

APPENDIX B-3
DEVELOPMENT OF HUMAN HEALTH
PRELIMINARY REMEDIATION GOALS

APPENDIX B-3

HUMAN HEALTH PRELIMINARY REMEDIATION GOALS

This appendix documents the calculation of Human Health Risk-Based Preliminary Remediation Goals (PRGs) presented in Section 2 of this Feasibility Study. It includes: (1) a summary of and rationale for selecting the location/receptor/exposure pathway combinations that form the basis of PRGs; (2) the rationale for choosing which contaminants of concern (COCs) require PRGs; (3) the methods used to calculate PRGs; and (4) the results of these calculations.

B-3.1. Location/Receptor/Exposure Pathway Combinations That Form the Basis of PRGs

Table B-3.1 lists the location/receptor/exposure pathway combinations associated with:

- A cumulative incremental lifetime cancer risk (ILCR) greater than 10^{-4} ;
- A cumulative target organ-specific hazard index greater than 1;
- A greater than 5% probability of exceeding a blood lead concentration benchmark; or
- Exposure to elevated pH conditions in groundwater or surface water.

These combinations were derived from the July 27, 2007 draft Baseline Human Health Risk Assessment (BHHRA; See Appendices M and N, RAGS Part D Table 10 series) defined by USEPA Region 1 as those with potentially actionable risk (total receptor cancer risks greater than 10^{-4} and/or target organ hazards greater than 1). The last four entries in Table B-3.1 are not potentially actionable for the risk management reasons provided in the last column of the table. In addition, naphthalene, which appears on Table 10.7.RME in Appendix M of the BHHRA for a future resident at Lot 208/Lot 209 with a hazard index of 2, is not included as a COC on Table B-3.1. As part of risk management, the inhalation dose of naphthalene, estimated as 100% of the ingestion dose in the BHHRA, is likely to be lower for naphthalene resulting in a hazard index of 1 or less for this exposure point.

In January 2008, EPA completed a BHHRA addendum to include risks associated with asbestos in soil at the site, based on site-specific activity-based air sampling for a lawn mowing scenario. The BHHRA addendum is presented in Appendix B-1. The risks and hazards estimated in the July 2007 BHHRA for soil contaminants of potential concern (COPCs) were summed to the asbestos inhalation risks to determine whether the location/receptor/exposure pathways associated with actionable human health risk, as specified in Table B-3.1, remained unchanged. As described in the BHHRA addendum, the West of South Street On-Facility area was additionally identified as associated with risks greater than 10^{-4} for a residential scenario based on cumulative exposure to soil COPCs, including asbestos. Table B-3.2 provides a summary of the location/receptor/exposure pathways with actionable human health risk based on the combined results of the July 2007 BHHRA and January 2008 BHHRA addendum.

For the most part, PRGs were calculated for the specific location/receptor/exposure pathway combinations listed in Table B-3.2. However, those involving future residential use of the East of South Street On-Facility, West of South Street On-Facility, and Old Railroad and Former Lower Mill Pond areas do not represent possible future uses of these areas as discussed below in Section B-3.3.3. Therefore, PRGs for these areas were calculated, as applicable, based on the

most highly exposed non-residential scenario for current and possible future uses of these areas (i.e., a daycare child and site worker).

B-3.2. Chemicals of Concern that Require Calculation of PRGs

PRGs were calculated for COCs associated with each location/receptor/exposure pathway combination that are:

- Carcinogenic compounds that contribute an ILCR greater than 10^{-6} to a cumulative ILCR greater than 10^{-4} ; or
- Noncarcinogenic compounds that individually contribute hazard quotients (HQs) greater than 1 when target organ hazards also exceed 1.

Even though asbestos in soil is associated with a risk in excess of 10^{-6} , no risk-based PRG has been developed for asbestos-containing soil. A site-specific BHHRA addendum evaluating asbestos in soil is included in Appendix B-1, performed using activity-based sampling data (raking and mowing) gathered from on-site areas where asbestos soil concentrations were less than the soil detection limit. Asbestos structures were not detected in air samples collected from personal monitors during the raking activity, assumed to be representative of exposures during low intensity site-wide activities such as walking and jogging. For the mowing activity, the arithmetic mean asbestos air concentration was assumed to be representative of exposures during high intensity human activities occurring across the site (e.g., landscaping, gardening, bike riding, and excavation). Using the mean asbestos air concentration during mowing, the BHHRA addendum concluded that asbestos soil concentrations at less than the detection limit are associated with inhalation risks ranging from 2×10^{-6} to 3×10^{-5} during high intensity activities for the four receptors evaluated (trespassers, construction workers, site workers, and residents). Because the asbestos risk is less than 10^{-4} and associated with non-detect concentrations in soil, PRGs have not been developed for asbestos due to the infeasibility of cleanup below the soil detection limit. Instead, PRGs for other soil COCs have been established such that residual risk associated with soil exposures, including that for asbestos, will be less than 10^{-4} . Locations where asbestos in soil was detected above the detection limit of 1% will be targeted for action during this Feasibility Study.

B-3.3. Selection of Exposure Scenarios That Should Be the Basis of PRG Calculations

Medium-specific PRG development is discussed in the following sections for surface water, groundwater, and soil. Groundwater PRGs are applicable to the area outside the contaminated media compliance boundary and are designed to meet remedial action objectives (RAOs) for off-site groundwater and protect the surface water in the tailrace. For soil, PRGs were calculated for the current and reasonably anticipated future exposure scenarios with the highest possible exposure potential, as described in Section B-3.3.3.

B-3.3.1 Surface Water

There is no current guidance on how to evaluate human health risk from exposure to high or low pH in surface water. However, elevated pH is listed as a COC for surface water in Table B-3.2

because surface water concentrations evaluated in the BHHRA exceeded surface water screening criteria. For pH in surface water, the PRG has been set at the pH criterion for Class B waters in Massachusetts in 314 CMR 4; specifically a range between 6.5 and 8.3 in order to protect the designated uses, including but not limited to protection of aquatic species and contact and non-contact recreation.

B-3.3.2 Groundwater

Groundwater PRG development is documented in Table B-3.3. Groundwater COCs were identified as described above (compounds contributing to greater than a 10^{-6} cancer risk or HQ greater than 1). Two additional compounds that did not meet these risk criteria were identified as COCs (toluene and styrene) because their maximum detected concentrations exceeded their respective MCL, identified as ARARs for the site. For each of these COCs, risk-based values were calculated corresponding to target ILCRs of 10^{-6} , 10^{-5} , and 10^{-4} and a target HQ of 1, as applicable, using the same assumptions and formulas as presented in the BHHRA. Table B-3.3 includes the exposure point concentration (EPC) used in the BHHRA for each COC along with the calculated risk or hazard at the EPC, from which groundwater concentrations corresponding to the target ILCRs and target HQ are back-calculated. In addition, ARARs and lifetime health advisories were identified for each COC along with feasible analytical detection limits. These values are also presented in Table B-3.3.

For compounds with available MCLs, the MCL was identified as the PRG. In the absence of MCLs, risk-based values, lifetime health advisories, or analytical detection limits were selected as PRGs. Table B-3.3 documents the selected PRGs and provides documentation for the basis of each value (i.e., MCL, HQ of 1, ILCR of 10^{-6} or 10^{-5} , lifetime health advisory, or analytical detection limit). The 2007 BHHRA evaluated the inhalation exposure pathway for volatile components released during household water use by assuming that the inhalation dose was equal to the ingestion dose. To better estimate the inhalation pathway for PRG development, refinement of the inhalation pathway for naphthalene and 2-methylnaphthalene was performed based on Equation 2 provided in USEPA, 1991. This equation estimates the inhalation dose received during whole house water usage through the use of a volatilization factor (Andelman, 1990). Revised inhalation hazards for naphthalene and 2-methylnaphthalene are presented in Table 6 of Attachment 1. The PRGs resulting from use of this equation for naphthalene and 2-methylnaphthalene and the ingestion and dermal contact hazards calculated in the 2007 BHHA are presented in Table B-3.3.

Manganese does not have a federal or state MCL, yet it does have a federally-established health advisory. The health advisory concentration was considered as the basis for the groundwater PRG of 300 $\mu\text{g/L}$. It is possible that naturally-occurring levels of manganese in the aquifer may be in excess of the health advisory for manganese (300 $\mu\text{g/L}$). Therefore, as part of remedial design, naturally-occurring levels of manganese in the aquifer will be further investigated. In the event that naturally-occurring levels are determined to exceed the health advisory, consideration will be given to the naturally-occurring concentrations of manganese in the aquifer in identifying an appropriate higher groundwater cleanup level.

