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6.4.3.1 Air

This pathway is based on the scenario that a receptor is immersed in air that contains suspended particulates and volatile organic vapors originating from the source areas as part of daily living. Subsequent exposure of the receptor occurs upon inhalation of the ambient air.

Initially, a qualitative comparison of maximum detected soil concentrations and EPA Generic SSLs for inhalation, based on intermedia transfer (from soil to air), was performed to determine if additional quantitative analysis of this potential exposure pathway was warranted. The inhalation SSLs are based on residential land use and lifetime exposure scenarios and are therefore relatively conservative values for potential receptors under current land use conditions. Exposures to fugitive dust and VOCs released from soil (shallow soil and "all soil") were found to be insignificant in most cases based on the qualitative screening, which is summarized in the site-specific COPC screening tables. Maximum chemical detections in soil were less than the SSLs for most COPCs identified in the study areas; the inhalation exposure pathway therefore was not considered for further evaluation. A discussion of the inhalation pathway, as it pertains to each section of the Area III study area, is provided in the area-specific exposure assessments in Sections 6.7 and 6.8.

6.4.3.2 Direct Contact with Soil/Wetland Soils/Sediment

Receptors may come into direct contact with soil/wetland soils/sediments affected by the release of chemicals from the source areas. During the receptor's period of contact, the individual may be exposed via inadvertent ingestion of a small amount of soil or via dermal absorption of certain contaminants from the soil.

Because of the limited guidance available to estimate exposure to soil via dermal contact, EPA Region I recommends performing a quantitative evaluation of dermal risks for arsenic; cadmium; chlordane; lindane; 2,4-dichlorophenoxyacetic acid (2,4-D); 4,4'-DDT; dioxins, PAHs (benzo(a)pyrene); PCBs (Aroclor 1254 and 1242); and pentachlorophenol, only. Most of these chemicals were selected as COPCs for the Area III study areas. Therefore, dermal risks associated with soil were quantitatively addressed in the risk assessment. Dermal contact with other chemicals detected in the site soils may or may not result in a significant exposure. It

should be noted that organics such as PAHs, which were detected frequently in the soil samples and selected as COPCs, tend to strongly adhere to organic matter in soil. For these chemicals to be percutaneously absorbed, they must first desorb from soil and diffuse through the skin. Various factors affect the rate of dermal absorption, including the amount of soil on the skin surface, soil characteristics (moisture, pH, organic carbon content, etc.), skin characteristics (thickness, temperature, hydration, etc.), volatilization losses, and chemical-specific properties.

6.4.3.3 Direct Contact with Groundwater

As discussed previously, the groundwater resource at the Area III study area is not evaluated in this baseline risk assessment. It is possible that an excavation (for construction, utility maintenance, etc.) could be deep enough to come into contact with the shallow groundwater. In such an instance, workers could be exposed to the groundwater via dermal contact. However, the nature of the Ferry Creek wetland material and local construction practices would preclude excavation/construction in much of the study areas. Potable use of groundwater is not considered to be likely to occur under current and/or future land use because of the brackish conditions.

6.4.3.4 Direct Contact with Surface Water

Receptors may also come into direct contact with surface water containing chemicals in a suspended or dissolved phase. This exposure would be of short duration and individuals may be exposed via dermal contact.

6.4.4 Potential Receptors

Several potential receptors have been identified under both current and future land use conditions. These receptors were identified by analyzing the interaction of current and anticipated future land use practices and the identified sources of contamination.

Several receptor groups have been defined for this risk assessment. These receptors are as follows:

- Commercial Workers - Adults working 40 hours per week at a commercial facility within the Area III study area.

- Frequent recreational users - Residents (adults and children) who reside at properties located in the vicinity of the study area and who may periodically visit (recreate) within the study area.

- Wetland/Marsh receptors- Adults and pre-adolescent children who infrequently visit (recreate) within the study area. The portions of the study area where these receptors may be exposed do not invite frequent use due to vegetative growth. Consequently, exposure to these individuals is anticipated to be less frequent than the exposure anticipated for the frequent recreational users.

One or more of these receptor groups are evaluated quantitatively for each section of the Area III study area. Table 6-8 contains a matrix summary of the particular combinations of receptor groups developed for the Area III study area. Figure 6-1 presents the locations of exposures evaluated for each receptor in this report. The rationale for the selection of receptor groups for each area is provided in the area - specific exposure assessments in Sections 6.7 and 6.8.

The adult commercial worker was evaluated for exposures to surface (depths of 0 to 2 feet bgs without pavement) and "all soils" (to a depth of 15 feet bgs regardless of pavement) for the current and future land use scenarios, respectively. Workers are not expected to contact surface water, sediment, or wetland soils.

Adult and child recreational users and adult and pre-adolescent child (ages 6 to 11 years) wetland/marsh receptors were evaluated for exposures to exposed shallow soils, wetland soils, sediments, and/or surface waters. The frequent recreational user was evaluated in Area D, where the boat launch area has been developed for recreational use. The wetland/marsh receptor, an infrequent recreational user, was evaluated for wetland/marsh portions of Area D and for exposures in Area E.

Two bounding estimates of each exposure scenario are considered, as per EPA Region I guidance. The first is identified as a central tendency exposure (CTE) receptor, which was developed using both regional guidance (EPA, 1994c) and professional judgment regarding site-specific conditions. The second class of receptor is called the reasonable maximum exposure (RME) and was developed according to EPA guidance (EPA, 1989d and 1994c).

6.4.5 Exposure Pathways

An exposure pathway consists of four elements: a source and mechanism of release, a route of contaminant transport through an environmental medium, a contact point for a human receptor, and an exposure route at the point of contact. All four components must be present for the exposure pathway to be considered complete. This section summarizes the potentially complete exposure pathways that are quantitatively evaluated in the risk assessment and provides the rationale for those pathways that are not evaluated. Table 6-9 presents a summary of the potentially complete and incomplete exposure pathways and receptors.

6.4.6 Quantification of Exposure

Estimates of exposure are based on the contaminant concentrations at the exposure points and on scenario-specific assumptions and intake parameters. The models and equations used to quantify intakes are described in this section and have been obtained from a variety of EPA guidance documents, which are cited in the specific intake estimation sections that follow.

Exposures depend on the predicted concentrations of chemicals in environmental media and local land use practices, and both are subject to change over time. This results in a large number of possible combinations of receptors, media, exposure pathways, and concentrations. As mentioned previously, Table 6-8 presents a summary of the exposure pathways evaluated in the quantitative risk assessment. Some of these scenarios (such as occupational and recreational scenarios) may be applicable under both current and future land use conditions.

Exposure model parameters are presented in Tables 6-10 and 6-11 for soils/sediments and surface water, respectively. The values reflect current EPA guidance and comments received from EPA Region I on the Draft Final Work Plan Remedial Investigation/Feasibility Study for

the Raymark – Ferry Creek study areas, December, 1996. All parameters are referenced in footnotes on each table. These parameters are used in the equations presented in this section, along with the exposure point concentrations presented in the site-specific sections, to calculate intakes, which are used to determine risks. Individual chemical intakes for each receptor/exposure route combination are presented in the spreadsheets in Appendices F-9 and F-10.

Incidental Ingestion of Soil/Wetland Soil/Sediment. The estimation of intake of contaminants in soils/sediments is determined using the predicted concentration of a contaminant in the area of interest. This pathway is evaluated for both child and adult receptors involved in recreational activities and commercial workers. In general, intakes associated with soil ingestion are calculated using the following equation:

$$Intake_{si} = \frac{(C_{si})(IR)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where: $Intake_{si}$ = intake of contaminant "i" from soil (mg/kg/day)

C_{si} = concentration of contaminant "i" in soil (mg/kg)

IR = ingestion rate (mg/day)

FI = fraction ingested from contaminated source (decimal fraction)

EF = exposure frequency (days/yr)

ED = exposure duration (yr)

CF = conversion factor (10-6 kg/mg)

BW = body weight (kg)

AT = averaging time (days);
for non-carcinogens, AT=ED*365 days/yr;
for carcinogens, AT=70 yr*365 days/yr

To evaluate the RME, TtNUS used soil ingestion rates of 100 mg/day for the commercial/industrial worker under current and future land use, 200 mg/day for child recreational users, and 100 mg/day for adult recreational users. Soil ingestion rates for the CTE were set at 100 mg/day for child recreational users and 50 mg/day for adult recreational users and commercial/industrial workers.

No attempt was made to vary a receptor's exposure frequency for the RME and CTE. A value of 250 days/year was used for workers, which is consistent with EPA and DEP default values. Site-specific considerations were used to determine exposure frequencies for the remaining potential receptors. A value of 150 days/year was used for frequent recreational users in Area D. This value assumes that the receptor is exposed approximately three days/week year-round. Wetland/marsh receptors (infrequent recreational users) were assumed to be only exposed 1 day/week during the summertime months (May through September for a total of 20 weeks).

A majority of the proposed exposure duration values are based on EPA guidance for RME and CTE evaluation. Values for small children and pre-adolescent children for the RME reflect the entire age span for the receptor evaluated. The associated CTE values reflect a short period of time (basically one-third to one-half of the RME value). Exposure duration for commercial/industrial workers is assumed to be 25 years for the RME and 9 years for the CTE. RME exposure durations for child and adult receptors under recreational scenarios are 6 years and 24 years, respectively. CTE exposure duration for these receptors is 2 years (child) and 7 years (adult).

Table 6-10A contains a summary of the input parameters for incidental ingestion of soil/sediment.

Dermal Contact with Soil/Wetland Soil/Sediment

Dermal contact exposures to soil/sediment may also occur during recreational, trespassing, and commercial/industrial scenarios. A quantitative evaluation of dermal exposure to soil/sediment was performed for arsenic, cadmium, chlordane, DDT, dioxins, PAHs, and PCBs only. Exposure to other chemicals detected at the Area III study area is addressed in a qualitative fashion.

The following equation was used to estimate the dermal exposure dose for soil/sediment:

$$DAD_{si} = \frac{(C)(ABS)(AF)(SA)(EF)(ED)(CF)}{(BW)(AT)}$$

where: DAD_{si} = Dermally absorbed dose of chemical "i" from soil/sediment (mg/kg/day)

C = Exposure concentration for soil/sediment (mg/kg)

ABS = Absorption factor (unitless)

AF = Soil-to skin adherence factor (mg/cm^2)

SA = Skin area available for contact (cm^2/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

CF = Conversion factor (1E-6 kg/mg)

BW = Body weight (kg)

AT = Averaging (days);

AT = 70 years * 365 days/year for carcinogens;

AT = ED * 365 days/year for noncarcinogens

Chemical-specific absorption factors (ABS) presented in current dermal assessment guidance (EPA, 1998) or in the literature as suggested by EPA Region I were used to estimate exposure doses. Unfortunately, limited information regarding dermal absorption is available. The cited guidance presents sufficient data to evaluate arsenic, cadmium, chlordane, lindane, 2,4-dichlorophenoxyacetic acid (2,4-D), 4,4'-DDT, dioxins, PAHs (benzo(a)pyrene), PCBs (Aroclor 1254 and 1242), and pentachlorophenol, only. The ABS for benzo(a)pyrene, was applied as a surrogate for all PAHs and the ABS for Aroclor 1242 and Aroclor 1254 was applied as a surrogate for all PCBs. The ABS ranges presented for these chemicals are presented in Table 6-10B. Because of the absence of dermal absorption data, TtNUS qualitatively evaluated dermal exposures to all other COPCs.

