Exponent®

Multi-Site Risk Assessment Framework

Former Manufactured Gas Plant Sites

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Prepared for

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
BERA	Baseline Ecological Risk Assessment
BLRA	Baseline Risk Assessment
BTEX	benzene, toluene, ethybenzene, xylene
CBSQGs	consensus-based sediment quality guidelines
COPCs	constituents of potential concern
CSM	conceptual site model
EcoSSL	ecological soil screening level
EPA	U.S. Environmental Protection Agency
EPC	exposure-point (area) concentration
EPRI	Electric Power Research Institute
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ES	Enforcement Standards
ESB	equilibrium partitioning sediment benchmark
ESB Sum-TU	equilibrium partitioning sediment benchmarks toxic units
ESL	Ecological Screening Level
ET	EcoTox Threshold
FSP	Field Sampling Plan
HHRA	Human Health Risk Assessment
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IRIS	Integrated Risk Information System
LIF	laser-induced fluorescence
MCL	maximum contaminant level
MGP	manufactured gas plant
NSG	North Shore Gas Company
NRWQC	National Recommended Water Quality Criteria
PGL	Peoples Gas Light and Coke Company
PAHs	polynuclear aromatic hydrocarbons
PVOCs	petroleum volatile organic compounds
RAF	risk assessment framework
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
SQGs	sediment quality guidelines
SLERA	screening-level ecological risk assessment
SMDPs	scientific/management decision points
SPME	solid-phase microextraction
SSWP	site-specific work plan
TarGOST®	Tar-specific Green Optical Screening Tool
UCL	upper confidence limit

WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources
WPSC	Wisconsin Public Service Corporation

1 Introduction

The Risk Assessment Framework (RAF) provides a consistent approach for performing Baseline Risk Assessments (BLRAs) for the Wisconsin Public Service Corporation (WPSC), Peoples Gas Light and Coke Company (PGL), and North Shore Gas Company (NSG), collectively the "Companies," manufactured gas plant (MGP) sites being addressed by the U.S. Environmental Protection Agency (USEPA). The RAF was developed in accordance with USEPA risk assessment guidance and provides a common framework that will be used in conjunction with information obtained from site specific work. The RAF will use an adaptive management approach, so that experience from one site will be used to guide subsequent site specific evaluations. At this time, it is anticipated that the adaptive management approach will be reflected in the refinements of the habitat evaluations, the site-specific data collection procedures, the characterization of risk, and the manner in which risk information is used in the decision-making process.

The results of the BLRA will be used to determine whether MGP-related constituents found at a site pose an unacceptable risk to human health or the environment. In doing so, the BLRA will take into account, if present, both organic and inorganic chemicals and will identify both human health and ecological risks that may need to be considered further in the FS.

1.1 Scope of Framework

The RAF covers both human health and ecological risk assessments and outlines screening-level and baseline approaches that may be applied to upland areas and adjacent water bodies. The RAF recognizes that some of the sites under consideration were investigated previously, and in some cases, remedial action has occurred in upland areas of sites. In addition, risk management actions have been implemented at some sites to manage residual subsurface MGP contamination or contaminated groundwater.

The human health portion of the RAF will address potential risk under both current and potential future land-use conditions. Human exposures to the adjacent water body will consider the adjacent land use and the characteristics of the water body. These assessments will be conducted on a site-specific basis.

The RAF also includes approaches for evaluating ecological risks to receptors in upland terrestrial and aquatic environments. Because the availability and characteristics of habitats vary from site to site, the RAF calls for a biological habitat evaluation for each site. This habitat evaluation will be used to refine the areas and ecological receptors to be considered in the site-specific CSM. For example, some upland areas are in commercial or industrial use and do not provide the type of habitat that would support ecological receptors considered in an ecological risk assessment. The biological habitat evaluation will also consider planned future use of the site, as some upland and wetland areas at former industrial sites may undergo ecological restoration. The biological habitat evaluation will be used to select site-specific ecological receptors.

The RAF also describes the general procedures that will be used to evaluate the spatial extent of risks associated with contaminated sediments. The outcome of the assessments will be used to define the following risk zones: "potential for substantial exposure"; "potential for low exposure"; "no significant risk"; and "ambient conditions." These provide a spatial context for the risk assessments and serve to focus evaluations on delineating the boundaries between zones. The zones are discussed in more detail in Section 8.

1.2 Overview of Risk Assessment Framework

An overview of the RAF is provided in Figure 2. Initial steps include a site-specific land-use survey and an evaluation of ecological habitat in terrestrial and aquatic environments. These activities will be used to refine the site-specific CSM and scope elements of the Site-Specific Work Plan (SSWP). As part of the SSWP, both human health and ecological risks will be evaluated under a process that is tailored to the specific MGP Site. The RAF includes the following elements:

- Summary of CSM (Section 2)
- Remedial investigation (RI) Design and Approach for the BLRA (Section 3)
- Human Health Risk Assessment Framework, and Screening Levels and Methods (Sections 4 and 5)
- Ecological Risk Assessment Framework Elements, and Screening Levels and Methods (Sections 6 and 7)
- Defining Risk Zones Within the Aquatic Environment (Section 8).

With regard to ecological risk assessment, several sections of the RAF reflect what is commonly referred to as problem formulation. These include Section 2, which provides a Conceptual Site Model; Section 3, which describes the rationale and approach to data collections and utilization; and Sections 6 and 7, which outline the elements of the ecological risk assessment. In addition to these sections, an overview of problem formulation is provided in Section 6.

2 Summary of Conceptual Site Model

The Generalized CSM considers the primary MGP-related constituents (contaminants of potential concern [COPCs]), potential transport mechanisms, and the relevant human and ecological receptors (Figure 1).

Within each site, there are two areas where human and ecological receptors may be exposed to potentially MGP-contaminated environmental media—upland areas of the site where the former MGP processes were located, and adjacent surface-water bodies, where present. Human and ecological receptors interact with these two areas (upland and surface-water body) in different ways.

The following is a summary of the generalized CSM as it pertains to the development of the RAF.

2.1 MGP-Related Constituents and Transport Mechanisms

As discussed in the CSM, the MGP-related constituents are expected to be similar at each of the sites (Table 1). As noted on Table 1, the PAH analyses in sediment will include the parent and alkylated PAHs identified in the EPA methodology for estimating risks to benthic invertebrates (U.S. EPA 2003b).

The CSM illustrates the different transport processes that affect the distribution of MGP-related constituents. The primary transport mechanisms were the release of MGP-related by-products to the ground and/or the discharge of process water to the nearby water bodies. Both mechanisms may have resulted in tars and other MGP constituents being deposited in the surface-water bodies of the site. Tars and other wastes in process equipment (e.g., tar wells) may also affect groundwater if the contaminants leaked from process equipment. Groundwater containing MGP-related constituents may be transported away from the process area and may discharge to surface-water bodies. Where tar materials were released near water bodies, the potential exists for the tar material to migrate to the directly adjacent surface-water bodies via gravity flow.

Based on experience, common locations of MGP residuals are in subsurface areas near former process equipment and in directly adjacent surface-water bodies. Thus, the main environmental media of concern at an MGP site include:

- Soils (both surface and subsurface)
- Groundwater beneath and downgradient of the former MGP facility

- Air (primarily indoor air) at sites with existing or reasonably anticipated future buildings overlying contaminated soil and/or groundwater

- Sediment and surface water in water bodies directly adjacent to the former MGP facility.

2.2 Potential Human Health Receptors and Exposure Pathways

2.2.1 Upland Areas

Under current and likely future land-use conditions at the MGP sites, the potential human "receptors" are:

- Industrial or commercial workers—potentially exposed to surface soils; there may be cases when exposures to subsurface soils and vapors emanating from subsurface contamination may also need to be considered

- Construction workers—potentially exposed to surface and subsurface soils, to groundwater if excavation activities reach the water table, and to vapor

- People who visit the site (e.g., for recreational use)—potentially exposed to surface soils

- Residents (if future residential development may occur on a site)—potentially exposed to surface soils; there may be cases when exposures to subsurface soils and vapors emanating from subsurface contamination may also need to be considered.

On a site-specific basis, the appropriate human receptors and exposure pathways will be evaluated as part of the SSWP development. A site reconnaissance will be performed as part of scoping the work plan to evaluate site conditions and evaluate how the site is used.

2.2.2 Surface-Water Bodies

The former MGP sites are typically located next to water bodies (e.g., rivers). Receptors using or living near these water bodies will be evaluated for exposure to MGP-related contamination. Some or all of the following populations could be exposed:

- Recreational boaters

- Recreational fishermen

- Waders or swimmers.

Of these recreational uses, the more intensive potential exposure to MGP-related constituents occurs from wading or swimming. This recreational use will be evaluated quantitatively within the BLRA as a reasonable maximum exposure (RME) scenario for the water-body portion of the site on a site-specific basis. Key parameters of the exposure assumptions (e.g., access, water depth, etc.) are described in Section 4.

PAHs are typically the group of chemicals that are of concern to human health and ecological receptors in aquatic environments (based on the experience of Menzie-Cura and Exponent at numerous MGP sites). Most fish species have enzymatic systems that metabolize and detoxify PAHs (Hahn et al. 1994), which are eliminated at different rates for different PAHs. For this reason, fish do not bioaccumulate PAHs into their fillets to levels that pose a health risk, and exposure via fish consumption is therefore less important than other pathways. Bioaccumulation of inorganic metals into the fillets of fish is low. Bioaccumulation of inorganic metals generally involves accumulation into shellfish.

Organic forms of mercury, selenium, and arsenic may bioaccumulate in fish tissue. This usually occurs in sediments near industries that make large use of mercury, or in water bodies where the watershed has experienced deposition of atmospheric mercury (ICF 2006). The introduction of inorganic mercury to aquatic environments, and subsequent methylation, does not appear to be an issue for former MGP sites. However, if high levels of total mercury are observed in the sediments at a site, the potential for formation of methylmercury and accumulation into fish may be evaluated. The evaluation of site-specific mercury levels will consider ambient levels of mercury in each watershed.

Selenium rarely results in human health concerns as a result of bioaccumulation into fish tissue. However, selenium in sediments at each site will also be evaluated and compared to ambient levels. If selenium is present above ambient concentrations, the potential for bioaccumulation into fish tissue will be evaluated.

Several organic arsenicals have been found to accumulate in fish. The Agency for Toxic Substances and Disease Registry (ATSDR 2000) notes that these derivatives (mainly arsenobetaine and arsenocholine, also referred to as "fish arsenic") are nontoxic. The toxicity of arsenic is related to inorganic forms; if inorganic forms are present at high enough levels, they will contribute to laboratory-measured toxicity to benthic invertebrates.

Iron cyanide complexes associated with oxide box wastes may be present at MGP sites (Ghosh et al. 2006); however, they are much less toxic than simple cyanide salts or free cyanide (Borowitz et al. 2006). In aquatic environments, the toxicity of cyanide complexes is largely a function of their dissociation to free cyanide (Gensemer et al. 2006). The free cyanides and simple cyanide salts are taken up by organisms but are not bioaccumulated or passed up the food web (Lanno and Menzie 2006). Free cyanides that may result from MGP processes react quickly with biological materials, and can cause toxic effects on benthic invertebrates if they occur at sufficient levels. Such effects will be measured through laboratory toxicity testing.

The potential for fish bioaccumulation of site-specific chemicals is constrained further by the small areas of the sediment portions of the sites, in comparison to the area over which local populations of fish will forage and areas where people will fish. For these reasons, the exposure pathway involving bioaccumulation of MGP constituents into fish will be reviewed on a site-by-site basis.

2.3 Potential Ecological Receptors and Exposure Pathways

2.3.1 Biological Habitat Evaluation

A biological habitat evaluation will be performed at each site to identify the presence and characteristics of terrestrial and aquatic habitats and associated ecological receptors. The information gained from the evaluation will be used to identify appropriate ecological receptors to include in the ecological risk assessment. Two field forms may be used to guide the habitat evaluation and document the results (Appendix A). The first form is adopted from the Ohio EPA Ecological Risk Assessment Guidance (Ohio EPA 2003) and is used to document whether the ecological habitat that is available at a site is adequate to warrant further ecological risk assessment. The second form is a general checklist for a habitat assessment that is provided in the Ecological Risk Assessment Guidance for Superfund (ERAGS; U.S. EPA 1997), which is used to document the results of the qualitative walk-through habitat assessment. The evaluation will also consider the future use of the upland and potential or existing wetland areas of sites, as there may be some cases when the future use may involve restoration of habitat. A screening-level risk assessment (SLERA) and, if appropriate, a baseline ecological risk assessment (BERA) would be completed for upland and potential/existing wetland areas on a site-specific basis.

The habitat evaluation will include:

- Review of aerial photographs, topographic maps, wetland delineation maps, and floodplain mapping
- Review of information on the physical characteristics and the types of biota that use the water body (e.g., bottom substrate, bank conditions, flow conditions, water depth, benthic invertebrates, and aquatic vegetation)
- Inquiries to the U.S. Fish and Wildlife Services, and appropriate State agencies, including the Wisconsin Department of Natural Resources (WDNR) – Bureau of Endangered Resources in Wisconsin, or the Illinois Department of Natural Resources (IDNR) – Division of Natural Heritage in Illinois, regarding potentially endangered or threatened species or critical habitat present in the vicinity of the site
- Onsite qualitative examination of the existing vegetative characteristics (vegetation community, cover types, dominant vegetation, size, and location)
- Onsite qualitative observations regarding the presence or absence of birds and mammal species (e.g., tracks, scat, nests, etc.).

For each of the ecological receptors identified in the CSM (Figure 1), a determination will be made as to the potential for that receptor to be present at the site. The SSWP will include a discussion of the initial ecological habitat assessment and will present the justification for carrying selected exposure scenarios forward in the SLERA. The methods and level of additional habitat evaluation will be discussed in the SSWP.

2.3.2 Upland Areas

The RAF recognizes that soils at some upland environments have been remediated and that some of these upland areas may not provide the type of habitat that would support ecological receptors that may be evaluated in an ecological risk assessment. The biological habitat evaluation will document the presence or absence of habitats, and the results will be discussed in the SSWP. The biological habitat evaluation will be the basis for identifying ecological receptors that should be included in the assessment. As noted above, potential future land use will be considered.

2.3.3 Surface-Water Bodies and Associated Wetlands

The biological habitat evaluation at each site will be used to identify the aquatic and wetland receptors for site-specific evaluation. These may include fish, small mammals, birds, and benthic invertebrates. The selection of receptors will consider such factors as the location and extent of sediment contamination, water depth, availability of prey to wildlife, and the presence of wildlife and fish communities of particular interest or concern. These relationships will all be reflected in the site-specific conceptual site model. The risk evaluation will consider risks to benthic invertebrates at each site, because:

- Benthic organisms spend most of their life within a very small area; other aquatic species and wildlife tend to range over larger areas and thus experience less exposure than benthic invertebrates
- Benthic organisms are in direct contact with potentially contaminated sediments and surface/pore waters; fish and wildlife species contact these media incidentally—for example, the main exposure to fish is associated with foraging on benthic invertebrates or resting on the bottom
- Benthic invertebrates have less developed metabolic systems that do not metabolize PAHs or metals as readily as higher-level organisms (e.g., fish and waterfowl).

The potential for exposures to fish, small mammals, and bird species associated with surface-water bodies and wetlands will be determined for each site from the biological habitat evaluation. In most cases, this will include a qualitative evaluation and reliance on the quantitative evaluation of risks to benthic invertebrates. However, in cases where there are fish and wildlife of particular interest or concern, and where there is a potential for exposure, it may be appropriate to quantify risks to fish and wildlife species.

3 Remedial Investigation Design and Approach

The following is a discussion of the remedial investigation design and approach as it relates to evaluating risks to human health and ecological receptors. The sampling methods will be described in a Multi-Site Field Sampling Plan.

3.1 General RI Sampling Design

The proposed RI sampling results and the results of previously performed site investigations will be used to perform the human health and ecological risk assessments. Although there may be cases where additional data are needed on soil and groundwater contamination, it is anticipated that existing information will be of adequate quality and distribution to perform upland risk assessments at many of the sites. Therefore, the additional sampling efforts will likely focus on characterizing the surface water and sediments of the water body adjacent to the former MGP facility. If additional sampling is needed, it will be detailed in the SSWP. The data from the previously collected samples and proposed samples will be used to assess the nature and extent of contaminants and the potential risk to the receptors identified in the site-specific CSM.

The evaluation of potential pathways of MGP-residuals to the water body will use samples from both upstream and downstream of the MGP site. The upstream data will establish ambient conditions for the water body. These upstream samples may evaluate other anthropogenic influences or offsite, non-MGP-related sources, which may also be affecting areas within the site.

Collection of field data and evaluation of site conditions and risks in the aquatic environment are designed to characterize the spatial extent and boundaries of the risk zones (Section 8). Previously collected sediment data will be used in the assessment and will also be used, as needed, to focus additional sampling efforts. Additional sampling efforts will be performed to address data gaps and/or to help define the boundaries of risk zones.

3.2 Site Reconnaissance/SSWP Development

A site reconnaissance and biological habitat evaluation (Section 2.3.1) will be conducted as part of developing the SSWP. The reconnaissance will be used to identify or confirm existing land use and site conditions, as this influences exposures of humans and ecological receptors. With regard to the aquatic environment, the reconnaissance will involve identifying access points for recreational equipment (e.g., boat launches), determining the sediment and surface-water characteristics of the water body, and identifying any potential source areas (e.g., seeps and stormwater outfalls).

As a result of the site reconnaissance, the generalized CSM will be refined to reflect site-specific conditions. The site-specific CSM will be used as the basis for developing the SSWP. The biological habitat evaluation will also be performed during the site reconnaissance, as part of the first step of an ecological risk assessment. Results of the site reconnaissance, and explanations for the receptors carried forward, will be incorporated into the SSWP, as described further in Section 6.

3.3 Soil Sampling Strategy

The need to collect additional soil samples, and the appropriate constituents to be analyzed, will be evaluated on a site-specific basis. Prior to completing the SSWP, the project team will evaluate the quality and quantity of the soil data in the upland area, to assess the adequacy of the existing data set to perform the risk assessments. If data gaps exist, they will be presented in the Completion Report or SSWP, and additional soil characterization may be included in the RI to address them. If soil data gaps are not addressed, risk management tools may be required. Information on the levels of contamination in soils in relation to current or future buildings will also be used to assess potential vapor intrusion concerns on a site-specific basis.

3.4 Groundwater Sampling Strategy

The need to analyze additional groundwater parameters, and the need to install additional groundwater monitoring wells, will be evaluated on a site-specific basis. Ongoing groundwater sampling is performed at some of the sites, as described in the Site-Specific Completion Reports or SSWPs. As part of developing the SSWP, the project team will evaluate the quality and quantity of the groundwater data to determine whether the necessary data exist to perform the risk evaluation. If data gaps exist, additional groundwater parameters may be included in subsequent sampling events, or additional groundwater monitoring wells may be installed as part of the RI field activities. Data gaps for the purpose of assessing risks will be considered with respect to direct contact and/or use of groundwater and the potential for vapor intrusion within existing or planned buildings, and to support the evaluation of ecological risks. From an ecological perspective, an objective of the groundwater evaluation for each site will be to evaluate whether contaminated groundwater is discharging to the surface-water body. If this migration pathway is judged to be complete, then the risk associated with the groundwater discharge will be evaluated with respect to exposure of ecological receptors.

If groundwater data gaps are not addressed, risk management tools may be required.

3.5 Surface-Water Sampling Strategy

Surface-water samples will be collected to evaluate potential risk to human health and ecological receptors and, if appropriate, the potential for migration of affected groundwater to the adjacent surface-water body. Surface-water samples typically will be collected from an upstream, offsite transect; up to two onsite transects; and a downstream, offsite transect (based on the size of the site and potential offsite sources). Surface-water samples will be collected as described in the FSP and analyzed for the same constituents as the sediment samples, along with any volatile organic chemicals that may be present in groundwater that may be discharging to surface water.

