

4.4 Area D: Beacon Point Area - Summary of Contamination

A summary of the nature and extent of contamination in sediment, surface water, soil and biota in Area D is provided below. Sample locations are depicted on Figure 4-1. A list of samples collected and the analyses performed is provided in Table 4-5. Tables 4-6, 4-7, 4-8 and 4-9 provide ranges of concentrations, frequency of detection, and locations of maximum concentrations; and comparison to criteria for sediment, surface water, soil, and biota, respectively.

4.4.1 Sediment

This section presents a summary of sediment results for Area D. See Table 4-6 for a statistical summary and comparison to criteria.

Asbestos

Asbestos was detected infrequently in surface and subsurface sediment samples in Area D. In surface samples only 8 of 42 samples contained asbestos, which ranged from trace amounts to twenty percent. Locations BR-A+200 (20 percent), BR C+00 (10 percent), D-SD03 (10 percent), and BRG07 (5 percent) are all located on the edge of wetlands along the boat launch and dry dock areas.

Three of eight subsurface sediment samples contained asbestos, none contained more than 1 percent. Samples were collected to a depth of 4 feet bgs. Figures 4-6 and 4-7 show concentrations of asbestos in surface and subsurface sediment in Area D.

Dioxins/Furans

Elevated concentrations of dioxins and furans were detected frequently in surface sediment samples from throughout the north and south wetland areas. TEQ values ranged from 0.001747667 µg/kg to a maximum of 0.945951 µg/kg at SD-BS02. Only one subsurface sediment sample, D-SD03 from 2 to 4 feet bgs, was analyzed for dioxins/furans. The TEQ

value of 0.16346 µg/kg exceeded the average sediment background concentration of 0.0045 µg/kg.

Metals

Elevated metals concentrations were detected frequently in surface and subsurface sediment samples. Antimony, arsenic, barium, cadmium, chromium, copper, lead, and manganese were detected in surface sediment samples at concentrations exceeding the CT DEC. Chromium and lead were detected most often above the CT DEC. Chromium concentrations ranged from 9.7 mg/kg to 496 mg/kg at D-SD07 from 0 to 2 feet bgs; lead concentrations ranged from 7.3 mg/kg to 17400 mg/kg at BN03. Both D-SD07 and BN03 are located on the southern edge of the northern wetland area.

In subsurface sediment samples antimony, arsenic, cadmium, chromium and lead were detected at concentrations exceeding the CT DEC similar to the surface sediment samples. Average concentrations of these metals were generally slightly higher in subsurface samples. The highest concentrations were found almost exclusively at D-SD06 from 2 to 4 feet bgs, which is located on the southern edge of the northern wetland area near D-SD07 and BN03 (locations with high metals in surface samples). Figures 4-4 and 4-5 show concentrations of lead in surface and subsurface sediment in Area D.

SVOCs

SVOCs, mainly PAHs, were detected frequently in the surface and subsurface sediments throughout the area. Phthalates and phenols were detected less frequently. Elevated SVOC concentrations were detected mostly in surface sediments; 17 SVOCs were detected at elevated concentrations in surface samples, while only two were detected in subsurface sediments. Similarly, most exceedances of CT PMC and CT DEC were found in surface sediments throughout Area D.

Concentrations of SVOCs including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, hexachlorobenzene, and indeno(1,2,3-cd)pyrene exceeded both the CT PMC and CT DEC. Average sediment background concentrations of these contaminants (except hexachlorobenzene) also exceeded the CT PMC

and CT DEC. Highest concentrations were detected in D-3 from 0 to 0.5 feet bgs and D-SD03 from 0 to 2 feet bgs. In subsurface samples, concentrations of dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene exceeded the CT PMC. No other SVOCs exceeded the CT PMC or CT DEC in subsurface sediments. Subsurface samples were collected to a depth of 4 feet bgs.

VOCs

Overall, the analytical results of sediment samples indicate that VOCs were detected infrequently in the surface and subsurface samples throughout Area D, and at relatively low concentrations. One sample was collected to 4 feet bgs, and the rest of the samples were collected from less than 2 feet bgs. Concentrations of 2-butanone, acetone, and carbon disulfide exceeded average sediment background concentrations, however, no VOC concentrations exceeded the CT PMC or CT DEC.

Pesticides/PCBs

Numerous pesticides and PCBs, including Aroclors 1262 and 1268, were detected at elevated concentrations in the surface and subsurface sediments. The highest concentrations of pesticides were detected at location D-SD02 from 0 to 2 feet bgs for surface samples, and from 2 to 4 feet bgs for subsurface samples. Twelve of 26 pesticides analyzed for in surface sediment samples and 8 of 21 pesticides analyzed for in subsurface sediment samples had concentrations exceeding the CT PMC. The CT DEC were also exceeded in surface and subsurface samples collected throughout Area D.

PCBs were detected in surface and subsurface sediment samples, but the frequency of detection was low. Aroclors 1016, 1248, 1254, 1260, 1262, and 1268 were all detected in surface sediments, and concentrations exceeded the CT DEC of 1,000 µg/kg in at least one sample. Aroclor 1262 was detected most frequently; concentrations ranged from 20 µg/kg at SD-BS06 from 0 to 0.5 feet bgs to 8600 µg/kg at D-SD03 from 0 to 2 feet bgs. Both samples were collected from the wetlands in the south portion of Area III. Aroclor 1254 was the most frequently detected PCB in subsurface sediment samples, in addition to the presence of Aroclors 1260, 1262, and 1268. Concentrations of Aroclor 1254 ranged from 30 µg/kg at D-

SD09 from 2 to 4 feet bgs to 34,000 µg/kg at D-SD02 from 2 to 4 feet bgs, with concentrations from three locations exceeding the CT DEC of 1,000 µg/kg. Concentrations of Aroclor 1260 also exceeded the CT DEC of 1,000 µg/kg at D-SD02 from 2 to 4 feet bgs. Figures 4-2 and 4-3 show concentrations of total Aroclors in surface and subsurface sediments in Area D.

4.4.2 Surface Water

This section presents a summary of surface water results for Area D. See Table 4-7 for a statistical summary and comparison to criteria. Surface water samples were not analyzed for dioxins/furans or asbestos.

Metals

Elevated concentrations of metals were infrequent in surface water samples from Area D. Copper most often exceeded average surface water concentrations (in six of seven samples). Copper concentrations ranged from 6 to 802 µg/l, with an average concentration of 131 µg/l. This average concentration is higher than the average background concentration of 19.75 µg/l. The one lead detection also exceeded the average background concentration as shown on Figure 4-4. No metals exceeded the CT AWQ criteria.

SVOCs

Di-n-butylphthalate was the only SVOC detected (3 µg/l) in surface water samples collected from Area D.

VOCs

Acetone was the only VOC detected (16 µg/l) in surface water samples collected from Area D.

Pesticides and PCBs

Pesticides and PCBs were not detected at elevated concentrations in surface water samples from Area D. However, concentrations of alpha-BHC (0.0062 µg/l) and heptachlor epoxide

(0.014 µg/l) exceeded the CT AWQC (0.0039 µg/l and 0.0001 µg/l, respectively) in two samples collected from the northern wetland area. No PCBs were detected as shown on Figure 4-2.

4.4.3 Soil

This section presents a summary of soil results for Area D. See Table 4-8 for a statistical summary and comparison to criteria.

Asbestos

Asbestos was detected infrequently in surface (22 of 72 samples) and subsurface (25 of 62 samples) soil samples. In surface soils, amounts of asbestos ranged from trace to 30 percent asbestos, with an average of 5 percent detected asbestos. Similarly, in subsurface soils asbestos ranged from 1 percent to 40 percent with an average of 6 percent. The highest amounts of asbestos were found at D-SB02 in the dry dock area. Asbestos was detected from 0 to 10 feet bgs in that boring. Forty percent asbestos was found at 2 to 4 feet bgs and 20 percent was found in the deepest sample from 8 to 10 feet. Figures 4-6 and 4-7 show asbestos concentrations in surface and subsurface soils in Area D.

Dioxins/Furans

Two surface soil and four subsurface soil samples were analyzed for dioxins/furans, which were detected frequently in both media. TEQ values ranged from 0.0022 µg/kg at D-SB05 from 4 to 6 feet bgs, to a maximum of 7.8391 µg/kg at D-SB02 from 2 to 4 feet bgs. D-SB02 is located in the dry dock area along Beacon Point Road. Dioxins/furans were detected as deep as 14 feet bgs at D-SB04 located in the parking lot of the boat launch area. No samples below 14 feet were analyzed for dioxins/furans.

Metals

Eight surface and 16 subsurface soil samples were analyzed for TAL metals. A total of 16 samples were analyzed for copper and 78 were analyzed for lead. Metals were frequently

detected in both surface and subsurface soil samples, but concentrations were somewhat higher in subsurface samples. The highest concentrations in surface samples were detected in the dry dock area, and the highest concentrations in subsurface samples were detected throughout Area D. Elevated metal concentrations were detected as deep as 16 feet bgs in several borings. Concentrations of copper, lead, and manganese exceeded the CT DEC in surface soil samples. In addition to those three metals, arsenic, barium, cadmium, chromium, and nickel concentrations exceeded the CT DEC in subsurface soil samples.

Two surface and four subsurface soil samples were also analyzed for SPLP metals. Concentrations of lead and copper exceeded the CT PMC of 150 µg/l and 13,000 µg/l, respectively, in one surface soil sample (D-SB03). Two subsurface soil samples (D-SB02 and D-SB06 from 2 to 4 foot interval) contained lead concentrations that exceeded the CT PMC. No other metals exceeded the CT PMC.

VOCs

Soil sample results indicate that VOCs were detected infrequently in surface and subsurface soils collected in Area D. 2-Butanone and acetone are the only VOCs that were detected in one surface soil sample collected (D-SB01); concentrations were elevated, but did not exceed the CT PMC or CT DEC. Five subsurface soil samples were collected, and elevated concentrations of acetone and carbon disulfide were detected; concentrations did not exceed the CT PMC or the CT DEC. Carbon disulfide was detected at a depth of 6 to 8 feet bgs. No VOCs were detected in deeper samples.

SVOCs

Three surface and 16 subsurface samples were analyzed for SVOCs. PAHs, frequently detected in both surface and subsurface samples, were the only SVOCs to exceed the CT PMC or CT DEC. Average concentrations of SVOCs were typically higher in surface samples; maximum concentrations were most frequently detected at D-SS03 from 0 to 1 foot bgs. Maximum SVOC concentrations in subsurface soils were detected primarily at D-SB09 from 1 foot to 3 feet bgs.

Pesticides/PCBs

Pesticides and PCBs were detected infrequently in surface and subsurface soils. Concentrations of pesticides were generally higher in surface samples collected from the dry dock area along Beacon Point Road. The CT PMC were exceeded for 4,4'-DDE, 4,4'-DDT and aldrin. In subsurface samples only dieldrin exceeded the CT PMC.

