Thursday, August 04, 2005

Mr. Lucas Beresford
SCDHEC
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201-1708

Subject: Final Ecological Risk Assessment Step 3 Report for the
Pine Street MGP Site, Spartanburg, South Carolina

Mr. Beresford:

Please find the attached Ecological Risk Assessment report for the subject site. This report was prepared on behalf of Duke Power and incorporates changes as we discussed at our July 6, 2005 meeting.

If you need any additional information, please to contact me at 864-834-5513 or thwood@bellsouth.net.

Sincerely,

Henry Wood
Senior Risk Assessor
Blue Ridge Environmental Consulting, Inc.

cc:
R. Roberts/ J. Bednarcik – Duke

Ecological Risk Assessment (ERA) Process Step 3

for the

Spartanburg Pine Street MGP Site

Prepared for:

Duke Power
Charlotte, North Carolina

August 2005

Prepared by:

Blue Ridge Environmental Consulting, Inc.
Travelers Rest, South Carolina

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

This ERA problem formulation addresses ecological chemicals of potential concern (COPCs) at Duke Power's former Spartanburg Manufactured Gas Plant (MGP) site, located at 684 N. Pine Street, Spartanburg, South Carolina (see inset on Figure 1). The screening-level ecological risk assessment (SLERA) concluded that semivolatile organic compounds (SVOCs), primarily polycyclic aromatic hydrocarbons (PAHs), in sediment and soil should be carried through the problem formulation (Process Step 3) of the ERA process (Duke 2004). The resulting list of COPCs (Table 1) serves as the starting point for the problem formulation.

The draft ERA Step3 document was submitted the South Carolina Department of health and Environmental Control (SDHEC) in August 2004. SCDHEC provided comments during October 2004 (Appendix A) and during subsequent discussions requested sampling of site-specific fractional organic carbon (F_{oc}) in sediment. Results of the additional sampling were provided to SCDHEC in a May 2005 letter report (Appendix B). The site-specific Foc was very low (<0.1%) and did not meet the 0.2% theoretical requirement of the equilibrium partitioning methodology used to develop sediment hazard quotients (HQs) in the draft document. Consequently, this final document has been updated to use established effects-based benchmarks to derive sediment organism HQs, replacing the prior equilibrium partitioning methods included in the initial draft. This final document also addresses other SCDHEC comments as noted in Appendix A.

This problem formulation follows current USEPA ecological risk assessment guidance (e.g. USEPA 1997; USEPA 2001a; USEPA 2001b) and concludes with the identification of final ecological COPCs, which are constituents that contribute significantly to an exposure pathway posing potentially unacceptable ecological risk. Within the context of the Process Document (USEPA 1997), final COPCs from Step 3 can either be further investigated (e.g. biological sampling or further abiotic sampling) to reduce uncertainty or they can be classified as ecological COCs and carried into the risk management phase of the remedial investigation process. The results of the problem formulation are summarized in the scientific management decision point (SMDP) provided in Section 3.

1.1 Site History

The operational history of the site and a summary of the phased environmental characterization/remediation were described in prior site reports (e.g. Duke 2002, Duke 2004). The remediation effort at the site included the excavation and associated treatment/disposal of

over 60,000 tons of material, divided between the Main Process area, Parking Lot area, area South of Chinquapin Creek, and area bordering the north side of Chinquapin Creek and west of the substation (Figure 1). All phases of the characterization and remediation were completed as of June 2004.

1.2 Summary of Site Data

The terrestrial area of interest includes surface soil located adjacent to the site streams (stream banks) and the larger wooded area located south of Chinquapin Creek. The aquatic area of interest includes the aquatic habitats associated with the streams on the property (Figure 1). The data used for the ERA include soil sample locations (labeled AOI), stream bank sample locations (labeled SB), and sediment sample locations (labeled 1-12), as seen in Figure 1 and discussed below.

1.2.1 Soil

The September 2003 soil sampling results provide the dataset for the ERA. Data from this sampling event includes 27 0-1 ft soil samples (AOI-1 through AOI-22, AOI-25 through AOI-29), 28 0-1 ft soil/sediment samples (SB-1 through SB-26, SB-28 and SB-30), and 12 soil background samples (BG-1 through BG-12) for a total of 67 samples (Figure 1). Due to the soil removal actions completed to date, the following locations were removed from the soil data set: AOI-21, AOI-26, AOI-27, AOI-29, SB-10, SB-11, SB-12, SB-13, and SB-17. Thus, there are a total of 46 site-related samples for soil. Full documentation of analytical results is provided in the SLERA (Duke 2004). Table 2 presents a data summary for the soil COPCs.

1.2.2 Sediment

The 2000 and 2002 sediment sampling events used for the ERA include two upstream locations (locations number 6 and 7) and 10 downstream locations (Figure 1). Samples 1 through 8 were collected during the 2000 sampling event, while samples 9 through 12 were collected during the 2002 sampling event. Full documentation of analytical results is provided in the SLERA (Duke 2004). Table 3 presents a data summary for the sediment COPCs.

1.3 Habitats, Receptors, and Exposure Pathways

A complete discussion of fate and transport, potential exposure pathways, and the ecological characteristics of the site was provided in the SLERA (Duke 2004) and was summarized in the site conceptual site models (Figures 2 and 3).

There were three vegetative cover types identified at the site: Mature Hardwoods, Disturbed Habitat (open field), and Mixed Composition. Mature hardwoods exist in areas south of Chinquapin Creek, while the Mixed Composition habitat is concentrated around the banks of Chinquapin Creek and Courthouse Branch. The Disturbed Habitat is mainly areas of open field, related to prior industrial processes. Within the area of concern, the disturbed habitat areas are primarily backfilled "clean" areas that should not impact the ecological risk assessment.

Chinquapin creek is a small stream, with an active channel width of approximately 8 ft at bank-full and a depth generally less than 2 feet. The dominant substrate is composed of unconsolidated gravel and sand. Most of the stream west of the electrical substation has been channelized (straightened). Chinquapin Creek is characterized as having poor stream health, a common condition in urban areas where channelization, nonpoint source pollution, and altered flow regimes degrade stream quality.

A variety of mammals and birds adapted to urban environments would be expected at the site. Bird species noted at the site include the great blue heron (*Ardea herodias*) and the belted-kingfisher (*Ceryle alcyon*). Both birds are largely piscivorous, suggesting that Chinquapin creek provides adequate populations of fish to support higher order aquatic predators. Mammal species including the American beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), and raccoon (*Procyon lotor*) are known to utilize the site. No threatened, endangered, or sensitive plant or animal species were identified at the site.

2.0 Problem Formulation (ERA Process Step 3)

ERA Process Step 3 initiates the problem formulation phase of the baseline risk assessment. The problem formulation establishes the goals, breadth, and focus of the ERA as well as establishes the assessment approach. The questions and issues that need to be addressed in the baseline ERA are defined based on potentially complete exposure pathways and ecological effects. The conceptual model for the site is refined and includes questions about the assessment endpoints and the relationship between exposure and effects. The initial step in the problem formulation is a review and refinement of the COPCs identified in the SLERA.

2.1 Refinement of Chemicals of Potential Concern

The SLERA identified COPCs warranting further evaluation at the Spartanburg MGP site (Table 1). Because of the conservative assumptions used during the SLERA, some of these COPCs might also pose acceptable levels of risk. At this stage, the COPCs are further evaluated based on the following considerations:

(1) Comparison to site background;

(2) Site-Specific HQ Development; and

(3) Lines of Evidence.

2.1.1 Site Background

Since all of the COPCs for the Spartanburg MGP site were anthropogenic organics, a background screening was not employed. Nevertheless, background data are germane to the interpretation of site results and will be used as appropriate in the lines of evidence discussion (Section 2.1.3). A summary discussion of available background is provided here.

A total of twelve soil background samples were collected in areas peripheral to the Spartanburg MGP site (Figure 1). A summary of the site-specific soil background is provided on Table 4. The site-specific results show that PAHs are common in the vicinity, with constituents such as benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, and pyrene being detected in a majority of background samples. The concentrations of total PAHs in the background soil ranged from 0.34 mg/kg (BG-03) to 26.9 mg/kg (BG-10). BG-10 was significantly higher than other background results and may represent an outlier. Excluding BG-10, the range of total PAHs in soil background ranged from 0.34 mg/kg

to 5.4 mg/kg (BG-12). The range for site related samples was ND to 26.4 mg/kg. The soil background results for the Spartanburg MGP site are consistent with PAH concentrations in urban areas, which generally have individual PAH concentrations ranging from 0.2 to 3 mg/kg and total PAH concentrations on the order of 20 mg/kg (Bradley et al 1994; ATSDR 1995; Menzie et al, 1992). The background PAHs in urban soil environments can be largely attributed to atmospheric deposition of combustion particles (from automobile exhaust or other combustion processes), but can also result from small spills of petroleum products or the dust/debris/runoff from asphalt pavement of roads and parking lots. As presented in the uncertainty discussion (Section 2.6), the potential influence of urban background on the Spartanburg MGP site soil is minimal (e.g. site PAH concentrations generally much greater than local background) and does not impact the ERA conclusions.

For sediment, the available site-specific background was limited to two samples just upstream of the site (SED-6 and SED-7). Both of these samples were reported as non-detect for PAHs. However, there is uncertainty surrounding this result as the detection limits (0.96 to 1.2 mg/kg) were slightly elevated compared to the normal PAH detection limit of 0.33 mg/kg. Given the urban characteristics of the area and the abundant asphalt, tires, and other debris in the stream, it is reasonable to conclude at least some of the PAHs detected in site sediment samples could be attributable to sources other than the former MGP operations. Nonpoint source pollution is well documented as one of the most important contributors to PAH concentrations in urban aquatic systems (Stout et al 2004).

2.1.2 Site-Specific HQ Development

The ecological COPCs can be further refined through the development of HQs based on site-specific exposure conditions. The site-specific HQ is simply the site-specific exposure dose (ED) divided by a literature toxicity reference value (TRV). HQs equal to or greater than one are indicative of a potential concern, while HQs less than one are indicative a minimal potential ecological risk.

2.1.2.1 Preliminary Assessment and Measurement Endpoints

To facilitate the site-specific HQ evaluation, preliminary assessment and measurement endpoints were developed while considering the contaminants present, the habitats, and the groups of organisms representing complete exposure pathways. Based on these considerations, the

following preliminary assessment endpoints and their representative receptors, where necessary, were selected for evaluation:

- Protection of soil organism (invertebrate) communities to maintain species diversity and nutrient cycling. Soil invertebrate communities are selected because the community is ecologically important, is susceptible to constituents in soil, and is exposed at the site. The soil organism community is essential for decomposition of detritus and for energy and nutrient cycling. Soil invertebrates are also an important component of the diet of insectivorous mammals and birds. Earthworms are chosen as the representative species of soil organisms because they are probably the most important species in promoting soil fertility, they are highly exposed to soil constituents, and toxicity information for earthworms is readily available.

- Protection of insectivorous mammal communities to ensure that exposure of contaminants in prey, forage, and soils does not have a negative impact on growth, survival, and reproduction. Insectivorous mammals are ecologically important because they help to control the size of the terrestrial invertebrate population that might otherwise damage populations of plant primary producers. Short-tailed shrews (*Blarina carolinensis*) are chosen as the representative species for the insectivorous mammals because they are highly exposed to constituents by their consumption of large quantities of terrestrial invertebrates. They also ingest soil during feeding, including soil within the bodies of earthworms and other prey. Insectivorous mammals such as the short-tailed shrew are possible inhabitants of the Spartanburg MGP site.

- Protection of insectivorous bird communities to ensure that exposure of contaminants in prey, forage, and soils does not have a negative impact on growth, survival, and reproduction. Insectivorous birds are ecologically important because they help to control the size of the terrestrial invertebrate population that might otherwise damage plant primary producers. American robins (*Turdus migratorius*) are chosen as the representative species for the insectivorous birds because they are highly exposed to constituents by their consumption of terrestrial invertebrates. They also ingest soil during feeding, including soil within the bodies of earthworms and other prey. American robins are common across the area.

- Protection of benthic macro-invertebrate organism communities (identification of a specific receptor for this endpoint is not necessary) from toxic effects of contaminants in order to maintain species diversity, biomass, and nutrient cycling (trophic structure). The benthic invertebrate community is ecologically important, serving as prey items for many other species as well as maintaining nutrient cycling in the aquatic system. Benthic organisms are also susceptible to constituents in sediment and are potentially exposed at the site.

- Protection of avian aquatic predators in order to ensure that exposure to contaminants in aquatic prey and abiotic media does not have a negative impact on growth, survival, and reproduction. Aquatic predators are ecologically important, are susceptible to constituents in sediment, and are potentially exposed to sediment COPCs via food chain uptake. The great blue heron (*Ardea herodias*) was chosen as the representative receptor since it is a known inhabitant of the area and would be exposed via ingestion of prey and abiotic media.

- Protection of mammalian aquatic predators in order to ensure that exposure to contaminants in aquatic prey and abiotic media does not have a negative impact on growth, survival, and reproduction. Aquatic predators are ecologically important, are susceptible to constituents in sediment, and are potentially exposed to sediment COPCs via food chain uptake. The raccoon (*Procyon lotor*) was chosen as the representative receptor since it is a known inhabitant of the area and would be exposed via ingestion of prey and abiotic media.

There are various other assessment endpoints/receptor classes that could have been included in this step of the ERA process (e.g., herbivorous birds, reptiles, amphibians, carnivorous birds, etc). However, the assumption was made that the receptor classes selected represent the greatest potential risk and are the most likely groups of organisms to regularly utilize the site. The representative receptors and selected exposure parameters provide a conservative assessment that should be protective of all potential receptor classes.

2.1.2.2 Exposure Dose Calculations

The site-specific exposure dose (ED) was calculated for each COPC using a food chain uptake model consistent with US EPA Region IV guidance (USEPA 2001b). The ED is generated using

COPC media concentrations and takes into account the unit foraging factor (UFF) and other receptor-specific input parameters (e.g., ingestion rates and body weight). The specific ED equations used at the Spartanburg MGP site are presented in Table 5. Input parameters used in the ED equations are summarized in Table 6. Bioaccumulation factors (BAFs) and soil to plant uptake factors are taken from the literature and are summarized in Table 7. Note that ED calculations are not required for organisms exposed only via the direct contact route (e.g. earthworms and benthic organisms).

ED calculations are provided in Tables 8 through 11 and include calculations for soil (insectivorous mammals and insectivorous birds) and sediment (mammalian and avian aquatic predators). The equations used to calculate the EDs are provided on these tables along with all input values. The ED calculations are performed using both the maximum detected COPC concentrations as well as the average COPC concentrations. The average concentrations are generally the most appropriate values to use in assessing ecological risk because ecological receptors are not exposed to one location. Rather, they typically range across a broader area and consequently get an "averaged" dose from multiple locations. The exception to this is relatively immobile receptors (e.g. earthworms) that could be exposed to only one sample location over an entire lifetime. However, the average concentration is still appropriate for these receptors since the ERA is designed to protect local populations/communities of organisms rather than individuals.

2.1.2.3 Toxicity Reference Values

The EDs calculated as above are divided by toxicity reference values (TRVs) obtained from the literature to generate the site-specific HQs. TRVs compiled for mammals and birds include No Observed Adverse Effect Levels (NOAELs) and Lowest Observed Adverse Effect Levels (LOAELs), as summarized on Table 12 (mammals) and Table 13 (birds).

For mammals, a TRV (or surrogate TRV) was located for each COPC. The benzo(a)pyrene NOAEL and LOAEL from Sample et al (1996) was used as a surrogate for all other carcinogenic PAHs. Several TRVs were obtained from the USEPA's Intergrated Risk Information System (IRIS), where laboratory mammal studies are frequently cited for use in deriving human health toxicity benchmarks. In cases where a subchronic NOAEL or LOAEL was cited, the value was divided by 10 to estimate the chronic NOAEL or LOAEL for use in the ERA.

The only COPCs that had avian toxicity values were di-n-butylphthalate and dimethylphthalate (Table 13). Formal NOAEL or LOAEL values for use as avian TRVs for PAHs could not be located in the available scientific literature. The COPCs missing TRVs will be addressed as appropriate in the lines-of-evidence discussion and the uncertainty discussion.

The soil invertebrate TRV for all PAHs was set to 30 mg/kg (Table 14), which is the toxicity benchmark for fluorene (Efroymson et al. 1997).