3.6 Sediment Sampling Strategy

3.6.1 Sediment Sampling Depths

Sampling will be conducted to characterize the extent of MGP contamination, as well as for use in the assessment of risk. Extent sampling involves the use of cores and other methods to examine the horizontal and vertical distribution of contamination. For the purpose of assessing risks to human health, the depth of sediment sampling is normally limited to the top 2 ft of soft sediment located in wadeable areas. Exposure to ecological receptors is typically limited to the surficial 6 inches (15 cm) of sediment (the biologically active zone). Ecological receptors typically do not live below this depth due to low-oxygen conditions. Therefore, samples for assessing risk to ecological receptors will be collected from 0 to 6 in. below the sediment/surface water interface.

Below a depth of 2 ft, MGP constituents present in sediment are not accessible to humans or benthic organisms. However, deeper sediment samples will be collected for vertical delineation and feasibility study parameters, and it may be necessary to collect sediments with the desired range of PAHs for toxicity testing (step one; see Section 3.6.2 below). Sediment sampling depths will depend on site-specific conditions (i.e. sediment thickness, sediment stability, rocky substrate, etc.) and will be addressed in the SSWP.

3.6.2 Stepped Approach

The evaluation of sediments will begin by examining existing data. In some cases, these data may be adequate (sufficient spatial and vertical coverage) for conducting a screening-level analysis. However, in most cases, there will be a need to collect additional sediment data. Unless previous information is adequate to reduce the list of analytes, sediments for use in risk assessment will be evaluated for the full suite of site-specific chemicals, to identify the potential for risk.

The sediment sampling may consist of one or two sampling steps (events) that are designed to characterize the sediment, assess the potential toxicity to benthic invertebrates, and delineate the risk zones, as mentioned in Section 1.1 and discussed in Section 8. Details of the sampling techniques are provided in the FSP, and the site-specific sampling approach will be presented in the SSWP.

The difference between a one-step approach and a two-step approach relates to the anticipated extent and magnitude of contaminated sediment (based on previously collected sediment data) and the degree of refinement needed to evaluate risks and define the spatial boundaries of risk zones. In some cases, a single sampling event that relies on chemistry data will suffice to evaluate potential risk using screening levels (Sections 5 and 7). In cases where there is apparent site-related contamination (indicated primarily by elevated PAHs that also exceed screening levels) over a broader area or greater volume than anticipated, Step 1 may include the collection of samples for toxicity testing. The evaluation of existing data, along with data collected during the Step 1 sampling event, may indicate the need for further sampling to resolve boundaries of risk zones. This second sampling event is referred to as Step 2.

If a one-step approach is used, sediment samples will be collected to characterize the bulk chemistry concentrations with comparisons to screening levels (described in Sections 5 and 7) and, if appropriate, to delineate the risk zones (Section 8). For the first sampling step, a mobile (in-field) chemical laboratory or quick-turnaround fixed facility may be used to provide "real-time" data. If these real-time data indicate that screening concentrations for sediments are generally exceeded, the data set may be used to select a set of sediment samples for toxicity testing (see Section 6 for further discussion). It is anticipated that ecological risks will likely be related to the presence of PAH compounds in sediments, and therefore, the concentrations of these chemicals will guide the design of studies. However, if other site-specific chemicals (e.g., monoaromatic hydrocarbons and metals) are present at levels that suggest gradients of exposure, that information will also be used to guide the sampling strategy. Assuming that PAHs and ecological receptors are the likely risk drivers for sediments, the selected samples will span a total PAH concentration range, to ensure the inclusion of samples with PAH concentrations above and below those likely to result in toxicity, based on experience at other MGP sites. (This experience base will continue to build over the course of the program.) If necessary, sediment samples may be collected at depths greater than 0 to 6 in. (the biologically active zone) to develop the total PAH concentration range or to collect feasibility study parameters. The appropriateness of toxicity testing during a one-step approach will be reviewed with USEPA personnel while field efforts are underway. That review will consider previously collected data as well as data gathered for other sites in the program. As such, the review will be consistent with an adaptive management strategy for the evaluation and management of risks. There is also a potential that a one-step approach may be used to assess risk at sites that have the benefit of earlier investigations.

If toxicity studies are performed during Step 1, they will be designed to identify a dose-response relationship between concentrations of PAHs and possibly monoaromatic hydrocarbons in sediments, and the degree of toxicity to an amphipod test species. Based on prior experience, the relationship is expected to exhibit toxicity thresholds, one below which sediments are not toxic, one within which there may be some toxicity, and one above which sediments tend to be toxic. These thresholds may be related to the bioavailable fraction of PAHs in sediments, and synoptic data will be obtained to examine that relationship (see Section 3.6.3). The relationships developed between toxicity and PAH concentrations, expressed as bulk measurements or as bioavailable fractions, will provide site-specific predictive tools for identifying whether other sediments for which chemistry data have been obtained are below, within, or above the toxic thresholds.

A two-step approach is used when the results of the first step indicate a need for further refinement, or previously collected sediment data indicate concentrations above ecological screening levels. Factors that influence the conduct and design of a Step 2 sampling event include the spatial extent of sediment contamination and the results of previous toxicity tests. The second sampling event will make use of the predictive tools developed from the first sampling event and data from other sites. Together, these data will be used to develop a dose-response, risk-based database to predict toxicity. These predictive tools will also be used to evaluate the characteristics and boundaries of risk zones (Section 8). The second sampling step will use the information gained in the first step to define and/or refine the boundaries of the risk zones, and to complete the BLRA. A limited number of toxicity tests may also be needed to confirm these boundaries.

Toxicity studies may be conducted at each of the sites to define risk zones and to validate the predictive tools on a site-specific basis (i.e., to "ground truth" the predictive tools by comparing to actual site conditions). However, it is anticipated that the number of toxicity tests needed to characterize a site will decrease as experience is gained on earlier sites in regard to the data needed to validate the predictive tools.

3.6.3 Bioavailability Assessments

Although the risk assessment process begins by considering the full suite of site-specific chemicals present in sediments at the site, some of these will be screened out during the SLERA, and exposure to others will be influenced by their bioavailability within the sediment matrix. To evaluate the latter, an assessment of bioavailability may be carried out as part of Step 1 and/or 2 sampling events. The assessment will focus on PAHs, because this is the group of site-related chemicals that is most likely to pose risks to benthic invertebrates and therefore where an assessment of bioavailability is of greatest value for defining risk zones. If other chemicals, such as monoaromatic hydrocarbons or metals, are present at potentially toxic levels, these will be evaluated either through toxicity tests or through bioavailability measures specific to the chemicals. Whether or not PAHs in sediments are toxic to benthic invertebrates depends on the bioavailability of these compounds. Therefore, measurements or estimates of bioavailability can be used to explain the presence or absence of toxicity and can also be used together with toxicity tests to help delineate the boundaries of risk zones.

Several approaches are available for characterizing the potential bioavailability of PAHs in sediments. These include measurements of percent black carbon and percent total organic carbon to predict the bioavailable fraction of PAH in sediment using an equilibrium partitioning approach (Gustafsson et al. 1997, Accardi-Dey and Gschwend 2002), as well as the use of solid-phase microextraction (SPME) to measure the concentration of bioavailable PAHs in sediment porewater (Hawthorne et al. 2005; U.S. EPA 2000). Both black carbon and SPME have shown promise for predicting the bioavailability and toxicity of MGP-related PAH compounds in sediments (Kreitinger et al. 2007; Kane Driscoll and Burgess 2007). These approaches, either individually or in combination, provide a means of explaining the presence or absence of toxicity to benthic invertebrates. If an assessment of bioavailability is incorporated into a work plan, data quality objectives (accuracy, precision, and detection levels) will be specified.

The Electric Power Research Institute (EPRI) has funded studies at a number of MGP sites to support the use of black carbon measurements. This research was carried out by Menzie-Cura and has been transferred to Exponent. A consortium of utilities and other companies in the Northeast funded the use of SPME methods. One or both of these measures may be included in developing a synoptic data set for the MGP sites. According to EPA guidance (U.S. EPA 2003b), sediment PAHs with equilibrium partitioning sediment benchmarks toxic units (ESB Sum-TU) of less than or equal to 1.0 are acceptable for the protection of benthic organisms. For the current assessments, the relationship between observed toxicity and ESB Sum-TU for the bioavailable fraction of PAHs (e.g., measured using SPME or estimated using black carbon) will be used to develop a predictive toxicity model. The model may be used in the development of target sediment levels and risk zones (see Section 8).

The results for each site can be compared to the data sets already developed by EPRI and the multi-utility group to evaluate the consistency of the results. As additional sites are analyzed, the predictive power of this cumulative synoptic data set will increase.

The state of the practice to assess bioavailability is improving rapidly. Additional bioavailability assessment methods may be considered as new methods become available.

3.6.4 In-Situ Profiling Techniques

On a site-specific basis, in-situ tools may also be used to characterize the presence or absence of tar and concentration of total PAHs. These tools may include Tar-specific Green Optical Screening Tool (TarGOST®) or Dart profiling systems. Both technologies use laser-induced fluorescence (LIF) to semi-quantitatively correlate the total PAH concentrations to the degree of fluorescence. These tools provide continuous profiling and, therefore, relative PAH concentrations with depth at each location.

If selected, it is anticipated that these tools will be used during Step 1 to focus the sediment sampling and define potential source areas. Similar to bioavailability assessments, emerging in-situ profiling techniques may be considered as they become available.

4 Human Health Risk Assessment Framework

4.1 General Approach

The HHRA portion of the BLRA will include an evaluation of risks associated with the upland area and the adjacent surface-water body of the site. The HHRA will conform to the applicable risk assessment guidance documents referenced in Section 3.3.2 of the Statement of Work. In addition to these guidance documents, other applicable risk assessment guidance documents may be utilized, as appropriate.

Because remedial activities have been performed on the land portions of some of the sites, it is anticipated that exposures to the upland soils at those sites are already protective of selected human receptors. However, based on land use at each site, a screening-level evaluation of potential risks to human health in the upland areas will be performed as part of the risk evaluation. The screening-level evaluation will compare health-based screening criteria to previously collected soil and groundwater concentrations at the site. This screening evaluation will be used to evaluate whether portions of the site may require additional investigation, warrant additional risk assessment, require a remedial response, and/or require risk management tools to protect human health. If additional risk assessment is required to further assess potential risk to human health (e.g., vapor intrusion), the risk assessment approach will be evaluated on a site-specific basis.

For each site, the risks associated with the aquatic environments also will be evaluated. The human health risk evaluation for the surface-water bodies will focus on the RME scenario, which is considered to be recreational use of the water body. The evaluation will be site specific and may vary based on the land use adjacent to the water body (e.g., commercial versus recreational) and the characteristics (e.g., water depth, flow conditions, etc.) of the water body at the site.

The general HHRA approach (Figure 2) follows a two-step process:

- **Step 1**: Perform a screening-level assessment. (upland areas only, based on risk-based soil and groundwater criteria and a consideration for the potential of vapor intrusion)
- **Step 2**: Focused human health risk evaluation (surface-water body and site-specific upland exposure pathways that were not addressed in the screening process).

4.2 Screening-Level Assessment (Step 1)

The potential risks to humans will be evaluated through a generic residential and commercial/industrial exposure scenario that evaluates RME levels of MGP constituents to concentrations reported in the site soils and groundwater and, if appropriate, vapor intrusion related to soil gas. The screening-level evaluation will be used to define whether all (or portions) of the site are appropriate for unrestricted use and unlimited access (generally evaluated with the residential exposure scenario) or whether portions of the site will require risk management tools to protect human health.

The application of human health soil and groundwater screening values (Tables 2 and 3, respectively) is discussed in Section 5. The soil screening levels are provided for generic scenarios (residential and commercial/industrial) based on USEPA Soil Screening Levels (U.S. EPA 2002) and WDNR Wisconsin Administrative Code (WAC) Chapter NR720, and IEPA Tier I soil remediation objectives, IAC Title 35, Subtitle G, Chapter I, Subchapter f, Part 742, Appendix B: Table A - Residential Properties, and Table B - Industrial/Commercial Properties, effective February 2007. The groundwater screening levels include federal drinking-water standards and WDNR Enforcement Standards (ESs) provided in WAC Chapter NR140 and Illinois Class I and Class II groundwater standards. Risk-based soil and groundwater values will be used to evaluate whether there is a potential for human health concerns under the RME scenarios for residential and commercial/industrial uses. For these comparisons, the maximum concentration of each MGP-related constituent will be compared to the RME-based soil or groundwater screening levels, with the following potential outcomes:

- If there is no potential risk associated with upland site conditions (i.e., screening values are not exceeded), no further human health risk evaluation will be performed
- If the maximum concentration of one (or more) MGP-related constituent is above the RME-based soil or groundwater screening level, implement Step 2 (Figure 2) and further evaluate potential risk using the general process described in the Section 4.3. Alternatively, the risk evaluation may end at this point, and other risk management tools may be used to manage the potential risks in the upland portions of the site.

4.3 Further Human Health Risk Evaluation (Step 2)

The following steps will be used to perform the HHRA within the surface-water body. In addition, this same process will be used on a site-specific basis if other exposure pathways (e.g., direct contact with surface soil in the upland) need to be evaluated at the site beyond the screening assessment presented in Section 4.2. The process includes:

- Selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization.

4.3.1 Selection of Chemicals of Potential Concern

The selection of COPCs will be based on representative site data judged to be usable from a QA/QC standpoint to perform the risk assessment.

If sediment and surface-water concentrations are consistent with upstream ambient concentrations, the risks associated with these chemicals will be discussed qualitatively in the RI Report. On a site-specific basis, the site and ambient conditions may be evaluated and quantified for potential risk to human health. For those chemicals above ambient conditions in surface water and/or sediment, potential human health risk will be quantified.

If environmental media in the upland environment are to be evaluated further, then analytes that exceeded screening levels in the preliminary screening assessment (Step 1), described in Section 4.2, will be carried forward into the HHRA for further risk evaluation. It is anticipated that this evaluation will focus on contamination of surface and subsurface soils. However, there may be cases where exposure to groundwater or vapors (for indoor air) will be evaluated.

Human health risks to PAHs will be evaluated using a subset of the 34 PAHs that are used to assess risk to ecological receptors. The subset includes those PAH compounds for which USEPA has developed either cancer potency factors or reference doses. If any PAH compound in the subset exceeds screening levels and is above ambient levels, all of the PAH compounds in the subset will be included in the exposure evaluation. Inclusion of all the compounds in the subset ensures that potential additive effects are taken into account.

4.3.2 Exposure Assessment

The exposure assessment will characterize the magnitude of potential exposures that people may incur from the upland or aquatic areas of the site. The exposure scenarios will use the exposure factors provided in EPA risk assessment guidance (U.S. EPA December 1989, March 1991, 2002), as appropriate. Professional judgment is also used, in part, to develop exposure factors. The proposed exposure factors will be discussed with EPA personnel prior to performing the risk characterization.

Exposures to soils and vapors will be evaluated as appropriate for upland portions of the sites. These exposure scenarios will rely on standard EPA methods and exposure assumptions for onsite workers, recreational users, and residents, as appropriate.

The evaluation of the surface-water and sediment exposure pathways will be developed on a site-specific basis, considering the following sequence:

1. Evaluate the completeness of the sediment and surface-water exposure pathway
2. Characterize the amount of exposure on a site-specific basis for exposure pathways considered to be complete.

The criteria that will be used to evaluate completeness of the surface water and sediment exposure pathway will include the following:

- Accessibility of the water body to people (i.e., are there floodwalls that prevent entry?)
- Depth of water, to determine whether people may wade in the water body
- Accessibility of soft sediment (i.e., is soft sediment present?)
- Use of the water body (i.e., a recreational waterway where boaters may anchor or sportsman may fish)
- Presence of tars in sediment or sheen on the water.

If site-specific conditions indicate that surface-water and/or sediment exposure pathways are potentially complete for human health (based on the land use), an evaluation of the exposure to the sediment and surface water will be tailored to the site-specific conditions within the BLRA. If the exposure pathway is not considered complete, that conclusion will be documented in the BLRA.

The sediment and surface-water exposure equations used to evaluate recreational use are described in Appendix B and are based on USEPA guidance (USEPA 1989, 2004). RME assumptions will be used to characterize human health exposures in the water body using the recreational exposure scenario. These exposure conditions will be developed on a site-specific basis, considering actual site conditions and the factors described above. A central tendency recreational exposure scenario may also be presented for some sites to provide a more complete picture of exposure. The central tendency exposure scenario will not be evaluated unless the RME exposure scenario is not considered adequate to characterize risk at the site.

Key exposure factors include:

- The age of the receptor
- Duration of exposure to the water body (in years)
- Frequency of contact with the water body (i.e., how many times per week the site is accessed)
- Ingestion rate of site media
- The area of skin in direct contact with MGP-contaminated media.

These exposure assumptions are based on professional judgment and EPA risk assessment guidance for noncancer type and carcinogenic effects. The general methods that will be used to estimate human health risks are provided in Appendix B. The actual exposure assumption considered applicable at a site will be based on site conditions.

A key site-specific input into the exposure estimates for the site is the exposure-point (area) concentration (EPC), which represents the concentration of each COPC to which people may be exposed. The EPC for each COPC in surface water and sediment will be calculated using current EPA ProUCL software. This software calculates the 95% upper confidence limit (UCL) of the arithmetic mean of a data set, which represents an estimate of the average concentration for which there is 95% confidence that the true average of the data set is no greater than the estimated UCL value.

4.3.3 Toxicity Assessment

The toxicity assessment for the HHRA will summarize available non-cancer and cancer toxicity values for the COPCs as appropriate for the environmental media. At the time that the risk evaluation is performed, these toxicity values will be obtained from current USEPA sources (e.g., Integrated Risk Information System [IRIS]) as part of each site-specific assessment.

4.3.4 Risk Characterization

Non-cancer and cancer risk estimates will be calculated for each applicable exposure pathway identified in the site-specific CSM. The risks from each exposure pathway will be summed to evaluate the cumulative risk associated with exposure to the surface-water body. The methods to be used to calculate the noncancer and cancer risk estimates are provided in Appendix B. As part of the risk characterization, the uncertainty associated with the risk estimates will be summarized.

5 Human Health Screening Levels and Methods: Selection and Application

As discussed in Section 4.2, human health screening levels will be used to determine when it may be appropriate to conduct further human health risk assessment within soil and groundwater in upland areas of the sites. The screening values proposed for soil and groundwater are provided in Tables 2 and 3, respectively. While USEPA screening values will be relied upon, comparisons also will be made to appropriate state applicable or relevant and appropriate requirements (ARARs). If a concentration exceeds a state ARAR but is less than the USEPA value, that finding will be noted. These chemicals will be discussed qualitatively within the risk assessment.

An additional screening step may also be required to evaluate vapor migration into buildings at some sites. The approach for evaluating vapor migration will be developed on a site-specific basis. However, a process for the screening evaluation is provided.

The screening approach to assess human health exposures to sediments and surface water will also be developed on a site-specific basis. Standard screening levels based on recreational use of a water body do not exist at present. Evaluation of potential human health risks associated with this exposure scenario depends on the characteristics of the surface-water body and the manner in which people interact with it (see Section 4.3.2).

5.1 Soil Screening

USEPA values (USEPA 2002) were developed to consider exposure to soil under a generic residential land-use scenario and industrial land-use exposure scenario. The soil concentrations of each analyte will be compared to the USEPA and appropriate state soil screening values for the applicable land-use scenario. Areas of the site with analyte concentrations below screening values will not be considered as a risk to human health and will not be evaluated further. For those areas of a site where analyte concentrations exceed the USEPA screening values for a particular land-use scenario, there are two possible outcomes:

1. Further risk evaluation will be conducted for those areas exceeding screening values; or
2. Other risk management tools will be considered to address the potential risks, rather than performing further risk evaluation.

