TABLE 5. SEDIMENT QUALITY VALUES REPRESENTING THE SEDIMENT CLEANUP OBJECTIVES RELATED TO ENVIRONMENTAL RISKS

Chemical	Sediment Cleanup Objective[a]
Metals (mg/kg dry weight; ppm)	
Antimony	150[B]
Arsenic	57[B]
Cadmium	5.1[B]
Copper	390[L]
Lead	450[B]
Mercury	0.59[L]
Nickel	>140[A,B]
Silver	6.1[A]
Zinc	410[B]
Organic Compounds (μg/kg dry weight; ppb)	
Low molecular weight PAH	5,200[L]
Naphthalene	2,100[L]
Acenaphthylene	1,300[A,B]
Acenaphthene	500[L]
Fluorene	540[L]
Phenanthrene	1,500[L]
Anthracene	960[L]
2-Methylnaphthalene	670[L]
High molecular weight PAH	17,000[L]
Fluoranthene	2,500[L]
Pyrene	3,300[L]
Benz(a)anthracene	1,600[L]
Chrysene	2,800[L]
Benzofluoranthenes	3,600[L]
Benzo(a)pyrene	1,600[L]
Indeno(1,2,3-c,d)pyrene	690[L]
Dibenzo(a,h)anthracene	230[L]
Benzo(g,h,i)perylene	720[L]
Chlorinated organic compounds	
1,3-Dichlorobenzene	170[A,L,B]
1,4-Dichlorobenzene	110[B]
1,2-Dichlorobenzene	50[L,B]
1,2,4-Trichlorobenzene	51[A]
Hexachlorobenzene (HCB)	22[B]
Total PCBs	1,000[B,*]

TABLE 5. Continued

Chemical	Sediment Cleanup Objective[a]
Phthalates	
Dimethyl phthalate	160[L]
Diethyl phthalate	200[B]
Di-n-buytl phthalate	1,400[A,L]
Butyl benzyl phthalate	900[A,B]
Bis(2-ethylhexyl)phthalate	1,300[B]
Di-n-octyl phthalate	6,200[B]
Phenols	
Phenol	420[L]
2-Methylphenol	63[A,L]
4-Methylphenol	670[L]
2,4-Dimethylphenol	29[L]
Pentachlorophenol	360[A]
Miscellaneous extractables	
Benzyl alcohol	73[L]
Benzoic acid	650[L,B]
Dibenzofuran	540[L]
Hexachlorobutadiene	11[B]
N-nitrosodiphenylamine	28[B]
Volatile organics	
Tetrachloroethene	57[B]
Ethylbenzene	10[B]
Total xylenes	40[B]
Pesticides	
p,p'-DDE	9[B]
p,p'-DDD	16[B]
p,p'-DDT	34[B]

[a] Option 2 - Lowest AET among amphipod, oyster, and benthic:

A - Amphipod mortality bioassay
L - Oyster larvae abnormality bioassay
B - Benthic infauna
* - The sediment quality objective for human health has been established at 150 ppb for PCBs at the CB/NT site according to a method combining equilibrium partitioning and risk assessment methods.

complexity and the lack of available regulatory standards or guidelines for establishing cleanup criteria for contaminated sediments, a decision-making approach was developed specifically for the CB/NT investigations that included characterization of sediment problems, development of sediment quality objectives, identification of problem chemicals, and definition of problem areas requiring sediment remediation.

The environmental risk assessment framework developed for the remedial investigation incorporates a preponderance-of-evidence approach that is implemented in a stepwise manner to identify and rank toxic problem areas and problem chemicals.

Ideally, sediment quality objectives and sediment management decisions would be supported by definitive cause and effect information relating specific chemicals to biological effects in various aquatic organisms and to quantifiable human health risks. However, very little information of this type is currently available, and it is unlikely that additional information will be available in the near future. In the interest of protecting human health and the environment, regulatory agencies must proceed with sediment management decisions based on the best information available.

The application of the ecological risk assessment approach for the CB/NT site was based on three important premises. First, it was assumed that the development of cleanup objectives to define problem sediments and chemicals would require the analysis of site-specific data collected as part of the remedial investigation. Second, it was assumed that no single chemical or biological indicator could be used to define problem sediments. Therefore, the risk assessment would be based on several independent measures of contamination and biological effects. Third, it was assumed that adverse biological effects are linked to sediment contamination and that these links could be characterized empirically. Thus, a preponderance of field and laboratory evidence linking contaminant concentrations with adverse biological effects could be used to establish an empirical relationship despite the lack of information establishing cause and effect relationships.