Aroclors 1254, 1262, and 1268 were detected in surface soil samples. Aroclor 1262 was detected most frequently (in four of eight samples), and had the highest concentrations. Concentrations ranged from 270 µg/kg to 30,000 µg/kg at BPMB+50, with an average detected concentration of 7,900 µg/kg. Aroclors 1262 and 1268 were the only PCBs detected in subsurface soils, and concentrations exceeded the CT DEC of 1,000 µg/kg in one sample (D-SB02 from 2 to 4 feet bgs).

4.4.4 Biota

Five mussel samples were collected from the wetland/Housatonic River interface and analyzed for metals, PAHs, pesticides and PCBs and PCB homologues. See Table 4-9 for a statistical summary and comparison to criteria. Metals were detected in every sample, and concentrations were highest in the sample from location D-6 collected from the southern portion of the Area D. Frequently detected PAHs were concentrated in sample D-2 from the northern portion of the study area. Only two pesticides were detected (4,4'-DDD and 4,4'-DDE) and the highest concentrations were found in the sample from location D-1. The sum of PCB homologues was highest at D-1 and D-2 collected from the northern portion of Area D.

4.5 Area E: Elm Street Wetlands - Summary of Contamination

A summary of the nature and extent of contamination in sediment, surface water, and soil in Area E is provided below. Sample locations are depicted on Figure 4-8. A list of samples collected and the analyses performed is provided in Table 4-10. Tables 4-11, 4-12, and 4-13 provide ranges of concentrations, frequency of detection, and locations of maximum concentrations, and comparison to criteria for sediment, surface water, and soil, respectively.

4.5.1 Sediment

This section presents a summary of sediment results for Area E. See Table 4-11 for a statistical summary and comparison to criteria.

Asbestos

Three surface and three subsurface samples were analyzed for asbestos. It was not detected in any of the samples.

Dioxins/Furans

Twelve surface samples and one subsurface sediment sample were collected. Dioxin/furans were detected frequently in surface samples, and in the one subsurface sample. Concentrations were elevated in surface samples, but not elevated in the subsurface sample. TEQ values ranged from 0.00096 µg/kg to 0.2164 µg/kg at E-1 in the northeast corner of Area E. The average TEQ value of 0.031 µg/kg is considerably higher than the average sediment background TEQ value of 0.0045 µg/kg.

Metals

Elevated concentrations of most metals were frequently detected in 14 surface and three subsurface sediment samples from Area E. Arsenic and chromium are the only metals with concentrations exceeding the CT DEC. These exceedances occurred only in surface samples. Figures 4-11 and 4-12 show lead concentrations in surface and subsurface sediment in Area E.

SVOCs

Fourteen surface and three subsurface sediment samples were collected from Area E. PAHs were detected frequently in surface samples, but infrequently in subsurface samples. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene concentrations exceeded the CT PMC.

These compounds (except chrysene) also exceeded the CT DEC, and the highest concentrations were typically detected in E-3 and ES02. In subsurface sediments, only concentrations of indeno(1,2,3-cd)pyrene exceeded the CT PMC. No other SVOCs were detected at elevated concentrations or exceeded the CT PMC or the CT DEC.

VOCs

Seven surface sediment samples from Area E were analyzed for VOCs. No subsurface samples were analyzed for VOCs. VOCs were detected infrequently in surface samples. The VOCs that were detected include: 2-butanone, acetone, carbon disulfide, chloromethane, and toluene; however, only 2-butanone, acetone, and toluene had elevated concentrations. No VOC concentrations exceeded the CT PMC or CT DEC.

Pesticides/PCBs

Fourteen surface and three subsurface sediment samples were collected from Area E. Pesticides were detected infrequently in surface and frequently in subsurface samples. Concentrations, however, were comparable between surface and subsurface samples. Concentrations of pesticides exceeded the CT PMC in surface and subsurface sediment samples.

Aroclors were detected in both surface and subsurface sediment samples. In surface samples, concentrations of Aroclors 1242, 1254, and 1262 exceeded the CT DEC. Aroclor 1254 was detected most frequently with concentrations ranging from 36 µg/kg to 40,000 µg/kg at E-SD03. Aroclor 1254 was the only Aroclor detected in subsurface sediment. Concentrations in the subsurface ranged from 1,000 µg/kg to 18,000 µg/kg at E-SD03 from 2 to 4 feet bgs.

4.5.2 Surface Water

This section presents a summary of surface water results for Area E. See Table 4-12 for a statistical summary and comparison to criteria. Concentration of PCBs are shown on Figure 4-9, and concentrations of lead are shown on Figure 4-11.

Six surface water samples were collected from Area E. Few VOCs and SVOCs were detected. Only acetone and styrene (VOCs), and bis(2-ethylhexyl)phthalate (SVOC) were detected in one sample each. Pesticides were also detected infrequently in Area E surface water samples. All pesticide detections exceeded the CT AWQ criteria including alpha-BHC, alpha-chlordane, gamma-chlordane, and heptachlor epoxide. High concentrations of PCBs were detected. Aroclors 1254 and 1268 were detected at concentrations exceeding the CT AWQ criteria. Aroclor 1268 was detected at ES01 at 0.26 µg/l. Concentrations of Aroclor 1254 ranged from 0.21 µg/l to 4.7 µg/l. Metals were detected frequently at elevated concentrations. The highest metal concentrations were most frequently detected at ES07. Concentrations of arsenic and lead exceeded the CT AWQ criteria of 0.018 µg/l and 50 µg/l, respectively. No samples were analyzed for dioxins/furans or asbestos.

4.5.3 Soil

One surface soil sample was collected along the northwest border of Area E. The sample was analyzed for SVOCs, pesticides, PCBs, dioxins/furans, and metals. SVOCs, pesticides, and PCBs (Aroclor 1268) were infrequently detected, and concentrations did not exceed average soil background concentrations, the CT PMC, or the CT DEC. No dioxins/furans were detected. Metals were detected, some at elevated concentrations, but concentrations did not exceed the CT DEC. The soil sample was not analyzed for asbestos or VOCs. See Table 4-13 for a statistical summary and comparison of criteria. Figures 4-9 and 4-10 show the concentrations of PCBs and lead, respectively, in this surface soil sample.

4.6 Correlations Among Contaminants of Concern (COCs)

Relationships among the COCs were investigated to see how strongly the COCs varied together and whether they changed from area to area. The relationships have the potential to be used for assessing the source(s) of contaminants and the likelihood that a restricted set of COCs could be used as surrogates for all of the COCs.

4.6.1 COCs in Sediment

The analysis consisted of calculating correlation coefficients using logarithms of the concentrations for:

Arsenic	Lead	Zinc
Cadmium	Mercury	Total PAHs
Chromium	Nickel	Total PCBs
Copper	Silver	Total 2,3,7,8-TCDD TEQ

Total PAHs, PCBs, and toxicity equivalents (TEQ) for dioxins were used to simplify the analysis.

In Area D, strongest relationships occurred between metals, with correlation coefficients as high as 0.95 for nickel and zinc and 0.93 for arsenic and nickel (Table 4-14). This means that 90 percent ($[0.95]^2 = 0.90$, or 90 percent) of the variation in nickel and zinc concentrations, and 86 percent of the variation in arsenic and nickel concentrations, can be explained by the relationships between the metals in each pairing. Strong relationships also occurred among cadmium, chromium, copper, lead, and silver. Mercury and PCBs had, at one each, the smallest number of significant correlations. PAHs and dioxins each had two significant correlations; they were related to each other and PAHs were also related to lead, while dioxins were also related to PCBs.

Area E had fewer samples, 8 to 12, than Area D which had 22 to 32, probably explaining the lower number of significant correlations in Area E (Table 4-14). Correlations occurred among several metals, including copper, chromium, nickel, and arsenic. Among the organic COCs only PCB concentrations were correlated with other COCs, namely copper and lead.

For the reference area only three or four samples are in the data base, making interpretation of the correlation results speculative. Table 4-14 includes correlation coefficients for all surface sediment data, including Areas A, B, and C. The results for the combined data are more similar to those for Area D than they are to the results for Area E. Some of the coefficients for the combined data are quite low, especially for the organic COCs, yet they are statistically significant. This results from the large number of samples, between 164 and 244. In these cases a low coefficient means that the relationship explains relatively little of the variation

between the two COCs, yet there is still the same level of confidence (99.5 percent or more) that a relationship exists. Although the number of samples is high for the combined data, it is apparent that some relationships are strong, especially among the metals chromium, copper, lead, nickel, and zinc.

A somewhat similar analysis was undertaken by SAIC (1997) on the surface sediment data that were available at the time for all areas. The purpose of the analysis was to determine whether groups of sampling locations had unique chemical patterns and which chemicals were primarily responsible for these patterns. A multivariate statistical approach was used, principal components analysis (PCA). The combined data showed that sampling locations with high PAH concentrations were distinguished from those with high metals and PCB concentrations, suggesting different transport mechanisms for the different COC classes. The PCA analysis of metals suggested that "copper/lead contamination is a distinct chemical signature for site sediments." In the summary, PCBs were included with copper and lead as COCs that were likely to indicate Raymark waste. This supported criteria developed earlier by EPA for Raymark waste that included asbestos, lead, and PCBs at certain levels. The correlation analysis (Table 4-14) corroborates these findings. The correlations also show that dioxins, PAHs, and several other metals are related to PCBs, copper, and lead overall, and that differences in some of these relationships are seen for Areas D and E.

4.6.2 COCs in Soil

Correlations among concentrations of COCs in soil were performed to see how well they varied together. If the COCs vary together, one or two COCs may be used as surrogates for the others, in order to save time and effort. Asbestos, lead, arsenic, chromium, dieldrin, several "individual" Aroclors, total PCBs, several individual PAHs, total PAHs, and summed dioxin (TCDD) equivalents were investigated for this purpose. Most of the Aroclors had all, or nearly all, of their values not detected, so only Aroclor-1262 and Aroclor-1268 were retained for calculations.

Correlations among all data from Areas II and III were calculated first, to discern overall patterns (Table 'All and AIII'). High correlation coefficients (about 0.5 or greater, associated with an error level of 0.005 or lower) were seen among several COCs. Some of these were

obvious results, such as the Aroclors correlating with total PCBs. There were also high correlations among asbestos, lead, and PCBs, which were the COCs considered most characteristic of Raymark waste during past removal actions. Among these COCs the highest coefficients are obtained between total PCBs and asbestos (0.636) and total PCBs and lead (0.749). Squaring the coefficients provides an indication of how much of the data's variation is explained by the relationship. Therefore, the relationship between total PCBs and asbestos explains $0.636 \times 0.636 = 0.4$ or 40 percent of the variation in their concentrations. The relationship between total PCBs and lead explains 56 percent of the variation in the data. High correlations are also seen between asbestos and total PAHs, lead and PAHs, dioxins and PCBs, and between dieldrin and PCBs.

A correlation was also performed for subarea D and for strata (surface soil and subsurface soil) within that area. Only one surface soil sample was collected from Area E, so a correlation could not be performed. Lead and asbestos concentrations were correlated in both surface and subsurface soils in Area D, explaining about 44 percent of the variation in each case (Table 4-15). Lead and total PCBs were also correlated in both strata, with these relationships explaining about 70 to 80 percent of the data variability. In subsurface soils, asbestos concentrations were correlated with PCBs, and dieldrin levels were correlated with PCBs and lead. The subsurface data for Area D resembled most closely the data for the combined Area II and Area III data set (Table 4-15).