Under Outcome 1, additional risk evaluation would follow the procedures in Section 4.3. Risks will be estimated for spatially defined areas of the site that represent reasonable areas for the applicable exposure scenario (e.g., residential or commercial). In addition, the risk to construction workers will be evaluated, because this scenario will be applicable to the site under either land-use scenario (residential or commercial). The exposure assumptions used to characterize exposure to soil will be taken from applicable USEPA risk assessment guidance, as described in Section 4.3.

If Outcome 2 is selected for a site, the screening evaluation will be used to document which areas of the site would pose a potential human health risk and under what exposure scenario. This information will be used, in part, to determine the appropriate risk management tools to apply at a site.

5.2 Groundwater Screening

Groundwater screening values (Table 3) will include the USEPA maximum contaminant levels (MCLs) and appropriate state values. These screening values were developed assuming that people drink the groundwater on a daily basis over their lifetime. These screening values will be compared to site groundwater concentrations to assess the potential risk if groundwater were to be used as a drinking-water source. This screening evaluation will be used only to document where concentrations of groundwater contamination occur at levels that present a potential risk. The results of the groundwater screening will be documented in the risk assessment. It is anticipated that the potential risk associated with groundwater will be assessed in the Feasibility Study, considering risk management tools and/or remediation.

5.3 Vapor Migration Screening

The potential for risk associated with vapor migration into indoor air will be considered for sites where existing or potential future building locations are located over areas of groundwater and/or soil contamination. This determination will be made based on site reconnaissance, the potential for future construction of buildings, and a review of available data on soil and groundwater. The state of the practice in regard to evaluating the vapor intrusion pathway is evolving rapidly in the scientific and regulatory community. Therefore, the method used at each site will likely evolve with the state of the practice and will be described in the SSWP.

Screening evaluations may be used to evaluate the significance of the vapor intrusion exposure pathway in those cases where volatile compounds are present in soil or groundwater and future residential or commercial development may occur. For the volatile compounds in the soil or groundwater, a generic vapor intrusion scenario may be evaluated using EPA's version of the Johnson and Ettinger model (U.S. EPA 2004), OSWER *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (Subsurface Vapor Intrusion Guidance, Draft Guidance (U.S. EPA 2002, November), or EPA guidance that is current at the time of evaluation. The screening tools would be used to evaluate whether additional risk evaluation is required, or if other risk management tools need to be considered to manage this potential exposure pathway.

5.4 Surface-Water and Sediment Screening

Human health-based surface-water and sediment screening values relevant to a recreational use scenario do not exist at present. Rather, surface-water and sediment exposures associated with recreational use of the water body will be addressed on a site-specific basis, and will involve a site-specific evaluation of the potential risks associated with surface water and sediment, as described in Section 4.3.

6 Ecological Risk Assessment Framework

This section provides a general framework for performing the ecological risk assessment (ERA) component of the risk assessments (SLERA and/or BLRA). The generalized ERA process for both the upland environment (Figure 2C) and the aquatic environment (Figure 2D) at each site is consistent with USEPA's eight-step ERA process (Figure 3). An ERA may consist of a SLERA, or may progress to a more detailed assessment, referred to as a baseline ecological risk assessment (BERA). The ERAs at each of the sites are expected to include a SLERA with elements of a BERA.

The ERA process allows for scientific/management decision points (SMDPs), at which risk managers review the progress of the ERA in an effort to avoid performing unnecessary assessments and to redirect the efforts of the ERA, as necessary. It is anticipated that SMDPs will be used on a site-specific basis. Common SMDPs are shown on Figure 3. Additional SMDPs may be used during the field investigation.

The scope of the ERA focuses primarily on the aquatic environment but will also address upland areas, as appropriate, based on the results of the ecological habitat assessment. Both the upland and aquatic portions of the site will be evaluated in terms of quality and quantity of ecological habitat on a site-by-site basis during the habitat assessment. The results of the biological habitat assessment will be used to develop a site-specific CSM for each site. The site-specific CSM will be used to formulate an approach for each site-specific ERA. The general ERA framework that will be used for the sites is described herein and will be modified based on site-specific conditions and lessons learned from earlier sites.

6.1 Problem Formulation

As noted in the Introduction, several parts of the RAF provide elements of problem formulation and will be incorporated into the SSWP. The primary focus of the ERAs will be to evaluate the risks associated with site-specific chemicals in aquatic and, in some cases, upland environments. Problem formulation defines the focus of such assessments through the development of site-specific conceptual models, review of historical operations, and evaluation of available data. Problem formulation is also used to identify the ecological receptors and the rationale for their inclusion in the assessment. An overview of problem formulation is provided below. It serves as a road map for highlighting sections of the RAF where information relevant to the problem formulation process can be found and where site-specific information will be sought.

The beginning step of problem formulation is the development of a conceptual site model using the data available and knowledge of the site-specific conditions. This aspect of Problem Formulation is described in Section 2. Various elements of the generic MGP-specific problem formulation are provided in the Generalized CSM (NRT 2007a) and include:

- Site characteristics and chemicals of potential ecological concern
- Potential contaminant transport mechanisms

- A description of the receptors that may be affected by the MGP-related constituents and their mode of effect
- The most likely potentially complete exposure pathways
- The assessment and measurement endpoints that will be used to evaluate the potential for ecological risks.

Certain problem formulation elements contained within the Generalized CSM will be refined in the SSWPs. These refinements will be used to adjust the problem formulation and CSM to the specific conditions present at each site. The following is a brief synopsis of the common elements of the ecological risk assessment problem formulation specific to the majority of the MGP sites that will be evaluated using this RAF. These generalizations will not apply to all sites. Site-specific modifications to the problem formulation will occur, as necessary.

6.1.1 Site Characteristics and COPCs

The reconnaissance survey and biological habitat assessment will be used to provide information on the characteristics of the site. Section 2 describes the CSM as it pertains to evaluating MGP sites. The site-specific information would be used to refine this CSM. In particular, the problem formulation will specify the upland and aquatic habitats to be considered in the evaluation. As noted in Section 3, the MGP-related contaminants of concern are primarily PAHs, and to a lesser extent, petroleum volatile organic compounds (PVOCs) and specific metals (see Table 1). This list of chemicals was developed from a review of the literature and from experience pertinent to MGP sites. As noted in Sections 2 and 3, MGP-related COPCs generally do not biomagnify through the terrestrial or aquatic food chain, so the strategy developed for the ecological risk assessment is to evaluate ecological receptors that have the most direct contact with the contaminated media that contain the highest concentrations of the MGP-related COPCs (i.e., either surface soils or sediments). Chemicals such as methyl mercury with the potential to biomagnify will be considered on a site-specific basis.

6.1.2 Fate and Transport Considerations

Historically, the highest concentrations of MGP-related COPCs were found in soils in the upland area of the site. However, at some of the sites, remediation of the upland soils has occurred, and this will have to be factored into the site-specific problem formulations for these sites. Overland flow of surface water or direct discharges to the river while the MGP was in operation may have led to contamination of the sediment adjacent to the MGP sites. The majority of the MGP-related COPCs are found associated with the organic matter in soils and sediment, because they are not very water soluble, so the main repositories for the MGP-related COPCs are in the soils and sediment, rather than groundwater or surface water.

The spatial extent of the contamination is specific to each site and is affected by the specific characteristics of the former MGP and the water body next to it (e.g., its hydrology, boat and barge traffic, development and land use along the riparian corridor). Discharge of contaminated groundwater may be a possible migration pathway from land to the surface-water body at some sites and will be evaluated as part of the groundwater and surface-water investigations conducted for the site. However, this pathway is normally of less significance than the other migration pathways (i.e., historical discharges to the river or overland transport of contaminated soils). As part of each risk assessment, the concentrations of the MGP constituents will be compared to screening levels for potentially affected media, including soil, groundwater, surface water, and sediment. This comparison will be used to evaluate where unacceptable exposure of ecological receptors may be possible on a spatial scale within both the upland and the aquatic environment, and to verify the points of potential exposure.

6.1.3 Potentially Complete Exposure Pathways and Ecological Receptors in the Uplands

Section 2.3 of the RAF describes the procedures for identifying ecological receptors and pathways of exposure.

Where habitat is identified for upland environments, the applicable terrestrial receptors will be identified. Based on general site conditions and Generalized CSM, it is anticipated that the most likely terrestrial receptors to be considered will include small mammals and ground-nesting birds that are exposed to surface soil and subsurface soils.

6.1.4 Assessment Endpoint for the Uplands

If terrestrial habitat is present at a site, then the assessment endpoint will be the sustainability of local populations of small mammals and resident nesting birds that use the site.

6.1.5 Potentially Complete Exposure Pathways and Ecological Receptors in the Aquatic Environment

The nature of exposure to fish, wildlife and benthic invertebrates are described in Sections 2 and 3 of the RAF. In the aquatic environment adjacent to the former MGPs, it is known that ecological habitat exists in the rivers. Therefore, if site-related chemicals have migrated from the MGP to the adjacent water body, there is a potential for exposure that would be identified within problem formulation.

6.1.6 Assessment Endpoints for the Aquatic Environment

The primary assessment for the aquatic environment at each site will be the sustainability of the benthic invertebrate community. The appropriateness of this assessment endpoint will be evaluated on a site-specific basis. At some sites, it may be appropriate to include assessment endpoints for fish and wildlife.

6.2 ERA Approach Specific to Former MGPs Adjacent to Water Bodies

A streamlined ERA approach will be used, consistent with the EPA guidance for conducting ERAs (USEPA June 1997, 1998), to incorporate the results of investigations performed previously. An ERA will be conducted under the classic USEPA approach, in which existing data are used to conduct a SLERA, followed, if necessary, by a more detailed BERA. This standard process will be used for the upland areas of the sites, where the SLERA will begin with an initial ecological habitat evaluation, which is used to determine what level of ecological evaluation is warranted. However, for water bodies, it is anticipated that additional steps beyond a standard SLERA will likely be needed at most of the sites. Therefore, the ERA approach for the aquatic environment will be a modified approach that utilizes both elements of a SLERA and additional BERA-level evaluations to streamline the risk evaluation.

It is anticipated that the results from investigations and risk assessments at the sites investigated earlier will be used to refine the site-specific approach applied to sites that are investigated later in the process. The first step of the SLERA for the upland environment will be to conduct an ecological habitat assessment, to determine whether sufficient ecological habitat is present in the upland areas to warrant further evaluation with the SLERA. If sufficient upland habitat is present, the existing and proposed surface soil data in the upland environment will be used to conduct an initial risk characterization typical of a SLERA, which will be used to determine whether further ecological risk assessment may be required beyond the SLERA (e.g., a BERA). If sufficient habitat does not exist in the upland environment to require further evaluation within the SLERA, this will be documented as part of the BLRA.

A modified SLERA/BERA approach will be applied to the aquatic environments of the sites, because sufficient aquatic habitat exists and ecological screening levels are anticipated to be exceeded in the sediments at some locations (based on previously collected sediment data).

A screening-level evaluation will be conducted for each site, using either existing data and/or new data. The screening-level evaluation will be used to guide subsequent steps. Data collection activities during this modified SLERA/BERA will provide lines of evidence (e.g., sediment toxicity testing, additional habitat evaluations, and indicators of bioavailability) that would normally occur in subsequent evaluations (i.e., after the SLERA step) as part of a streamlined BERA.

The screening-level evaluation may indicate the need for additional chemistry data and will be used to determine whether to proceed to collecting samples for toxicity testing. The sediment sampling to support the aquatic environment SLERA-BERA is described in Section 3.6.2 of the RAF. This includes an initial sampling event that will include "real-time" measurements by a mobile laboratory or a fixed-base analytical laboratory with fast turnaround times. Depending on the results of this sampling, Step 1 may also include the collection of appropriate sediment samples for toxicity testing. Samples selected for toxicity testing will also be analyzed for PVOCs, phenols, selected metals, cyanide, sediment grain size, black carbon, and total organic carbon, to further characterize the sediment and evaluate confounding effects. In addition, during the initial field investigation, a more detailed evaluation will be conducted for the existing benthic invertebrate community using methods adopted from the Rapid Bioassessment

Protocol (U.S. EPA 1999). The protocol identifies the type of sampling gear to be used for various substrates. Selection of appropriate gear will be based on site-specific conditions. Sediment samples identified for toxicity testing may also be selected for characterization of benthic invertebrates to provide a collocated measure of the benthic invertebrate community. All these lines of evidence will be used to evaluate whether MGP-related constituents are having an adverse effect on aquatic ecological receptors.

To evaluate ambient conditions within the water body and assess potential offsite sources, sediment and surface-water samples also will be collected in upstream locations that have physical sediment characteristics similar to the site. These upstream samples will be analyzed in a manner consistent with the site samples, to allow for a comparison of onsite versus offsite sediment quality. The ambient conditions can be used to assess confounding effects and determine whether site sediments have an adverse effect on aquatic ecological receptors.

Field sampling methods are presented in the Multi-Site FSP, and the site-specific considerations will be presented in SSWPs.

The surface-water and sediment chemical data, and the results of the sediment toxicity tests, if conducted, will be used to:

1. Support the modified SLERA-BERA of the aquatic environment; and
2. Identify concentrations of COPCs (Table 1) that are associated with toxicity. It is assumed that toxicity will be correlated with the total PAH concentration (34) normalized with the percent carbon (black carbon and total carbon).

Based on the results of the SLERA in the terrestrial environment and the modified SLERA-BERA in the aquatic environment, a decision will be made concerning the need to conduct further BERA-level evaluations in the aquatic and/or terrestrial environment. Any additional BERA elements that are needed will be developed through a BERA Problem Formulation step and may include the following:

1. Additional evaluation of risks to benthic invertebrates;
2. Evaluation of risks to fish (this may be a qualitative or quantitative assessment); or
3. Evaluation of risks to wildlife species that use the aquatic environment or terrestrial environment.

Food-chain exposures to fish and wildlife will be evaluated if river and terrestrial habitat exist and sediment and soil contamination of bioaccumulative chemicals are above ambient levels. Models and/or measurements will be used to evaluate food-chain exposures of fish and wildlife as part of the BERA.

The overall ERA process for the upland environment is shown in Figure 2C, and for the aquatic environment, in Figure 2D. The following is a more detailed discussion of the elements of the SLERA and BERA.

6.2.1 Screening-Level Ecological Risk Assessment

Steps 1 and 2 of the ERA process are shown in Figure 3. The SLERA accepts a higher level of uncertainty and uses protective assumptions to manage data gaps. The goal of the SLERA is to compare maximum concentrations of chemicals in media of concern to screening values (discussed in Section 7), to quickly determine whether a more detailed ecological assessment is warranted. If the results of the SLERA indicate that site concentrations are below screening levels that pose an ecological health concern, then no further assessment is warranted. The exception to this would be if COPCs are detected that tend to bioaccumulate through a food chain. Under this circumstance, further evaluation may be needed. However, based on experience at other MGPs, it is anticipated that COPCs that bioaccumulate up the food chain will not be detected. If necessary, the additional level of evaluation required will be addressed after the initial SLERA screening steps are performed.

The following is a description of the SLERA elements that will be performed for each MGP site:

- Perform a site reconnaissance to assess the ecology of the area and potential chemical transport processes
- Obtain information on the potential presence of any threatened or endangered species or sensitive environments in the area of the site from government resources
- Revise the Generalized CSM for the site-specific conditions (this is an ongoing process)
- Review any existing or newly acquired analytical data for the site
- Perform terrestrial screening evaluation for upland areas based on existing data if ecological habitat exists; the screening assessment will compare surface soil data to ecological soil screening values (Section 7)
- Perform aquatic screening evaluations based on comparison to step-one data from the surface-water and sediment investigation. The screening assessment will compare surface-water and sediment data to ecological screening values (Section 7).

For purposes of this RAF, the SLERA process will be used only for a site that has sufficient upland terrestrial habitat. The upland SLERA will be performed using previously collected soil data (reviewed for data quality).

A SLERA-BERA is anticipated to be conducted in the aquatic environment to focus the aquatic ERA and to complement the BERA-level evaluations that are being performed. The SLERA for the aquatic environment will use surface-water and sediment data collected during the first step of the field investigation. These data will be used to:

- Select an appropriate group of sediment samples for toxicity testing, if conducted, and ultimately evaluate whether there is a dose-response relationship between the COPC concentrations (assumed to be driven by total PAHs) and toxicity test results
- Focus the ERA and further aquatic investigations on only those chemicals that have a potential to pose an ecological concern in the aquatic environment
- If appropriate, eliminate the need for further evaluation of certain media (e.g., surface water).

6.2.2 Baseline Ecological Risk Assessment

BERA-level assessments rely on in-depth risk calculations and site-specific studies of exposure and toxicity. As discussed above, a combined SLERA-BERA will be conducted for aquatic sediments, because it is expected, based on historical data, that there will be sediment concentrations of COPCs that will exceed sediment screening values. However, if surficial sediment concentrations measured as part of the remedial investigation do not exceed screening values, or if the spatial extent of the exceedances is limited, the need for the sediment toxicity testing and additional habitat evaluation will be re-evaluated in the field in conjunction with USEPA.

When sediment screening levels are exceeded and trigger the need for further evaluation, information from other lines of evidence, including a qualitative benthic invertebrate community field survey and toxicity studies, will be used to characterize whether unacceptable ecological risks are predicted to occur at the site. If ecological risk is predicted based on these multiple lines of evidence, they will be used to identify spatially explicit areas that are predicted to pose various degrees of exposure and risks.

It is not anticipated that a BERA will be required for the terrestrial portion of most sites. However, this will be determined based on the terrestrial SLERA results. The following is a discussion of the anticipated BERA elements for the aquatic environments at each site. Subsequent BERA tasks may be needed based on site-specific conditions and the results of the SLERA-BERA tasks proposed for the aquatic portions of the sites.

6.2.2.1 Qualitative Biological Survey of Aquatic Habitat and Benthic Invertebrate Community

A qualitative biological assessment will be conducted to obtain more in-depth information on the biological community (including fish and benthic invertebrate habitat quality). This work will be conducted concurrently with sampling for chemistry and toxicity during the first step of the surface-water and sediment investigation. The assessment will include evaluating habitat quality for fish and benthic invertebrates and may also include collecting samples to characterize the composition of the benthic invertebrate community. Results of this biological assessment will be used to complement the results of the toxicity testing.

The Rapid Bioassessment Protocols (Barbour et al. 1999) (a "non-quantitative" methodology that yields comparative indices) may be applied to the benthic invertebrate community at each site to determine whether there are obvious effects on the benthic invertebrate community associated with the presence of MGP-related contaminants that may correlate to toxicity test results. The specific bioassessment protocols will be tailored to the characteristics of the water body present at the site, and the details of the methods will be provided in the SSWP. The evaluation will involve a comparison of upstream ambient locations with adjacent and downstream stations, taking into account habitat conditions that may influence abundance and diversity. As part of the sediment investigation, selected areas where sediment samples are collected for sediment toxicity testing may be evaluated in regard to the benthic invertebrate community. Information obtained from the qualitative (e.g., non-quantitative) assessment will be used as a line of evidence in the BERA with the quantitative toxicity test results, to delineate areas within which there are various degrees of exposure and risks (see discussion in Section 8).

