4.3 mg/L throughout Group #1 and Group #2, respectively, and were safely above the required concentration of 2.5 mg/L. Ammonia concentrations measured in all samples were ≤ 2.9 and 1.9 mg/L during Group #1 and Group #2, respectively, and were safely below levels where toxicity is observed. Water temperature measured daily in exposure vessels ranged from 22 to 25 °C during Group #1 and 23 to 25 °C during Group #2.

A summary of the *Chironomus tentans* survival and growth during both 10-day subchronic tests is presented in Table 2. The mean percent laboratory control survival at test termination was 94% for Group #1 and Group #2. The mean ash-free dry weight of midge at test termination in the laboratory control was 1.17 and 1.15 mg per larvae for Group #1 and Group #2, respectively. These results met the minimum performance criteria for this type of test. The results of the laboratory control organisms established that the test system and conditions were appropriate for the survival and growth of *Chironomus tentans*. The laboratory control results were used to evaluate the toxicity potential of the test samples during this study.

At test day 10 of the exposure, the mean percent survival among midge exposed to sediment samples T-OCA-2-C2L, T-BG-4-A, OS-2, T-6A, T-OCA-20-A, T-BG-3-A, C-OCA-16, T-BG-6-A, T-OCA-26-OBIR and T-OCA-34-C1L was 84, 93, 90, 96, 95, 91, 93, 95, 94 and 89%, respectively, and was not statistically different from the survival observed among laboratory control organisms (94%). The mean percent survival among midge exposed to

sediment samples C-OCA-15 and T-OCA-14-C1R was 99 and 89%, respectively, and was not statistically different from the survival observed among laboratory control organisms (94%).

Following 10 days of exposure, the mean ash-free dry weight among midge exposed to sediment samples T-OCA-2-C2L, T-BG-4-A, OS-2, T-6A, T-OCA-20-A, T-BG-3-A, C-OCA-16, T-BG-6-A, T-OCA-26-OBIR and T-OCA-34-C1L was 1.63, 1.29, 1.25, 1.31, 1.15, 1.29, 1.37, 1.63, 1.28 and 1.44 mg per larvae, respectively, and was not statistically different from the mean ash-free dry weight observed among laboratory control organisms (1.17 mg per larvae). The mean ash-free dry weight among midge exposed to sediment samples C-OCA-15 and T-OCA-14-C1R was 1.05 and 1.14 mg per larvae, respectively, and was not statistically different from the mean ash-free dry weight observed among laboratory control organisms (1.15 mg per larvae).

CONCLUSIONS

Results of the samples tested established that the laboratory control organism survival and growth were within the range of acceptance criteria. The survival and growth endpoints evaluated in the midge test are thus reliable. No adverse effects were observed on midge survival and growth for all sediment samples tested compared to the survival and growth observed in the laboratory control.

SUMMARY OF TEST CONDITIONS

10-Day Sediment Toxicity Tests with *Chironomus tentans*

DATE SAMPLES RECEIVED:	Group #1: 16 May 2007 Group #2: 7 June 2007
TEST DATES:	Group #1: 29 May to 8 June 2007 Group #2: 19 June to 29 June 2007
TEST TYPE:	Whole-sediment toxicity test with renewal of overlying water
TEMPERATURE:	Group #1: 14 to 24 °C Group #2: 23 to 25 °C
PHOTOPERIOD:	16 hours light, 8 hours dark Group #1: 39 to 74 footcandles Group #2: 31 to 59 footcandles
TEST CHAMBER SIZE:	300 mL
SEDIMENT VOLUME:	100 mL
OVERLYING WATER VOLUME:	175 mL
RENEWAL OF TEST SOLUTIONS:	2 volume additions/day
AGE OF TEST ORGANISMS:	9 days old at start of test
NUMBER OF ORGANISMS PER TEST CHAMBER:	10
NUMBER OF REPLICATE TEST CHAMBERS PER TREATMENT:	8
NUMBER ORGANISMS/SAMPLE:	80
FEEDING:	1.5 mL of a 4.0 mg/mL flaked fish food suspension daily per chamber
AERATION:	None

TEST CONCENTRATION:	100% (no dilutions)
TEST DURATION:	10 days
ENDPOINTS:	Survival and growth (ash-free dry weight)
TEST ACCEPTABILITY:	Minimum mean control survival of 70% Minimum mean control growth of ≥ 0.48 mg per larvae

Table 1. Water quality summary for the *Chironomus tentans* 10-day exposure.

Sample Identification	Dissolved Oxygen (mg/L)		pH		Ammonia as N (mg/L)	
	Day 0	Day 10	Day 0	Day 10	Day 0	Day 10
Group #1						
Laboratory Control	7.4 – 9.1	4.8 – 5.7	6.1 – 6.8	6.5 – 6.6	0.98	2.9
T-OCA-2-C2L	8.3 – 9.2	5.0 – 6.0	7.4 – 7.6	7.0 – 7.2	0.24	1.2
T-BG-4-A	7.5 – 9.2	6.2 – 7.0	7.4 – 7.9	7.1 – 7.3	2.2	0.93
OS-2	6.4 – 9.1	5.5 – 6.2	7.4 – 7.5	7.0 – 7.1	0.25	0.50
T-6A	8.9 – 9.1	4.4 – 5.9	6.8 – 7.3	7.0 – 7.2	1.0	--[a]
T-OCA-20-A	7.4 – 9.0	5.0 – 6.3	7.4 – 7.6	7.1 – 7.2	2.2	0.66
T-BG-3-A	7.9 – 8.7	5.6 – 6.9	7.5 – 7.6	7.1 – 7.2	0.58	0.33
C-OCA-16	8.8 – 9.0	5.6 – 6.5	7.4 – 7.5	7.0 – 7.1	0.27	0.46
T-BG-6-A	8.4 – 8.9	4.3 – 7.3	7.4 – 7.5	7.2 – 7.5	0.34	1.1
T-OCA-26-OBIR	6.9 – 8.8	3.8 – 5.9	7.3 – 7.8	7.2 – 7.3	0.073	1.5
T-OCA-34-C1L	8.8 – 9.1	5.1 – 6.6	7.3 – 7.5	7.0 – 7.2	2.6	0.53
Group #2						
Laboratory Control	7.2 – 7.7	5.2 – 6.3	6.7 – 6.9	6.8 – 6.9	0.80	1.9
C-OCA-15	6.7 – 7.4	4.3 – 5.6	7.3 – 7.5	7.2	0.25	0.54
T-OCA-14-C1R	7.2 – 7.7	4.9 – 5.9	7.4	7.2 – 7.3	≤ 0.10	0.27

Sample Identification	Alkalinity (mg/L as $CaCO_3$)		Hardness (mg/L as $CaCO_3$)		Conductivity (µmhos/cm)	
	Day 0	Day 10	Day 0	Day 10	Day 0	Day 10
Group #1						
Laboratory Control	10	20	36	42	220	210
T-OCA-2-C2L	14	14	48	68	210	280
T-BG-4-A	16	16	48	60	210	280
OS-2	24	24	60	60	230	280
T-6A	12	12	48	68	200	290
T-OCA-20-A	16	16	48	64	210	280
T-BG-3-A	20	20	52	60	210	280
C-OCA-16	18	18	52	64	210	270
T-BG-6-A	18	18	52	76	210	300
T-OCA-26-OBIR	18	18	52	68	220	290
T-OCA-34-C1L	16	16	48	64	210	295
Group #2						
Laboratory Control	10	22	36	44	290	250
C-OCA-15	28	40	60	64	290	280
T-OCA-14-C1R	30	34	56	60	280	270

[a] The T-6-A sample was inadvertently not analyzed for ammonia on day 10.

Table 2. Summary of the survival and growth of *Chironomus tentans* after a 10-day exposure.

Sample Identification	Mean Percent Survival (Standard Deviation)	Mean Ash-Free Dry Weight in mg/larvae (Standard Deviation)
Group #1		
Laboratory Control	94 (7)	1.17 (0.24)
T-OCA-2-C2L	84 (9)	1.63 (0.41)
T-BG-4-A	93 (5)	1.29 (0.15)
OS-2	90 (11)	1.25 (0.26)
T-6A	96 (5)	1.31 (0.22)
T-OCA-20-A	95 (5)	1.15 (0.12)
T-BG-3-A	91 (8)	1.29 (0.23)
C-OCA-16	93 (9)	1.37 (0.33)
T-BG-6-A	95 (8)	1.63 (0.12)
T-OCA-26-OBIR	94 (7)	1.28 (0.29)
T-OCA-34-C1L	89 (6)	1.44 (0.40)
Group #2		
Laboratory Control	94 (5)	1.15 (0.13)
C-OCA-15	99 (4)	1.05 (0.14)
T-OCA-14-C1R	89 (10)	1.14 (0.14)

NOTE: Statistical analysis determined no significant reduction in survival or growth for all test sediments tested compared to the survival and growth observed in the laboratory control.

REFERENCES

ASTM. 2004. Guideline E 1706-04 Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh Water Invertebrates Volume 11.05. ASTM 100 Barr Harbor Drive, West Conshohocken, PA.

U.S. EPA. 1994. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates. U.S. Environmental Protection Agency. Office of Research and Development. EPA/600/R-94/024.

APPENDIX 1

10-Day Toxicity Test with Midge (*Chironomus tentans*) o Meet U.S. EPA Guidelines.

1.0 INTRODUCTION

The objective of this study is to determine the toxicity of a contaminated sediment sample(s) to midge (*Chironomus tentans*) during a 10-day exposure. Midge are exposed to the sediment sample to assess survival and growth on test day 10 (test termination). The methods (Springborn Smithers Laboratories test method #: SED-Ct-101) described in this study plan meet the standard procedures described in the "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates", test method 100.2 (U.S. EPA 1994).

2.0 MATERIALS AND METHODS

2.1 Test System

2.1.1 Species

The dipteran midge larvae, (*Chironomus tentans*), will be used to conduct the toxicity tests. The midge larvae used in the test will be second (5 to 8 days post hatch) to third (9 to 11 days post hatch) larval instars at test initiation with at least 50% of the organisms at third instar.

2.1.2 Justification of Test System

Midges (*Chironomus tentans*) will be used for several reasons. The larvae are bottom dwellers, widely distributed throughout North America, and are considered a reasonable representative of aquatic benthic invertebrates (Adams et al., 1985). The organism is easily cultured and has a relatively short life cycle (approximately 30 days at 25°C), making it suitable for toxicity tests.

2.1.3 Source

The midge larvae will be obtained from in-house cultures and will cultured at the requested test temperature (23 ± 1°C). Second and third instar larvae will be collected from egg masses 5-11 days after hatching. During the final 48 hours of larval holding, the reserved population will be examined for mortality and general behavior. If significant mortality (e.g., 10%) is observed during the 48 hour period, then the reserved population will be discarded.

2.1.4 Feeding

During culturing and the static-renewal toxicity test, the midge larvae, generally, will be fed daily. The feeding regime may be adjusted to meet the nutritional requirements of the midges which may vary upon the stage of their development during both testing and culturing. The test midge will be fed 1.5 mL of a finely ground flaked fish food suspension (4.0 mg/mL).

2.1.5 Handling

Wide-bore pipets will be used to transfer the midge larvae, taking care to minimize possible stress due to handling. Midges that are damaged or dropped during transfer will not be used.

2.2 Physical System

2.2.1 Sediment

Sediment samples should be shipped overnight to Springborn Smithers Laboratories after collection. Upon receipt at Springborn Smithers, sample containers will be inspected for leakage or damage and the sample identity recorded. If storage is required, the samples will be refrigerated at approximately 4°C. In addition, if possible, a sediment sample will be collected from an uncontaminated location near the site of interest to be used as a reference sediment. A laboratory control sediment, prepared or collected by Springborn Smithers Laboratories, will be included in the test to evaluate performance of the test organisms and exposure system. Prior to use, each sediment sample will be sieved through a 2 mm stainless steel sieve to remove large particles. The test will be initiated within 14 days of sediment collection.

2.2.2 Test Vessels

The test vessels used in the static-renewal toxicity test will be 300 mL glass beakers which are chemically clean. Each test vessel has a 2-cm hole cut on the top portion of the vessel and is covered with 40-mesh Nitex® screen for drainage. Each vessel will contain 100 mL (approximately 2 cm layer) of sediment and 175 mL of overlying water. Test vessels will be cleaned by an appropriate method to remove residue of test substance previously used (i.e., acid to remove metals and bases; detergents and organic solvents to remove organic compounds) and rinsed several times using diluent water.

2.2.3 Overlying Water

Water from a 100 meter bedrock well is pumped to a concrete reservoir where it is supplemented on demand with untreated, unchlorinated, Town of Wareham well water. The water is characterized as being "soft" with a normal pH range of 6.9 - 7.7, a total hardness of 30 - 60 mg/L and a specific conductance of 110 - 160 µmhos/cm. The pH,

total hardness, alkalinity, and specific conductance of this water will be monitored weekly at a central location in the laboratory to assure that these parameters are within the normal, acceptable ranges. Total hardness and alkalinity will be determined according to *Standard Methods for the Examination of Water and Wastewater*, (APHA, 1992).

The quality of the water is judged by periodic analyses of representative samples conducted to ensure the absence of potential toxicants, including pesticides, PCBs and selected toxic metals, at concentrations which may be harmful to midge larvae, as well as the ability of midge cultures to survive and reproduce in the water free of stress. TOC analyses are conducted once a month in the overlying water source.

2.3 Test Procedures

2.3.1 Test Concentration

Eight replicates will be maintained for each sediment sample consisting of 100% whole sediment sample (no dilutions). A common reference control, conducted with eight replicates, will be used to evaluate the survival and growth potential of the test organism in a non-contaminated sediment. If a reference control sediment is not provided, a laboratory control sediment, prepared or collected by Springborn Smithers Laboratories, will be used to evaluate the survival and growth potential of the test organisms. The laboratory control sediment will also be conducted with eight replicates. Ten midge (second to third instar) per replicate (80 organisms per sediment sample or control) will be used to initiate the test.

2.3.2 Test Initiation

The day before test initiation (day -1) test sediment, reference control and laboratory control sediments will be added to the replicate test vessels and the overlying water added. The water will be added gently to prevent resuspension of the sediment layer in the water column. This allows the sediment and water to equilibrate prior to addition of the test organisms.

Midge larvae (5-11 days old) will be removed from the cultures. Ten larvae will be randomly selected and pipeted into each replicate test or control vessel. This procedure will be repeated until all vessels contain ten larvae (eighty per test sample and control).

2.3.3 Renewal of Overlying Water

During the 10-day study, the overlying water will be renewed by adding two volume additions (i.e., 350 mL) per day using an intermittent delivery system in combination with a calibrated water-distribution system (Zumwalt et al., 1994). The intermittent delivery system will be calibrated to provide 1 liter of water per cycle to the water-distribution system, which subsequently provides 50 mL of water per cycle to each

replicate test chamber. The water delivery system cycles 7 times per day, providing 2 volume additions every 24 hours. Delivery of two volume replacements per day is sufficient to provide consistent and acceptable water quality characteristics throughout the duration of the 10 day exposure.

2.3.4 Photoperiod

The test vessels will be illuminated to a light intensity of 30-100 footcandles using a combination of fluorescent bulbs. A 16-hour light, 8-hour dark photoperiod will be maintained with an automatic timer. Sudden transitions from light to dark and vice versa will be avoided.

2.3.5 Measurement of Water Quality Variables

Total hardness, alkalinity, specific conductance, pH and ammonia will be determined at the beginning and end of the test in the overlying water from a composite sample from all eight replicate vessels. The composite sample will be taken from 1 to 2 cm from the sediment surface using a pipet. Dissolved oxygen and temperature will be measured in all replicate vessels at test initiation and test termination. Dissolved oxygen and temperature will be monitored daily in one alternating replicate during the course of the study (test days 1-9). Temperature will be monitored continuously in the waterbath using a minimum-maximum thermometer. Readings of temperature extremes will be recorded daily.

2.3.6 Dissolved Oxygen

Total dissolved oxygen will not be allowed to drop below 40% or exceed 100% of saturation for the duration of the study. Aeration (with oil-free air) will be initiated to raise and maintain the dissolved oxygen concentration at or above 40% of saturation.

2.3.7 Temperature

Water temperature of the test solutions will be maintained at 23 ± 1°C by conducting the study in a temperature controlled water bath at the appropriate test temperature.

2.3.8 Biological Data

Survival of the midge larvae will be determined in each test vessel at test termination (test day 10) by sieving the sediment to remove all surviving midges. In addition, daily observations of organism behavior (e.g., sublethal effects) and characteristics of sediment and overlying water will also be observed and recorded daily. The growth of surviving midge larvae in each replicate will also be recorded at test termination by pooling all surviving midge larvae from each replicate vessel and drying at 60°C for 24 hours. Pooled midge larvae will be weighed on a calibrated analytical balance to the nearest 0.01 mg.

2.3.9 Test Acceptability

At termination of the study, mean survival in the laboratory control must be ≥ 70% and mean growth must be ≥ 0.60 mg per midge larvae.

3.0 STATISTICAL ANALYSIS

The mean survival and growth of organisms exposed in each test sediment and reference control sample will be tested for normality and homogeneity of variance using Shapiro-Wilks Test and Ba F-Test. If the data set passes these two tests, then a parametric method (e.g., ANOVA 2-Sample T-Test or Dunnett's Test) will be used to evaluate the results of the mean survival and growth of each test sample for significant adverse effects. If the data set fails the test for normality and homogeneity of variance, then a non-parametric method (e.g., Steel's Many-One Rank Test) will be used to determine significant adverse effects. If necessary, mean survival values will be transformed (e.g., arcsine square).

4.0 REPORTING

The raw data and the final summary report will be reviewed by the Study Director. The test results will be presented in an outline format on a per sample basis.

5.0 REFERENCES

Adams, W.J., R.A. Kimerle, and R.G. Mosher. 1985. Aquatic safety assessment of chemicals sorbed to sediments. In: *Aquatic Toxicology and Hazard Assessment: Seventh Symposium* ASTM STP 854. R.D. Cardwell, R. Purdy and R.C. Bahner, Eds. American Society for Testing Materials. 1985. pp. 429-453.