Table 15 documents the TRVs used to assess the sediment organism endpoint. These values include threshold effects concentrations (TECs) as well as probable effects concentrations (PECs). Most of the available literature TECs for individual PAHs are less than the practical quantitation limit (PQL) and therefore the PQL was selected as the TEC-TRV. PEC-TRVs were selected from available literature sources. The TRVs selected for dimethylphthalate and di-n-butylphthalate are surrogate values from bis-2-ethylhexylphthalate.

2.1.2.4 Site Specific HQs

The site-specific HQs were generated by simply dividing the ED by the associated TRV (for mammals and birds) or dividing the media concentration by the TRV (for soil organisms and benthic organisms). Since EDs were calculated for both maximum and average site COPC concentrations, there are a total of four HQs presented for mammals and birds ($HQ_{MAX\text{-}NOAEL}$, $HQ_{AVE\text{-}NOAEL}$, $HQ_{MAX\text{-}LOAEL}$, and $HQ_{AVE\text{-}LOAEL}$). For benthic organisms, HQs were derived for both TEC and PEC TRVs, so there are also four HQs ($HQ_{MAX\text{-}TEC}$, $HQ_{AVE\text{-}TEC}$, $HQ_{MAX\text{-}PEC}$, and $HQ_{AVE\text{-}PEC}$). The HQ calculations for the Spartanburg MGP site are provided in Tables 16 through 18 (soil) and Tables 19 through 22 (sediment).

If the site-specific HQs are less than 1, then the constituent is dropped from further consideration. For constituents with HQs exceeding one, a lines of evidence discussion (Section 2.1.3) is provided to identify the constituents that warrant designation as final COPCs.

2.1.3 Lines-of-Evidence Discussion

Constituents with a site specific HQ greater than 1 are further evaluated based on the following lines of evidence: alternate TRVs (e.g., NOAEL versus LOAEL comparisons), frequency of detection (i.e., analytical qualifier evaluation), background, and patterns of detections (i.e., pattern of hits indicating contaminant migration from a source). This evaluation is based on

interpretation of the available data, range of calculated HQs, magnitude of exceedance, and professional judgment. Constituents remaining upon completion of the line of evidence evaluation are identified as final ecological COPCs.

2.1.3.1 Surface Soil

Insectivorous Mammals

The insectivorous mammal HQs (Table 16) were less than one, indicating negligible ecological risk. Consequently, no final soil COPCs are identified for the insectivorous mammal endpoint.

Insectivorous Birds

HQs could not be calculated for the insectivorous bird (Table 17) because no PAH TRVs were available. However, a literature review did reveal that mallard ducks (*Anas platyrhynchos*) fed diets containing 4,000 mg/kg PAHs for seven months showed no overt signs of toxicity (Eisler 1987). The total PAH concentrations for maximum and average soil at the Spartanburg MGP site are 26 mg/kg and 4 mg/kg, respectively. These values are orders of magnitude less than the no effect level of 4,000 mg/kg cited by Eisler (1987). PAHs are not considered final COPCs for the insectivorous bird.

Soil Organisms

The soil organism HQs (Table 18) were less than one, indicating negligible ecological risk. Consequently, no final soil COPCs were established for the soil organism endpoint.

2.1.3.2 Sediment

Mammalian Aquatic Predator

The mammalian aquatic predator HQs for sediment (Table 19) were less than one, indicating negligible ecological risk. Consequently, no final sediment COPCs were identified for this endpoint.

Avian Aquatic Predator

The avian aquatic predator HQs (Table 20) were less than one for dimethylphthalate and di-n-butylphthalate, indicating negligible ecological risk from these constituents. For PAHs in sediment, HQs could not be calculated because no TRVs were available for the avian receptor. However, a literature review did reveal that mallard ducks (*Anas platyrhynchos*) fed diets containing 4,000 mg/kg PAHs for seven months showed no overt signs of toxicity (Eisler 1987).

The total PAH concentrations for maximum and average sediment conditions at the Spartanburg MGP site were 46.9 mg/kg and 17.5 mg/kg, respectively. These values are orders of magnitude less than the no effect level of 4,000 mg/kg cited by Eisler (1987). The relatively small unit foraging factor (0.035) for the great blue heron, and the low likelihood for PAHs to biomagnify (Eisler 1987) are also indicative of a low potential for adverse ecological impacts to avian aquatic predators at the Spartanburg MGP site. Given these facts, PAHs are not considered final COPCs for this endpoint.

Benthic Organisms

The ecological HQs for benthic organisms are summarized in Tables 21 and 22. As documented in Table 21, all of the sediment COPCs have $HQ_{max\text{-}TEC}$ exceeding one, with HQs ranging from 1.8 (dibenz(a,h)anthracene) to 41.2 (di-n-butyl-phthalate). HQs based on average unit results and PEC-TRVs are significantly lower. Only eight constituents (2-methylnaphthalene, acenaphthene, benzo(a)anthracene, fluorene, naphthalene, phenanthrene, pyrene, and di-n-butylphthalate) have $HQ_{avg\text{-}PEC}$ exceeding one, ranging from 1.1 to 2.3.

The phthalate detections at the site are not consistently co-located with PAHs and are all noted in the laboratory report as estimated values due to potential presence in laboratory equipment. Given the low PEC-HQs and uncertainty surrounding the laboratory results, dimethylphthalate and di-n-butylphthalate are not identified as final ecological COPCs.

Station-specific HQs (Table 22) provide further insight for interpretation of the ecological significance of sediment PAHs. Of the ten unit-related stations, five are reported as non-detect for all PAHs (SED-2, SED-3, SED-8, SED-10, and SED-11; see Figure 1 for sample locations). Two additional stations (SED-5 and SED-9) have total PAH HQs only marginally greater than one, with $HQ_{max\text{-}TEC}$ values of 2.4 and 1.2 and $HQ_{max\text{-}PEC}$ values less than 1. The remaining three stations (SED-1, SED-4, and SED-12) have total PAH $HQ_{max\text{-}TEC}$ values of 29, 16, and 13, respectively. $HQ_{max\text{-}PEC}$ values for these three stations are 2.1, 1.1, and <1.

The data generally do not provide clear evidence that the MGP site is currently contributing significantly as a source. The frequency of detection for individual PAHs is low (Table 3), with only fluoranthene, phenanthrene, and pyrene detected in three or more stations. All other PAHs are detected in only one or two locations. This low rate of detection in the areas immediately adjacent to the site suggests that the current surface sediments of Chinquapin Creek are not

widely impacted releases from the historical MGP operations. The distribution and relative abundance of PAHs also does not suggest the site is a continuing source for sediment impacts. In general, one would expect elevated PAH concentrations near the source with a general decline in concentrations with distance downstream. At the Spartanburg MGP site, three of the six stations downstream from the operation area were non-detect, and the two downstream stations with PAH detections (SED-1 and SED-12) had a PAH signature that was distinct from the station nearest to the area of known impact (SED-4). The PAH concentration from station SED-4 was dominated by naphthalene and 2-methylnapthalene (Figure 4; Table 22). In contrast, stations SED-1 and SED-12 had a distinctly different PAH signature dominated by fluoranthene and pyrene. Such a fluoranthene/pyrene signature has recently been cited as an indicator of urban background (Stout et al., 2004). These results suggest that PAHs associated with stations SED-01 and SED-12 may be indicative of urban runoff or sources other than the Spartanburg MGP site. Station SED-5 also had the fluoranthene/pyrene signature, but had a total PAH concentration a factor of three less than stations SED-1 and SED-12.

Station SED-4 (Figure 1) is in the direct proximity to the known impacted areas north and south of Chinquapin Creek. This area has been remediated extensively with soil and stream-bank removals to address tar seeps and process piping in the vicinity. Site workers indicated that a significant portion of the stream bottom was excavated during the bank removal/stabilization activities. Thus, removals to date likely eliminated this area as a continued concern.

The degraded, urban character of Chinquapin Creek also supports the conclusion that adverse impacts to the benthic community are unlikely to result from sediment PAHs. In reality, stressors such as non-point source pollution, extreme flow variations, and altered stream morphology are obvious, severe, and extend over broad area. Under such circumstances it is unrealistic to conclude that a limited number of stations with elevated HQs represent a valid ecological concern.

Given the reasons discussed above, the PAHs in Chinquapin Creek sediment are not designated final ecological COPCs for benthic organisms. The remaining sections of Process Step 3 follow the outline as presented in the USEPA (1997) guidance.

2.2. Literature Search on Known Ecological Effects

The literature search employed for the Spartanburg MGP site during Process Step 3 identified NOAELs and LOAELs, as documented on Tables 12 through 15. These literature benchmarks were employed in the development of site-specific ecological HQs. Since no final ecological COPCs were identified in lines-of-evidence evaluation (Section 2.1.3), additional discussion/research of potential ecological effects is not required.

2.3. Contaminant Fate and Transport, Ecosystems Potentially at Risk, and Complete Exposure Pathways

The contaminant fate and transport, ecosystems potentially at risk, and complete exposure pathways identified in the SLERA (Process Step 1) are reevaluated and refined as necessary during this step.

2.3.1 Contaminant Fate and Transport

The relevant fate and transport mechanisms at the site were discussed in the SLERA (Duke 2004) and have not changed based on the ERA. However, since there are no final ecological COPCs identified for the Spartanburg MGP Site, the existing transport pathways do not present a concern to ecological receptors. Further fate and transport discussion is not required.

2.3.2 Ecosystems Potentially At Risk

The site-specific HQ development and lines-of-evidence discussion concluded that ecological risks are minimal and no final ecological COPCs are present at the Spartanburg MGP site. Consequently, no further evaluation of the local ecosystem(s) is required.

2.3.3 Complete Exposure Pathways

The complete exposure pathways were originally identified in the SLERA and shown in the CSM (Figures 2 and 3). Based on the refinement of COPCs completed in Step 3, no final COPCs are present and these exposure pathways are no longer considered a potential concern.

2.4. Selection of Assessment Endpoints

Preliminary assessment endpoints were established in Section 2.1.2.1. The refinement of COPCs in Section 2.1 concluded that no final COPCs are present in soil or sediment. Therefore, there is no need to establish assessment endpoints for these media and no further assessment is required.

2.5 Ecological Risk Questions

Ecological risk questions are based on the assessment endpoints and provide a basis for developing the study design (Process Step 4), evaluating the results of the site investigation in the analysis phase (Process Step 6), and developing the risk characterization (Process Step 7). This section evaluates whether risk questions should be addressed and how they should be addressed. This is a critical step since additional studies should be performed only if necessary to reduce critical uncertainty in the unit evaluation.

Since no final ecological COPCs are identified at the Spartanburg MGP Site, no unit-specific risk questions are developed and no further ecological investigations are planned.

2.6. Uncertainty

Uncertainty is inherent in each step of the ecological risk assessment process. Specific areas of uncertainty relative to Process Step 3 are qualitatively addressed in subsequent sections.

2.6.1 Uncertainties in Exposure Assessment

Uncertainty in the exposure assessment is minimized by conducting unit-specific ecological characterizations and field surveys. Nevertheless, the receptor species listed as potentially present at the unit are a limited subset of the species that may use the area to some extent for at least a portion of the year. The endpoint species evaluated in the ERA are considered to provide a conservative representation of the range of exposures that may be experienced by other species not evaluated.

In calculating constituent intakes, conservative exposure factors are assumed in order to be protective of all potential receptors. The conservative exposure factors and exposure concentrations provide confidence that calculated intakes are reasonably conservative estimates for the selected receptor populations. Intakes from dermal and inhalation exposures are not quantifiable for ecological receptors. However, this does not significantly increase the uncertainty of the estimated total intake because, for most receptors, intakes via these routes are likely to be minimal relative to intakes via ingestion.

At the Spartanburg MGP Site, there was uncertainty surrounding slightly elevated detection limits for PAHs in sediment. Within the exposure assessment, non-detected PAHs were conservatively assumed to be present at concentrations equal to one-half the detection limit. Note that the slightly elevated detection limits were present in all samples, including background. Given this fact, it is reasonable to conclude that non-detect results at downstream locations do not significantly increase the uncertainty in the data set, but rather are simply equivalent to background urban stream conditions.

2.6.2 Uncertainties in Effects Assessment

There is uncertainty associated with TRVs used in Process Step 3 of the ERA because the toxicity data are not unit-specific. TRVs used in this assessment were obtained from the available scientific literature, including compilations for terrestrial and aquatic toxicity benchmarks. Limitations in these toxicity values are common to most toxicity data and include: variations in physiological or biochemical factors that may exist among species; behavioral and ecological parameters that may make species' sensitivity to a contaminant different from that of the test organism; and limited information on long-term effects on natural populations. In addition, most of the laboratory-derived TRVs are based on administration of soluble chemical forms rather than insoluble forms typically encountered in the environment. Thus, the potential for ecological risk could be overestimated. This is potentially significant in the assessment of Chinquapin Creek sediment, where the numerous chunks of asphalt may skew the analytical results, but in reality may not be readily bioavailable.

2.6.3 Uncertainties in Risk Characterization

Uncertainty in the risk characterization is a direct result of the methodology used in the preceding sections of the ERA. The conservative methodology and assumptions used in the COPC selection, exposure assessment, and toxicity assessment are expected to overestimate, rather than underestimate, the potential for COPCs to pose risk to assessment endpoints. By overestimating risk, the actual risk of deleterious effects is likely to be less than indicated by the calculated ecological quotients.

Although the HQ is not a linear measure of potential adverse effects, the magnitude of the HQ provides important information regarding the probability of ecological effects. An HQ is interpreted in terms of probability and uncertainty. For many reasons, including uncertainties

regarding TRVs, the documented low bioavailability of many soil-bound contaminants, and possible compensatory reproductive effects among stressed receptor populations, a high level of uncertainty exists that adverse ecological effects will occur when the HQ is equal to or near 1. If there were no uncertainty about both the concentration to which receptors are exposed and the effects-threshold concentration, then an HQ greater than or equal to 1 would mean that the effect associated with the threshold concentration will occur with a probability equal to 1. However, since uncertainties regarding exposure and effects-threshold concentrations do exist in any ERA, there is a range of HQ values above and below 1 for which there is some degree of uncertainty about the actual risk to the receptor. Due to these uncertainties, even when HQs are slightly greater than 1, it is possible that there is no risk. Thus, the list of constituents having HQs greater than 1 is reviewed using professional judgment and all available lines of evidence to reduce uncertainty and identify which COPCs actually pose ecological risk and thereby warrant designation as final COCs. Lines-of-evidence discussion employed for the Spartanburg MGP site can be found in Section 2.1.3.

Ecological COPCs with no threshold data show uncertainty. If TRVs cannot be obtained, HQs cannot be calculated, resulting in uncertainty in assessing magnitude of risk. For the Spartanburg MGP site, there were no avian TRVs for PAHs and thus no HQs could be calculated. However, a semi-quantitative discussion of potential PAH toxicity was developed based on the available literature and was applied during the refinement of COPCs. Ultimately, there is a low degree of uncertainty surrounding the risk assessment results for avian receptors.

Lastly, there is risk characterization uncertainty due to the urban character of the site and particularly Chinquapin Creek. In relation to soil, the uncertainty from urban background is minimal. PAH concentrations in site soil were greater than the available background, but the HQs were nevertheless consistently below one, indicating minimal concern. Consequently, any uncertainty between site-related soil PAHs and urban background PAHs is a moot point and the soil medium is concluded not to present an ecological concern.

For Chinquapin Creek sediment, given the obvious impacts in the stream from nonpoint source pollution, flow variations, and changes to stream morphology, it is considered highly unlikely that a limited number of stations with HQs exceeding 1 could adversely impact the ecological community of the stream. In fact, as discussed in Section 2.1.3, several of the sediment sampling

stations have PAH signatures that could be indicative of "urban background" rather than site-related contributions.

In summary, while there are areas of uncertainty in Process Steps 1 through 3 of the ERA, they do not seriously affect the credibility of the conclusions of the Problem Formulation. Namely, no final ecological COCs exist for soil or sediment at the Spartanburg MGP site.

3.0. Summary and Scientific/Management Decision Point (SMDP)

The COPCs identified in the SLERA were carried through ERA Process Step 3. During the refinement of COPCs, site-specific HQs were developed for receptor functional groups relevant to the site. These included soil organisms, insectivorous mammals, and insectivorous birds for soil as well as benthic organisms, mammalian aquatic predators, and avian aquatic predators for sediment.

For the soil assessment, all HQs were less than one, indicating minimal ecological concern.