6.2.2.2 Toxicity Testing and Evaluation

A decision will be made regarding the collection of sediment samples for toxicity testing based on the chemistry results for total PAH provided by the mobile laboratory or fixed-base analytical laboratory with fast turnaround. The approach to collecting the subsamples will be included in the SSWP. These analyses will be used to select the sediment samples to be tested for toxicity. These "real-time" analyses are intended for use only in identifying a subset of sediment samples for toxicity testing that have a suitable range of PAH concentrations. Subsamples of the sediment samples that are selected for toxicity testing will also be analyzed for the COPCs in Table 1, sediment grain size, black carbon, and total organic carbon, using standard methods in a fixed laboratory. The toxicity of ambient upstream sediments will also be determined for areas that exhibit sediment characteristics similar to those at the site.

The aquatic test species to be used in the sediment toxicity testing is the freshwater amphipod, *Hyalella azteca.* This species has been recommended for use by USGS (Christopher Ingersoll, USGS, personal communication with Charles Menzie, Exponent) and is the species tested most frequently when deriving freshwater consensus values (MacDonald et al. 2000). The toxicity test endpoint will be 28-day survival and growth (weight and length) to evaluate the toxicity of whole sediments.

The toxicity test data will be used to evaluate concentrations of chemicals of concern (normalized with black carbon and total organic carbon using the ESB approach described in Section 7.2) that pose a potential risk to benthic invertebrates. The toxicity test results will be plotted against the chemical concentrations and ESB toxicity scores (Section 7.2) to determine whether there is a dose-response relationship. Both measures of survival and growth will be evaluated separately.

6.2.3 Application of Synoptic Data Across Sites

Under the multi-site approach, information from one or more of the initial site investigations may be applied to an ERA performed at a later site. For example, if there is a dose-response relationship found between total PAH (34) concentrations (or ESB toxicity scores) that is a reliable predictor of-sediment toxicity, results from the ERA conducted at an earlier site may be used to help evaluate and refine screening values at future sites. Also, environmental parameters and bioavailability tools (see Section 3) found to correlate well with sediment toxicity in earlier investigations (e.g., contaminant concentrations, organic carbon, and black carbon) may be measured in the later investigations to predict which sediment may be potentially toxic, and thus to reduce the scope of any subsequent site-specific toxicity testing.

7 Ecological Screening Levels and Methods

The ecological screening levels to be used in the SLERA to evaluate soil, sediment, and surface-water analyte concentrations are described in this section, along with the screening-level approaches that may be used at the MGP sites. It should be noted that the ecological screening values are used only as a conservative tool in the SLERA, to determine whether further ERA is required (i.e., the need for a BERA).

7.1 Ecological Screening Levels for Sediment

The ecological screening level for sediments will be taken from federal and state (Wisconsin or Illinois, as appropriate) sources. While comparisons will be made to all the various benchmarks, screening will be based primarily on comparisons to values that are relied upon by EPA. If concentrations are above state values but below EPA values, this will be noted in the risk assessments. Such chemicals will be discussed qualitatively within the SLERA and BERA. The following are the proposed sources of ecological screening levels for sediment that will be used for screening purposes only in the SLERA. The proposed sediment screening values are presented in Table 4. The first three benchmarks are from federal sources, while the remaining two are applicable to Wisconsin or Illinois, respectively.

1. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures (USEPA 2003b)

2. Consensus-based Sediment Quality Guidelines ([SQGs], MacDonald et al. 2002)

3. RCRA Ecological Screening Levels (ESLs) (USEPA Region 5 August 2003)

4. EcoTox Threshold (ET) value (USEPA January 1996)

5. Consensus-based Sediment Quality Guidelines (CBSQGs): Recommendations for use and application - interim guidance (WDNR December 2003)

6. IEPA values from the Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments (IEPA 2003, Draft Update); Baseline Sediment Cleanup Objectives (BSCOs) for petroleum product releases; Evaluation of Illinois Sieved Stream Sediment Data 1982–1995 (IEPA 1997), and Sediment Classification for Illinois Inland Lakes (Kelly and Hite 1996), an Update to Kelly and Hite (1981).

These references will be used in a hierarchical approach. For example, if all chemicals except one can be compared to Equilibrium Partitioning Sediment Benchmarks (ESBs) and MacDonald et al. (2000), that document will be used for all chemicals, and the one remaining chemical will use a screening value from other sources in the order listed above. Values that are assigned a higher tier are those that have undergone a more thorough and/or current peer review. The lower tiers are based on less current data than higher tiers or have not been peer reviewed.

7.2 Ecological Screening Levels for Surface Water

The following is the proposed hierarchy for sources of ecological screening levels for surface water that will be used for screening purposes only in the SLERA. The proposed surface-water screening values are presented in Table 5.

- EPA National Recommended Water Quality Criteria (NRWQC) (U.S. EPA 2002): http://www.epa.gov/waterscience/criteria/wqcriteria.html
- EPA Eco Update 3.2 EcoTox Thresholds: http:www.epa.goc/oswer/riskassessment/pdf/eco_updt.pdf
- Canadian Council of Ministers of the Environment. 2003. Canadian environmental quality guidelines: Summary table. December: http:www.ccme.ca/publications/ceqg_rcqe.html
- Suter, G.W. II, and C.L. Tsao. 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota. ES-ER/TM-96/Rs: http:www.esd.ornl.gov/programs/ecorisk/tm96r2.pdf.
- RCRA Ecological Screening Levels (USEPA Region 5 August 2003).

The NRWQC were developed in the most scientifically sound manner and have undergone a great deal of scientific review. These criteria will be used as first-tier values when they are available. The ESLs were often based on limited data sets and will be used only if a specific NRWQC is not available.

7.3 Ecological Screening Levels for Soils

The following is the proposed hierarchy for sources of ecological screening levels for soil that will be used for screening purposes only in the SLERA. These benchmarks both come from federal sources, and there are currently no published ecological soil screening benchmarks for soils in Wisconsin or Illinois. The proposed soil screening values are presented in Table 6.

- Ecological Soil Screening Levels ([EcoSSLs] (USEPA 2007)
- RCRA Ecological Screening Levels ([ESL] (USEPA Region 5 August 2003).

The EcoSSLs were developed in the most scientifically sound manner and have undergone a great deal of scientific review. These levels will be used as first-tier values when they are available. The ESLs were often based on limited data sets and thus are used only if an EcoSSL is not available.

For purposes of the SLERA, the ecological screening level will be used to determine whether the COPCs may present an ecological risk and therefore require further analysis. The maximum detected concentration in sediment, surface water, and soil will be compared to the applicable ecological screening value for a given medium. If COPCs do not exceed ecological screening levels, no further ecological evaluation is warranted.

7.4 Equilibrium Partitioning Sediment Benchmark (ESB) Analysis

EPA has developed a method to evaluate whether a mixture of PAHs in a sediment sample would be predicted to pose a health concern to benthic invertebrates. The use of a site-specific ESB approach that accounts for the contribution that different forms of organic carbon can have on the partitioning behavior of PAHs in sediment is a method that has undergone review and is currently being refined by the scientific community. Each of the sediment samples-evaluated in the toxicity test will also be analyzed for parent and alkylated PAHs (34), PVOCs, phenols, metals, cyanide, sediment grain size, black carbon content, and total organic carbon content. Total PAHs (34), black carbon content, and total organic carbon content will be used with the ESB approach to calculate a toxicity score for each-sediment sample for the mixture of PAHs present in the samples that are used in the laboratory toxicity testing. These scores will be used as a covariate when evaluating and predicting the toxicity of the sediment samples.

The *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures* (USEPA 2003b) will be used to develop toxicity scores for each of the sediment samples. This guidance recognizes that black carbon can have an effect on PAH bioavailability, but does not provide a method for factoring in black carbon. Therefore, additional analysis will be included in the current ESB method to account for the presence of black carbon.

8 Defining Risk Zones Within the Aquatic Environment

The information developed from the BLRA and BERA will be used to identify the magnitude and nature of risks within the aquatic environment. Both human health and ecological risks will be evaluated. However, it is expected that the risk to ecological receptors will be the primary focus. These ecological risks could include effects on benthic invertebrates, as well as fish and wildlife. It is anticipated that the risk-related information for benthic invertebrates will be used to identify geographic areas within which there are various degrees of exposure and risks. It is anticipated that any risks to wildlife will occur largely along the shoreline or in shallow water, because these are the areas most accessible to those groups of animals.

The results of the BLRA and BERA will be used to distinguish areas exhibiting different degrees of exposure and risk. These areas may be defined in terms of concentrations for individual compounds or groups of compounds (e.g., total PAHs or carcinogenic PAHs). Normalization methods will be used to provide consistency in the application of these levels. Risks and risk zones might also be related to the presence and absence of toxicity.

Information on either a chemical concentration basis or a toxicity basis will be used to define the boundaries of the risk zones (Figure 4). These are geographic areas or sets of conditions that provide insight into the spatial extent, nature, and magnitude of risks. Experience gained at initial sites will be used to refine the process of describing and identifying zones. For the present, EPA's qualitative terms[1] "substantial exposure" and "low exposure" (USEPA 2005) are adopted to describe areas or conditions where human health and ecological risks are present in the river. As data are gathered, these zones may be refined further. Two additional zones, beyond the areas where risks are identified, may also be characterized. The first is referred to as the "zone of no significant risk." This zone would include areas where initial screening of chemicals or other measures to assess exposure and effects indicates that risks are not present or are considered to be insignificant. The second zone is referred to as "ambient conditions." This is the region of the river that is outside of any measurable imprint associated with the site. For rivers, these may be characterized by physical and/or biological conditions upstream from the site. It should be noted that the focus of the BLRA will be on refining the boundaries of the zones to distinguish zones of "substantial risk" from "low exposure."

Zones (Figure 4) will be defined either by using results of the BLRA or by using screening values (e.g., threshold effects concentration and probable effects concentration). An appropriate use of screening values to define zones may be when a zone of significant risk (defined by source materials or very high PAH concentrations) attenuates very quickly to a screening value (e.g., PEC) moving away from the source. In such an instance, there may be little difference in area and volume, such that an adaptive management decision could be to include all areas above the screening value into an area to be evaluated in the FS.

[1] This qualitative terminology is taken from USEPA (2005) Highlight 7-2 and is intended as a general tool for project managers as they look more closely at particular remedial approaches when certain characteristics are present. The terms are used here because the risk information will be used to guide response actions.

Defining the geographic boundaries of these zones will eventually serve to inform management decisions and evaluate the appropriate response actions to be considered in the FS.

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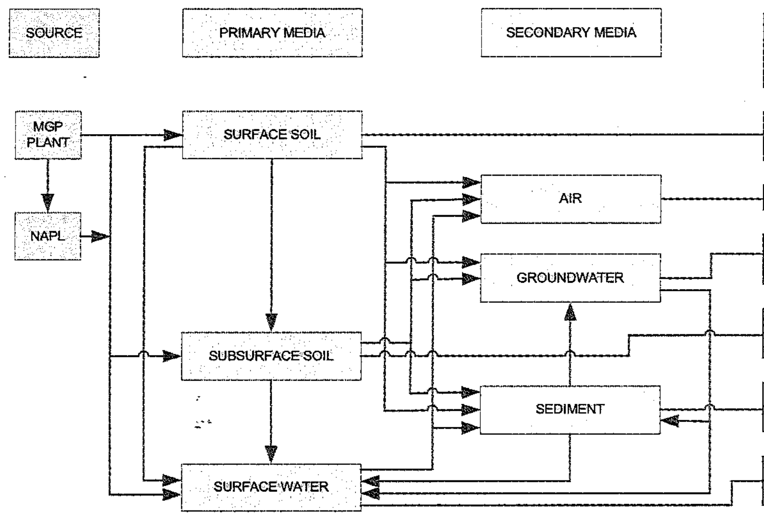
Figures



EXPOSURE ROUTE	HUMAN RECEPTORS				ECOLOGICAL RECEPTORS			
	INDUSTRIAL/ COMMERCIAL WORKER	CONSTRUCTION WORKER	RECREATIONAL	RESIDENTIAL	BIRDS	MAMMALS	FISH	BENTHIC INVERTEBRATES
INGESTION	●	●	●	●	◊	◊	NA	NA
DERMAL	●	●	●	●	◊	NA	NA	NA
INHALATION	●	●	●	●	NA	NA	NA	NA
INGESTION	●	○	○	●	NA	NA	NA	NA
DERMAL	●	●	○	●	NA	NA	NA	NA
INGESTION	●	●	○	●	NA	◊	NA	NA
DERMAL	●	●	○	●	NA	NA	NA	NA
INGESTION	○	○	●	○	◊	◊	◊	●
DERMAL	○	○	●	○	◊	NA	◊	●
INGESTION	○	○	●	○	◊	◊	◊	●
DERMAL	○	○	●	○	◊	NA	◊	●

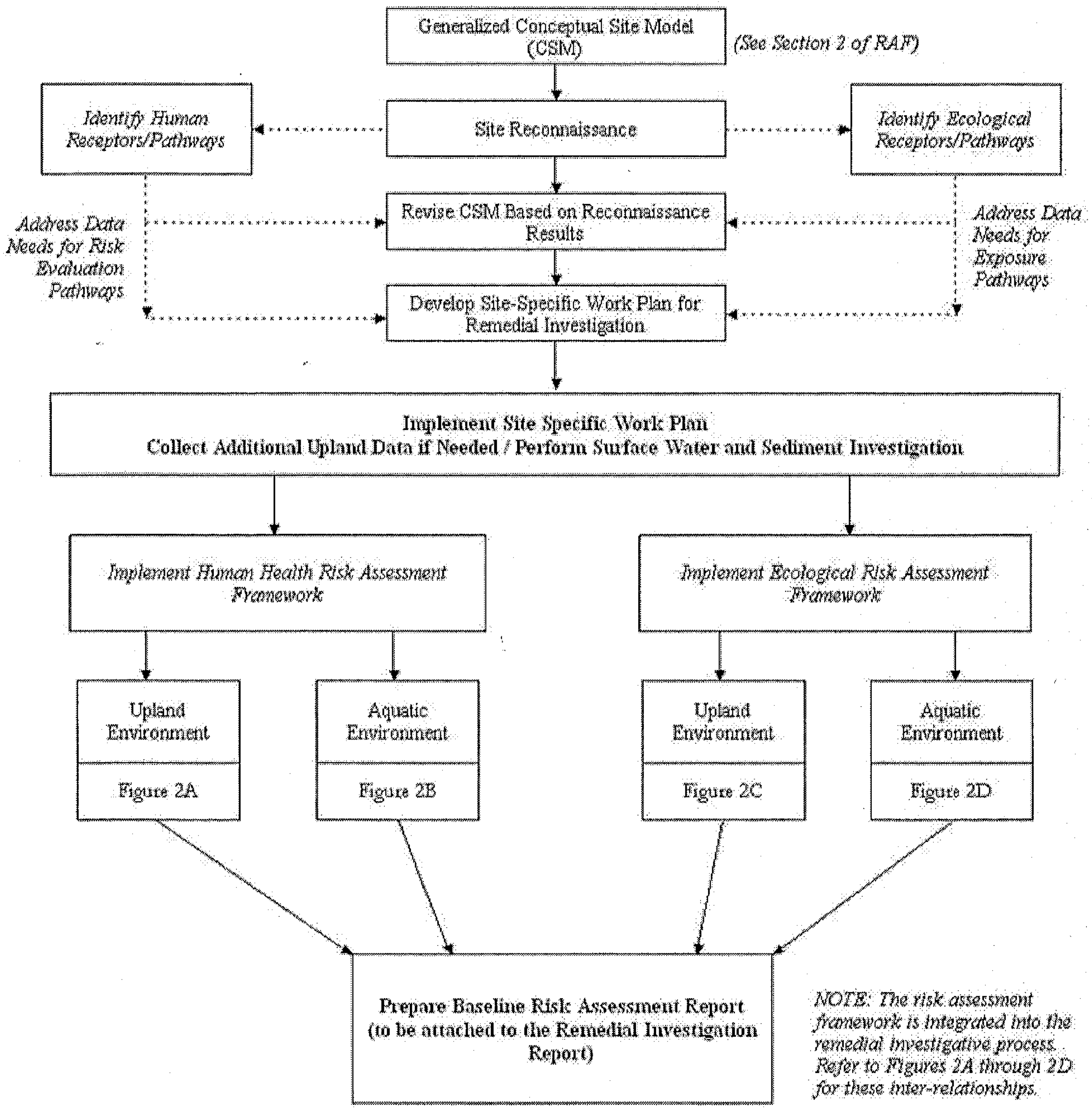
LEGEND:

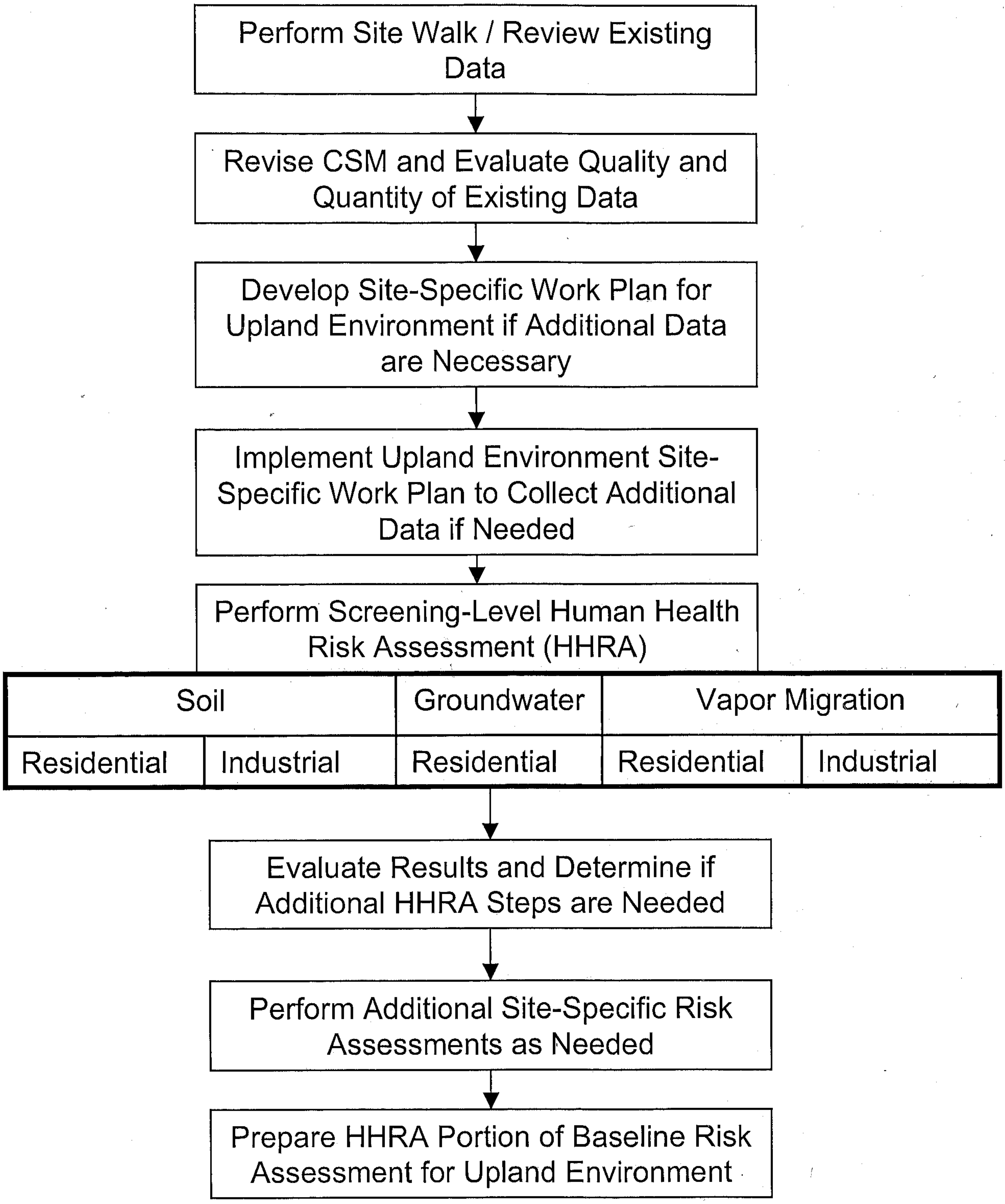
- ● Pathway potentially complete and warrants further evaluation within the Baseline Risk Assessment. The level of evaluation will be dependent on site conditions.
- ○ Pathway not complete or considered insignificant; No further evaluation is recommended unless warranted based on site-specific conditions.
- ◊ Pathway potentially complete and will be evaluated based on the results of the ecological habitat assessment described in the Site-Specific Work Plan.
- NA: Not Applicable

NOTES:

1. The Generalized Conceptual Site Model will be evaluated on a site-by-site basis. Pathways shown as complete may not be complete at all sites and may be handled qualitatively or quantitatively within the Baseline Risk Assessment.
2. Discussion of exposure assumptions will be included in the Site-Specific Work Plans.
3. Birds and mammals may include aquatic and terrestrial ecological receptors.