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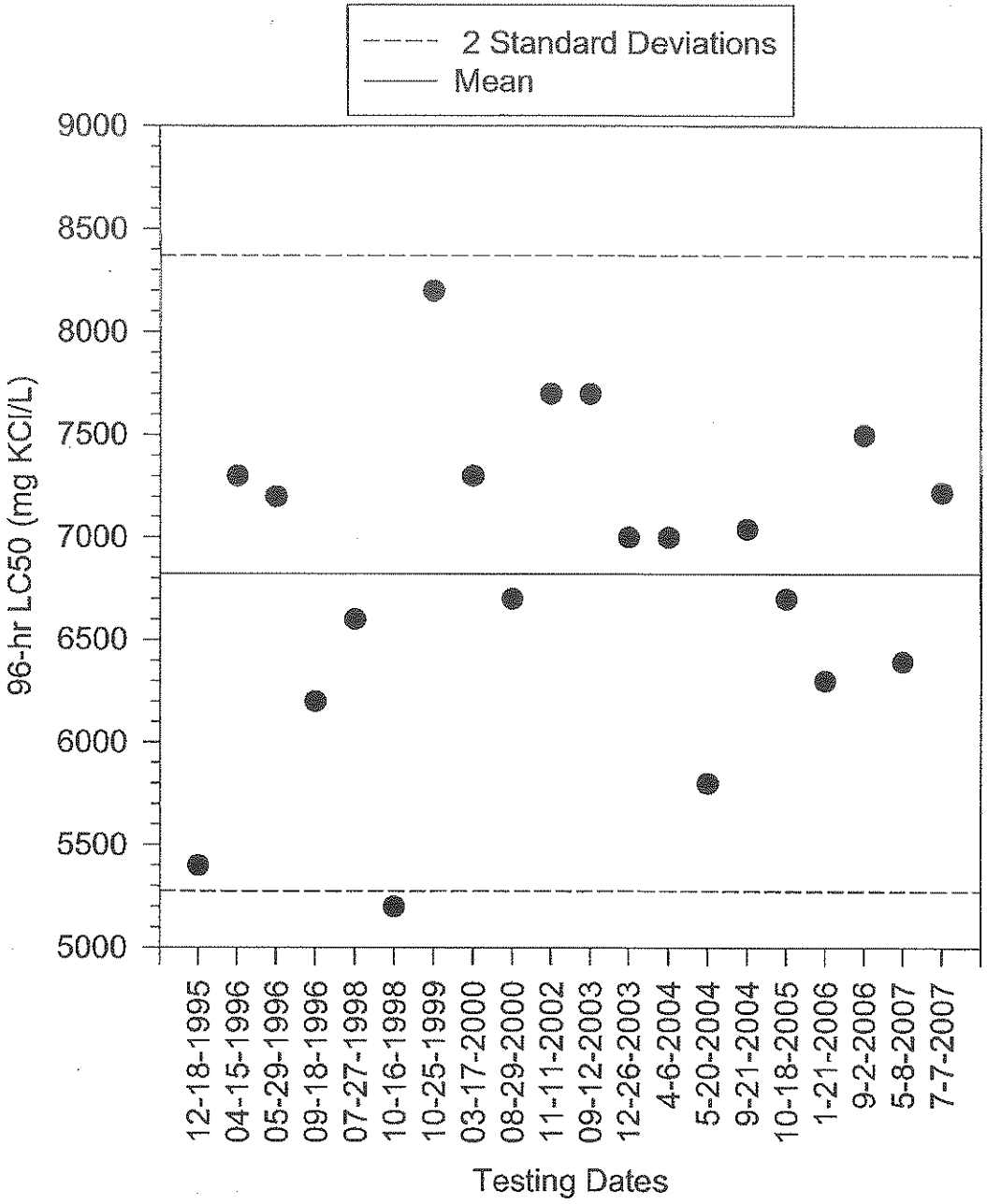
APPENDIX 2

Summary of Chironomus tentans Reference Testing with Potassium Chloride



Appendix H

Additional Screening Evaluation

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Appendix H
Additional Screening Evaluation

To screen the potential chemicals of interest (PCoIs) in soil, sludge, and sediment, site concentration data were compared with commonly used risk-based benchmarks, i.e., the risk-based concentrations (RBCs) for soil that were developed by the U.S. Environmental Protection Agency (EPA) Region III using standard EPA default assumptions and algorithms (U.S. EPA 2002).[1] After these screening analyses were performed, the Ohio Environmental Protection Agency (OEPA) stated that they do not endorse the use of Region III RBCs, and expressed a preference for use of the preliminary remediation goals (PRGs) developed by EPA Region IX as the basis for screening analyses in risk assessments performed under their review. Because they are based on a similar set of assumptions and calculations, these PRGs are similar to the Region III RBCs, differing only in the exposure pathways included in the calculations. Use of the Region IX PRGs in place of the Region III RBCs would not significantly change the results of the screening process, nor the risk analyses and conclusions reached in this human health risk assessment (HHRA). As a result, the screening process presented within the main text of the HHRA was not modified. At OEPA's request, the results of a screening analysis using the EPA Region IX PRGs are provided in this appendix. When OEPA originally requested that this evaluation (and appendix) be included with the report, there were some differences between the two sets of screening values, such that one additional chemical would have exceeded a residential screening value using the Region IX PRGs, but which did not exceed any screening values from the Region III RBCs. However, during recent updates to the Region III RBCs, this difference between the two sets of screening values (specifically for hexavalent chromium) has diminished. At this point in time (June 2004), using the Region IX PRGs in the screening analysis would not result in any additional chemicals being retained as CoIs for the risk evaluation because of consideration of other factors, such as land use and environmental chemistry. This appendix discusses the implications of the results of OEPA's requested alternative screening process for the risk analyses presented in the HHRA.

The EPA Region III RBCs and Region IX PRGs are calculated to correspond to risk levels typically applied by EPA as starting point risk estimates of interest (i.e., an incremental lifetime probability of developing cancer of one-in-one-million or 1×10^{-6} and a hazard index of 1 for noncancer effects). OEPA also frequently requires that the EPA Region IX PRGs be multiplied

[1] As discussed in Section 6.2.2.1, *Screening Evaluation for Soil, Sediment, and Sludge*, the oral reference doses (RfDs) and RBCs for chromium were modified after the original screening was conducted using the values available in 1997. Based on a comparison of the site data with the modified values, only two chromium concentrations in the East Fenced Area sludge were observed to exceed one of the modified RBCs (i.e., the RBC for chromium(VI) in residential soil). This criterion represents a highly conservative benchmark for comparison with the East Fenced Area sludge because chromium(III) (which has much higher RBCs) is the more prevalent form expected in environmental samples and because the East Fenced Area is not a current or potential future residential area, but instead is a fenced area of limited access within an property where future use is expected to remain industrial/commercial. As a result, this compound was not included in the quantitative risk analyses presented in the HHRA. The analyses presented in this appendix demonstrate that excluding this compound from the quantitative risk analyses does not alter the risk assessment results or the conclusions drawn based on those results.

by an additional safety factor of 0.1 prior to using these values to screen site data. Using this safety factor of 0.1 reduces the PRGs and the risk levels associated with them by a factor of 10. This approach is intended to ensure that the screening process does not overlook exposures associated with certain chemicals that may yield significant levels only in combination with exposures to other chemicals.

However, the Site has a limited number of chemicals that occur at concentrations of concern from a risk-based perspective, and few affect similar target organs. Based on these considerations, OEPA agreed that a screening process conducted without use of the 0.1 safety factor would appropriately identify all chemicals that would significantly contribute to overall site-related risks.

The maximum observed concentration for each PCoI in soil, sludge, and sediment was compared with the EPA Region IX PRGs for soil (U.S. EPA 2002). As in the original HHRA, risk-based values based on both occupational and residential scenarios were considered in this comparison. As noted above, the target risk level associated with Region IX PRGs for carcinogenic chemicals is an incremental cancer risk of 1×10^{-6}. The standard EPA hazard index of 1 is incorporated into the PRG values based on noncancer health effects, indicating an exposure level at which adverse health effects are not expected to occur. A standard PRG is not available for lead. Instead, as in the original HHRA, the EPA screening level of 400 mg/kg was used (U.S. EPA 1994).

Tables H-1 through H-8 show the results of this comparison to Region IX PRGs. When compared with the original results obtained using the EPA Region III RBCs as the benchmarks, no additional chemicals would have been included as a CoI, based on use of the PRGs rather than the RBCs, once other factors are taken into account (e.g., land use, environmental chemistry). Therefore, the risk evaluation, as it currently stands in the screening of PCoIs, is accurate. The total chromium concentration exceeds the residential standard (RBC or PRG) for hexavalent chromium at the East Fenced Area. However, as described in the main body of the report, chromium at the site is not expected to be present in the more toxic, hexavalent form. Additionally, because future use of the East Fenced Area will continue to be industrial/commercial, the exposure frequency at the East Fenced Area will be lower than assumed for residential standards. Therefore, it was established that chromium need not be carried through the risk assessment as a CoI for the Site.

Thus, these analyses confirm that the screening process used in the HHRA identified all necessary CoIs that might have any significant contributions to total exposure and risk estimates for the Site.

References

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Tables

Table H-1. Comparison of maximum soil concentrations in the East Fenced Area with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b]	
		Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	10.2	31	400
Arsenic	28.9	0.39	1.6
Barium	114	5,400	67,000
Chromium[c]	47	210 [c]	450 [c]
Fluoride	160	3,700	37,000
Lead	347	400	--
Nickel	21.6	1,600	20,000

Note: -- - not available
EPA - U.S. Environmental Protection Agency
PRG - preliminary remediation goal

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

Table H-2. Comparison of maximum sludge concentrations in the East Fenced Area with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b]	
		Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	68	31	400
Arsenic	358	0.39	1.6
Barium	3,600	5,400	67,000
Chromium[c]	362	210 [c]	450 [c]
Fluoride	161	3,700	37,000
Lead	13,800	400	--
Nickel	26	1,600	20,000

Note: -- - not available
EPA - U.S. Environmental Protection Agency
PRG - preliminary remediation goal

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

Table H-3. Comparison of maximum soil concentrations in the East Swale with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b]	
		Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	604	31	400
Arsenic	530	0.39	1.6
Barium	2,670	5,400	67,000
Chromium[c]	198	210 [c]	450 [c]
Fluoride	8,100	3,700	37,000
Lead	23,500	400	--
Nickel	124	1,600	20,000

Note: -- - not available
EPA - U.S. Environmental Protection Agency
PRG - preliminary remediation goal

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

Table H-4. Comparison of maximum soil concentrations at the former Oil Skimmer Pond with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b]	
		Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	1.8	31	400
Arsenic	11.8	0.39	1.6
Barium	63.1	5,400	67,000
Chromium[c]	9.7	210 [c]	450 [c]
Lead	55.6	400	--
Nickel	18.5	1,600	20,000
Organic Compounds			
Acetone	0.021	1,600	6,000
Carbon disulfide	0.0031	360	720
Di-*n*-butyl-phthalate	0.11	6,100	62,000
Methylene chloride	0.015	9.1	21
Toluene	0.0044	520	520
TPH	1,950	--	--

Note: -- - not available
EPA - U.S. Environmental Protection Agency
PRG - preliminary remediation goal
TPH - total petroleum hydrocarbon

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

Table H-5. Comparison of maximum soil/sediment concentrations in the South Ditch with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b] Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	51.5	31	400
Arsenic	239	0.39	1.6
Barium	233	5,400	67,000
Chromium[c]	35.7	210 [c]	450 [c]
Lead	16,200	400	--
Nickel	24.8	1,600	20,000
Organic Compounds			
bis(2-Ethylhexyl)phthalate	9.3	35	120
2-Butanone	0.042	7,300	27,000
Carbon disulfide	0.024	360	720
TPH	140,000	--	--
PAHs			
Anthracene	0.25	22,000	100,000
Benz[a]anthracene	3.9	0.62	2.1
Benzo[b]fluoranthene	11	0.62	2.1
Benzo[k]fluoranthene	1.4	6.2	21
Benzo[a]pyrene	7.2	0.062	0.21
Carbazole	0.3	24	86
Chrysene	7.4	62	210
Dibenz[a,h]anthracene	0.26	0.062	0.21
Indeno[1,2,3-cd]pyrene	2.5	0.62	2.1
Benzo[ghi]perylene	3.2	56 [d]	190 [d]
Fluoranthene	15	2,300	22,000
Phenanthrene	5.1	56 [d]	190 [d]
Pyrene	13	2,300	29,000

Note: -- - not available
EPA - U.S. Environmental Protection Agency
PAH - polycyclic aromatic hydrocarbon
PRG - preliminary remediation goal
TPH - total petroleum hydrocarbon

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

[d] Using the most current data available, there are no PRGs for this chemical. However, it is not classified as a carcinogen (U.S. EPA 2004). Therefore, the value for the noncarcinogenic PAH with the lowest PRG was used as a screening value.

Table H-6. Comparison of maximum soil/sediment concentrations in the Offsite Creek Area with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b]	
		Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	113	31	400
Arsenic	222	0.39	1.6
Barium	649	5,400	67,000
Chromium[c]	77	210 [c]	450 [c]
Lead	15,800	400	--
Nickel	46	1,600	20,000
Organic Compounds			
TPH	26.8	--	--

Note: -- - not available
EPA - U.S. Environmental Protection Agency
PRG - preliminary remediation goal
TPH - total petroleum hydrocarbon

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

Table H-7. Comparison of maximum soil concentrations in the Adjacent Fields with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b]	
		Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	5.4	31	400
Arsenic	113	0.39	1.6
Barium	524	5,400	67,000
Chromium[c]	33	210 [c]	450 [c]
Fluoride	650	3,700	37,000
Lead	218	400	--
Nickel	83	1,600	20,000

Note: -- - not available
EPA - U.S. Environmental Protection Agency
PRG - preliminary remediation goal

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

Table H-8. Comparison of maximum detected soil concentrations in Onsite Soils with EPA risk-based concentrations for soil

Analyte[a]	Maximum Detected Concentration (mg/kg)	EPA Soil PRG (mg/kg)[b]	
		Residential Soil	Industrial Soil
Inorganic Compounds			
Antimony	ND	31	400
Arsenic	31.3	0.39	1.6
Barium	417	5,400	67,000
Chromium[c]	ND	210 [c]	450 [c]
Lead	242	400	--
Nickel	16	1,600	20,000
Organic Compounds			
TPH	ND	--	--

Note: -- - not available
EPA - U.S. Environmental Protection Agency
ND - not detected
PRG - preliminary remediation goal
TPH - total petroleum hydrocarbon

[a] Includes all chemicals observed in at least one sample included in data set.

[b] Values from EPA Region IX PRG tables (October 2002) (U.S. EPA 2002) except for lead. The lead value is a soil screening level recommended for use by EPA in determining whether additional evaluation is required at a site (U.S. EPA 1994).

[c] PRGs for total chromium (assumed to be a 1:6 ratio of Cr VI to Cr III) were used as a conservative approach. PRG values for chromium III (the more likely form in environmental samples) are 100,000 mg/kg for residential and industrial soil, which is the maximum "ceiling limit" equivalent to a chemical representing 10 percent by weight of the soil sample.

Appendix I

Hypothetical Residential Exposure Scenario For Offsite Creek Area

Appendix I
Residential Exposure Assessment for the Offsite Creek Area

This revised addendum to the April 1998 draft human health risk assessment (HHRA) was prepared in response to an Ohio Environmental Protection Agency (OEPA) request (OEPA 2002) that the Respondents evaluate a hypothetical residential exposure scenario for lead in soil at the Offsite Creek Area (OCA), with modifications based on later comments (OEPA 2008, 2009). For the OCA, land use that would result in more extensive exposure (residential land use) is unlikely to occur because these areas are within the 100-year flood plain of the Scioto River. Based on these conditions, the Respondents had determined that a potential trespasser (or recreational) exposure scenario was most applicable for this area. Residential land uses within the lead-affected drainage areas are unlikely because of the occasional flooding of the areas. Because of these limitations, the previous evaluation for the OCA incorporated exposure assumptions for adults and older children only.

The OCA's hypothetical future residential scenario was requested by OEPA because the Respondents do not control the future land use and/or development, because the OCA is owned by a local resident farmer. However, on November 9, 2007, a Declaration of Use Restriction ("DUR") was executed by Richards Farms, Inc., Richards Land Company, William J. Richards, and Grace S. Richards ("Richards entities") covering the OCA. The DUR was signed by the Richards entities and recorded on November 14, 2007. The DUR evidences the commitment and obligation of the Richards entities to restrict the OCA to the limited uses set forth in the DUR, to prohibit other uses of the OCA, and prohibit the use of groundwater for any potable purposes. In anticipation that the long-term property restrictions will need to be in a form and substance acceptable to OEPA, the Richards entities have agreed in writing to sign, and then record in the future, an Environmental Covenant (as defined in ORC Chapter 5301.80 (D)) in a form satisfactory to GE and OEPA, which Environmental Covenant will include land use restriction terms comparable to the terms used in the DUR. Thus, the DUR and subsequent Environmental Covenant will create a restriction to safeguard present uses.

Until full negotiations are completed regarding the implications of the DUR and Environmental Covenant, the Respondent has conducted the risk assessment as stipulated by OEPA. Therefore, hypothetical future residential use of the OCA has been evaluated. This appendix provides a brief summary of the exposure setting, the methods and data used in conducting the residential exposure assessment, and the results of blood lead modeling associated with this hypothetical future use of the OCA. A more complete discussion of many of the parameters or data used in this assessment is provided in Section 6 of the remedial investigation report for the Site, and the reader is directed to specific sections of the remedial investigation report for additional details.

Exposure Setting

For the purpose of this evaluation, the OCA was divided into three areas as described in the remedial investigation report: the deltaic area, the non-deltaic area, and the upper creek area. The deltaic area no longer receives discharges of non-contact cooling water from the Thomson

facility. However, the area remains a heavily vegetated wetland area that receives surface water drainage from the surrounding area and conveys that drainage to the Scioto River. It is also subject to intermittent inundation associated with various precipitation events. The non-deltaic area has soil that is typically above water or dry for at least part of the year, and the upper creek area includes the portion of the drainage between Highway 23 and the railroad tracks, which is characterized by steep embankments and a small narrow "floodplain" that is typically wet. The data set for the non-deltaic area also includes samples from the Farm Ditch outside of the deltaic area. Under the residential scenario evaluated in this Addendum, it is assumed by the Respondents that a hypothetical residence could be placed only in the non-deltaic area of the OCA and young children (ages 0 to 6 years), the most sensitive population, could be exposed to lead in soil at or in the vicinity of the hypothetical residence. This "hypothetical future residential" exposure scenario for the OCA was evaluated using EPA's Integrated Exposure Uptake/Biokinetic (IEUBK) model, which is consistent with agency guidance for assessing exposures to lead under a residential exposure scenario. Further discussion of the model is provided below.

The IEUBK analysis was used to evaluate the residential exposure scenario for only the non-deltaic area of the OCA, and an additional evaluation in this Addendum was performed for potential exposures (by a trespasser) to lead in soil or sediments in the deltaic and upper creek areas. The Respondents presumed a residence could not be placed in the deltaic area as it now exists, and the upper creek area is generally too narrow or steep for any future residential use directly upon the drainage area. Additionally, as described above, the current property owner has executed a DUR, which (when combined with the future Environmental Covenant) will limit the future use of the impacted areas of the OCA. The exposure evaluation of the deltaic and upper creek area soils was conducted assuming that older, more independent children (ages 9 to 18 years) living in the non-deltaic area of the OCA could visit or play in the deltaic or upper creek area. Thus, while under the residential exposure scenario it was assumed that young children (age 0 to 6 years) would play in soils near an actual residence, the young children would not be exposed to deltaic or upper creek area soils where water flow conditions or steep embankments may pose a safety hazard that would discourage visits by a young child.

Non-Deltaic Area

As discussed above, a hypothetical residential exposure scenario was evaluated for the non-deltaic area of the OCA. This residential scenario assumes that young children could be exposed to lead in soil at or near their residence. EPA's IEUBK model, Version 1.1, Build 9 (U.S. EPA 2009a), was used to assess lead exposure to young children (the sensitive population) under this residential scenario. The model incorporates inputs for lead exposure from a number of sources including soil, diet, air, maternal contribution *in utero*, and water. It estimates a geometric mean blood lead level based on site exposure as well as other background sources. A geometric standard deviation (GSD) is then applied to estimate upper percentile blood lead levels. The model also estimates the probability of a fetus or child exceeding a target blood lead level of 10 μg/dL. EPA currently considers a blood lead concentration of 10 μg/dL as a level of concern for young children and uses 5 percent as the regulatory limit for the probability of exceeding 10 μg/dL (U.S. EPA 1994, 2003a; Beringer 2009). EPA model default assumptions

were used (U.S. EPA 2007, 2009a), along with Site-specific soil concentrations. Model inputs are presented in Table I-1.

Dietary lead intake by children has decreased since 1988 (Bolger et al. 1996, Griffin et al. 1999; Liu 2001). These lower dietary intakes are reflected in the updated default values of the most current version of the IEUBK model (U.S. EPA 2009b). These updated values are based on data obtained by an analysis of the FDA Total Diet Study (FDA 2006) and food consumption data from NHANES III (CDC 1997).

A soil lead concentration of 127 mg/kg was used in the model for the first model run. This value of 127 mg/kg represents the arithmetic mean of the surface soil (0 to 6 in.) lead concentrations for samples from the non-deltaic area of the OCA (Table I-2). A second model run was conducted using a soil lead concentration of 135 mg/kg, which represents the highest arithmetic mean concentration for depth-specific intervals in this area, and is associated with the 6- to 12-in. depth interval. The use of this higher soil concentration is intended to encompass potential future scenarios that might allow deeper soils to reach the surface (e.g., septic system repair, gardening) (U.S. EPA 2003b), and OEPA specifically requested that it be included in the risk assessment. The use of the arithmetic mean soil concentration as the input is consistent with the requests of OEPA (i.e., use of arithmetic mean rather than geometric mean concentrations), and the requirement of the IEUBK model to use a central tendency estimate for this input value.

The results from blood lead modeling for residential exposures in the non-deltaic area of the OCA indicate that soil lead in this area would not likely result in blood lead levels that exceed regulatory thresholds of exposure (Table I-3). Specifically, using the IEUBK model and the Site-specific surface soil concentration data, the estimate of mean blood lead in the hypothetical residential population of the OCA would be 2.06 μg/dL, with a 0.038 percent probability of exceeding 10 μg/dL. Similarly, using the highest average soil concentration, the estimate of mean blood lead in the hypothetical residential population of the OCA would be 2.13 μg/dL with a 0.050 percent probability of exceeding 10 μg/dL. These values are well below the regulatory limit of less than 5 percent probability of exceeding a blood lead level of 10 μg/dL.