The preponderance-of-evidence approach required the selection of several measurements to serve as indicators of contamination and biological effects at the CB/NT site. The following five groups of indicator variables were selected:

- **Sediment contamination**—Concentrations of chemicals and chemical groups
- **Bioaccumulation**—Contaminant concentrations in English sole
- **Sediment toxicity**—Acute mortality of amphipods and abnormalities in oyster larvae
- **Benthic infauna**—Abundances of major taxa
- **Fish histopathology**—Prevalences of liver lesions in English sole.

7.2.2 Identification of Problem Chemicals

The CB/NT investigations indicated that area sediments were contaminated by numerous inorganic and organic chemicals at levels substantially above Puget Sound reference conditions. Because of the extensive list of sediment contaminants, a procedure was developed to identify and rank problem chemicals so that source and cleanup evaluations could be focused on the chemicals posing the greatest environmental or public health risk. The overall identification of problem chemicals involved a three-step process. In the first step, historical data for the site were reviewed to select a suite of chemicals to be analyzed in the remedial investigation. This suite of chemicals included EPA priority pollutants, many EPA Hazardous Substance List compounds, and several organic compounds that are not on the EPA lists. Following the remedial investigation sampling, a group of chemicals of concern was then identified from the overall list of analytes. Chemicals of concern were defined as chemicals with concentrations exceeding all Puget Sound reference conditions. These chemicals are not necessarily considered problem chemicals because sediments may be contaminated above reference conditions without exhibiting toxicity or biological effects. In the final step, the chemicals of concern were evaluated for their relationship to biological effects. The objective of this step was to define problem chemicals so that source identification

and remedial alternatives analyses could be focused on a limited suite of chemicals that apparently posed the greatest environmental risk. Problem chemicals were defined as those chemicals whose concentration exceeded the apparent effects threshold (AET) in the problem area. Because the AET was defined as the contaminant concentration above which toxicity or benthic effects are always observed, chemicals present in concentrations above this threshold are likely contributors to observed biological effects.

Problem chemicals were further ranked according to their association with toxicity or biological effects. Based on this approach, three priorities of problem chemicals were given for each problem area. The highest priority (Priority 1) chemicals were defined as those present above an AET in a problem area and that also exhibited a concentration gradient corresponding to observed changes in sediment toxicity or benthic effects. For example, strong linear relationships were found between sediment toxicity and PCB concentrations in Hylebos Waterway and between sediment toxicity and 4-methylphenol concentrations in St. Paul Waterway. Other contaminants were found at levels above AET in these problem areas, but none displayed these strong relationships with sediment toxicity. Therefore, these two chemicals were given the highest priority for source evaluation and cleanup actions because of their demonstrated correspondence with observed toxicity. Priority 1 chemicals included:

- Mercury, lead, zinc, and arsenic
- PCBs, 4-methylphenol, HPAHs, and LPAHs.

Priority 2 chemicals were defined as those that occurred above the AET in the problem area but showed no particular relationship with effects gradients (or insufficient data were available to evaluate their correspondence with gradients). Chemicals with concentrations above the AET only at nonbiological stations were therefore placed no higher than Priority 2 because of the lack of biological data. These chemicals included:

- Cadmium, nickel, and antimony
- Hexachlorobutadiene, chlorinated benzenes, chlorinated ethenes, phenol, 2-methylphenol, N-nitrosodiphenylamine, dibenzofuran, selected phthalate esters, and selected tentatively identified compounds (e.g., 2-methoxyphenol).

Finally, chemicals with concentrations above AET at only one station within the problem area were assigned Priority 3. Problem chemicals for problem areas that were small hotspots of sediment contamination usually fell into this category.

7.2.3 Identification of Problem Areas

A series of simple indices was developed for each of the five indicators for contamination, toxicity, and biological effects to enable ranking of areas based on the relative magnitude of observed contamination and effects. These indices were defined in the general form of a ratio between the value of a variable at the CB/NT site and the value of the variable at a reference site. The indicator ratios were structured so that the value of the index increased as the deviation from reference conditions increased. Thus, each ratio was termed an elevation above reference (EAR) index. The environmental contamination and effects indicators (EAR) were used to compare the entire CB/NT study area and for individual waterways with individual sampling stations or groups of stations (i.e., waterway segments) as the study units.