5.0 CONTAMINANT FATE AND TRANSPORT

Complex factors govern the fate and transport of contaminants within Area III. The past operations and disposal history associated with the Raymark Facility, the varying geologic and hydrogeologic conditions of Area III and environs, and the transfer and cross-migration of contaminants between environmental media, all influence the migration of contaminants in the sediment, surface water, soil, and groundwater. This section presents a summary of the fate and transport for contaminants in sediment, surface water, and soil within Area III. A detailed discussion of the general mechanisms and factors that govern fate and transport are presented in Appendix E.

Section 5.0 summarizes the fate and transport of contamination including:

- Section 5.1 - Contaminant Sources and Releases
- Section 5.2 - Contaminant Fate and Transport in the Area III Study Area

The location of Area III is shown on Figure 1-2 and is defined in Section 1.3.2. Sample locations are identified on Figures 4-1 and 4-8, Areas D and E.

5.1 Contaminant Sources and Releases

Contaminants were released into the environment in Area III by various historical disposal and operational practices associated with the Raymark Facility, and potentially from other commercial and industrial operations within the OU3 area. A summary of past sources and releases of contamination is presented below. A description of facility operations and manufacturing processes is presented in Section 1.3.

Throughout the history of the Raymark Facility, large quantities of organic and inorganic chemicals and fuels were handled in storage tanks, drums, and process equipment situated throughout the property. The moving, opening, and emptying of drums and the loading and unloading of tanks may have resulted in discharges or spills of solvents and fuel. Solvents and fuels reportedly leaked to soils from above and underground storage tanks (ELI, 1995).

Acid neutralization pits were located on the facility and received spent acids and caustic solutions laden with metals. Solvents may also have been disposed of in the acid neutralization pits.

In addition, a series of four lagoons were used to retain and settle particulate matter from clarified process waters generated as a by-product of the manufacturing activities. Liquid wastes bearing residual VOCs, heavier organic compounds, asbestos, and metals were directly discharged into the lagoons. A system of drains under the buildings of the facility also conveyed process water, spills, and discharges to the lagoons, which ultimately discharged to Ferry Creek. Storm drains throughout the facility directed surface runoff into this discharge system. Thus, the Raymark Facility runoff, storm and facility drains, and process water all discharged to Ferry Creek, which then flowed to the Housatonic River and Long Island Sound. The discharge from the lagoons continued until 1995 when drainage was diverted around the lagoons directly into a stormwater drain. Off-site discharge of process water and manufacturing facility drainage ceased in 1984.

Sludges excavated or dredged from the lagoons, "off-specification" materials that were discarded, and other waste products were disposed of as fill materials throughout a substantial portion of the Raymark Facility property, as well as at residential, commercial, and industrial properties within Stratford, including properties in Area III. The nature and concentrations of contaminants in the fill materials changed over the 70-year operational lifetime of the Raymark Facility due to alterations in manufacturing processes and product lines.

Area III does include other commercial and industrial properties that probably are, or have in the past, contributed to the contamination of the soil, surface water, sediment, and groundwater. The likelihood of these releases of petroleum hydrocarbons, volatile organic and semi-volatile organic compounds, and other contaminants is based on the long history of industrial and commercial activities in the area. However, identification and evaluation of releases from these potential sources are not within the scope of this RI.

A summary of the distribution of contaminants in Area III follows:

Area D – Beacon Point Area – The upland portions of the area received a direct discharge of Raymark waste as Raymark soil-waste/fill to create the boat launch and other areas. The wetlands portion of the area received Raymark waste as washout from erosion of Raymark soil-waste/fill placed on the upland areas within the study area (in both Ferry Creek and the Housatonic River).

Area E – Elm Street Wetland – This area is wetlands that received contaminants as both a direct discharge of Raymark waste as fill and as washout from erosion of Raymark soil-waste/fill placed on the surrounding properties.

The nature, distribution, and concentration of contaminants in the sediment indicates that the fill may have contributed to the presence of contaminants in the sediment. The disposal of fill material from the Raymark Facility occurred at or near both the Beacon Point wetlands and the Elm Street wetlands. This resulted in the direct release of contaminants in areas where Raymark soil-waste/fill was disposed, and the potential indirect release to naturally occurring sediment and soil in the vicinity. Surface water flow, runoff, infiltration, and tidal fluctuations are the key transport mechanisms moving the contaminants. Dissolution of select contaminants in the fill material caused by this runoff, groundwater infiltration, or tidal fluctuations may also result in indirect release to groundwater and/or downgradient environmental media.

Area III Summary

The main sources and releases of contaminants to Area III are summarized as follows:

- Discharge of surface runoff, facility drains, and process water from the former Raymark Facility into Ferry Creek, and ultimately the Housatonic River and Long Island Sound.
- Disposal of contaminated Raymark wastes, including sludges from the lagoons, "off-specification materials" that were discarded, and Raymark soil-waste/fill from

the facility that was used to fill in low topographic areas. These fill materials have become sources of further release to the wetlands, the Housatonic River, and other low lying topography through erosion, surface water transport (dissolved and suspended contaminants), and volatilization.

- Spillage, leakage, and other sources of release of contaminants from the Raymark Facility discharged into the ground, into the local drainage area and as base-flow to Ferry Creek, and ultimately the Housatonic River and Long Island Sound.
- Spillage, leakage, and other sources of release of contaminants from other (non-Raymark) commercial and industrial properties within the drainage area.

5.2 Contaminant Fate and Transport in the Area III Study Area

The fate and transport of contaminants within the Area III study area were evaluated to support the human health and ecological risk assessments, and for future use in the feasibility study that will evaluate potential remediation options.

This section describes the distribution and releases of contaminants, summarizes the physical states of contaminants in the environmental media (soil, sediment, and surface water), and discusses the primary pathways for contaminants to move from the potential source areas into the environmental media within Area III. A detailed discussion of the mechanisms and factors governing fate and transport are provided in Appendix E.

The fate and transport discussions are focused on the major contaminants of concern (COCs) identified from both the human health risk assessment and the ecological risk assessment. These COCs include: PAHs, PCBs, dioxins/furans (expressed as TEQ concentrations), metals, pesticides, and asbestos.

Contaminants in Area III are present in sediment, surface water, and soil samples. A summary of the activities resulting in contaminant release to the area, the physical state of the contaminants present in these environmental media, and the associated fate and transport mechanisms are presented below. The fate and transport mechanisms for the

sediment/surface water and soil media are presented in Appendix E (see Sections E.4.3 and E.4.4).

Direct discharge of both organic and inorganic contaminants from the Raymark Facility lagoons into the northern reaches of Ferry Creek, and the potential leaching of Raymark soil-waste/fill have contributed to the contamination of sediment throughout Area III. Surface water flow, runoff, infiltration, and tidal fluctuations are the key transport mechanisms moving contaminants in these areas. PAHs, PCBs, dioxins/furans, metals, and asbestos were frequently detected in Area III sediments. VOCs were detected less frequently.

Contaminated Raymark wastes as fill are a source of soil contamination. Contaminants are directly released in areas where Raymark soil-waste/fill materials were disposed, and the potential indirect release to naturally occurring sediment and soil. Contamination by these direct releases then become a source of indirect releases. These sources and releases appear to have contributed to contamination of the soil with elevated levels of PAHs, PCBs, dioxins/furans, pesticides, and metals, as well as infrequent detections of VOCs and asbestos.

Dissolution of soluble contaminants from the fill, caused by runoff and/or groundwater infiltration, contact with solvents or acids (if present), or tidal fluctuations may also result in indirect release to downgradient environmental media. This transport mechanism may have contributed to subsurface soil contamination as well as to contamination of sediment and/or surface water.

Migration of chemical contaminants from impacted sediment and soil, and transport as a result of surface water flows and tidal fluctuations, appear to continue to impact downgradient regions of the Housatonic River and wetland areas along the river bank. Contaminants may accumulate in these regions by adsorption to sediment/silt particles with high organic carbon content (Area D).

The fate and transport of contamination in Areas D and E is dependent on the physical, chemical, and biological processes and the type of chemical contaminant present. A summary discussion of the fate and transport of the various categories of chemical contaminants in

sediment and surface water, and the soils throughout the Area III study area is presented below, with detailed discussions provided in Appendix E.

5.2.1 Soil

The main contaminants of interest for the soils in Area III are discussed below, with a brief description of the frequency of detection and the apparent source and transport mechanisms.

Various chemical contaminants are present in the soil in Area III. Several pathways are available for contaminants to have entered these media, and for them to have been subsequently transported to adjacent media. The main pathways of soil contamination in Area III are as follows:

- Direction deposition of Raymark soil-waste/fill.
- Transport and redeposition of contaminated soil and sediment particles via erosion from contaminated soils and Raymark soil-waste/fill.
- Transport of dissolved contaminants into soils via surface water runoff from private and commercial/industrial properties, and roadways, including those that have Raymark soil-waste/fill.
- Transport of contaminants into soils via discharge of contaminated groundwater as base-flow seepage into Ferry Creek and ultimately into the Housatonic River.
- Transport of adsorbed contaminants throughout Ferry Creek and the Housatonic River via erosion and redeposition of contaminated sediment caused by surface flow and tidal fluctuations.

VOCs - Dissolution of the more soluble contaminants, such as VOCs, in the Raymark soil-waste/fill caused by runoff and/or groundwater infiltration may have resulted in a release of contamination downward into the subsurface soil. VOCs were detected infrequently in the surface and subsurface soil in Area D. The surface VOCs detected are: 2-butanone and

acetone; the subsurface VOCs are: acetone and carbon disulfide. The presence of these contaminants may have been the result of localized releases at the properties. In Area D, VOCs were detected in the subsurface soils in the dry dock storage area. In Area E, no VOC samples were obtained.

SVOCs (primarily PAHs) – SVOCs are generally not as soluble in water as VOCs. The primary SVOCs of concern are the PAHs. PAHs were frequently detected in surface soil, with somewhat lower frequencies and concentrations in subsurface soil. The high frequency of detections suggests that the PAHs were adsorbed onto soil particles placed in the area as fill material. The somewhat higher frequency of detections in the surface samples suggests a more recent source of contamination, such as vehicle exhaust and tire degradation from nearby roads and parking lots.

PCBs - Aroclor 1262 and Aroclor 1268 (with less frequent detection of Aroclor 1254 in surface soils only) were detected in both surface and subsurface soil in Area D. The high frequency of PCB detections in both surface and subsurface soil suggests that the PCBs were adsorbed onto soil particles placed in the area as Raymark soil-waste/fill. Due to the low mobility of PCBs in the environment, they are likely to have remained where they were deposited. No detections above background concentrations were found for Area E.

Dioxins and Furans – Dioxins/furans (as TEQ concentrations) were frequently detected in the limited number of surface and subsurface soil samples collected in Area D. These contaminants were detected in the same regions as the PCBs and are believed to have been transported to these regions in a similar manner. No detections above background concentrations were found for Area E.