For the sediment assessment, HQs were less than one for the mammalian and avian predators, indicating minimal concern for these endpoints. The assessment of benthic organisms revealed that HQs for Chinquapin Creek sediment exceeded one for PAHs at a limited number of locations. However, during the lines-of-evidence discussion it was concluded that PAHs do not warrant designation as final ecological COPCs. The reasons justifying this conclusion are detailed in the lines of evidence discussion (Section 2.1.3). In summary:

- Most sediment stations are essentially the same as background (non-detect) and the HQs exceeding one are limited to a few selected locations;
- Different PAH signatures between SED-4 and distal stations suggest nonpoint source pollution may be a contributing source of PAHs at stations SED-01 and SED-12;
- The average sediment HQ for total PAHs is eleven (11) when using the threshold effects benhmark and less than one when using the probable effects cncentration;
- Station SED-4 and vicinity have been addressed by the removals completed to date; and
- Chinquapin Creek is heavily impacted by nonpoint source pollution and is unlikely to show an adverse effect from a limited number of stations having HQs exceeding one.

Given the conclusion of no final ecological COPCs, no further ecological investigations are proposed and the ERA process is complete.

4.0 References

ATSDR (Agency for Toxic Substances and Disease Registry) 1995. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs) (Update).* US Department of Health and Human Services. August

Bradley, L.J.N., B.H. Magee, and S.L. Allen 1994. *Background Levels of Polycyclic Aromatic Hydrocarbons (PAH) and Selected Metals in New England Urban Soils.* Journal of Soil Contamination, Vol. 3 (4), pp. 1-13.

Butler, R.W. 1992. Great Blue Heron (Ardea herodias) P. 1-19 In A. Poole, P. Stettenheim, and F. Gill (ed.) The Birds of North America, No. 25. The Birds of North America, Inc., Philadelphia, PA.

Duke 2004. *Screening Level Ecological Risk Assessment for the Spartanburg Pine Street MGP Site.* Prepared by Blue Ridge Environmental Consulting, Inc. for Duke Power, Charlotte, North Carolina.

Duke 2002. *Spartanburg-Pine Street MGP Site Assessment: Results from Phase 1 Efforts and Proposal for Additional Assessment Activities (Revision 1).*

Efroymson, R.A., M.E. Will, and G.W. Suter. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heteratrophic Process: 1997 Revision.* Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (http://www.esd.ornl.gov/programs/ecorisk/benchmark_reports .html)

Eisler, R. 1987. *Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* US Fish and Wildlife Service Biological Report. 85:1-11. Washington, D.C.

Jones, D.S., G.W. Suter and R.N. Hull. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision.* Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-95/R4. (http://www.esd.ornl.gov/programs/ecorisk/benchmark_reports .html)

Menzie, C.A., B.B Potocki, and J. Santodonato, 1992. *Exposure to Carcinogenic PAHs in the Environment,* Environmental Science and Technology, Vol. 26(7) pp 1278-1284.

Sample, B.E., D.M. Opresko, and G.W. Suter, 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* US Department of Energy, Oak Ridge National Laboratory. ES/ER/TM-86/R3. June 1996. (http://www.esd.ornl.gov/programs/ecorisk/benchmark_reports .html)

Sample, B.E. and G.W. Suter, II, 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants*, ER/ES/TM/-125, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee. . (http://www.esd.ornl.gov/programs/ecorisk/benchmark reports . html)

Stout, S.A., A.D. Uhler, and S.D. Mattingly, 2004. *Comparative Evaluation of Background Anthropogenic Hydrocarbons in Surficial Sediments from Nine Urban Waterways*, Environmental Science and Technology, Vol. 38(11) pp 2987-2994.

Travis, C.C. and A.D. Arms, 1988. *Bioconcentration of Organics in Beef, Milk, and Vegetation,* Environmental Science and Technology 22(3), pp. 271-274.

USEPA 2004. Integrated Risk Information System (IRIS), US EPA On-Line Database of Toxicity Values, Office of Research and Development, United States Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio, March 2004, www.epa.gov/iris .

USEPA 2003. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks for the Protection of Benthic Organisms: PAH Mixtures*, United States Environmental Protection Agency, Office of Research and Development, November 2003.

USEPA 2001a. *ECO Update: The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*, United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C. June 2001.

USEPA 2001b. *Supplemental Guidance to RAGS Region IV Bulletins (Human Health and Ecological Risk Assessment)*, Interim Draft, Office of Technical Services, United States Environmental Protection Agency, Region IV, Atlanta, Georgia. (http://www.epa.gov/region4/waste/ots/). Updated online in 2001.

USEPA 1993. *Wildlife Exposure Factors Handbook,* EPA/600/R-93/187a & b, Office of Research and Development, United States Environmental Protection Agency, Washington, D.C.

TABLES

Table 1.
Summary of Ecological COPCs
Spartanburg MGP Site

Constituent	Soil (0-1 ft)	Sediment
2-Methylnaphthalene		X
Acenaphthene		X
Acenaphthylene[a]		X
Anthracene	X	X
Benzo(a)anthracene	X	X
Benzo(a)pyrene	X	X
Benzo(b)fluoranthene	X	X
Benzo(g,h,I)perylene	X	X
Benzo(k)fluoranthene	X	X
Chrysene	X	X
Dibenzo(a,h)anthracene[a]	X	X
Dimethylphthalate		X
di-n-Butylphthalate		X
Fluoranthene	X	X
Fluorene		X
Indeno(1,2,3-cd)pyrene	X	X
Naphthalene		X
Phenanthrene	X	X
Pyrene	X	X

(a) These constituents were not detected in sediment but are included as COPCs since sediment detection limits exceeded ESVs and PAHs are a primary concern at the site.

Table 2.
Summary of Analytical Data for Soil COPCs - Surface Soil (0 to 1 ft bls)
Spartanburg MGP Site

CAS Number	Chemical	Minimum Concentration	Min Qual	Maximum Concentration	Max Qual	Units	Average Concentration [a]	Location of Maximum Concentration	Det Freq	Range of Detection Limits	Background Value[a]
120-12-7	Anthracene	2.73E-02		8.46E-01		mg/kg	1.12E-01	SB-16	5/46	0.022-0.44	1.36E-01
56-55-3	Benzo(a)anthracene	5.33E-03		1.25E+00		mg/kg	2.91E-01	SB-16	41/46	0.00433-0.0866	2.19E-01
50-32-8	Benzo(a)pyrene	5.99E-03		1.87E+00		mg/kg	4.33E-01	SB-16	42/46	0.00333-0.0666	3.15E-01
205-99-2	Benzo(b) fluoranthene	1.66E-02		1.56E+00		mg/kg	3.99E-01	SB-28	42/46	0.00599-0.12	2.87E-01
191-24-2	Benzo(g,h,I)perylene	2.80E-02		1.13E+00		mg/kg	2.91E-01	SB-16	17/46	0.0253-0.506	2.36E-01
207-08-9	Benzo(k)fluoranthene	6.99E-03		7.79E-01		mg/kg	2.01E-01	SB-28	39/46	0.00566-0.113	1.22E-01
218-01-9	Chrysene	1.17E-02		1.42E+00		mg/kg	3.67E-01	SB-16	40/46	0.005-0.0999	2.67E-01
53-70-3	Dibenzo(a,h)anthracene	3.63E-02		8.46E-01		mg/kg	1.44E-01	SB-24	26/46	0.00999-0.2	6.82E-02
206-44-0	Fluoranthene	1.83E-02		5.39E+00		mg/kg	1.05E+00	SB-16	42/46	0.00699-0.14	7.75E-01
193-39-5	Indeno(1,2,3-cd)pyrene	3.00E-02		1.13E+00		mg/kg	2.50E-01	SB-16	29/46	0.0143-0.286	2.62E-01
85-01-8	Phenanthrene	2.83E-02		5.13E+00		mg/kg	4.66E-01	SB-16	30/46	0.0213-0.426	3.19E-01
129-00-0	Pyrene	1.37E-02		5.00E+00		mg/kg	8.91E-01	SB-16	41/46	0.00899-0.18	7.31E-01

(a) The average result is calculated using one-half the detection limit for non-detect results.

(b) Background value is 2X average while using one-half the detection limit for non-detects.

Table 3.
Summary of Analytical Data for Sediment COPCs
Spartanburg MGP Site

CAS Number	Chemical	Minimum Concentration	Min Qual	Maximum Concentration	Max Qual	Units	Average Concentration[a]	Location of Maximum Concentration	Det Freq	Range of Detection Limits	Background Value[b]
91-57-6	2-Methylnaphthalene	1.00E+01		1.00E+01		mg/kg	1.50E+00	SED-4	1/12	.96-1.2	ND
83-32-9	Acenaphthene	4.00E+00		4.00E+00		mg/kg	8.97E-01	SED-4	1/12	.96-1.2	ND
208-96-8	Acenaphthylene[c]	< 9.60E-01		< 1.20E+00		mg/kg	5.52E-01	NA	0/12	.96-1.2	ND
120-12-7	Anthracene	1.20E+00		1.20E+00		mg/kg	6.23E-01	SED-1	1/12	.96-1.2	ND
56-55-3	Benzo(a)anthracene	2.10E+00		4.70E+00		mg/kg	1.12E+00	SED-1	2/12	.96-1.2	ND
50-32-8	Benzo(a)pyrene	1.90E+00		4.00E+00		mg/kg	1.03E+00	SED-1	2/12	.96-1.2	ND
205-99-2	Benzo(b)fluoranthene	1.20E+00		3.20E+00		mg/kg	8.83E-01	SED-1	2/12	.96-1.2	ND
191-24-2	Benzo(g,h,i)perylene	2.00E+00		2.00E+00		mg/kg	7.03E-01	SED-1	1/12	.96-1.2	ND
207-08-9	Benzo(k)fluoranthene	1.40E+00		3.40E+00		mg/kg	9.23E-01	SED-1	2/12	.96-1.2	ND
218-01-9	Chrysene	1.90E+00		4.60E+00		mg/kg	1.09E+00	SED-1	2/12	.96-1.2	ND
53-70-3	Dibenzo(a,h)anthracene[c]	< 9.60E-01		< 1.20E+00		mg/kg	5.52E-01	NA	0/12	.96-1.2	ND
131-11-3	Dimethylphthalate	5.90E+00		5.90E+00		mg/kg	1.08E+00	SED-12	1/12	.96-1.2	ND
84-74-2	di-n-Butylphthalate	1.80E+00		7.50E+00		mg/kg	2.87E+00	SED-12	5/12	2.4-2.7	ND
206-44-0	Fluoranthene	1.60E+00		8.00E+00		mg/kg	1.81E+00	SED-1	3/12	.96-1.2	ND
86-73-7	Fluorene	1.60E+00		1.60E+00		mg/kg	6.57E-01	SED-4	1/12	.96-1.2	ND
193-39-5	Indeno(1,2,3-c,d)pyrene	2.00E+00		2.00E+00		mg/kg	7.03E-01	SED-1	1/12	.96-1.2	ND
91-20-3	Naphthalene	8.10E+00		8.10E+00		mg/kg	1.31E+00	SED-4	1/12	.96-1.2	ND
85-01-8	Phenanthrene	1.90E+00		3.00E+00		mg/kg	1.28E+00	SED-1	4/12	.96-1.2	ND
129-00-0	Pyrene	2.20E+00		7.90E+00		mg/kg	1.91E+00	SED-1	3/12	.96-1.2	ND

(a) The average result is calculated using one-half the detection limit for non-detect results.

(b) Background value is 2X average while using one-half the detection limit for non-detects.

(c) These constituents were not detected, but were included as COPCs due to detection limits exceeding the ecological screening values. The values shown here are based on the sample specific detection limits.

Table 4.
Summary of Analytical Data for Background Soil
Spartanburg MGP Site

CAS Number	Chemical	Minimum Concentration	Min Qual	Maximum Concentration	Max Qual	Units	Average Concentration[a]	Location of Maximum Concentration	Det Freq	Range of Detection Limits
120-12-7	Anthracene	2.56E-01		2.56E-01		mg/kg	6.81E-02	BG-07	1/12	0.022-0.22
56-55-3	Benzo(a)anthracene	1.83E-02		1.48E+00		mg/kg	2.19E-01	BG-10	12/12	0.00433-0.0433
50-32-8	Benzo(a)pyrene	2.46E-02		2.45E+00		mg/kg	3.15E-01	BG-07	11/12	0.00333-0.0333
205-99-2	Benzo(b)fluoranthene	3.10E-02		1.72E+00		mg/kg	2.87E-01	BG-10	12/12	0.00599-0.0599
191-24-2	Benzo(g,h,i)perylene	3.10E-02		1.53E+00		mg/kg	2.36E-01	BG-08	7/12	0.0253-0.253
207-08-9	Benzo(k)fluoranthene	1.37E-02		7.26E-01		mg/kg	1.22E-01	BG-11	11/12	0.00566-0.0566
218-01-9	Chrysene	2.23E-02		1.64E+00		mg/kg	2.67E-01	BG-10	12/12	0.005-0.05
53-70-3	Dibenzo(a,h)anthracene	6.06E-02		5.09E-01		mg/kg	6.83E-02	BG-07	2/12	0.00999-0.0999
206-44-0	Fluoranthene	6.33E-02		5.36E+00		mg/kg	7.75E-01	BG-10	12/12	0.00699-0.0699
86-73-7	Fluorene	1.66E-02		1.66E-02		mg/kg	1.89E-02	BG-07	1/12	0.00699-0.0699
193-39-5	Indeno(1,2,3-cd)pyrene	1.93E-02		1.37E+00		mg/kg	2.62E-01	BG-11	9/12	0.0143-0.143
91-20-3	Naphthalene	2.04E-01		1.37E+00		mg/kg	2.41E-01	BG-07	3/12	0.0333-0.333
85-01-8	Phenanthrene	5.19E-02		2.72E+00		mg/kg	3.19E-01	BG-07	5/12	0.0213-0.213
129-00-0	Pyrene	4.10E-02		5.43E+00		mg/kg	7.31E-01	BG-10	12/12	0.00899-0.0899

(a) The average result is calculated using one-half the detection limit for non-detect results.

Table 5
Definition of Exposure Dose (ED) Equations and Parameters
Spartanburg MGP Site

Short-Tailed Shrew	$ED = C_s \times [(SP_v \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_s)] \times UFF / BW$
American Robin	$ED = C_s \times [(SP_r \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_s)] \times UFF / BW$
Raccoon (sediment)	$ED = C_{sed} \times [(SP_v \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_{sed})] \times UFF / BW$
Great Blue Heron (sediment)	$ED = C_{sed} \times [(SP_v \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_{sed})] \times UFF / BW$

Cs = Soil concentration (Cs_{max} = maximum soil concentration; Cs_{ave} = average soil concentration).
Csed = Sediment concentration ($Csed_{max}$ = maximum sediment concentration; $Csed_{ave}$ = average sediment concentration).
UFF = Unit foraging factor = smaller of 1 and area/home range.
ED = exposure dose (ED_{max} = exposure dose based on maximum concentration; ED_{ave} = exposure dose based on average concentration).
SP_r = Soil-to-plant uptake factor, reproductive parts.
SP_v = Soil-to-plant uptake factor, vegetative parts.
I_p = Daily plant ingestion rate.
BAF_{inv} = Soil-to-invertebrate uptake factor.
I_a = Daily animal ingestion rate.
ST = Soil-to-tissue uptake factor (assumed as 1)
I_s = Daily soil ingestion rate.
I_{sed} = Daily sediment ingestion rate.
BW = Body weight

Table 6.
Dietary Intake Factors and Unit Foraging Factors
Spartanburg MGP Site

Receptor	Dietary Intake Rates				BW (kg)	Home Range (ha)	UFFs	
	Ip (kg/d)	Ia (kg/d)	Is (kg/d)	Iw (L/d)			Terrestrial Area (2.5 ha)	Chinquapin Creek (0.3 ha)
Short-tailed shrew [a]	1.24E-03	7.76E-03	1.17E-03	--	1.50E-02	3.90E-01	1.00E+00	--
American robin [b]	4.65E-02	4.65E-02	1.90E-03	--	7.70E-02	4.20E-01	1.00E+00	--
Raccoon (aquatic) [c]	0.00E+00	1.04E+00	1.10E-01	--	6.20E+00	5.20E+01	--	5.77E-03
Great Blue heron [d]	0.00E+00	4.20E-01	0.00E+00	--	2.39E+00	8.40E+00	--	3.57E-02

(a) From Sample and Suter (1994), using 13.8% plant and 86.2% invertebrate diet.