Chemical contamination of CB/NT sediments was very uneven. Some chemicals [e.g., arsenic, copper, 4-methylphenol, and benzo(a)pyrene] were measured at concentrations exceeding 1,000 times reference levels. Biological effects were also highly varied among study areas. For example, amphipod mortality reached 95-100 percent at two sites, while mortalities in several other areas were indistinguishable from reference levels (7-25 percent). Similarly, analyses of benthic infauna indicated severe stress, as evidenced by very low abundances, at some sampling stations and apparently normal benthic assemblages at other sites. English sole were very abundant in the

CB/NT waterways. However, 25-40 percent of the sole from several waterways had one or more serious liver abnormalities, including cancers and precancerous conditions. Only about 7 percent of reference area sole had these liver abnormalities.

Toxic problem areas were defined as those areas with sufficient evidence of contamination and biological effects to warrant the evaluation of contaminant sources and possible remedial alternatives. The identification of these problem areas required the specification of criteria incorporating combinations of contamination and effects indices that would result in problem area identification. It was assumed that an area or segment would require no action unless at least one of the indicators of contamination, toxicity, or biological effects was significantly elevated above reference conditions. Final prioritization of problem areas for remedial action was determined based on three additional criteria:

- Environmental significance (i.e., the number and magnitude of significant contaminant and effects indices)
- Spatial extent of contamination
- Confidence in source identification.

Based on these criteria, nine discrete areas of sediment contamination were identified in the feasibility study as priority problem areas warranting further evaluation and response under Superfund (Figure 12). Overall, these priority problem areas displayed the following characteristics: multiple biological effects and significantly elevated chemicals, relatively large spatial extent, and one or more identified sources of contamination.

7.2.4 Relationship to Sediment Quality Objectives

The next step in the remedial investigation/feasibility study process was to evaluate the relationship between sediment contamination and biological effects so that measurable sediment quality objectives could be defined for both sediment chemistry and sediment biology. Details of the decision-making process used to select a method for evaluating sediment toxicity as it relates to biological effects are provided in Tetra Tech (1988a) and PTI (1989). As part of the remedial investigation/feasibility study, sediment quality objectives were required that could be used to:

- Identify problem chemicals in sediments
- Identify sources associated with problem chemicals
- Establish spatial designation of problem areas, especially in areas where site-specific biological testing results were not available.

Several approaches to sediment quality objectives based on laboratory, field, and theoretical relationships were evaluated for application to the CB/NT site. Approaches evaluated included reference areas, screening level concentrations, AET, and equilibrium partitioning. Based on consideration of management and technical criteria and on results of a verification exercise with field-collected data, the AET approach was selected and confirmed as the preferred method for developing sediment quality values in the CB/NT area. An AET is the sediment concentration of a chemical above which statistically significant ($P \leq 0.05$) biological effects are always observed in the data set used to generate AET values. In other words, if any chemical exceeds its AET for a particular biological indicator, then an adverse biological effect is predicted for that indicator. Alternatively, if all chemical concentrations are below their AET, then no adverse effects are predicted. The AET approach can be used to provide chemical-specific sediment quality values for the greatest number and widest range of chemicals of concern in Commencement Bay and throughout Puget Sound. AET can also be developed for a range of biological indicators, including laboratory-controlled bioassays and *in situ* benthic infaunal analyses. An additional advantage of using existing AET for the CB/NT site is that the remedial investigation data constitute a relatively large proportion of the total data set used to generate AET values. The AET approach has also been selected for application in other Puget Sound regulatory programs.