Values of 0.07 mg/ cm^2 and 0.01 mg/cm^2 were used as soil-to-skin adherence factors for the RME and CTE, respectively, for adult recreational users in Area D. This area is dry or predominantly dry. Values of 0.2 mg/cm^2 and 0.06 mg/cm^2 were used as soil-to-skin adherence values for the RME and CTE, respectively for child recreational users in Area D. For adult wetland/marsh receptors, soil-to-skin adherence factors of 0.3 mg/cm^2 and 0.04 mg/cm^2 were used for RME and CTE cases, respectively. For child wetland/marsh receptors, soil-to-skin adherence factors of 1.0 mg/cm^2 and 0.2 mg/cm^2 were used for the RME and CTE

cases, respectively. Soil-to-skin adherence factors of 0.2 mg/cm^2 and 0.02 mg/cm^2 were used for the commercial worker for the RME and CTE cases, respectively. The values have been recommended in working drafts of EPA Interim Guidance entitled: "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Interim Guidance" (EPA, 1998). The values were based on data presented in the 1997 version of the EPA Exposure Factor Handbook.

For the skin surface areas available for contact, the proposed values were determined by making assumptions about a receptor's exposed body areas. For adult commercial workers, the face, hands, and forearms are expected to be available for contact. For adult recreational users, the face, hands, forearms, and lower legs are expected to be available for contact. For child recreational users, the face, hands, forearms, lower legs, and feet are expected to be available for contact. Skin surface areas corresponding to each of these areas of the body for each age group were obtained from the EPA Exposure Factor Handbook (EPA, 1997).

Exposure frequencies and exposure duration for dermal contact are the same as those previously identified for incidental ingestion of soil/sediment.

Input parameters for dermal contact with soil/sediment are summarized in Table 6-10A.

Inhalation of Fugitive Dust and Volatile Emission

As discussed previously, a qualitative evaluation (comparison of study area data to EPA SSLs for transfers from soil to air) of this exposure pathway was performed for each study area. No quantitative evaluation was conducted because no significant exceedances of EPA SSLs were observed.

Dermal Contact with Surface Water

Wetland/marsh receptors were evaluated for dermal exposure to surface water while wading. The following equation was used to estimate exposures resulting from dermal contact with water (EPA, 1998):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(SA)}{(BW)(AT)}$$

where: DAD_{wi} = dermally absorbed dose of chemical "i" from water (mg/kg/day)

DA_{event} = absorbed dose per event (mg/cm^2-event)

EV = event frequency (events/day)

ED = exposure duration (yr)

EF = exposure frequency (days/yr)

SA = skin surface area available for contact (cm^2)

BW = body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT=ED*365 days/yr;
for carcinogens, AT=70yr*365 days/yr

The absorbed dose per event (DA_{event}) is estimated using a nonsteady-state approach for organic compounds and a more traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} \le t^*, \text{ then : } DA_{event} = (2\,K_p)\,(C_{wi})\,(CF)\left(\frac{\sqrt{6\,\tau\,t_{event}}}{\pi}\right)$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (K_p)(C_{wi})(CF)\left(\frac{t_{event}}{1+B} + 2\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right)$$

where: t_{event} = duration of event (hr/event)

t^* = time it takes to reach steady-state conditions (hr)

K_p = permeability coefficient from water through skin (cm/hr)

C_{wi} = concentration of chemical "i" in water (mg/L)

τ = lag time (hr)

π = constant (unitless; equal to 3.141592654)

CF = conversion factor (10^{-3} L/cm^3)

B = partitioning constant derived by Bunge Model (dimensionless)

Values for the chemical-specific parameters (t_{event}, t^*, K_p, τ, and B) were obtained from the November 1998 draft dermal guidance. If no published values were available for a particular organic compound, they were calculated using equations provided in the cited guidance. Details regarding the procedures used to derive the constants, as well as sample calculations, are provided in Appendix F-8.

The following nonsteady-state equation is used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)(C_{wi})(t_{event})(CF)$$

In general, the recommended default K_p value of 0.001 was used for inorganic constituents (EPA, 1998).

Under the RME and CTE, the event frequency was set at 1 event/day. No attempt was made to vary exposure time for the RME and CTE. The exposure times for wetland/marsh receptors were set at 1 hour/day.

Area-specific considerations were used to determine exposure frequencies. Wetland/marsh receptors are assumed to contact surface water in the study area 1 day/week during 20 weeks/year, for a total of 20 days/year.

A majority of the proposed exposure duration values are based on EPA guidance for RME and CTE evaluation. Values for children for the RME reflect the entire age span for the receptor evaluated. The associated CTE value for children reflects a shorter period of time. RME exposure durations for child and adult receptors under the wetland/marsh scenario are 6 years and 24 years, respectively. CTE exposure durations for these receptors are 2 years (child) and 7 years (adult).

Only a receptor's hands, feet, and lower legs were assumed to be exposed for wading scenarios. These body parts represent 25 percent of total body surface area. The skin surface areas for the wading scenario were set at 4,500 cm^2 for adults and 2,500 cm^2 for pre-adolescent children. These values represent 25 percent of total body surface area for the appropriate ages of receptors as presented in the Exposure Factor Handbook (EPA, 1997).

Input parameters for dermal contact with surface water are summarized in Table 6-11.

6.4.7 Exposure to Lead

Exposure to lead was evaluated using the EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead, version 0.99D (EPA, 1994a). This model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Exposures to lead by nonresidential adults are evaluated by use of a slope-factor approach developed by the EPA Technical Review Workgroup for Lead (EPA, 1996c and 1996d). The approach focuses on estimating fetal blood lead concentrations in women exposed to lead contaminated soils.

Blood lead concentration is the most widely used index of internal lead body burdens associated with potential adverse health effects. Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. The threshold for toxic effects to children from this chemical is believed to be in the range of 10 µg/dL to 15 µg/dL. Blood lead levels greater than 10 µg/dL are considered to be a "concern."

In general, the IEUBK Model and Technical Review Work Group Model for lead were used to address exposure to lead when detected soil concentrations exceeded the OSWER soil screening level of 400 mg/kg for residential land use (EPA, 1994b). Exposure concentrations, as well as default parameters for some input parameters, were used in the evaluation. In the IEUBK model, lead concentrations in house dust were set equal to 70 percent of the lead concentration in outdoor soil, assuming a multi-source model. The IEUBK model presents 70 percent as a default value for house dust concentrations when contaminated soil is at some distance from the house and no other source of lead is known. Exposures to lead are discussed in the site-specific sections (Sections 6.7 and 6.8). The input parameters used and the results of lead models, estimated blood lead levels, and probability density histograms are presented in Appendix F-11.

6.5 Risk Characterization

This section provides a characterization of the potential human health risks associated with the potential exposure to COPCs in environmental media in the Area III study area. Section 6.5.1 outlines the methods used to estimate the type and magnitude of health risks, and area-specific sections (Sections 6.7 and 6.8) present the results for the current and potential future land use conditions for each section of the Area III study area.

6.5.1 Risk Characterization Methodology

Potential human health risks resulting from exposure to COPCs are estimated using algorithms established by EPA. The methods described by EPA are protective of human health and are likely to overestimate (rather than underestimate) risk. The methodology uses specific algorithms to calculate risk as a function of chemical concentration, human exposure parameters, and toxicity.

Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may also exhibit noncarcinogenic effects. Potential impacts are then characterized for both types of health effects.

Chemical Carcinogens. Risks attributable to exposure to chemical carcinogens are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the incremental lifetime cancer risk (ILCR) is determined as follows (EPA, 1989d):

$$ILCR_i = (Intake_i)(CSF_i)$$

where: $ILCR_i$ = Incremental Lifetime Cancer Risk for chemical "i", expressed as a unitless probability

$Intake_i$ = Intake of chemical "i" (mg/kg/day)

CSF_i = Cancer Slope Factor of chemical "i" $(mg/kg/day)^{-1}$

Risks below 10^{-6} (or a risk less than 1 in 1 million) are generally considered to be acceptable by EPA, and risks greater than 10^{-4} (1 in 10,000) are generally considered to be unacceptable.

Risks are estimated for all carcinogenic compounds regardless of the class designation (See Section 6.3.1).

Noncarcinogens. The hazards associated with the effects of noncarcinogenic chemicals are evaluated by comparing an exposure level or intake to a Reference Dose (RfD). The ratio of the intake to the RfD is called the Hazard Quotient (HQ) and is defined as follows (EPA, 1989d):

$$HQ_i = \frac{Intake_i}{RfD_i}$$

where: HQ_i = Hazard Quotient for chemical "i" (unitless)

$Intake_i$ = Intake of chemical "i" (mg/kg/day), a function of exposure and chemical concentration

RfD_i = Reference Dose of chemical "i" (mg/kg/day)

If the ratio of the intake to the RfD exceeds unity, there exists a potential for noncarcinogenic (toxic) effects to occur. A Hazard Index (HI) is generated by summing the individual HQs for all the COPCs. If the value of the HI exceeds unity, it is necessary to segregate the HQs by target organ effects and access an HI for the specific target organ. If the endpoint specific HI exceeds unity, there is a potential for noncarcinogenic health effects. The HQ should not be construed as a probability in the manner of the ILCR, but rather as a numerical indicator of the extent to which a predicted intake exceeds or is less than a RfD.

6.6 Uncertainties Analysis

There is uncertainty associated with all aspects of the baseline human health risk assessment presented in the preceding sections. This section presents a summary of these uncertainties, with a discussion of how they may affect the final risk numbers discussed in Sections 6.7 and 6.8.

There is uncertainty associated with all steps of the risk assessment process. The selection of contaminants of concern is based on exposure assumptions and toxicity information, which in turn have associated uncertainties. Uncertainty in the selection of COPCs is associated with the current status of the predictive databases and the procedures used to include or exclude constituents as chemicals of concern. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route, the methods used and the assumptions made to determine exposure point concentrations, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing data to support dose-response relationships and the weight-of-evidence used for determining the carcinogenicity of chemicals of concern. Uncertainty in risk characterization includes that associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

While there are various sources of uncertainty, as described above; throughout the entire risk assessment, assumptions were made so that the final calculated risks would be conservative estimates, which are protective of public health.

Generally, risk assessments carry two types of uncertainty: measurement and informational uncertainty. Measurement uncertainty refers to the variance that can be attributed to sampling techniques and laboratory analysis of contaminants. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used.

Informational uncertainty refers to estimates of toxicity and exposure. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, the biological mechanism of action of a chemical, or the behavior of a chemical in soil.

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the particular assumptions

made are protective of sensitive sub-populations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward over-predicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation is especially relevant when the risks exceed the point-of-departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are below an "acceptable" risk level (10^{-6}), the interpretation of no significant risk is straightforward. However, when risks calculated using a high degree of uncertainty are above an "acceptable" risk level (10^{-4}), a conclusion can be difficult unless uncertainty is considered.