(b) American robin is evaluated assuming 50% plant and 50% invertebrate consumption and food ingestion rate of 0.093 kg/d from Sample and Suter (1994).

(c) Raccoon body weight is mean (Missouri study) from US EPA (1993). Home range is mean (Georgia) from US EPA (1993). Food ingestion rate is estimated using Equation 11 from Sample and Suter (1994), assuming 70.5% moisture for correction.

(d) Great Blue Heron body weight was found in Sample and Suter (1994). Food ingestion rate is estimated using an allometric equation, assuming a 100% piscivorous diet (Sample & Suter 1994). Home range value was dervied from Butler 1992 as cited in "EPA Species Profile for the Great Blue Heron".

I_a = Daily ingestion of animals
I_s = Daily ingestion of soil or sediment
I_w = Daily ingestion of water
BW = Body weight
UFF = Unit foraging factor = smaller of 1 and unit area/home range.
-- = not applicable for this receptor

Table 7.
Transfer Factors for Exposure Dose Calculations
Spartanburg MGP Site

COPC	Soil-to-Plant Factor[a]	Log Kow[b]	BAFinv	BAFinv Source
2-methylnaphthalene	4.55E-02	3.86E+00	5.00E-02	Beyer 1990
Acenaphthene	3.73E-02	4.01E+00	5.00E-02	Beyer 1990
Acenaphthylene	1.07E-01	3.22E+00	5.00E-02	Beyer 1990
Anthracene	1.87E-02	4.53E+00	5.00E-02	Beyer 1990
Benzo(a)anthracene	4.09E-03	5.67E+00	3.00E-02	USEPA 1999
Benzo(a)pyrene	2.28E-03	6.11E+00	7.00E-02	USEPA 1999
Benzo(b)fluoranthene	1.84E-03	6.27E+00	7.00E-02	USEPA 1999
Benzo(g,h,i)perylene	1.34E-03	6.51E+00	5.00E-02	Beyer 1990
Benzo(k)fluoranthene	1.79E-03	6.29E+00	8.00E-02	USEPA 1999
Chrysene	3.88E-03	5.71E+00	4.00E-02	USEPA 1999
Dibenzo(a,h)anthracene	1.02E-03	6.71E+00	7.00E-02	USEPA 1999
Di-n-butyl phthalate	1.94E-02	4.50E+00	5.00E-02	Beyer 1990
Dimethylphthalate	9.21E-01	1.60E+00	5.00E-02	Beyer 1990
Fluoranthene	8.97E-03	5.08E+00	5.00E-02	Beyer 1990
Fluorene	2.86E-02	4.21E+00	5.00E-02	Beyer 1990
Indeno(1,2,3-c,d)pyrene	1.01E-03	6.72E+00	8.00E-02	USEPA 1999
Naphthalene	8.85E-02	3.36E+00	5.00E-02	Beyer 1990
Phenanthrene	1.77E-02	4.57E+00	5.00E-02	Beyer 1990
Pyrene	1.11E-02	4.92E+00	5.00E-02	Beyer 1990

(a) Soil-to-plant transfer factor calculated from Travis and Arms (1988) equation:
= 10^(1.588-0.578 log Kow) x % moisture , where 20% moisture content assumed

(b) Log Kow for PAHs taken from USEPA 2003. Log Kow for phthalates are from the risk assessment information system (RAIS) database of chemical properties (http://risk.lsd.ornl.gov/cgi-bin/tox/TOX_select?select=csf)

Table 8.
Ecological Intake Calculation for Insectivorous Mammals - Surface Soil
Spartanburg MGP Site

COPCs[a]	Cs_{max} [b] (mg/kg)	Cs_{avg} [b] (mg/kg)	SP_v [c]	I_p (kg/d)	BAF_{inv} [c]	I_a (kg/d)	I_s (kg/d)	UFF [c]	BW (kg)	ED_{max} [d] (mg/kg bw-d)	ED_{avg} [d] (mg/kg bw-d)
Anthracene	8.46E-01	1.12E-01	1.87E-02	1.24E-03	5.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	8.92E-02	1.18E-02
Benzo(a)anthracene	1.25E+00	2.91E-01	4.09E-03	1.24E-03	3.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	1.17E-01	2.73E-02
Benzo(a)pyrene	1.87E+00	4.33E-01	2.28E-03	1.24E-03	7.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	2.14E-01	4.95E-02
Benzo(b)fluoranthene	1.56E+00	3.99E-01	1.84E-03	1.24E-03	7.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	1.78E-01	4.56E-02
Benzo(g,h,I)perylene	1.13E+00	2.91E-01	1.34E-03	1.24E-03	5.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	1.17E-01	3.02E-02
Benzo(k)fluoranthene	7.79E-01	2.01E-01	1.79E-03	1.24E-03	8.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	9.31E-02	2.40E-02
Chrysene	1.42E+00	3.67E-01	3.88E-03	1.24E-03	4.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	1.41E-01	3.64E-02
Dibenzo(a,h)anthracene	8.46E-01	1.44E-01	1.02E-03	1.24E-03	7.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	9.67E-02	1.65E-02
Fluoranthene	5.39E+00	1.05E+00	8.97E-03	1.24E-03	5.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	5.64E-01	1.10E-01
Indeno(1,2,3-c,d)pyrene	1.13E+00	2.50E-01	1.01E-03	1.24E-03	8.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	1.35E-01	2.99E-02
Phenanthrene	5.13E+00	4.66E-01	1.77E-02	1.24E-03	5.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	5.40E-01	4.91E-02
Pyrene	5.00E+00	8.91E-01	1.11E-02	1.24E-03	5.00E-02	7.76E-03	1.17E-03	1.00E+00	1.50E-02	5.24E-01	9.34E-02

For purposes of identifying input values, the short-tailed shrew was selected as the representative receptor for insectivorous mammals.

(a) COPCs from Table 1.

(b) Cs = Soil concentration; Cs_{max} = maximum soil concentration; Cs_{avg} = average soil concentration.

(c) UFF = Unit foraging factor = smaller of 1 and area/home range (see Table 6).

(d) ED = exposure dose; ED_{max} = exposure dose based on maximum soil concentration; ED_{avg} = exposure dose based on average soil concentration.

$ED = C_s \times [(SP_v \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_s)] \times UFF / BW$, where ST = 1.

(e) Sources provided in Table 7.

Table 9.
Ecological Intake Calculation for Insectivorous Birds - Surface Soil
Spartanburg MGP Site

COPCs[a]	Cs_{max} [b] (mg/kg)	Cs_{avg} [b] (mg/kg)	SP_r [c]	I_p (kg/d)	BAF_{inv} [c]	I_a (kg/d)	I_s (kg/d)	UFF [c]	BW (kg)	ED_{max} [d] (mg/kg bw-d)	ED_{avg} [d] (mg/kg bw-d)
Anthracene	8.46E-01	1.12E-01	1.87E-02	4.65E-02	5.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	5.59E-02	7.41E-03
Benzo(a)anthracene	1.25E+00	2.91E-01	4.09E-03	4.65E-02	3.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	5.66E-02	1.32E-02
Benzo(a)pyrene	1.87E+00	4.33E-01	2.28E-03	4.65E-02	7.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	1.28E-01	2.95E-02
Benzo(b)fluoranthene	1.56E+00	3.99E-01	1.84E-03	4.65E-02	7.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	1.06E-01	2.71E-02
Benzo(g,h,I)perylene	1.13E+00	2.91E-01	1.34E-03	4.65E-02	5.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	6.29E-02	1.62E-02
Benzo(k)fluoranthene	7.79E-01	2.01E-01	1.79E-03	4.65E-02	8.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	5.77E-02	1.49E-02
Chrysene	1.42E+00	3.67E-01	3.88E-03	4.65E-02	4.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	7.27E-02	1.88E-02
Dibenzo(a,h)anthracene	8.46E-01	1.44E-01	1.02E-03	4.65E-02	7.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	5.72E-02	9.75E-03
Fluoranthene	5.39E+00	1.05E+00	8.97E-03	4.65E-02	5.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	3.25E-01	6.34E-02
Indeno(1,2,3-c,d)pyrene	1.13E+00	2.50E-01	1.01E-03	4.65E-02	8.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	8.32E-02	1.84E-02
Phenanthrene	5.13E+00	4.66E-01	1.77E-02	4.65E-02	5.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	3.36E-01	3.05E-02
Pyrene	5.00E+00	8.91E-01	1.11E-02	4.65E-02	5.00E-02	4.65E-02	1.90E-03	1.00E+00	7.70E-02	3.08E-01	5.49E-02

For purposes of identifying input values, the American robin was selected as the representative receptor for insectivorous birds.

(a) COPCs from Table 1.

(b) Cs = Soil concentration; Cs_{max} = maximum soil concentration; Cs_{avg} = average soil concentration.

(c) UFF = Unit foraging factor = smaller of 1 and area/home range (see Table 6).

(d) ED = exposure dose; ED_{max} = exposure dose based on maximum soil concentration; ED_{avg} = exposure dose based on average soil concentration.

$ED = C_s \times [(SP_r \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_s)] \times UFF / BW$, where ST = 1.

(e) Sources provided in Table 7.

Table 10.
Ecological Intake Calculation for Mammalian Aquatic Predators - Sediment
Spartanburg MGP Site

COPCs[a]	$Csed_{max}$ [b] (mg/kg)	$Csed_{avg}$ [b] (mg/kg)	SP_v [c]	I_p (kg/d)	BAF_{inv} [c]	I_a (kg/d)	I_{sed} (kg/d)	UFF [c]	BW (kg)	ED_{max} [d] (mg/kg bw-d)	ED_{avg} [d] (mg/kg bw-d)
2-Methylnaphthalene	1.00E+01	1.50E+00	4.55E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	1.51E-03	2.26E-04
Acenaphthene	4.00E+00	8.97E-01	3.73E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	6.03E-04	1.35E-04
Acenaphthylene	6.00E-01	5.52E-01	1.07E-01	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	9.05E-05	8.32E-05
Anthracene	1.20E+00	6.23E-01	1.87E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	1.81E-04	9.39E-05
Benzo(a)anthracene	4.70E+00	1.12E+00	4.09E-03	0.00E+00	3.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	6.18E-04	1.48E-04
Benzo(a)pyrene	4.00E+00	1.03E+00	2.28E-03	0.00E+00	7.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	6.80E-04	1.76E-04
Benzo(b)fluoranthene	3.20E+00	8.83E-01	1.84E-03	0.00E+00	7.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	5.44E-04	1.50E-04
Benzo(g,h,I)perylene	2.00E+00	7.03E-01	1.34E-03	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	3.02E-04	1.06E-04
Benzo(k)fluoranthene	3.40E+00	9.23E-01	1.79E-03	0.00E+00	8.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	6.11E-04	1.66E-04
Chrysene	4.60E+00	1.09E+00	3.88E-03	0.00E+00	4.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	6.49E-04	1.54E-04
Dibenzo(a,h)anthracene	6.00E-01	5.52E-01	1.02E-03	0.00E+00	7.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	1.02E-04	9.39E-05
Dimethylphthalate	5.90E+00	1.08E+00	9.21E-01	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	8.90E-04	1.63E-04
di-n-Butyl phthalate	7.50E+00	2.87E+00	1.94E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	1.13E-03	4.33E-04
Fluoranthene	8.00E+00	1.81E+00	8.97E-03	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	1.21E-03	2.73E-04
Fluorene	1.60E+00	6.57E-01	2.86E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	2.41E-04	9.91E-05
Indeno(1,2,3-c,d)pyrene	2.00E+00	7.03E-01	1.01E-03	0.00E+00	8.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	3.60E-04	1.26E-04
Naphthalene	8.10E+00	1.31E+00	8.85E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	1.22E-03	1.97E-04
Phenanthrene	3.00E+00	1.28E+00	1.77E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	4.52E-04	1.93E-04
Pyrene	7.90E+00	1.91E+00	1.11E-02	0.00E+00	5.00E-02	1.04E+00	1.10E-01	5.77E-03	6.20E+00	1.19E-03	2.88E-04

For purposes of identifying input values, the raccoon was selected as the representative receptor for mammalian aquatic predators.

(a) COPCs from Table 1.

(b) Csed = Sediment concentration; $Csed_{max}$ = maximum sediment concentration; $Csed_{avg}$ = average sediment concentration.

(c) UFF = Unit foraging factor = smaller of 1 and area/home range (see Table 6).

(d) ED = exposure dose; ED_{max} = exposure dose based on maximum sediment concentration; ED_{avg} = exposure dose based on avg sediment concentration.

$ED = C_{sed} \times [(SP_v \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_{sed})] \times UFF / BW$, where ST = 1.

(e) Sources provided in Table 7.

Table 11.
Ecological Intake Calculation for Avian Aquatic Predators - Sediment
Spartanburg MGP Site

COPCs[a]	$Csed_{max}$ [b] (mg/kg)	Csedavg [b] (mg/kg)	SP_v [c]	I_p (kg/d)	BAF_{inv} [c]	I_a (kg/d)	I_{sed} (kg/d)	UFF [c]	BW (kg)	ED_{max} [d] (mg/kg bw-d)	ED_{avg} [d] (mg/kg bw-d)
2-Methylnaphthalene	1.00E+01	1.50E+00	4.55E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	3.14E-03	4.70E-04
Acenaphthene	4.00E+00	8.97E-01	3.73E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.25E-03	2.81E-04
Acenaphthylene	6.00E-01	5.52E-01	1.07E-01	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.88E-04	1.73E-04
Anthracene	1.20E+00	6.23E-01	1.87E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	3.76E-04	1.95E-04
Benzo(a)anthracene	4.70E+00	1.12E+00	4.09E-03	0.00E+00	3.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	8.85E-04	2.11E-04
Benzo(a)pyrene	4.00E+00	1.03E+00	2.28E-03	0.00E+00	7.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.76E-03	4.54E-04
Benzo(b)fluoranthene	3.20E+00	8.83E-01	1.84E-03	0.00E+00	7.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.41E-03	3.88E-04
Benzo(g,h,I)perylene	2.00E+00	7.03E-01	1.34E-03	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	6.27E-04	2.21E-04
Benzo(k)fluoranthene	3.40E+00	9.23E-01	1.79E-03	0.00E+00	8.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.71E-03	4.63E-04
Chrysene	4.60E+00	1.09E+00	3.88E-03	0.00E+00	4.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.15E-03	2.74E-04
Dibenzo(a,h)anthracene	6.00E-01	5.52E-01	1.02E-03	0.00E+00	7.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	2.63E-04	2.42E-04
Dimethylphthalate	5.90E+00	1.08E+00	9.21E-01	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.85E-03	3.39E-04
di-n-Butyl phthalate	7.50E+00	2.87E+00	1.94E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	2.35E-03	9.00E-04
Fluoranthene	8.00E+00	1.81E+00	8.97E-03	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	2.51E-03	5.67E-04
Fluorene	1.60E+00	6.57E-01	2.86E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	5.02E-04	2.06E-04
Indeno(1,2,3-c,d)pyrene	2.00E+00	7.03E-01	1.01E-03	0.00E+00	8.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	1.00E-03	3.53E-04
Naphthalene	8.10E+00	1.31E+00	8.85E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	2.54E-03	4.10E-04
Phenanthrene	3.00E+00	1.28E+00	1.77E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	9.41E-04	4.01E-04
Pyrene	7.90E+00	1.91E+00	1.11E-02	0.00E+00	5.00E-02	4.20E-01	0.00E+00	3.57E-02	2.39E+00	2.48E-03	5.99E-04

For purposes of identifying input values, the Great Blue Heron was selected as the representative receptor for avian aquatic predators.

(a) COPCs from Table 1.

(b) Csed = Sediment concentration; $Csed_{max}$ = maximum sediment concentration; $Csed_{avg}$ = average sediment concentration.

(c) UFF = Unit foraging factor = smaller of 1 and area/home range (see Table 6).

(d) ED = exposure dose; ED_{max} = exposure dose based on maximum sediment concentration; ED_{avg} = exposure dose based on avg sediment concentration.

$ED = C_{sed} \times [(SP_v \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_{sed})] \times UFF / BW$, where ST = 1.

(e) Sources provided in Table 7.