Figure 1		GENERALIZED CONCEPTUAL SITE MODEL FOR FORMER MGP SITES	Drawn By: TJG	Date 08/03/2007
			Checked	MK
Revision 0			Approved	SM


Generalized Conceptual Site Model (CSM)
(See Section 2 of RAF)
Identify Human Receptors/Pathways
Site Reconnaissance
Identify Ecological Receptors/Pathways
Address Data Needs for Risk Evaluation Pathways
Revise CSM Based on Reconnaissance Results
Address Data Needs for Exposure Pathways
Develop Site-Specific Work Plan for Remedial Investigation
Implement Site Specific Work Plan
Collect Additional Upland Data if Needed / Perform Surface Water and Sediment Investigation
Implement Human Health Risk Assessment Framework
Implement Ecological Risk Assessment Framework
Upland Environment
Figure 2A
Aquatic Environment
Figure 2B
Upland Environment
Figure 2C
Aquatic Environment
Figure 2D
Prepare Baseline Risk Assessment Report (to be attached to the Remedial Investigation Report)
NOTE: The risk assessment framework is integrated into the remedial investigative process. Refer to Figures 2A through 2D for these inter-relationships.

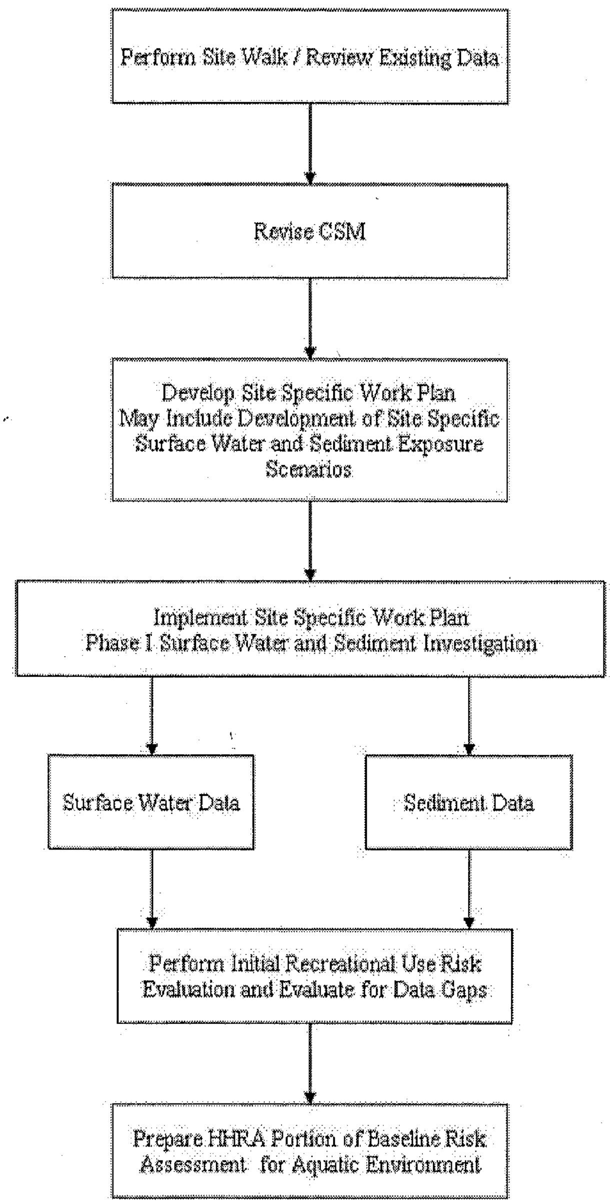


Exponent®

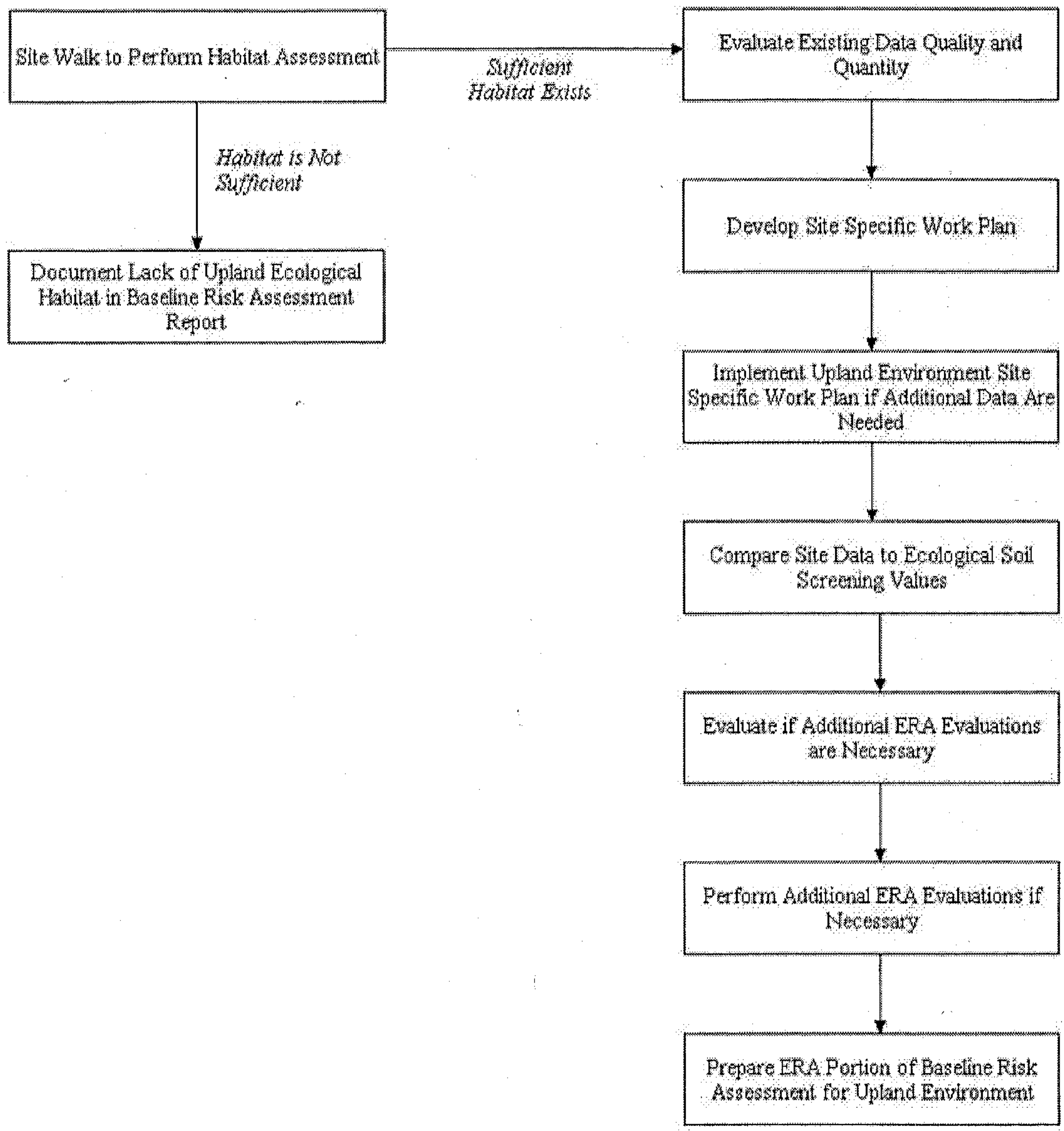
Baseline Ecological Risk Assessment

UPLAND HUMAN HEALTH RISK ASSESSMENT FRAMEWORK

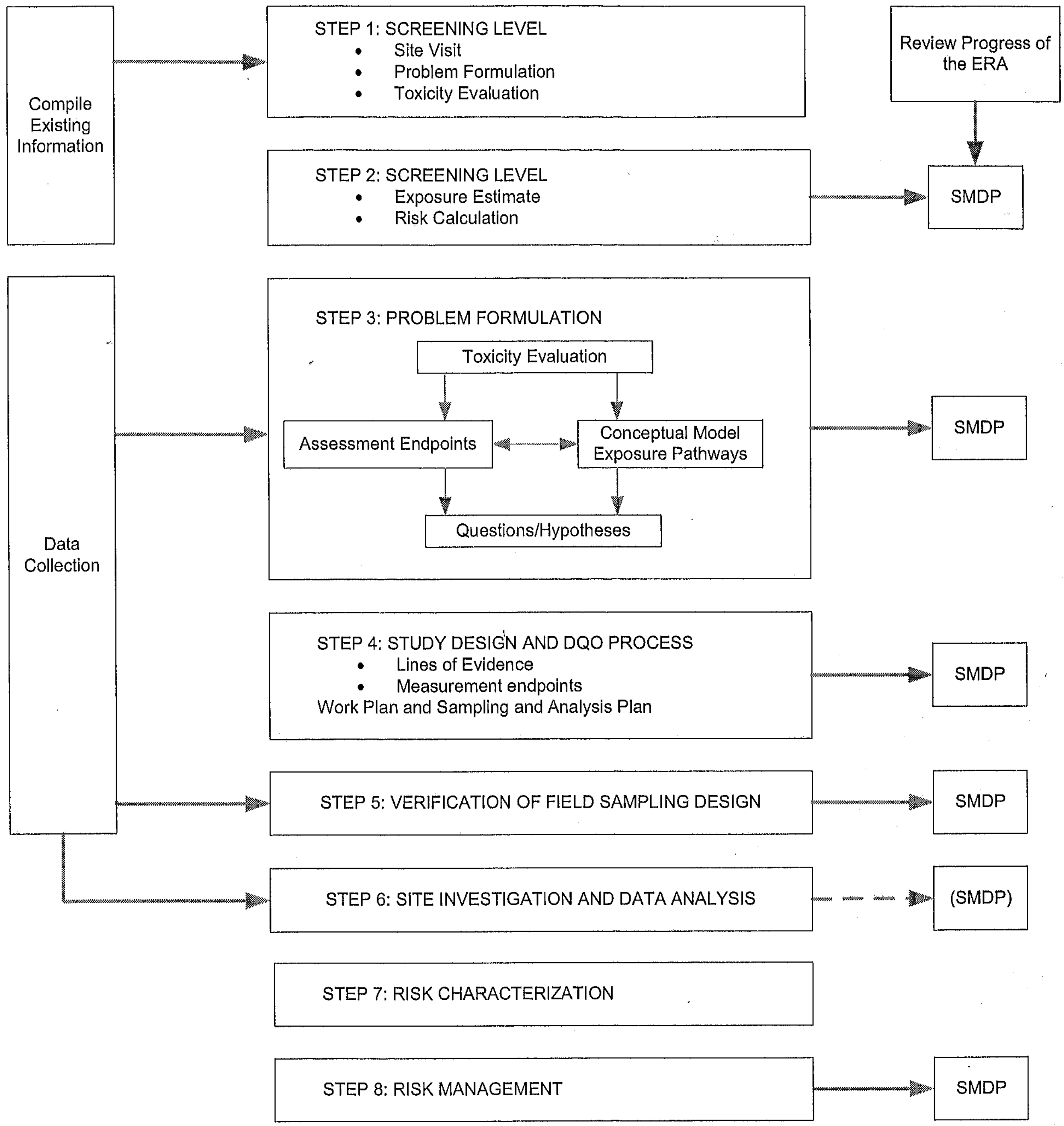
FIGURE 2A



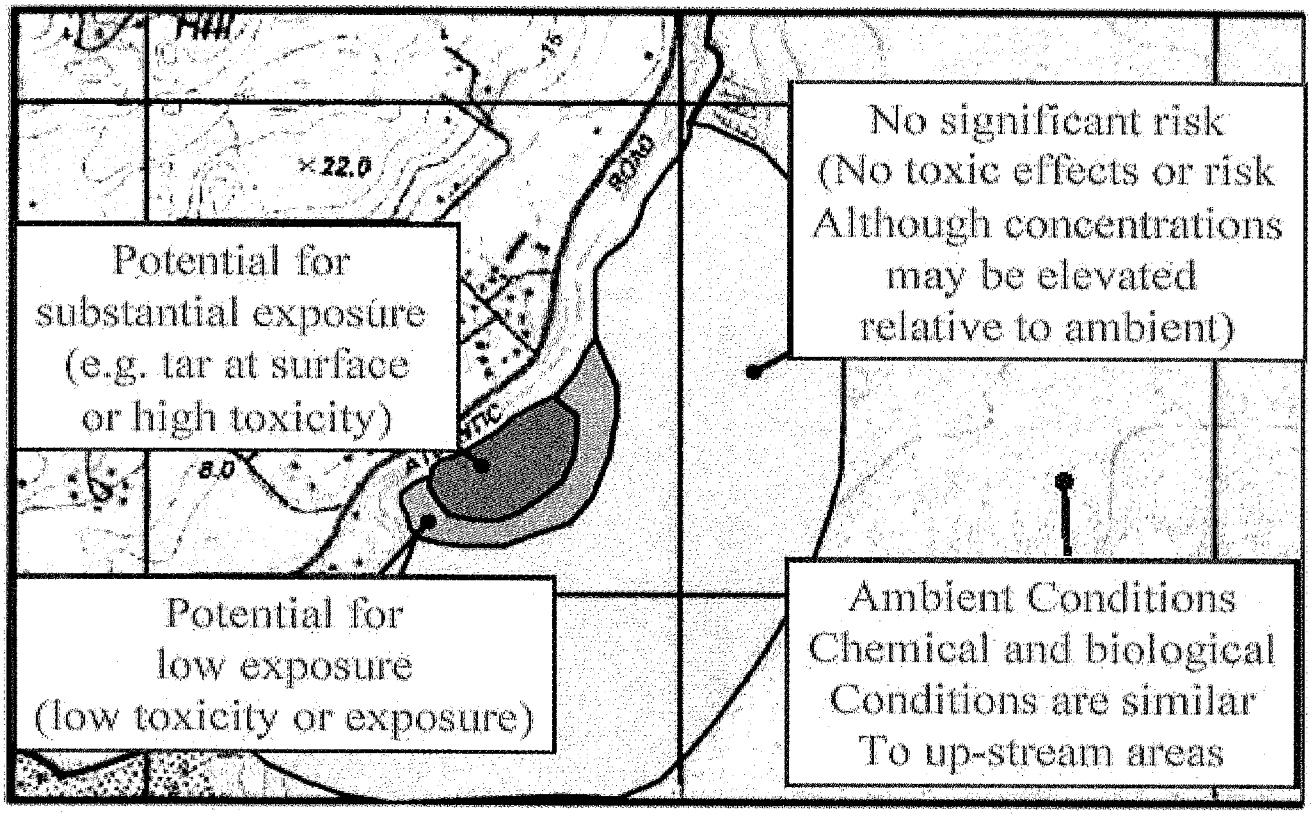
Exponent	Baseline Ecological Risk Assessment	AQUATIC ENVIRONMENT HUMAN HEALTH RISK ASSESSMENT (HHRA) FRAMEWORK	FIGURE 2B



Exponent	Baseline Ecological Risk Assessment	UPLAND ECOLOGICAL RISK ASSESSMENT (ERA) FRAMEWORK	FIGURE 2C



Exponent®	Baseline Ecological Risk Assessment	EIGHT STEP ECOLOGICAL RISK ASSESSMENT PROCESS (USEPA 1997)	FIGURE 3



Exponent	Baseline Ecological Risk Assessment	RISK ZONES WITHIN THE AQUATIC ENVIRONMENT	FIGURE 4

Tables

Table 1. MGP-related contaminants of potential concern, former MGP sites, EPA Region 5

PAHs	PVOCs	Inorganic Compounds	Acid Extractable Organic Compounds
Naphthalene	Benzene	Aluminum	2,4-Dimethylphenol
C1-Naphthalenes[a]	Ethylbenzene	Antimony	2-Methylphenol
C2-Naphthalenes[a]	Toluene	Arsenic	4-Methylphenol
C3-Naphthalenes[a]	Xylenes (Total)	Barium	Phenol
C4-Naphthalenes[a]	1,3,5-trimethylbenzene	Cadmium	
Acenaphthylene	1,2,4-trimethylbenzene	Chromium	
Acenaphthene		Copper	
Fluorene		Cyanide	
C1-Fluorenes[a]		Iron	
C2-Fluorenes[a]		Lead	
C3-Fluorenes[a]		Manganese	
Phenanthrene		Mercury	
Anthracene		Nickel	
C1-Phenanthrenes/Anthracenes[a]		Selenium	
C2-Phenanthrenes/Anthracenes[a]		Silver	
C3-Phenanthrenes/Anthracenes[a]		Vanadium	
C4-Phenanthrenes/Anthracenes[a]		Zinc	
Fluoranthene			
Pyrene			
C1-Fluoranthenes/Pyrenes[a]			
Benzo[a]anthracene			
Chrysene			
C1-Chrysenes[a]			
C2-Chrysenes[a]			
C3-Chrysenes[a]			
C4-Chrysenes[a]			
Benzo[b]fluoranthene			
Benzo[k]fluoranthene			
Benzo[e]pyrenea			
Benzo[a]pyrene			
Perylene[a]			
Indeno[1,2,3-cd]pyrene			
Dibenzo[a,h]anthracene			
Benzo[g,h,i]perylene			
2-Methylnaphthalene			

Note: EPA - U.S. Environmental Protection Agency
PAH - polycyclic aromatic hydrocarbon
PVOC - petroleum volatile organic compounds

[a] Additional PAHs to be analyzed in sediment only for comparison to *Equilibrium Partitioning Sediment Benchmarks* (U.S. EPA 2003).