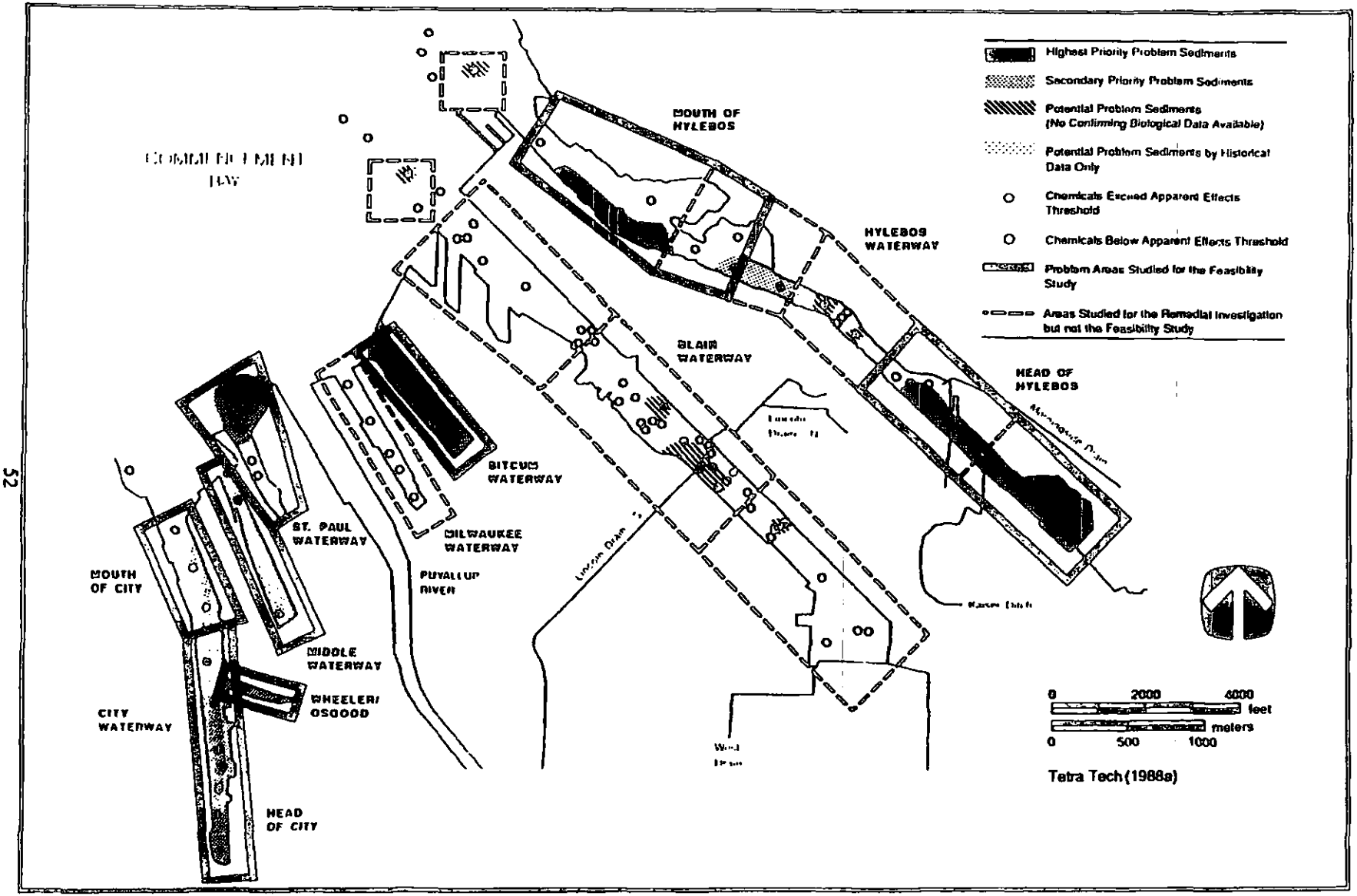

Figure 12. Relationship between problem areas identified during the remedial investigation and those studied for the feasibility study

8.2.1 Cleanup Levels

Table 19 lists sediment cleanup levels for RAOs 1, 2, and 4, and Table 20 lists sediment cleanup levels for RAO 3. Sediment cleanup levels for contaminants for RAO 3 are point-based and applicable to any sample location; for the other RAOs, cleanup levels are applied to a specific area (see Table 19). Benthic cleanup levels are based on the benthic SCO in the SMS (WAC 173-204-562). For RAO 3, the SCO numerical chemical criteria can be overridden by the SCO biological criteria (see text box "What are the Sediment Management Standards?" on page 26) unless they are co-located with exceedances of remedial action levels (RALs) associated with human health COCs, which are also point-based. Exceedances of RALs for human health COCs cannot be overridden by toxicity testing.