Table 12.
Toxicity Reference Values for Mammals
Spartanburg MGP Site

Constituent	NOAEL (mg/kg-BW-day)	LOAEL (mg/kg-BW-day)	Test Species	Source(s)	Comment
2-Methylnaphthalene	10	20	Rat		Naphthalene used as surrogate.
Acenaphthene	17.5	35	Mouse	USEPA 2004 (IRIS)	Subchronic values divided by 10.
Acenapthylene	17.5	35	Mouse		Acenaphthene used as surrogate.
Anthracene	100	1000	Mouse	USEPA 2004 (IRIS)	
Benzo(a)anthracene	1	10	Mouse		B(a)P used as surrogate
Benzo(a)pyrene	1	10	Mouse	Sample et al., 1996	
Benzo(b)fluoranthene	1	10	Mouse		B(a)P used as surrogate
Benzo(k)fluoranthene	1	10	Mouse		B(a)P used as surrogate
Benzo(g,h,I)perylene	75	125	Mouse		Pyrene used as surrogate
Chrysene	1	10	Mouse		B(a)P used as surrogate
Dibenzo(a,h)anthracene	1	10	Mouse		B(a)P used as surrogate
Dimethylphthalate	550	1830	Dog		Di-n-butylphthalate used as surrogate
Di-n-butylphthalate	550	1830	Dog	Sample et al., 1996	
Fluoranthene	12.5	125	Mouse	USEPA 2004 (IRIS)	Subchronic values divided by 10.
Fluorene	12.5	25	Mouse	USEPA 2004 (IRIS)	Subchronic values divided by 10.
Indeno(1,2,3-cd)pyrene	1	10	Mouse		B(a)P used as surrogate
Naphthalene	10	20	Rat	USEPA 2004 (IRIS)	Subchronic values divided by 10.
Phenanthrene	75	125	Mouse		Pyrene used as surrogate
Pyrene	75	125	Mouse	USEPA 2004 (IRIS)	Subchronic values divided by 10.

Table 13.
Toxicity Reference Values for Birds
Spartanburg MGP Site

Constituent	NOAEL (mg/kg-BW-day)	LOAEL (mg/kg-BW-day)	Test Species	Source(s)	Comment
2-Methylnaphthalene	None	None			
Acenaphthene	None	None			
Acenapthylene	None	None			
Anthracene	None	None			
Benzo(a)anthracene	None	None			
Benzo(a)pyrene	None	None			
Benzo(b)fluoranthene	None	None			
Benzo(k)fluoranthene	None	None			
Benzo(g,h,I)perylene	None	None			
Chrysene	None	None			
Dibenzo(a,h)anthracene	None	None			
Dimethylphthalate	0.11	1.11	Ringed Dove	Sample et al, 1996	DNB used as surrogate
Di-n-butylphthalate	0.11	1.11	Ringed Dove	Sample et al, 1996	
Fluoranthene	None	None			
Fluorene	None	None			
Indeno(1,2,3-cd)pyrene	None	None			
Naphthalene	None	None			
Phenanthrene	None	None			
Pyrene	None	None			

Table 14.
Toxicity Reference Values for Soil Organisms
Spartanburg MGP Site

Constituent	TRV (mg/kg)	Source	Comment
2-Methylnaphthalene	30	Efroymson et al. (1997)	used fluorene as surrogate
Acenaphthene	30	Efroymson et al. (1997)	used fluorene as surrogate
Acenaphthylene	30	Efroymson et al. (1997)	used fluorene as surrogate
Anthracene	30	Efroymson et al. (1997)	used fluorene as surrogate
Benzo(a)anthracene	30	Efroymson et al. (1997)	used fluorene as surrogate
Benzo(a)pyrene	30	Efroymson et al. (1997)	used fluorene as surrogate
Benzo(b)fluoranthene	30	Efroymson et al. (1997)	used fluorene as surrogate
Benzo(k)fluoranthene	30	Efroymson et al. (1997)	used fluorene as surrogate
Benzo(g,h,I)perylene	30	Efroymson et al. (1997)	used fluorene as surrogate
Chrysene	30	Efroymson et al. (1997)	used fluorene as surrogate
Dibenzo(a,h)anthracene	30	Efroymson et al. (1997)	used fluorene as surrogate
Fluoranthene	30	Efroymson et al. (1997)	used fluorene as surrogate
Fluorene	30	Efroymson et al. (1997)	
Indeno(1,2,3-cd)pyrene	30	Efroymson et al. (1997)	used fluorene as surrogate
Naphthalene	30	Efroymson et al. (1997)	used fluorene as surrogate
Phenanthrene	30	Efroymson et al. (1997)	used fluorene as surrogate
Pyrene	30	Efroymson et al. (1997)	used fluorene as surrogate

Table 15
Summary of Toxicity Reference Values - Sediment Organisms
Spartanburg MGP Site

COPC	TEC - TRV (mg/kg)	Source/ Comment	PEC- TRV (mg/kg)	Source/ Comment
2-Methylnaphthalene	3.30E-01	EPA Region 4 ESV (PQL)	6.70E-01	NOAA ER-M (Jones et al 1997)
Acenaphthene	3.30E-01	EPA Region 4 ESV (PQL)	5.00E-01	NOAA ER-M (Jones et al 1997)
Acenaphthylene	3.30E-01	EPA Region 4 ESV (PQL)	6.40E-01	NOAA ER-M (Jones et al 1997)
Anthracene	3.30E-01	EPA Region 4 ESV (PQL)	8.45E-01	USEPA 2002; Consensus-PEC
Benzo(a)anthracene	3.30E-01	EPA Region 4 ESV (PQL)	1.05E+00	USEPA 2002; Consensus-PEC
Benzo(a)pyrene	3.30E-01	EPA Region 4 ESV (PQL)	1.45E+00	USEPA 2002; Consensus-PEC
Benzo(b)fluoranthene	6.55E-01	EPA Region 4 ESV (PQL)	1.45E+00	used B(a)P value
Benzo(g,h,i)perylene	6.55E-01	EPA Region 4 ESV (PQL)	1.45E+00	used B(a)P value
Benzo(k)fluoranthene	6.55E-01	EPA Region 4 ESV (PQL)	1.45E+00	used B(a)P value
Chrysene	3.30E-01	EPA Region 4 ESV (PQL)	1.29E+00	USEPA 2002; Consensus-PEC
Dibenzo(a,h)anthracene	3.30E-01	EPA Region 4 ESV (PQL)	1.45E+00	used B(a)P value
Fluoranthene	4.23E-01	USEPA 2002; Consensus-TEC	2.23E+00	USEPA 2002; Consensus-PEC
Fluorene	3.30E-01	EPA Region 4 ESV (PQL)	5.36E-01	USEPA 2002; Consensus-PEC
Indeno(1,2,3-cd)pyrene	6.55E-01	EPA Region 4 ESV (PQL)	1.45E+00	used B(a)P value
Naphthalene	3.30E-01	EPA Region 4 ESV (PQL)	5.61E-01	USEPA 2002; Consensus-PEC
Phenanthrene	3.30E-01	EPA Region 4 ESV (PQL)	1.17E+00	USEPA 2002; Consensus-PEC
Pyrene	3.30E-01	EPA Region 4 ESV (PQL)	1.52E+00	USEPA 2002; Consensus-PEC
Total PAHs	1.61E+00	USEPA 2002; Consensus-TEC	2.28E+01	USEPA 2002; Consensus-PEC
Dimethylphthalate	1.82E-01	EPA Region 4 ESV; bis-2-ethylhexylphthalate	2.65E+00	FDEP- PEL (Jones et al 1997); Bis-2-ethylhexyl
Di-n-butylphthalate	1.82E-01	EPA Region 4 ESV; bis-2-ethylhexylphthalate	2.65E+00	FDEP- PEL (Jones et al 1997); Bis-2-ethylhexyl

TEC - Threshold Effects Concentration (Note that literature TECs are generally less than the standard PQL, therefore the PQL was used as the TRV.)

PEC - Probable Effects Concentration

PQL - Practical Quantitation Limit

TRV - Toxicity Reference Value

Table 16.
Site Specific HQs for Insectivorous Mammals - Surface Soil
Spartanburg MGP Site

COPC	Cs_{max} (mg/kg)	Cs_{avg} (mg/kg)	ED_{max} [a]	ED_{avg} [a]	TRV_{NOAEL} [b]	TRV_{LOAEL} [b]	$HQ_{max-NOAEL}$ [c]	$HQ_{avg-NOAEL}$ [c]	$HQ_{max-LOAEL}$ [c]	$HQ_{avg-LOAEL}$ [c]	Any HQ > 1?
Anthracene	8.46E-01	1.12E-01	8.92E-02	1.18E-02	1.00E+02	1.00E+03	8.92E-04	1.18E-04	8.92E-05	1.18E-05	No
Benzo(a)anthracene	1.25E+00	2.91E-01	1.17E-01	2.73E-02	1.00E+00	1.00E+01	1.17E-01	2.73E-02	1.17E-02	2.73E-03	No
Benzo(a)pyrene	1.87E+00	4.33E-01	2.14E-01	4.95E-02	1.00E+00	1.00E+01	2.14E-01	4.95E-02	2.14E-02	4.95E-03	No
Benzo(b)fluoranthene	1.56E+00	3.99E-01	1.78E-01	4.56E-02	1.00E+00	1.00E+01	1.78E-01	4.56E-02	1.78E-02	4.56E-03	No
Benzo(g,h,I)perylene	1.13E+00	2.91E-01	1.17E-01	3.02E-02	7.50E+01	1.25E+02	1.57E-03	4.03E-04	9.40E-04	2.42E-04	No
Benzo(k)fluoranthene	7.79E-01	2.01E-01	9.31E-02	2.40E-02	1.00E+00	1.00E+01	9.31E-02	2.40E-02	9.31E-03	2.40E-03	No
Chrysene	1.42E+00	3.67E-01	1.41E-01	3.64E-02	1.00E+00	1.00E+01	1.41E-01	3.64E-02	1.41E-02	3.64E-03	No
Dibenzo(a,h)anthracene	8.46E-01	1.44E-01	9.67E-02	1.65E-02	1.00E+00	1.00E+01	9.67E-02	1.65E-02	9.67E-03	1.65E-03	No
Fluoranthene	5.39E+00	1.05E+00	5.64E-01	1.10E-01	1.25E+01	1.25E+02	4.51E-02	8.80E-03	4.51E-03	8.80E-04	No
Indeno(1,2,3-cd)pyrene	1.13E+00	2.50E-01	1.35E-01	2.99E-02	1.00E+00	1.00E+01	1.35E-01	2.99E-02	1.35E-02	2.99E-03	No
Phenanthrene	5.13E+00	4.66E-01	5.40E-01	4.91E-02	7.50E+01	1.25E+02	7.20E-03	6.54E-04	4.32E-03	3.92E-04	No
Pyrene	5.00E+00	8.91E-01	5.24E-01	9.34E-02	7.50E+01	1.25E+02	6.99E-03	1.25E-03	4.19E-03	7.47E-04	No

(a) EDmax = exposure dose based on maximum soil concentration; EDavg = exposure dose based on average soil concentration.

(b) TRV = toxicity reference value (Table 12)

(c) HQ = hazard quotient = ED/TRV.

NC = Not calculated.

Table 17.
Site Specific HQs for Insectivorous Birds - Surface Soil
Spartanburg MGP Site

COPC	Cs_{max} (mg/kg)	Cs_{avg} (mg/kg)	ED_{max} [a]	ED_{avg} [a]	TRV_{NOAEL} [b]	TRV_{LOAEL} [b]	$HQ_{max-NOAEL}$ [c]	$HQ_{avg-NOAEL}$ [c]	$HQ_{max-LOAEL}$ [c]	$HQ_{avg-LOAEL}$ [c]	Any HQ > 1?
Anthracene	8.46E-01	1.12E-01	5.59E-02	7.41E-03	None	None	NC	NC	NC	NC	---
Benzo(a)anthracene	1.25E+00	2.91E-01	5.66E-02	1.32E-02	None	None	NC	NC	NC	NC	---
Benzo(a)pyrene	1.87E+00	4.33E-01	1.28E-01	2.95E-02	None	None	NC	NC	NC	NC	---
Benzo(b)fluoranthene	1.56E+00	3.99E-01	1.06E-01	2.71E-02	None	None	NC	NC	NC	NC	---
Benzo(g,h,I)perylene	1.13E+00	2.91E-01	6.29E-02	1.62E-02	None	None	NC	NC	NC	NC	---
Benzo(k)fluoranthene	7.79E-01	2.01E-01	5.77E-02	1.49E-02	None	None	NC	NC	NC	NC	---
Chrysene	1.42E+00	3.67E-01	7.27E-02	1.88E-02	None	None	NC	NC	NC	NC	---
Dibenzo(a,h)anthracene	8.46E-01	1.44E-01	5.72E-02	9.75E-03	None	None	NC	NC	NC	NC	---
Fluoranthene	5.39E+00	1.05E+00	3.25E-01	6.34E-02	None	None	NC	NC	NC	NC	---
Indeno(1,2,3-cd)pyrene	1.13E+00	2.50E-01	8.32E-02	1.84E-02	None	None	NC	NC	NC	NC	---
Phenanthrene	5.13E+00	4.66E-01	3.36E-01	3.05E-02	None	None	NC	NC	NC	NC	---
Pyrene	5.00E+00	8.91E-01	3.08E-01	5.49E-02	None	None	NC	NC	NC	NC	---

(a) EDmax = exposure dose based on maximum soil concentration; EDavg = exposure dose based on average soil concentration.

(b) TRV = toxicity reference value (Table 13)

(c) HQ = hazard quotient = ED/TRV.

NC = Not calculated.

Table 18.
Site-Specific HQs for Soil Organisms - Surface Soil
Spartanburg MGP Site

COPC	Cs_{max} (mg/kg)	Cs_{avg} (mg/kg)	TRV[a]	HQ_{max}[b]	HQ_{avg}[b]	Any HQ > 1?
Anthracene	8.46E-01	1.12E-01	3.00E+01	2.82E-02	3.73E-03	No
Benzo(a)anthracene	1.25E+00	2.91E-01	3.00E+01	4.17E-02	9.70E-03	No
Benzo(a)pyrene	1.87E+00	4.33E-01	3.00E+01	6.23E-02	1.44E-02	No
Benzo(b)fluoranthene	1.56E+00	3.99E-01	3.00E+01	5.20E-02	1.33E-02	No
Benzo(g,h,I)perylene	1.13E+00	2.91E-01	3.00E+01	3.77E-02	9.70E-03	No
Benzo(k)fluoranthene	7.79E-01	2.01E-01	3.00E+01	2.60E-02	6.69E-03	No
Chrysene	1.42E+00	3.67E-01	3.00E+01	4.73E-02	1.22E-02	No
Dibenzo(a,h)anthracene	8.46E-01	1.44E-01	3.00E+01	2.82E-02	4.81E-03	No
Fluoranthene	5.39E+00	1.05E+00	3.00E+01	1.80E-01	3.51E-02	No
Indeno(1,2,3-cd)pyrene	1.13E+00	2.50E-01	3.00E+01	3.77E-02	8.35E-03	No
Phenanthrene	5.13E+00	4.66E-01	3.00E+01	1.71E-01	1.55E-02	No
Pyrene	5.00E+00	8.91E-01	3.00E+01	1.67E-01	2.97E-02	No

(a) TRV = toxicity reference value (Table 14)

(b) HQ = hazard quotient = Cs/TRV; Cs = maximum or average soil concentration.

NC = not calculated.