Recent EPA guidance on risk assessment (EPA, 1992 and 1994c) requires risk assessors to use exposure and toxicity assumptions from the "high end" and the "central tendency" of their distributions. These values correspond to the RME and CTE scenarios. The RME is conceptually the "high end" exposure above the 90th percentile of the population distribution but not higher than the individual in the population with the highest exposure. The CTE reflects the central (average) estimates of exposure.

6.6.1 Uncertainty in Selection of Chemicals of Concern

There is a minor amount of uncertainty associated with the selection of COPCs on the final risk values in the quantitative risk assessment. Conservative screening values were used to select COPCs; thus, it is unlikely that any contaminants that may pose a risk were eliminated from the risk assessment.

6.6.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises for the methods used to calculate exposure point concentrations, determination of land use conditions, selection of receptors, and selection of exposure parameters. Each of these is discussed below.

Calculation of Exposure Point Concentrations. For media in some areas, fewer than ten samples were available. This makes the estimation of the upper 95 percent confidence limit on the mean highly uncertain and, therefore, the maximum detected chemical concentrations were used to assess risks. As a result, the estimations of risk where maxima were used as exposure concentrations are most likely to be overstated because it is unlikely that potential receptors would be exposed to the maximum concentration over the entire exposure period.

Exposure Routes and Receptor Identification. Exposure routes and receptor groups were based on discussions with the EPA and CTDEP and on site visits. This may either under- or over-estimate the risks, with the final result dependent on how well the receptors were defined.

Selection of Exposure Parameters. Each exposure factor selected for use in this risk assessment has some associated uncertainty. Generally, exposure factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid underestimation of exposure, EPA guidelines on the RME receptor were used that generally consist of the 95th percentile for most parameters. Therefore, the selected values for the RME receptor represent the upper bound of the observed or expected habits of the majority of the population.

Many of the exposure parameters were determined from statistical analyses on human population characteristics. Often the database used to summarize a particular exposure parameter (body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty. For many parameters for which limited information exists (dermal absorption of organic chemicals from soil), there is greater uncertainty.

Many of the quantities used to calculate exposures and risks in this report are selected from a distribution of possible values. For the RME scenario, values representing the 90th-95th percentile values are selected for some, but not all, parameters to ensure that the assessment bounds the actual risks from a postulated exposure. In order to estimate a central tendency estimate of exposure, EPA has suggested the use of the CTE receptor, whose intake variables are set at approximately the 50th percentile of the distribution. The risks for this receptor seek to incorporate the range of uncertainty associated with various intake assumptions. Many of

the parameters were estimated using professional judgment, although EPA Region I provides some default parameters (EPA, 1994c).

6.6.3 Uncertainty in the Toxicological Evaluation

A toxicity evaluation is the hazard identification and dose-response assessment of a chemical. The hazard identification deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard identification of carcinogenicity is an evaluation of the weight-of-evidence that a chemical causes cancer. Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of non-cancer effects, however, positive animal data suggest the nature of the effects (the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arises from the nature and quality of the animal and human data. Uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when pharmacokinetic data indicate a similar fate in humans and animals; when postulated mechanisms of toxicity are similar for humans and animals; and when the chemical of concern is structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation includes the determination of a slope factor for the carcinogenic assessment and derivation of a RfD or Reference Concentration (RfC) for the noncarcinogenic assessment. The slope factor is an upper bound estimate of the human cancer risk per milligram of contaminant per milligram of body weight per day. The RfD and RfC are estimates with uncertainty spanning perhaps an order of magnitude of daily exposure to humans that below which is likely to be without appreciable risk of adverse effect over a lifetime. Uncertainty is introduced from interspecies (animal to human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also results from intra-species variation. Most toxicity experiments are performed with animals that are very similar in age and genotype so that intra-group biological variation is minimal, but the human

population of concern may reflect a great deal of heterogeneity, including unusual sensitivity or tolerance to the COPC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not unusually sensitive to the chemical are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study from which the quantitative estimate is derived and from the database.

For cancer effects, the uncertainty associated with dose-response factors is mitigated by assuming the 95 percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a non-threshold assumption of carcinogenesis. There is evidence to suggest, however, that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (William and Weisburger, 1991); therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity.

For non-cancer effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for non-cancer effects arises from the use of an effect level in the estimation of an RfD or RfC, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises in estimation of a RfD or RfC for chronic exposure from less-than-chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less-than-chronic study. Uncertainty in the derivation of RfDs is mitigated by the use of uncertainty and modifying factors that normally range between 3 and 10. The resulting combination of uncertainty and modifying factors may reach 1,000 or more.

Class C carcinogens are classified as possible human carcinogens because the evidence for their carcinogenicity in animals is limited. The inclusion of these compounds in the estimation

of total carcinogenic risk adds to the uncertainty of the final risk numbers by potentially overestimating the human health effects.

The derivation of dermal RfDs and CSFs from oral values may cause uncertainty. This is particularly the case when no gastrointestinal absorption rates are available in the literature or when only qualitative statements regarding absorption are available.

Uncertainty in the dose-response evaluation is associated with a lack of toxicity values for some contaminants for some or all routes of exposure. The unavailability of toxicity values precludes quantitative evaluations of these contaminants. Therefore, total risks may be underestimated.

Uncertainty also arises in the dose-response assessment for values derived for several principal chemicals of concern by using studies with limitations. For example, Class B2 PAHs for which no toxicity data are available are evaluated using benzo(a)pyrene toxicity data with estimated orders of potential potency for the average and RME receptors. This may either underestimate or overestimate the carcinogenic risks associated with PAHs.

Uncertainty arises in the non-carcinogenic evaluation of PCBs through the use of the RfD for Aroclor 1254 in combination with total Aroclor concentrations. The predominant Aroclors in Area D soils are Aroclors 1262 and 1268. Aroclor 1254 predominates in the wetland/marsh portion of Area D. Since non-carcinogenic toxicity values are unavailable for Aroclors other than Aroclor 1254 and Aroclor 1016, non-carcinogenic risks from Aroclors other than Aroclor 1254 may be over- or under- estimated.

Uncertainty is associated with the exclusion of copper from the quantitative risk assessment. EPA Region I does not generally quantitatively evaluate non-carcinogenic hazards posed by copper because the toxicity value (RfD) has not been verified by EPA. Copper is a major contaminant in Area III. Exclusion of copper from this risk assessment may result in an under estimate of non-carcinogenic risks.

The carcinogenicity of arsenic via ingestion is not confirmed by the available data. However, EPA has proposed an oral unit risk factor that was used for all oral and dermal exposures to arsenic at this site. Since arsenic is a major risk driver, the risks may be overstated.

Some uncertainty is associated with the evaluation of chromium, which was assumed to be present in its hexavalent state. Since hexavalent chromium is considered to be more toxic than the trivalent state, which is essentially more common, risks for this chemical are probably overestimated to some degree.

Uncertainty in final calculations of risk results from assumptions made regarding additivity of effects from exposure to multiple compounds from various exposure routes. High uncertainty exists when cancer risks for several substances are summed across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the body, so additivity may not be an appropriate assumption. However, the assumption of additivity is made to provide a conservative estimate of risk.

Finally, the risk characterization does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the COPCs. Therefore, this uncertainty cannot be discussed for its impact on the risk assessment, since it may either underestimate or overestimate potential human health risk.

Uncertainty is associated with the evaluation of exposures to lead. Two methods have been used in this risk characterization to evaluate lead exposures. Exposures of children to lead are evaluated using EPA's IEUBK model. Uncertainty is associated with the use of default values for exposures to lead via pathways other than soil ingestion. The IEUBK model was developed based on children exposed in a residential scenario. Application of this model to the recreational scenarios at this site results in uncertainties beyond those already inherent in the model. Exposures of commercial workers to lead are evaluated by use of the EPA Technical

Review Workgroup Model for lead. This approach focuses on estimating fetal blood-lead concentrations in women exposed to lead contaminated soils in non-residential scenarios. Uncertainty is associated with estimation of maternal blood-lead concentrations and with the relationship between maternal blood-lead concentrations and fetal blood-lead concentrations.

This risk characterization does not include a quantitative risk evaluation of the risks associated with potential receptor exposures to asbestos because of the lack of appropriate toxicity criteria. Uncertainty in the risk characterization is associated with the presence of asbestos-containing material, defined as material containing more than 1 percent asbestos (EPA Regulation 40 CFR Subpart M, Part 61). Asbestos is considered a potential inhalation hazard if it is "friable" (can be crumbled, pulverized, or reduced to powder) and, consequently, subject to entrainment/migration into the air. It is chosen as a COPC based on the health effects exhibited in occupationally exposed workers in epidemiological studies. Inhalation studies in animals and humans indicate that exposure to asbestos fibers may lead to asbestosis, lung cancer, tumors of the thin membranes surrounding internal organs such as the pleural and peritoneal membranes (mesotheliomas), and an increased risk of extrathoracic cancers. Asbestos exposure leading to cancer depends not only on dose but also on underlying risk factors such as smoking.

6.7 Baseline Human Health Risk Assessment - Area D, Beacon Point Area

This section contains the baseline risk assessment performed for soil, wetland soil, sediment, and surface water exposures at Area D, Beacon Point Area. Section 6.7.1 provides an overview of Area D, Section 6.7.2 contains a discussion of the selection of COPCs, Section 6.7.3 contains information on the potential receptors considered and the routes by which they might be exposed, Section 6.7.4 contains the numerical results of the risk assessment, and Section 6.7.5 presents site-specific uncertainties.

6.7.1 Overview of Area D, Beacon Point Area

Area D, Beacon Point Area encompasses undeveloped wetlands that are tidally influenced by the Housatonic River, a public boat launch area, and a dry dock area. The area covers approximately 20.1 acres wetlands. A more detailed description of Area D is provided in

Section 6.7.3.1. The nature and extent of the contamination detected in Area D was discussed in Section 4. Descriptive statistics (frequency of detection, range of positive detections, range of non-detects, location of maximum detections, and arithmetic mean) for target analytes detected in the Area D environmental media are also summarized in Tables 6-12 through 6-15.

6.7.2 Data Evaluation

Tables 6-12, 6-13, and 6-15 present a summary of the COPCs for quantitative risk assessment for Area D surface soils/wetland soils/sediments, "all soils" to a depth of 15 feet bgs, and surface waters, respectively. COPCs were identified based on a comparison of site data to the COPC screening levels defined in Section 6.2. All validated CLP data collected through 1997 except soil data collected from depths greater than 15 feet, were used to identify COPCs. The 1999 data collected by SAIC, Inc. are not included in the human health risk assessment. Soil data for depths greater than 15 feet were not used because human exposure to soils deeper than 15 feet below ground surface is considered very unlikely. Because of the significant correlation observed between field screening data and validated CLP data for lead and copper, screening data were also used for these chemicals at sample locations where no CLP data are available. An evaluation of groundwater is not part of the scope of work for this human health risk assessment, but will be addressed as part of an area-wide groundwater assessment to be provided as a separate document.