Table 19. Cleanup Levels for PCBs, Arsenic, cPAHs, and Dioxins/Furans in Sediment for Human Health and Ecological COCs (RAOs 1, 2 and 4)

COC	Cleanup Levels				Application Area and Depth		
	RAO 1: Human Seafood Consumption	RAO 2: Human Direct Contact	RAO 4: Ecological (River Otter)	Basis for Cleanup Levels[a]	Spatial Scale of Application[b]	Spatial Compliance Measure[e]	Compliance Depth[b]
PCBs (µg/kg dw)	**2**	1,300	128	background (RAO 1) RBTC (RAO 2) RBTC (RAO 4)	LDW-wide	UCL95	0 – 10 cm
	NA	500	NA	RBTC	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	1,700	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm
Arsenic (mg/kg dw)	NA	7	NA	background	LDW-wide	UCL95	0 – 10 cm
	NA	7	NA	background	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	7	NA	background	Individual Beaches[d]	UCL95	0 – 45 cm
cPAH (µg TEQ/kg dw)	NA	380	NA	RBTC	LDW-wide	UCL95	0 – 10 cm
	NA	150	NA	RBTC	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	90	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm
Dioxins/Furans (ng TEQ/kg dw)	**2**	37	NA	background (RAO 1) RBTC (RAO 2)	LDW-wide	UCL95	0 – 10 cm
	NA	13	NA	RBTC	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	28	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm

NOTE: where there are multiple cleanup levels for a cleanup area, the lowest cleanup level is shown in bold.

a. Background – see Table 3 and Section 5.3.4.1; RBTC – Risk-based threshold concentration (based on 1 in 1,000,000 excess cancer risk or HQ of 1)

b. In intertidal areas including beaches used for recreation and clamming, human-health direct contact cleanup levels (for PCBs, arsenic, cPAHs, and dioxins/furans) must be met in the top 45 cm because in intertidal areas exposure to sediments at depth is more likely through digging or other disturbances. Human health cleanup levels for RAO 1 (seafood consumption) and ecological cleanup levels must be met in surface sediments (top 10 cm). In subtidal areas, cleanup levels for all COCs must be met in surface sediments (top 10 cm).

c. Clamming areas are identified in Figure 6.

d. Beach play areas are identified in Figure 6.

e. The UCL 95 is the upper confidence limit on the mean. The determination of compliance with RAOs 1, 2 and 4 cleanup levels will be made by one of two methods: 1) comparison of the UCL 95 of LDW data with the RBTC or background-based cleanup level, or 2) for background-based cleanup levels, a statistical comparison of the distribution of LDW data to the OSV BOLD study background dataset (USACE et al. 2009) may be used. In either case, testing will use an alpha level of 0.05 and a beta level of 0.10. For details, see ProUCL technical manual (EPA 2013b) or most current version). For either method, a sufficient number of samples must be collected to assure statistical power for the test.

Table 20. Sediment Cleanup Levels for Ecological (Benthic Invertebrate) COCs for RAO 3[a]

Benthic COC	Cleanup Level for RAO 3[a]	Benthic COC	Cleanup Level for RAO 3[a]
Metals, (mg/kg dw)[c]		***OC-normalized Organic Compounds (continued) (mg/kg OC)***	
Arsenic	57	Total PCBs	12
Cadmium	5.1	Benzo(g,h,i)perylene	31
Chromium	260	Chrysene	110
Copper	390	Dibenz(a,h)anthracene	12
Lead	450	Indeno(1,2,3-cd)pyrene	34
Mercury	0.41	Fluoranthene	160
Silver	6.1	Fluorene	23
Zinc	410	Naphthalene	99
Dry Weight Basis Organic Compounds, (µg/kg dw)		Phenanthrene	100
4-methylphenol	670	Pyrene	1,000
2,4-dimethylphenol	29	HPAH	960
Benzoic acid	650	LPAH	370
Benzyl alcohol	57	Bis(2-ethylhexyl)phthalate	47
Pentachlorophenol	360	Butyl benzyl phthalate	4.9
Phenol	420	Dimethyl phthalate	53
		1,2-dichlorobenzene	2.3
OC-normalized Organic Compounds, (mg/kg OC)[b]		1,4-dichlorobenzene	3.1
Acenaphthene	16	1,2,4-trichlorobenzene	0.81
Anthracene	220	2-methylnaphthalene	38
Benzo(a)pyrene	99	Dibenzofuran	15
Benz(a)anthracene	110	Hexachlorobenzene	0.38
Total benzofluoranthenes	230	n-Nitrosodiphenylamine	11

a. Cleanup Levels for RAO 3 are based on the benthic SCO chemical criteria in the SMS (WAC 173-204-562). Benthic SCO biological criteria (WAC 173-204-562, Table IV) may be used to override benthic SCO chemical criteria where human health-based RALs are not also exceeded.

b. PCBs and arsenic are also human health COCs; see Table 19.