Table 2. Human health soil benchmarks, former Wisconsin MGP sites, EPA Region 5

	EPA[a] (mg/kg)							NR 720[b] (mg/kg, dry)		IEPA[c] (mg/kg, dry)	
Project Compound List	Residential SSLs Ingestion-Dermal	Residential SSLs Inhalation of Volatiles	Residential SSLs Inhalation of Fugitive Particles	Outdoor Worker SSLs Ingestion-Dermal	Outdoor Worker SSLs Inhalation of Volatiles	Outdoor Worker SSLs Inhalation of Fugitive Particles	Indoor Worker SSLs Ingestion-Dermal	Soil Non-Industrial	Soil Industrial	Soil Residential Ingestion	Soil Residential Inhalation
PVOCs											
Benzene	1.2E+01	8.0E-01	NA	5.8E+01	1.0E+00	NA	1.0E+02	NA	NA	1.2E+01	8.0E-01
Ethylbenzene	7.8E+03	4.0E+02	NA	1.1E+05	4.0E+02	NA	2.0E+05	NA	NA	7.8E+03	4.0E+02
Toluene	1.6E+04	6.5E+02	NA	2.3E+05	6.5E+02	NA	4.1E+05	NA	NA	1.6E+04	6.5E+02
Xylenes	1.6E+05	NA	NA	1.0E+06	NA	NA	1.0E+06	NA	NA	1.6E+04	3.2E+02
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Semivolatile Organic Compounds											
PAHs											
Acenaphthene	3.4E+03	NA	NA	3.7E+04	NA	NA	1.2E+05	NA	NA	4.7E+03	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	1.7E+04	NA	NA	1.8E+05	NA	NA	6.1E+05	NA	NA	2.3E+04	NA
Benzo[a]anthracene	6.0E-01	NA	NA	2.0E+00	NA	NA	8.0E+00	NA	NA	9.0E-01	NA
Benzo[b]fluoranthene	6.0E-01	NA	NA	2.0E+00	NA	NA	8.0E+00	NA	NA	9.0E-01	NA
Benzo[k]fluoranthene	6.0E+00	NA	NA	2.3E+01	NA	NA	7.8E+01	NA	NA	9.0E+00	NA
Benzo[a]pyrene	6.0E-02	NA	NA	2.0E-01	NA	NA	8.0E-01	NA	NA	9.0E-02	NA
Benzo[g,h,i]perylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	6.2E+01	NA	NA	2.3E+02	NA	NA	7.8E+02	NA	NA	8.8E+01	NA
Dibenzo[a,h]anthracene	6.0E-02	NA	NA	2.0E-01	NA	NA	8.0E-01	NA	NA	9.0E-02	NA
Fluoranthene	2.3E+03	NA	NA	2.4E+04	NA	NA	8.2E+04	NA	NA	3.1E+03	NA
Fluorene	2.3E+03	NA	NA	2.4E+04	NA	NA	8.2E+04	NA	NA	3.1E+03	NA
Indeno[1,2,3-cd]pyrene	6.0E-01	NA	NA	2.0E+00	NA	NA	8.0E+00	NA	NA	9.0E-01	NA
Naphthalene	1.1E+03	1.7E+02	NA	1.2E+04	2.4E+02	NA	4.1E+04	NA	NA	1.6E+03	1.7E+02
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1.7E+03	NA	NA	1.8E+04	NA	NA	6.1E+04	NA	NA	2.3E+03	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenols											
2,4-dimethylphenol	1.2E+03	NA	NA	1.4E+04	NA	NA	4.1E+04	NA	NA	1.6E+03	NA
2-methylphenol	3.1E+03	NA	NA	3.4E+04	NA	NA	1.0E+05	NA	NA	3.9E+03	NA
4-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	1.8E+04	NA	NA	2.1E+05	NA	NA	6.1E+05	NA	NA	2.3E+04	NA
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Antimony	3.1E+01	NA	NA	4.5E+02	NA	NA	8.2E+02	NA	NA	3.1E+01	NA
Arsenic	4.0E-01	NA	7.7E+02	2.0E+00	NA	1.4E+03	4.0E+00	**3.9E-02**	1.6E+00	NA	7.5E+02
Barium	5.5E+03	NA	7.1E+05	7.9E+04	NA	1.0E+06	1.4E+05	NA	NA	5.5E+03	6.9E+05

Table 2. (cont.)

Project Compound List	EPA[a] (mg/kg) Residential SSLs Ingestion-Dermal	Residential SSLs Inhalation of Volatiles	Residential SSLs Inhalation of Fugitive Particles	Outdoor Worker SSLs Ingestion-Dermal	Outdoor Worker SSLs Inhalation of Volatiles	Outdoor Worker SSLs Inhalation of Fugitive Particles	Indoor Worker SSLs Ingestion-Dermal	NR 720[b] (mg/kg, dry) Soil Non-Industrial	Soil Industrial	IEPA[c] (mg/kg, dry) Soil Residential Ingestion	Soil Residential Inhalation
Cadmium	7.0E+01	NA	1.8E+03	9.0E+02	NA	3.4E+03	2.0E+03	8.0E+00	5.1E+02	7.8E+01	1.8E+03
Chromium (trivalent)	1.2E+05	NA	NA	1.0E+06	NA	NA	1.0E+06	**1.6E+04**	NA	1.2E+05	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.9E+03	NA
Cyanide (free)	1.6E+03	NA	NA	2.3E+04	NA	NA	4.1E+04	NA	NA	1.6E+03	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	**5.0E+01**	5.0E+02	**4.0E+02**	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	**1.6E+03**	6.9E+04
Mercury	2.3E+01	1.0E+01	NA	3.4E+02	1.4E+01	NA	6.1E+02	NA	NA	2.3E+01	1.0E+01
Nickel	1.6E+03	NA	1.4E+04	2.3E+04	NA	2.6E+04	4.1E+04	NA	NA	1.6E+03	1.3E+04
Selenium	3.9E+02	NA	NA	5.7E+03	NA	NA	1.0E+04	NA	NA	3.9E+02	NA
Silver	3.9E+02	NA	NA	5.7E+03	NA	NA	1.0E+04	NA	NA	3.9E+02	NA
Vanadium	5.5E+02	NA	NA	7.9E+03	NA	NA	1.4E+04	NA	NA	5.5E+02	NA
Zinc	2.3E+04	NA	NA	3.4E+05	NA	NA	6.1E+05	NA	NA	2.3E+04	NA

Table 2. (cont.)

	IEPA[c] (mg/kg, dry)			
Project Compound List	Soil Industrial-Commercial Ingestion	Soil Industrial-Commercial Inhalation	Soil Construction Worker Ingestion	Soil Construction Worker Inhalation
PVOCs				
Benzene	1.0E+02	1.6E+00	2.3E+03	2.2E+00
Ethylbenzene	2.0E+05	4.0E+02	2.0E+04	5.8E+01
Toluene	4.1E+05	6.5E+02	4.1E+05	4.2E+01
Xylenes	4.1E+05	3.2E+02	4.1E+04	5.6E+00
1,3,5-Trimethylbenzene	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA
Semivolatile Organic Compounds				
PAHs				
Acenaphthene	1.2E+05	NA	1.2E+05	NA
Acenaphthylene	NA	NA	NA	NA
Anthracene	6.1E+05	NA	6.1E+05	NA
Benzo[a]anthracene	8.0E+00	NA	1.7E+02	NA
Benzo[b]fluoranthene	8.0E+00	NA	1.7E+02	NA
Benzo[k]fluoranthene	7.8E+01	NA	1.7E+03	NA
Benzo[a]pyrene	8.0E-01	NA	1.7E+01	NA
Benzo[g,h,i]perylene	NA	NA	NA	NA
Chrysene	7.8E+02	NA	1.7E+04	NA
Dibenzo[a,h]anthracene	8.0E-01	NA	1.7E+01	NA
Fluoranthene	8.2E+04	NA	8.2E+04	NA
Fluorene	8.2E+04	NA	8.2E+04	NA
Indeno[1,2,3-cd]pyrene	8.0E+00	NA	1.7E+02	NA
Naphthalene	4.1E+04	2.7E+02	4.1E+03	1.8E+00
Phenanthrene	NA	NA	NA	NA
Pyrene	6.1E+04	NA	6.1E+04	NA
2-Methylnaphthalene	NA	NA	NA	NA
Phenols				
2,4-dimethylphenol	4.1E+04	NA	4.1E+04	NA
2-methylphenol	1.0E+05	NA	1.0E+05	NA
4-methylphenol	NA	NA	NA	NA
Phenol	6.1E+05	NA	6.1E+04	NA
Inorganics				
Aluminum	NA	NA	NA	NA
Antimony	8.2E+02	NA	8.2E+01	NA
Arsenic		1.2E+03	6.1E+01	2.5E+04
Barium	1.4E+05	9.1E+05	1.4E+04	8.7E+05

Table 2. (cont.)

Project Compound List	Soil Industrial-Commercial Ingestion	Soil Industrial-Commercial Inhalation	Soil Construction Worker Ingestion	Soil Construction Worker Inhalation
	IEPA[c] (mg/kg, dry)			
Cadmium	2.0E+03	2.8E+03	2.0E+02	5.9E+04
Chromium (trivalent)	1.0E+06	NA	3.1E+05	NA
Copper	8.2E+04	NA	8.2E+03	NA
Cyanide (free)	4.1E+04	NA	4.1E+03	NA
Iron	NA	NA	NA	NA
Lead	**8.0E+02**	NA	**7.0E+02**	NA
Manganese	**4.1E+04**	9.1E+04	**4.1E+03**	8.7E+03
Mercury	6.1E+02	1.6E+01	6.1E+01	1.0E-01
Nickel	4.1E+04	2.1E+04	4.1E+03	4.4E+05
Selenium	1.0E+04	NA	1.0E+03	NA
Silver	1.0E+04	NA	1.0E+03	NA
Vanadium	1.4E+04	NA	1.4E+03	NA
Zinc	6.1E+05	NA	6.1E+04	NA

Note: EPA - U.S. Environmental Protection Agency
IEPA - Illinois Environmental Protection Agency
MGP - manufactured gas plant
NA - not available
PAH - polycyclic aromatic hydrocarbon
PVOC - petroleum volatile organic compounds
SSL - soil screening level

[a] EPA supplemental guidance for developing soil screening levels for Superfund sites. OSWER 9355.4-24. December 2002. Appendix A. Generic SSLs for the residential and commercial/industrial scenarios. (www.epa.gov/superfund/health/conmedia/soil/index.htm)

[b] Wisconsin DNR NR 720 Soil Cleanup Standards. January 2001.

[c] IEPA Tier I soil remediation objectives, IAC Title 35, Subtitle G, Chapter I, Subchapter f, Part 742. Appendix B: Table A - Residential Properties and Table B - Industrial/Commercial Properties, effective February 2007.

Table 3. Human health groundwater quality standards, former MGP sites, EPA Region 5

Project Compound List	CAS Number	NR 140 ES[a] mg/L	MCL[b] mg/L	IEPA Class I[c] mg/L	IEPA Class II[c] mg/L
PVOCs					
Benzene	71-43-2	0.005	0.005	0.005	0.025
Ethylbenzene	100-41-4	0.7	0.7	0.7	1.0
Toluene	108-88-3	1	1	1	2.5
Xylenes	1330-20-7	10	10	10	10
1,3,5-Trimethylbenzene[d]	108-67-8	0.48	NA	NA	NA
2,4,6-Trimethylbenzene		NA	NA	NA	NA
Semivolatile Organic Compounds					
PAHs					
Acenaphthene	83-32-9	NA	NA	0.42	2.1
Acenaphthylene	208-96-8	NA	NA	NA	NA
Anthracene	120-12-7	3	NA	2.1	10.5
Benzo[a]anthracene	56-55-3	NA	NA	0.00013	0.00065
Benzo[b]fluoranthene	205-99-2	0.0002	NA	0.00018	0.0009
Benzo[k]fluoranthene	207-08-9	NA	NA	0.00017	0.00085
Benzo[a]pyrene	50-32-8	0.0002	0.0002	0.0002	0.002
Benzo[g,h,i]perylene	191-24-2	NA	NA	NA	NA
Chrysene	218-01-9	0.0002	NA	0.0015	0.0075
Dibenzo[a,h]anthracene	53-70-3	NA	NA	0.0003	0.0015
Fluoranthene	206-44-0	0.4	NA	0.28	1.4
Fluorene	86-73-7	0.4	NA	0.28	1.4
Indeno[1,2,3-cd]pyrene	193-39-5	NA	NA	0.00043	0.00215
Naphthalene	91-20-3	0.1	NA	0.14	0.22
Phenanthrene	85-01-8	NA	NA	NA	NA
Pyrene	119-00-0	0.25	NA	0.21	1.05
2-Methylnaphthalene	91-57-6	NA	NA	NA	NA
Phenols					
2,4-dimethylphenol	105-67-9	NA	NA	0.14	0.14
2-methylphenol	95-48-7	NA	NA	0.35	0.35
4-methylphenol	106-44-5	NA	NA	NA	NA
Phenol	108-95-2	6	NA	0.1	0.1
Inorganics					
Aluminum	7429-90-5	NA	NA	NA	NA
Antimony	7440-36-0	0.006	0.006	0.006	0.024
Arsenic	7440-38-2	0.01	0.010	0.05	0.2
Barium	7440-39-3	2	2	2	2
Cadmium	7440-43-9	0.005	0.005	0.005	0.05
Chromium (total)	16065-83-1	0.1	0.1	0.1	1
Copper	7440-50-8	1.3	1.3	0.65	0.65
Cyanide (hydrogen)	57-12-5	0.2	0.2	0.2	0.6
Iron	7439-89-6	0.3 *	NA	5	5
Lead	7439-92-1	0.015	0.015	0.0075	0.1
Manganese	7439-96-5	0.05 *	NA	0.15	10
Mercury	7439-97-6	0.002	0.002	0.002	0.01
Nickel	7440-02-0	0.1	NA	0.1	2.0
Selenium	7782-49-2	0.05	0.05	0.05	0.05
Silver	7440-22-4	0.05	NA	0.05	NA
Vanadium	7440-62-2	0.03	NA	0.049	0.1
Zinc	7440-66-6	5 *	NA	5	10

Note: * -
EPA - U.S. Environmental Protection Agency
IEPA - Illinois Environmental Protection Agency
MCL - maximum contaminant level
MGP - manufactured gas plant
NA - not available
PAH - polycyclic aromatic hydrocarbon
PVOC - petroleum volatile organic compounds

[a]Wisconsin DNR NR 140 Groundwater Quality Standards. January 2007.

[b]Wisconsin DNR NR 809 Safe Drinking Water Standards. May 2005.

[c] IEPA Tier I groundwater remediation objectives, IAC Title 35, Subtitle G, Chapter I, Subchapter f, Part 742. Appendix B: Table E - Groundwater ingestion, effective February 2007.

[d]NR140ES reported as (1,2,4- and 1,3,5- combined) Trimethylbenzene.

Table 4. Ecological sediment benchmarks, former MGP sites, EPA Region 5

Project Compound List	Freshwater TEC[a] (mg/kg)	Freshwater PEC[a] (mg/kg)	CBSQG TEC[b] (mg/kg)	CBSQG PEC[b] (mg/kg)	EPA RegV ESL[c] (mg/kg)	EPA Ecotox Thresholds[d] (mg/kg)	IEPA BSCO[e] (mg/kg)	IEPA Stream Sediment[f]	IEPA Lake Sediment[g]
PVOCs									
Benzene	NA	NA	0.057	0.11	0.142	0.057	0.082	NA	NA
Ethylbenzene	NA	NA	NA	NA	0.175	3.6	0.023	NA	NA
Toluene	NA	NA	0.89	1.8	1.22	0.67	0.49	NA	NA
Xylenes (total)	NA	NA	0.025	0.05	0.433	0.025	0.42	NA	NA
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Semivolatile Organic Compounds									
PAHs									
Acenaphthene	NA	NA	0.0067	0.089	0.00671	0.62	0.585	NA	NA
Acenaphthylene	NA	NA	0.0059	0.128	0.00587	NA	0.186	NA	NA
Anthracene	0.0572	0.845	0.0572	0.845	0.0572	NA	0.085	NA	NA
Benzo[a]anthracene	0.108	1.05	0.108	1.05	0.108	NA	0.23	NA	NA
Benzo[b]fluoranthene	NA	NA	0.24	13.4	10.4	NA	0.886	NA	NA
Benzo[k]fluoranthene	NA	NA	0.24	13.4	0.24	NA	4.4	NA	NA
Benzo[a]pyrene	0.15	1.45	0.15	1.45	0.15	0.43	0.073	NA	NA
Benzo[g,h,i]perylene	NA	NA	0.17	3.2	0.17	NA	NA	NA	NA
Chrysene	0.166	1.29	0.166	1.29	0.166	NA	0.4	NA	NA
Dibenz[a,h]anthracene	0.033	NA	0.033	0.135	0.033	NA	0.06	NA	NA
Fluoranthrene	0.423	2.23	0.423	2.23	0.423	2.9	2.79	NA	NA
Fluorene	0.0774	0.536	0.0774	0.536	0.0774	0.54	0.035	NA	NA
Indeno[1,2,3-cd]pyrene	NA	NA	0.2	3.2	0.2	NA	0.34	NA	NA
Naphthalene	0.176	0.561	0.176	0.561	0.176	0.48	0.34	NA	NA
Phenanthrene	0.204	1.17	0.204	1.17	0.204	0.85	0.81	NA	NA
Pyrene	0.195	1.52	0.195	1.52	0.195	0.66	0.35	NA	NA
2-Methylnaphthalene	NA	NA	0.0202	0.201	0.0202	NA	NA	NA	NA
Phenols									
2,4-Dimethylphenol	NA	NA	0.29	0.29	0.304	NA	NA	NA	NA
2-Methylphenol	NA	NA	6.7	6.7	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	4.2	12	0.0491	NA	NA	NA	NA
Inorganics									
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	2	25	NA	NA	NA	NA	NA
Arsenic	9.79	33	9.8	33	9.79	8.2	NA	<7.2	4.1 < 14
Barium	NA	NA	NA	NA	NA	NA	NA	<145	94 < 271
Cadmium	0.99	4.98	0.99	5	0.99	1.2	NA	<2.0	< 5
Chromium	43.4	111	43	110	43.4	81	NA	<37	13 < 27
Copper	31.6	149	32	150	31.6	34	NA	<37	16.7 < 100
Cyanide (hydrogen)	NA	NA	NA	NA	0.0001	NA	NA	NA	NA
Iron	NA	NA	20,000	40,000	NA	NA	NA	<26,105	1,6000 < 37,000

Table 4. (cont.)

Project Compound List	Freshwater TEC[a] (mg/kg)	Freshwater PEC[a] (mg/kg)	CBSQG TEC[b] (mg/kg)	CBSQG PEC[b] (mg/kg)	EPA RegV ESL[c] (mg/kg)	EPA Ecotox Thresholds[d] (mg/kg)	IEPA BSCO[e] (mg/kg)	IEPA Stream Sediment[f]	IEPA Lake Sediment[g]
Lead	35.8	128	36	130	35.8	47	NA	<60	14 < 59
Manganese	NA	NA	460	1100	NA	NA	NA	<1,100	500 < 1,700
Mercury	0.18	1.06	0.18	1.1	0.174	0.15	NA	<0.28	< 0.15
Nickel	22.7	48.6	23	49	22.7	21	NA	<26	14.3 < 31
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	1.6	2.2	0.5	NA	NA	≤5	< 0.1
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	121	459	120	460	121	150	NA	<170	59 < 145

Note:

BSCO - baseline sediment cleanup objective
CBSQG - consensus-based sediment quality guideline
EPA - U.S. Environmental Protection Agency
ESL - ecological screening level
IEPA - Illinois Environmental Protection Agency
MGP - manufactured gas plant
NA - not available
PAH - polycyclic aromatic hydrocarbon
PEC -
PVOC - petroleum volatile organic compounds
TEC -

Screening benchmarks would be applied according to the following hierarchy of accepted sources:

[a] MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20–31.

[b] Wisconsin DNR. 2003. Consensus-based sediment quality guidelines (CBSQGs): Recommendations for use and application—interim guidance.

[c] EPA Region 5 ESL (2003).

[d] EPA Office of Solid Waste and Emergency Response. January, 1996. ECO Update: Ecotox thresholds. EPA540/F-95/038.

[e] IEPA 2003. Tiered approach for evaluation and remediation of petroleum product releases to sediments. Draft-Update 3, March 21, 2003. Table 1. Baseline sediment cleanup objectives (BSCO) for petroleum product releases.

[f] IEPA 1997. Evalution of Illinois sieved stream sediment data 1982–1995, Table 5, non-elevated concentrations.

[g] Kelly and Hite. 1996. Sediment classification for Illinois inland lakes, Table 3, normal range. Update to Kelly and Hite, 1981.