Metals (primarily Copper and Lead) – Copper and lead were infrequently detected above background levels in both surface and subsurface sediment in Areas D and E. The slightly higher frequency of detections in the surface soils is due to the low mobility of metals in the environment. Metals are likely to remain where deposited.

Asbestos – Asbestos is relatively immobile in the environment, except through bulk advective movement or dispersion in aqueous or airborne environments. Elevated levels of asbestos

were detected frequently in both surface and subsurface soil throughout Area D, in similar areas where copper and lead were detected. Due to the low likelihood of asbestos mobility in the environment, it is likely to have remained where it was deposited in the fill material from the Raymark Facility. No asbestos samples were taken in Area E.

5.2.2 Sediment and Surface Water

The main contaminants of interest in the sediment and surface water in Area III are discussed below, with a brief description of the frequency of detection and the apparent source and transport mechanisms.

Various chemical contaminants are present in the sediment and surface water in Area III. Several pathways are available for contaminants to have entered these media, and for them to have been subsequently transported downstream and/or to adjacent media. The main pathways of surface water and sediment contamination in Area III are as follows:

- Direct deposition of Raymark soil-waste/fill
- Transport and redeposition of contaminated soil and sediment particles via erosion from contaminated soils and Raymark soil-waste/fill.
- Transport of dissolved contaminants into sediment and surface water via discharge of contaminated groundwater as base-flow seepage into Ferry Creek and ultimately into the Housatonic River.
- Transport of adsorbed contaminants through Ferry Creek and the Housatonic River via erosion and redeposition of contaminated sediment caused by surface flow and tidal fluctuations.

VOCs - VOCs were detected infrequently in the surface and subsurface sediments throughout Area D. The VOCs detected that exceeded background concentrations were 2-butanane, acetone, and carbon disulfide. In Area E, only surface sediment samples were analyzed; these indicated infrequent detections of VOCs along the northern edge of the wetland abutting

the property where a removal action took place. The VOCs that were detected with higher concentrations include 2-butanone, acetone, and toluene, although none exceeded regulatory standards. VOCs were also infrequently detected in surface water in both areas.

SVOCS (primarily PAHS) - SVOCS, mainly PAHs, were frequently detected in the surface and subsurface sediment throughout Area D. SVOCS, mainly PAHs, were frequently detected in the surface sediments but infrequently detected in the subsurface sediments in Area E. The occurrence of these PAHs in this area may be caused by surface water runoff flows infiltrating into the pavement and the subsequent adsorption to sediment particles. SVOCS are more readily adsorbed to sediment particles than VOCs. SVOCS are generally not as soluble in water as the VOCs. SVOCS in sediment can volatilize but not to the degree of VOCs. SVOCS usually are not transported by surface or groundwater but from more localized Raymark soil-waste/fill deposits. SVOCS were detected infrequently in the surface water in both areas.

Pesticides/PCBs – Pesticides and PCBs are readily adsorbed to sediment particles and PCBs are less soluble in water. Pesticides and PCBs were infrequently detected in the both surface sediment and subsurface sediment samples in Area D. In Area E, pesticides and PCBs were frequently detected in the subsurface sediment and infrequently detected in the surface sediment. In Area D, infrequent detections of pesticides were observed in both the surface and subsurface sediments, with 12 of 26 surface and 8 of 21 subsurface samples exceeding Connecticut standards.

In Area D, Aroclor 1262 was most frequently detected in the surface sediment and less frequently in the subsurface sediment. In Area E, Aroclor 1254 was detected most frequently in the surface sediment, less frequently in the subsurface sediments. Aroclors 1016, 1242, 1248, and 1268 were detected above Connecticut standards but less frequently detected in both surface and subsurface sediments. The higher frequency of PCB detection in surficial samples suggests that the PCBs were adsorbed onto sediment particles that may have migrated to the areas with surface water flows, runoff, or tidal fluctuations. Pesticides and PCBs were not detected at elevated concentrations in the surface water.

Dioxins and Furans - In a pattern similar to the PCBs because of their adsorption tendencies and low water solubilities, dioxins/furans (as TEQ concentrations) were frequently detected in

surface sediment and less frequently detected in subsurface samples in Areas D and E. Surface water was not analyzed for dioxins/furans in either Area D or Area E.

Metals – Metals tend to be less mobile in the environment than organic contaminants. Some dissolution of metals does occur in the presence of water, however, as these metals precipitate out of solution they adsorb to sediment particles. Copper and lead were frequently detected at significant levels above background in both surface and subsurface sediment of Areas D and E. A lower frequency of detections in the surface water in Area D was detected. Concentrations of lead and copper in most Area E surface water samples suggest these metals may have leached out of contaminated sediment.

In the sediment, the similar frequency of detections in surface and subsurface sediment samples suggests that deposition of contaminated sediment has occurred over an extended period of time (resulting in deposition of contamination with depth), and/or the metals migrated in the dissolved state and precipitated on sediment particles upon contact.

Asbestos - Asbestos is relatively immobile in the environment, except through bulk advective movement, dispersion in aqueous or airborne environments, or physical erosion and transport in surface water flows.

Elevated levels of asbestos were detected in sediment in the same relative locations as were copper and lead, thereby supporting the conclusion that placement of contaminated fill material in or adjacent to the wetlands in Area D was the source of contamination. No asbestos was detected in the surface and subsurface sediment in Area E.

Elevated levels of asbestos were detected infrequently in surface sediment in Area D and Area E. The findings suggest the asbestos may have been transported tidally from Ferry creek, as well as by transport in rainwater runoff from asbestos-laden fill materials placed on the banks in Area D.

Surface water was not analyzed for asbestos in either Area D or Area E.

5.3 Summary

Contaminants were released into the environment in Area III by various historical disposal and operational practices associated with the former Raymark Facility and potentially from other commercial and industrial operations within the OU3 area. The main sources and releases of contaminants to Area III include the disposal of Raymark soil-waste/fill, discharge from the former Raymark Facility into Ferry Creek and connecting waterways, local spillage and/or leakage into the ground, and the possible discharge of contaminated groundwater to proximate water bodies.

VOCs were not widely detected in Area III, so it is unlikely that VOCs have migrated through leaching or erosion. Because no monitoring wells exist in Area III, the possibility of contaminants leaching to groundwater cannot be evaluated. SVOCs were also not widely detected, but PAHs have been detected. PAHs typically have low volatility and are less soluble than VOCs. These SVOCs are likely to remain adsorbed to soil particles and are only gradually leached by precipitation infiltration. Erosion of soils can cause SVOCs to be deposited in sediments in the Housatonic River, and SVOCs adsorbed to sediment particles could migrate through erosion and redeposition, as well as surface water flow.

Pesticides, PCBs, and dioxins are relatively nonvolatile organic compounds that are generally insoluble in water. Most likely, limited leaching of these chemicals to groundwater is occurring, although no monitoring wells exist in Area III to confirm or deny this is happening. Erosion and runoff in Area III can convey these chemicals into nearby waterways. Wind erosion may also cause dusts containing pesticides, PCBs, or dioxins to become mobilized to the air. This could occur in Area D where non-vegetated soils could be prone to erosion.

Metals in Area III soils may become mobilized through erosion and runoff, and although less likely, through fugitive dust emissions. SPLP results for metals indicate that lead and copper could be leaching to groundwater, but no monitoring wells exist in Area III to evaluate metal concentrations in groundwater and the source(s) of contaminants. Metals bound to sediments will be conveyed downstream through sediment transport processes such as mixing, advection, and sedimentation. Unadsorbed metals may continue migrating to surface water. Analytical results indicate that metal concentrations are not exceeding the CT AWQ criteria.

6.0 BASELINE HUMAN HEALTH RISK EVALUATION

Section 6.0 presents the methodology for and the results of a baseline human health risk assessment conducted for the Area III study area. The objective of the assessment is to estimate potential current or future risks to the public from the organic and inorganic chemicals detected in the surface water, soil, wetland soil, and sediment samples collected in the study areas. Section 6.1 provides an overview of the risk assessment process. Sections 6.2 through 6.5 outline the methodology used to conduct the baseline human health risk assessment. An analysis of the uncertainties associated with the risk assessment is presented in Section 6.6. The results of the baseline risk assessment of area-specific chemical concentrations in the environmental media are presented in Sections 6.7 and 6.8. Section 6.9 presents a summary of the baseline human health risk evaluation. The risk assessment conducted for this report follows the most recent guidance from the EPA (EPA, 1989d and 1991a), including regional EPA guidance (EPA, 1989b, 1994c, 1995, and 1996c).

6.1 Introduction - Overview of Risk Assessment Process

A risk assessment provides the framework for developing risk information necessary to assist in determining the need for remediation at a site and developing potential remedial alternatives for a site. A baseline human health risk assessment consists of five major components, as follows:

- Data evaluation and identification of chemicals of potential concern (COPCs)
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Characterization of uncertainty in the risk estimates

To assess potential public health risks, four major aspects of chemical contamination and exposure must be considered: contaminants with toxic characteristics must be found in environmental media; the contaminants must be released by either natural processes or by human action; potential exposure points must exist; and human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of the

requirements listed above is absent for a specific site, the exposure route is regarded as incomplete and no potential risks will be considered for human receptors.

The risk assessment for the Area III study areas estimates the potential for human health risk at each of two sections of Area III shown in Figure 1-2:

- Area D – Beacon Point Area
- Area E – Elm Street Wetlands

The Data Evaluation Section is primarily concerned with the selection of COPCs that are representative of the type and magnitude of potential human health effects. Both current and historical data are considered in developing a list of COPCs for each medium. In turn, these COPCs are used to evaluate potential risks. A generic discussion of the process is contained in Section 6.2.1, and area-specific discussions for Areas D and E are presented in Sections 6.7 and 6.8.

The Toxicity Assessment presents the available human health criteria for all the selected COPCs. This assessment is contained in Section 6.3; however the final lists of COPCs for Areas D and E are presented later in the document. This section is presented early to avoid repetition of the toxicity information because many COPCs are common to the two areas. Quantitative toxicity indices are presented where they are available. Enforceable standards such as Maximum Contaminant Levels (MCLs), regulatory guidelines such as Ambient Water Quality Criteria (AWQC) and Health Advisories, and dose-response parameters such as Reference Doses (RfDs) and Cancer Slope Factors (CSFs) are presented for each COPC.

The Exposure Assessment section (Section 6.4) identifies potential human exposure pathways in Area III. Exposure routes are identified based on information on observed chemical concentrations, chemical release mechanisms, patterns of human activity, and other pertinent information to develop conceptual site models for each type of source. One overall set of exposure routes was developed for this report, but not all routes are applicable in all parts of Area III. Section 6.4.6 presents the equations and relevant input parameters for estimating chemical intake. The area-specific risk assessments (Sections 6.7 and 6.8) present only those

routes relevant to that section of Area III, and refer to Section 6.4.6 for the details on the estimation methods.