Elevated pH is also listed as a groundwater COC in Table B-3.2, but there is no current guidance on how to evaluate human health risk from exposure to high or low pH. A secondary drinking water standard (SMCL) has been set for pH (6.5 - 8.5 s.u.). This SMCL has been used as the PRG for pH in groundwater, as presented in Table B-3.3. Because elevated pH conditions are the concern at this site, the PRG is stated as <8.5.

B-3.3.3 Soil

Actionable risk was quantified for residential Lot 33-257 and non-residential areas in the Town of Walpole's Limited Manufacturing zoning district (i.e., the East of South Street On-Facility area, the West of South Street On-Facility area, and the Old Railroad and Former Lower Mill Pond area). Soil PRGs are shown in Tables B-3.4.

B-3.3.3.1 Lot 33-257

Lead requires a PRG at Lot 33-257, where current and future residential use is associated with a greater than 5% probability of a child's blood lead concentration exceeding 10 µg/dL. In the BHHRA, a 400 mg/kg risk-based concentration of lead in soil was calculated using the IEUBK model for protection of a young child resident (see Tables 42 and I1.6b in the BHHRA). This value and the method used to calculate the lead PRG are consistent with USEPA guidance (USEPA Region 1 November 1996 Risk Update; USEPA 2003 "Superfund Lead-Contaminated Residential Sites Handbook," OSWER 9285.7-50). Actionable risk also was quantified for a future construction worker on this lot using USEPA's TRW model; however, the value protective of the young child resident (400 mg/kg), as the most sensitive receptor, is selected as the lead PRG for Lot 33-257.

B-3.3.3.2 East of South Street On-Facility, West of South Street On-Facility, and Old Railroad/Formal Lower Mill Pond Areas

COCs that require PRGs at the East of South Street On-Facility, West of South Street On-Facility, and Old Railroad and Former Lower Mill Pond areas are arsenic and the subset of carcinogenic PAHs (cPAHs) listed for these three areas in Table B-3.2 (i.e., benzo(a)anthracene, benzo(b)fluoranthene, dibenz(ah)anthracene, indeno(1,2,3-cd)pyrene, and benzo(a)pyrene). In addition, TCE requires a PRG for the "SB-09 area" of the East of South Street On-Facility area.

These three areas are within Walpole's Limited Manufacturing (LM) zoning district; therefore, current and possible future exposure scenarios include: the site worker, construction worker, and trespasser evaluated in the BHHRA, and other possible future uses allowed in the LM zoning district, such as a municipal or commercial worker, groundskeepers engaged in landscaping activities, and children attending libraries, schools, and daycare facilities. Unrestricted future residential use is not considered to be a possible future use in the Limited Manufacturing zoning district, and will be restricted through the use of an institutional control.

PRGs could be calculated for a variety of these current and possible future exposure scenarios. To simplify the calculations, the most conservative PRGs were developed for the receptors considered to be having the most exposure at the site. One adult exposure scenario and one child

exposure scenario were selected from among those considered to be reasonable that result in the lowest PRG values: the current/future site worker and the future young child attending daycare. The site worker and child in daycare can be exposed to COCs in soil via direct contact (i.e., dermal contact and incidental ingestion) and indirect contact (i.e., inhalation of COCs that migrate from soil to indoor or outdoor air).

Rationale for Selection of the Daycare Child Scenario for the East of South Street On-Facility, West of South Street On-Facility, and Old Railroad/Former Lower Mill Pond Areas

For a given scenario, the noncancer-based PRGs tend to decrease as the age of the receptor decreases. The young child in daycare represents the youngest age group among current and possible future exposure scenarios and was therefore selected for PRG calculations. The soil PRG calculations for the young child in daycare assume exposure to COCs via direct contact (i.e., dermal contact and incidental ingestion) and indirect contact (i.e., inhalation of COCs that migrate from soil to outdoor or indoor air). Because this exposure scenario was not included in the BHHRA, exposure assumptions were selected for the young child in daycare.

For direct contact with soil, the exposure assumptions used in the BHHRA for a young child resident were adopted. This means the daycare child is assumed to play outside 150 days/year, or 5 days of the week in fair weather months (April-October). An exposure frequency of 250 days/year was assumed, which is the exposure frequency for an adult worker, and presumably the number of days for which daycare would be needed. For indirect contact with soil from vapor migration of TCE into indoor air, the daily exposure time was reduced from 24 hours per day for a resident to 8 hours per day for a young child in daycare (See USEPA, 2006a and Attachment 1). For asbestos exposures via inhalation of fugitive dusts, the daycare child was assumed to be exposed 22 days/year during the following high intensity activities: mowing (2 hours/day), landscaping (2 hours/day), and biking (1 hour/day). This exposure assumes that the child is in the care of the adult performing an activity that could cause asbestos in soil to release into air, hence leading to both the child and the adult inhaling asbestos fibers in air. For the remaining 3 hours on-site on those days when high intensity activities occur, the child in daycare was assumed to be exposed to background asbestos air concentrations present at the site. For the additional 228 days/year on-site when high intensity activities do not occur, exposure to background asbestos concentrations, 8 hours/day, was assumed. The unit risk used for the asbestos risk calculation was selected for a 5 year exposure duration, with exposure beginning at birth and ending at age 5.

Actionable Risk Associated with the Daycare Child Scenario

The daycare child scenario was not evaluated in the BHHRA or BHHRA addendum, and therefore, was not considered when developing Table B-3.2. However, had this scenario been included, actionable risk would have been quantified for a future child attending daycare at the East of South Street On-Facility and Old Railroad/Former Lower Mill Pond areas because:

1. The daycare child's direct contact exposure with soil is assumed to be identical to that of the child resident; and

2. ILCR estimates for the child resident from direct contact with soil in these two areas exceed 10^{-4} (See Table N.2.5 of the BHHRA).

Tables 1 and 2 in Attachment 1 document the risks and hazards for the future child attending daycare at the East of South Street On-Facility and Old Railroad/Former Lower Mill Pond areas, respectively. TCE is associated with actionable risk for the soil to indoor air pathway for the daycare child only at the “SB-09 area” of the East of South Street On-Facility area.

For the West of South Street On-Facility area, actionable risk would not have been quantified for a future child attending daycare. Table 3 in Attachment 1 presents the risk and hazard calculation for the future child attending daycare at the West of South Street On-Facility area, including asbestos. Because the cumulative ILCR is below 10^{-4} and target organ HIs are less than 1 for the daycare scenario, PRGs have not been developed for the West of South Street On-Facility area in the FS.

Rationale for Selection of Site Worker Scenario for the East of South Street On-Facility and Old Railroad/Former Mill Pond Areas

The most highly exposed adult worker scenario with respect to soil exposure is not as immediately apparent as the most highly exposed child scenario. Two examples of relatively highly exposed adult worker scenarios are a site worker and groundskeeper, which differ with respect to the intensity and frequency of exposure. Neither of these workers have exposures equivalent to construction workers.

Table 4 in Attachment 1 lists exposure assumptions used for the site worker in the BHHRA and exposure assumptions applicable for a groundskeeper. In the BHHRA, the site worker is assumed to be an outdoor worker who spends most of the workday conducting maintenance activities outdoors such as moderate digging and landscaping, and who inadvertently ingests 100 mg of soil each day (See BHHRA, Appendix G, Table 4.1RME).

For the groundskeeper, an exposure frequency of 60 days/year was selected as reasonable for the size of the parcels at the site. The ingestion rate of 100 mg/day was chosen for the groundskeeper because the groundskeeper’s activity was assumed to be primarily lawn maintenance and some gardening. Therefore, the USEPA-recommended soil ingestion rates for adults were used.

Table 4 in Attachment 1 also includes the corresponding dose equations and example dose calculations at the bottom of the table, which show the somewhat higher exposure for the site worker. Even if a higher ingestion rate of 200 mg/day is assumed for the groundskeeper, the site worker’s exposure to soil would still be higher than the groundskeeper’s exposure (i.e., $3.9E-07$ mg/kg-d for the site worker versus $1.9E-07$ mg/kg-d for the groundskeeper).