Table 19.
Site Specific HQs for Mammalian Aquatic Predators - Sediment
Spartanburg MGP Site

Retained Constituents	$Csed_{max}$ (mg/kg)	$Csed_{avg}$ (mg/kg)	ED_{max} [a]	ED_{avg} [a]	TRV_{NOAEL} [b]	TRV_{LOAEL} [b]	$HQ_{max-NOAEL}$ [c]	$HQ_{avg-NOAEL}$ [c]	$HQ_{max-LOAEL}$ [c]	$HQ_{avg-LOAEL}$ [c]	Any HQ > 1?
2-Methylnaphthalene	1.00E+01	1.50E+00	1.51E-03	2.26E-04	1.00E+01	2.00E+01	1.51E-04	2.26E-05	7.54E-05	1.13E-05	No
Acenaphthene	4.00E+00	8.97E-01	6.03E-04	1.35E-04	1.75E+01	3.50E+01	3.45E-05	7.73E-06	1.72E-05	3.86E-06	No
Acenaphthylene	6.00E-01	5.52E-01	9.05E-05	8.32E-05	1.75E+01	3.50E+01	5.17E-06	4.76E-06	2.58E-06	2.38E-06	No
Anthracene	1.20E+00	6.23E-01	1.81E-04	9.39E-05	1.00E+02	1.00E+03	1.81E-06	9.39E-07	1.81E-07	9.39E-08	No
Benzo(a)anthracene	4.70E+00	1.12E+00	6.18E-04	1.48E-04	1.00E+00	1.00E+01	6.18E-04	1.48E-04	6.18E-05	1.48E-05	No
Benzo(a)pyrene	4.00E+00	1.03E+00	6.80E-04	1.76E-04	1.00E+00	1.00E+01	6.80E-04	1.76E-04	6.80E-05	1.76E-05	No
Benzo(b)fluoranthene	3.20E+00	8.83E-01	5.44E-04	1.50E-04	1.00E+00	1.00E+01	5.44E-04	1.50E-04	5.44E-05	1.50E-05	No
Benzo(g,h,I)perylene	2.00E+00	7.03E-01	3.02E-04	1.06E-04	7.50E+01	1.25E+02	4.02E-06	1.41E-06	2.41E-06	8.48E-07	No
Benzo(k)fluoranthene	3.40E+00	9.23E-01	6.11E-04	1.66E-04	1.00E+00	1.00E+01	6.11E-04	1.66E-04	6.11E-05	1.66E-05	No
Chrysene	4.60E+00	1.09E+00	6.49E-04	1.54E-04	1.00E+00	1.00E+01	6.49E-04	1.54E-04	6.49E-05	1.54E-05	No
Dibenzo(a,h)anthracene	6.00E-01	5.52E-01	1.02E-04	9.39E-05	1.00E+00	1.00E+01	1.02E-04	9.39E-05	1.02E-05	9.39E-06	No
Dimethylphthalate	5.90E+00	1.08E+00	8.90E-04	1.63E-04	5.50E+02	1.83E+03	1.62E-06	2.97E-07	4.86E-07	8.91E-08	No
di-n-Butylphthalate	7.50E+00	2.87E+00	1.13E-03	4.33E-04	5.50E+02	1.83E+03	2.06E-06	7.87E-07	6.18E-07	2.36E-07	No
Fluoranthene	8.00E+00	1.81E+00	1.21E-03	2.73E-04	1.25E+01	1.25E+02	9.65E-05	2.18E-05	9.65E-06	2.18E-06	No
Fluorene	1.60E+00	6.57E-01	2.41E-04	9.91E-05	1.25E+01	2.50E+01	1.93E-05	7.92E-06	9.65E-06	3.96E-06	No
Indeno(1,2,3-cd)pyrene	2.00E+00	7.03E-01	3.60E-04	1.26E-04	1.00E+00	1.00E+01	3.60E-04	1.26E-04	3.60E-05	1.26E-05	No
Naphthalene	8.10E+00	1.31E+00	1.22E-03	1.97E-04	1.00E+01	2.00E+01	1.22E-04	1.97E-05	6.11E-05	9.85E-06	No
Phenanthrene	3.00E+00	1.28E+00	4.52E-04	1.93E-04	7.50E+01	1.25E+02	6.03E-06	2.57E-06	3.62E-06	1.54E-06	No
Pyrene	7.90E+00	1.91E+00	1.19E-03	2.88E-04	7.50E+01	1.25E+02	1.59E-05	3.84E-06	9.53E-06	2.30E-06	No

(a) EDmax = exposure dose based on maximum sediment concentration; EDavg = exposure dose based on average sediment concentration.

(b) TRV = toxicity reference value (Table 12).

(c) HQ = hazard quotient = ED/TRV.

NC = Not calculated.

Table 20.
Site Specific HQs for Avian Aquatic Predators - Sediment
Spartanburg MGP Site

Retained Constituents	$Csed_{max}$ (mg/kg)	$Csed_{avg}$ (mg/kg)	ED_{max} [a]	ED_{avg} [a]	TRV_{NOAEL} [b]	TRV_{LOAEL} [b]	$HQ_{max-NOAEL}$ [c]	$HQ_{avg-NOAEL}$ [c]	$HQ_{max-LOAEL}$ [c]	$HQ_{avg-LOAEL}$ [c]	Any HQ > 1?
2-Methylnaphthalene	1.00E+01	1.50E+00	3.14E-03	4.70E-04	None	None	NC	NC	NC	NC	---
Acenaphthene	4.00E+00	8.97E-01	1.25E-03	2.81E-04	None	None	NC	NC	NC	NC	---
Acenaphthylene	6.00E-01	5.52E-01	1.88E-04	1.73E-04	None	None	NC	NC	NC	NC	---
Anthracene	1.20E+00	6.23E-01	3.76E-04	1.95E-04	None	None	NC	NC	NC	NC	---
Benzo(a)anthracene	4.70E+00	1.12E+00	8.85E-04	2.11E-04	None	None	NC	NC	NC	NC	---
Benzo(a)pyrene	4.00E+00	1.03E+00	1.76E-03	4.54E-04	None	None	NC	NC	NC	NC	---
Benzo(b)fluoranthene	3.20E+00	8.83E-01	1.41E-03	3.88E-04	None	None	NC	NC	NC	NC	---
Benzo(g,h,I)perylene	2.00E+00	7.03E-01	6.27E-04	2.21E-04	None	None	NC	NC	NC	NC	---
Benzo(k)fluoranthene	3.40E+00	9.23E-01	1.71E-03	4.63E-04	None	None	NC	NC	NC	NC	---
Chrysene	4.60E+00	1.09E+00	1.15E-03	2.74E-04	None	None	NC	NC	NC	NC	---
Dibenzo(a,h)anthracene	6.00E-01	5.52E-01	2.63E-04	2.42E-04	None	None	NC	NC	NC	NC	---
Dimethylphthalate	5.90E+00	1.08E+00	1.85E-03	3.39E-04	1.10E-01	1.11E+00	1.68E-02	3.09E-03	1.67E-03	3.06E-04	No
di-n-Butylphthalate	7.50E+00	2.87E+00	2.35E-03	9.00E-04	1.10E-01	1.11E+00	2.14E-02	8.18E-03	2.12E-03	8.11E-04	No
Fluoranthene	8.00E+00	1.81E+00	2.51E-03	5.67E-04	None	None	NC	NC	NC	NC	---
Fluorene	1.60E+00	6.57E-01	5.02E-04	2.06E-04	None	None	NC	NC	NC	NC	---
Indeno(1,2,3-cd)pyrene	2.00E+00	7.03E-01	1.00E-03	3.53E-04	None	None	NC	NC	NC	NC	---
Naphthalene	8.10E+00	1.31E+00	2.54E-03	4.10E-04	None	None	NC	NC	NC	NC	---
Phenanthrene	3.00E+00	1.28E+00	9.41E-04	4.01E-04	None	None	NC	NC	NC	NC	---
Pyrene	7.90E+00	1.91E+00	2.48E-03	5.99E-04	None	None	NC	NC	NC	NC	---

(a) EDmax = exposure dose based on maximum sediment concentration; EDavg = exposure dose based on average sediment concentration.

(b) TRV = toxicity reference value (Table 13).

(c) HQ = hazard quotient = ED/TRV.

NC = Not calculated.

Table 21.
Toxicity Reference Value Comparison and HQ Development for Sediment Organisms
Spartanburg MGP Site

COPC	$Csed_{max}$ (mg/kg)	$Csed_{avg}$ (mg/kg)	TEC TRV (mg/kg)	PEC TRV (mg/kg)	$HQ_{max\text{-}TEC}$	$HQ_{avg\text{-}TEC}$	$HQ_{max\text{-}PEC}$	$HQ_{avg\text{-}PEC}$	Any HQ > 1?
2-Methylnaphthalene	1.00E+01	1.50E+00	3.30E-01	6.70E-01	**3.0E+01**	**4.5E+00**	**1.5E+01**	**2.2E+00**	Yes
Acenaphthene	4.00E+00	8.97E-01	3.30E-01	5.00E-01	**1.2E+01**	**2.7E+00**	**8.0E+00**	**1.8E+00**	Yes
Acenaphthylene	6.00E-01	5.52E-01	3.30E-01	6.40E-01	**1.8E+00**	**1.7E+00**	< 1	< 1	Yes
Anthracene	1.20E+00	6.23E-01	3.30E-01	8.45E-01	**3.6E+00**	**1.9E+00**	**1.4E+00**	< 1	Yes
Benzo(a)anthracene	4.70E+00	1.12E+00	3.30E-01	1.05E+00	**1.4E+01**	**3.4E+00**	**4.5E+00**	**1.1E+00**	Yes
Benzo(a)pyrene	4.00E+00	1.03E+00	3.30E-01	1.45E+00	**1.2E+01**	**3.1E+00**	**2.8E+00**	< 1	Yes
Benzo(b)fluoranthene	3.20E+00	8.83E-01	6.55E-01	1.45E+00	**4.9E+00**	**1.3E+00**	**2.2E+00**	< 1	Yes
Benzo(g,h,I)perylene	2.00E+00	7.03E-01	6.55E-01	1.45E+00	**3.1E+00**	**1.1E+00**	**1.4E+00**	< 1	Yes
Benzo(k)fluoranthene	3.40E+00	9.23E-01	6.55E-01	1.45E+00	**5.2E+00**	**1.4E+00**	**2.3E+00**	< 1	Yes
Chrysene	4.60E+00	1.09E+00	3.30E-01	1.29E+00	**1.4E+01**	**3.3E+00**	**3.6E+00**	< 1	Yes
Dibenzo(a,h)anthracene	6.00E-01	5.52E-01	3.30E-01	1.45E+00	**1.8E+00**	**1.7E+00**	< 1	< 1	Yes
Fluoranthene	8.00E+00	1.81E+00	4.23E-01	2.23E+00	**1.9E+01**	**4.3E+00**	**3.6E+00**	< 1	Yes
Fluorene	1.60E+00	6.57E-01	3.30E-01	5.36E-01	**4.8E+00**	**2.0E+00**	**3.0E+00**	**1.2E+00**	Yes
Indeno(1,2,3-cd)pyrene	2.00E+00	7.03E-01	6.55E-01	1.45E+00	**3.1E+00**	**1.1E+00**	**1.4E+00**	< 1	Yes
Naphthalene	8.10E+00	1.31E+00	3.30E-01	5.61E-01	**2.5E+01**	**4.0E+00**	**1.4E+01**	**2.3E+00**	Yes
Phenanthrene	3.00E+00	1.28E+00	3.30E-01	1.17E+00	**9.1E+00**	**3.9E+00**	**2.6E+00**	**1.1E+00**	Yes
Pyrene	7.90E+00	1.91E+00	3.30E-01	1.52E+00	**2.4E+01**	**5.8E+00**	**5.2E+00**	**1.3E+00**	Yes
Total PAHs	4.69E+01	1.75E+01	1.61E+00	2.28E+01	**2.9E+01**	**1.1E+01**	**2.1E+00**	< 1	Yes
Dimethylphthalate	5.90E+00	1.08E+00	1.82E-01	2.65E+00	**3.2E+01**	**5.9E+00**	**2.2E+00**	< 1	Yes
di-n-Butylphthalate	7.50E+00	2.87E+00	1.82E-01	2.65E+00	**4.1E+01**	**1.6E+01**	**2.8E+00**	**1.1E+00**	Yes

TRV = toxicity reference value; TEC = threshold effects concentration; PEC = probable effects concentration.

HQ = hazard quotient = Csed/TRV.

NC = Not calculated.

Table 22.
Station Specific HQ Calculation for Chinquapin Creek Sediment
Spartanburg MGP Site

	TEC-TRV (ug/kg)	PEC-TRV (ug/kg)	SED-01			SED-2			SED-3			SED-04			SED-5		
			Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}
2-Methylnaphthalene	330	670	ND	NC	NC	ND	NC	NC	ND	NC	NC	10000	30.3	14.9	ND	NC	NC
Acenaphthene	330	500	ND	NC	NC	ND	NC	NC	ND	NC	NC	4000	12.1	8.0	ND	NC	NC
Acenaphthylene	330	640	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Anthracene	330	845	1200	3.6	1.4	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Benzo(a)anthracene	330	1050	4700	14.2	4.5	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Benzo(a)pyrene	330	1450	4000	12.1	2.8	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Benzo(b)fluoranthene	655	1450	3200	4.9	2.2	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Benzo(g,h,i)perylene	655	1450	2000	3.1	1.4	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Benzo(k)fluoranthene	655	1450	3400	5.2	2.3	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Chrysene	330	1290	4600	13.9	3.6	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Dibenzo(a,h)anthracene	330	1450	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Fluoranthene	423	2230	8000	18.9	3.6	ND	NC	NC	ND	NC	NC	ND	NC	NC	1600	3.8	<1
Fluorene	330	536	ND	NC	NC	ND	NC	NC	ND	NC	NC	1600	4.8	3.0	ND	NC	NC
Indeno(1,2,3-cd)pyrene	655	1450	2000	3.1	1.4	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Naphthalene	330	561	ND	NC	NC	ND	NC	NC	ND	NC	NC	8100	24.5	14.4	ND	NC	NC
Phenanthrene	330	1170	3000	9.1	2.6	ND	NC	NC	ND	NC	NC	2100	6.4	1.8	ND	NC	NC
Pyrene	330	1520	7900	23.9	5.2	ND	NC	NC	ND	NC	NC	ND	NC	NC	2200	6.7	1.4
Total PAHs[a]	1610	22800	46900	29.1	2.1	--	--	--	--	--	--	25800	16.0	1.1	3800	2.4	<1

(a) - Total PAHs includes non-detected species at one-half the detection limit.

Table 22.
Station Specific HQ Calculation for Chinquapin Creek Sediment
Spartanburg MGP Site

			SED-8			SED-9			SED-10			SED-11			SED-12		
	TEC-TRV (ug/kg)	PEC-TRV (ug/kg)	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}	Result (ug/kg)	HQ_{TEC}	HQ_{PEC}
2-Methylnaphthalene	330	670	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Acenaphthene	330	500	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Acenaphthylene	330	640	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Anthracene	330	845	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Benzo(a)anthracene	330	1050	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	2100	6.4	2.0
Benzo(a)pyrene	330	1450	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	1900	5.8	1.3
Benzo(b)fluoranthene	655	1450	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	1200	1.8	<1
Benzo(g,h,i)perylene	655	1450	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Benzo(k)fluoranthene	655	1450	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	1400	2.1	1.0
Chrysene	330	1290	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	1900	5.8	1.5
Dibenzo(a,h)anthracene	330	1450	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Fluoranthene	423	2230	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	4600	10.9	2.1
Fluorene	330	536	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Indeno(1,2,3-cd)pyrene	655	1450	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Naphthalene	330	561	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC
Phenanthrene	330	1170	ND	NC	NC	1900	5.8	1.6	ND	NC	NC	ND	NC	NC	2500	7.6	2.1
Pyrene	330	1520	ND	NC	NC	ND	NC	NC	ND	NC	NC	ND	NC	NC	5100	15.5	3.4
Total PAHs[a]	1610	22800	--	--	--	1900	1.2	<1	--	--	--	--	--	--	20700	12.9	<1

(a) - Total PAHs includes non-detected species at one-half the detection limit.