Table 5. Proposed ecological surface-water benchmarks, former MGP sites

Project Compound List	National Recommended Water Quality Criteria[a] (μg/L)	EPA Region 5 ESL[b] (μg/L)
PVOCs		
Benzene	NA	114
Ethylbenzene	NA	14.00
Toluene	NA	253
Xylenes (total)	NA	27
1,3,5-Trimethylbenzene	NA	NA
2,4,6-Trimethylbenzene	NA	NA
Semivolatile Organic Compounds		
PAHs		
Acenaphthene	NA	38
Acenaphthylene	NA	4840
Anthracene	NA	0.035
Benzo[a]anthracene	NA	0.025
Benzo[b]fluoranthene	NA	9.07
Benzo[k]fluoranthene	NA	NA
Benzo[a]pyrene	NA	0.014
Benzo[g,h,i]perylene	NA	7.64
Chrysene	NA	NA
Dibenz[a,h]anthracene	NA	5[d]
Fluoranthrene	NA	1.9
Fluorene	NA	19
Indeno[1,2,3-cd]pyrene	NA	4.31
Naphthalene	NA	13
Phenanthrene	NA	3.6
Pyrene	NA	0.3
2-Methylnaphthalene	NA	330
Phenols		
2,4-Dimethylphenol	NA	100
2-Methylphenol	NA	NA
4-Methylphenol	NA	NA
Phenol	NA	180
Inorganics		
Aluminum	87	NA
Antimony	NA	80
Arsenic	150	148
Barium	NA	220
Cadmium	0.25	0.15
Chromium[c]	74	42
Copper	9.0	1.58
Cyanide	5.2	5.2
Iron	1,000	NA
Lead	2.5	1.17
Manganese	NA	NA
Mercury	0.77	0.0013
Nickel	52	28.9
Selenium	5.0	5
Silver	NA	0.12
Vanadium	NA	12
Zinc	120	65.7

Table 5. (cont.)

Note:	CCC	-	
	EPA	-	U.S. Environmental Protection Agency
	ESL	-	ecological screening level
	MGP	-	manufactured gas plant
	NA	-	not available
	NRWQC	-	National Recommended Water Quality Criteria
	PAH	-	polycyclic aromatic hydrocarbon
	PVOC	-	petroleum volatile organic compounds

Screening benchmarks would be applied according to the following hierarchy:

[a] NRWQC, 2006. EPA Office of Water, www.epa.gov/waterscience/criteria/wqcriteria.html. Accessed March 21, 2007.

[b] EPA Region 5 ESLs (2003).

[c] The NRWQC presented for chromium is the Freshwater CCC for trivalent chromium

[d] The value for dibenz[a,h]anthracene is from Texas Surface Water Quality Standards (referred by Dan Mazur, EPA Region 5).

Table 6. Ecological soil benchmarks, former MGP sites, EPA Region 5

Project Compound List	EPA Region 5 ESL[a] (mg/kg)	Eco-SSL[b] (mg/kg dry weight soil) Plants	Soil Invertebrates	Wildlife Avian	Mammalian
PVOCs					
Benzene	0.255	NA	NA	NA	NA
Ethylbenzene	5.16	NA	NA	NA	NA
Toluene	5.45	NA	NA	NA	NA
Xylenes (total)	10	NA	NA	NA	NA
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA
2,4,6-Trimethylbenzene	NA	NA	NA	NA	NA
Semivolatile Organic Compounds					
PAHs					
Acenaphthene	682	NA	NA	NA	NA
Acenaphthylene	682	NA	NA	NA	NA
Anthracene	1,480	NA	NA	NA	NA
Benzo[a]anthracene	5.21	NA	NA	NA	NA
Benzo[b]fluoranthene	59.8	NA	NA	NA	NA
Benzo[k]fluoranthene	148	NA	NA	NA	NA
Benzo[a]pyrene	1.52	NA	NA	NA	NA
Benzo[g,h,i]perylene	119	NA	NA	NA	NA
Chrysene	4.73	NA	NA	NA	NA
Dibenz[a,h]anthracene	18.4	NA	NA	NA	NA
Fluoranthene	122	NA	NA	NA	NA
Fluorene	122	NA	NA	NA	NA
Indeno[1,2,3-cd]pyrene	109	NA	NA	NA	NA
Naphthalene	0.0994	NA	NA	NA	NA
Phenanthrene	45.7	NA	NA	NA	NA
Pyrene	78.5	NA	NA	NA	NA
2-Methylnaphthalene	3.24	NA	NA	NA	NA
Phenols					
2,4-Dimethylphenol	0.01	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA
Phenol	120	NA	NA	NA	NA
Inorganics					
Aluminum	NA	[c]	[c]	[c]	[c]
Antimony	0.142	NA	78	NA	0.27
Arsenic	5.7	18	NA	43	46
Barium	1.04	NA	330	NA	2000
Cadmium	0.00222	32	140	0.77	0.36
Chromium	0.4	NA	NA	Cr III - 26 Cr VI - NA	Cr III - 34 Cr VI - 81
Copper	5.4	70	80	28	49
Cyanide	1.33				
Iron	NA	[d]	[e]	[e]	[e]
Lead	0.0537	120	1,700	11	56
Manganese	NA	NA	NA	NA	NA
Mercury	0.1	NA	NA	NA	NA
Nickel	13.6	38	280	210	130

Table 6. (cont.)

Project Compound List	EPA Region 5 ESL[a] (mg/kg)	Eco-SSL[b] (mg/kg dry weight soil) Plants	Soil Invertebrates	Wildlife Avian	Mammalian
Selenium	0.0276	NA	NA	NA	NA
Silver	4.04	560	NA	4.2	14
Vanadium	1.59	NA	NA	7.8	280
Zinc	6.62	NA	NA	NA	NA

Note: CoPC - chemical of potential concern!
EPA - U.S. Environmental Protection Agency
ESL - ecological screening level
MGP - manufactured gas plant
NA - not available
PAH - polycyclic aromatic hydrocarbon
PVOC - petroleum volatile organic compounds

[a] EPA Region 5 ESLs (2003).

[b] EPA ecological soil screening levels. www.epa.gov/ecotox/ecossl/. Updated March 7, 2007. Chemical-specific documents accessed March 21, 2007.

[c] Aluminum is identified as a CoPC only for those soils with a soil pH less than 5.5.

[d] In well-aerated soils between pH 5 and 8, the iron demand of plants is higher than the amount available. Under these soil conditions, iron is not expected to be toxic to plants.

[e] Determination of geochemical conditions (i.e. pH and Eh at a minimum) of the environmental setting, as well as the presence of iron floc and toxic metals, is critical to the determination of the relative importance of iron at the site.

Appendix A

Habitat Assessment Field Forms

SAMPLE FORM A
Ecological Scoping Checklist

Part 1			
SITE INFORMATION			
Site Name:		Date:	
Personnel (Identify team leader)		Time Arrived: Time Departed:	
Site Address:			
Site Location:	Latitude:	Longitude:	
Site Size (acres): Entire "site" linear length _____ woodlot area _____			
Weather Conditions (note any unusual conditions):			
Land uses at and adjacent to the site: (Circle all that apply and record at or adjacent)			
Residential	Commercial	Recreational	Industrial
Agricultural	Urban	Green-Space/ undeveloped	Other:____________

SAMPLE FORM A

Part 2		
CONTAMINANTS OF INTEREST		
Contaminants of Interest and *Ecological Stressors* (Types, names including CAS number, classes, or specific *hazardous substances* and non-chemical stressors either known or suspected)	Onsite (O) or Adjacent (A) to the site	Media (soil, sediment, surface water, groundwater (seeps/springs))

SAMPLE FORM A

Part 3	
SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS/HABITAT	
Terrestrial - Wooded __% of site (Beaver dam area of MEDE-woodlot) Dominant vegetation (circle one): Coniferous Deciduous Mixed Dominant tree diameter (*dbh*): _____ Evidence/observation of wildlife*: ________________________________ ________________________________.	**Terrestrial - Shrub/scrub/grasses** ____% of site Dominant vegetation (circle one): shrub/scrub grasses vegetation density: Dense, Patchy, Sparse Prominent height of shrub/scrub (<2', 2' to 5', >5') Prominent height of grasses/herbs (<2', 2' to 5', >5') Evidence/observation of wildlife*: _________ ________________________________
Terrestrial -_______/Engineered % of site Dominant vegetation/surfaces (circle one): Landscaped Agricultural Bare ground Parking lot Artificial surfaces Dominant vegetation height (0', >0' - 2', 2' - 5', >5') Vegetation Density: Dense Patchy Sparse Evidence/observation of wildlife*: ________________________________ ___________________________	**Aquatic - Non-Flowing (Lentic)** ____% of site Type: Lake Pond Vernal Pool Lagoon Engineered** Impoundment Reservoir Water source: Surface water Groundwater Industrial discharge Surface water runoff Discharge Point: Surface water Groundwater Wetlands Bottom Substrate***: ______________________ Vegetation: Submerged Emergent Floating Wetland Present: (Yes/No) Evidence/Observation of wildlife*: __________
Aquatic - Flowing (Lotic) ____% of site Aquatic Life Use designation (if available)______ Type: River Stream Intermittent Stream Ditch Water source: Surface water Groundwater Industrial discharge (seeps/springs) Storm water runoff Discharge Point: Surface water Groundwater Wetlands impoundment Bottom Substrate**: _______________ Vegetation: Submerged Emergent Floating Wetland Present: (Yes/No) Evidence/Observation of wildlife*:___________	**Aquatic - Wetlands** ____% of site Size _______ (acres) Obvious or designated wetland: (Yes / No) Water source: Surface water Groundwater Industrial discharge Surface water runoff Discharge Point: Surface water Groundwater Wetlands impoundment Bottom Substrate**: _________________________ Vegetation: Submerged Emergent Floating Evidence/Observation of wildlife*:______________ ____ ____

* Wildlife includes: macroinvertebrates, reptiles, amphibians, birds, mammals and fish.

** Engineered can mean any surface water body that has been artificially created or significantly altered.

** Bottom substrate types include but not limited to: cobble, gravel, sand, silt, clay, muck, artificial (*e.g.*, concrete).

SAMPLE FORM A

Part 4
Ecologically Important Resources Observed

SAMPLE FORM A

EVALUATION OF POTENTIAL ECOLOGICAL HARM		Y	N	U
Are *hazardous substances* present or potentially present in:				
a	Soil?			
b	Surface Waters?			
c	Sediment?			
d	Groundwater?			
e	Other (biotic media)?			
f	Are surface waters present at or potentially influenced by the site?			
g	Are *ecologically important* terrestrial resources located at, adjacent to, or influenced by the site?			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

When answering the above questions, consider the following:

- X Known or suspected presence of *hazardous substances* stored, used or manufactured at the site.
- X Ability of *hazardous substances* to migrate from one medium to another.
- X The mobility of the various media.
- X Transfer of contaminants through food webs and uptake of chemicals by organisms.
- X The presence of *important ecological resources* on, adjacent to, or influenced by the site.

(a) If "**Y**" or "**U**" boxes in Sample Form B are checked for row **f or g** and any other row, then a recommendation to move to Level II should be made for an assessment of the appropriate aquatic and/or terrestrial habitat. In completing this Attachment, a lack of knowledge, presence of high uncertainty, or any "unknown" circumstances should be tabulated as a "**U**".

(b) If all of the "**No**" boxes in Sample Form B are checked, or if only row **f and/or g**, or rows **a** through e are checked **"No"**, then the site is highly unlikely to present significant risks to important ecological receptors and a recommendation for no further ecological investigations should be made.

SAMPLE C REPORT FORMAT
Level I Deliverable - Site Ecology Scoping Report
Outline

(1) EXISTING DATA SUMMARY
- (a) Site location (Part 1, Sample Form A)
- (b) Site history (Summary of all available data)
- (c) Site land and/or water use(s)
  - (i) Current
  - (ii) Future (list all potential uses)
- (d) Known or suspected hazardous substance releases
- (e) *Sensitive environments*
- (f) Threatened and/or endangered species (USFWS/ODNR/DOW data)

(2) SITE VISIT SUMMARY
- (a) *Contaminants of Interest* (Part 2, Sample Form A)
- (b) Ecological features (Part 3, Sample Form A)
- (c) *Ecologically important* species/habitats (Part 4, Sample Form A)
  - (i) Threatened and/or endangered species
  - (ii) Threatened and/or endangered species habitat
- (d) Exposure pathways (Sample Form B)

(3) RECOMMENDATIONS

(4) ATTACHMENTS
- (a) Regional map showing location of site
- (b) Local map showing site in relation to adjacent property
- (c) Site map
- (d) Sketch/develop a map of ecological features as an overlay to the site map or as a separate map.
- (e) Sketch/develop a map of known or suspected extent of *hazardous substances* as an overlay to the site map or as a separate map
- (f) Summary of available site data
- (g) Site photograph(s)
- (h) Copies of letters from USFWS and ODNR, responding to queries about threatened and endangered species

(5) REFERENCES / DATA SOURCES

DEFINITIONS

1) *"Areas surrounding the property"*means all areas located within one half-mile of the property boundaries.

2) *"Biota"* means the animal or plant life of a particular region.

3) *"Contaminant of Interest (COI)"* means any chemical suspected to be present due to past use, storage, or disposal practices that may have occurred at a site.

4) *"Ecological stressor"* means any physical, chemical (including petroleum) or, biological entity that can induce an adverse response to an ecological receptor including hazardous substances.

5) *"dbh"* means diameter of a tree trunk measured at breast height.

6) "Hazardous substance" includes all of the following;

   (a) Any substance identified or listed in rules adopted under division (B)(1)(c) of section 3750.02 of the Revised Code;

   (b) Any product registered as a pesticide under section 921.02 of the Revised Code when the product is used in a manner inconsistent with its required labeling;

   (c) Any product formerly registered as a pesticide under that section for which the registration was suspended or canceled under section 921.05 of the Revised Code; and

   (d) Any mixture of a substance described in paragraphs (A)(20)(a) to (A)(20)(c) of this Rule with radioactive material.

   (e) Any pollution as defined under division (A) of section 6111.01 of the Revised Code.

7) "*Important Ecological Resources*" means specific ecological communities, populations or individual organisms protected by federal, state or local laws and regulations, or ecological resources that provide important natural or economic resource functions and values, or *sensitive environments*. *Important ecological resources* include, but are not limited to: surface waters and wetlands protected under federal law and state of Ohio's water quality laws; dedicated natural areas and preserves; threatened and endangered species and their associated habitats that are designated by the federal government or the state of Ohio; special

interest or declining species, and their associated habitats, designated by the state of Ohio; Wildlife populations and their associated important nesting areas and food resources, taking into consideration land use and the quality and extent of habitat on and in the vicinity of the property.

(a) For purposes of filing out Sample Form B, any of the following are considered "*ecologically important*":

(a)

Individual listed threatened and endangered species;

(ii) Local populations of species that are recreational and/or commercial resources;

(iii) Local populations of any species with a known or suspected susceptibility to the hazardous substance(s);

(iv) Local populations of invertebrate species that:

Provide a critical (*i.e.*, not replaceable) food resource for higher organisms and whose function as such would not be replaced by more tolerant species; or

Perform a critical ecological function (such as organic matter decomposition) and whose function would not be replaced by other species; or

Can be used as a surrogate measure of adverse effects for individuals or populations of other species.

(b) "*ecologically important*" plants are those that form the habitat for an ecologically important species as defined above, or are themselves listed as threatened and endangered species.

(c) Because they are not members of natural communities, any of the following should not be considered "ecologically important" species:

(i) Pest and opportunistic species that populate an area entirely because of artificial or anthropogenic conditions;

(ii) Domestic animals (*e.g.*, pets and livestock);

(iii) Plants or animals whose existence is maintained by continuous human intervention (*e.g.*, agricultural crops).

Thus, determining whether or not a particular site contains or could potentially impact an important ecological resource, requires an evaluation of factors such as life history, habitat utilization, behavioral characteristics, and physiological parameters of potential receptors. For example, some small areas (<0.5 acre) may be considered *important ecological resources* if important functions are provided by the area (*e.g.*, vernal pools that provide breeding habitat for amphibians). Larger maintained areas (*e.g.*, areas mowed regularly) may also function as an *important ecological resources* (*e.g.*, green space for wide ranging predators) . The definition of *important ecological resources* is, however, meant to exclude areas such as mowed, maintained (*e.g.*, manicured lawns) or other areas that do not exhibit or exhibit only minimal important ecological resource functions.

8) "*Locality of the site*" means any point where a human or ecological receptor contacts, or is reasonably likely to come into contact with, facility-related *ecological stressors,* considering:

(a) The chemical and physical characteristics of the hazardous substance;

(b) Physical, meteorological, hydrogeological, and ecological characteristics that govern the tendency for hazardous substances to migrate through environmental media or to move and accumulate through food webs;

(c) Any human activities and biological processes that govern the tendency for hazardous substances to move into and through environmental media or to move and accumulate through food webs; and,

(d) The time required for contaminant migration to occur based on factors described in subsections (a) through (c).

9) "*Ruderal*" means compacted, plowed, paved, or otherwise disturbed ground usually related to industrial or commercial activities.

10) "*Sensitive Environment*" The following is a list of sensitive environments as used in the Hazard Ranking system:

Critical habitat for designated endangered or threatened species; Marine Sanctuary; National Park; Designated Federal Wilderness Area, Critical areas identified under the Clean Lakes Program; National Monument; National Lakeshore Recreational Area; Habitat known to be used by Federal designated or proposed endangered or threatened species; National Preserve; National or State Wildlife Refuge; Federal land designated for the protection of natural ecosystems; Administratively Proposed Federal Wilderness Area; Spawning areas critical for the maintenance fish/shellfish species within a river, lake, or coastal waters; Migratory pathways and feeding areas critical for maintenance of anadromous fish species within river reaches or areas of lakes or costal tidal waters in which the fish spend extended periods of time; Terrestrial areas utilized for breeding by large or dense aggregations of animals; National river reach designated as Recreational; Habitat known to be used by state designated endangered or threatened species; Habitat known to be used by species under review as to its Federal endangered or threatened status; Federally-designated Scenic or Wild River; State land designated for wildlife or game management; State-designated Scenic or Wild River; State-designated Natural Areas; Particular areas, relatively small in size, important to maintenance of unique biotic communities; State-designated areas for the protection or maintenance of aquatic life; Wetlands.

See Federal Register, vol. 55, pp. 51624 and 51648 for additional information regarding definitions. Under the Hazardous Ranking System, wetlands are ranked on the basis of size. See Federal Register, vol. 55, pp. 51625 and 51662 for additional information. The OEPA designate wetlands based on quality and size. The OEPA Division of Surface Water should contacted regarding the classification of wetlands.

11) "*Site*" means any parcel or multiple parcels of real property, contiguous or non-contiguous, or portion of such property or properties, where the treatment, storage, disposal and/or the discharge into the waters of the state of industrial waste or other wastes or hazardous substances and petroleum, has occurred, including any other area where these hazardous substances and petroleum have migrated or threatened to migrate.

CHECKLIST FOR ECOLOGICAL ASSESSMENT/SAMPLING

I. SITE DESCRIPTION

1. Site Name: ______________________________

   Location: ______________________________

   ____

   County: ____________ City: ____________ State: ____________

2. Latitude: ____________ Longitude: ____________

3. What is the approximate area of the site? ____________

4. Is this the first site visit? ☐ yes ☐ no. If no, attach trip report of previous site visit(s), if available.

   Date(s) of previous site visit(s): ____________

5. Please attach to the checklist USGS topographic map(s) of the site, if available.

6. Are aerial or other site photographs available? ☐ yes ☐ no. If yes, please attach any available photo(s) to the site map at the conclusion of this section.

7. The land use on the site is:

   ______ % Urban

   ______ % Rural

   ______ % Residential

   ______ % Industrial (☐ light ☐ heavy)

   ______ % Agricultural

   (*Crops*: ____________)

   ______ % Recreational

   (Describe; note if it is a park, etc.)