Actionable Risk Associated with the Site Worker Scenario

Current and future non-residential uses of the East of South Street On-Facility area were not associated with actionable risk from soil in the BHHRA, except for a future site worker exposed

to TCE migrating to indoor air in the SB-09 area. Current uses of the Old Railroad and Former Lower Mill Pond area were not associated with actionable risk. However, only construction worker and resident scenarios were evaluated for future use of this area. The RME future resident HI and ILCR from exposure to soil via ingestion and dermal contact were 0.2 and 7E-05, respectively (See BHHRA, Appendix K, Table 7.39 Adult RME). This ILCR does not include an early life evaluation of PAHs, which is not applicable to a site worker. A future site worker would be slightly more exposed to soil than the future adult resident, with all exposure assumptions the same except for exposure duration (resident = 24 years; site worker = 25 years), skin surface area available for contact (resident = 5,700 cm²; site worker = 3,300 cm²), and dermal adherence (resident = 0.07, site worker = 0.2) (See BHHRA Appendix G, Table 4.2.RME). Therefore, risk estimates for a future site worker at the Old Railroad and Former Lower Mill Pond area would be slightly higher than risk estimates for a future resident in this area, but would not rise to actionable levels (i.e., ILCR = 8E-05 and a total HI < 1; see Attachment 1, Table 5). The addition of asbestos risk for the site worker (ILCR = 4E-06) to the cumulative risk presented in Attachment 1, Table 5, would result in a total receptor ILCR of 9E-05. Therefore, no actionable risk from direct contact with soil for the site worker exists at the Old Railroad and Former Lower Mill Pond Area.

Because cPAHs and arsenic are not associated with actionable risk for a current or future site worker, PRGs for these COCs are not calculated for a site worker. However, actionable risk was identified for a site worker inhaling TCE migrating from soil to indoor air at the East of South Street On-Facility “SB-09 area;” therefore, a TCE PRG is calculated for the site worker in this area. Risk-based PRGs are also calculated for the child attending daycare based on both direct contact with soils containing TCE and the inhalation of TCE migrating from soil to indoor air.

Calculation of Soil PRGs

Except where otherwise noted in Section B-3.3.3, the same exposure assumptions, toxicity values, and risk equations were used as those in the BHHRA to calculate PRGs. PRGs for the carcinogenic PAHs for the daycare child were calculated in accordance with applicable USEPA guidance regarding early life exposure evaluations (USEPA, 2005; USEPA, 2006b). For each soil COC, risk-based values were calculated corresponding to target ILCRs of 10⁻⁶, 10⁻⁵, and 10⁻⁴ and a target HQ of 1, as applicable. Table B-3.4 includes the exposure point concentration (EPC) used in the BHHRA for each COC along with the calculated risk or hazard at the EPC, from which soil concentrations corresponding to the target ILCRs and target HQ can be back-calculated. In addition, Massachusetts background concentrations for native soils and for soils containing coal ash were identified for each COC along with feasible analytical detection limits. For TCE, two PRGs were calculated for the daycare child; one applicable to direct contact exposures and the second applicable to inhalation of indoor air. However, because the site worker PRG for the inhalation of TCE in indoor air is lower than those calculated for the child in daycare (0.065 mg/kg for the site worker vs. 0.097 mg/kg for the daycare child), the site worker PRG for TCE (0.065 mg/kg) is selected as the most conservative value. Table B-3.4 presents the PRGs and provides documentation for the basis of each value (i.e., HQ of 1, ILCR of 10⁻⁶ or 10⁻⁵, background, analytical detection limit).

Because a risk-based PRG has not been established for asbestos in soil, cumulative risk at the soil PRGs was summed to the asbestos soil risk for the child attending daycare to determine the magnitude of the residual soil risk once the action is completed. The cumulative risk at the PRGs summed to the asbestos soil risk is presented in Table B-3.5. As shown in this table, the cumulative risk at the selected soil PRGs, summed to the asbestos risk, does not exceed the EPA risk range of 10^{-6} to 10^{-4} . Therefore, the selected soil PRGs are protective of exposures for the most sensitive receptor for locations where asbestos is present in soil at non-detect levels and therefore, not identified for remedial action.

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TABLE B-3.1
Potentially Actionable Human Health Risks - 2007 BHHRA

Blackburn & Union Privileges Superfund Site
Walpole, Massachusetts

Location	Receptor	Medium	COC contributing an ILCR >1E-06 to a cumulative ILCR >1E-04, contributing an HQ >1 to a target organ-specific HI>1, PBL >5%, or elevated pH	Exposure Route	RME ILCR	Max RME Target Organ-Specific HI	PBL	Elevated pH	COC (ILCR <1E-06, HI <1, PBL <5%, but EPC > MCL) ⁽¹⁾	Rationale for Exclusion from Further Consideration
Residential Scenarios										
Lot 33-257	Current Resident	Soil	lead	ingestion	<1E-04	<1	13.40%	No	NA	
East of South Street On-Facility	Future Resident (see note 2)	Soil	trichloroethene; benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(ah)anthracene; indeno(1,2,3-cd)pyrene; arsenic	ingestion and dermal contact	1.E-03	<1	<5%	No	NA	
		Indoor air from soil vapor (SB-09 area)	trichloroethene	inhalation	6E-04	<1	- ⁽³⁾	- ⁽⁴⁾	NA	
Old Railroad and Former Lower Mill Pond Area	Future Resident (see note 2)	Soil	benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(ah)anthracene; indeno(1,2,3-cd)pyrene; arsenic	ingestion and dermal contact	5.E-04	2	<5%	No	NA	
Off-Facility groundwater Lot 208 / Lot 209	Future Resident (see note 2)	Tap water from groundwater	benzene; benzo(a)pyrene; dibenz(ah)anthracene; arsenic; manganese; vanadium; lead; pH	ingestion and dermal contact	2.E-03	20	8.08%	Yes	no COCs for which this is true	
On-Site Groundwater	Future Resident (see note 2)	Tap water from groundwater	methylene chloride; trichloroethene; benz(a)anthracene; benzo(b)fluoranthene; dibenz(ah)anthracene; indeno(1,2,3-cd)pyrene; bis(2-ethylhexyl)phthalate; carbazole; benzene; 2-methylnaphthalene; naphthalene; benzo(a)pyrene; 4-methylphenol; antimony; arsenic; chromium; manganese; nickel; vanadium; zinc; pH	ingestion and dermal contact	2.E-02	200	<5%	Yes	lead, styrene	
		Vapor from use of groundwater as tap water	ethylbenzene; trichloroethene; benzene; 2-methylnaphthalene; naphthalene	inhalation	3.E-04	200	- ⁽³⁾	- ⁽⁴⁾		
Construction Worker Scenarios										
Lot 33-257	Future Construction Worker	Soil	lead	ingestion	<1E-04	<1	6.50%	No	NA	
West of South Street On-Facility	Future Construction Worker	Dermal contact with groundwater	pH	dermal contact	<1E-04	<1	<5%	Yes	NA	
Off-facility groundwater Lot 208 / Lot 209	Future Construction Worker	Dermal contact with groundwater	pH	dermal contact	<1E-04	<1	<5%	Yes	NA	
Wader Scenarios										
Former Mill Tailrace	Current/Future Wader	Surface water	pH	dermal contact	<1E-04	<1	<5%	Yes	NA	
Site Worker Scenarios										
East of South Street on-Facility	Future Site Worker	Indoor air from soil vapor (SB-09 area)	trichloroethene	inhalation	2E-04	<1	- ⁽³⁾	- ⁽⁴⁾	NA	
Asbestos Scenarios										
Soil	All	Inhalation of asbestos fibers from soil having concentrations greater than or equal to 1%	asbestos	inhalation	Not evaluated in BHHRA	Not evaluated in BHHRA	-	-	NA	
Sediment	All	Inhalation of asbestos fibers from sediment having concentrations greater than or equal to 1%	asbestos	inhalation	Not evaluated in BHHRA	Not evaluated in BHHRA	-	-	NA	