Deltaic and Upper Creek Areas

In addition to the residential assessment for the portions of the OCA that fall outside of the deltaic area, potential exposures to lead in soils/sediments of the deltaic and upper creek area of the OCA were also evaluated. The evaluation of these two areas was conducted assuming that older children (ages 9 to 18 years) living in the non-deltaic area of the OCA might play in the deltaic or upper creek areas on a regular basis. The IEUBK is designed only to evaluate exposure in children up to age six, and is therefore not appropriate for use in evaluating exposures in this older population. However, EPA has developed a simplified exposure model for evaluating risks associated with adult exposure to lead in soil (U.S. EPA 2003a). Although the model is designed to evaluate risks to the fetus of a pregnant female exposed to lead in soil, the guidance for the model indicates that it can be modified to accommodate assessment of alternative exposure scenarios (U.S. EPA 2003a). The adult lead model was modified to assess risks to older children by omitting the fetal to maternal blood lead ratio from the calculation.

This change causes the model to provide predictions of the blood lead concentration for the older child, rather than the fetus, and results in a higher blood lead estimate for a given soil lead concentration input value. As with the IEUBK model, the adult lead model also calculates the likelihood that blood lead will exceed the target level of 10 μg/dL. A more detailed description of the model, including an uncertainty analysis and comparisons to lower target blood lead levels, is provided in Sections 6.3.4 and 6.6.3 of the remedial investigation report.

Because there are no standard assumptions available for application of the adult lead model to an older child exposure scenario, a "matrix" approach combining varying exposure frequencies and soil ingestion rates was used in order to provide results from a full range of potential exposure scenarios, as requested by OEPA (Table I-4). Site-specific values were used for soil concentration. In addition, a target blood lead concentration, identified by EPA to be protective of fetuses and small children, was conservatively used as the target blood lead concentration that would be protective of older children (i.e., 10 μg/dL). The young child regulatory limit of 5 percent chance of exceeding the target level of 10 μg/dL was also used for the older child scenario. Additional comparisons to lower target blood lead levels are provided in Section 6.6.3 of the remedial investigation report.

A soil lead exposure point concentration of 2,221 mg/kg and 884 mg/kg was used in the model for the deltaic and upper creek areas, respectively. These values are the arithmetic mean of the surface soil (0 to 6 in.) lead concentrations for samples from the deltaic or upper creek areas of the OCA (Table I-2). These concentrations also represent the highest average concentration for depth-specific intervals, and thus provide a higher estimate of exposure than would result from exposures to deeper soils if they were brought to the surface. Additional calculations using data from each depth interval are provided in Table 6-19 of the remedial investigation report.

This adult lead model also requires input parameters of baseline blood lead (geometric mean, GM) and geometric standard deviation (GSD). EPA recently updated their recommendations for these parameters for adults, and now recommends using a GM of 1.0 μg/dL and a GSD of 1.8 in the Adult Lead Model. These values are based on NHANES III and subsequent NHANES surveys (1999–2004) (U.S. EPA 2009c). There are no recommendations for children ages 9–18 years, so following the recommendations of OEPA, the baseline values for adults were used for the older child scenario.

This assessment for the deltaic and upper creek areas used the EPA default soil ingestion rate of 50 mg/day. In addition, to provide a range of values, this assessment also incorporated a soil ingestion rate of 25 mg/day and a contact-intensive value of 100 mg/day.

The lower soil ingestion rate of 25 mg/day was based on multiple factors. The default ingestion rate of 50 mg/day is based on occupational exposure to soil and dust, and implicitly assumes a full 8-hour workday, whereas a trespasser is more likely to be in contact with Site-related soils for only a few hours at each visit. Additionally, the default ingestion rate incorporates ingestion of both outdoor soil and indoor dust. However, only a fraction of an individual's total daily soil ingestion comes from outdoor sources. Specifically, the IEUBK model recommends a value of 0.45 as the fraction of the total soil ingestion attributable to outdoor soil rather than indoor dust. The few studies that have attempted to quantify the amount of soil versus dust ingested by children appear to be consistent with EPA's default assumption for outdoor soil ingestion (e.g.,

49 percent; Stanek and Calabrese 1992). EPA Region VIII has also used a fractional intake (FI) of 0.45 for outdoor soil versus indoor dust ingestion in risk assessments of arsenic in soil when the concentrations of arsenic in soil and house dust differ. A soil ingestion rate of 25 mg/day is consistent with this understanding of sources for inadvertent soil ingestion, and with the IEUBK analysis conducted for the residential scenario. Even this lower soil ingestion rate is a conservative assumption that is likely to overestimate actual ingestion of soil from the deltaic or upper creek area because only a portion of a child's total time outdoors would be spent visiting this area. It is unlikely that the exposure time for each visit would account for 100 percent of outdoor exposure time on each visit to the area. Also, because much of the contaminated deltaic or upper creek area soils are isolated and occasionally flooded, actual contact and ingestion of these soils would be unlikely. However, it is difficult to quantify the specific fraction of outdoor time that might be spent in the deltaic or upper creek area.

This assessment also incorporated a higher soil ingestion rate of 100 mg/day to address OEPA's concerns regarding potential contact-intensive activities under the trespasser scenario. This value was recommended by the TRW as an appropriate value for contact-intensive occupational tasks such as digging or construction work (U.S. EPA 2003c, 2009d). When coupled with the implicit assumption of an 8-hour exposure, which is likely to overestimate a trespasser's exposure duration, this soil ingestion rate should provide a high-end exposure estimate.

In order to evaluate a range of potential exposures, the model was run using four different exposure frequencies:

- Weekly (50 out of 365 days),
- Twice weekly (100 out of 365 days),
- Every other day (175 out of 365 days), and
- Daily (350 out of 365 days).

The weekly exposure is the lowest frequency that the model will support; a less frequent exposure would be expected to produce oscillations in blood lead concentrations associated with the absorption and subsequent clearance of lead from the blood between exposure events (U.S. EPA 2003a). The assumptions of higher exposure frequencies were included in the assessment in order to provide OEPA with a full range of exposure levels.

The results of the deltaic and upper creek area evaluation are presented in Table I-4, and indicate that soil lead in this area would be unlikely to result in blood lead levels above regulatory threshold levels in older children playing regularly in either of those areas. Modeled blood lead concentrations were compared to regulatory benchmarks that specify that the 95th percentile blood lead concentration should be less than 10 μg/dL, and that the probability of exceeding 10 μg/dL should be below 5 percent (U.S. EPA 1994, 2003a). Specifically, modeled predictions for these areas are presented in Table I-4, and indicate that:

- *Both areas, weekly exposure*: The 95th percentile blood lead concentrations for weekly exposure were below the regulatory benchmark for all scenarios for both the deltaic and upper creek areas.

- *Both areas, lower soil ingestion rate*: Using the lower soil ingestion rate of 25 mg/day yielded 95th percentile blood lead concentrations that fall below the regulatory benchmark for all scenarios for both the deltaic and upper creek areas.

- *Deltaic area, default soil ingestion rate:* For the deltaic area, when using the default soil ingestion rate of 50 mg/day, a majority of results were below the regulatory benchmark (i.e., for exposure frequencies of weekly, twice weekly, and every other day), while only the scenario combining the default soil ingestion rate with daily exposures exceeded the benchmark.

- *Deltaic area, contact-intensive soil ingestion rate*: For the deltaic area, when incorporating the contact-intensive soil ingestion rate of 100 mg/day, results for weekly exposures were below the regulatory benchmark, while results for higher exposure frequencies exceeded the benchmark.

- *Upper creek area*: For the upper creek area, modeled results for all combinations of input parameters were below the regulatory benchmark, with the single exception of daily exposures assuming contact-intensive soil ingestion rate.

Conclusions

Although the OCA site conditions make exposure to area soils under future residential use within the OCA unlikely, a hypothetical future residential exposure assessment was conducted in order to provide a conservative evaluation. The OCA's hypothetical future residential scenario was requested by OEPA because the Respondents do not control the future land use and/or development, although the current owner executed a DUR, which when combined with the future Environmental Covenant will limit the future use of the impacted areas of the OCA.. Exposure assumptions for the residential assessment were based on the most likely scenario, specifically that a house might be built in the non-deltaic area of the OCA, and that exposure to soils from the deltaic or upper creek areas would occur with older children who might visit the area. Residential exposures were evaluated for a young child using the IEUBK Model, and the results from this assessment indicate that exposures to non-deltaic soils would not increase blood lead concentrations above current regulatory target levels. In addition to the residential exposure scenario, potential exposures by older children visiting the deltaic or upper creek areas were evaluated using EPA's adult lead exposure model. The results of this assessment indicate that exposure to lead in soils in the upper creek areas of the OCA would not increase blood lead concentrations in older children above regulatory limits, with the single exception of daily exposures assuming a contact-intensive soil ingestion rate (of 100 mg/day). For exposures by an older child to lead in soils of the deltaic area of the OCA, modeling results under most scenarios were below the regulatory benchmark, although certain combinations of higher inputs for exposure frequency or soil ingestion rates produced results that exceeded benchmarks. This matrix approach combining varying exposure frequencies and ingestion rates was used in order to provide OEPA with results from a full range of potential exposure scenarios (Table I-4).

Additional comparisons to lower target levels are provided in Section 6.6.3 of the remedial investigation report.

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Tables

Table I-1. EPA IEUBK lead model exposure parameters and input values for the hypothetical future residential scenario in the Offsite Creek Area (younger child)

Parameter	Input Value(s)	Source
Air		
Outdoor lead concentration (μg/m^3)	0.100	EPA default
Indoor air lead concentration (% of outdoor air)	30%	EPA default
Time spent outdoors (hrs/day)	1, 2, 3, 4, 4, 4, 4[a]	EPA default
Ventilation rates (m^3/day)	2, 3, 5, 5, 5, 7, 7[a]	EPA default
Lung absorption (%)	32%	EPA default
Diet		
Diet intake (μg/day)	2.26, 1.96, 2.13, 2.04, 1.95, 2.05, 2.22[a]	EPA default
Alternative diet values	Not used	EPA default
Gastrointestinal absorption from diet (%)	50%	EPA default
Drinking Water		
Lead concentration in drinking water (µg/L)	4.00	EPA default
Drinking water intake (L/day)	0.20, 0.50, 0.52, 0.53, 0.55, 0.58, 0.59[a]	EPA default
Alternative water values	Not used	EPA default
Gastrointestinal absorption from drinking water (%)	50%	EPA default
Soil/Dust		
Soil lead levels (ppm or μg/g)	127[b], 135[c]	Site data[b,c]
Indoor dust lead levels (% of soil levels)	70%	EPA default
Ingestion weighting factor (% soil/% dust)	45% / 55%	EPA default
Amount of soil/dust ingested daily (g/day)	0.085, 0.135, 0.135, 0.135, 0.100, 0.090, 0.085[a]	EPA default
Gastrointestinal absorption from soil and dust (%)	30%	EPA default
Other		
Paint lead intake (μg/day)	0.0	EPA default
Alternative paint values	Not used	EPA default
Gastrointestinal absorption from leaded paint (%)	Not used	EPA default
Maternal contribution method	Infant model	EPA default
Maternal blood lead at birth of child (µg/dL)	1.0	EPA default
Geometric standard deviation	1.6	EPA default

Note: Model runs conducted using IEUBKwin version 1.1, build 9 (June 2009).
EPA - U.S. Environmental Protection Agency
IEUBK - Integrated Exposure Uptake/Biokinetic

[a] Value varies by age group. Values listed are for the following ages, respectively: 0–1, 1–2, 2–3, 3–4, 4–5, 5–6, 6–7 yrs.

[b] Value is the arithmetic mean of lead concentrations from non-deltaic Offsite Creek Area (OCA) surface (0–6") soil samples.

[c] Value is the arithmetic mean of lead concentrations from non-deltaic Offsite Creek Area (OCA) 6–12" soil samples, which had the highest mean concentration for depth horizons in that area (see Table I-2).

Table I-2. Lead concentrations in surface soils/sediments from the Offsite Creek Area

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Deltaic Area				
Historical	SS-2/3	03/11/92	0–1	1,360
Historical	SS-4/5	03/11/92	0–1	2,730
Historical	SS-6/7	03/11/92	0–1	3,310
Historical	SS-01	03/11/92	0–2	87.8
Remedial Investigation	C-OCA-1	11/29/95	0–6	4,410
Remedial Investigation	C-OCA-10	11/29/95	0–6	1,090 *J*
Remedial Investigation	C-OCA-11	11/30/95	0–6	169 *J*
Supplemental	C-OCA-13	10/14/03	0–6	4,550 *J*
Supplemental	C-OCA-14	10/14/03	0–6	1,890 *J*
Supplemental	C-OCA-15	10/14/03	0–6	1,620
Supplemental	C-OCA-16	10/14/03	0–6	1,100 *J*
Supplemental	C-OCA-17	10/14/03	0–6	3,460 *J*
Supplemental	C-OCA-18	10/14/03	0–6	706 *J*
Supplemental	C-OCA-19	10/14/03	0–6	10,100 *J*
Remedial Investigation	C-OCA-2	11/29/95	0–6	9,920 *J*
Supplemental	C-OCA-20	10/14/03	0–6	8,510
Supplemental	C-OCA-21	10/14/03	0–6	3,160
Supplemental	C-OCA-22	10/14/03	0–6	1,670 *J*
Remedial Investigation	C-OCA-3	11/29/95	0–6	8,080 *J*
Remedial Investigation	C-OCA-4	11/29/95	0–6	7,740 *J*
Remedial Investigation	C-OCA-5	11/29/95	0–6	7,490 *J*
Remedial Investigation	C-OCA-6	11/29/95	0–6	5,270
Remedial Investigation	C-OCA-7	11/29/95	0–6	7,980
Remedial Investigation	C-OCA-8	11/29/95	0–6	3,640
Remedial Investigation	C-OCA-9	11/29/95	0–6	365
Interim Action	IA-01	10/01/02	0–6	21.3
Interim Action	IA-02	10/01/02	0–6	27.45
Interim Action	IA-03	10/01/02	0–6	30.7
Interim Action	IA-04	10/01/02	0–6	24.4
Interim Action	IA-05	10/01/02	0–6	38.1
Interim Action	IA-06	10/02/02	0–6	264
Interim Action	IA-07	10/02/02	0–6	25.1
Interim Action	IA-10	10/02/02	0–6	22.5
Interim Action	IA-11	10/02/02	0–6	16.9
Interim Action	IA-15	10/02/02	0–6	169
Historical	M-1	09/26/90	0–6	6,380
Historical	M-2	09/26/90	0–6	1,310
Historical	M-3	09/26/90	0–6	4,040
Historical	M-4	09/26/90	0–6	709
Historical	M-5	09/26/90	0–6	1,880
Historical	MD-1	10/01/90	0–6	947
Historical	MD-2	10/01/90	0–6	1,230
Historical	OS-2	10/04/88	0–6	1,160
Historical	OS-3	10/04/88	0–6	179
Historical	T-4-C2R	09/26/90	0–6	1,740
Historical	T-5-A	09/26/90	0–6	633
Historical	T-5-C1L	09/26/90	0–6	1,200
Historical	T-5-C1R	09/26/90	0–6	1,270
Historical	T-5-C2L	09/26/90	0–6	62.6

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Deltaic Area (cont.)				
Historical	T-6-A	10/01/90	0–6	1,060
Historical	T-6-C1L	10/01/90	0–6	1,610
Historical	T-6-C1R	10/01/90	0–6	14.6
Supplemental	T-OCA-17-OB1L	10/14/03	0–6	704 *J*
Supplemental	T-OCA-18-OB1L	10/14/03	0–6	3,505
Supplemental	T-OCA-19-OB1R	10/15/03	0–6	7,950
Supplemental	T-OCA-19-OB2R	10/15/03	0–6	136
Supplemental	T-OCA-21-OB1R	10/15/03	0–6	1,830
Supplemental	T-OCA-22-OB1R	10/14/03	0–6	7,870 *J*
Supplemental	T-OCA-23-OB1R	10/14/03	0–6	12,100 *J*
Supplemental	T-OCA-24-OB1R	10/14/03	0–6	8,040
Supplemental	T-OCA-25-OB1R	10/13/03	0–6	1,370 *J*
Supplemental	T-OCA-26-OB1R	10/13/03	0–6	1,115 *J*
Supplemental	T-OCA-27-OB1R	10/09/03	0–6	1,110
Supplemental	T-OCA-29-C2R	10/09/03	0–6	836
Supplemental	T-OCA-29-OB1L	10/09/03	0–6	74.5
Supplemental	T-OCA-29-OB1R	10/09/03	0–6	1,860
Supplemental	T-OCA-29-OB2R	10/09/03	0–6	259
Supplemental	T-OCA-29-OB3R	10/09/03	0–6	160
Supplemental	T-OCA-30-C2R	09/23/03	0–6	825.5
Supplemental	T-OCA-30-OB1R	09/23/03	0–6	527
Supplemental	T-OCA-30-OB2R	09/23/03	0–6	199
Supplemental	T-OCA-30-OB3R	09/23/03	0–6	116
Supplemental	T-OCA-48-A	10/09/03	0–6	83.4
Supplemental	T-OCA-48-C1L	10/09/03	0–6	192
Supplemental	T-OCA-48-C1R	10/09/03	0–6	23.3
Supplemental	T-OCA-48-C2L	10/09/03	0–6	3,080
Supplemental	T-OCA-48-C2R	10/09/03	0–6	2,690
Supplemental	T-OCA-48-OB1R	10/09/03	0–6	127
Supplemental	T-OCA-48-OB2R	10/09/03	0–6	66.1
Supplemental	T-OCA-49-A	10/09/03	0–6	15.6
Supplemental	T-OCA-49-C1L	10/09/03	0–6	64.6
Supplemental	T-OCA-49-C1R	10/09/03	0–6	73.5
Supplemental	T-OCA-49-C2L	10/09/03	0–6	1,290
Supplemental	T-OCA-49-C2R	10/09/03	0–6	8,600
Supplemental	T-OCA-49-OB1R	10/09/03	0–6	40.8
Supplemental	T-OCA-49-OB2R	10/09/03	0–6	13
Supplemental	T-OCA-50-A	10/15/03	0–6	137
Supplemental	T-OCA-50-C2L	10/15/03	0–6	4,450
Supplemental	T-OCA-50-C2R	10/15/03	0–6	4,220
Supplemental	T-OCA-50-OB1L	10/15/03	0–6	4,510
Supplemental	T-OCA-50-OB2L	12/10/03	0–6	15.1 *J*
Supplemental	T-OCA-51-A	10/15/03	0–6	386
Supplemental	T-OCA-51-C2L	10/15/03	0–6	2,740
Supplemental	T-OCA-51-C2R	10/15/03	0–6	68.2
Supplemental	T-OCA-51-OB1L	10/15/03	0–6	4,390
Supplemental	T-OCA-51-OB2L	12/10/03	0–6	12.7 *J*
Historical	SS-2/3	03/11/92	2–5	3,670
Historical	SS-4/5	03/11/92	2–6	1,340
Historical	SS-6/7	03/11/92	2–6	559