Table 6-14A and 6-14B compare maximum chemical concentrations detected in the surface soils, wetland soils, and sediments data set and the "all soils" data set, respectively, to the groundwater protection benchmarks defined in Section 6.2.1.1 (the Generic SSLs for migration from soil to groundwater and State Pollutant mobility GB criteria). Although groundwater data were not addressed in this risk assessment, the comparison allows for a preliminary evaluation of the potential for chemicals to migrate to groundwater and potentially impact the quality of groundwater. Chemicals in excess of groundwater protection benchmarks, but not in excess of direct exposures criteria are not carried through the quantitative risk assessment (numerical risk estimates are not developed) because they are not considered to be significant contributors to the direct exposure pathways identified for potential human receptors.

A media-specific discussion of COPCs is presented in the following paragraphs.

6.7.2.1 COPCs for Soil/Wetland Material/Sediment

The COPC selection process for soil, wetland material, and sediment is summarized in Tables 6-12 and 6-13. The following chemicals were identified as direct exposure COPCs based on a comparison of maximum Area D concentrations to risk-based COPC screening levels for residential land use, Generic SSLs for migration from soil to air, State RSRs, and maximum background concentrations (inorganic chemicals only):

- Asbestos
- PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k) fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene)
- Aroclors (1016, 1248, 1254, 1260, 1262, and 1268)
- Pesticides (aldrin, alpha chlordane, and heptaclor epoxide)
- PCB congeners (total heptachlorobiphenyls, total hexachlorobiphenyls, total octachlorobiphenyls, and total trichlorobiphenyls)
- Metals (antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, thallium, vanadium, and zinc)
- Dioxins/Furans

Hexachlorobenzene and heptaclor were not accepted as COPCs due to the low frequency of detection and only slight exceedances of the selection criteria.

Aluminum and iron were not accepted as COPCs because EPA Region I does not advocate quantitative risk assessment of the health effects of aluminum or iron because of the lack of adequate toxicity criteria. However, all Aroclors and PCB congeners were accepted as COPCs

because at least one Aroclor and one congener were detected at maximum concentrations exceeding COPC screening levels.

Benzo(k)fluoranthene was selected as a COPC for the 0 to 15 feet bgs category only, since the maximum concentrations in the surface soil samples (from depths of 0 to 2 feet bgs) was less than the direct exposure screening levels.

Maximum detections in soil, wetland material, and sediment were also compared to Generic SSLs for migration from soil to groundwater and Connecticut RSRs for pollutant mobility in a GB classified area. Maximum concentrations of the following chemicals exceeded the generic soil pollutant mobility criteria, indicating a potential for these chemicals to migrate to groundwater and potentially impact the quality of groundwater:

- SVOCs (carbazole, hexachlorobenzene, and pentachlorophenol)
- PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene)
- Pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, alpha-BHC, alpha chlordane, beta-BHC, delta-BHC, dieldrin, gamma-BHC, gamma chlordane, heptaclor, and heptaclor epoxide)
- Metals (antimony, arsenic, barium, cadmium, chromium, mercury, nickel, selenium, and thallium)

Under the Connecticut RSR guidance (CT DEP, January 1996), concerns regarding the mobility of inorganics are addressed using TCLP and/or SPLP data. A comparison of site-specific SPLP data to State RSRs for pollutant mobility is provided in Table 6-14C. Reported concentrations of copper, lead, and manganese in the SPLP extracts from three soil samples exceeded the State pollutant mobility criteria.

6.7.2.2 COPCs for Surface Water

Table 6-15 presents a summary of the COPC selection process for surface water. Based on a comparison of maximum Area D concentrations to risk-based COPC screening levels for tap water use and drinking water standards (federal and state MCLs), the following chemicals were identified as COPCs:

- Pesticides (heptaclor epoxide)
- Metals (antimony, copper, lead, and manganese)

Although surface water in the area is not currently used or expected to be used in the future as a drinking water supply, drinking water criteria (federal and state MCLs) were included for informational purposes and to conservatively identify COPCs for Area D. Iron was not selected as a COPC, despite concentrations above the risk-based COPC screening levels. EPA Region I does not advocate quantitative risk assessment of the health effects of this metal due to the lack of adequate toxicity criteria. The Connecticut State MCL for sodium is a state notification level and is not risk based. For this reason, sodium was not selected as a COPC, despite concentrations above the state MCL.

6.7.3 Area D, Exposure Assessment

The exposure assessment contains a discussion of the potential for human exposure at Area D and identifies the rationale for the selection of exposure input parameters used to estimate exposure intakes. A detailed description of the potential receptors, exposure routes, and intake estimation methods used in the exposure assessment is presented in Section 6.4. Area-specific information regarding exposure is provided in this section.

The potential for exposure at Area D is based on several factors, including current and future land uses, activity patterns, site access controls, chemical behavior in the environment, and the presence of human receptors. Based on these variables, exposure scenarios were developed to characterize the potential for human exposure under both current and future site

conditions. The future scenario accounts for likely or anticipated changes in land use and area characteristics that may alter exposure and/or concentrations of COPCs in a given medium.

The exposure assessment is based on the assumptions that, in general, chemical compositions for environmental media are identical under current and future conditions. Under current conditions, potential human receptors (the frequent recreational user, wetland/marsh receptor, and commercial worker) are assumed to be exposed to surface soil and/or sediment (0 to 2 feet bgs). In the future, contaminated soils currently located at depth and/or beneath pavement to a maximum depth of 15 feet bgs may be brought to the surface during land development (excavation/construction). Under future conditions, commercial workers are evaluated for exposure to soils collected from depths of 0 to 15 feet bgs at the commercial property only. With the exception of the receptors involved in commercial activities, similar soil/sediment exposure is likely for potential receptors under current and future conditions. Given that future changes to the chemical composition of the river/creek/marshy waters are difficult to predict, it is assumed for purposes of this risk assessment that chemical concentrations in surface water would not change in the future.

A summary of the potentially significant exposures identified for quantitative evaluation for Area D is provided in Table 6-16.

6.7.3.1 Area D, Land Use and Access

Area D, Beacon Point Area, is located to the south and adjacent to Area C, as shown in Figure 1-2. It encompasses undeveloped wetlands that are tidally influenced by the Housatonic River, a public boat launch area that EPA refers to as the Birdseye Boat Launch, and a dry dock area that EPA refers to as the Beacon Point Dry Dock. The area covers approximately 20.1 acres, including approximately 5.0 acres of wetlands.

Area D is bounded by Beacon Point Road and Harbour Woods Condominium Complex to the west, the Housatonic River to the south and east, and the Tide Harbours Condominium Complex Boat Dock to the north.

6.7.3.2 Area D, Potential Receptors

As identified in Section 6.4, several potential receptor populations were initially considered for inclusion in the exposure assessment. However, the majority of these receptors were eliminated from further evaluation based on the current land use, site access, COPCs, and the likelihood of exposure. Of the receptors initially considered (residents, recreational users, commercial workers, construction workers, and trespassers), the receptors retained for quantitative evaluation are frequent recreational users, wetland/marsh receptors, and commercial workers.

Possible exposures of frequent visitors to site-related contaminants would be through recreational activities, such as walking, or picnicking. Persons involved in recreational activities (the frequent recreational user) may visit the boat launch area of Area D, thereby coming in contact with potentially contaminated media. It is not anticipated that these receptors will visit the river or wetland/marsh areas bordering the boat launch area. Rather, exposures to the river and wetland areas of Area D are evaluated for the wetland/marsh receptors. The wetland/marsh receptors may visit the river and wetland/marsh areas bordering the boat launch area, thereby coming in contact with potentially contaminated wetland soils, sediments, and surface water. It is not anticipated that these receptors will contact sediments found within the river in areas covered by 4 or more feet of water at low tide.

Possible exposures of commercial workers to site-related contaminants would be through commercial/industrial activities in Area D. These receptors are assumed to be exposed to soils in a limited area (soils within the dry dock area). No major construction projects are planned for Area D or the surrounding areas. However, the baseline risk assessment was conducted assuming that the commercial worker may be exposed in a limited area to soils as deep as 15 feet bgs in the future.

Future on-site residents were not included in the baseline risk assessment for Area D. Current land use suggests that the area is valuable as commercial property. Additionally, much of the soil in Area D surrounding the Housatonic River is wetland and local construction practices preclude subsurface excavation and/or development of Area D for residential purposes. In

addition, groundwater in the area is not used or expected to be used in the future as a potable water supply because of brackish conditions.

6.7.3.2.1 Frequent Recreational Users

Area D, Beacon Point Area, is primarily recreational. Frequent recreational users are evaluated for exposure to surficial soils (0 to 2 feet bgs) in the boat launch area of Area D, under current and future land use. Recreational users are assumed to be exposed to site media frequently (150 days/year). These receptors are assumed to ingest an average of 200 mg/day for 6 years for the child and 100 mg/day for 24 years for the adult for the RME, and an average of 100 mg/day for 2 years for the child and 50 mg/day for 7 years for the adult for the CTE. Face, hands, forearms, and lower legs are expected to be available for dermal contact with soil/sediment.

6.7.3.2.2 Wetland/Marsh Receptors

Area D, Beacon Point Area is primarily recreational. Wetland/marsh receptors are evaluated for exposure to surficial soils, sediments, and wetland soils (0 to 2 feet bgs) in the river and wetland areas of Area D, under current and future land use. Areas covered by 4 or more feet of water at low tide are excluded from consideration. Wading is included as a possible recreational use of this area, therefore, direct, but limited, contact with surface water in the Housatonic River is anticipated for these receptors. Wetland/marsh receptors, both adult and pre-adolescent child (ages 6 to 11 years), are assumed to be exposed to area media infrequently (20 days/year). These receptors are assumed to ingest an average of 200 mg/day for 6 years for the child and 100 mg/day for 24 years for the adult for the RME, and an average of 100 mg/day for 2 years for the child and 50 mg/day for 7 years for the adult for the CTE. Face, hands, forearms, and lower legs are expected to be available for dermal contact with soil/sediment. Hands, lower legs, and feet are expected to be available for dermal contact with surface water while wading.

6.7.3.2.3 Commercial Workers

Possible exposures of commercial workers to site-related contaminants would be through inadvertent contact. Under the current land use, commercial workers are evaluated for exposure to currently exposed surficial soils (0 to 2 feet bgs) at a limited area (soils within the dry dock area) only. In the future, contaminated soils currently located at depth and/or beneath pavement may be brought to the surface through excavation and land development. Commercial workers were evaluated for exposure to soils at 0 to 15 feet bgs at a limited area (soils within the dry dock area) under future land use. Workers are not expected to be exposed to contaminated wetland soil, sediments, or surface water in the river or along the banks of the river. Commercial workers are assumed to be exposed to area media 250 days/year. These receptors are assumed to ingest an average of 50 mg/day for 9 years for the CTE and 100 mg/day for 25 years for the RME. Face, hands, and forearms are expected to be available for dermal contact with soils.

6.7.3.3 Area D, Exposure Pathways

The primary routes of exposure for potential human receptors at Area D are incidental ingestion of and dermal contact with soil, sediment, and wetland soils, and dermal contact with surface water. Exposure routes associated with soil contact are evaluated for commercial workers. Exposure routes associated with soil, sediment, and wetland soils, and surface water contact are evaluated for recreational users.