**TABLE B-3.1
Potentially Actionable Human Health Risks - 2007 BHHRA**

**Blackburn & Union Privileges Superfund Site
Walpole, Massachusetts**

Location	Receptor	Medium	COC contributing an ILCR >1E-06 to a cumulative ILCR >1E-04, contributing an HQ >1 to a target organ-specific HI>1, PBL >5%, or elevated pH	Exposure Route	RME ILCR	Max RME Target Organ-Specific HI	PBL	Elevated pH	COC (ILCR <1E-06, HI <1, PBL <5%, but EPC > MCL) ⁽¹⁾	Rationale for Exclusion from Further Consideration
Scenarios That Will Not Be Considered Further in the Feasibility Study										
West of South Street On-Facility	Future Resident (see note 2)	Soil	arsenic & PAHs	ingestion and dermal contact	1E-04	<1	<5%	No	NA	As a result of the uncertainty in the home garden pathway for arsenic, the uncertainty in the early life evaluation of PAHs, as well as the generally low COC concentrations on this parcel (arsenic EPC = 9.5 mg/kg; PAH EPCs range from 0.5-4 mg/kg), the RME cumulative ILCR of 2E-4 for West of South Street On-Facility was not actionable. If the home garden pathway was not included (but early life evaluation of PAHs retained), the ILCR from direct contact (ingestion & dermal contact) with arsenic in soil is 1E-04. Uncertainty in the home garden pathway is due to the use of screening-level bioconcentration factors (BCFs), with unknown relevance to Site conditions, to predict COC concentrations in plant tissue. BCFs were selected from USEPA's Soil Screening Guidance (USEPA, 1996), and for COCs without a USEPA BCF, from MADEP's (2001) document in support of Proposed MCP Numerical Standards.
		Plant tissue from Soil	none	ingestion of plant tissue	<1E-04	<1	- ⁽³⁾	- ⁽⁴⁾	NA	
Old Railroad and Former Lower Mill Pond Area	Future Resident (see note 2)	Plant tissue from Soil	arsenic	ingestion of plant tissue	3.E-04	2	- ⁽³⁾	- ⁽⁴⁾	NA	As discussed in the note above for the West of South Street On-Facility area, the ILCR and non-cancer hazard index for arsenic via the home garden pathway are uncertain because they are based on a non-site-specific BCF for arsenic from USEPA's soil screening guidance. Therefore, preliminary remediation goals (PRGs) for soil in the Old Railroad and Former Lower Mill Pond area will not incorporate the garden exposure pathway given the uncertainty associated with doing so.
Off-site groundwater east of Neponset River (SH-27)	Future Resident (see note 2)	Tap Water from Groundwater	trichloroethene; manganese	ingestion	<1E-04	2	<5%	No	no COCs for which this is true	While the concentrations of TCE and manganese in groundwater from the 2003 sampling round suggest potentially actionable risk in this exposure area, these potential risks will not be further evaluated in the FS for the following reasons: 1. This potential risk is based on only one sampling round (e.g., the 2003 sampling round). If data from the more recent 2006 sampling round were used to calculate potentially actionable risk, TCE and manganese would not present actionable risk as defined in this table. 2. TCE was detected in only one groundwater sample (concentration of 5.1 µg/L) in one of the wells (SH-27R during the 2003 sampling round) at a concentration slightly above the MCL for TCE of 5 µg/L. Concentrations of TCE were below the MCL in groundwater samples collected from wells SH-27S, SH-27D, and SH-27R in the 2006 sampling round. 3. Manganese was detected in two groundwater samples from this area during the 2003 sampling round at concentrations above the federal lifetime health advisory level of 300 µg/L (420 µg/L in well SH-27R, and 320 µg/L in well SH-27S). Concentrations of manganese were below the federal lifetime health advisory level in the groundwater samples collected from wells SH-27S, SH-27D, and SH-27R in the 2006 sampling round.
Off-site groundwater east of Neponset River (SH-28)	Future Resident (see note 2)	Tap water from Groundwater	manganese	ingestion	<1E-04	3	<5%	No	no COCs for which this is true	While the concentrations of manganese in groundwater from the 2003 sampling round suggest potentially actionable risk in this exposure area, this potential risk will not be further evaluated in the FS for the following reasons. 1. This potential risk is based on only one sampling round (e.g., the 2003 sampling round). If data from the more recent 2006 sampling round were used to calculate potentially actionable risk, manganese would not present actionable risk as defined in this table. 2. Manganese was detected in only one groundwater sample (760 µg/L) in one of the wells (SH-28S during the 2003 sampling round) at a concentration above the federal lifetime health advisory level of 300 µg/L. Concentrations of manganese were below the federal lifetime health advisory level in the groundwater samples collected from wells SH-28S, SH-28D, and SH-28R in the 2006 sampling round.

Notes:

- Contaminants of Concern (COCs) in this column are not associated with the levels of risk defined in column 4, but have Exposure Point Concentrations (EPCs) that are greater than Maximum Contaminant Levels (MCLs). "NA" means that a comparison to MCLs is not relevant for the receptor/medium combination. "No COCs for which this is true" means that the receptor/medium meets the first three criteria in the column header (i.e. ILCR < 1E-6, HI < 1, and PBL < 5%) and does not have any COCs with EPCs that are greater than MCLs.
- Unrestricted future residential use is not considered a reasonably anticipated future use in these areas of the Site due to the current zoning by-laws. Under current zoning, the most sensitive possible future Site receptor for soil exposure pathways is a child at a daycare facility. A future daycare facility was not considered as part of the Baseline Human Health Risk Assessment (BHHRA), and the potential risks associated with future residential use are likely higher than those associated with a daycare facility. Therefore, the development of human health risk based PRGs for use in the evaluation of remedial alternatives for the Feasibility Study (FS) are based on a daycare facility scenario, and not unrestricted residential use.
- Exposures to lead for this receptor/medium combination were not quantified in the BHHRA.
- pH is not a COC for the inhalation pathway or garden pathway.
- ILCR - Incremental Lifetime Cancer Risk
- Following standard approaches used for human health risk assessments completed under the Comprehensive Environmental Response and Liability Act (CERCLA), the BHHRA evaluated baseline potential risks only. The BHHRA did not draw conclusions about whether COCs are present in the environment because of site-related activities, or whether they represent a background condition unrelated to the site. Additionally, the BHHRA did not draw conclusions about whether chemicals are elevated in the environment over concentrations that may be expected to be naturally occurring, or whether a potential risk is of sufficient magnitude to warrant remedial action. In circumstances where potential risks exceeded the criteria described in note 7 below, rationale for exclusion of these risk from further consideration in the FS is provided in the "Rationale for Exclusion from Further Consideration" column of this table.
- COCs were identified that contribute an ILCR greater than 1E-6 to a cumulative ILCR of 1E-4; a non-cancer HI greater than 1 to a target organ-specific HI greater than 1; a PBL greater than 5%; an elevated pH to groundwater or surface water; those groundwater analytes that exceed their respective USEPA MCLs; or soils or sediment with asbestos concentrations greater than 1%.

TABLE B-3.2
Potentially Actionable Human Health Risks - 2007 BHHRA and 2008 BHHRA Addendum

Blackburn Union Privileges Superfund Site
Walpole, Massachusetts

Location	Receptor	Medium	COC contributing an ILCR >1E-06 to a cumulative ILCR >1E-04, contributing an HQ >1 to a target organ-specific HI>1, PBL >5%, or elevated pH	Exposure Route	RME ILCR	Max RME Target Organ-Specific HI	PBL	Elevated pH	COC (ILCR <1E-06, HI <1, PBL <5%, but EPC > MCL) ⁽¹⁾
Residential Scenarios									
Lot 33-257	Current Resident	Soil	lead	ingestion	<1E-04	<1	13.40%	No	NA
East of South Street On-Facility	Future Resident (see note 2)	Soil	trichloroethene; benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(ah)anthracene; indeno(1,2,3-cd)pyrene; arsenic; asbestos	ingestion; dermal contact; inhalation	1.E-03	<1	<5%	No	NA
		Indoor air from soil vapor (SB-09 area)	trichloroethene	inhalation	6E-04	<1	- ⁽³⁾	- ⁽⁴⁾	NA
Old Railroad and Former Lower Mill Pond Area	Future Resident (see note 2)	Soil	benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(ah)anthracene; indeno(1,2,3-cd)pyrene; arsenic; asbestos	ingestion; dermal contact; inhalation	5.E-04	2	<5%	No	NA
West of South Street On-Facility	Future Resident (see note 2)	Soil	benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(ah)anthracene; indeno(1,2,3-cd)pyrene; arsenic; asbestos	ingestion; dermal contact; inhalation	2.E-04	<1	<5%	No	NA
Off-Facility groundwater Lot 208 / Lot 209	Future Resident (see note 2)	Tap water from groundwater	benzene; benzo(a)pyrene; dibenz(ah)anthracene; arsenic; manganese; vanadium; lead; pH	ingestion and dermal contact	2.E-03	20	8.08%	Yes	no COCs for which this is true
On-Site Groundwater	Future Resident (see note 2)	Tap water from groundwater	methylene chloride; trichloroethene; benz(a)anthracene; benzo(b)fluoranthene; dibenz(ah)anthracene; indeno(1,2,3-cd)pyrene; bis(2-ethylhexyl)phthalate; carbazole; benzene; 2-methylnaphthalene; naphthalene; benzo(a)pyrene; 4-methylphenol; antimony; arsenic; chromium; manganese; nickel; vanadium; zinc; pH	ingestion and dermal contact	2.E-02	200	<5%	Yes	lead, styrene, toluene
		Vapor from use of groundwater as tap water	ethylbenzene; trichloroethene; benzene; 2-methylnaphthalene; naphthalene	inhalation	3.E-04	200	- ⁽³⁾	- ⁽⁴⁾	
Construction Worker Scenarios									
Lot 33-257	Future Construction Worker	Soil	lead	ingestion	<1E-04	<1	6.50%	No	NA
West of South Street On-Facility	Future Construction Worker	Dermal contact with groundwater	pH	dermal contact	<1E-04	<1	<5%	Yes	NA
Off-facility groundwater Lot 208 / Lot 209	Future Construction Worker	Dermal contact with groundwater	pH	dermal contact	<1E-04	<1	<5%	Yes	NA
Wader Scenarios									
Former Mill Tailrace	Current/Future Wader	Surface water	pH	dermal contact	<1E-04	<1	<5%	Yes	NA
Site Worker Scenarios									
East of South Street on-Facility	Future Site Worker	Indoor air from soil vapor (SB-09 area)	trichloroethene	inhalation	2E-04	<1	- ⁽³⁾	- ⁽⁴⁾	NA
Asbestos Scenarios									
Soil	All	Inhalation of asbestos fibers from soil having concentrations greater than or equal to 1%	asbestos	inhalation	Not evaluated in BHHRA	Not evaluated in BHHRA	-	-	NA