   ____

   ____

   ______ % Undisturbed

   ______ % Other

   The area surrounding the site is: ____________ mile radius

   ______ % Urban

   ______ % Rural

   ______ % Residential

   ______ % Industrial (☐ light ☐ heavy)

   ______ % Agricultural

   (*Crops*: ____________)

   ______ % Recreational

   (Describe; note if it is a park, etc.)

   ____

   ____

   ______ % Undisturbed

   ______ % Other

8. Has any movement of soil taken place at the site? ☐ yes ☐ no. If yes, please identify the most likely cause of this disturbance:

_______ Agricultural Use	_______ Heavy Equipment	_______ Mining
_______ Natural Events	_______ Erosion	_______ Other

Please describe:

9. Do any potentially sensitive environmental areas exist adjacent to or in proximity to the site, e.g., Federal and State parks, National and State monuments, wetlands, prairie potholes? *Remember, flood plains and wetlands are not always obvious; do not answer "no" without confirming information.*

Please provide the source(s) of information used to identify these sensitive areas, and indicate their general location on the site map.

10. What type of facility is located at the site?

☐ Chemical ☐ Manufacturing ☐ Mixing ☐ Waste disposal

☐ Other (specify) ________________________________

11. What are the suspected contaminants of concern at the site? If known, what are the maximum concentration levels?

12. Check any potential routes of off-site migration of contaminants observed at the site:

☐ Swales ☐ Depressions ☐ Drainage ditches

☐ Runoff ☐ Windblown particulates ☐ Vehicular traffic

☐ Other (specify) ________________________________

13. If known, what is the approximate depth to the water table? ________________________

14. Is the direction of surface runoff apparent from site observations? ☐ yes ☐ no. If yes, to which of the following does the surface runoff discharge: Indicate all that apply.

☐ Surface water ☐ Groundwater ☐ Sewer ☐ Collection impoundment

15. Is there a navigable waterbody or tributary to a navigable waterbody? ☐ yes ☐ no.

16. Is there a waterbody anywhere on or in the vicinity of the site? If yes, also complete Section III: Aquatic Habitat Checklist - Non-Flowing Systems and/or Section IV: Aquatic Habitat Checklist - Flowing Systems.

☐ yes (approx. distance ______________________) ☐ no

17. Is there evidence of flooding? ☐ yes ☐ no. *Wetlands and flood plains are not always obvious; do not answer "no" without confirming information.* If yes, complete Section V: Wetland Habitat Checklist.

18. If a field guide was used to aid any of the identifications, please provide a reference. Also, estimate the time spent identifying fauna. (Use a blank sheet if additional space is needed for text.)

19. Are any threatened and/or endangered species (plant or animal) known to inhabit the area of the site? ☐ yes ☐ no. *If yes, you are required to verify this information with the U.S. Fish and Wildlife Service.* If species' identities are known, please list them next.

20. Record weather conditions at the time this checklist was prepared:

DATE: ______________________________

____________	Temperature (°C/°F	____________	Normal daily high temperature
____________	Wind (direction/speed)	____________	Precipitation (rain, snow)
____________	Cloud cover		

IA. SUMMARY OF OBSERVATIONS AND SITE SETTING

Completed by ______________________________ Affiliation ______________

Additional Preparers ______________________________

Site Manager ______________________________

Date ______________

II. TERRESTRIAL HABITAT CHECKLIST

IIA. WOODED

1. Are there any wooded areas at the site? ☐ yes ☐ no. If no, go to Section IIB: Shrub/Scrub.

2. What percentage or area of the site is wooded? (______ % ______ acres). Indicate the wooded area on the site map which is attached to a copy of this checklist. Please identify what information was used to determine the wooded area of the site.

3. What is the dominant type of vegetation in the wooded area? (Circle one: Evergreen/Deciduous/Mixed) Provide a photograph, if available.

   Dominant plant, if known: ____

4. What is the predominant size of the trees at the site? Use diameter at breast height.

   ☐ 0-6 in. ☐ 6-12 in. ☐ >12 in.

5. Specify type of understory present, if known. Provide a photograph, if available.

IIB. SHRUB/SCRUB

1. Is shrub/scrub vegetation present at the site? ☐ yes ☐ no. If no, go to Section IIC: Open Field.

2. What percentage of the site is covered by scrub/shrub vegetation? (______ % _______ acres). Indicate the areas of shrub/scrub on the site map. Please identify what information was used to determine this area.

3. What is the dominant type of scrub/shrub vegetation, if known? Provide a photograph, if available.

4. What is the approximate average height of the scrub/shrub vegetation?

   ☐ 0-2 ft. ☐ 2-5 ft. ☐ >5 ft.

5. Based on site observations, how dense is the scrub/shrub vegetation?

   ☐ Dense ☐ Patchy ☐ Sparse

IIC. OPEN FIELD

1. Are there open (bare, barren) field areas present at the site? ☐ yes ☐ no. If yes, please indicate the type below:

   ☐ Prairie/plains ☐ Savannah ☐ Old field ☐ Other (specify) ____________________

2. What percentage of the site is open field? (______ % ______ acres). Indicate the open field on the site map.

3. What is/are the dominant plant(s)? Provide a photograph, if available.

4. What is the approximate average height of the dominant plant? ____________________________

5. Describe the vegetation cover: ☐ Dense ☐ Sparse ☐ Patchy

IID. MISCELLANEOUS

1. Are other types of terrestrial habitats present at the site, other than woods, scrub/shrub, and open field? ☐ yes ☐ no. If yes, identify and describe them below.

2. Describe the terrestrial miscellaneous habitat(s) and identify these area(s) on the site map.

3. What observations, if any, were made at the site regarding the presence and/or absence of insects, fish, birds, mammals, etc.?

4. Review the questions in Section I to determine if any additional habitat checklists should be completed for this site.

III. AQUATIC HABITAT CHECKLIST – NON-FLOWING SYSTEMS

Note: Aquatic systems are often associated with wetland habitats. Please refer to Section V, Wetland Habitat Checklist.

1. What type of open-water, non-flowing system is present at the site?

   ☐ Natural (pond, lake)

   ☐ Artificially created (lagoon, reservoir, canal, impoundment)

2. If known, what is the name(s) of the waterbody(ies) on or adjacent to the site?

   ____

3. If a waterbody is present, what are its known uses (e.g.: recreation, navigation, etc.)?

4. What is the approximate size of the waterbody(ies)? ______________________acre(s).

5. Is any aquatic vegetation present? ☐ yes ☐ no. If yes, please identify the type of vegetation present is known.

   ☐ Emergent ☐ Submergent ☐ Floating

6. If known, what is the dept of the water? ______________________

7. What is the general composition of the substrate? Check all that apply.

☐ Bedrock	☐ Sand (coarse)	☐ Muck (fine/black)
☐ Boulder (> 10 in.)	☐ Silt (fine)	☐ Debris
☐ Cobble (2.5-10 in.)	☐ Marl (shells)	☐ Detritus
☐ Gravel (0.1-2.5 in.)	☐ Clay (slick)	☐ Concrete

   ☐ Other (specify) ______________________

8. What is the source of water in the waterbody?

☐ River/Stream/Creek	☐ Groundwater	☐ Other (specify)__________
☐ Industrial discharge	☐ Surface runoff	

9. Is there a discharge from the site to the waterbody? ☐ yes ☐ no. If yes, please describe this discharge and its path.

10. Is there a discharge from the waterbody? ☐ yes ☐ no. If yes, and the information is available, identify from the list below the environment into which the waterbody discharges.

☐ River/Steam/Creek	☐ On-site	☐ Off-site	Distance ____________
☐ Groundwater	☐ On-site	☐ Off-site	
☐ Wetlands	☐ On-site	☐ Off-site	Distance ____________
☐ Impoundment	☐ On-site	☐ Off-site	

11. Identify any field measurements and observations of water quality that were made. For those parameters for which data were collected provide the measurement and the units of measure below:

_______ Area

_______ Depth (average)

_______ Temperature (depth of the water at which the reading was taken) ____________

_______ pH

_______ Dissolved oxygen

_______ Salinity

_______ Turbidity (clear, slightly turbid, turbid, opaque) (Secchi disk depth _______, visual)

_______ Other (specify)

12. Describe observed color and area of coloration.

13. Mark the open-water, non-flowing system on the site map attached to his checklist.

14. What observations, if any, were made at the waterbody regarding the presence and/or absence of benthic macroinvertebrates, fish, birds, mammals, etc.?

IV. AQUATIC HABITAT CHECKLIST – FLOWING SYSTEMS

Note: *Aquatic systems are often associated with wetland habitats. Please refer to Section 4, Wetland Habitat Checklists.*

1. What type(s) of flowing water system(s) is (are) present at the site?

☐ River ☐ Stream ☐ Creek

☐ Dry wash ☐ Arroyo ☐ Brook

☐ Artificially created (ditch, etc.) ☐ Intermittent Stream ☐ Channeling

☐ Other (specify) ______________________________

2. If known, what is the name of the waterbody? ______________________________

3. For natural systems, are there any indicators of physical alteration (e.g., channeling, debris, etc.)?

☐ yes ☐ no. If yes, please describe indicators that were observed.

4. What is the general composition of the substrate? Check all that apply.

☐ Bedrock ☐ Sand (coarse) ☐ Muck (fine/black)

☐ Boulder (> 10 in.) ☐ Silt (fine) ☐ Debris

☐ Cobble (2.5-10 in.) ☐ Marl (shells) ☐ Detritus

☐ Gravel (0.1-2.5 in.) ☐ Clay (slick) ☐ Concrete

☐ Other (specify) ______________________________

5. What is the condition of the bank (e.g., height, slope, extent of vegetation cover)?

6. Is the system influenced by tides? ☐ yes ☐ no. What information was used to make this determination?

7. Is the flow intermittent? ☐ yes ☐ no. If yes, please note the information that was used in making this determination.

8. Is there a discharge from the site to the waterbody? ☐ yes ☐ no. If yes, please describe the discharge and its path.

9. Is there a discharge from the waterbody? ☐ yes ☐ no. If yes, and the information is available, please identify what the waterbody discharges to and whether the discharge is on-site or off-site.

10. Identify any field measurement sand observations of water quality that were made. For those parameters for which data were collected, provide the measurement and the units of measure in the appropriate space below:

_______ Width (ft)

_______ Depth (ft)

_______ Velocity (specify units): ______________________

_______ Temperature (depth of the water at which the reading was taken ____________)

_______ pH

_______ Dissolved oxygen

_______ Salinity

_______ Turbidity (clear, slightly turbid, turbid, opaque) (Secchi disk depth ____________)

_______ Other (specify) ______________________

11. Describe observed color and area of coloration.

12. Is any aquatic vegetation present? ☐ yes ☐ no. If yes, please identify the type of vegetation present, if known.

☐ Emergent ☐ Submergent ☐ Floating

13. Mark the flowing water system on the attached site map.

14. What observations were made at the waterbody regarding the presence and/or absence of benthic macroinvertebrates, fish, birds, mammals, etc.?

V. WETLAND HABITAT CHECKLIST

1. Based on observations and/or available information, are designated or known wetlands definitely present at the site?

   ☐ yes ☐ no

   Please note the sources of observations and information used (e.g., USGS Topographic Maps, National Wetland Inventory, Federal or State Agency, etc.) to make this determination.

2. Based on the location of the site (e.g., along a waterbody, in a floodplain) and site conditions (e.g., standing water, dark, wet soils; mud cracks; debris line; water marks), are wetland habitats suspected? ☐ yes ☐ no. If yes, proceed with the remainder of the wetland habitat identification checklist.

3. What type(s) of vegetation are present in the wetland?

   ☐ Submergent ☐ Emergent

   ☐ Scrub/Shrub ☐ Wooded

   ☐ Other (specify) ______________________________

4. Provide a general description of the vegetation present in and around the wetland (height, color, etc.). Provide a photograph of the known or suspected wetlands, if available.

5. Is standing water present? ☐ yes ☐ no. If yes, is this water: ☐ fresh ☐ brackish. What is the approximate area of the water (sq. ft.) ______________. Please complete questions 4, 11, 12 in Checklist III – Aquatic Habitat – Non-Flowing Systems.

6. Is there evidence of flooding at the site? What observations were noted?

   ☐ Buttressing ☐ Water marks ☐ Mud cracks

   ☐ Debris line ☐ Other (describe below)

7. If known, what is the source of the water in the wetland?

   ☐ Steam/River/Creek/Lake/Pond ☐ Groundwater

   ☐ Flooding ☐ Surface Runoff

8. Is there a discharge from the site to a known or suspected wetland? ☐ yes ☐ no. If yes, please describe.

9. Is there a discharge from the wetland? ☐ yes ☐ no. If yes, to what waterbody is discharge released?

☐ Surface Stream/River ☐ Groundwater ☐ Lake/Pond ☐ Marine

10. If a soil sample was collected, describe the appearance of the soil in the wetland area. Circle or write in the best response.

Color (blue/gray, brown, black, mottled) ________________

Water content (dry, wet, saturated/unsaturated) ____________

11. Mark the observed wetland area(s) ion the attached site map.

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Appendix B

Risk Assessment Methods for Human Health Evaluation

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The human health risk assessment (HHRA) portion of the Baseline Risk Assessment (BlRA) will include a quantitative evaluation of risks to surface water and sediment associated with each site where such exposures can occur. This appendix provides the general methods that will be used to estimate these human health risks. The actual surface water and sediment exposure factors will be tailored based on a site-specific basis, and therefore are not provided herein.

1 EXPOSURE QUANTIFICATION

1.1 Sediment Intake Equations

The equations used to evaluate exposure derived from chemicals in sediment are as follows:

$$\text{Ingestion Intake (mg/kg-day)} = \frac{\text{CS x CF x IngR x EF x ED}}{\text{BW x AT}}$$

where:

CS	=	Chemical Concentration in Sediment (mg/kg)
CF	=	Conversion Factor (10^{-6} kg/mg)
IngR	=	Ingestion Rate (mg sediment/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

$$\text{Dermal Intake (mg/kg-day)} = \frac{\text{CS x CF x SA x AF x ABS x EvF x EF x ED}}{\text{BW x AT}}$$

where:

CS	=	Chemical Concentration in Sediment (mg/kg)
CF	=	Conversion Factor (10^{-6} kg/mg)
SA	=	Skin Surface Area (cm^2)
AF	=	Soil Adherence Factor (mg/cm^2-event)
ABS	=	Dermal Absorption Factor (unitless)
EvF	=	Event Frequency (events/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged–days)

1.2. Surface water Intake Equations

The equations used to evaluate exposure to chemicals in surface water are as follows:

$$\text{Ingestion Intake (mg/kg-day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

where:

CW	=	Chemical Concentration in Surface Water (mg/L)
IR	=	Ingestion Rate (L water/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

$$\text{Dermal Intake (mg/kg-day)} = \frac{DA_{event} \times EV \times SA \times EF \times ED}{BW \times AT}$$

where:

DA_{event}	=	Absorbed Dose Per Event (mg/cm^2-event)
EV	=	Event Frequency (events/day)
SA	=	Skin Surface Area (cm^2)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

1.2. Equations for Estimating Dermal Exposure From Surface Water

The equations used to estimate dermal absorption from water are presented in the U.S. Environmental Protection Agency's (EPA's) *Dermal Risk Assessment* guidance (U.S. EPA, 2004). These equations are derived from a model where the skin is assumed to be composed of two layers: the stratum corneum and the viable epidermis. The stratum corneum forms the main barrier to uptake.

A two-compartment model was derived to describe the absorption of chemicals from water through the skin as a function of both the thickness of the stratum corneum and the event duration (i.e., the exposure time). The first compartment has the chemical in a non-steady state condition with the chemical only in the stratum corneum. The second compartment is a function of the event time after steady state conditions are reached. The model assumes that absorption continues long after the exposure has ended.

The primary equation for estimating dermal uptake is:

$$\text{Dermal Dose (mg/kg-day)} = \frac{DA_{event} \text{ x } EV \text{ x } SA \text{ x } ED \text{ x } EF}{BW \text{ x } AT}$$

where:

DA_{event}	=	Absorbed dose per event (mg/cm^2-event)
EV	=	Event frequency (events/day)
SA	=	Skin surface area available for contact (cm^2)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

DA_{event} is calculated based on different equations for organic and inorganic constituents.

For organic constituents, the calculation of DA_{event} depends upon whether the exposure time for a given event is more or less than the time for a chemical to achieve steady-state conditions as it diffuses across the stratum corneum layer in the skin. This time to achieve steady-state conditions is defined as t*.

Where the exposure time is less than or equal to t*, DA_{event} is calculated as follows:

$$DA_{event} = 2 \text{ x } FA \text{ x } K_p \text{ x } C_w \text{ x } CF \text{ x } \sqrt{\frac{6\tau_{event} \text{ x } t_{event}}{\pi}}$$

Where the exposure time exceeds t*, DA_{event} is calculated as follows:

$$DA_{event} = FA \text{ x } K_p \text{ x } C_w \text{ x } CF \text{ x } \left[\frac{t_{event}}{1+B} + 2 \text{ x } \tau_{event} \text{ x} \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

where:

FA	=	Fraction absorbed (accounting for loss of chemicals due to desquamation of the skin) (unitless)
K_p	=	Permeability coefficient (cm/hr)
C_w	=	Chemical concentration in water (mg/L)
CF	=	Conversion factor (10^{-3} L/cm^3)
t_{event}	=	Event duration (hr/event)
τ_{event}	=	Lag time per event (hr/event)
B	=	Ratio of the permeability coefficient of a compound through The stratum corneum relative to its permeability coefficient across the epidermis (dimensionless)

The event duration is specific to the exposure scenario. Other than event duration, all other parameters are chemical-specific. These parameters will be taken from Exhibit B-3 of EPA's *Dermal Risk Assessment Guidance* (U.S. EPA, 2004) or will be calculated based on equations in section 3.1.2 of the guidance.

For inorganics, DA_{event} is calculated as follows:

$$DA_{event} = K_p \times C_w \times t_{event}$$

The permeability constants for the inorganic constituents will be taken from Exhibit B-3 of the *Dermal Risk Assessment Guidance* (U.S. EPA, 2004).

2 TOXICITY ASSESSMENT AND RISK CHARACTERIZATION

This section provides the equations used to combine the exposure doses described above with estimates of toxicity to estimate risk based on noncancer and cancer type effects.

Risks were quantified based on the exposure estimates and the toxicity of the constituents involved. For carcinogens, risk estimates represent the incremental probability that an individual will develop cancer over a lifetime as a result of exposure to a potential carcinogen or a set of carcinogens (EPA, 1989). These risks are termed excess or incremental individual lifetime cancer risks and are calculated using the following equation:

Incremental Lifetime Cancer Risk (Risk) = LDI x CSF

where:

LDI	=	Lifetime Daily Intake (mg/kg/day)
CSF	=	Cancer Slope Factor (mg/kg/day)

A carcinogenic risk is expressed as a probability, such as one additional cancer in an exposed population of one million, which is expressed in scientific notation as 1×10^{-6}.

Studies of carcinogenicity tend to focus on identifying the slope of the linear portion of a curve of dose versus response. A plausible upper-bound value of the slope is called the CSF. In accordance with current scientific policy concerning carcinogens, it is assumed that any dose, no matter how small, has some associated response. This is called a nonthreshold effect. The lifetime daily intake is the exposure dose averaged over a 70-year lifetime. This is in keeping with the concept that there are no threshold doses for carcinogens.

The potential for individuals to experience adverse effects other than cancer is evaluated by comparing an exposure dose developed over a specific exposure period to a reference dose (RfD) developed over a similar exposure period. This comparison takes the form of a ratio termed the hazard quotient, which is calculated by dividing the chronic daily intake (CDI) by the reference dose (RfD):

$$\text{Hazard Quotient} = \frac{CDI}{RfD}$$

where:

CDI	=	Chronic Daily Intake (mg/kg/day)
RfD	=	Reference Dose (mg/kg/day).