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Non-Deltaic Area				
Remedial Investigation	C-OCA-12	11/30/95	0–6	633 *J*
Supplemental	C-OCA-23	12/10/03	0–6	406 *J*
Historical	FD-1	10/01/90	0–6	98.9
Historical	FD-2	10/01/90	0–6	58.9
Historical	LS-1	10/01/90	0–6	144
Historical	OS-4	10/04/88	0–6	170
Historical	OS-5	10/04/88	0–6	375
Historical	RS-1A	10/04/88	0–6	51.9
Historical	T-1-A	09/25/90	0–6	53.3
Historical	T-1-C1L	09/25/90	0–6	20.1
Historical	T-1-C1R	09/25/90	0–6	65.2
Historical	T-1-C2L	09/25/90	0–6	29.1
Historical	T-1-C2R	09/25/90	0–6	12.5
Historical	T-2-A	09/25/90	0–6	32.7
Historical	T-2-C1L	09/25/90	0–6	12.4
Historical	T-2-C1R	09/25/90	0–6	35.1
Historical	T-3-A	09/26/90	0–6	60.5
Historical	T-3-C1L	09/26/90	0–6	26.2
Historical	T-3-C1R	09/26/90	0–6	50.2
Historical	T-4-A	09/26/90	0–6	69.9
Historical	T-4-C1L	09/26/90	0–6	178
Historical	T-4-C1R	09/26/90	0–6	14.9
Historical	T-4-C2L	09/26/90	0–6	106
Supplemental	T-OCA-19-A	10/15/03	0–6	61.3
Supplemental	T-OCA-19-C1L	10/15/03	0–6	12.7
Supplemental	T-OCA-19-C1R	10/15/03	0–6	21.8
Supplemental	T-OCA-19-C2L	10/15/03	0–6	50.3
Supplemental	T-OCA-19-C2R	10/15/03	0–6	48.1
Supplemental	T-OCA-19-OB1L	10/15/03	0–6	60
Remedial Investigation	T-OCA-1-A	11/22/95	0–6	41.3
Remedial Investigation	T-OCA-1-C1L	11/22/95	0–6	204
Remedial Investigation	T-OCA-1-C1R	11/22/95	0–6	83.1
Remedial Investigation	T-OCA-1-C2L	11/22/95	0–6	27.2
Remedial Investigation	T-OCA-1-C2R	11/22/95	0–6	45.5
Supplemental	T-OCA-20-A	10/15/03	0–6	209
Supplemental	T-OCA-20-C1L	10/15/03	0–6	197
Supplemental	T-OCA-20-C1R	10/15/03	0–6	12.8
Supplemental	T-OCA-20-C2L	10/15/03	0–6	54.9
Supplemental	T-OCA-20-C2R	10/15/03	0–6	23.8
Supplemental	T-OCA-21-A	10/15/03	0–6	90.9
Supplemental	T-OCA-21-C1L	10/15/03	0–6	16.1
Supplemental	T-OCA-21-C1R	10/15/03	0–6	37.6
Supplemental	T-OCA-21-C2L	10/15/03	0–6	111
Supplemental	T-OCA-21-C2R	10/15/03	0–6	36
Supplemental	T-OCA-21-OB1L	10/15/03	0–6	43
Supplemental	T-OCA-22-A	10/14/03	0–6	61.6 *J*
Supplemental	T-OCA-22-C1L	10/14/03	0–6	52 *J*
Supplemental	T-OCA-22-C1R	10/14/03	0–6	14.3 *J*
Supplemental	T-OCA-22-C2L	10/14/03	0–6	36.2 *J*
Supplemental	T-OCA-22-C2R	10/14/03	0–6	29 *J*

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Non-Deltaic Area (cont.)				
Supplemental	T-OCA-22-HWL	10/14/03	0–6	25.7 *J*
Supplemental	T-OCA-23-A	10/14/03	0–6	60.5
Supplemental	T-OCA-23-C1L	10/14/03	0–6	70.25
Supplemental	T-OCA-23-C1R	10/14/03	0–6	16.7
Supplemental	T-OCA-23-C2L	10/14/03	0–6	40
Supplemental	T-OCA-23-C2R	10/14/03	0–6	34.4
Supplemental	T-OCA-23-OB1L	10/13/03	0–6	33.8
Supplemental	T-OCA-24-A	10/14/03	0–6	73.8 *J*
Supplemental	T-OCA-24-C1L	10/14/03	0–6	27.2 *J*
Supplemental	T-OCA-24-C1R	10/14/03	0–6	21.4 *J*
Supplemental	T-OCA-24-C2L	10/14/03	0–6	77.2 *J*
Supplemental	T-OCA-24-C2R	10/14/03	0–6	36.9 *J*
Supplemental	T-OCA-24-OB1L	10/13/03	0–6	47.1 *J*
Supplemental	T-OCA-25-A	10/13/03	0–6	71.4 *J*
Supplemental	T-OCA-25-C1L	10/13/03	0–6	16.6 *J*
Supplemental	T-OCA-25-C1R	10/13/03	0–6	35.3 *J*
Supplemental	T-OCA-25-C2L	10/13/03	0–6	59.7 *J*
Supplemental	T-OCA-25-C2R	10/13/03	0–6	51.4 *J*
Supplemental	T-OCA-25-OB1L	10/13/03	0–6	47 *J*
Supplemental	T-OCA-27-A	10/13/03	0–6	60.1
Supplemental	T-OCA-27-C1L	10/13/03	0–6	16.2
Supplemental	T-OCA-27-C1R	10/13/03	0–6	101
Supplemental	T-OCA-27-C2L	10/13/03	0–6	62.2
Supplemental	T-OCA-27-C2R	10/13/03	0–6	53.3
Supplemental	T-OCA-27-OB1L	10/13/03	0–6	47.9
Supplemental	T-OCA-28-A	10/09/03	0–6	59.4
Supplemental	T-OCA-28-C1L	10/09/03	0–6	21.7
Supplemental	T-OCA-28-C1R	10/09/03	0–6	18.2
Supplemental	T-OCA-28-C2L	10/09/03	0–6	32.7
Supplemental	T-OCA-28-C2R	10/09/03	0–6	28.05
Supplemental	T-OCA-28-OB1L	10/09/03	0–6	43.1
Supplemental	T-OCA-29-A	10/09/03	0–6	121.05
Supplemental	T-OCA-29-C1L	10/09/03	0–6	21.4
Supplemental	T-OCA-29-C1R	10/09/03	0–6	305
Supplemental	T-OCA-29-C2L	10/09/03	0–6	295
Remedial Investigation	T-OCA-2-A	11/22/95	0–6	83.6
Remedial Investigation	T-OCA-2-C1L	11/28/95	0–6	80.6
Remedial Investigation	T-OCA-2-C1R	11/28/95	0–6	254
Remedial Investigation	T-OCA-2-C2L	11/28/95	0–6	53.1
Remedial Investigation	T-OCA-2-C2R	11/28/95	0–6	36.3
Supplemental	T-OCA-30-A	09/23/03	0–6	438
Supplemental	T-OCA-30-C1L	09/23/03	0–6	29
Supplemental	T-OCA-30-C1R	09/23/03	0–6	16.1
Supplemental	T-OCA-30-HWL	09/23/03	0–6	188
Supplemental	T-OCA-31-A	09/23/03	0–6	36.9
Supplemental	T-OCA-31-C1L	09/23/03	0–6	455
Supplemental	T-OCA-31-C1R	09/23/03	0–6	319
Supplemental	T-OCA-31-C2R	09/23/03	0–6	368
Supplemental	T-OCA-31-HWL	09/23/03	0–6	78.9
Supplemental	T-OCA-31-OB1R	09/23/03	0–6	43

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Non-Deltaic Area (cont.)				
Supplemental	T-OCA-31-OB2R	09/23/03	0–6	195
Supplemental	T-OCA-31-OB3R	09/23/03	0–6	189
Supplemental	T-OCA-32-A	09/23/03	0–6	10.6
Supplemental	T-OCA-32-C1L	09/23/03	0–6	39.4
Supplemental	T-OCA-32-C1R	09/23/03	0–6	586
Supplemental	T-OCA-32-C2R	09/23/03	0–6	23.5
Supplemental	T-OCA-32-HWL	09/23/03	0–6	175
Supplemental	T-OCA-32-OB1R	09/23/03	0–6	340
Supplemental	T-OCA-32-OB2R	09/23/03	0–6	169
Supplemental	T-OCA-33-A	10/08/03	0–6	91.8
Supplemental	T-OCA-33-C1L	10/08/03	0–6	83.1
Supplemental	T-OCA-33-C1R	10/08/03	0–6	16.65
Supplemental	T-OCA-33-C2R	10/08/03	0–6	65.6
Supplemental	T-OCA-33-HWL	10/08/03	0–6	228
Supplemental	T-OCA-33-OB1R	10/08/03	0–6	624
Supplemental	T-OCA-33-OB2R	10/08/03	0–6	254
Supplemental	T-OCA-34-A	10/08/03	0–6	99
Supplemental	T-OCA-34-C1L	10/08/03	0–6	614
Supplemental	T-OCA-34-C1R	10/08/03	0–6	12.2
Supplemental	T-OCA-34-C2R	10/08/03	0–6	50.1
Supplemental	T-OCA-34-HWL	10/08/03	0–6	127
Supplemental	T-OCA-34-OB1R	10/08/03	0–6	728
Supplemental	T-OCA-34-OB2R	10/08/03	0–6	244
Supplemental	T-OCA-35-A	10/08/03	0–6	74.5
Supplemental	T-OCA-35-C1L	10/08/03	0–6	77.85
Supplemental	T-OCA-35-C1R	10/08/03	0–6	17
Supplemental	T-OCA-35-C2R	10/08/03	0–6	166
Supplemental	T-OCA-35-HWL	10/08/03	0–6	50.5
Supplemental	T-OCA-35-OB1R	10/08/03	0–6	244
Supplemental	T-OCA-35-OB2R	10/08/03	0–6	117
Supplemental	T-OCA-35-OB3R	10/08/03	0–6	8.4
Supplemental	T-OCA-36-A	10/08/03	0–6	141
Supplemental	T-OCA-36-C1L	10/08/03	0–6	16.5
Supplemental	T-OCA-36-C1R	10/08/03	0–6	62.5
Supplemental	T-OCA-36-C2R	10/08/03	0–6	131
Supplemental	T-OCA-36-HWL	10/08/03	0–6	21
Supplemental	T-OCA-36-OB1R	10/08/03	0–6	33.6
Supplemental	T-OCA-37-A	10/08/03	0–6	219
Supplemental	T-OCA-37-C1L	10/08/03	0–6	552
Supplemental	T-OCA-37-C1R	10/08/03	0–6	36.8
Supplemental	T-OCA-37-C2L	10/08/03	0–6	39.3
Supplemental	T-OCA-37-C2R	10/08/03	0–6	37.1
Supplemental	T-OCA-37-HWL	10/08/03	0–6	41.5
Supplemental	T-OCA-37-OB1R	10/08/03	0–6	52.9
Supplemental	T-OCA-38-A	10/07/03	0–6	180
Supplemental	T-OCA-38-C1L	10/07/03	0–6	132
Supplemental	T-OCA-38-C1R	10/07/03	0–6	13.6
Supplemental	T-OCA-38-C2R	10/07/03	0–6	161
Supplemental	T-OCA-38-HWL	10/07/03	0–6	38.4
Supplemental	T-OCA-38-OB1R	10/07/03	0–6	158

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Non-Deltaic Area (cont.)				
Supplemental	T-OCA-39-A	10/07/03	0–6	127
Supplemental	T-OCA-39-C1L	10/07/03	0–6	481
Supplemental	T-OCA-39-C1R	10/07/03	0–6	78.1
Supplemental	T-OCA-39-C2R	10/07/03	0–6	195
Supplemental	T-OCA-39-HWL	10/07/03	0–6	34
Supplemental	T-OCA-39-OB1R	10/07/03	0–6	88.5
Supplemental	T-OCA-39-OB2R	10/07/03	0–6	128
Supplemental	T-OCA-39-OB3R	10/07/03	0–6	104.5
Remedial Investigation	T-OCA-3-A	11/28/95	0–6	120
Remedial Investigation	T-OCA-3-C1L	11/28/95	0–6	167
Remedial Investigation	T-OCA-3-C1R	11/28/95	0–6	41.7
Remedial Investigation	T-OCA-3-C2L	11/28/95	0–6	46.1
Remedial Investigation	T-OCA-3-C2R	11/28/95	0–6	286
Supplemental	T-OCA-40-A	10/07/03	0–6	139
Supplemental	T-OCA-40-C1L	10/07/03	0–6	38.8
Supplemental	T-OCA-40-C1R	10/07/03	0–6	131
Supplemental	T-OCA-40-C2R	10/07/03	0–6	42.6
Supplemental	T-OCA-40-HWL	10/07/03	0–6	48.3
Supplemental	T-OCA-40-OB1R	10/07/03	0–6	223
Supplemental	T-OCA-41-A	10/07/03	0–6	236
Supplemental	T-OCA-41-C1L	10/07/03	0–6	28.7
Supplemental	T-OCA-41-C1R	10/07/03	0–6	97
Supplemental	T-OCA-41-C2R	10/07/03	0–6	155
Supplemental	T-OCA-41-HWL	10/07/03	0–6	39.6
Supplemental	T-OCA-41-OB1R	10/07/03	0–6	341
Supplemental	T-OCA-41-OB2R	10/07/03	0–6	102
Supplemental	T-OCA-41-OB3R	10/07/03	0–6	97.5
Supplemental	T-OCA-42-A	10/07/03	0–6	217.5
Supplemental	T-OCA-42-C1L	10/07/03	0–6	13.4
Supplemental	T-OCA-42-C1R	10/07/03	0–6	71.8
Supplemental	T-OCA-42-C2R	10/07/03	0–6	104
Supplemental	T-OCA-42-HWL	10/07/03	0–6	23.3
Supplemental	T-OCA-42-OB1R	10/07/03	0–6	181
Supplemental	T-OCA-42-OB2R	10/07/03	0–6	81.7
Supplemental	T-OCA-43-A	10/06/03	0–6	252
Supplemental	T-OCA-43-C1L	10/06/03	0–6	17.9
Supplemental	T-OCA-43-C1R	10/06/03	0–6	177
Supplemental	T-OCA-43-C2R	10/06/03	0–6	162
Supplemental	T-OCA-43-HWL	10/06/03	0–6	22
Supplemental	T-OCA-43-OB1R	10/06/03	0–6	198
Supplemental	T-OCA-43-OB2R	10/06/03	0–6	94.35
Supplemental	T-OCA-43-OB3R	10/06/03	0–6	106
Supplemental	T-OCA-44-A	10/06/03	0–6	303.5
Supplemental	T-OCA-44-C1L	10/06/03	0–6	101
Supplemental	T-OCA-44-C1R	10/06/03	0–6	63.9
Supplemental	T-OCA-44-C2R	09/22/03	0–6	515
Supplemental	T-OCA-44-HWL	09/22/03	0–6	81.6
Supplemental	T-OCA-44-OB1R	09/22/03	0–6	96.9
Supplemental	T-OCA-44-OB2R	09/22/03	0–6	104
Supplemental	T-OCA-44-OB3R	09/22/03	0–6	77.9

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Non-Deltaic Area (cont.)				
Supplemental	T-OCA-45-A	09/22/03	0–6	168.5
Supplemental	T-OCA-45-C1L	09/22/03	0–6	30.7
Supplemental	T-OCA-45-C1R	09/22/03	0–6	622
Supplemental	T-OCA-45-C2R	09/22/03	0–6	136
Supplemental	T-OCA-45-HWL	09/22/03	0–6	86.4
Supplemental	T-OCA-45-OB1R	09/22/03	0–6	190
Supplemental	T-OCA-45-OB2R	09/22/03	0–6	112
Supplemental	T-OCA-46-A	09/21/03	0–6	454.5
Supplemental	T-OCA-46-C1L	09/21/03	0–6	55.6
Supplemental	T-OCA-46-C1R	09/21/03	0–6	56.7 *J*
Supplemental	T-OCA-46-C2R	09/21/03	0–6	530 *J*
Supplemental	T-OCA-46-HWL	09/21/03	0–6	232
Supplemental	T-OCA-46-OB1R	09/21/03	0–6	245 *J*
Supplemental	T-OCA-46-OB2R	09/21/03	0–6	108 *J*
Supplemental	T-OCA-46-OB3R	09/21/03	0–6	104 *J*
Supplemental	T-OCA-47-A	09/20/03	0–6	673.5 *J*
Supplemental	T-OCA-47-C1L	09/20/03	0–6	49.9 *J*
Supplemental	T-OCA-47-C1R	09/20/03	0–6	58 *J*
Supplemental	T-OCA-47-C2L	09/20/03	0–6	65.6 *J*
Supplemental	T-OCA-47-C2R	09/20/03	0–6	258
Supplemental	T-OCA-47-OB1R	09/20/03	0–6	144
Supplemental	T-OCA-47-OB2R	09/20/03	0–6	88.4
Supplemental	T-OCA-47-OB3R	09/20/03	0–6	70.2
Remedial Investigation	T-OCA-4-A	11/28/95	0–6	188
Remedial Investigation	T-OCA-4-C1L	11/28/95	0–6	66.3
Remedial Investigation	T-OCA-4-C1R	11/28/95	0–6	57.4
Remedial Investigation	T-OCA-4-C2L	11/28/95	0–6	45.6
Remedial Investigation	T-OCA-4-C2R	11/28/95	0–6	42.1
Supplemental	T-OCA-52-OB1R	12/10/03	0–6	113 *J*
Supplemental	T-OCA-52-OB2R	12/10/03	0–6	578 *J*
Supplemental	T-OCA-52-OB3R	12/10/03	0–6	28.1
Supplemental	T-OCA-53-OB1R	12/10/03	0–6	75.8
Supplemental	T-OCA-53-OB2R	12/10/03	0–6	33.3
Supplemental	T-OCA-53-OB3R	12/10/03	0–6	24.4
Remedial Investigation	T-OCA-5-A	07/31/96	0–6	675
Remedial Investigation	T-OCA-5-C1L	07/31/96	0–6	56.4
Remedial Investigation	T-OCA-5-C1R	07/31/96	0–6	313
Remedial Investigation	T-OCA-5-C2L	07/31/96	0–6	29.3
Remedial Investigation	T-OCA-5-C2R	07/31/96	0–6	23
Remedial Investigation	T-OCA-6-A	07/31/96	0–6	267
Remedial Investigation	T-OCA-6-C1L	07/31/96	0–6	48
Remedial Investigation	T-OCA-6-C1R	07/31/96	0–6	82.4
Remedial Investigation	T-OCA-6-C2L	07/31/96	0–6	70
Remedial Investigation	T-OCA-6-C2R	07/31/96	0–6	101
Upper Creek Area				
Historical	OS-1	10/04/88	0–6	216
Historical	T-8-A	10/01/90	0–6	136
Historical	T-8-C1L	10/01/90	0–6	4,870
Historical	T-8-C1R	10/01/90	0–6	1,570
Historical	T-9-A	10/01/90	0–6	204

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Upper Creek Area (cont.)				
Historical	T-9-C1L	10/01/90	0–6	2,520
Historical	T-9-C1R	10/01/90	0–6	15.1
Historical	T-9-C2L	10/01/90	0–6	27.9
Historical	T-9-C2R	10/01/90	0–6	12.9
Supplemental	T-OCA-10-A	10/01/03	0–6	1,610
Supplemental	T-OCA-10-C1L	10/01/03	0–6	7,820
Supplemental	T-OCA-10-C1R	10/01/03	0–6	238.5
Supplemental	T-OCA-10-C2L	10/01/03	0–6	2,860
Supplemental	T-OCA-10-C2R	10/01/03	0–6	36.2
Supplemental	T-OCA-10-OB1R	10/01/03	0–6	34.3
Supplemental	T-OCA-11-A	10/01/03	0–6	625
Supplemental	T-OCA-11-C1L	10/01/03	0–6	1,760
Supplemental	T-OCA-11-C1R	10/01/03	0–6	392
Supplemental	T-OCA-11-C2L	10/01/03	0–6	5,030
Supplemental	T-OCA-11-C2R	10/01/03	0–6	59.9
Supplemental	T-OCA-11-OB1L	10/01/03	0–6	71.8
Supplemental	T-OCA-11-OB1R	10/01/03	0–6	18
Supplemental	T-OCA-12-A	10/01/03	0–6	174
Supplemental	T-OCA-12-C1L	10/01/03	0–6	2,570
Supplemental	T-OCA-12-C1R	10/01/03	0–6	6,020
Supplemental	T-OCA-12-C2L	10/01/03	0–6	2,580
Supplemental	T-OCA-12-C2R	10/01/03	0–6	50
Supplemental	T-OCA-12-OB1L	10/01/03	0–6	55.3
Supplemental	T-OCA-12-OB1R	10/01/03	0–6	22.9
Supplemental	T-OCA-13-A	09/30/03	0–6	69.3
Supplemental	T-OCA-13-C1L	09/30/03	0–6	357
Supplemental	T-OCA-13-C1R	09/30/03	0–6	8.6
Supplemental	T-OCA-13-C2L	09/30/03	0–6	4,290
Supplemental	T-OCA-13-C2R	09/30/03	0–6	13.3
Supplemental	T-OCA-13-OB1L	09/30/03	0–6	1,020
Supplemental	T-OCA-13-OB1R	09/30/03	0–6	18.45
Supplemental	T-OCA-14-A	09/30/03	0–6	36.9
Supplemental	T-OCA-14-C1L	09/30/03	0–6	918
Supplemental	T-OCA-14-C1R	09/30/03	0–6	1,050
Supplemental	T-OCA-14-C2L	09/30/03	0–6	985
Supplemental	T-OCA-14-C2R	09/30/03	0–6	2,350
Supplemental	T-OCA-14-OB1R	09/30/03	0–6	24.35
Supplemental	T-OCA-15-A	09/30/03	0–6	136
Supplemental	T-OCA-15-C1L	09/30/03	0–6	282
Supplemental	T-OCA-15-C1R	09/30/03	0–6	29.3
Supplemental	T-OCA-15-C2L	09/30/03	0–6	1,400
Supplemental	T-OCA-15-C2R	09/30/03	0–6	479.5
Supplemental	T-OCA-15-OB1L	09/30/03	0–6	37.4
Supplemental	T-OCA-15-OB1R	09/30/03	0–6	27.3
Supplemental	T-OCA-16-A	09/30/03	0–6	174
Supplemental	T-OCA-16-C1L	09/30/03	0–6	5,400
Supplemental	T-OCA-16-C1R	09/30/03	0–6	611
Supplemental	T-OCA-16-C2L	09/30/03	0–6	1,910
Supplemental	T-OCA-16-C2R	09/30/03	0–6	148
Supplemental	T-OCA-16-OB1L	09/30/03	0–6	24.5

Table I-2. (cont.)