Other potential exposure routes such as groundwater uses, inhalation of fugitive dust and volatile emissions, and ingestion of surface water were not evaluated for the following reasons:

- The shallow aquifer at Area D is not used as a potable water supply either at Area D or in the surrounding areas. Shallow groundwater in the area discharges to the Housatonic River and its tributaries. Thus, domestic groundwater exposures by nearby residents are eliminated. In addition, as previously mentioned, groundwater in the area is not used or expected to be used in the future as a potable water supply because of brackish conditions and productivity constraints. It should be noted that groundwater quality at Ferry Creek is being investigated as a separate operable unit.

- Potential exposure to volatile emissions and fugitive dust from Area D is considered to be minimal, thereby eliminating the need for quantitative evaluation of this exposure pathway. As shown in Tables 6-12 and 6-13, all reported surface and subsurface soil concentrations are less than the EPA Generic SSLs for transfers from soil to air (EPA, 1996a) except for those reported for hexachlorobenzene, heptaclor, chromium. Hexachlorobenzene and heptachlor were not accepted as COPCs due to the low frequency of detection and only slight exceedances of the selection criteria. Additionally, the SSL_{AIR} for chromium assumes that chromium (C_{MAX} = 3560 mg/kg) is present in the hexavalent state. The assumption that ALL chromium is in the hexavalent state is overly conservative. The average chromium concentration detected in the solid matrix samples (214 mg/kg) is less than the SSL_{AIR} (270 mg/kg).

- Potential exposure to contaminants in surface water from Area D through incidental ingestion is considered to be minimal due to the limited nature of contact with surface water in this area.

6.7.3.4 Area D, Exposure Point Concentrations

Current EPA risk assessment guidance (EPA, 1992 and 1994c) was used to identify appropriate exposure point concentrations for CTE and RME conditions. Exposure point concentrations used in the risk assessment are presented in Table 6-17. For wetland soil, soil, sediment, and surface water, 95 percent UCLs of the arithmetic mean were used as exposure point concentrations in estimating chemical intakes for the RME and CTE. In data sets with 10 samples or less and data sets in which the calculated 95 percent exceeded the maximum detected concentration, the maximum detected concentration was used as the exposure point concentration for the RME and the average concentration was used for the CTE case. Listings of sample locations included in the evaluation of each receptor group are presented in Appendix F-5. Support documentation for the calculation of dioxin TEQ concentrations, 95 percent UCLs, and distributions of data sets for COPCs are presented in Appendix F-6.

6.7.3.5 Area D, Estimates of Chemical Intake

Estimates of chemical intake were calculated using equations presented in Section 6.4. Tables 6-10 and 6-11 contain the various assumptions used as input parameters to determine chemical intakes for each potential receptor and exposure route. Chemical intake estimates for Area D are provided in the site-specific risk assessment spreadsheets contained in Appendix F-9.

6.7.4 Risk Characterization

A summary of the quantitative risk assessment for Area D, Beacon Point Area, is provided in this section. Total noncarcinogenic and carcinogenic risks for each exposure route, as well as the cumulative risk for the RME and CTE scenarios, are summarized in Table 6-18 for commercial workers, frequent adult and child recreational users, and adult and pre-adolescent wetland/marsh receptors. Sample calculations are provided in Appendix F-8. Appendix F-9 contains the chemical specific risks for Area D.

6.7.4.1 Noncarcinogenic Risks

Hazard indices developed for the commercial worker, frequent adult and child recreational user, and wetland/marsh adult and pre-adolescent receptor were as follows:

	RME Case	CTE Case
Frequent Recreational User – Adult (Current/Future)(Surface Soils)	1.1E-01	2.0E-02
Frequent Recreational User – Child (Current/Future)(Surface Soils)	1.9E-01	4.7E-02
Commercial Worker (Current/Future) (Surface Soils)	4.0E+00	4.4E-01
Commercial Worker (Future) (All soils – 0 to 15 ft)	7.5E+00	5.1E-01
Wetland/Marsh Receptor – Adult (Current/Future) (Surface Materials/Surface Waters)	7.7E-01	2.0E-01
Wetland/Marsh Receptor – Pre-adolescent (Current/Future) (Surface Materials/Surface Waters)	2.7E-00	7.1E-01

Hazard indices (HIs) for the current commercial worker exposed to surface soils, the future commercial worker exposed to "all soils", and wetland/marsh pre-adolescent receptors exposed to surface soils and surface water are slightly in excess of unity when the RME cases were evaluated. Total Aroclor and chromium were the main contributors to the hazard index for the commercial worker.

The chemical-specific (and target-organ specific) hazard indices for chromium alone are slightly in excess of unity. In the absence of any chromium speciation data, the chromium observed was assumed to be the more toxic hexavalent form. Since it is unlikely that all the observed chromium is hexavalent chromium and the chromium exceedances of unity are slight, adverse non-carcinogenic health effects are unlikely from chromium.

The chemical-specific hazard indices for total Aroclor alone are in excess of unity for each of these receptors. Adverse non-carcinogenic health effects are possible from exposure to Aroclors.

Hazard indices for the frequent recreational users and the wetland/marsh adult receptors, under both the RME and CTE scenarios, were less than unity indicating that adverse

noncarcinogenic health effects are not anticipated under the conditions established in the exposure assessment.

6.7.4.2 Carcinogenic Risks

Incremental cancer risk estimates for the commercial worker, frequent adult and child recreational user, and wetland/marsh adult and pre-adolescent receptor were as follows:

	RME Case	CTE Case
Frequent Recreational User – Adult[1] (Current/Future) (Surface Soils)	3.5E-06	2.6E-07
Frequent Recreational User – Child[1] (Current/Future) (Surface Soils)	7.9E-06	7.2E-07
Commercial Worker (Current/Future) (Surface Soils)	1.0E-04	4.7E-06
Commercial Worker (Future) (All soils - 0 to 15 ft)	5.7E-04	4.0E-05
Wetland/Marsh Receptor - Adult[1] (Current/Future)(Surface Materials/Surface Waters)	1.8E-05	8.4E-07
Wetland/Marsh Receptor - Pre-adolescent[1] (Current/Future)(Surface Materials/Surface Waters)	1.5E-05	8.1E-07

1) Summation of total risk for Frequent Recreational User (adult plus child): 1.1E-05 (RME case), and 9.8E - 07 (CTE case). Summation of total risk for Wetland/Marsh Receptor (adult plus pre-adolescent): 3.3E-05 (RME case), and 1.7E - 06 (CTE case).

The EPA target cancer risk range is 10^{-4} to 10^{-6}. The CT DEP target cancer risk level is 10^{-6} for single contaminants and 10^{-5} for total risk from multiple contaminants. The risk estimate for the commercial worker exposed to all soils exceeds the EPA target cancer risk range (10^{-4} to 10^{-6}) when the RME case is evaluated. RME and CTE cancer risk estimates for the commercial worker exposed to surface soils, the wetland/marsh receptor, and the frequent recreational user, and CTE cancer risk estimates for the commercial worker exposed to all soils are within or below the EPA target cancer risk range (10^{-4} to 10^{-6}). RME risk estimates for the commercial worker and the wetland/marsh receptor, and CTE cancer risk estimates for the commercial worker exposed to all soils, exceed the CT DEP target total risk level of 10^{-5} for multiple contaminants. RME cancer risks for the frequent adult and child recreational user

when the two age groups are added together for a lifetime exposure exceed the CT DEP target total risk level of 10^{-5}. As detailed on Table 6-18, dioxin/furans, PAH compounds (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene), Aroclors, and arsenic in soils and sediments are predominant risk drivers. Cancer risks for these contaminants exceed the CT DEP target risk level of 10^{-6} for single contaminants under RME conditions. Cancer risk estimates for dioxins/furans alone exceed 10^{-4} when the future commercial worker (RME case) is evaluated. Under CTE scenarios, only benzo(a)pyrene and dioxin/furans exceed 10^{-6} risk levels.

6.7.4.3 Exposure to Lead

Lead was identified as a COPC in soils/wetland soils/sediments at the Beacon Point Area. Lead was detected at a maximum concentration of 96,400 mg/kg.

Exposure to lead in soil by the commercial worker was evaluated by use of a slope-factor approach developed by the EPA Technical Review Workgroup for Lead (EPA, December 1996d). The exposure point concentration of 997 mg/kg for surface soil at the Beacon Point commercial area and 2,880 mg/kg for all soil under the future scenario as well as several default parameters were used to estimate the probability that the fetal blood-lead levels of fetuses born to workers exposed to lead in a commercial setting will exceed 10 µg/dL. EPA's stated goal for lead is that individuals exposed would have no more than 5 percent probability of exceeding the level of concern of 10 µg/dL. Under the current RME commercial scenario at Beacon Point, assuming a soil ingestion rate of 100 mg/d, the probability that the fetal blood-lead concentration exceeds 10 µg/dL is 8.6 to 17.02 percent. Under the CTE exposure scenario assuming a soil ingestion rate of 50 mg/d, the probability that the fetal blood-lead level exceeds 10 µg/dL is 2.04 to 7.60 percent. Using EPA's default values for baseline adult blood-lead concentration and standard deviation in combination with the CTE soil ingestion rate of 50 mg/d, the probability that the fetal blood-lead level exceeds 10 µg/dL is 5.4 percent. Under the future RME commercial scenario, the probability that the fetal blood-lead concentration exceeds 10 µg/dL is 50.28 to 53.32 percent. Under the CTE exposure scenario, the probability that the fetal blood-lead level exceeds 10 µg/dL is 17.63 to 26.26 percent. Using EPA's default values for baseline adult blood-lead concentration and standard deviation

in combination with the CTE soil ingestion rate of 50 mg/d, the probability that the fetal blood-lead level exceeds 10 µg/dL is 23.5 percent.

Exposure to lead in soil by the adult frequent recreational user was evaluated by use of a slope-factor approach developed by the EPA Technical Review Workgroup for Lead (EPA, December 1996d). The exposure point concentration of 506 mg/kg for surface soil at the Beacon Point boat launch area was used to estimate the probability that the blood-lead levels of fetuses born to women exposed to lead in a recreational setting will exceed 10 µg/dL. EPA's stated goal for lead is that individuals exposed would have no more than 5 percent probability of exceeding the level of concern of 10 µg/dL. Under the current RME frequent recreational scenario at Beacon Point, assuming a soil ingestion rate of 100 mg/d, the probability that the fetal blood-lead concentration exceeds 10 µg/dL is 0.88 to 4.66 percent. Under the CTE exposure scenario assuming a soil ingestion rate of 50 mg/d, the probability that the fetal blood-lead level exceeds 10 µg/dL is 0.29 to 2.82 percent. Using EPA's default values for baseline adult blood-lead concentration and standard deviation in combination with the CTE soil ingestion rate of 50 mg/d, the probability that the fetal blood-lead level exceeds 10 µg/dL is 1.6 percent.

Exposure to lead in surface soil by the frequent child recreational user was evaluated using the EPA IEUBK Model, as discussed in Section 6.4.7. The IEUBK model was developed to evaluate exposures to lead by children in a residential setting. Consequently, using the IEUBK model for child recreational exposures should provide a very conservative evaluation of exposures to lead. The time-weighted exposure point concentration of 266 mg/kg as well as several default parameters were used to estimate blood-lead levels for children in a residential setting. IEUBK Model outputs are included in Appendix F-11. The estimated geometric mean blood-lead level for children exposed to lead in site soil was 4.0 µg/dL, which is less than the established level of concern of 10 µg/dL. The IEUBK model estimates that 2.39 percent of children are expected to have blood-lead levels greater than 10 µg/dL, which does not exceed the acceptable level of 5 percent.