The Risk Characterization section (Section 6.5) describes how the estimated intakes are combined with the toxicity information to estimate risks. The actual numerical results of this exercise are presented in the area-specific sections of this report. General uncertainties associated with the risk assessment process are discussed qualitatively in Section 6.6. Uncertainties associated with a particular area are provided in the area-specific sections.

6.2 Data Evaluation Methodology

Data evaluation is an area-specific task that uses a variety of information to determine which of the detected chemicals in an area are most likely to present a risk to potential receptors. The end result of this qualitative selection process is a list of COPCs and representative exposure point concentrations for each medium. The rationale for the selection and/or exclusion of each detected chemical is presented in the area-specific sections, Sections 6.7 and 6.8. The methodology used to identify COPCs is provided in Section 6.2.1. The methodologies used to determine exposure point concentrations for the selected COPCs are presented in Section 6.2.2.

6.2.1 Selection of Chemicals of Potential Concern

COPCs for the baseline human health risk assessments are limited to those chemicals that exceed a selection criterion. For this risk assessment, federal and state risk-based and health-based criteria were used to reduce the number of chemicals and exposure routes considered in a risk assessment. The premise of this screening step is that risk is typically dominated by a few chemicals and that, although dozens may actually be detected, many chemicals may contribute minimally to the total risk. The purpose of using federal and state criteria is to satisfy the potential concerns of each regulatory agency since similar federal and state criteria may not be developed using the same methodologies and exposure assumptions.

Maximum detected concentrations (in a single sample) in each area and in each medium were compared to the risk-based and health-based screening criteria. If the maximum concentration

exceeded any of the screening criteria, that chemical was retained as a COPC for all exposure routes involving that medium. For example, if barium was retained for soil, this chemical was evaluated as a COPC for both ingestion and dermal exposure routes.

In general, all available validated data and unvalidated field screening data for copper and lead from historical investigations and the 1997 sampling effort were used to identify COPCs for a study area. The 1999 data collected by SAIC, Inc. are not included in the human health risk assessment because COPCs were identified in 1998. As provided in Appendix F-1, an evaluation of the field screening data for copper and lead indicate a good correlation between field-screening and fixed-base laboratory results for copper and lead. Consequently, the field screening data for lead and copper were used in the baseline risk assessment. Area- and medium-specific COPC summary screening tables are provided in Sections 6.7 and 6.8. Field screening data (other than lead and copper), unvalidated analytical data, and analytical results qualified as rejected (R) during the data validation process were not considered because of their potential unreliability. For soil, data obtained from excavated locations, soil collected from depths greater than 15 feet (the maximum assumed depth for potential human exposure during excavation/construction based on the State of Connecticut definition of accessible soils), and composite soil samples were not used in the COPC selection process.

Essentially, two types of COPCs are identified in the baseline human health risk assessment: direct exposure COPCs and additional COPCs based on potential contaminant migration tendencies, i.e. groundwater protection benchmarks. Direct exposure COPCs are those chemicals detected at maximum concentrations in excess of criteria developed for the protection of direct human contact with a medium, e.g., risk-based EPA Region III COPC screening levels for soil and tap water ingestion. Residential soil and tap water risk-based concentrations were included in the screening criteria for selection of COPCs. This approach is quite conservative for a site where no residential use is anticipated and surface water is not potable due to salinity. The approach was taken to assure protection of nearby residents and to allow chemicals that may produce marginal risks to be included in the quantitative assessment. Other health-based criteria, e.g., Connecticut Remediation Standard Regulations for pollutant mobility are used to identify groundwater protection benchmarks based on likely contaminant migration pathways in Area III. Only chemicals selected as COPCs based on comparisons to direct contact criteria were evaluated quantitatively in the baseline risk

assessment. All criteria used to identify COPCs for solid environmental matrices (soil, wetland soils, and sediments) and aqueous environmental matrices (surface water) are presented in Table 6-1 and Table 6-2, respectively. As discussed previously, the groundwater resource at Ferry Creek is not evaluated in this baseline risk assessment.

A discussion of the criteria used for COPC selection is provided in the remainder of this section, on a medium-specific basis.

6.2.1.1 Soils/Wetland Soils/Sediments

The solid matrix samples from the Area III study areas have been divided into soils, wetland soils, and sediments for the purposes of human health exposure evaluation. This breakdown is useful in distinguishing samples to which specific receptor groups may be exposed. Soils are defined as solid matrix samples collected from relatively dry areas located outside designated wetland boundaries and not associated with creeks, creek beds, or the Housatonic River. Wetland soils are defined as solid matrix samples collected from within designated wetland boundaries. It should be noted that these samples may have been designated as either soils or sediments previously. Sediments are defined as solid matrix samples collected from creeks, creek beds, or the Housatonic River.

COPCs for solid environmental matrices (soils, wetland soils, and sediments) were selected for each of the two sections of Area III. The COPCs selected for shallow soils, wetland soils, and sediments from depths of 0 to 2 feet bgs are presented separate from COPCs selected for "all soils". The "all soil" category refers to soil and sediment samples collected from depths of 0 to 15 feet bgs and is used to account for soil to which commercial workers may be potentially exposed. Soils to a depth of 15 feet are considered "accessible" by the State of Connecticut. If a chemical is identified as a COPC for shallow soils and sediments, it is automatically retained as a COPC for "all soil." If a compound is found at a concentration of concern (in excess of screening criteria) only in the subsurface soil, it is retained as a COPC for the "all soil" category only. All sample locations within a given area were used to determine COPCs for that area without regard to later division of the area data into subsets of data based on receptor locations.

The following screening criteria were used to identify COPCs for direct contact exposure to soils, wetland soils, and sediments:

- **EPA Region III COPC Screening Levels for Residential Soil Ingestion.** Although current and likely future land use within the Area III study area is commercial/industrial and recreational, risk-based concentrations for soil ingestion for residential land use were used as a conservative approach. These values were developed using the current EPA Region III Risk-Based Concentration (RBC) Table (EPA, 1999b), which identifies concentrations of potential concern for nearly 600 chemicals in various media (air, drinking water, fish tissue, and soil) using certain reasonable maximum exposure default assumptions. The EPA Region III residential soil ingestion values were calculated by assuming that a receptor is exposed to soil for 350 days per year for a 30-year exposure period. For carcinogenic chemicals, the values used for COPC screening are based on a 1E-6 target incremental lifetime cancer risk and incorporate age-adjusted factors (for small children and adults). The EPA Region III criteria for non-carcinogenic chemicals are based on a target hazard quotient (HQ) of 1.0 and incorporate exposure defaults for small children. These residential soil ingestion values for noncarcinogenic chemicals were adjusted to COPC screening levels based on a target hazard quotient (HQ) of 0.1, which is one-tenth of the suggested cumulative target noncarcinogenic risk for a potential receptor. The estimation of cumulative target noncarcinogenic risks is described in greater detail in Section 6.5. Table 6.1 presents the Region III RBCs for residential soil ingestion prior to the adjustment of non-carcinogenic values to correspond to a HQ of 0.1. The adjusted values are shown on the COPC selection tables discussed in Sections 6.7 and 6.8.
- **EPA and Connecticut Screening Levels for Lead.** EPA Region III has not developed risk-based concentrations for lead. Although current and likely future land use within Area III is commercial/industrial and recreational, risk-based lead concentrations for soil ingestion for residential land use were used as a conservative approach. The OSWER soil screening level of 400 mg/kg for residential land use (EPA, 1994b) and the state screening levels of 500 mg/kg for residential exposure and 1,000 mg/kg for industrial exposure were used for COPC screening. The EPA's Integrated Exposure Uptake and

Biokinetic (IEUBK) model which estimates the risk to a child resident is the basis for the OSWER residential soil screening level.

- **National Emission Standards for Hazardous Air Pollutants Benchmark for Asbestos.** EPA Region III has not developed risk-based concentrations for asbestos. Asbestos was a primary component of friction materials, e.g., gaskets material, sheet packing and friction materials, including clutch facing, transmission plates, and brake linings, manufactured at the Raymark facility. Quantitative risk estimates (inhalation risk estimates) cannot be developed for this parameter, however asbestos is considered a potential inhalation hazard. The National Emission Standards for Hazardous Air Pollutants - EPA Regulation 40 CFR Subpart M, Part 61 (NESHAP) defines asbestos as material containing more than 1 percent asbestos. Since asbestos was detected at the site, TtNUS has adopted the NESHAP benchmark of 1 percent for an asbestos screening value.
- **Connecticut Remediation Standard Regulations (RSRs) for Direct Exposure (Residential and Industrial).** Connecticut RSRs for direct exposure to soil under residential and industrial land use are presented in the COPC screening tables. Although the standards for residential direct exposure are the limiting factor for COPC selection (values for residential exposure are less than those for industrial exposure), both of these standards are provided for informational purposes. RSRs for direct exposure are calculated using methodologies similar to those used to develop the EPA Region III COPC Screening Levels for soil ingestion. However, reasonable maximum exposure default assumptions employed by the state are slightly different than those advocated by EPA Region III (a residential receptor is assumed to be exposed to soil at a frequency of 365 days per year, instead of the EPA's 350 days per year assumption). The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. The State of Connecticut has not developed RSRs for all chemicals positively detected within the Area III study area. For those chemicals lacking adopted RSRs, TtNUS has calculated RSRs (B&RE, 1997) using the methodologies outlined in the RSR guidance (CT DEP, 1996). These values were submitted to the state for review during the preparation of a report for the Lower Subbase Remedial Investigation

for Naval Submarine Base New London, and they were revised based on comments received from the state (B&RE, 1998). A summary of the RSRs developed by B&RE and used in this risk assessment are presented in Appendix F-2.

- **EPA Generic Soil Screening Levels (SSLs) for Transfers from Soil to Air (Inhalation).** EPA Generic SSLs (EPA, 1996a) for direct inhalation are used to evaluate chemicals that may volatilize from soil, as well as contaminated particulates that may be present in air (fugitive dust) as a result of particulate entrainment from soil. The inhalation SSLs are calculated using default, residential land use exposure factors, infinite source models, and conservative default assumptions for source delineation. Therefore, these values are conservative and are designed to be protective of potential exposure at most sites. The EPA has calculated generic SSLs for approximately 110 organic and inorganic chemicals. SSLs for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. For noncarcinogenic chemicals, the SSLs are based on a target HQ of 1.

Background concentrations for chemicals in soil, wetland soil, and sediment are presented in Appendix F-3. Metals concentrations in the background soils samples were used to select COPCs. Specifically, a noncarcinogenic metal detected in soils/wetland soils/sediments at a concentration greater than the COPC screening levels for soil, but equal to or less than the EPA Region III residential RBC for soil ingestion AND the maximum detected background concentration was not selected as a COPC. A discussion of the data in comparison to the established inorganic and organic background levels is provided in each area-specific uncertainty section. It should be noted that background concentrations were considered when developing recommendations and conclusions for each area (identifying whether additional sampling or remediation is warranted).

Frequency of detection was used as a COPC selection criteria for parameters not known to be predominant study area contaminants (the predominant Area III study area contaminants are PCBs, PAHs, dioxins, asbestos, and metals [especially copper, lead, and barium]). In general, other chemicals detected once or twice within an area at a maximum concentration marginally exceeding a screening criteria were not selected as COPCs. The decisions to delete

parameters on the basis of frequency of detection were reviewed with EPA Region I prior to the finalization of the COPC selection tables.