No sediment cleanup levels were identified for arsenic or cPAHs for the human health seafood consumption pathway (RAO 1). Seafood consumption excess cancer risks for these two COCs were largely attributable to eating clams. However, data collected during the RI/FS showed little relationship between concentrations of arsenic or cPAH in sediment and their concentrations in clam tissue. EPA will define the sediment cleanup footprint based on other cleanup levels, then use the clam target tissue levels (Section 8.2.3) to measure reduction in arsenic and cPAH concentrations in clams. Research will be conducted during the remedial design phase to study the relationships between sediment concentrations for arsenic and cPAHs and concentrations in clam tissue and methods to reduce concentrations of these contaminants in clams. If EPA determines, based on these studies, that additional remedial action is needed to reduce clam tissue arsenic and cPAH concentrations for the purpose of achieving RAO 1, EPA will document and select those actions in a future decision document.

The sediment cleanup levels for PCBs and dioxins/furans (RAO 1) and for arsenic (RAO 2) are set at natural background consistent with the SCO for human health risks (HH SCO). Modeling conducted during the RI/FS could not predict that long term LDW COC concentrations would achieve natural background. This is because the concentrations of these contaminants in incoming sediments (suspended solids) from the Green/Duwamish River are currently higher than natural background and current practical limitations on control of sources within the LDW and Green/Duwamish River drainage basins may not allow sufficient future reductions in these incoming concentrations. The term cleanup objective was used in the FS to mean the PRG or as close as practicable to the PRG (sediment PRGs in the FS and Proposed Plan are cleanup levels in the ROD). This ROD uses the term "FS cleanup objective" when referring to the term as it was used in the FS to distinguish it from the new term SCO in the 2013 SMS. For the purposes of comparing alternative remedies, the lowest model-predicted concentration was used as a surrogate for "as close as practicable to the PRG" when the PRG was not predicted to be achieved within a 45-year period.

These long-term COC concentrations predicted by the model are highly uncertain. As discussed in the FS (LDWG 2012a), concentrations of COCs coming in to the LDW from upstream and lateral sources vary over time and are difficult to predict; therefore, the values used to represent these COC concentrations, used as model inputs, are uncertain. In particular, the data used to estimate Green/Duwamish River surface water and sediment inputs to the RI/FS models were relatively sparse and highly variable. In addition, it is difficult to predict what concentrations in upstream and lateral-source sediments will be many years in the future. High and low bounds on these inputs were evaluated in the FS to portray model sensitivity. For example, RI/FS models predict that all alternatives will reduce PCB concentrations in LDW sediments to approximately 40 – 45 µg/kg in 40 years using mid-range model input parameters (Table 5). In contrast, the sensitivity analysis indicates that future PCB sediment concentrations could range from 9 – 100 µg/kg. The great majority of this range is due to varying assumptions about incoming suspended sediment concentrations. Ecology and King County are currently conducting studies to refine estimates of contaminant inputs from the Green/Duwamish River, and to better understand upstream sources of contamination. Ecology in coordination with EPA will use this information to further assess upstream source control. EPA is retaining natural background, along with the risk-based values (RBTCs), as the basis for cleanup levels for LDW sediments.

8.2.2 ARARs

ARARs are legally applicable or relevant and appropriate substantive (as opposed to administrative) standards, requirements, criteria, or limitations under any federal environmental law, or promulgated under any state environmental or facility siting law that is more stringent than under federal law. This section discusses MTCA and surface water quality requirements; these ARARs are also discussed in Sections 10.1.2 and 14.2, and a complete list of ARARs is in Table 26.

8.2.2.1 Sediment Quality ARARs

The most significant ARARs for developing cleanup levels during the RI/FS and for the Proposed Plan for the In-waterway Portion of the Site were in MTCA and its rules in WAC 173-340 for Washington cleanup sites generally, and the SMS rules for sediment cleanups in WAC 173-204, which are referred to in the MTCA general cleanup rules (WAC 173-340-760). Major portions of the SMS were revised in September 2013, after the Proposed Plan was issued, in part to update sediment cleanup requirements in Part V (Sediment Cleanup Standards) of the SMS and harmonize Part V requirements with the

Table 17. Surface Sediment Contaminant Concentrations from FS Dataset, with Comparison to SMS Chemical Criteria for Protection of Benthic Invertebrates