**TABLE B-3.2
Potentially Actionable Human Health Risks - 2007 BHHRA and 2008 BHHRA Addendum**

**Blackburn Union Privileges Superfund Site
Walpole, Massachusetts**

Location	Receptor	Medium	COC contributing an ILCR >1E-06 to a cumulative ILCR >1E-04, contributing an HQ >1 to a target organ-specific HI >1, PBL >5%, or elevated pH	Exposure Route	RME ILCR	Max RME Target Organ-Specific HI	PBL	Elevated pH	COC (ILCR <1E-06, HI <1, PBL <5%, but EPC > MCL) ⁽¹⁾
Sediment	All	Inhalation of asbestos fibers from sediment having concentrations greater than or equal to 1%	asbestos	inhalation	Not evaluated in BHHRA	Not evaluated in BHHRA	-	-	NA

Notes:

- Contaminants of Concern (COCs) in this column are not associated with the levels of risk defined in column 4, but have Exposure Point Concentrations (EPCs) that are greater than Maximum Contaminant Levels (MCLs). "NA" means that a comparison to MCLs is not relevant for the receptor/medium combination. "No COCs for which this is true" means that the receptor/medium meets the first three criteria in the column header (i.e. ILCR < 1E-6, HI < 1, and PBL < 5%) and does not have any COCs with EPCs that are greater than MCLs.
- Unrestricted future residential use is not considered a reasonably anticipated future use in these areas of the Site due to the current zoning by-laws. Under current zoning, the most sensitive possible future site receptor for soil exposure pathways is a child at a daycare facility. A future daycare facility was not considered as part of the Baseline Human Health Risk Assessment (BHHRA), and the potential risks associated with future residential use are likely higher than those associated with a daycare facility. Therefore, the development of human health risk based PRGs for use in the evaluation of remedial alternatives for the Feasibility Study (FS) are based on a daycare facility scenario, and not unrestricted residential use.
- Exposures to lead for this receptor/medium combination were not quantified in the BHHRA.
- pH is not a COC for the inhalation pathway or garden pathway.
- ILCR - Incremental Lifetime Cancer Risk
- COCs were identified that contribute an ILCR greater than 1E-6 to a cumulative ILCR of 1E-4; a non-cancer HI greater than 1 to a target organ-specific HI greater than 1; a PBL greater than 5%; an elevated pH to groundwater or surface water; those groundwater analytes that exceed their respective USEPA MCLs; or soils or sediment with asbestos concentrations greater than 1%.

TABLE B-3.3 - HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) - GROUNDWATER

Media of Concern	COC	EPC (µg/L)	Estimated ILCR	Estimated HQ	Lifetime Health Advisory	Regulatory Criteria		Risk-Based PRGs ⁽²⁾				Additional Information			Selected PRG	Basis
						Federal MCLs	MassDEP MCLs	ILCR			HQ = 1	Site-specific Range of Background Levels	MassDEP Background Levels	PQL		
								10 ⁻⁶	10 ⁻⁵	10 ⁻⁴						
Groundwater - µg/L (Residential Scenario)																
	Benzene	580	8.0E-04	23	--	5	5	0.68	6.8	68	31	0.005	--	0.5	5	MCL
	Ethylbenzene	353	2.0E-05	0.5	700	700	700	19	190	1900	706	0.005	--	0.5	700	MCL
	Methylene chloride	34	4.0E-06	N/A	--	5	5	6.5	65	650	N/A	0.005	--	0.5	5	MCL
	Toluene ⁽¹⁾	1200	N/A	1	--	1000	1000	N/A	N/A	N/A	1200	--	--	0.5	1000	MCL
	Trichloroethene	2.53	3.0E-05	0.9	--	5	5	0.075	0.75	7.5	2.8	--	--	0.5	5	MCL
	Styrene ⁽¹⁾	320	N/A	0.2	--	100	100	N/A	N/A	N/A	1600	--	--	0.5	100	MCL
	Benzo(a)anthracene	0.78	2.0E-05	N/A	--	--	--	0.051	0.51	5.1	N/A	--	--	0.1	0.1	PQL
	Benzo(a)pyrene	1.6	3.0E-04	N/A	--	0.2	0.2	0.0051	0.051	0.51	N/A	--	--	0.1	0.2	MCL
	Benzo(b)fluoranthene	0.405	8.0E-06	N/A	--	--	--	0.051	0.51	5.1	N/A	--	--	0.1	0.1	PQL
	bis(2-Ethylhexyl)phthalate	37.2	2.0E-05	0.4	--	6	6	1.7	17	170	93	--	--	0.5	6	MCL
	Carbazole	62.7	4.0E-05	N/A	--	--	--	1.8	18	180	N/A	--	--	0.5	1.8	ILCR = 10 ⁻⁶
	Dibenz(a,h)anthracene	0.627	1.0E-04	N/A	--	--	--	0.0051	0.051	0.51	N/A	--	--	0.1	0.1	PQL
	Indeno(1,2,3-cd)pyrene	0.285	6.0E-06	N/A	--	--	--	0.051	0.51	5.1	N/A	--	--	0.1	0.1	PQL
	2-Methylnaphthalene ⁽⁵⁾	503	N/A	100	--	--	--	N/A	N/A	N/A	5	--	--	0.1	5	HQ = 1
	4-Methylphenol	92	N/A	2	--	--	--	N/A	N/A	N/A	49	0.005	--	5	49	HQ = 1
	Naphthalene ⁽⁵⁾	3130	N/A	526	100	--	--	N/A	N/A	N/A	6	0.005	--	0.1	6	HQ = 1
	Antimony	34	N/A	8	6	6	6	N/A	N/A	N/A	4.2	--	--	2	6	MCL
	Arsenic	631	2.0E-02	200	--	10	10	0.038	0.38	3.8	3.1	--	5.5	1	10	MCL
	Chromium	130	N/A	6	--	100	100	N/A	N/A	N/A	23	--	4.9	2	100	MCL
	Lead	302	N/A	N/A	--	15	15	N/A	N/A	N/A	N/A	--	8.8	1	15	MCL
	Manganese	3900	N/A	20	300	--	--	N/A	N/A	N/A	250	--	--	1.5	300	Health Adv.
	Nickel	629	N/A	3	100	--	--	N/A	N/A	N/A	210	--	--	4	210	HQ = 1
	Vanadium	3350	N/A	80	--	--	--	N/A	N/A	N/A	45	--	--	5	45	HQ = 1
	Zinc	4840	N/A	2	2000	--	--	N/A	N/A	N/A	3100	--	--	6	3100	HQ = 1
	pH ⁽⁴⁾	14.1	N/A	N/A	--	6.5 - 8.5 ⁽³⁾	6.5 - 8.5 ⁽³⁾	N/A	N/A	N/A	N/A	--	--	NA	< 8.5	MCL ⁽⁴⁾

Notes

EPC - Exposure Point Concentrations (maximum detected on-site concentration)

COC - Contaminant of Concern

MCL - Maximum Contaminant Level

ILCR - Incremental Lifetime Cancer Risk

HQ - Hazard Quotient

PQL - Practical Quantification Limit

N/A - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects

1. The concentration did not exceed a HQ of 1 during calculation. However, the maximum detected concentration exceeded its MCL. Therefore, the interim cleanup level has been established as the MCL.