In order to identify potential contaminant migration to groundwater tendencies, the following criteria were used to evaluate shallow soil and "all soil" (soil collected from depths of 0 to 15 feet bgs), but, these criteria were not used to select COPCs for quantitative risk assessment:

- **EPA Generic Soil Screening Levels (SSLs) for Migration to Groundwater.** EPA Generic SSLs for migration to groundwater, associated with a dilution and attenuation factor of 20 were also used to identify chemicals detected in soils/wetland soils/sediments at concentrations that may impact groundwater quality. The migration to groundwater SSLs are calculated using default, residential land use exposure factors, infinite source models, and conservative default assumptions for source delineation. Therefore, these values are conservative and are designed to be protective of potential exposure at most sites. The EPA has calculated generic SSLs for approximately 110 organic and inorganic chemicals. SSLs for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. For noncarcinogenic chemicals, the SSLs are based on a target HQ of 1.
- **Connecticut RSRs for Pollutant Mobility (GB Classified Area).** The state has developed pollutant mobility RSRs for GA/GAA (drinking water source) and GB (non-drinking water source) classified areas. Since the Area III study area is classified by the state as a GB area, Connecticut RSRs for GB pollutant mobility were used to identify groundwater protection benchmarks. For most organic chemicals, RSRs for pollutant mobility are calculated using methodologies similar to those used to develop the EPA generic SSLs for migration to groundwater. However, the actual models and reasonable maximum exposure default assumptions employed by the state are different from those advocated by EPA Region III. The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. It should be noted that RSRs for inorganics and PCBs apply to SPLP or TCLP analytical results only. RSRs for these chemicals were compared to SPLP or TCLP analytical results to identify groundwater protection benchmarks in the baseline human health risk assessment.

The comparison of area-specific data to these standards is presented in tables following the COPC screening tables. As mentioned previously, the State of Connecticut has not developed RSRs for all chemicals positively detected at the Area III study area. Therefore, TtNUS has calculated RSRs using state guidance (CT DEP, 1996) for use in the risk assessment (Appendix F-2).

6.2.1.2 Surface Water

COPCs for surface water were selected using unfiltered sample data. COPCs for direct exposure to surface water were identified using the following screening criteria:

- **EPA Region III COPC Screening Levels for Tap Water Ingestion.** Although surface water in the Area III study areas is not currently used as a drinking water supply and is not expected to be used as such in the future (Ferry Creek is tidally influenced), risk-based concentrations for tap water ingestion were used to conservatively identify COPCs. The EPA Region III criteria are calculated using an age-adjusted exposure equation, which assumes that a receptor uses a water supply for household purposes at a frequency of 350 days per year for 30-year exposure period. The screening values for tap water ingestion, which actually incorporate exposure via inhalation of volatiles, were developed from the current EPA Region III RBC Table (EPA, 1999b). For carcinogenic chemicals, the values used for COPC screening are taken directly from the EPA Region III RBC Table and are based on a 1E-6 target incremental lifetime cancer risk. The criteria for noncarcinogenic chemicals from the EPA Region III RBC Table have been adjusted based on a target HQ of 0.1. Table 6-2 presents the Region III RBCs for tap water ingestion prior to the adjustment of non-carcinogenic values to correspond to a HQ of 0.1. The adjusted values are shown on the COPC selection tables discussed in Section 6.7 and 6.8.
- **Federal and State Maximum Contaminant Levels (MCLs).** Federal MCLs are standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health (direct ingestion). State MCLs have been promulgated under guidance for Connecticut agencies (Title 19, Health and Safety, the Public Code of the State of Connecticut, Chapter II Environmental Health). Both federal and state

MCLs are developed in a similar manner (they are based on laboratory or epidemiological studies and apply to drinking water supplies). They are designed in a similar manner as the EPA Region III RBCs (for the prevention of human health effects associated with lifetime exposure of an average adult who consumes 2 liters of water per day). However, MCLs also reflect the technical feasibility of removing the contaminant from water. MCLs are typically enforceable standards for public drinking water supplies; these standards are not strictly applicable to surface waters within the Area III study area because these waters are not currently used as a drinking water supply and they are not expected to be used as such in the future. Consequently, the use of MCLs as a COPC selection criteria is very conservative. It should also be noted that only primary (health-based) MCLs are used to identify COPCs. Secondary MCLs, based on aesthetic drinking water qualities (color, odor, taste, etc.), are not used to select COPCs.

Given the relatively small size of the background and study area data sets for the Area III study area, chemicals detected in surface water were not eliminated as COPCs on the basis of comparisons to background or on the basis of frequency of detection.

In order to identify potential ARARs exceedances, Connecticut Water Quality Standards (WQSs) (CT DEP, 1997) for the protection of saltwater and freshwater quality and for the protection of human health may be used to further evaluate chemical concentrations in the surface water in the Area III study area (Appendix F-4), but were not used to select COPCs for quantitative risk assessment. Saltwater and freshwater criteria are considered because Ferry Creek is tidally influenced (the salinity in this resource fluctuates).

It should be noted that federal AWQCs are other health-based benchmarks that were not used to identify surface water COPCs or identify potential ARARs exceedances in the baseline human health risk assessment. These criteria were not used because they are extremely similar to the risk-based and health-based criteria identified in the previous paragraphs.

6.2.1.3 Exposure Point Concentrations

According to the regional guidance, risk assessments are conducted using an exposure point concentration for each COPC (except when assessing exposure to groundwater, where the maximum detected concentration and the average plume concentration are used as exposure point concentrations). The exposure point concentration is defined as the 95 percent upper confidence limit (UCL) and is calculated using the latest risk assessment guidance from EPA (EPA, 1992 and 1994c). A value of one-half the detection limit is substituted for nondetected values in the calculation. Because of potential problems with sample heterogeneity, the maximum detected concentration reported for field duplicate pair samples was used in the calculation for soil and sediment matrices at the direction of EPA. The average for the duplicate pair was employed for aqueous matrices.

Within Area D, subsets of data were used to determine exposure point concentrations based on differing exposure scenarios. These subsets are described in the area-specific section. Sample lists for each receptor evaluated are provided in Appendix F-5.

For sample sets consisting of less than 10 samples, the maximum concentrations were used as the exposure point concentrations for the reasonable maximum exposure (RME) and the average concentrations were used for the central tendency exposure (CTE), since the UCL does not provide a good estimation of the upper bound of the mean concentration for these small data sets (EPA, 1992 and EPA, 1994c). For larger sample sets, the methodology used depends on the distribution of the sample set. For this risk assessment, the distribution was determined using the Shapiro-Wilk W-Test (Gilbert, 1987). When the results of the test were inconclusive and the distribution was regarded as undefined, the distribution was assumed to be log normal and the 95 percent UCL for log-normally distributed data sets was selected as the exposure point concentration for both the RME and CTE cases, unless the 95 percent UCL for log-normally distributed data sets exceeded the maximum reported concentration. In all large data sets whenever the appropriate 95 percent UCL exceeded the maximum concentration, the maximum concentration is selected as exposure point concentration for the RME case and the average concentration is selected for the CTE case.

For normally distributed data, the calculation of the UCL is a two-step process. First the standard deviation of the sample set must be determined, as follows:

$$S = \left[\frac{\sum(X_i - \bar{X})^2}{(n-1)} \right]^{1/2}$$

where: S = standard deviation
 X_i = individual sample value
 n = number of samples
 \bar{X} = mean sample value

The one-sided UCL on the mean is then calculated as follows:

$$UCL = \bar{X} + t \left(\frac{S}{n^{1/2}} \right)$$

where: UCL = 95 percent Upper confidence limit of the mean
 \bar{X} = Arithmetic average
 t = One-sided t distribution factor ($t_{0.95, n-1}$)
 S = standard deviation
 n = number of samples

For log-normally distributed data sets, the UCL is calculated using the following equation:

$$UCL = \exp \left(\bar{X} + 0.5s^2 + \frac{Hs}{(n-1)^{1/2}} \right)$$

where: UCL = 95 percent UCL of the mean
 exp = Constant (base of the natural log, e)
 \bar{X} = Mean of the transformed data
 s = Standard deviation of the transformed data
 H = H-statistic (from Gilbert, 1987; $H_{0.95}$)
 n = Number of samples

This equation uses individual sample results that have been transformed by taking the natural logarithm of the results.

Sample calculations for determining the distribution of a data set, UCL, and average and maximum plume concentrations are provided in Appendix F-6. After the UCL was calculated, it was compared to the maximum detected concentration within the data set; the smaller of the two was selected as the exposure point concentration for the RME case. Whenever the UCL exceeded the maximum, the average was selected as the exposure point concentration for the CTE case.

6.3 Toxicity Assessment

The toxicity assessment for the COPCs examines information concerning the potential human health effects of exposure to COPCs. The goal of the toxicity assessment is to provide, for each COPC, a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values presented in this section are integrated with the exposure assessment (Section 6.4) to characterize the potential for the occurrence of adverse health effects (Sections 6.5 and the site-specific sections).

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the data determines both the nature of the health effects associated with a particular chemical and the probability that a given quantity of a chemical could result in the referenced effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for the chemicals of potential concern.

The entire toxicological database is used to guide the derivation of cancer slope factors (CSFs) for carcinogenic effects and Reference Doses (RfDs) for noncarcinogenic effects. These data may include epidemiological studies, long-term animal bioassays, short-term tests, and evaluations of molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Because of the lack of available human studies,

however, the majority of toxicity data used to derive CSFs and RfDs comes from animal studies.

For noncarcinogenic effects, the most appropriate animal model (the species most biologically similar to the human) is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive species is chosen. The RfD is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern; in the absence of such data; however, a RfD for one route of exposure may be extrapolated from data from a study that evaluated a different route of exposure. Such extrapolation must take into account pharmacokinetic and toxicological differences between the routes of exposure. Uncertainty factors are applied to the highest no-observed-adverse-effect-level (NOAEL) to adjust for inter- and intraspecies variation, deficiencies in the toxicological database, and use of subchronic rather than chronic animal studies. Additional uncertainty factors may be applied to estimate a NOAEL from a lowest-observed-adverse-effect-level (LOAEL) if the key study failed to determine a NOAEL. When chemical-specific data are not sufficient, a RfD may be derived from data for a chemical with structural and toxicologic similarity.

CSFs for weight-of-evidence Group A or B chemicals are generally derived from positive cancer studies that adequately identify the target organ in the test animal data and characterize the dose-response relationship. CSFs are derived for Group C compounds for which the data are sufficient but are not derived for Group D or E chemicals. (An explanation/definition of these weight-of-evidence classes is provided in Section 6.3.1). No consideration is given to similarity in the animal and human target organ(s), because a chemical capable of inducing cancer in any animal tissue is considered potentially carcinogenic to humans. Preference is given to studies using the route of exposure of concern, in which normal physiologic function was not impaired, and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the CSF. When a number of studies of similar quality are available, the data may be combined in the derivation of the CSF.