FIGURES

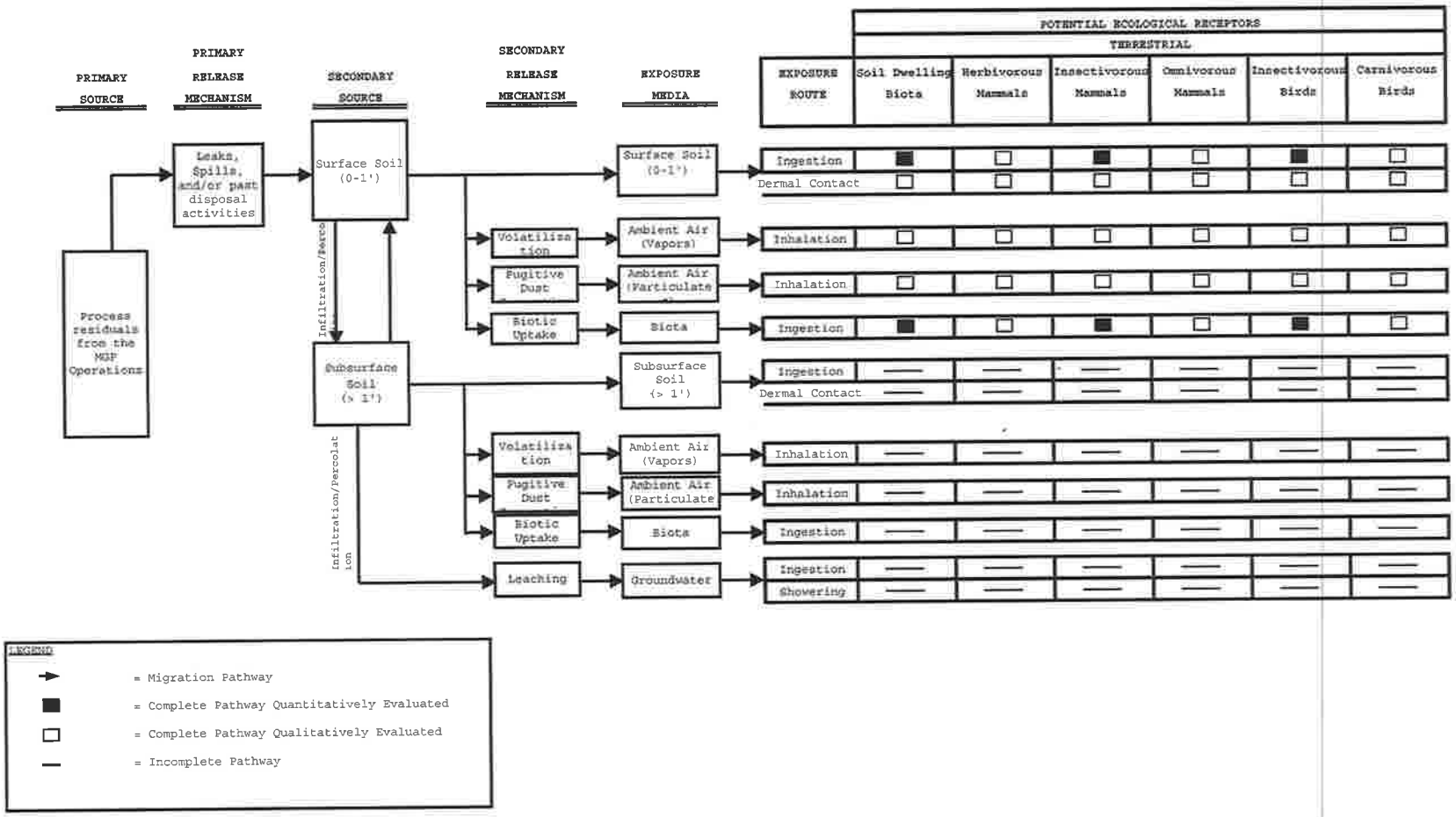


Figure 2. Terrestrial Conceptual Site Model, Spartanburg MGP Site, Spartanburg, South Carolina.

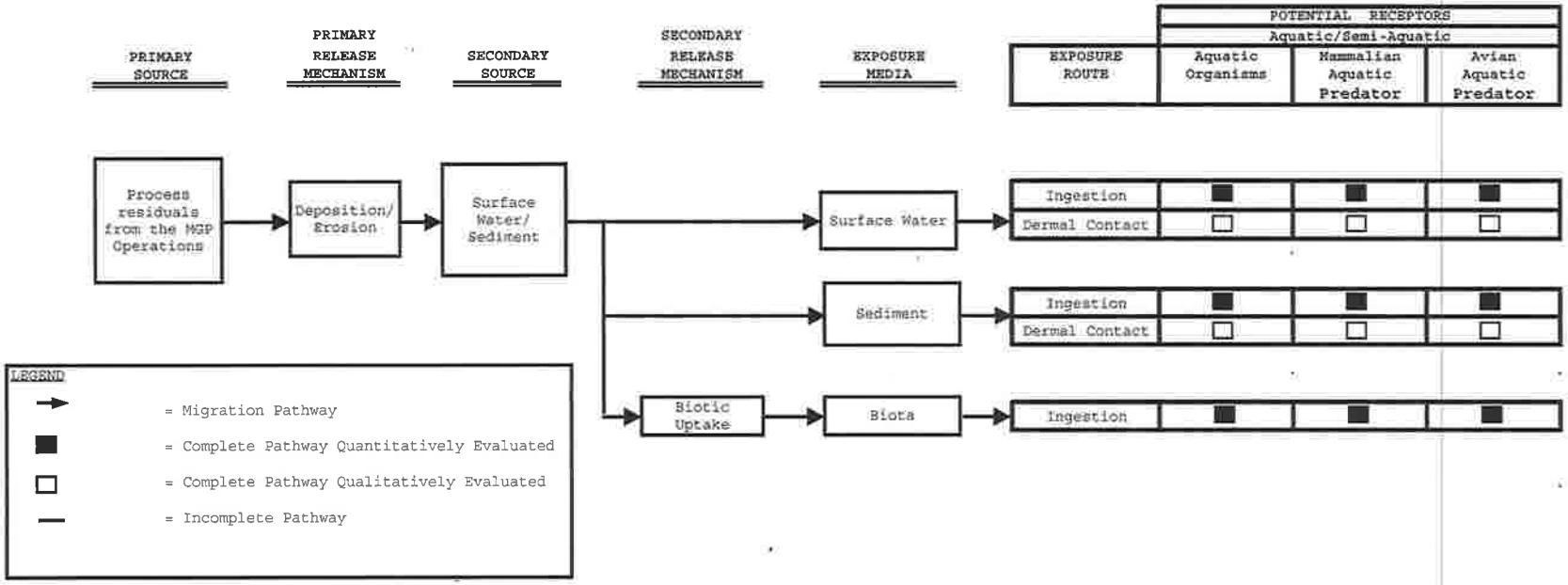
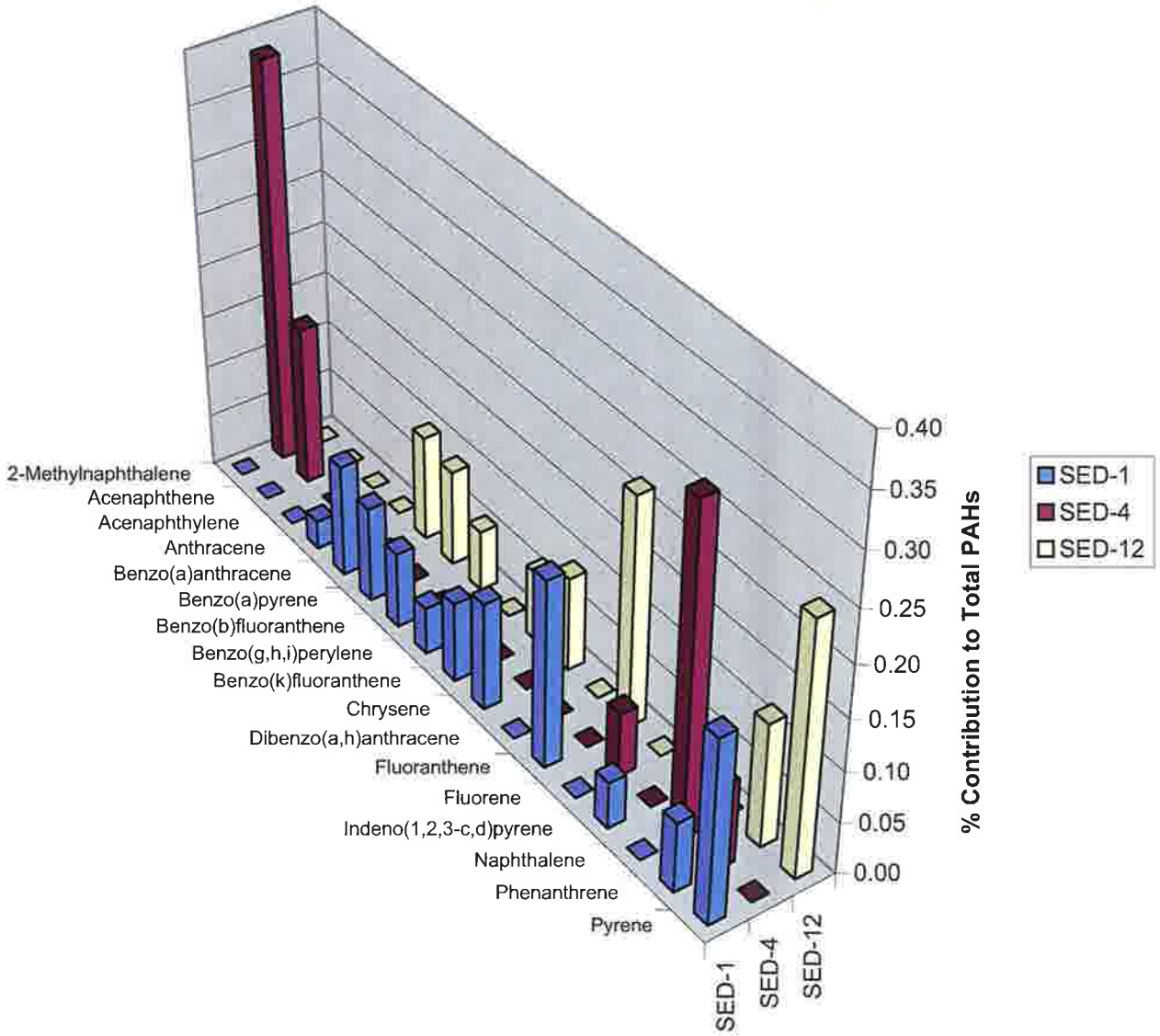


Figure 3. Aquatic Conceptual Site Model, Spartanburg MGP Site, Spartanburg, South Carolina.

Figure 4. Comparison of PAH Signatures from Sediment Samples
Spartanburg MGP Site



APPENDICES

APPENDIX A

Responses to
South Carolina Department of Health and Environmental Control
Comments on
ERA Process Step 3,
Spartanburg Pine Street MGP Site – August 2004

General Comments

1. Background comparisons are not appropriate for anthropogenic organic chemicals.

Response:
The soil background actually had no impact on the ERA conclusions. Soil background was not used to screen ecological COPCs. Further, background was not used as a primary line of evidence for interpreting soil hazard quotients (HQs). The unit-related soil actually had all HQs less than one for ecological receptors, even while using the maximum detected concentrations. The background samples had maximum detections less than the unit samples. Thus, re-assigning data will not alter the conclusions of the ERA for soil (i.e. HQs for maximum concentrations will still remain less than one for all receptors). Additional calculations for soil are not warranted.

Resolution:
The Process Step 3 text was revised to clarify state there are uncertainties surrounding the background soil data set, but that these uncertainties do not impact the conclusion of the ERA. Namely, soil has no final COPCs and is not a medium of ecological concern at the site.

2. Background comparison of anthropogenic organics: RAGS Part A, Section 4.4.2, Page 4-8 states that "Background samples are collected at or near the hazardous waste site in areas not influenced by site contamination. They are collected from each medium of concern in these offsite areas. That is, the locations of background samples must be areas that could not have received contamination from the site, but that do have the same basic characteristics as the medium of concern at the site." It does not appear that many of the background locations used meet these criteria. Please discuss how this deficiency can be rectified at this site.

Response:
See General Comment #1.

Resolution:
See General Comment #1.

3. Background comparison of anthropogenic organics: RAGS Part A, Section 5.7.3, Page 5-19 states that "The presence of organic chemicals in background samples collected during a site investigation actually may indicate that the sample was collected in an area influenced by site contamination and therefore does not qualify as a true background sample. Such samples should instead be included with other site

samples in the risk assessment." There are background samples that meet this criterion but were not included with the regular dataset. Please reevaluate and discuss the potential reassignment of some of the background soil samples.

Response:
See General Comment #1.

Resolution:
See General Comment #1.

Specific Comments

1. Page 4, Section 2.1.1: Many of the soil background locations are problematic. Locations 5 through 12 are sidegradient and downgradient of the excavated areas and are questionable as background because they were likely influenced by past site activities.

Response:
See General Comment #1.

Resolution:
See General Comment #1.

2. Page 4, Section 2.1.1: The Department recommends resampling of sediment background locations if the detection limits are inappropriate for comparative uses.

Response:
Following discussion of this issue and a site visit by SCDHEC, it was agreed that additional background sampling would likely provide little benefit to reducing ERA uncertainties. Consequently, SCDHEC verbally indicated no additional background sampling was required.

Resolution:
As agreed with SCDHEC personnel, no action was required for this comment.

3. Page 9, Section 2.1.2.4: The ESB approach is only valid for sediments with = 0.2 percent organic carbon by dry weight. Site-specific ecological COPC decisions cannot be made on the basis of generic assumptions. Obtaining site-specific fraction of organic carbon data is advised.

Response:
Following discussion of this issue and a site visit by SCDHEC, site-specific Foc data were collected. The Foc it was less than 0.2 percent and therefore the ESB approach was concluded to be inappropriate for the site. ERA Process Step 3 was updated to replace the ESB methodology with HQs developed from standard effects based benchmarks.

Resolution:
The Process Step 3 document has been updated to use HQs based on effects based benchmarks rather than the organic-carbon normalized "ESB" benchmarks.

4. Page 9, Section 2.1.2.4: Unlike the RAGS ecological COPC selection process, the ESB process for PAH mixtures does "not consider the antagonistic, additive or synergistic effects of other sediment contaminants in combination with PAHs or the potential for bioaccumulation and trophic transfer of PAHs to aquatic life, wildlife or humans". Discuss how bioaccumulation and trophic transfer will be addressed.

Response:

Upper trophic level exposures were quantitatively evaluated in the risk assessment for the great blue heron and raccoon. HQs were calculated using a food chain model consistent with EPA guidance. All HQs were less than one.

Resolution:

No action is required based on this comment.

5. Page 9, Section 2.1.2.4: The 50th percentile correction factor of 2.3 is not consistent with the ESB guidance and the conservative nature of the BERA. The Department recommends using the 95th percentile correction factor of 8.56 to be consistent with guidance and conservative.

Response:

Since the ESB methodology has been removed from the document as described in response to comment #4, this issue is no longer relevant.

Resolution:

No action required because the ESB methodology has been removed.

6. Page 9, Section 2.1.2.4: The ESB guidance suggests that using correction factors to adjust ESBTUs when having less than the recommended 34 PAHs can be problematic when the PAHs are primarily of petrogenic origin. The guidance states that uncertainty factors derived from "sediments containing mostly pyrogenic PAHs, will underestimate the total PAH toxic unit contribution of the PAH mixture in sediments contaminated with mostly petrogenic PAHs". The effect of urban combustion particles (pyrogenic PAHs) was suggested on page 4. The PAHs of concern are primarily petrogenic. Please discuss the potential for underestimating the total PAH toxic unit contribution at this site.

Response:

Since the ESB methodology has been removed from the document as described in response to comment #4, this issue is no longer relevant.

Resolution:

No action required because the ESB methodology has been removed.

7. Page 11, Section 2.1.3.2, Benthic Organisms: Sediment background locations SED-6 and SED-7 are located in the downstream reaches of the stream and are likely affected by previous site activities. Please reevaluate the use of these locations as background.

Response:
SED-6 and SED-7 are upstream from the former MGP area.

Resolution:
No action required.

Editorial Comments

1. Page 2, Section1.2.1: "Full documentation of analytical results is provided in SLERA (Duke 2004)." Please add the word "the" in front of "SLERA" for greater readability. This comment also applies to the same sentence on page 2 in section 1.2.2.

Response:
Agree.

Resolution:
Document has been revised as suggested.

2. Page 16, Section 2.6.2: The full list of PAHs numbers 34 not 43. Please correct.

Response:
Since the ESB methodology has been removed from the document as described in response to comment #4, this issue is no longer relevant.

Resolution:
The ESB methodology has been removed and the text in question was deleted.

3. Page 17, Section 3.0: "The reasons justifying this conclusion include are detailed in the lines of evidence discussion (Section 2.1.3)." Please reword this sentence to improve readability.

Response:
Agree.

Resolution:
The word "include" was deleted.

APPENDIX B

May 5, 2005

Mr. Lucas Beresford
SCDHEC
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201-1708

Subject: Results of TOC Sampling for Duke Power's Pine Street MGP Site, Spartanburg, South Carolina.

Mr. Beresford:

On behalf of Duke Power, this letter report summarizes the activities and results of additional sediment sampling and total organic carbon (TOC) analyses for the Pine Street MGP site in Spartanburg, SC. The additional TOC sampling was initiated at the request of SCDHEC during comment resolution on the draft Ecological Risk Assessment (ERA) Step 3 (Duke 2004). The purpose of the TOC sampling is to validate assumptions employed in the draft document.