6.7.4.4 Summary of "Hot Spot" Analysis of Lead Results Area D

Given the fact that Area D covers approximately 20.1 acres, the data for one of the predominant COCs (lead) were reviewed to determine if contaminant "hot spots" exist within

the study area. Two potential "hot spots" locations were identified, as shown in Figure 6-1. A hot spot evaluated for frequent recreational user exposure is located within the boat launch area. A hot spot evaluated for commercial exposure is located within the commercial area. Sample lists for Area D lead hot spots are included in Appendix F-11. The EPCs for lead in the "hot spots" are presented in the following table and compared to the EPCs presented above for initial lead evaluations (the EPCs used in the initial lead evaluations are presented in *italics*);

Exposure Area	Lead EPC Concentration (mg/kg)
Recreational Hot Spot (Surface Soils/Sediments) Boat Launch Area	5,970 *(506)*
Commercial Hot Spot Area (Surface Soils within Commercial Area)	4,816 *(997)*
Commercial Hot Spot Area (Subsurface Soils within Commercial Area)	11,711 *(2,880)*

The lead concentrations in the "hot spot" locations are roughly an order of magnitude greater than the EPCs presented used in the initial lead evaluations. The EPCs for the "hot spot" areas are average reported lead concentrations for the recreational hot spot and commercial hot spots. As detailed in Section 6.4.7 and 6.7.4.3, the EPA IEUBK model and the slope-factor approach model developed by the EPA Technical Review Workgroup for Lead (EPA, December 1996d) were used to evaluate the "hot spot" concentrations in the soils.

The results of the analysis are included in Appendix F-11 and indicate that blood-lead levels in the receptors evaluated would exceed the established level of concern of 10 μg/dL. The IEUBK model estimates that the probability that children will have blood-lead level greater than 10 μg/dL is 36.05 percent when exposed to lead soil concentrations of 1,436 mg/kg (the time-weighted average concentration based on soil lead concentration of 5,970 mg/kg in the

recreational hot spot). Under the current/future commercial worker RME scenario, the EPA Technical Review Workgroup (TRW) model predicts that the probability that blood-lead concentration among fetuses born to women having site exposure to lead concentrations of 4,816 mg/kg (commercial surface soil hot spot) would exceed 10 μg/dL ranges from 73.07 to 79.50 percent. Under the current/future commercial worker CTE scenario, the TRW model predicts that the probability that blood-lead concentration among fetuses born to women having site exposure to lead concentrations of 4,816 mg/kg (commercial surface soil hot spot) would exceed 10 μg/dL ranges from 40.29 to 44.97 percent. Using EPA's default values for baseline adult blood-lead concentration and standard deviation in combination with the CTE soil ingestion rate of 50 mg/d, the probability that the fetal blood-lead level exceeds 10 μg/dL is 43.5 percent. Under the future commercial worker RME scenario, the TRW model predicts that the probability that blood-lead concentration among fetuses born to women having site exposure to lead concentrations of 11,711 mg/kg (commercial subsurface soil hot spot) would exceed 10 μg/dL ranges from 95.85 to 98.64 percent. Under the future commercial worker CTE scenario, the TRW model predicts that the probability that blood-lead concentration among fetuses born to women having site exposure to lead concentrations of 11,711 mg/kg (commercial subsurface soil hot spot) would exceed 10 μg/dL ranges from 80.37 to 86.85 percent. Using EPA's default values for baseline adult blood-lead concentration and standard deviation in combination with the CTE soil ingestion rate of 50 mg/d, the probability that the fetal blood-lead level exceeds 10 μg/dL is 82.5 percent.

6.7.4.5 Asbestos

Asbestos was detected in 42 of 141 solid matrix samples collected in the 0- to 15- foot interval at a concentration range of 0.99 to 30 percent. The average concentration was 2 percent. Although quantitative risk estimates (inhalation risk estimates) cannot be developed for this parameter, it should be noted that asbestos-containing material is material containing more than 1 percent asbestos (Appendix A to Subpart M of 40 CFR 61).

6.7.5 Uncertainties

A detailed discussion of uncertainties associated with the various aspects of risk assessment, in general, was provided in Section 6.6. Area-specific uncertainties for Area D are presented in the following narrative.

- Copper concentrations exceeded COPC screening criteria in Area D soils/sediments; however due to the lack of a verifiable toxicity value, no quantitative estimate of risks can be performed. Copper is a significant contaminant in Raymark waste. It is reported in Area D soils/sediments (0 to 15 feet bgs) at concentrations ranging from 11 mg/kg to 69,600 mg/kg. The maximum concentration exceeds the EPA Region III residential soil ingestion risk-based concentrations of 3,100 mg/kg. The absence of a quantitative risk evaluation of copper may result in an underestimate of total non-cancer risks.

- The PCB congener data set available for Area D is a source of uncertainty in this baseline risk assessment. Specifically, only two sediment samples (OU3-D-SD03-0002 and 0U3-D-SD05-0002) collected from Area D were analyzed for the PCB congeners and, consequently, the available PCB congener data may not be representative of the concentrations of dioxin-like and non-dioxin-like PCB congeners in the environmental media. Consequently, a cursory risk evaluation of the PCB congener data is presented in this uncertainty section and detailed in Appendix F-12. The maximum concentrations of dioxin-like and non-dioxin-like PCB congeners in the sediment samples were 0.15 µg/kg (in terms of dioxin toxic equivalents) and 2.6 mg/kg, respectively. Assuming that an adult wetland/marsh receptor is exposed to the sediments, cancer risk estimates for the dioxin-like and non-dioxin-like PCB congeners are 6.1E-07 and 4.7E-07, respectively. Assuming that commercial workers are exposed to the same sediments, cancer risk estimates for the dioxin-like and non-dioxin-like PCB congeners are 7.9E-06 and 3.1E-06, respectively. As noted previously, only two sediment samples were analyzed for PCB congeners. Consequently, the samples cannot be considered representative of site conditions.

- As noted in Section 4, several PAHs selected as COPCs were detected at concentrations that are within an order of magnitude of the background concentrations determined for sediments. These include benzo(a)anthracene, benzo(a)pyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Additionally, benzo(b)fluoranthene was detected at a maximum concentration equal to its background concentration of 12,000 μg/kg. Dibenzo(a,h)anthracene was detected at a maximum concentration only slightly greater than background, 2,300 μg/kg and 2,000 μg/kg, respectively.

- Of the 15 inorganics that were selected as COPCs, vanadium was the only parameter detected at concentrations that were less than twice background concentrations. Vanadium, with a background concentration of 81.9 mg/kg, was detected at concentrations ranging from 7.8 to 110 mg/kg.

6.7.6 Summary of Human Health Risk Assessment

This section and Table 6-19 present a summary of major risk assessment findings for Area D. Three potential receptor groups were evaluated: the frequent recreational user, the wetland/marsh receptor, and the commercial worker.

- The hazard indices (HI) for current and future commercial workers exposed to soil and pre-adolescent wetland/marsh receptors exposed to soils and surface water are slightly in excess of unity when the RME cases were evaluated. The chemical-specific hazard quotients for total Aroclor and chromium are slightly in excess of unity. However, adverse noncarcinogenic health effects from chromium at the conditions of the exposure assessment are unlikely since the exceedances for chromium are slight and the chromium was evaluated conservatively, assuming that the observed chromium was the more toxic hexavalent species. Adverse non-carcinogenic health effects are possible from exposures to Aroclors.

- All hazard indices for the recreational users and adult wetland/marsh receptors were less than unity, indicating that adverse noncarcinogenic health effects are not anticipated under the conditions established in the exposure assessment.

- The RME cancer risk estimates for commercial workers exceed the EPA target cancer risk range (10^{-4} to 10^{-6}) and the CT DEP target total risk level of 10^{-5}. Dioxin/furans, Aroclors, arsenic, and PAH compounds (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) are the predominant risk drivers, with estimated cancer risks greater than the CT DEP target risk level for single contaminants of 10^{-6}.

- Cancer risks for the wetland/marsh receptors are within the EPA target risk range, but exceed the CT DEP target total risk level of 10^{-5} and the CT DEP target risk level of 10^{-6} for single contaminants for Aroclors, arsenic, dioxins, and benzo(a)pyrene when the RME case is evaluated and lifetime exposures are considered. The cancer risks for the future commercial worker exceed the CT DEP target total risk level of 10^{-5} when the CTE case is evaluated, with dioxins and benzo(a)pyrene exceeding 10^{-6} risk levels. Total RME cancer risks to frequent recreational users are greater than 10^{-5} risk level, with risks from Aroclors and arsenic exceeding the CT DEP target risk level of 10^{-6} for single contaminants.

- Exposure to lead in soil by commercial workers was evaluated by use of a slope-factor approach developed by the EPA Technical Review Workgroup for Lead (EPA, December 1996d). The results of the slope-factor approach indicate that adverse effects are anticipated for fetuses of pregnant workers exposed to lead in soil at Area D.

- Exposure to lead in soil by adult recreational users was evaluated by use of a slope-factor approach developed by the EPA Technical Review Workgroup for Lead (EPA, December 1996d). The results of the slope-factor approach indicate that adverse effects are not anticipated for fetuses of pregnant recreational users exposed to lead in soil at Area D.

- Exposure to lead in soil by child recreational users was evaluated by use of the IEUBK model. The results of the model indicate that adverse effects are not anticipated for child recreational users exposed to lead in soil at Area D.

- Further evaluation of lead "hot spots" using average lead concentrations within limited areas indicates that exposures to lead in these more limited locations would result in blood-lead levels of significantly greater concern.

- Asbestos was detected in 42 of 141 solid matrix samples collected in the 0 to 15 foot interval at a concentration range of 0.99 to 30 percent. The average concentration was 2 percent.

6.8 Baseline Human Health Risk Assessment - Area E, Elm Street Wetlands

This section contains the baseline risk assessment performed for soil, wetland soil, sediment, and surface water exposures at Area E, Elm Street Wetlands. Section 6.8.1 provides an overview of Area E, Section 6.8.2 contains a discussion of the selection of COPCs, Section 6.8.3 contains information on the potential receptors considered and the routes by which they might be exposed, Section 6.8.4 contains the numerical results of the risk assessment, and Section 6.8.5 presents area-specific uncertainties.

6.8.1 Overview of Area E, Elm Street Wetlands

Area E, Elm Street Wetlands, is a 30-foot-wide strip covering approximately 1.1 acres, including wetlands. A more detailed description of Area E is provided in Section 6.8.3.1. The nature and extent of the contamination detected in Area E was discussed in Section 4. Descriptive statistics (frequency of detection, range of positive detections, range of non-detects, location of maximum detections, and arithmetic mean) for target analytes detected in the Area E environmental media are also summarized in Tables 6-20 through 6-23.