Reference	Station	Sampling Date	Depth Range (in.)	Lead (mg/kg)
Upper Creek Area (cont.)				
Supplemental	T-OCA-16-OB1R	09/30/03	0–6	61.35
Supplemental	T-OCA-7-A	10/02/03	0–6	66.4
Supplemental	T-OCA-7-C1L	10/02/03	0–6	83.7
Supplemental	T-OCA-7-C1R	10/02/03	0–6	56.2
Supplemental	T-OCA-7-C2L	10/02/03	0–6	117
Supplemental	T-OCA-7-C2R	10/02/03	0–6	94.6
Supplemental	T-OCA-7-OB1R	10/02/03	0–6	21.45
Supplemental	T-OCA-8-A	10/01/03	0–6	120 *J*
Supplemental	T-OCA-8-C1L	10/01/03	0–6	27.15 *J*
Supplemental	T-OCA-8-C1R	10/01/03	0–6	23.1 *J*
Supplemental	T-OCA-8-C2L	10/01/03	0–6	407 *J*
Supplemental	T-OCA-8-C2R	10/01/03	0–6	32.4 *J*
Supplemental	T-OCA-8-OB1R	10/01/03	0–6	24.7
Supplemental	T-OCA-9-A	10/01/03	0–6	162
Supplemental	T-OCA-9-C1L	10/01/03	0–6	47.6
Supplemental	T-OCA-9-C1R	10/01/03	0–6	133
Supplemental	T-OCA-9-C2L	10/01/03	0–6	34.3
Supplemental	T-OCA-9-C2R	10/01/03	0–6	504
Supplemental	T-OCA-9-OB1R	10/01/03	0–6	25.9
Summary Statistics				
Deltaic (0–6")	Number of samples			99
	Arithmetic mean			2,221
Deltaic (6–12")	Number of samples			84
	Arithmetic mean			2,080
Deltaic (12–18")	Number of samples			65
	Arithmetic mean			848
Deltaic (18–24")	Number of samples			52
	Arithmetic mean			630
Non-Deltaic (0–6")	Number of samples			244
	Arithmetic mean			127
Non-Deltaic (6–12")	Number of samples			219
	Arithmetic mean			135
Non-Deltaic (12–18")	Number of samples			197
	Arithmetic mean			85.6
Non-Deltaic (18–24")	Number of samples			25
	Arithmetic mean			134
Upper Creek (0–6")	Number of samples			74
	Arithmetic mean			884
Upper Creek (6–12")	Number of samples			69
	Arithmetic mean			453
Upper Creek (12–18")	Number of samples			48
	Arithmetic mean			164
Upper Creek (18–24")	Number of samples			5
	Arithmetic mean			800

Note: *J* - estimated value

Table I-3. Results of IEUBK modeling for a younger child under the hypothetical future residential scenario in the Offsite Creek Area

Soil Lead Concentration (μg/g)	Predicted Mean Blood-Lead Level (μg/dL)	Predicted Chance of Exceeding 10 μg/dL (%)
127 [a]	2.06	0.038%
135 [b]	2.13	0.050%

Note: IEUBK model assumes daily exposure.

Model runs conducted using IEUBKwin version 1.1, build 9 (June 2009).

IEUBK - Integrated Exposure Uptake/Biokinetic

[a] Soil lead concentration is the arithmetic mean of surface (0–6") soil lead concentrations from the non-deltaic area portion of the Offsite Creek Area (see Table I-2).

[b] Soil lead concentration is the arithmetic mean of lead concentrations from non-deltaic Offsite Creek Area (OCA) 6–12" soil samples, which had the highest mean concentration for depth horizons in that area (see Table I-2).

Table I-4. Results of lead modeling for the older child under the hypothetical future residential scenario in the Offsite Creek Area

	Input Parameters							Calculated Values		
Exposure Scenario	Baseline Blood Lead **PbB_0** [a] (µg/dL)	Soil Lead Conc. **PbS** [b] (µg/g)	Biokinetic Slope Factor **BKSF** [c] (µg/dL per µg/day uptake)	Soil and Dust Ingestion Rate **IR_s** [d] (g/day)	Exposure Frequency **EF** [e] (days/yr)	Absorption Factor **AF** [f] (fractional)	Geometric Standard Deviation **GSD** [g] (µg/dL)	PbB Older Child, Central [h] (µg/dL)	PbB Older Child, 95th Percentile [i] (µg/dL)	Probability of Exceeding 10 µg/dL [j] (%)
DELTAIC AREA										
Lower Soil Ingestion										
Weekly	1.0	2,221	0.40	0.025	50	0.12	1.8	1.4	3.6	0.04%
Twice Weekly	1.0	2,221	0.40	0.025	100	0.12	1.8	1.7	4.6	0.1%
Every Other Day	1.0	2,221	0.40	0.025	175	0.12	1.8	2.3	6.0	0.6%
Daily	1.0	2,221	0.40	0.025	350	0.12	1.8	3.6	9.4	3.9%
Default Soil Ingestion										
Weekly	1.0	2,221	0.40	0.05	50	0.12	1.8	1.7	4.6	0.1%
Twice Weekly	1.0	2,221	0.40	0.05	100	0.12	1.8	2.5	6.5	0.9%
Every Other Day	1.0	2,221	0.40	0.05	175	0.12	1.8	3.6	9.4	3.9%
Daily	1.0	2,221	0.40	0.05	350	0.12	1.8	6.1	16.1	20%
Contact-Intensive Soil Ingestion										
Weekly	1.0	2,221	0.40	0.1	50	0.12	1.8	2.5	6.5	0.9%
Twice Weekly	1.0	2,221	0.40	0.1	100	0.12	1.8	3.9	10.3	5.6%
Every Other Day	1.0	2,221	0.40	0.1	175	0.12	1.8	6.1	16.1	20%
Daily	1.0	2,221	0.40	0.1	350	0.12	1.8	11.2	29.5	58%
UPPER CREEK AREA										
Lower Soil Ingestion										
Weekly	1.0	884	0.40	0.025	50	0.12	1.8	1.1	3.0	0.01%
Twice Weekly	1.0	884	0.40	0.025	100	0.12	1.8	1.3	3.4	0.02%
Every Other Day	1.0	884	0.40	0.025	175	0.12	1.8	1.5	4.0	0.06%
Daily	1.0	884	0.40	0.025	350	0.12	1.8	2.0	5.3	0.3%
Default Soil Ingestion										
Weekly	1.0	884	0.40	0.05	50	0.12	1.8	1.3	3.4	0.02%
Twice Weekly	1.0	884	0.40	0.05	100	0.12	1.8	1.6	4.2	0.09%
Every Other Day	1.0	884	0.40	0.05	175	0.12	1.8	2.0	5.3	0.3%
Daily	1.0	884	0.40	0.05	350	0.12	1.8	3.0	8.0	2.1%
Contact-Intensive Soil Ingestion										
Weekly	1.0	884	0.40	0.1	50	0.12	1.8	1.6	4.2	0.09%
Twice Weekly	1.0	884	0.40	0.1	100	0.12	1.8	2.2	5.7	0.5%
Every Other Day	1.0	884	0.40	0.1	175	0.12	1.8	3.0	8.0	2.1%
Daily	1.0	884	0.40	0.1	350	0.12	1.8	5.1	13.3	12%

(footnotes on following page)

Table I-4. (cont.)

Note: Values highlighted in yellow exceed EPA benchmarks. See text for details.

[a] See text for details regarding derivation of baseline blood-lead level.

[b] Soil exposure concentration at the site. Based on arithmetic mean of surface soil samples, which is also the highest mean value for any depth-specific interval in this area. Additional calculations using data from each depth interval are provided in Table 6-19 of the remedial investigation report.

[c] Rise in blood-lead level per amount of lead absorbed (default, U.S. EPA 2003a).

[d] Daily soil and dust ingestion rates = 0.025, 0.05 or 0.1 g/day. See text for details.

[e] Exposure frequency: Weekly = 50 out of 365 days; Twice weekly = 100 out of 365 days; Every other day = 175 out of 365 days; Daily = 350 out of 365 days.

[f] Gastrointestinal absorption of lead in soil (default, U.S. EPA 2003a).

[g] Geometric standard deviation of blood lead levels. See text for details.

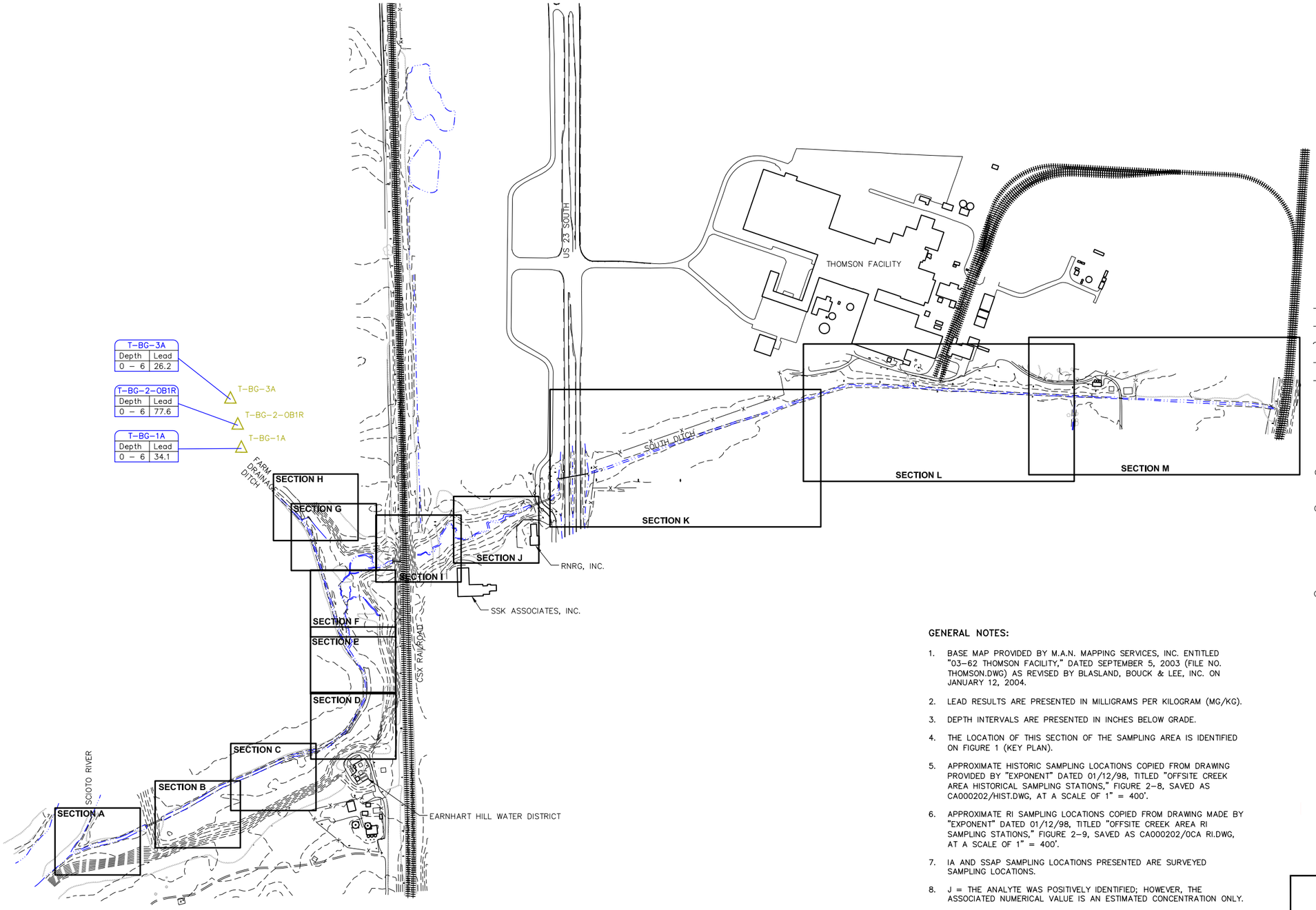
[h] $PbB_{\text{older child, central}} = PbB_0 + (PbS \times BKSF \times IR_s \times (EF/365) \times AF)$. Central estimate of blood lead concentration for older children.

[i] $PbB_{\text{older child, 95th percentile}} = [PbB_{\text{older child, central}}] \times GSD^{1.645}$. Estimate of 95th percentile blood lead concentration for older children.

[j] Percent chance of exceeding EPA's target blood lead level of 10 µg/dL (U.S. EPA 2003a).
Percent Above Target = 1 - normsdist (Z score); expressed as %, where
Z score = $(LN (10/PbB_{\text{older child, central}}) / LN (GSD))$
"Normsdist" is the Microsoft Excel function providing the fraction of the distribution below the calculated z-score.

Appendix J

Lead Concentration Sampling Results for South Ditch and Offsite Creek Area



LEGEND:

- ● SOUTH DITCH AND OFFSITE CREEK AREA SUPPLEMENTAL SAMPLING PLAN (SSAP) TRANSECT SAMPLING LOCATION AND BIOASSAY SAMPLE LOCATIONS
- ▲ SSAP CORE SAMPLING LOCATION
- HISTORICAL GRAB SAMPLE OR CORE STATION
- □ HISTORICAL TRANSECT LOCATION
- △ REMEDIAL INVESTIGATION (RI) CORE STATION
- ○ RI TRANSECT STATION
- ■ INTERIM ACTION (IA) SAMPLING POINTS
- EXISTING CONTOUR
- EDGE OF WATER
- TREELINE
- EXISTING GUARD RAIL
- EXISTING FENCE
- EXISTING UTILITY POLE
- A — SAMPLE AT CENTER OF THE STREAM CHANNEL FROM THE 0 TO 6-INCH INTERVAL BELOW GRADE
- B — CORE SAMPLE BELOW LOCATION A BEGINNING FROM THE 6 TO 12-INCH INTERVAL BELOW GRADE
- C1 (L OR R) — CORE SAMPLES ON BOTH SIDES OF THE STREAM CHANNEL (RIGHT OR LEFT, FACING UPSTREAM) AT THE SEDIMENT CONTACT WITH SLOPE OF THE STREAM CHANNEL
- C2 (L OR R) — CORE SAMPLES ON BOTH SIDES OF THE STREAM CHANNEL (RIGHT OR LEFT, FACING UPSTREAM) NEAR THE FIRST SIGNIFICANT BREAK IN SLOPE OUT OF THE STREAM CHANNEL (TOP OF BANK)
- HW (L) — CORE SAMPLES ON THE LEFT SIDE OF THE STREAM CHANNEL (FACING UPSTREAM) AT THE HIGH WATER MARK (HW) BETWEEN THE C1L AND C2L LOCATIONS
- OB (L OR R) — CORE SAMPLES ON BOTH SIDES OF THE STREAM CHANNEL (RIGHT OR LEFT, FACING UPSTREAM) SPACED AT 50-FOOT INTERVALS WITH THE FIRST OB (OVERBANK) SAMPLE LOCATION STARTING AT 50 FEET FROM THE CENTER OF THE STREAM CHANNEL. THE OB LOCATIONS WILL BE NUMBERED CONSECUTIVELY OUTWARD AWAY FROM THE CENTER OF THE STREAM CHANNEL ON EACH SIDE (E.G., OB1, OB2, AND OB3).
- △ BACKGROUND SAMPLE LOCATION

GENERAL NOTES:

1. BASE MAP PROVIDED BY M.A.N. MAPPING SERVICES, INC. ENTITLED "03-62 THOMSON FACILITY," DATED SEPTEMBER 5, 2003 (FILE NO. THOMSON.DWG) AS REVISED BY BLASLAND, BOUCK & LEE, INC. ON JANUARY 12, 2004.
2. LEAD RESULTS ARE PRESENTED IN MILLIGRAMS PER KILOGRAM (MG/KG).
3. DEPTH INTERVALS ARE PRESENTED IN INCHES BELOW GRADE.
4. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE 1 (KEY PLAN).
5. APPROXIMATE HISTORIC SAMPLING LOCATIONS COPIED FROM DRAWING PROVIDED BY "EXPONENT" DATED 01/12/98, TITLED "OFFSITE CREEK AREA HISTORICAL SAMPLING STATIONS," FIGURE 2-8, SAVED AS CA000202/HIST.DWG, AT A SCALE OF 1" = 400'.
6. APPROXIMATE RI SAMPLING LOCATIONS COPIED FROM DRAWING MADE BY "EXPONENT" DATED 01/12/98, TITLED "OFFSITE CREEK AREA RI SAMPLING STATIONS," FIGURE 2-9, SAVED AS CA000202/OCA RI.DWG, AT A SCALE OF 1" = 400'.
7. IA AND SSAP SAMPLING LOCATIONS PRESENTED ARE SURVEYED SAMPLING LOCATIONS.
8. J = THE ANALYTE WAS POSITIVELY IDENTIFIED; HOWEVER, THE ASSOCIATED NUMERICAL VALUE IS AN ESTIMATED CONCENTRATION ONLY.
9. L = ACTUAL CONCENTRATION IS LESS THAN THE REPORTED CONCENTRATION.
10. U = NOT DETECTED.
11. ARC = THE SAMPLE IS CURRENTLY BEING ARCHIVED BY THE LABORATORY FOR POTENTIAL FUTURE TOTAL LEAD ANALYSIS.
12. DOES NOT INCLUDE SAMPLES WITHIN THE IA REMOVAL AREA.