	Summary Statistics for Surface Sediments			Total Number of Surface Sediment Samples in FS Baseline Dataset					Exceedances Waterway Wide
Contaminant	Minimum Detect	Maximum Detect	Mean[a]	Total Samples	Detection Frequency	>Benthic SCO, ≤Benthic CSL, detected[b]	>Benthic CSL, detected[b]	>Benthic SCO or Benthic CSL, detected[b,c]	>Benthic SCO
Metals and TBT (mg/kg dw)									
Arsenic	1.2	1,100	17	916	94%	5	9	14	1.53%
Cadmium	0.03	120	1.0	894	71%	2	12	14	1.57%
Chromium	4.80	1,680	42	906	100%	1	10	11	1.21%
Copper	5.0	12,000	106	908	100%	0	13	13	1.43%
Lead	2.0	23,000	139	908	100%	2	23	25	2.75%
Mercury	0.015	247	0.53	927	88%	20	30	50	5.39%
Nickel	5.0	910	28	836	100%	NA	NA	NA	—
Silver	0.018	270	1.0	875	61%	0	10	10	1.14%
Vanadium	15	150	59	589	100%	NA	NA	NA	—
Zinc	16	9,700	194	905	100%	26	19	45	4.97%
Tributyltin as ion	0.28	3,000	90	189	94%	NA	NA	NA	—
PAHs (µg/kg dw)									
2-Methylnaphalene	0.38	3,300	42	884	19%	1	4	5	0.57%
Acenaphthene	1.0	5,200	65	891	40%	16	4	20	2.24%
Anthracene	1.3	10,000	134	891	73%	2	0	2	0.22%
Benzo(a)anthracene	7.3	8,400	322	891	92%	10	6	16	1.80%
Benzo(a)pyrene	6.5	7,900	309	886	92%	7	5	12	1.35%
Benzo(g,h,i)perylene	6.1	3,800	165	891	86%	10	12	22	2.47%
Total benzofluoranthenes	6.6	17,000	732	885	94%	6	6	12	1.36%
Chrysene	12	7,700	474	891	95%	29	3	32	3.59%
Dibenzo(a,h)anthrecene	1.6	1,500	63	891	56%	18	6	24	2.69%
Dibenzofuran	1.0	4,200	54	889	31%	7	3	10	1.12%
Fluoranthene	18	24,000	889	891	97%	35	12	47	5.27%
Fluorene	0.68	6,800	78	891	48%	11	3	14	1.57%
Indeno(1,2,3-cd)pyrene	6.4	4,300	180	891	90%	16	13	29	3.25%
Naphthalene	3.0	5,300	49	882	21%	0	2	2	0.23%
Phenanthrene	7.1	28,000	429	891	93%	27	3	30	3.37%
Pyrene	19	16,000	723	891	97%	2	6	8	0.90%
Total HPAH	23	85,000	3,809	891	98%	25	6	31	3.48%
Total LPAH	9.1	44,000	696	891	94%	4	3	7	0.79%

Contaminant	Summary Statistics for Surface Sediments			Total Number of Surface Sediment Samples in FS Baseline Dataset					Exceedances Waterway Wide
	Minimum Detect	Maximum Detect	Mean[a]	Total Samples	Detection Frequency	>Benthic SCO, ≤Benthic CSL, detected[b]	>Benthic CSL, detected[b]	>Benthic SCO or Benthic CSL, detected[b,c]	>Benthic SCO
Phthalates (µg/kg dw)									
Bis(2-ethylhexyl) phthalate	5.4	17,000	590	886	79%	46	58	104	11.74%
Butyl benzyl phthalate	2.0	7,100	87	878	54%	80	10	90	10.25%
Dimethyl phthalate	2.0	440	25	878	21%	0	2	2	0.23%
Chlorobenzenes (µg/kg dw)									
1,2,4-Trichlorobenzene	1.6	940	19	871	1%	0	2	2	0.23%
1,2-Dichlorobenzene	1.3	670	19	871	2%	0	4	4	0.46%
1,4-Dichlorobenzene	1.5	1,600	23	871	6%	0	4	4	0.46%
Hexachlorobenzene	0.4	95	17	874	5%	4	2	6	0.69%
Other SVOCs[d] and COCs (µg/kg dw)									
2,4-Dimethylphenol	6.1	290	44	869	3%	0	25	25	2.88%
4-Methylphenol	4.8	4,600	44	883	13%	0	4	4	0.45%
Benzoic acid	54	4,500	238	876	13%	0	9	9	1.03%
Benzyl alcohol	8.2	670	49	867	3%	9	7	16	1.85%
Carbazole	3.2	4,200	82	775	55%	NA	NA	NA	
n-Nitrosodiphenylamine	6.5	230	27	871	3%	0	2	2	0.23%
Pentachlorophenol	14	14,000	122	840	4%	1	1	2	0.24%
Phenol	10	2,800	91	886	32%	19	6	25	2.82%
Pesticides (µg/kg dw)									
Total DDTs	0.72	77,000	462	216	40%	NA	NA	NA	—
Total chlordanes	0.20	230	268	216	13%	NA	NA	NA	—
Aldrin	0.01	1.6	27	216	2%	NA	NA	NA	—
Dieldrin	0.10	280	29	218	4%	NA	NA	NA	—
alpha-BHC	0.14	1.8	1.1	207	1%	NA	NA	NA	—
beta-BHC	0.09	13	1.2	207	2%	NA	NA	NA	—
gamma-BHC	0.05	8.6	27	216	6%	NA	NA	NA	
Heptachlor	0.12	5.2	27	216	3%	NA	NA	NA	
Heptachlor epoxide	0.47	4.9	2.8	207	2%	NA	NA	NA	
Toxaphene	340	6,300	111	205	1%	NA	NA	NA	