6.8.2 Data Evaluation

Tables 6-20, 6-21, and 6-23 present a summary of the COPCs for quantitative risk assessment for Area E surface soils/wetland soils/sediments, "all soils" to a depth of 15 feet bgs, and surface waters, respectively. COPCs were identified based on a comparison of site data to the COPC screening levels defined in Section 6.2. All validated CLP data collected through 1997

except soil data collected from depths greater than 15 feet, were used to identify COPCs. The 1999 data collected by SAIC, Inc. are not included in the human health risk assessment. Soil data at depths greater than 15 feet were not used because human exposure to soils deeper than 15 feet below ground surface is considered very unlikely. Because of the significant correlation observed between field screening data and validated CLP data for lead and copper, screening data were also used for these chemicals at sample locations where no CLP data are available. An evaluation of groundwater is not part of the scope of work for this human health risk assessment, but will be addressed as part of an area-wide groundwater assessment to be provided as a separate document.

Tables 6-22A and 6-22B compare maximum chemical concentrations detected in the surface soils, wetland soils, and sediments data set and the "all soils" data set, respectively, to the groundwater protection benchmarks defined in Section 6.2.1.1 (the Generic SSLs for migration from soil to groundwater and State Pollutant mobility GB criteria). Although groundwater data were not addressed in this risk assessment, the comparison allows for a preliminary evaluation of the potential for chemicals to migrate to groundwater and potentially impact the quality of groundwater. Chemicals in excess of groundwater protection benchmarks, but not in excess of direct exposures criteria are not carried through the quantitative risk assessment (numerical risk estimates are not developed) because they are not considered to be significant contributors to the direct exposure pathways identified for potential human receptors.

A media-specific discussion of COPCs is presented in the following paragraphs.

6.8.2.1 COPCs for Soil/Wetland Material/Sediment

The COPC selection process for soil, wetland material, and sediment is summarized in Tables 6-20 and 6-21. The following chemicals were identified as direct exposure COPCs based on a comparison of maximum Area E concentrations to risk-based COPC screening levels for residential land use, Generic SSLs for migration from soil to air, State RSRs, and maximum background concentrations (inorganic chemicals only):

- PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo (a,h)anthracene, and indeno(1,2,3-cd)pyrene)

- Aroclors (1242, 1254, 1262, and 1268)
- Pesticides (aldrin and dieldrin)
- PCB congeners (total pentachlorobiphenyls)
- Metals (antimony, arsenic, chromium, copper, lead, thallium, and vanadium)
- Dioxins/Furans

Aluminum and iron were not selected as a COPCs, despite concentrations above the risk-based COPC screening levels because EPA Region I does not advocate quantitative risk assessment of the health effects of aluminum or iron due to the lack of adequate toxicity criteria. However, all Aroclors and PCB congeners were accepted as COPCs because at least one Aroclor and one congener were detected at maximum concentrations exceeding COPC screening levels.

Maximum detections in soil, wetland material, and sediment were also compared to Generic SSLs for migration from soil to groundwater and Connecticut RSRs for pollutant mobility in a GB classified area. Maximum concentrations of the following chemicals exceeded the generic soil pollutant mobility criteria, indicating a potential for these chemicals to migrate to groundwater and potentially impact the quality of groundwater:

- PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene)
- Pesticides (4,4'-DDE, aldrin, alpha chlordane, beta-BHC, delta-BHC, dieldrin, gamma chlordane, and heptaclor epoxide)
- Metals (chromium and thallium)

6.8.2.2 COPCs for Surface Water

Table 6-23 presents a summary of the COPC selection process for surface water. Based on a comparison of maximum Area E concentrations to risk-based COPC screening levels for tap water use and drinking water standards (federal and state MCLs), the following chemicals were identified as COPCs:

- Aroclors (1254 and 1268)
- Pesticides (alpha chlordane, gamma-chlordane, and heptaclor epoxide)
- Metals (arsenic, cadmium, chromium, copper, lead, manganese, and vanadium)

Although surface water in the area is not currently used or expected to be used in the future as a drinking water supply, drinking water criteria (federal and state MCLs) were included for informational purposes and to conservatively identify COPCs for the Area E. Aluminum and iron were not selected as COPCs, despite concentrations above the risk-based COPC screening levels and/or federal MCLs. EPA Region I does not advocate quantitative risk assessment of the health effects of these metals due to the lack of adequate toxicity criteria. The Connecticut State MCL for sodium is a state notification level and is not risk based. For this reason, sodium was not selected as a COPC, despite concentrations above the state MCL.

6.8.3 Area E, Exposure Assessment

The exposure assessment contains a discussion of the potential for human exposure at Area E and identifies the rationale for the selection of exposure input parameters used to estimate exposure intakes. A detailed description of the potential receptors, exposure routes, and intake estimation methods used in the exposure assessment is presented in Section 6.4. Area-specific information regarding exposure is provided in this section.

The potential for exposure at Area E is based on several factors, including current and future land uses, activity patterns, site access controls, chemical behavior in the environment, and

the presence of human receptors. Based on these variables, exposure scenarios were developed to characterize the potential for human exposure under both current and future site conditions. The future scenario accounts for likely or anticipated changes in land use and area characteristics that may alter exposure and/or concentrations of COPCs in a given medium.

The exposure assessment is based on the assumptions that, in general, chemical compositions for environmental media are identical under current and future conditions. Under current conditions, potential human receptors (wetland/marsh receptors) are assumed to be exposed to surface soil and/or sediment (0 to 2 feet bgs). Similar soil/sediment exposure is likely for potential receptors under future conditions. Given that future changes to the chemical composition of the marshy waters are difficult to predict, it is assumed for the purposes of this risk assessment that chemical concentrations in surface water would not change in the future.

A summary of the potentially significant exposures identified for quantitative evaluation for Area E is provided in Table 6-24.

6.8.3.1 Area E, Land Use and Access

Area E, Elm Street Wetlands, is a 30-foot-wide strip located approximately 600 feet west of the southern portion of Area D, as shown in Figure 1-2. Area E covers approximately 1.1 acres, including approximately 0.7 acres of wetlands.

Area E is bounded by residential properties along Elm Street to the west and north, the Stratford wastewater treatment plant to the east, and the remaining wetland area referred to by EPA as the Elm Street wetland.

6.8.3.2 Area E, Potential Receptors

As identified in Section 6.4, several potential receptor populations were initially considered for inclusion in the exposure assessment. However, the majority of these receptors were eliminated from further evaluation based on the current land use, site access, COPCs, and the likelihood of exposure. Of the receptors initially considered (residents, recreational users, construction workers, and trespassers), the only receptors retained for quantitative evaluation

are wetland/marsh receptors. The wetland/marsh receptors, an infrequent recreational user scenario was selected despite the proximity of residences because the height and density of vegetation makes frequent visits unlikely.

Possible exposures of nearby residents to site-related contaminants would be through recreational activities. Since access to the wetlands is not restricted, persons involved in recreational activities (the wetland/marsh receptor) may visit Area E, thereby coming in contact with potentially contaminated media.

Future on-site residents and construction workers were not included in the baseline risk assessment for Area E. No major construction projects are planned for Area E or the surrounding areas. The nature of the wetland material in Area E and local construction practices preclude subsurface excavation and/or development of Area E for residential or commercial purposes. In addition, groundwater at the site is not used or expected to be used in the future as a potable water supply because of brackish conditions.

6.8.3.2.1 Wetland/Marsh Receptors

Area E, Elm Street Wetlands, is primarily unused wetlands. Wetland/marsh receptors are evaluated for exposure to surficial wetland soil and sediments (0 to 2 feet bgs) and surface water under current and future land use. The nature of the wetlands precludes swimming in Area D. Therefore, limited direct contact with surface water within the wetlands is anticipated. Wetland/marsh receptors, both adult and pre-adolescent child (ages 6 to 11 years), are assumed to be exposed to site media infrequently (20 days/year) due to the density of vegetation. These receptors are assumed to ingest an average of 100 mg/day for 6 years for the child and 100 mg/day for 24 years for the adult for the RME, and an average of 50 mg/day for 2 years for the child and 50 mg/day for 7 years for the adult for the CTE. Face, hands, forearms, and lower legs are expected to be available for dermal contact with soils. Hands, lower legs, and feet are expected to be available for dermal contact with surface waters.

6.8.3.3 Area E, Exposure Pathways

The primary routes of exposure for potential human receptors at Area E are incidental ingestion of and dermal contact with soil and wetland soil, and dermal contact with surface water. Exposure routes associated with soil and surface water contact are evaluated for recreational users.

Other potential exposure routes such as groundwater uses, inhalation of fugitive dust and volatile emissions, and ingestion of surface water were not considered for the following reasons:

- The shallow aquifer at Area E is not used as a potable water supply either at Area E or in the surrounding areas. Shallow groundwater in the area discharges to Ferry Creek and its tributaries. Thus, domestic groundwater exposures by nearby residents are eliminated. In addition, as previously mentioned, groundwater in the area is not used or expected to be used in the future as a potable water supply because of brackish conditions and productivity constraints.

- Potential exposure to volatile emissions and fugitive dust from Area E is considered to be minimal, thereby eliminating the need for quantitative evaluation of this exposure pathway. As shown in Tables 6-20 and 6-21, all reported surface and subsurface soil concentrations are less than the USEPA Generic SSLs for transfers from soil to air (EPA, 1996a). Additionally, the majority of the site is vegetated and/or wet, therefore the generation of fugitive dust via wind erosion is not expected to contribute significantly to exposures.

- Potential exposure to contaminants in surface water from Area E through incidental ingestion is considered to be minimal due to the limited nature of contact with surface water in this area.

6.8.3.4 Area E, Exposure Point Concentrations

Current USEPA risk assessment guidance (USEPA, 1992 and 1994c) was used to identify appropriate exposure point concentrations for CTE and RME conditions. Exposure point concentrations used in the risk assessment are presented in Table 6-25. For soil, wetland soil, and surface water, 95 percent UCLs of the arithmetic mean were used as exposure point concentrations in estimating chemical intakes for the RME and CTE. In data sets with 10 samples or less and data sets in which the calculated 95 percent UCL exceeded the maximum detected concentration, the maximum detected concentration was used as the exposure point concentration for the RME and the average concentration was used for the CTE case. Listings of sample locations included in the evaluation of each receptor group are included in Appendix F-5. Support documentation for the calculation of dioxin TEQ concentrations, 95 percent UCLs, and distributions of data sets for COPCs are presented in Appendix F-6.

6.8.3.5 Area E, Estimates of Chemical Intake

Estimates of chemical intake were calculated using equations presented in Section 6.4. Tables 6-10 and 6-11 contain the various assumptions used as input parameters to determine chemical intakes for each potential receptor and exposure route. Chemical intake estimates for Area E are provided in the site-specific risk assessment spreadsheets contained in Appendix F-10.

6.8.4 Risk Characterization

A summary of the quantitative risk assessment for Area E, Elm Street Wetlands, is provided in this section. Total noncarcinogenic and carcinogenic risks for each exposure route, as well as the cumulative risk for the RME and CTE scenarios, are summarized in Table 6-26 for the wetland/marsh adult and pre-adolescent receptor. Sample calculations are provided in Appendix F-5. Appendix F-10 also contains the chemical specific risk for Area E.