2. Risk-based PRGs have only been calculated for those COCs shown to drive risk in the human health risk assessment.

3. Value is secondary MCL.

4. Unit for pH is s.u.; Because elevated pH conditions are the concern at this site, the PRG is stated as <8.5.

5. HQ presented include ingestion, dermal contact, and inhalation pathways. See Table 6 in Attachment 1 for calculation of inhalation contribution to HQ.

TABLE B-3.4 - HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) - SOIL

Media of Concern	COC	EPC (mg/kg)	Estimated ILCR	Estimated HQ	Risk-Based PRGs ⁽¹⁾				Additional Information				Selected PRG	Basis
					ILCR			HQ = 1	Site-specific Range of Background Levels	MassDEP Background Levels				
					10 ⁻⁶	10 ⁻⁵	10 ⁻⁴			"Natural" Soil	Ash Fill	PQL		
Soil - mg/kg (Daycare Child Scenario)														
	Trichloroethene - direct contact ⁽³⁾	9	2.0E-06	0.2	4.5	45	450	45	--	--	--	0.005	45	ILCR = 10 ⁻⁵
	Trichloroethene - vapor intrusion ^(4,5)	N/A	N/A	N/A	0.0097	0.097	0.97	3.8	--	--	--	0.005	0.097	ILCR = 10 ⁻³
	Benzo(a)anthracene	29.5	5.0E-05	N/A	0.51	5.1	51	N/A	--	2	9	0.0033	5.1	ILCR = 10 ⁻⁵
	Benzo(a)pyrene	27.6	5.0E-04	N/A	0.051	0.51	5.1	N/A	--	2	7	0.0033	2	Background
	Benzo(b)fluoranthene	32.4	7.0E-05	N/A	0.51	5.1	51	N/A	--	2	8	0.0033	5.1	ILCR = 10 ⁻³
	Dibenz(a,h)anthracene	2.45	4.0E-05	N/A	0.051	0.51	5.1	N/A	--	0.5	1	0.0033	0.51	ILCR = 10 ⁻⁵
	Indeno(1,2,3-cd)pyrene	9.17	1.5E-05	N/A	0.51	5.1	51	N/A	--	1	3	0.0033	5.1	ILCR = 10 ⁻³
	Arsenic	3.92	3.2E-06	0.08	1.3	13	130	51	--	20	20	1	20	Background
	Lead ⁽²⁾	657	N/A	N/A	N/A	N/A	N/A	N/A	--	100	600	1	400	IEUBK
Soil - mg/kg (Site Worker Scenario)														
	Trichloroethene - vapor intrusion ^(4,5)	N/A	N/A	N/A	0.0065	0.065	0.65	11	--	--	--	0.005	0.065	ILCR = 10 ⁻⁵

Notes

EPC - Exposure Point Concentrations

COC - Contaminant of Concern

ILCR - Incremental Lifetime Cancer Risk

HQ - Hazard Quotient

PQL - Practical Quantification Limit

IEUBK - Integrated Exposure Uptake Biokinetic Model for Lead in Children

N/A - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects

1. Risk-based PRGs for PAHs and arsenic are applicable to the East of South Street On-Facility and the Old Railroad and Former Lower Mill Pond areas.

Trichloroethene PRG is only applicable to the East of South Street On-Facility area (SB-09 area); lead PRG is only applicable to Residential Lot 33-257.

2. Value for lead is the maximum detected concentration at Residential Lot 33-257.

3. Based on ingestion and dermal contact exposures only.

4. Based on inhalation of indoor air following modeling from soil gas data. Soil gas concentrations were back-modeled to soil concentrations using the Johnson & Ettinger model and site-specific information.

5. Based on the upper range of the unit risk estimates proposed by EPA (1.1E-04 per ug/m³).

TABLE B-3.5 - HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) - RESIDUAL RISK CALCULATION

Media of Concern	COC	EPC (mg/kg)	Estimated ILCR	Estimated HQ	Risk-Based PRGs ⁽¹⁾				Selected PRG ⁽²⁾	Basis	Residual Risk At PRG		
					ILCR			HQ = 1			Estimated ILCR	Estimated HQ	
					10 ⁻⁶	10 ⁻⁵	10 ⁻⁴						
(Daycare Child Scenario)	Trichloroethene - vapor intrusion ^(3, 4)	N/A	N/A	N/A	0.0097	0.097	0.97	3.8	0.065	ILCR = 10 ⁻⁵⁽⁵⁾	6.7E-06	0.02	
	Benzo(a)anthracene	29.5	5.0E-05	N/A	0.51	5.1	51	N/A	5.1	ILCR = 10 ⁻⁵	1.0E-05	N/A	
	Benzo(a)pyrene	27.6	5.0E-04	N/A	0.051	0.51	5.1	N/A	2	Background	3.6E-05	N/A	
	Benzo(b)fluoranthene	32.4	7.0E-05	N/A	0.51	5.1	51	N/A	5.1	ILCR = 10 ⁻⁵	1.0E-05	N/A	
	Dibenz(a,h)anthracene	2.45	4.0E-05	N/A	0.051	0.51	5.1	N/A	0.51	ILCR = 10 ⁻⁵	1.0E-05	N/A	
	Indeno(1,2,3-cd)pyrene	9.17	1.5E-05	N/A	0.51	5.1	51	N/A	5.1	ILCR = 10 ⁻⁵	1.0E-05	N/A	
	Arsenic	3.92	3.2E-06	0.08	1.3	13	130	51	20	Background	1.6E-05	0.41	
	Lead ⁽²⁾	657	N/A	N/A	N/A	N/A	N/A	N/A	400	IEUBK	N/A	N/A	
	Asbestos	See Appendix B-1 for risk calculations			N/A	N/A	N/A	N/A	N/A	N/A	5.6E-06	N/A	
Notes											CUMULATIVE RISK		1.E-04

EPC - Exposure Point Concentrations
 COC - Contaminant of Concern
 ILCR - Incremental Lifetime Cancer Risk
 HQ - Hazard Quotient
 IEUBK - Integrated Exposure Uptake Biokinetic Model for Lead in Children
 N/A - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects

1. Risk-based PRGs for PAHs and arsenic are applicable to the East of South Street On-Facility and the Old Railroad and Former Lower Mill Pond areas. Trichloroethene PRG is only applicable to the East of South Street On-Facility area; lead PRG is only applicable to Residential Lot 33-257.
2. Value for lead is the maximum detected concentration at Residential Lot 33-257.
3. Based on inhalation of indoor air following modeling from soil gas data. Soil gas concentrations were back-modeled to soil concentrations using the Johnson & Ettinger model and site-specific information.
4. Based on the upper range of the unit risk estimates proposed by EPA (1.1E-04 per ug/m³).
5. PRG for TCE based on an ILCR of 10⁻⁵ for the site worker as the most sensitive receptor for indoor air exposures.

Attachment 1

**TABLE 1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS
REASONABLE MAXIMUM EXPOSURE**

**Blackburn & Union Privileges Site
Walpole, Massachusetts**

Scenario Timeframe: Future Receptor Population: Day Care Child Receptor Age: Child
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Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Non-Cancer Hazard Quotient					
				Ingestion	Dermal	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Inhalation	Exposure Routes Total	
Soil	Soil	East of South Street On-Facility	Trichloroethylene (TCE)	2.E-06	---	---	2.E-06	Hepatic; Renal; Developmental; Immunological Respiratory Whole Body Renal Renal Renal Renal Renal Renal Renal Whole Body; Hepatic Integumental; Cardiovascular None observed Neurological Immunological Renal Hematological	0.2	---	---	0.2	
			2-Methylnaphthalene	---	---	---	---		0.01	0.005	---	0.02	
			Naphthalene	---	---	---	---		0.006	0.002	---	0.008	
			Benz(a)anthracene	4.E-05	1.E-05	---	5.E-05		0.005	0.002	---	0.007	
			Benzo(a)pyrene	4.E-04	1.E-04	---	5.E-04		0.005	0.002	---	0.007	
			Benzo(b)fluoranthene	4.E-05	1.E-05	---	6.E-05		0.006	0.002	---	0.008	
			Benzo(k)fluoranthene	2.E-06	8.E-07	---	3.E-06		0.003	0.001	---	0.005	
			Chrysene	4.E-07	1.E-07	---	5.E-07		0.005	0.002	---	0.007	
			Dibenz(ah)anthracene	3.E-05	1.E-05	---	4.E-05		0.0004	0.0002	---	0.0006	
			Indeno(1,2,3-cd)pyrene	1.E-05	4.E-06	---	2.E-05		0.002	0.0006	---	0.002	
			Dibenzofuran	---	---	---	---		0.03	0.008	---	0.04	
			Antimony	---	---	---	---		0.03	---	---	0.03	
			Arsenic	3.E-06	2.E-07	---	3.E-06		0.07	0.006	---	0.08	
			Chromium VI	---	---	---	---		0.03	---	---	0.03	
			Manganese	---	---	---	---		0.02	---	---	0.02	
			Mercury	---	---	---	---		0.1	---	---	0.1	
			Vanadium	---	---	---	---		0.04	---	---	0.04	
			Zinc	---	---	---	---		0.03	---	---	0.03	
					Exposure Point Total		5.E-04		2.E-04	---	6.E-04		0.6
			Exposure Medium Total		5.E-04	2.E-04	---	6.E-04		0.6	0.03	---	0.6
	Fugitive Dust	East of South Street On-Facility											
			Asbestos ⁽¹⁾	---	---	6.E-06	6.E-06	NA	---	---	---	---	
			Exposure Point Total	---	---	6.E-06	6.E-06		---	---	---	---	
		Exposure Medium Total		---	---	6.E-06	6.E-06		---	---	---	---	
Soil Total				5.E-04	2.E-04	6.E-06	7.E-04		0.6	0.03	---	0.6	
Total Risk Across All Media							7.E-04	Total Hazard Across All Media					0.6