Toxicological profiles for each of the major COPCs are presented in Appendix F-7. These profiles present a summary of the available literature on carcinogenic and noncarcinogenic effects associated with human exposure to the chemical. Brief summaries of the toxicity profiles for the major COPCs are presented in Section 6.3.3.

6.3.1 Carcinogenic Effects

The toxicity information considered in the assessment of potential carcinogenic risks includes a weight-of-evidence classification and a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of three groups in EPA's classification system to denote its potential for carcinogenic effects:

- Group A - known human carcinogen
- Group B1 or B2 - probable human carcinogen
- Group C - possible human carcinogen

Chemicals that cannot be classified as a human carcinogen because of a lack of data are placed in Group D, and those for which there is evidence of noncarcinogenicity in humans are in Group E.

The CSF is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing chemicals. It is defined as the upperbound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals and are typically calculated for compounds in Groups A, B1, and B2, however, some Group C carcinogens also have slope factors and some B2 carcinogens, such as lead, have none. Slope factors are specific to a chemical and route of exposure and are expressed in units of $(\text{mg}/\text{kg}/\text{day})^{-1}$ for oral routes. CSFs for COPCs at the Area III study area are presented in Table 6-3. The primary sources of information for these values are EPA Headquarters (EPA, 1997b and 1999a) and EPA Region III (EPA, 1999b).

EPA's database (IRIS - the Integrated Risk Information System) (EPA, 1999a) was consulted as the primary source for CSF values, as well as for RfDs. EPA intends that IRIS supersede all other sources of toxicity information for risk assessment. If values are not available in IRIS, the annual Health Effects Assessment Summary Tables (HEAST) (EPA, 1997b) are consulted, as well as the current EPA Region III Risk-Based Concentration table (EPA, 1999b). If no CSF is available from any of these sources, carcinogenic risks are not quantified and potential exposures are addressed in the general uncertainty section, Section 6.6.

CSFs exist for several (but not all) Class C compounds, which are identified as "possible" human carcinogens. These compounds typically exhibit inadequate evidence of carcinogenicity in humans and limited evidence in animals. In this human health risk assessment, Class C compounds are evaluated quantitatively as class A/B1/B2 compounds, but the risks associated with exposure to Class C compounds are also discussed separately if these chemicals are major risk drivers, underscoring the uncertainty associated with these estimations.

Dermal CSFs are derived from the corresponding oral values. In the derivation of a dermal CSF, the oral CSF is divided by the gastrointestinal absorption efficiency to determine a CSF based on an absorbed dose rather than an administered dose. The oral CSF is divided by the absorption efficiency because CSFs are expressed as reciprocal doses. Dermal CSFs and the absorption efficiencies used in their determination are also included in Table 6-3. Adjustments were made to the oral CSFs according to EPA guidance following Table 4.1, "Summary of Gastrointestinal Absorption Efficiencies and Recommendations for Adjustment of Oral Slope Factors for Specific Compounds" (EPA, 1998).

Risk estimates for PAHs have (in the past) assumed that all carcinogenic PAHs have a potency equal to that for benzo(a)pyrene. While benzo(a)pyrene was well studied, other Class B2 PAHs had insufficient data to calculate a CSF. EPA has published provisional guidance to assess PAHs (EPA, 1993). Estimated orders of potential potency (rather than a toxicity equivalence factor or TEF) were developed based on skin painting tests and are rounded to one significant figure (based on an order of magnitude). The values are based on a comparable endpoint (complete carcinogenesis after repeated exposure to mouse skin). The quality of the data does not support any greater precision. The orders of potential potency

used in this health risk assessment are presented in Table 6-4 and are those proposed for use by EPA Region I (EPA, 1994c).

EPA has determined that the oral CSF for benzo(a)pyrene is $7.3 \text{ (mg/kg/day)}^{-1}$. A provisional inhalation CSF of $3.1 \text{ (mg/kg/day)}^{-1}$ was presented by NCEA (EPA, 1999b).

In light of the following statements from the "Dermal Risk Assessment, Interim Guidance" (EPA, 6/19/97) oral CSFs and RfDs for PAHs were used and not adjusted (EPA, 1999b) to evaluate dermal risk from PAHs: "The statement in RAGS claiming that it is inappropriate to use the oral slope factor to evaluate the risks associated with exposure to carcinogens such as benzo(a)pyrene which causes skin cancer through direct action at the point of application should not be interpreted to mean that exposure to dermally active chemicals should not be evaluated. In fact, there is a significant body of evidence in the literature to generate a dose-response relationship for the PAH effects as a result of dermal application of PAHs to the skin surface. In addition, PAHs have also been shown to induce systemic toxicity and tumors at distant organs. For these reasons, the lack of dermal toxicity values may significantly underestimate the risk of exposure to PAHs in soil."

The toxicity and cancer risk characterization assessment for chlorinated dioxin and furan congeners is performed using TEF methodology (EPA, 1989e). The TEFs presented in Table 6-5 were used to convert concentrations of dioxin and furan congeners to individual TEQs of TCDD. The total amount of toxic dioxin and furan congeners present at a site is usually expressed as toxic equivalents (TEQ) of 2,3,7,8- tetrachlorodibenzodioxin (TCDD) present. The total TEQ of TCDD concentration is evaluated in the risk characterization to produce cancer risk estimates for exposures to chlorinated dioxin and furan congeners. Sample calculations of dioxin TEQs are presented in Appendix F-6.

The toxicity and cancer risk characterization of PCBs and dioxin-like PCB congeners was conducted according to guidance presented in the EPA technical guidance document entitled, "PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures" (EPA, 1996b). The guidance document suggests methodology for the risk evaluation of the total Aroclor concentration in an environmental media as well as the evaluation of exposure to the dioxin-like PCB congeners that may be present. The assessment methodology uses "low" to

“high risk” cancer slope factors for total Aroclors that reflect: 1) the influence on toxicity of PCBs by chemical transformation in the environment; 2) the tendency of PCBs to partition into various media; and 3) the potential for PCBs to biomagnify through the food chain. The assessment recommends a tiered approach for determining central tendency and high-end cancer slope factors for use in risk assessment. When PCB congener information is limited, the exposure pathway is used to indicate whether environmental processes have increased or decreased a PCB’s mixture potency. When PCB congener information is available, further refinement of the potency estimate can occur. Three categories of slope factors were developed based on the exposure pathway or, if more information is available, the PCB congener makeup of the mixture (Table 6-6A). A “high-risk” category is used for exposure pathways associated with environmental processes that tend to increase risk; a “low-risk” category for those that tend to decrease risk; and a “lowest risk” category for cases where congener or isomer analyses verifies the absence of congeners with more than four chlorines per molecule (establishing sufficient similarity of an environmental mixture to the least potent PCB Aroclor tested). Conservatively, the “high-risk” cancer slope factor was used in this baseline risk assessment to evaluate the Aroclor data because: 1) there is limited PCB congener data available (one to two samples per study area), and 2) the PCB congener data that is available suggests that “dioxin-like” PCBs are present in the environmental media. The PCB congener data available for each site were evaluated using the toxicity equivalent factors and cancer slope factors presented in Tables 6-6A and 6-6B. The results of the toxicity assessment and cancer risk characterization of the PCB congener data are presented and discussed in the uncertainty section for each study area because the limited amount of PCB congener data cannot be used to characterize the study areas as a whole.

The PCB cancer risk estimates presented in this assessment were based on total Aroclor concentrations. Total Aroclor concentrations were determined on a sample-specific basis by summing individual Aroclor concentrations; one-half the detection limit was used as a surrogate for non-detect results. In situations in which only one or two Aroclors are detected, the total Aroclor value may be strongly influenced by detection limits of non-detected Aroclors. For example, the only individual Aroclors detected in Area E surface water were Aroclors 1254 and 1268. The evaluation of risks due to total Aroclor concentrations in surface water in Area E results in risks that are influenced by one-half detection limit values for the other Aroclors. For this reason, risks due to Aroclors in Area E surface water may be overestimated.

6.3.2 Non-carcinogenic Effects

For noncarcinogens, it is assumed that there exists a dose below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For noncarcinogens, a range of exposure exists that can be tolerated. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a chemical above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to a Reference Dose (RfD). The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. A RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Separate RfDs are presented for ingestion and inhalation pathways.

To derive a RfD, EPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the no-observed-adverse-effect-level (NOAEL) or, if the data are inadequate for such a determination, the lowest-observed-adverse-effect-level (LOAEL). The NOAEL corresponds to the dose (in mg/kg/day) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect." To derive a RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for extrapolation of data from laboratory animals to humans (interspecies extrapolation), variation in human sensitivity to the toxic effects of a compound (intraspecies differences), derivation of a chronic RfD based on a subchronic rather than a chronic study, or derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 1 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is one.

A dermal RfD is developed by multiplying an oral RfD (based on an administered dose) by the gastrointestinal tract absorption factor. The resulting dermal RfD, based on an absorbed dose, is used to evaluate the dermal (absorbed) dose calculated by the dermal exposure algorithms.

Reference Doses for the COPCs at the Area III study area are presented in Table 6-7. The primary source of these values is the IRIS database, followed by other EPA sources described for the carcinogens. This table also includes the primary target organs affected by a particular chemical. This information may be used in the Risk Characterization section to segregate risks by target organ effects, unless the total Hazard Index is below unity.

As discussed above, PCB risk characterization is generally addressed by evaluation of total Aroclor concentrations. For non-carcinogenic risk, two PCB commercial mixes, Aroclor 1016 and Aroclor 1254, have oral reference doses (RfDs) available and a noncarcinogenic risk evaluation can be performed using these reference doses. The oral RfD for Aroclor 1016 is 7.00E-05 mg/kg/day and the oral RfD for Aroclor 1254 is 2.00E-05 mg/kg/day. Aroclor 1016 was not detected in Area E and represents a small portion of total Aroclors in Area D. Therefore, non-cancer risk estimates for total Aroclors using the oral RfD for Aroclor 1254 are presented in this assessment.

6.3.3 Toxicity Summaries for Major Chemicals of Concern

This section contains brief summaries of the toxicological profiles for the major COPCs. The detailed profiles are contained in Appendix F-7.

6.3.3.1 Polyaromatic Hydrocarbons (PAHs)

Benzo(a)pyrene is the most widely studied chemical in this class. It is used as the basis for defining the toxicity of other potentially carcinogenic PAHs. Benzo(a)pyrene is widely distributed in the tissues of treated rats and mice but is primarily found in tissues high in fat. While the carcinogenicity of complex mixtures containing PAHs (such as coal tar, coke oven emissions, and cigarette smoke) is suggested, the carcinogenicity cannot be attributed solely to PAHs. The carcinogenicity of benzo(a)pyrene is based largely on the results of animal

studies in which the animals were exposed to large doses of purified compound via atypical routes of exposure.

The noncarcinogenic PAHs appear to affect the liver, kidneys, and blood of exposed laboratory animals. Considered exposure routes include ingestion and inhalation, and exposure has resulted in anemia and mild liver lesions and occasionally renal disease. The effects vary for the individual compounds.