6.8.4.1 Noncarcinogenic Risks

Hazard indices developed the wetland/marsh adult and pre-adolescent receptor were as follows:

	RME Case	CTE Case
Wetland/Marsh Receptor - Adult (Current/Future) (Surface Materials/Surface Waters)	7.5E+00	3.7E+00
Wetland/Marsh Receptor – Pre-adolescent (Current/Future) (Surface Materials/Surface Waters)	1.2E+01	4.8E+00

All hazard indices (HI) for the wetland/marsh adult receptor are greater than unity, indicating a need to evaluate target organ-specific HIs and chemical-specific hazard quotients (HQs). The RME HQs for total Aroclor in surface water for both adults and pre-adolescents and in soil for pre-adolescents are greater than unity, indicating a potential for adverse noncarcinogenic health effects.

6.8.4.2 Carcinogenic Risks

Incremental cancer risk estimates for the wetland/marsh adult and pre-adolescent receptor were as follows:

	RME Case	CTE Case
Wetland/Marsh Receptor - Adult (Current/Future) (Surface Materials/Surface Waters)	1.2E-04	7.6E-06
Wetland/Marsh Receptor - Pre-adolescent (Current/Future) (Surface Materials/Surface Waters)	5.3E-05	2.9E-06

(1) Summation of total risk for Wetland/Marsh Receptor (adult plus pre-adolescent): 1.7E-04 (RME case) and 1.1E-05 (CTE case).

The EPA target cancer risk range is 10^{-4} to 10^{-6}. The CT DEP target cancer risk level is10^{-6} for single contaminants and10^{-5} for total risk from multiple contaminants. The RME cancer risk estimates for the adult wetland/marsh receptor and the adult and pre-adolescent combined lifetime wetland/marsh exposure are 1.2 E-04 and 1.7E-04, respectively. Cancer risk estimates for the RME wetland/marsh receptors exceed the CT DEP target total risk level of 10^{-5}. Cancer risk estimates are less than 10^{-4}, but greater than the CT DEP target total risk level for the

adult and pre-adolescent recreational user from exposure to surface soils/ sediments/wetland soils. As detailed on Table 6-26, total Aroclors (PCBs) are predominant risk drivers, with PAH compounds (benzo(a)pyrene and dibenzo(a,h)anthracene) and arsenic also exceeding 10^{-6} risk levels. It should be noted that risk estimates developed for the dermal contact route of exposure exceed those calculated for the ingestion route of exposure for soils/wetland soils/sediments. Cancer risk estimates for total Aroclors (PCBs) for surface water from the dermal route for the adult and pre-adolescent wetland/marsh receptors combined exceed 10^{-4} when the RME case is evaluated and 10^{-5} when the CTE case is evaluated. Aroclor risk estimates for surface water exposures may be overestimated due to the inclusion of elevated detection limits for some non-detected Aroclors.

6.8.4.3 Exposure to Lead

Lead was identified as a COPC in soils/wetland soils/sediments at the Elm Street Wetlands. Lead was detected at a maximum concentration of 404 mg/kg. The lead models available are not reliable for evaluation of risks for infrequent exposures. Since the wetland/marsh receptor is the only receptor in this area and frequency of exposure for this receptor is inappropriate to use in the model, no quantitative evaluation of lead is included for this area. Study area average lead concentration in surface soils is 164 ppm.

6.8.5 Uncertainties

A detailed discussion of uncertainties associated with the various aspects of risk assessment, in general, was provided in Section 6.6. Area-specific uncertainties for Area E are presented in the following narrative.

- Copper concentrations exceeded COPC screening criteria in Area E soils/sediments; however due to the lack of a verifiable toxicity value, no quantitative estimate of risks can be performed. Copper is a significant contaminant in Raymark waste. It is reported in Area E soils/sediments (0 to 15 feet bgs) at concentrations ranging from 28.3 mg/kg to 425 mg/kg. Since the maximum concentration does not exceed the EPA Region III residential soil ingestion risk-based concentrations of 3,100 mg/kg, the

absence of a quantitative risk evaluation of copper is unlikely to result in a significant underestimate of total non-cancer risks.

- The PCB congener data set available for Area E is a source of uncertainty in this baseline risk assessment. Specifically, only two sediment samples (OU3-E-SD01-0002 and OU3-E-SD01-0204) collected from Area E were analyzed for the PCB congeners and, consequently, the available PCB congener data may not be representative of the concentrations of dioxin-like and non-dioxin-like PCB congeners in the environmental media. Consequently, a cursory risk evaluation of the PCB congener data is presented in this uncertainty section and detailed in Appendix F-12. The maximum concentrations of dioxin-like and non-dioxin-like PCB congeners in the sediment samples were 0.081 µg/kg (in terms of dioxin toxic equivalents) and 810 µg/kg, respectively. Assuming that a frequent recreational user is exposed to the sediments, cancer risk estimates for the dioxin-like and non-dioxin-like PCB congeners are 4.9E-07 and 1.5E-07, respectively. As noted previously, only two sediment samples were analyzed for the PCB congeners. Consequently, the samples cannot be considered representative of site conditions.

- All of the PAHs selected as COPCs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) were detected at concentrations that are below the background concentrations determined for sediments.

- Several inorganic COPCs for Area E were detected at levels that are less than twice their background concentrations. Lead, with a background concentration of 344 mg/kg, was detected at concentrations ranging from 5.9 to 404 mg/kg. Vanadium concentrations ranged between 33.3 and 125 mg/kg; the background concentration is 81.9 mg/kg.

6.8.6 Summary of Human Health Risk Assessment

This section presents a summary of major risk assessment findings for Area E. One potential receptor group was evaluated: the frequent recreational user.

- The hazard indices for the adult and pre-adolescent wetland/marsh receptors exceeded unity. The hazard quotients for total Aroclor in surface water and soil/sediments are greater than unity, indicating that there is a potential for adverse noncarcinogenic health effects under the conditions established in the exposure assessment.

- The risk estimates for the adult and pre-adolescent combined wetland/marsh receptor and adult wetland/marsh receptor exceed the EPA target cancer risk range (10^{-4} to 10^{-6}) when the RME cases were evaluated. The RME risk estimates for adult and pre-adolescent wetland/marsh receptors and the CTE risk estimates for adult receptors in combination with pre-adolescents exceed the CT DEP target total risk level of 10^{-5}. Total Aroclors (PCBs) are the predominant risk drivers for soils/wetland soils/sediments. The PAH compounds (benzo(a)pyrene and dibenzo(a,h)anthracene) and arsenic in soils/wetland soils/sediments, exceed 10^{-6}, the CT DEP target risk level for single contaminants. Total Aroclors (10^{-4}) are the only risk drivers for surface water.

- Exposure to lead in surface soil by the wetland/marsh receptor cannot be evaluated using currently accepted models due to the infrequency of exposures. However, the maximum concentration of lead in sediments and wetland soils in Area E is unlikely to cause adverse effects.

6.9 Summary of Human Health Risk Assessment for Areas D and E

This section presents a summary of major risk assessment findings for Areas D and E.

6.9.1 Noncarcinogenic Risks

- Hazard Indices for commercial workers and pre-adolescent wetland/marsh receptors in Area D under the RME scenarios exceed unity. Chemical-specific hazard quotients for total Aroclor exceed unity, indicating potential for adverse effects. Chemical-specific hazard quotients for chromium are also slightly above unity. However, since chromium was evaluated assuming that the observed chromium was in the toxic hexavalent form, actual adverse health effects are unlikely. All frequent recreational and adult

wetland/marsh receptor HIs are less than unity in Area D, indicating that adverse noncarcinogenic health effects are not anticipated under the conditions established in the exposure assessment for these receptors.

- In Area E, Hazard Indices for wetland/marsh receptors exceed unity. Chemical-specific hazard quotients for total Aroclor in both soil/sediments and surface water exceed unity, indicating potential for adverse effects.

6.9.2 Carcinogenic Risks

- Cancer risks for current and future commercial workers in Area D exceed the EPA target cancer risk range for the RME case. Cancer risks for combined adult and child frequent recreational users, adult, and pre-adolescent wetland/marsh receptors are within the EPA target risk range of 10^{-4} to 10^{-6}, but exceed the CT DEP target total risk level of 10^{-5} for the RME cases. The primary carcinogenic risk drivers are dioxin/furans, total Aroclors, arsenic, and PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) in soils and sediments. These contaminants have estimated cancer risks greater than the CT DEP target risk level of 10^{-6} for single contaminants.

- In Area E, the cancer risks for wetland/marsh receptors exceed the EPA target cancer risk range (10^{-4} to 10^{-6}) and the CT DEP target total risk level of 10^{-5}. Total Aroclors are the predominant risk drivers in both soils and surface water. In soils, PAH compounds (benzo(a)pyrene and dibenzo(a,h)anthracene) and arsenic also exceed 10^{-6} risk levels.

6.9.3 Exposure to Lead

Exposures to lead were evaluated using two models. Exposure to lead in soil by a child was evaluated with the EPA IEUBK Model. The IEUBK Model presents a geometric mean blood-lead level for children and estimates the percentage of children expected to have blood-lead levels greater than 10 µg/dl. The acceptable level established by EPA is 5 percent. Exposures to lead in soil for a pregnant adult were evaluated by use of a slope-factor developed by the Technical Review Workgroup for Lead (EPA, December 1996d). The probability that fetal blood-lead levels will exceed 10 µg/dL is estimated. EPA's stated goal for

lead is that individuals exposed would have no more than 5 percent probability of exceeding the level of concern of 10 µg/dL.

- Lead was detected at a maximum concentration of 96,400 mg/kg in Area D. The exposure point concentrations of 506 mg/kg for surface soil under the adult recreational scenario, 997 mg/kg for surface soil under the current commercial worker, and 2,880 mg/kg in all soil for the future commercial workers were used to estimate the probability that fetal blood-lead levels will exceed 10 µg/dL. The model predicts that the probability that the fetal blood-lead level exceeds 10 µg/dL is greater than the EPA's goal of 5 percent for all commercial worker scenarios. The model predicts that the probability that the fetal blood-lead level exceeds 10 µg/dL is less than the EPA's goal of 5 percent for adult recreational scenarios. The IEUBK model predicts that the probability that the child's blood-lead level exceeds 10 µg/dL is less than the EPA's goal of 5 percent for child recreational scenarios.

- Further evaluation of lead "hot spots" using average lead concentrations within limited areas indicates that exposures to lead in these more limited locations would result in blood-lead levels of significantly greater concern.

- In Area E, lead was detected at a maximum concentration of 404 mg/kg. The average lead concentration was 164 mg/kg for surface soil. Exposures in this area are too infrequent for the accepted models to be reliable.

6.9.4 Exposure to Asbestos

Although quantitative risk estimates (inhalation risk estimates) cannot be developed for asbestos, it should be noted that asbestos-containing material is material containing more than 1 percent asbestos (Appendix A to Subpart M of 40 CFR 61). Asbestos is considered a potential inhalation hazard if it is "friable" (can be crumbled, pulverized, or reduced to powder) and, consequently, subject to entrainment/migration into the air.

- In Area D, asbestos was detected in 42 of 141 solid matrix samples collected in the 0-to 15-foot depth interval at a concentration range of 0.99 to 30 percent. The average concentration was 2 percent.

- In Area E, no samples were evaluated for the presence of asbestos.