0 300' 600'
GRAPHIC SCALE

THOMSON FACILITY
CIRCLEVILLE, OHIO

KEY PLAN

ARCADIS BBL
infrastructure, environment, facilities

FIGURE
J-1

SYR-85-KMD LAF PGL LAYER: ON=*, OFF=*REF*, |CONTDEP*, CONTN*, STREAMCL*, {FRZ}
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003001.DWG SAVED: 8/21/2007 2:27 PM LAYOUT: J-1 PAGESETUP: DL2B-PDF PENTABLE: PLTFULL.CTB PRINTED: 8/21/2007 2:27 PM BY: KSARTORI
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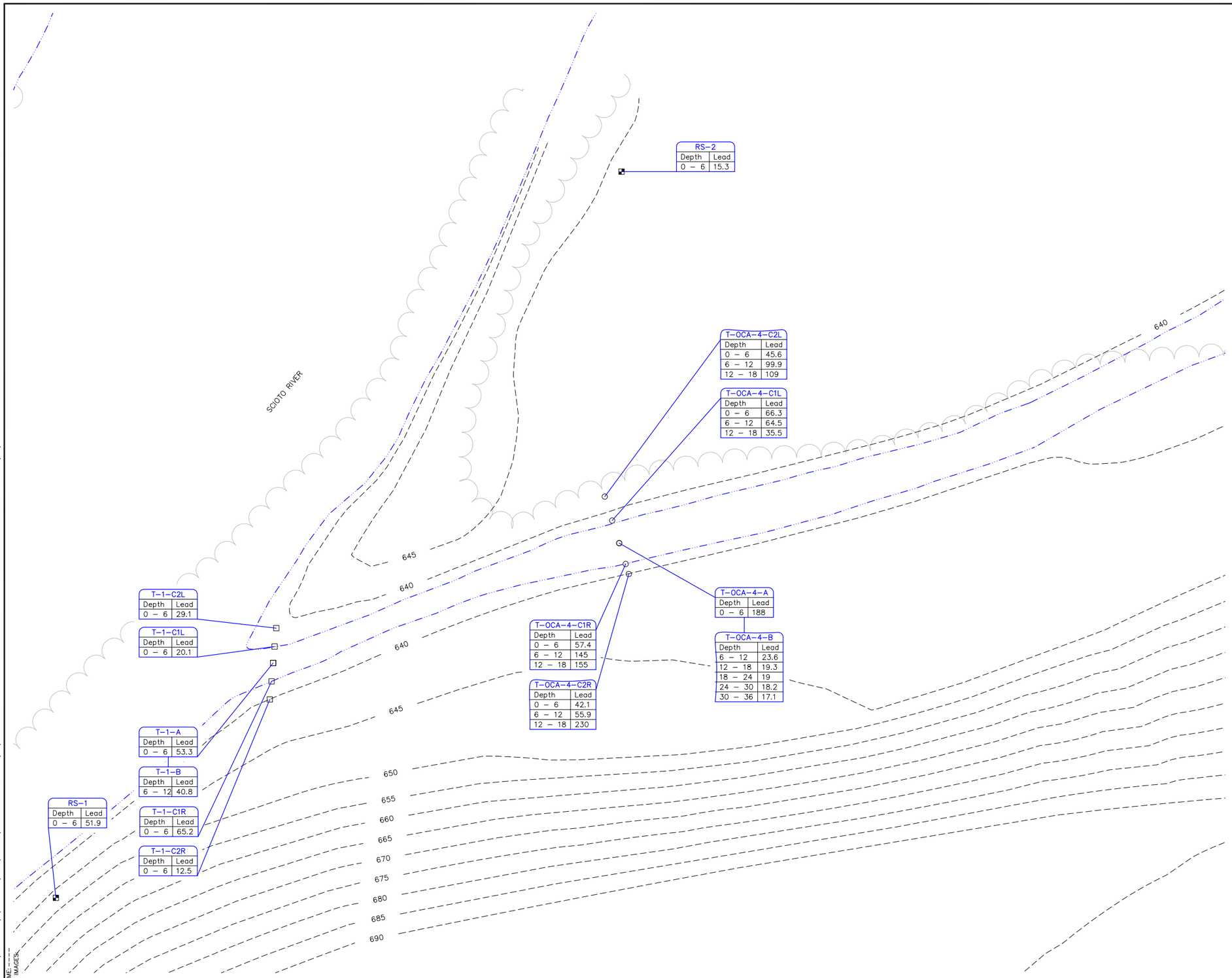

NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

0 20' 40'
GRAPHIC SCALE

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION A)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-2

SYR-85-KMD NES KLS LAYER: ON=*, OFF=*REF*
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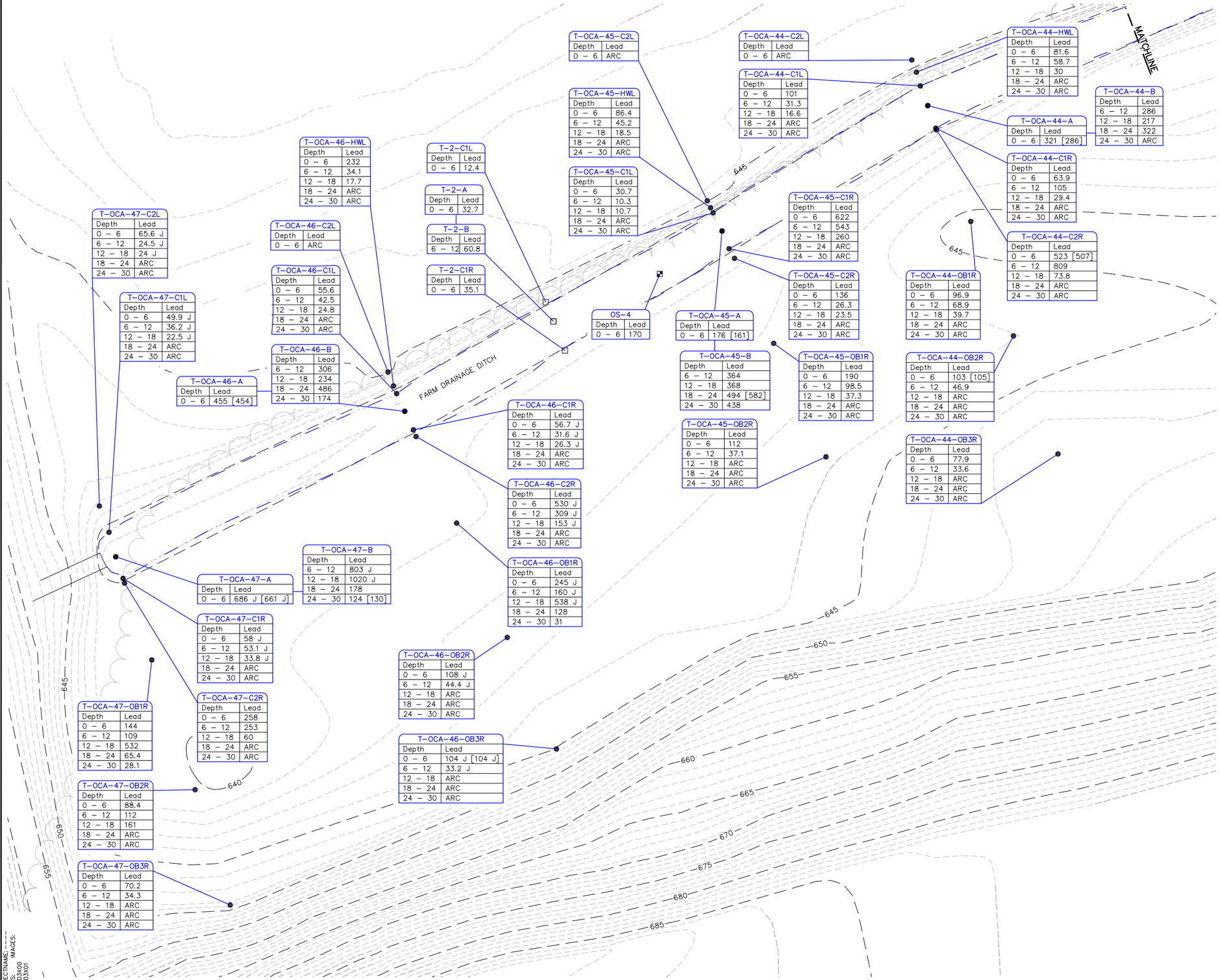

T-OCA-45-C2L	
Depth	Lead
0 – 6	ARC

T-OCA-44-C2L	
Depth	Lead
0 – 6	ARC

T-OCA-44-HWL	
Depth	Lead
0 – 6	81.6
6 – 12	58.7
12 – 18	30
18 – 24	ARC
24 – 30	ARC

T-OCA-44-C1L	
Depth	Lead
0 – 6	101
6 – 12	31.3
12 – 18	16.6
18 – 24	ARC
24 – 30	ARC

T-OCA-45-HWL	
Depth	Lead
0 – 6	86.4
6 – 12	45.2
12 – 18	18.5
18 – 24	ARC
24 – 30	ARC

T-OCA-44-B	
Depth	Lead
6 – 12	286
12 – 18	217
18 – 24	322
24 – 30	ARC

T-OCA-44-A	
Depth	Lead
0 – 6	321 [286]

T-OCA-46-HWL	
Depth	Lead
0 – 6	232
6 – 12	34.1
12 – 18	17.7
18 – 24	ARC
24 – 30	ARC

T-2-C1L	
Depth	Lead
0 – 6	12.4

T-OCA-45-C1L	
Depth	Lead
0 – 6	30.7
6 – 12	10.3
12 – 18	10.7
18 – 24	ARC
24 – 30	ARC

T-2-A	
Depth	Lead
0 – 6	32.7

T-OCA-44-C1R	
Depth	Lead
0 – 6	63.9
6 – 12	105
12 – 18	29.4
18 – 24	ARC
24 – 30	ARC

T-OCA-45-C1R	
Depth	Lead
0 – 6	622
6 – 12	543
12 – 18	260
18 – 24	ARC
24 – 30	ARC

T-OCA-47-C2L	
Depth	Lead
0 – 6	65.6 J
6 – 12	24.5 J
12 – 18	24 J
18 – 24	ARC
24 – 30	ARC

T-OCA-46-C2L	
Depth	Lead
0 – 6	ARC

T-2-B	
Depth	Lead
6 – 12	60.8

T-OCA-44-C2R	
Depth	Lead
0 – 6	523 [507]
6 – 12	809
12 – 18	73.8
18 – 24	ARC
24 – 30	ARC

T-OCA-46-C1L	
Depth	Lead
0 – 6	55.6
6 – 12	42.5
12 – 18	24.8
18 – 24	ARC
24 – 30	ARC

T-2-C1R	
Depth	Lead
0 – 6	35.1

T-OCA-45-C2R	
Depth	Lead
0 – 6	136
6 – 12	26.3
12 – 18	23.5
18 – 24	ARC
24 – 30	ARC

OS-4	
Depth	Lead
0 – 6	170

T-OCA-45-A	
Depth	Lead
0 – 6	176 [161]

T-OCA-44-OB1R	
Depth	Lead
0 – 6	96.9
6 – 12	68.9
12 – 18	39.7
18 – 24	ARC
24 – 30	ARC

T-OCA-46-A	
Depth	Lead
0 – 6	455 [454]

T-OCA-46-B	
Depth	Lead
6 – 12	306
12 – 18	234
18 – 24	486
24 – 30	174

T-OCA-45-B	
Depth	Lead
6 – 12	364
12 – 18	368
18 – 24	494 [582]
24 – 30	438

T-OCA-45-OB1R	
Depth	Lead
0 – 6	190
6 – 12	98.5
12 – 18	37.3
18 – 24	ARC
24 – 30	ARC

T-OCA-44-OB2R	
Depth	Lead
0 – 6	103 [105]
6 – 12	46.9
12 – 18	ARC
18 – 24	ARC
24 – 30	ARC

T-OCA-46-C1R	
Depth	Lead
0 – 6	56.7 J
6 – 12	31.6 J
12 – 18	26.3 J
18 – 24	ARC
24 – 30	ARC

T-OCA-45-OB2R	
Depth	Lead
0 – 6	112
6 – 12	37.1
12 – 18	ARC
18 – 24	ARC
24 – 30	ARC

T-OCA-44-OB3R	
Depth	Lead
0 – 6	77.9
6 – 12	33.6
12 – 18	ARC
18 – 24	ARC
24 – 30	ARC

T-OCA-46-C2R	
Depth	Lead
0 – 6	530 J
6 – 12	309 J
12 – 18	153 J
18 – 24	ARC
24 – 30	ARC

T-OCA-47-B	
Depth	Lead
6 – 12	803 J
12 – 18	1020 J
18 – 24	178
24 – 30	124 [130]

T-OCA-47-A	
Depth	Lead
0 – 6	686 J [661 J]

T-OCA-46-OB1R	
Depth	Lead
0 – 6	245 J
6 – 12	160 J
12 – 18	538 J
18 – 24	128
24 – 30	31

T-OCA-47-C1R	
Depth	Lead
0 – 6	58 J
6 – 12	53.1 J
12 – 18	33.8 J
18 – 24	ARC
24 – 30	ARC

T-OCA-46-OB2R	
Depth	Lead
0 – 6	108 J
6 – 12	44.4 J
12 – 18	ARC
18 – 24	ARC
24 – 30	ARC

T-OCA-47-C2R	
Depth	Lead
0 – 6	258
6 – 12	253
12 – 18	60
18 – 24	ARC
24 – 30	ARC

T-OCA-47-OB1R	
Depth	Lead
0 – 6	144
6 – 12	109
12 – 18	532
18 – 24	65.4
24 – 30	28.1

T-OCA-46-OB3R	
Depth	Lead
0 – 6	104 J [104 J]
6 – 12	33.2 J
12 – 18	ARC
18 – 24	ARC
24 – 30	ARC

T-OCA-47-OB2R	
Depth	Lead
0 – 6	88.4
6 – 12	112
12 – 18	161
18 – 24	ARC
24 – 30	ARC

T-OCA-47-OB3R	
Depth	Lead
0 – 6	70.2
6 – 12	34.3
12 – 18	ARC
18 – 24	ARC
24 – 30	ARC

NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

0 20' 40'
GRAPHIC SCALE

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION B)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-3

SYR-85-KMD KMD NES LAYER: ON=*; OFF=*REF*
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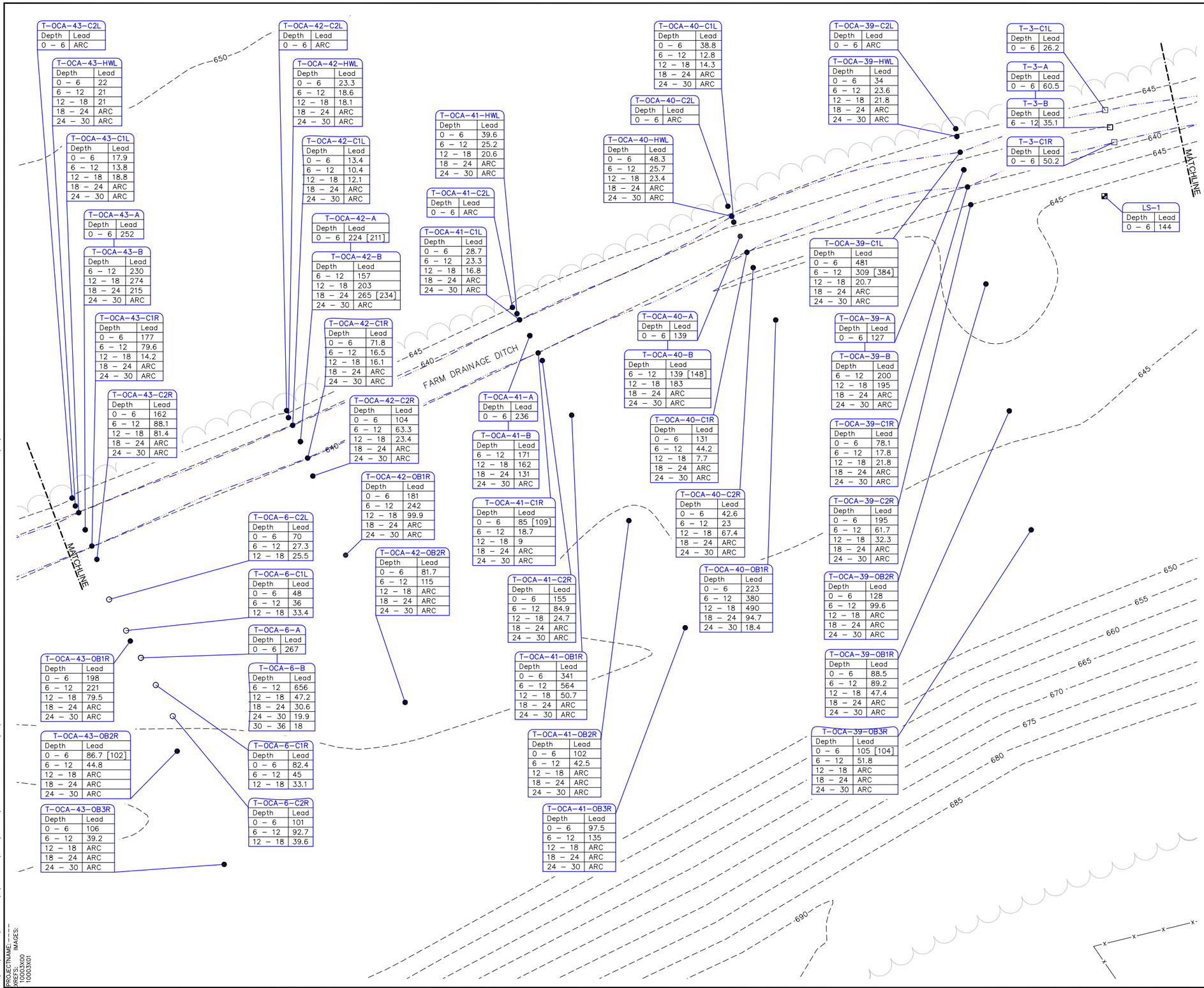

NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

0 20' 40'
GRAPHIC SCALE

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION C)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-4

SYR-85-KMD KLS LAF LAYER: ON=*; OFF=*REF*; |CONTINT*; STREAMCL*
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C01.DWG SAVED:8/22/2007 3:17 PM LAYOUT:J-4 PAGESETUP:DL2B-PDF PENTABLE:PLTFULL.CTB PRINTED:8/22/2007 3:17 PM BY:KSARTORI
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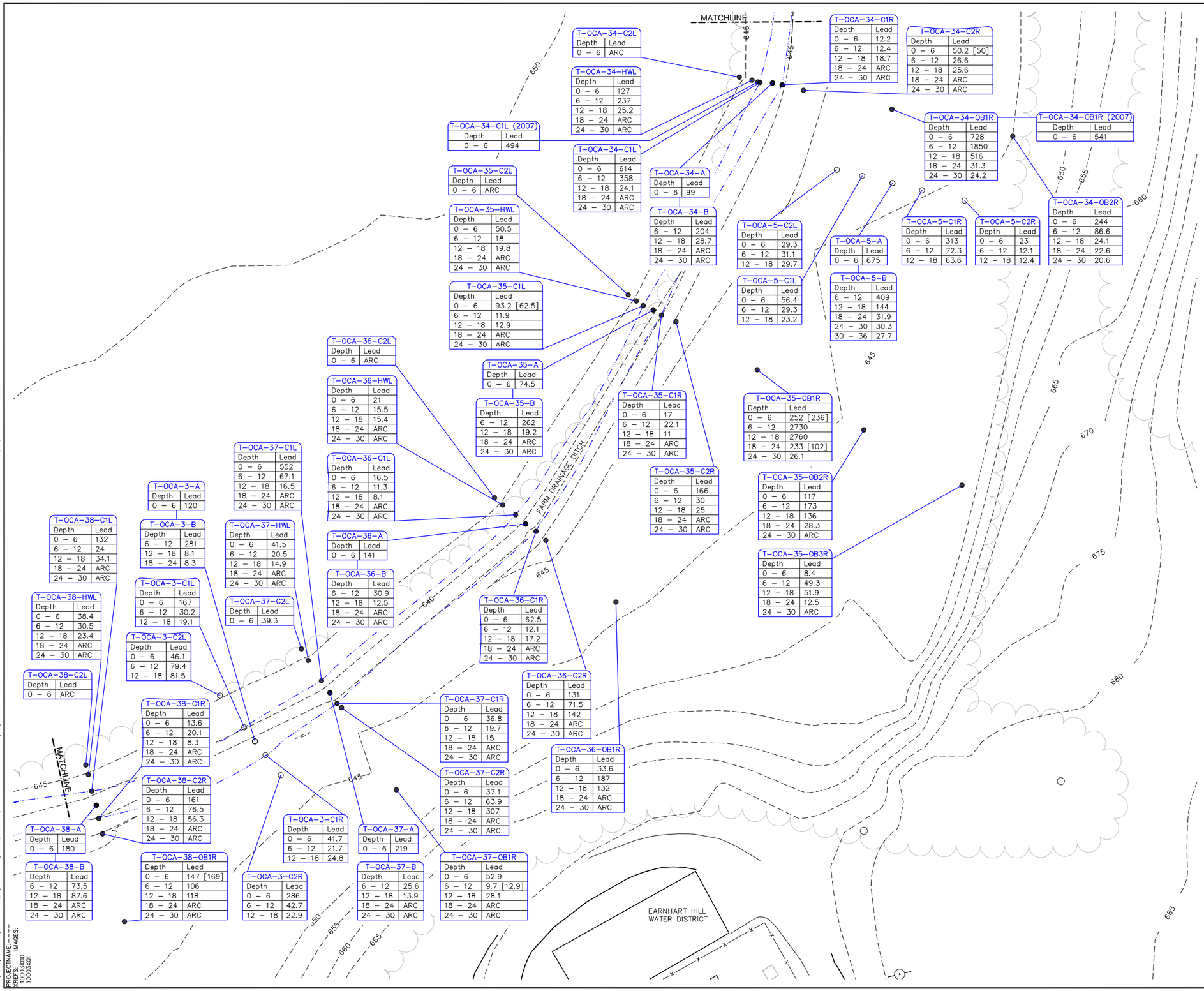

NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

0 20' 40'
GRAPHIC SCALE

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION D)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-5

SYR-KMD PGL KLS LAYER: ON=*, OFF=*REF*, !CONTIN*, STREAMCL* PRINTED:8/21/2007 2:10 PM BY:KSARTORI
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PROJECTNAME:----
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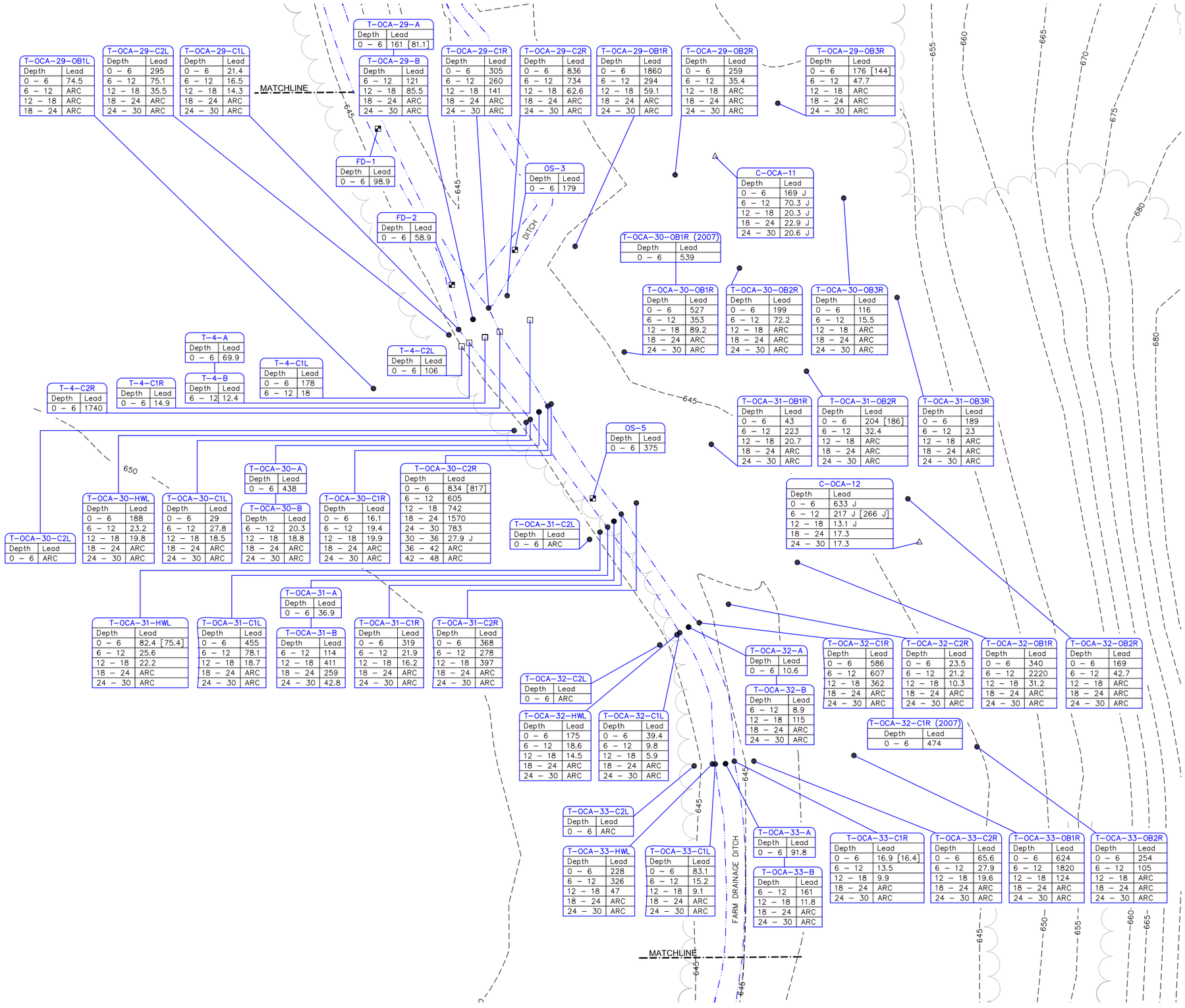
10003X01



NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION E)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-6

SYR-KMD PGL KLS LAYER: ON=*; OFF=*REF*; |CONTINT*; STREAMGL*; (FRZ)
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C03.DWG SAVED:8/21/2007 2:19 PM LAYOUT:J-6 PAGESETUP:DL2B-PDF PENTABLE:PLTFULL.CTB PRINTED:8/21/2007 2:19 PM BY:KSARTORI
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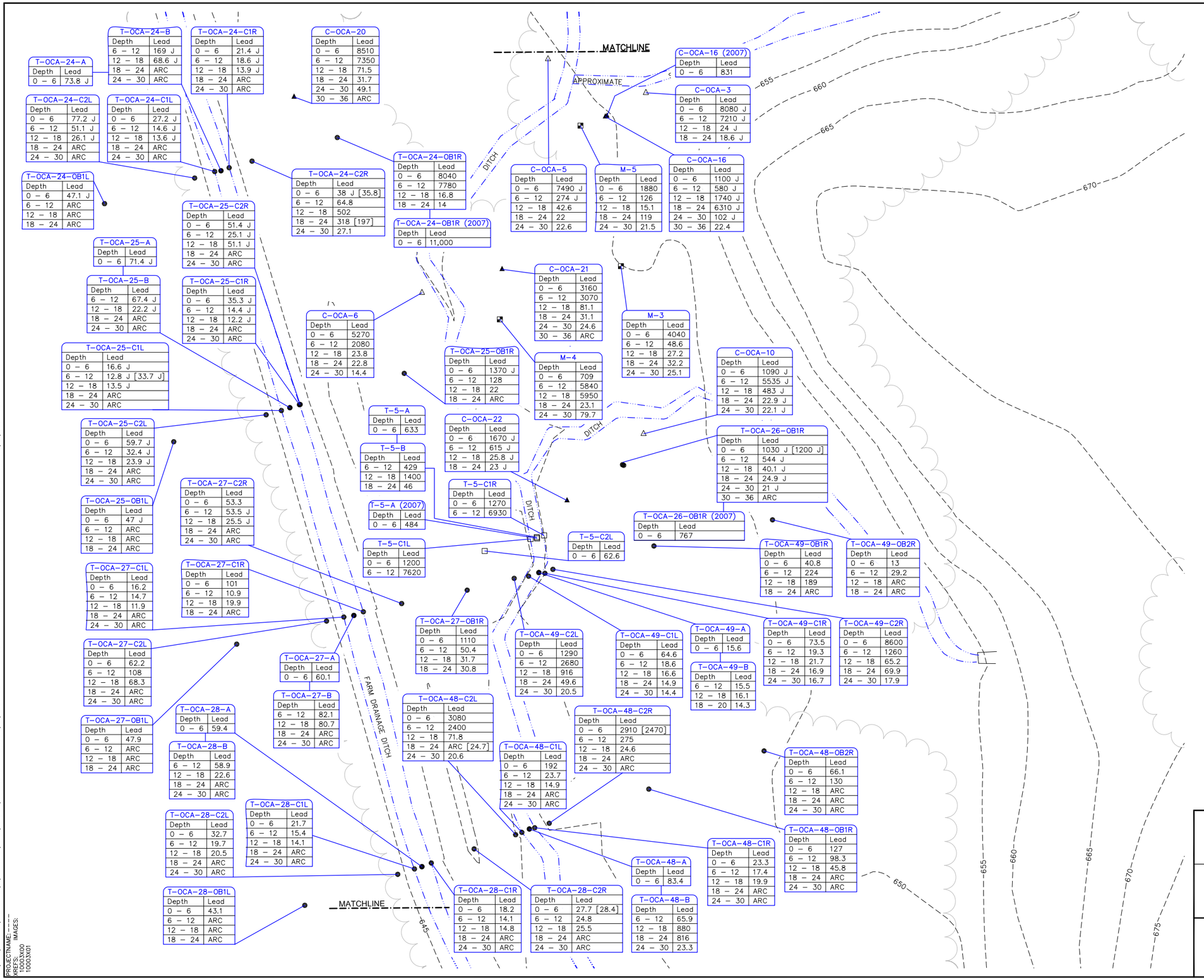
IMAGES: 10003X01



NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION F)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-7

SYR-85-KMD PGL KLS LAYER: ON=*; OFF=*REF*, |CONTDEP*, CONTIN*, STREAMGL*, (FR2)
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C04.DWG SAVED:8/21/2007 1:54 PM LAYOUT:J-7 PAGESETUP:DLZB-PDF PENTABLE:PLTFULL.CTB PRINTED:8/21/2007 1:54 PM BY:KSARTORI
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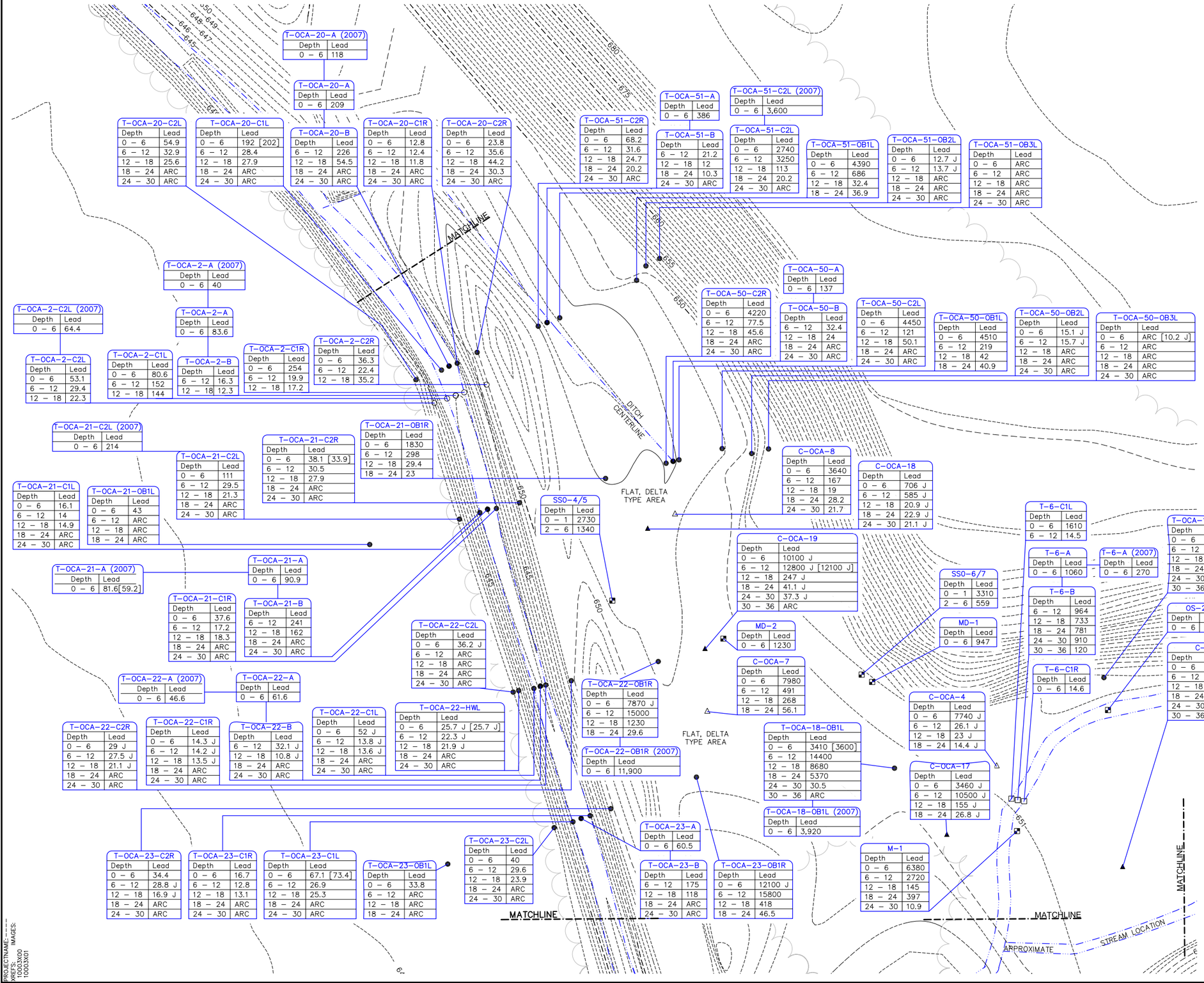

NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION G)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-8

SYR-85-KMD PGL KLS LAYER: ON=*, OFF=*REF*, |STREAMCL*, (FRZ)
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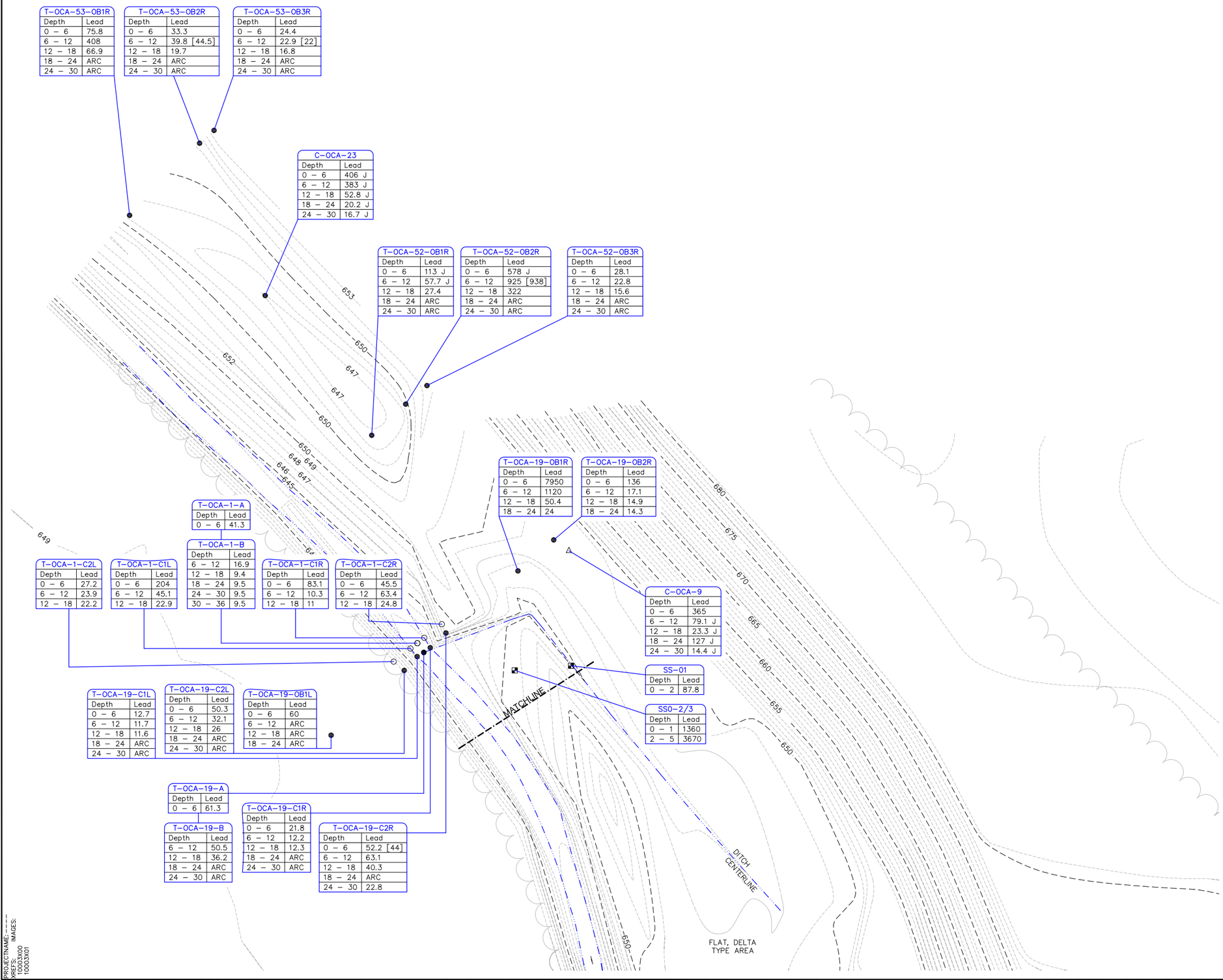

T-OCA-53-OB1R

Depth	Lead
0 – 6	75.8
6 – 12	408
12 – 18	66.9
18 – 24	ARC
24 – 30	ARC

T-OCA-53-OB2R

Depth	Lead
0 – 6	33.3
6 – 12	39.8 [44.5]
12 – 18	19.7
18 – 24	ARC
24 – 30	ARC

T-OCA-53-OB3R

Depth	Lead
0 – 6	24.4
6 – 12	22.9 [22]
12 – 18	16.8
18 – 24	ARC
24 – 30	ARC

C-OCA-23

Depth	Lead
0 – 6	406 J
6 – 12	383 J
12 – 18	52.8 J
18 – 24	20.2 J
24 – 30	16.7 J

T-OCA-52-OB1R

Depth	Lead
0 – 6	113 J
6 – 12	57.7 J
12 – 18	27.4
18 – 24	ARC
24 – 30	ARC

T-OCA-52-OB2R

Depth	Lead
0 – 6	578 J
6 – 12	925 [938]
12 – 18	322
18 – 24	ARC
24 – 30	ARC

T-OCA-52-OB3R

Depth	Lead
0 – 6	28.1
6 – 12	22.8
12 – 18	15.6
18 – 24	ARC
24 – 30	ARC

T-OCA-19-OB1R

Depth	Lead
0 – 6	7950
6 – 12	1120
12 – 18	50.4
18 – 24	24

T-OCA-19-OB2R

Depth	Lead
0 – 6	136
6 – 12	17.1
12 – 18	14.9
18 – 24	14.3

T-OCA-1-A

Depth	Lead
0 – 6	41.3

T-OCA-1-B

Depth	Lead
6 – 12	16.9
12 – 18	9.4
18 – 24	9.5
24 – 30	9.5
30 – 36	9.5

T-OCA-1-C2L

Depth	Lead
0 – 6	27.2
6 – 12	23.9
12 – 18	22.2

T-OCA-1-C1L

Depth	Lead
0 – 6	204
6 – 12	45.1
12 – 18	22.9

T-OCA-1-C1R

Depth	Lead
0 – 6	83.1
6 – 12	10.3
12 – 18	11

T-OCA-1-C2R

Depth	Lead
0 – 6	45.5
6 – 12	63.4
12 – 18	24.8

C-OCA-9

Depth	Lead
0 – 6	365
6 – 12	79.1 J
12 – 18	23.3 J
18 – 24	127 J
24 – 30	14.4 J

SS-01

Depth	Lead
0 – 2	87.8

SS0-2/3

Depth	Lead
0 – 1	1360
2 – 5	3670

T-OCA-19-C1L

Depth	Lead
0 – 6	12.7
6 – 12	11.7
12 – 18	11.6
18 – 24	ARC
24 – 30	ARC

T-OCA-19-C2L

Depth	Lead
0 – 6	50.3
6 – 12	32.1
12 – 18	26
18 – 24	ARC
24 – 30	ARC

T-OCA-19-OB1L

Depth	Lead
0 – 6	60
6 – 12	ARC
12 – 18	ARC
18 – 24	ARC

T-OCA-19-A

Depth	Lead
0 – 6	61.3

T-OCA-19-B

Depth	Lead
6 – 12	50.5
12 – 18	36.2
18 – 24	ARC
24 – 30	ARC

T-OCA-19-C1R

Depth	Lead
0 – 6	21.8
6 – 12	12.2
12 – 18	12.3
18 – 24	ARC
24 – 30	ARC

T-OCA-19-C2R

Depth	Lead
0 – 6	52.2 [44]
6 – 12	63.1
12 – 18	40.3
18 – 24	ARC
24 – 30	22.8

NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION H)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-9