FIELD SAMPLING

The field sampling focused on five prior stations: SED-01, SED-04, SED-05, SED-09, and SED-12. All of these stations had prior detections of PAHs and were adjacent to or downstream of the former MGP location (please refer to the site map contained in the draft ERA Step 3 document).

Sediment sampling was performed by Mr. Henry Wood and Ms. Katy Riggins on March 29, 2005. Upon reaching the site, the prior sampling stations were located and staked. A broken sewer line discharging raw sewage into Chinquapin Creek was found east of North Fairview Avenue and upstream of former sample location SED-12. Due to health and safety concerns associated with this release, the sampling for location SED-12 was moved to an area 150 ft downstream from the North Fairview Avenue bridge and just upstream from the broken sewer line. [Note: SCDHEC's Spartanburg EQC office was called and notified of the broken sewer line.]

At each station, a sediment sample was obtained using a stainless steel hand auger, collecting approximately the upper 6 to 8 inches of substrate. All samples were collected and transferred directly to a stainless steel bowl where they were visually inspected, photographed, and thoroughly mixed with a stainless steel spoon. The laboratory-supplied glass sample container was filled with the sediment and placed on ice. One sample was collected from each station, with a duplicate taken from SED-12. Field sheets completed for each sampling station are provided as Attachment 1. Attachment 2 provides photographs of the site samples.

The limited amount of sediment remaining after sampling was collected and placed along with decontamination fluids in IDW drums existing on site. Sufficient mixing bowls and auger buckets were available to complete four of the five samples before breaking to decontaminate between stations. Decontamination procedures included washing the equipment with a Liquinox solution, followed by rinsing with DI water, rinsing with isopropanol, and a final rinse with laboratory grade DI water. All fluids were captured and placed in the existing IDW drums on site.

Following completion of field work, the sediment samples were shipped overnight to Severn Trent Laboratories in Pensacola, Florida for TOC analysis using method EPA 9060.

RESULTS AND DISCUSSION

As documented on the field sheets (Attachment 1) the sediment collected from Chinquapin Creek was consistently comprised of relatively clean and coarse sand and gravel. There appeared to be little fine material such as silts and clays. The substrate in the creek is unconsolidated and is likely highly mobile. It was also noted that there is an abundance of material such as glass, metal, and asphalt throughout the system.

The sample chain of custody and the final lab report are provided in Attachment 3. The sample specific TOC results are as follows:

Sample ID	TOC (mg/kg)	TOC %
TOC-01	27	0.0027
TOC-04	21	0.0021
TOC-05	33	0.0033
TOC-09	26	0.0026
TOC-12	40	0.0040
TOC-12-DUP	21	0.0021

These TOC results are extremely low and somewhat unexpected. The units were double checked and confirmed by the laboratory. In retrospect, the results appear to be consistent with the clean sand observed in the field. Note that the samples were not sieved, which is consistent with prior site sampling events, so these TOC results represent the bulk sediment and not the "fines". It is possible sieving and analysis of the fine fraction (silts and clays) would provide a significantly greater TOC result. However, such as result would not be directly comparable to prior bulk sediment PAH data.

These low TOC results do not meet the 0.2% theoretical requirement of the equilibrium partitioning methodology (USEPA 2003) that was used in developing benthic organism HQs in the draft ERA Step 3. Given these considerations, it is recommended that the Step 3 ERA document be revised to utilize empirical effects-based levels to derive site-specific HQs for benthic organisms. Table 1 provides a derivation of ecological HQs while using total PAH concentrations (assuming ½ detection limit for non-detects)

benchmarked against consensus-based threshold effects concentrations (TECs) and probable effects concentrations (PECs) taken from USEPA 2002. As seen on Table 1, all stations exceed the TEC benchmark, while only three (SED-01, SED-04, and SED-12) exceed the PEC benchmarks. On average, the site exceeds the TEC but is less than the PEC. Table 2 provides a similar calculation while assuming 0 for non-detects.

Recall that 5 of the 10 site-related locations are "ND" for all PAHs, but have detection limits slightly greater than the ESVs (on the order of 0.5 to 0.6 mg/kg compared to the ESVs of 0.33 mg/kg) and thus are included in the HQ calculations. Also recall that the individual PAHs have a low frequency of detection across the site, with phenanthrene (4 / 10), pyrene (3 / 10), and fluoranthene (3 /10) being the only PAHs with more than two detections. We reiterate the position stated in the Step 3 ERA document that these sediment data are not suggestive of wide scale impact from tar constituents. Indeed, past experience suggests that tar impacted sediment should have a significantly more pronounced signature from heavy polynuclears such as benzo(a)pyrene as well as naphthalene. In reality, only two stations (SED-01 and SED-12) have polynuclear concentrations that possibly could be indicative of impact, and there is uncertainty surrounding these stations as discussed in the Step 3 ERA document. Station SED-04 had elevated naphthalene and 2-methylnaphthalene, but this was almost certainly related to the seeps and tar laden piping that were excavated from the vicinity of this location during the soil removal action.

We would appreciate the opportunity to meet, discuss these issues, and come to an agreement on a path forward for the site. Should you need any additional information regarding this submittal or the site in general, please feel free to contact me at 864-834-5513.

Sincerely,

Henry Wood
Senior Risk Assessor
Blue Ridge Environmental Consulting, Inc.

Attachments
(1)-Field Sampling sheets
(2)-Photograph of Sample
(3)-COC and Lab Report

cc:
Ralph Roberts - Duke
Jessica Bednarcik - Duke

REFERENCES

Duke 2004. *Ecological Risk Assessment Process Step 3 for the Spartanburg Pine Street MGP Site*, Prepared for Duke Power, Charlotte, North Carolina, August 2004.

USEPA 2003. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks for the Protection of Benthic Organisms: PAH Mixtures*, United States Environmental Protection Agency, Office of Research and Development, November 2003.

USEPA 2002. *A Guidance Manual to Support the Assessment of Contaminated Sediments in Freshwater Ecosystems, Volume III – Interpretation of the Results of Sediment Quality Investigations*, United States Environmental Protection Agency, Great Lakes National Program Office, Chicago, Illinois, December 2002.

TABLES

Table 1.
Ecological HQ Calculation for Chinquapin Creek Sediment - Benthic Organisms
(using 1/2 detection limit for ND)
Spartanburg MGP Site

	Total PAH (mg/kg)	TEC TRV [a] (mg/kg)	PEC TRV[a] (mg/kg)	HQ_{-TEC}	HQ_{-PEC}
SED-01	4.69E+01	1.61E+00	2.28E+01	29.2	2.1
SED-02	8.16E+00	1.61E+00	2.28E+01	5.1	< 1
SED-03	9.35E+00	1.61E+00	2.28E+01	5.8	< 1
SED-04	3.24E+01	1.61E+00	2.28E+01	20.1	1.4
SED-05	1.21E+01	1.61E+00	2.28E+01	7.5	< 1
SED-08	8.50E+00	1.61E+00	2.28E+01	5.3	< 1
SED-09	1.15E+01	1.61E+00	2.28E+01	7.1	< 1
SED-10	1.02E+01	1.61E+00	2.28E+01	6.3	< 1
SED-11	1.02E+01	1.61E+00	2.28E+01	6.3	< 1
SED-12	2.61E+01	1.61E+00	2.28E+01	16.2	1.1
Total PAHs (site average)	1.75E+01	1.61E+00	2.28E+01	10.9	< 1

a - TEC and PEC for total PAHs from USEPA 2002.

Table 2.
Ecological HQ Calculation for Chinquapin Creek Sediment - Benthic Organisms
(using 0 for ND)
Spartanburg MGP Site

	Total PAH (mg/kg) (ND=0)	TEC TRV [a] (mg/kg)	PEC TRV[a] (mg/kg)	HQ_{-TEC}	HQ_{-PEC}
SED-01	4.40E+01	1.61E+00	2.28E+01	27.3	1.9
SED-02	ND	1.61E+00	2.28E+01	< 1	< 1
SED-03	ND	1.61E+00	2.28E+01	< 1	< 1
SED-04	2.58E+01	1.61E+00	2.28E+01	16.0	1.1
SED-05	3.80E+00	1.61E+00	2.28E+01	2.4	< 1
SED-08	ND	1.61E+00	2.28E+01	< 1	< 1
SED-09	1.90E+00	1.61E+00	2.28E+01	1.2	< 1
SED-10	ND	1.61E+00	2.28E+01	< 1	< 1
SED-11	ND	1.61E+00	2.28E+01	< 1	< 1
SED-12	2.07E+01	1.61E+00	2.28E+01	12.9	< 1
Total PAHs (site average)	9.62E+00	1.61E+00	2.28E+01	6.0	< 1

a - TEC and PEC for total PAHs from USEPA 2002.

ATTACHMENT 1
Field Sampling Sheets

Site Name	Spartanburg MGP Site
Date	3/29/05
Time	10:33 AM
Weather	Sunny, warm
Sample ID	TOC-1

Location Description

Approximately 20 ft downstream from North Fairview Avenue bridge (former station SED-1) in Chinquapin Creek. Sample collected 8 ft from LAB.

Loose unconsolidated sand and gravel. Petroleum odor and sheen noted in sample.

Sampling

Uppermost 6-8" of stream bottom sampled using bucket auger.

Analytical

TOC using method 9060.

Site Name	Spartanburg MGP Site
Date	3/29/05
Time	12:25 PM
Weather	Sunny, warm
Sample ID	TOC-4

Location Description

Approximately 180 ft upstream from confluence with College Branch (former station SED-4) in Chinquapin Creek. Sample collected from mid-stream.

Loose unconsolidated sand and gravel. Faint petroleum odor in sample.

Sampling

Uppermost 6-8" of stream bottom sampled using bucket auger.

Analytical

TOC using method 9060.

Site Name	Spartanburg MGP Site
Date	3/29/05
Time	12:45 PM
Weather	Sunny, warm

Sample ID	TOC-5

Location Description

Approximately 50 ft upstream from confluence with Courthouse Branch. Former station SED-5 in Chinquapin Creek. Sample collected from 10 ft off RAB.

Loose unconsolidated sand and gravel. No odor noted in sample.

Sampling

Uppermost 6-8" of stream bottom sampled using bucket auger.

Analytical

TOC using method 9060.

Site Name	Spartanburg MGP Site
Date	3/29/05
Time	1:00 PM
Weather	Sunny, warm
Sample ID	TOC-9

Location Description

Approximately 85 ft downstream from the wooden bridge over Chinquapin Creek (Former station SED-9). Sample collected from 6 ft off RAB.

Loose unconsolidated sand and gravel. Petroleum odor and sheen noted in sample.

Sampling

Uppermost 6-8" of stream bottom sampled using bucket auger.

Analytical

TOC using method 9060.

Site Name	Spartanburg MGP Site
Date	3/29/05
Time	10:15 AM
Weather	Sunny, warm

Sample ID TOC-12 and TOC-12-DUP

Location Description

Station originally scheduled for former location SED-12 in Chinquapin Creek. However, due to raw sewage spilling into stream, the sample location was moved to point approximately 150 ft downstream from North Fairview Avenue bridge .

Sample collected 6 ft from LAB.
Sample consisted of sand and gravel. Petroleum odor and sheen noted in sample.

Sampling

Uppermost 6-8" of stream bottom sampled using bucket auger.

Analytical

TOC using method 9060.

ATTACHMENT 2
(Photographs of Sediment Samples)

Photograph 1. Sample TOC-1

Photograph 2. Sample TOC-4

Photograph 3. Sample TOC-5

Photograph 4. Sample TOC-9

ATTACHMENT 3
(Chain of Custody and Laboratory Report)

Henry Wood
Blue Ridge Environmental Consulting
67 McCarrell Road
Travelers Rest, SC 29690

Job Number: 400-1288.1
Lab Sample Id: 400-1288-3
Date Sampled: 03/29/2005 1124
Date Received: 03/30/2005 0940

Client Sample ID: TOC-4

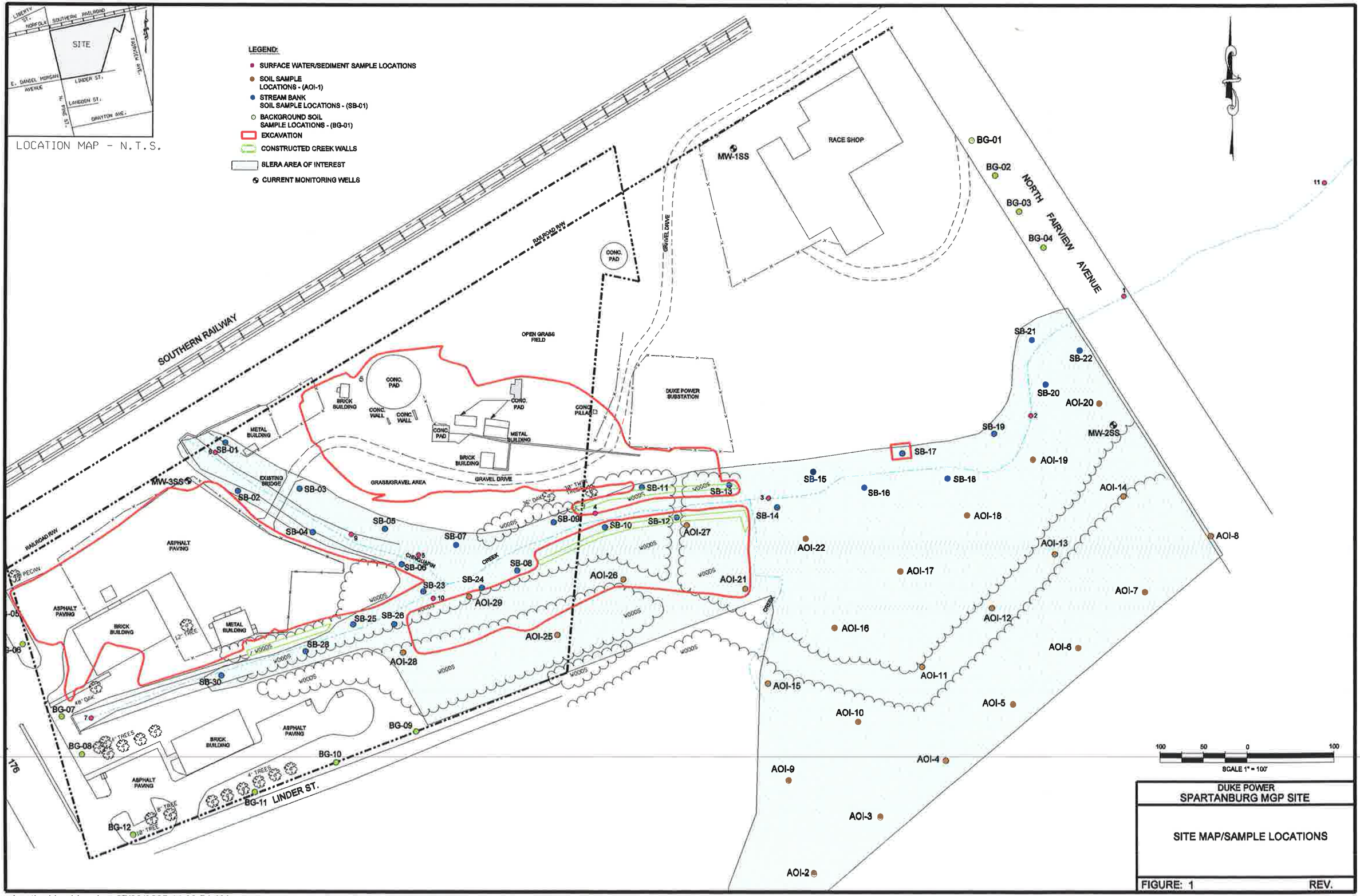
	Result/Qualifier	Unit	RL	Method	Date Prepared	Date Analyzed	Dilution
GENERAL CHEMISTRY							
Total Organic Carbon	21	mg/Kg	20	9060		04/04/2005 1642	20

Henry Wood
Blue Ridge Environmental Consulting
67 McCarrell Road
Travelers Rest, SC 29690

Job Number: 400-1288.1
Lab Sample Id: 400-1288-2
Date Sampled: 03/29/2005 0936
Date Received: 03/30/2005 0940

Client Sample ID: TOC-1

	Result/Qualifier	Unit	RL	Method	Date Prepared	Date Analyzed	Dilution
GENERAL CHEMISTRY							
Total Organic Carbon	27	mg/Kg	20	9060		04/04/2005 1642	20



...\sprtbrglueridge.dgn 07/29/2005 11:33:54 AM