6.3.3.2 Lead

Unborn children and young children are particularly sensitive to the adverse effects of exposure to lead. Exposure to a fetus through its mother may cause premature births, lower birth weight, and decreased mental ability of the infant. Lead exposure is dangerous for young children because they absorb lead at a greater rate than adults, retain more of the lead they ingest, and are more sensitive to its effects. Effects include decreased intelligence and decreased growth.

Lead is efficiently absorbed by children. The fate of lead in the body depends in part on the amount and rate of previous exposures, the age of the receptor, and the rate of exposure. The principal effects of acute oral exposure are colic, anemia, and, in severe cases, acute encephalopathy (particularly in children). Long-term exposure may result in neurological and hematological effects. Some of the effects on the blood and subtle neurobehavioral changes in children occur at levels so low that they are considered non-threshold effects. Rat and mouse studies have shown increases in renal tumors, but the human studies have yielded inconclusive results that failed to account for the presence of other potentially carcinogenic materials. EPA has classified lead as a B2 carcinogen based on the results of animal studies.

6.3.3.3 Copper

A deficiency of copper, an essential element, may result in anemia, loss of pigment, reduced growth, and loss of arterial elasticity. However, persons who are overexposed may exhibit Wilson's disease (disorder of copper metabolism) or liver cirrhosis (Lappenbusch, 1988).

6.3.3.4 Barium

Increased blood pressure has been observed in experimental animals (rats) routinely exposed to barium in drinking water. Barium is also toxic to the nervous system, the muscular system, and gastrointestinal system when ingested at high concentrations. The soluble barium salts are more toxic than the insoluble barium salts (Clements Associates Inc., 1985). This is probably due to the fact that the soluble barium salts are more likely to be absorbed than the insoluble barium salts.

6.3.3.5 Polychlorinated Biphenyls (PCBs)

PCBs are a group of synthetic organic chemicals (polychlorinated biphenyls) including 209 individual compounds (known as congeners). Mixtures of PCBs, or Aroclors, were manufactured for use in industry until 1977. EPA considers PCBs to be a probable human carcinogen based on evidence of the ability of PCBs to cause cancer in animal studies. Data on humans exposed to PCBs suggest an association between PCB exposure and human cancer, but lack of data on exposure dose, length of exposure, types of PCBs and other chemicals people were exposed to, precludes identification of a cause and effect relationship based only on human studies. Studies in animals have also demonstrated immunological, reproductive, and neurological effects from PCB exposure. Studies in mice, monkeys, guinea pigs, and rabbits have shown PCBs to be immunosuppressive. Some PCB congeners are considered dioxin-like.

6.3.3.6 Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans

Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are chemically classified as halogenated aromatic hydrocarbons. The most widely studied of these compounds is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. This compound, often called simply dioxin, represents the reference compound for this class of compounds. Toxic Equivalency Factors (TEFs) are used to estimate the toxicity of other PCDDs and PCDFs that have the chlorine in the 2,3,7, and 8 position. These compounds have been widely publicized as the most potent man-made toxicants ever studied. Exposure to dioxin and related compounds is associated with subtle biochemical and biological changes and with chloracne, a serious skin

condition. Laboratory studies suggest the probability that exposure to dioxin-like compounds may be associated with other health effects including cancer. Dioxins have been demonstrated to be potent modulators of cellular growth and differentiation, particularly in epithelial tissues.

6.3.3.7 Asbestos

Asbestos is poorly absorbed from the gastrointestinal tract and therefore displays low acute oral toxicity. However, respiratory exposure leads to pulmonary fibrosis called asbestosis, which symptoms include breathlessness, chest pain, cough, decreased lung function, and cyanosis. Occupational exposures to asbestos have resulted in higher incidences of lung cancer, especially in combination with cigarette smoking; the latent period is 15 to 30 years. An additional effect of asbestos exposure is the development of pleural or peritoneal mesotheliomas; the latent period is 3.5 to 30.0 years. (Hodgson et al., 1988).

6.4 Exposure Assessment

The exposure assessment defines and evaluates the exposures experienced by a receptor population. In order to have an exposure, several factors must be present: first, there must be a source of contamination; second, there must be a mechanism through which a receptor can come into contact with the contaminants in that medium; and third, there must actually (or potentially) be a receptor present at the point of contact.

The exposure assessment presented in this section of the report consists of several sections that characterize the physical site setting and the receptors of concern, identify the potential contaminant migration and exposure pathways, define the contaminant concentrations at the point of exposure, and present the equations used to quantify exposure in terms of contaminant intake (dose). Appendix F-8 of this report contains sample calculations for the exposure assessment. Tables of intakes are not presented in the body of the report, but the calculated values may be seen within the site-specific spreadsheets in Appendix F-9 and Appendix F-10.

6.4.1 Exposure Setting

This section contains information on the land use and receptor characteristics in Area III study area.

Land/Water Use. The Area III study area was described in detail in Section 2.0 and is shown in Figure 1-2. Summarizing, the study area includes: a commercial/industrial property; Ferry Creek and other ecological areas (the delineated wetland boundaries along Ferry Creek) impacted by Raymark Facility waste; some delineated wetland boundary areas along the Housatonic River, such as those in the vicinity of the Beacon Point boat launch area and; Elm Street wetlands. Property within the Area III study area has been developed for commercial/industrial or recreational purposes or is undeveloped (wetlands). None of the property within the Area III study area has been developed for residential purposes. The physical conditions within much of the study area (wetlands) would limit or preclude residential development. However, residential areas do border part of the Area III study area.

The lower reach of Ferry Creek and the Housatonic River are used for recreational fishing and boating. Evaluation of biota is included in the RI for Area II study area.

Area specific land use and access information is presented in Sections 6.7 and 6.8.

Exposed Populations. The Area III study area is located in Stratford, Fairfield County, Connecticut. The principal industries within the community of Stratford include manufacturing of aircraft, air conditioning, brake linings, chemicals, plastic, paper, rubber goods, electrical and machine parts, and toys. There were 49,389 people reported on the 1990 census for the Town of Stratford. The Stratford Town Clerk reported this as a slight decrease from the last census in 1980. Potentially exposed populations within each section of the Area III study area are discussed in Sections 6.7 and 6.8.

6.4.2 Conceptual Site Model

This section discusses the general conceptual site model for the Area III study area. A conceptual site model facilitates consistent and comprehensive evaluation of the risks to

human and ecological health by creating a framework for identifying the paths by which human health may be impacted by contaminants predicted to exist at the source areas. A conceptual site model depicts the relationships between the elements necessary to construct a complete exposure pathway, as follows:

- Sources and potential COPCs
- Contaminant release mechanisms
- Contaminant transport pathways
- Exposure mechanisms and exposure routes
- Receptors

One simple conceptual site model was developed for the entire Area III study area to provide the basis for identifying the potential risks to human health and the environment. The model considers the current and future conditions within the study area and the actual or potential receptors who could come into contact with the COPCs.

The conceptual site model first considers the contaminant sources assumed to be available, either currently or in the future. The sources are Raymark Facility soil-waste migrating from the Raymark Facility or disposed within the study area, or the contaminated soils, wetland soils, and sediments within the study area. Contaminants may be released from these sources by mechanisms such as wind or water erosion or leaching to the subsurface. Once released from a source, contaminants are transported in media such as air, surface water, or groundwater. Receptors may be exposed either directly or indirectly to contaminants in environmental media via a variety of mechanisms. The exposure mechanisms considered include recreational activities and working outdoors. These exposure mechanisms generally act along one or more exposure routes such as ingestion, inhalation, or direct dermal contact.

The conceptual site model also indicates those exposure routes that are carried through the quantitative risk assessment for each receptor. An objective of the development of the conceptual site model is to focus attention on those pathways that contribute the most to the potential impacts on human health and the environment, and to provide the rationale for screening out other exposure pathways that are minor components of the overall risk.

6.4.2.1 Sources of Contamination

The Raymark Industries, Inc. (Raymark) facility, formerly named Raybestos - Manhattan Company, is located at 75 East Main Street in Stratford, Fairfield County, Connecticut. This facility occupied 33 acres and manufactured friction materials containing asbestos and non-asbestos materials, metals, phenol-formaldehyde resins, and various adhesives. Primary products were gasket material, sheet packing and friction materials including clutch facings, transmission plates, and brake linings. As a result of these activities, soils at the Raymark Facility have been contaminated primarily with asbestos, lead, and PCBs. The Raymark Industries, Inc. Facility underwent a source control remedial action (Operable Unit No. 1), in 1996 and 1997.

Raymark operated from 1919 until 1989, when the plant was shut down and permanently closed. During Raymark's 70 years of operation, it was common practice to dispose of manufacturing waste at locations in Stratford. A number of these "locations" were the subject of time-critical removal actions conducted by the EPA and its contractors. The removal actions excavated soil from those locations around town with the highest levels of asbestos, lead, and PCBs. Contaminants present in these areas were designated a health threat and have been excavated, covered, and/or fenced. Other "locations" were identified as contaminated with asbestos, lead, and PCBs, but were not excavated during the removal actions. Many of these locations have been re-sampled and are included in this Area III study area RI.

6.4.2.2 Contaminant Release and Migration Mechanisms

Chemicals were released from the former Raymark Facility and from properties within the Area III study areas by a variety of mechanisms including stormwater runoff and subsequent erosion of surface soil, infiltration of soluble chemicals, and subsequent migration through the subsurface soil to the water table where the chemicals may migrate downgradient, and via wind erosion of surface soil from unpaved areas (Section 5.1). The Raymark Facility has been capped, therefore the current transport mechanisms from the Raymark Facility are limited to only the groundwater that migrates below the cap.

Transport mechanisms associated with storm water run-off and subsequent erosion of surface soil and wind erosion are valid within the Area III study area. Storms generate runoff, which is directed toward stormwater drainage-ways. Initially, this water may move across an area as sheet flow, which can entrain loose soil material. This soil is moved as a sediment and will be deposited where the flow velocity diminishes below that needed to carry a particular grain size. Typically in undeveloped areas, this soil/sediment is deposited in small drainage-ways and migrates farther downstream with each new storm, which also adds new material. Within the Area III study areas, contaminants entrained in/dissolved in surface water have migrated to Ferry Creek and bordering wetland areas.

Soluble chemicals released to the ground surface may also migrate downward through the soil column with infiltrating precipitation. The migration of these chemicals may be somewhat impeded by the chemical's tendency to bind to soil organic material. Eventually, these soluble chemicals may reach the water table. Once in the groundwater, chemicals may continue to migrate via dispersion and advection in the downgradient direction. Eventually, these chemicals may discharge with the groundwater to surface bodies such as Ferry Creek, Selby Pond, and wetlands.

Chemicals adsorbed to surface soil may also be released from a site via wind erosion of loose soil material. These particulates are carried downwind and potentially off site if the grain size is small enough and the wind velocity is great enough. Additionally, chemicals may also be released from soil via volatilization.

6.4.3 Potential Routes of Exposure

A receptor can come into contact with contaminants in a variety of ways, which are generally the result of interactions between a receptor's behavior or lifestyle and an exposure medium. This assessment defines an exposure route as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.