Note: Risk estimates shown for TCE are calculated using the upper end of the slope factor range.

(1) The unit risk used for this calculation [0.046 (f/cc)⁻¹] is the less-than-lifetime value for a child, exposed from birth to age 5.

**TABLE 2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS
REASONABLE MAXIMUM EXPOSURE**

**Blackburn & Union Privileges Site
Walpole, Massachusetts**

Scenario Timeframe: Future
Receptor Population: Day Care Child
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Non-Cancer Hazard Quotient						
				Ingestion	Dermal	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Inhalation	Exposure Routes Total		
Soil	Soil	Old Railroad and Former Lower Mill Pond Area	Benzo(a)anthracene	3.E-05	8.E-06	---	3.E-05	Renal	0.004	0.001	---	0.005		
			Benzo(a)pyrene	1.E-04	4.E-05	---	2.E-04	Renal	0.002	0.0006	---	0.002		
			Benzo(b)fluoranthene	2.E-05	6.E-06	---	3.E-05	Renal	0.003	0.001	---	0.004		
			Benzo(k)fluoranthene	9.E-07	3.E-07	---	1.E-06	Renal	0.001	0.0004	---	0.002		
			Chrysene	1.E-07	5.E-08	---	2.E-07	Renal	0.002	0.0008	---	0.003		
			Dibenz(ah)anthracene	3.E-05	9.E-06	---	4.E-05	Renal	0.0004	0.0001	---	0.0005		
			Indeno(1,2,3-cd)pyrene	1.E-05	4.E-06	---	2.E-05	Renal	0.002	0.0007	---	0.003		
			Antimony	---	---	---	---	Whole Body; Hepatic	0.05	---	---	0.05		
			Arsenic	7.E-05	6.E-06	---	7.E-05	Integumental; Cardiovascular	2	0.1	---	2		
			Chromium VI	---	---	---	---	None observed	0.04	---	---	0.04		
	Manganese	---	---	---	---	Neurological	0.02	---	---	0.02				
	Vanadium	---	---	---	---	Renal	0.03	---	---	0.03				
	Exposure Point Total				3.E-04	7.E-05	---	3.E-04		2	0.2	---	2	
	Exposure Medium Total				3.E-04	7.E-05	---	3.E-04		2	0.2	---	2	
	Soil	Fugitive Dust	Old Railroad and Former Lower Mill Pond Area	Asbestos ⁽¹⁾	---	---	6.E-06	6.E-06	NA	---	---	---	---	
Exposure Point Total				---	---	6.E-06	6.E-06	---	---	---	---			
Exposure Medium Total				---	---	6.E-06	6.E-06	---	---	---	---			
Soil Total				3.E-04	7.E-05	6.E-06	3.E-04		2	0.2	---	2		
Total Risk Across All Media				3.E-04				Total Hazard Across All Media					2	

Note: 'Whole Body' is included in all Total Target Organ Hazard Indices

(1) The unit risk used for this calculation [0.046 (f/cc)⁻¹] is the less-than-lifetime value for a child, exposed from birth to age 5.

Total Cardiovascular HI Across All Media	4
Total Integumental HI Across All Media	4

**TABLE 3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS
REASONABLE MAXIMUM EXPOSURE**

**Blackburn & Union Privileges Site
Walpole, Massachusetts**

Scenario Timeframe: Future
Receptor Population: Day Care Child
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Non-Cancer Hazard Quotient							
				Ingestion	Dermal	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Inhalation	Exposure Routes Total			
Soil	Soil	West of South Street On-Facility	Benz(a)anthracene	4.E-06	1.E-06	---	6.E-06	Renal	0.0006	0.0002	---	0.0008			
			Benzo(a)pyrene	5.E-05	2.E-05	---	6.E-05	Renal	0.0007	0.0002	---	0.0009			
			Benzo(b)fluoranthene	5.E-06	1.E-06	---	6.E-06	Renal	0.0007	0.0002	---	0.0009			
			Chrysene	5.E-08	2.E-08	---	7.E-08	Renal	0.0007	0.0003	---	0.001			
			Dibenz(ah)anthracene	5.E-06	2.E-06	---	7.E-06	Renal	0.00008	3E-05	---	0.0001			
			Indeno(1,2,3-cd)pyrene	2.E-06	7.E-07	---	3.E-06	Renal	0.0003	0.0001	---	0.0004			
			Arsenic	7.E-06	6.E-07	---	7.E-06	Integumental; Cardiovascular	0.2	0.01	---	0.2			
			Chromium VI	---	---	---	---	None observed	0.02	---	---	0.02			
			Manganese	---	---	---	---	Neurological	0.01	---	---	0.01			
			Mercury	---	---	---	---	Immunological	0.04	---	---	0.04			
	Vanadium	---	---	---	---	Renal	0.02	---	---	0.02					
	Exposure Point Total				7.E-05	2.E-05	---	9.E-05		0.3	0.02	---	0.3		
	Exposure Medium Total				7.E-05	2.E-05	---	9.E-05		0.3	0.02	---	0.3		
	Soil	Fugitive Dust	West of South Street On-Facility	Asbestos ⁽¹⁾	---	---	6.E-06	6.E-06	NA	---	---	---	---		
				Exposure Point Total				---	---	6.E-06	6.E-06		---	---	---
Exposure Medium Total				---	---	6.E-06	6.E-06		---	---	---	---			
Soil Total				7.E-05	2.E-05	6.E-06	1.E-04		0.3	0.02	---	0.3			
Total Risk Across All Media							1.E-04	Total Hazard Across All Media				0.3			

(1) The unit risk used for this calculation [0.046 (f/cc)⁻¹] is the less-than-lifetime value for a child, exposed from birth to age 5.

Table 4. Reasonable Maximum Exposure (RME) Assumptions for the Groundskeeper and Site Worker Exposure Scenarios

Soil Ingestion Dose (mg/kg-day) =	$\frac{\text{PRG} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED} \times \text{CF}}{\text{BW} \times \text{AT}}$		
Dermal Absorption Dose from Soil (mg/kg-day) =	$\frac{\text{PRG} \times \text{EF} \times \text{ED} \times \text{SA} \times \text{AF} \times \text{ABS}_d \times \text{CF}}{\text{BW} \times \text{AT}}$		
Where:		Groundskeeper¹	Site Worker²
PRG =	Contaminant concentration in soil (mg/kg)		
IR =	Ingestion rate (mg/day) - RME adult resident rate that is intended to account for soil exposure during activities such as gardening	100	100
FI =	Fraction of contaminated soil ingested (unitless)	1	1
EF =	Exposure frequency (days/year); groundskeeper: 2 d/wk April to October	60	150
ED =	Exposure duration (years)	25	25
CF =	Conversion factor (kg/mg)	0.000001	0.000001
SA =	Skin surface area available for contact (cm ² /day); groundskeeper: 50th%ile hands, forearms, and face	2,479	3,300
AF =	Weighted soil-to-skin adherence factor (mg/cm ²); groundskeeper: 50th%ile weighted adherence factors based on gardener data, which represents an upper bound representation of the groundskeeper scenario	0.1	0.2
ABS _d =	Dermal absorption fraction (unitless)	chemical-specific	chemical-specific
BW =	Body weight (kg) - average adult body weight	70	70
AT _c =	Carcinogenic averaging time (days) - 70 year lifetime	25,550	25,550
AT _{nc} =	Noncancer averaging time (days) - ED x 365 d/yr	9,125	9,125
Example Lifetime Average Daily Dose Calculations assuming exposure to 1 mg/kg B(a)P with a dermal absorption fraction of 0.13		Groundskeeper (mg/kg-d)	Site Worker (mg/kg-d)
	Ingestion:	8.4E-08	2.1E-07
	Dermal Contact:	2.7E-08	1.8E-07
	Ingestion and Dermal:	1.1E-07	3.9E-07

Notes:

¹ The exposure assumptions for the groundskeeper are taken from USEPA's BHHRA for the Housatonic River Rest of River Site, except for the exposure frequency which is based on a reasonable number of days per week given the size of areas with actionable risk (http://www.epa.gov/boston/ge/thesite/restofriver/reports/hhra_219190/219190_HHRA_Vol3A_DC.pdf, Table 4-20).