SYR-KMD LAF KLS LAYER: ON=*; OFF=*REF*; |STREAMCL*
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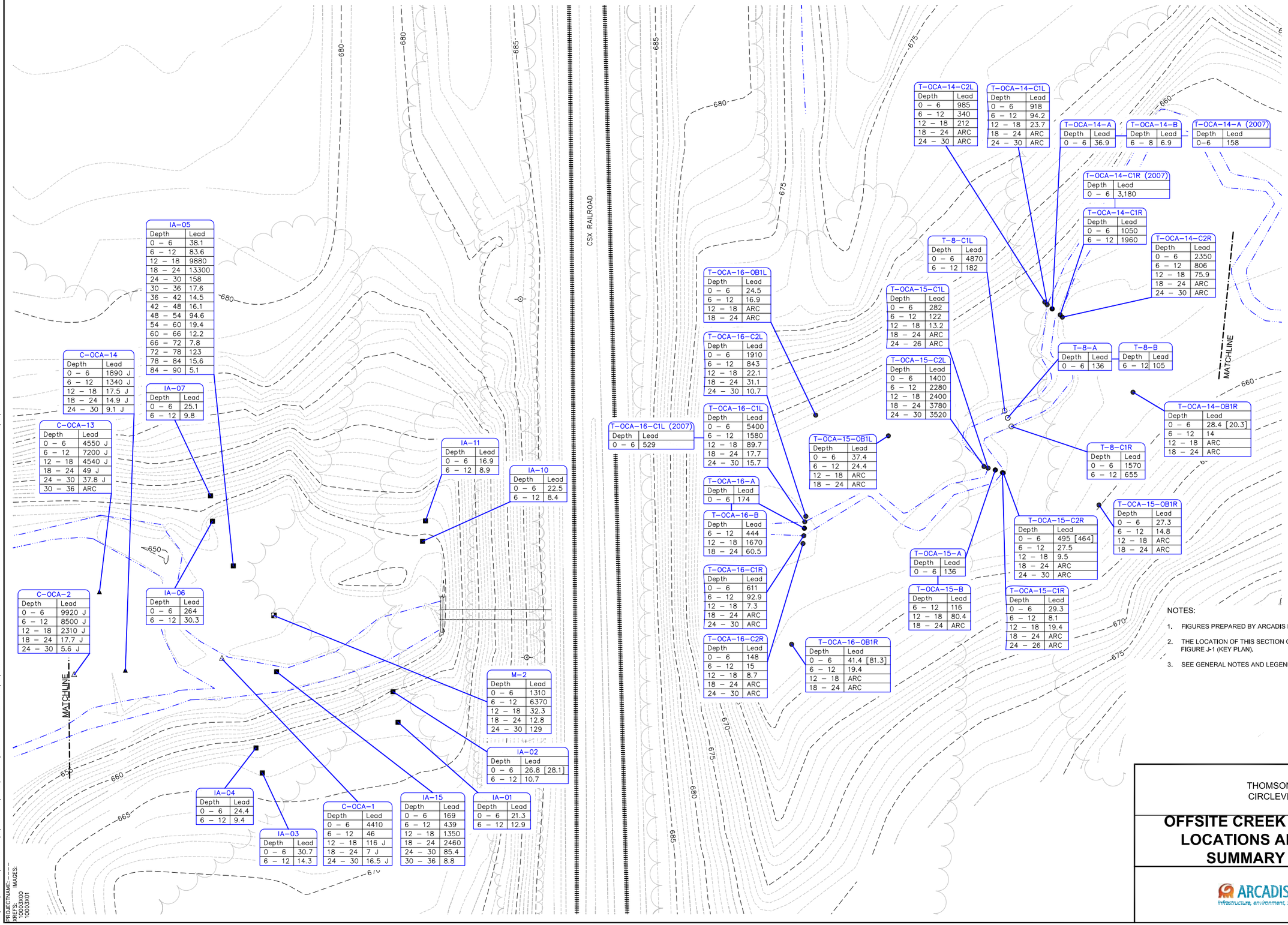


NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

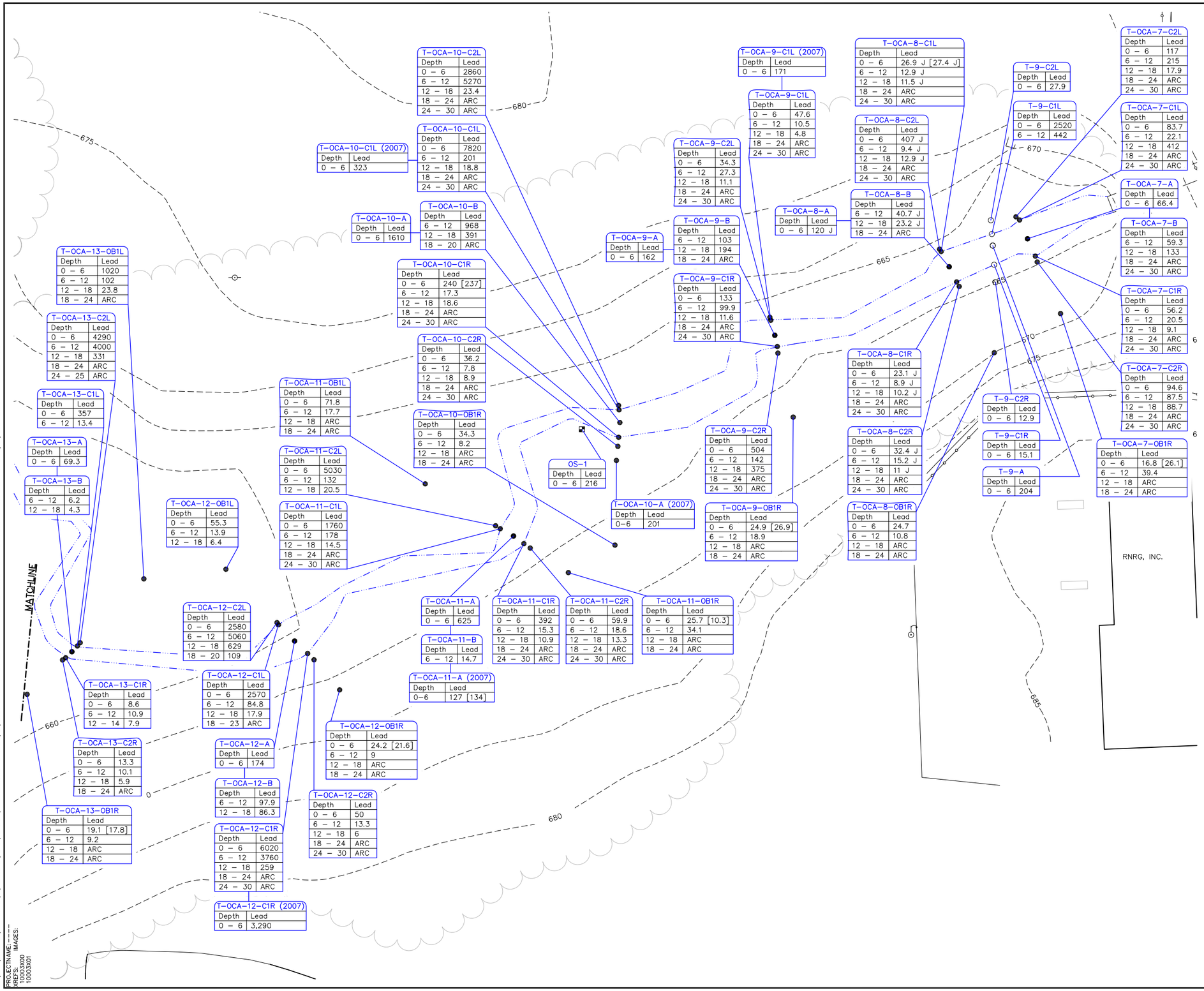
THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION I)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-10

SYR-85-KMD PGL KLS LAYER: ON=*, OFF=*REF*, [CONTINTTX*, STREAMCL*, (FRZ)
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C07.DWG SAVED: 8/21/2007 2:22 PM LAYOUT: J-10 PAGESETUP:---- PENTABLE:PLTFULL.CTB PRINTED: 8/21/2007 2:22 PM BY: KSARTORI
PROJECTNAME:---- IMAGES:
XREFS: 10003X00 10002X01



NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

0 20' 40'
GRAPHIC SCALE

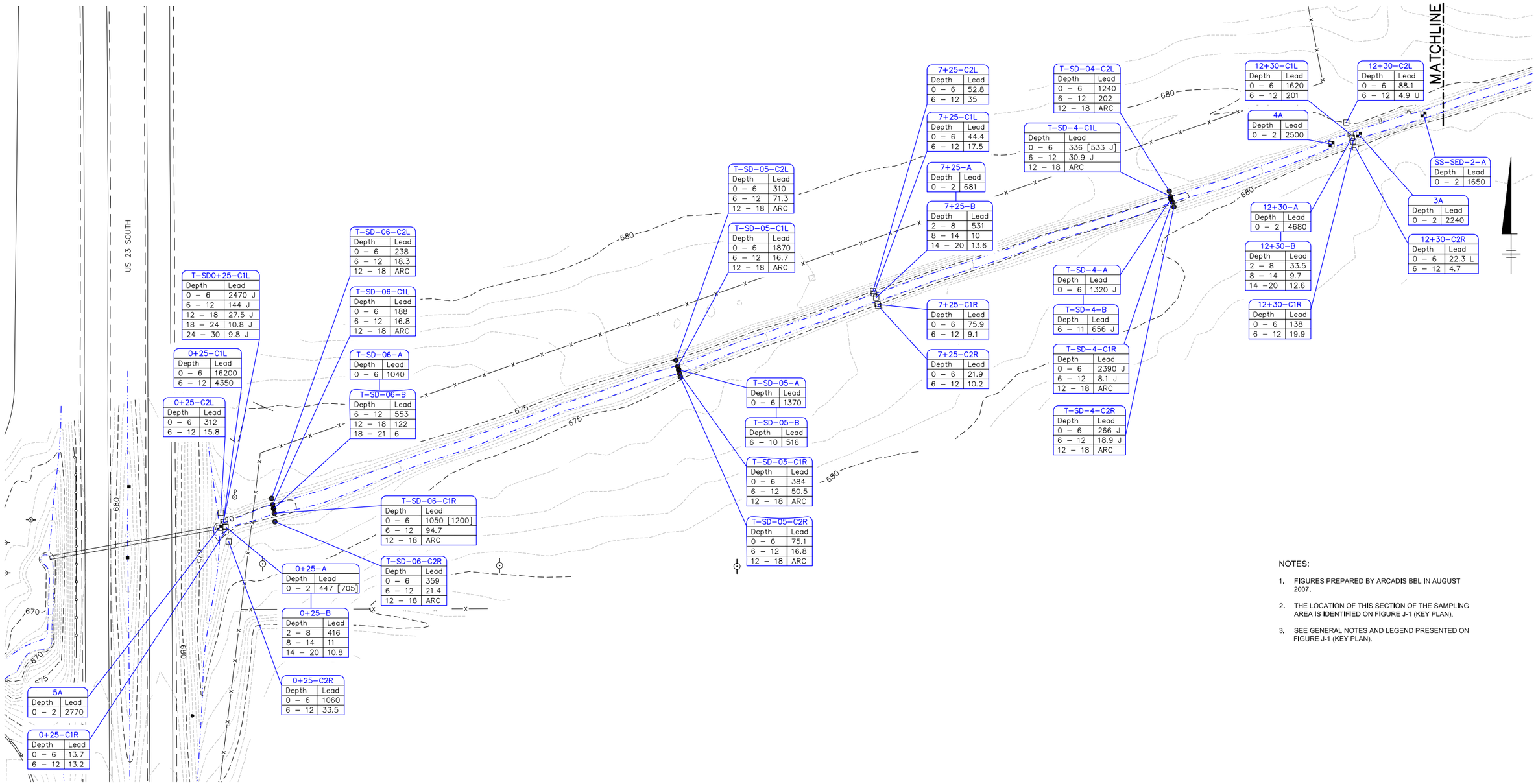
THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION J)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-11

SYR-85-KMD PGL KLS LAYER: ON=*, OFF=*REF*, {CONTDEP*, CONTIN*, STREAMCL*, (FRZ)
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C08.DWG SAVED: 8/21/2007 3:29 PM LAYOUT: J-11 PAGESETUP: DLZB-PDF PENTABLE: PLTFULL.CTB PRINTED: 8/21/2007 3:29 PM BY: KSARTORI
PROJECTNAME:----
XREFS: 10003X00
IMAGES: 10003I01



NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

0 50' 100'
GRAPHIC SCALE

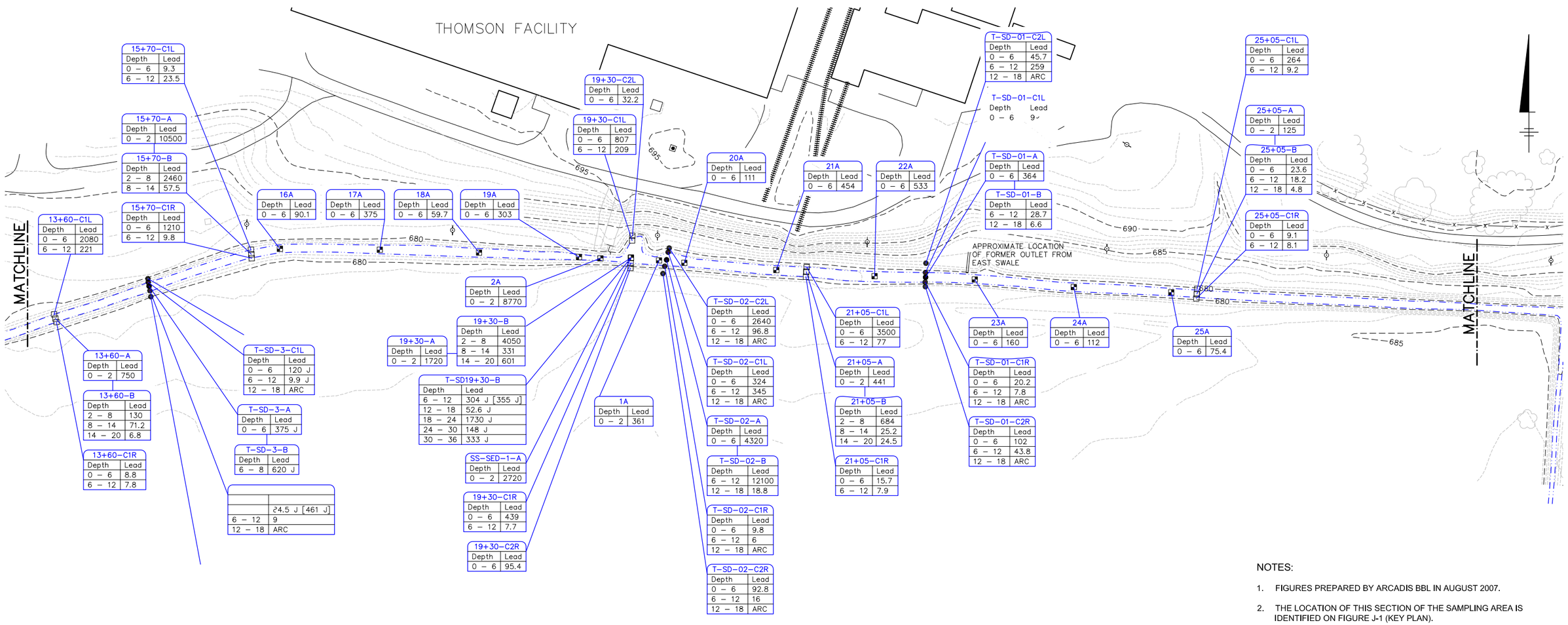
THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION K)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-12

SYR-KMD LAF KLS LAYER: ON=*, OFF=*REF*, |CONTDEP*, CONTINDTX*, CONTINTTX*
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C09.DWG SAVED: 8/22/2007 3:24 PM LAYOUT: J-12 PAGESETUP: DLZB-PDF PENTABLE: PLTFULL.CTB PRINTED: 8/22/2007 3:24 PM BY: KSARTORI
PROJECTNAME: ----
XREFS: 10003X00 IMAGES:
10003X01



NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).
4. APPROXIMATE LOCATION OF FORMER OUTLET FROM EAST SWALE AS SHOWN ON FIGURE 1-2, TITLED "SITE FEATURES" OF EXPONENTS APRIL 1998 DRAFT REMEDIAL INVESTIGATION REPORT.

0 50' 100'
GRAPHIC SCALE

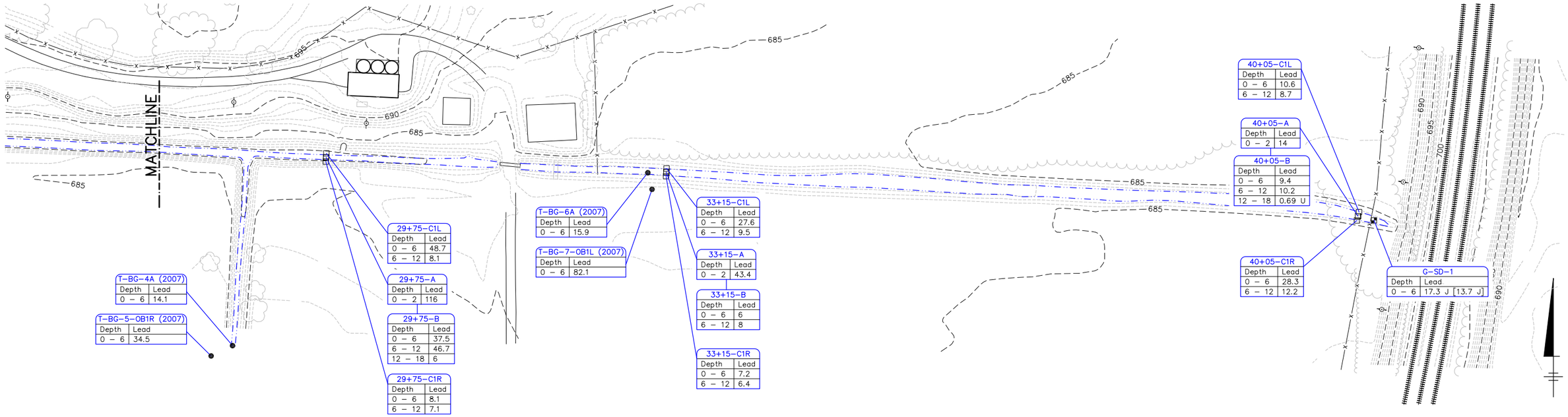
THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION L)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-13

SYR-KMD LAF KLS LAYER: ON=*; OFF=*REF*; |CONTDEP*; CONTINDTX*; CONTINTTX*
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C10.DWG SAVED:8/22/2007 3:28 PM LAYOUT:J-13 PAGESETUP:DL2B-PDF PENTABLE:PLTFULL.CTB PRINTED:8/22/2007 3:29 PM BY:KSARTORI
PROJECTNAME:----
XREFS: 10003X00 IMAGES:
10003X01



NOTES:

1. FIGURES PREPARED BY ARCADIS BBL IN AUGUST 2007.
2. THE LOCATION OF THIS SECTION OF THE SAMPLING AREA IS IDENTIFIED ON FIGURE J-1 (KEY PLAN).
3. SEE GENERAL NOTES AND LEGEND PRESENTED ON FIGURE J-1 (KEY PLAN).

0 50' 100'
GRAPHIC SCALE

THOMSON FACILITY
CIRCLEVILLE, OHIO

OFFSITE CREEK AREA SAMPLING LOCATIONS AND LEAD DATA SUMMARY (SECTION M)

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
J-14

SYR-BS-KMD PGL KLS LAYER: ON=*; OFF=*REF*, |CONTDEP*, CONTINDTX*, CONTINTTX*, (FRZ)
G:\CAD\GE-CAD\GE_ACTIVE\C\10003013\LEAD\REPORT\10003C11.DWG SAVED:8/21/2007 2:20 PM LAYOUT:J-14 PAGESETUP:---- PENTABLE.PLTFULL.CTB PRINTED:8/21/2007 2:21 PM BY:KSARTORI
PROJECTNAME:----
XREFS: 10003X00
IMAGES: 10003I01