² The exposure assumptions for the site worker are identical to those used in the draft BHHRA for the Blackburn and Union Privileges Site dated July 27, 2007.

Table 5
 Calculation of Chemical Cancer Risks and Non-Cancer Hazards
 Reasonable Maximum Exposure
 Blackburn & Union Privileges Site
 Walpole, Massachusetts

Scenario Timeframe: Future
 Receptor Population: Site Worker
 Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil	Soil	Old Railroad and Former Lower Mill Pond Area	Ingestion	Benz(a)anthracene	19.4	mg/kg	4.E-06	mg/kg/day	7.E-01	1/(mg/kg-day)	3.E-06	1.E-05	mg/kg/day	3.E-02	mg/kg-day	0.0004
				Benzo(a)pyrene	8.75	mg/kg	2.E-06	mg/kg/day	7.E+00	1/(mg/kg-day)	1.E-05	5.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0002
				Benzo(b)fluoranthene	15.4	mg/kg	3.E-06	mg/kg/day	7.E-01	1/(mg/kg-day)	2.E-06	9.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0003
				Benzo(k)fluoranthene	6.65	mg/kg	1.E-06	mg/kg/day	7.E-02	1/(mg/kg-day)	1.E-07	4.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0001
				Chrysene	11.3	mg/kg	2.E-06	mg/kg/day	7.E-03	1/(mg/kg-day)	2.E-08	7.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0002
				Dibenz(ah)anthracene	2.14	mg/kg	4.E-07	mg/kg/day	7.E+00	1/(mg/kg-day)	3.E-06	1.E-06	mg/kg/day	3.E-02	mg/kg-day	0.00004
				Indeno(1,2,3-cd)pyrene	10.8	mg/kg	2.E-06	mg/kg/day	7.E-01	1/(mg/kg-day)	2.E-06	6.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0002
				Antimony	3.85	mg/kg	8.E-07	mg/kg/day	NA	NA	---	2.E-06	mg/kg/day	4.E-04	mg/kg-day	0.006
				Arsenic	96.1	mg/kg	2.E-05	mg/kg/day	2.E+00	1/(mg/kg-day)	3.E-05	6.E-05	mg/kg/day	3.E-04	mg/kg-day	0.2
				Chromium VI	22.5	mg/kg	5.E-06	mg/kg/day	NA	NA	---	1.E-05	mg/kg/day	3.E-03	mg/kg-day	0.004
				Manganese	254	mg/kg	5.E-05	mg/kg/day	NA	NA	---	1.E-04	mg/kg/day	7.E-02	mg/kg-day	0.002
				Vanadium	23.5	mg/kg	5.E-06	mg/kg/day	NA	NA	---	1.E-05	mg/kg/day	5.E-03	mg/kg-day	0.003
				Exp. Route Total										5.E-05		
			Dermal	Benz(a)anthracene	19.4	mg/kg	3.E-06	mg/kg/day	7.E-01	1/(mg/kg-day)	3.E-06	1.E-05	mg/kg/day	3.E-02	mg/kg-day	0.0003
				Benzo(a)pyrene	8.75	mg/kg	2.E-06	mg/kg/day	7.E+00	1/(mg/kg-day)	1.E-05	4.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0001
				Benzo(b)fluoranthene	15.4	mg/kg	3.E-06	mg/kg/day	7.E-01	1/(mg/kg-day)	2.E-06	8.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0003
				Benzo(k)fluoranthene	6.65	mg/kg	1.E-06	mg/kg/day	7.E-02	1/(mg/kg-day)	9.E-08	3.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0001
				Chrysene	11.3	mg/kg	2.E-06	mg/kg/day	7.E-03	1/(mg/kg-day)	1.E-08	6.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0002
				Dibenz(ah)anthracene	2.14	mg/kg	4.E-07	mg/kg/day	7.E+00	1/(mg/kg-day)	3.E-06	1.E-06	mg/kg/day	3.E-02	mg/kg-day	0.00004
				Indeno(1,2,3-cd)pyrene	10.8	mg/kg	2.E-06	mg/kg/day	7.E-01	1/(mg/kg-day)	1.E-06	5.E-06	mg/kg/day	3.E-02	mg/kg-day	0.0002
				Arsenic	96.1	mg/kg	4.E-06	mg/kg/day	2.E+00	1/(mg/kg-day)	6.E-06	1.E-05	mg/kg/day	3.E-04	mg/kg-day	0.04
			Exp. Route Total										3.E-05			0.04
			Exposure Medium Total										8.E-05			0.2
Indoor Air	Old Railroad and Former Lower Mill Pond Area	Inhalation	Methylene chloride (Dichloromethane)	0.000229	mg/m3	3.E-05	mg/m3	5.E-07	1/(ug/m3)	1.E-08	8.E-05	mg/m3	1.E+00	mg/m3	0.00008	
			Naphthalene	0.00154	mg/m3	2.E-04	mg/m3	NA	NA	---	5.E-04	mg/m3	3.E-03	mg/m3	0.2	
Exposure Medium Total										1.E-08			0.2			
Soil Total										8.E-05			0.4			
					Total of Receptor Risks Across All Media					8.E-05	Total of Receptor Hazards Across All Media		0.4			

Note: NA = not available/not applicable

Table 6. Assumptions for Inhalation Contribution to Noncarcinogenic Effects for Residential Water

Basis:

Two volatile COCs listed on Table B-3.3 (2-methylnaphthalene and naphthalene) do not have MCLs. The inhalation contribution to noncarcinogenic effects for these COCs was originally estimated (in the BHHRA; SHA, 2007) through the assumption that the inhalation dose was equal to the ingestion dose. Current EPA guidance recommends the use of equations presented in RAGS Part B (Chapter 3).

The Hazard Quotient contribution calculated below will be used to replace that which was originally estimated in the BHHRA to generate PRGs in Table B-3.3. Ingestion and dermal contact contributions are presented in the 2007 BHHRA.

Non-cancer - Inhalation

$$HQ_{inh} = \frac{C \times K \times IR_a \times EF \times ED}{RfD_i \times BW \times AT \times 365 \text{ day/yr}}$$

where		Default
HQ _{inh}	Inhalation Hazard Quotient	
C	Chemical concentration in water (mg/L)	--
K	Volatilization Factor (L/m ³)	0.5
IR _a	Daily Indoor Inhalation Rate (m ³ /day)	15
EF	Exposure Frequency (day/yr)	350
ED	Exposure Duration (yr)	30
RfD _i	Inhalation Chronic Reference Dose (mg/kg-day)	chem specific
BW	Adult Body Weight (kg)	70
AT	Averaging time (yr)	30

Rather than adjusting an RfC to an RfD_i, the equation is adjusted to utilize an RfC:

$$HQ_{inh} = \frac{C \times K \times EF \times ED}{RfC \times AT \times 365 \text{ day/yr}}$$

where		Default	2-methylnaphthalene	naphthalene
HQ _{inh}	Inhalation Hazard Quotient		80	500
C	Chemical concentration in water (mg/L) ⁽¹⁾	--	0.503	3.13
K	Volatilization Factor (L/m ³)	0.5	0.5	0.5
EF	Exposure Frequency (day/yr)	350	350	350
ED	Exposure Duration (yr)	30	30	30
RfC	Inhalation Reference Concentration (mg/m ³)	chem specific ⁽²⁾	0.003	0.003
AT	Averaging time (yr)	30	30	30

Notes

(1) Exposure Point Concentrations (EPCs) - See Table B-3.3

(2) RfC for naphthalene used as a surrogate for 2-methylnaphthalene.

COC - Chemical of Concern