Total PCBs (µg/kg dw)									
Total PCBs[e]	2.2	223,000	1,136	1390	94%	336	179	515	37.05%

Source: LDWG (2012)

General: Contaminants identified as risk drivers for the benthic invertebrate community (RAO 3) are those with one or more surface sediment samples with exceedances of the SCO. Three additional contaminants (total DDTs, total chlordanes, and nickel) that do not have SMS criteria were also identified as COCs for the benthic community.

a. Calculated mean concentration is the average of concentrations using one-half the reporting limit substitution for non-detected results.

b. For non-polar organic compounds, comparisons to SCO and CSL were made using organic carbon-normalized concentrations. If total organic carbon (TOC) in the sample was <0.5% or >4%, dry weight concentrations were compared to the Apparent Effect Thresholds: (Lowest Apparent Effects Threshold) and Second Lowest Apparent Effects Threshold. Additional discussion can be found at *http://www.ecy.wa.gov/programs/tcp/smu/sed_pubs.htm#ApparentEffectsThreshold/*. See also Section 15 (Key Terms).

c. Sum of samples exceeding the SCO but not the CSL and samples exceeding the CSL.

d. SVOCs — semi-volatile organic compounds

e. Total PCB statistics and counts were generated with two outliers excluded (2,900,000 and 230,000 µg/kg dw at RM 2.2).

Table 18. Rationale for Selection of Contaminants as COCs for Ecological Risk

COPC	ROC	Maximum NOAEL-Based HQ	Maximum LOAEL-Based HQ	Additional Considerations	COC?
Total PCBs	crabs	10	1.0	Uncertainty in exposure data: whole-body concentrations were estimated Uncertainty in effects data: LOAEL-based HQ was based on a study with Aroclor 1016 and grass shrimp, and NOAEL was estimated using an uncertainty factor; selection of next higher TRV would result in LOAEL-based HQ < 1.0	no
	river otter	5.8	2.9	Uncertainty in exposure data: low uncertainty in diet assumptions and home range Uncertainty in effects data: low uncertainty in TRV (growth endpoint in kits)	yes
	English sole	4.9 – 25[a]	0.98 – 5.0[a]	Uncertainty in exposure data: low uncertainty in tissue concentrations Uncertainty in effects data: high uncertainty in lowest LOAEL TRV because of uncertain statistical significance of the fecundity endpoint for the low dose, a lack of dose-response in the fecundity endpoint, uncertain number of fish used in the experiment, and uncertainties associated with fish handling and maintenance protocols	no
	Pacific staghorn sculpin	3.8 – 19[a]	0.76 - 3.8[a]	Same considerations as listed above for English sole	no
PCB TEQ[b]	spotted sandpiper –Area 2 (high-quality foraging habitat)	15	1.5	Uncertainty in exposure data: low uncertainty in diet assumptions and home range Uncertainty in effects data: high uncertainty in TRV, which was based on study of reproduction with weekly IP injection; high uncertainty in TEFs; effects data for total PCBs are less uncertain than for PCB TEQs and the LOAEL-based HQ for total PCBs was < 1.0	no
Cadmium	juvenile chinook salmon	5.0	1.0	Uncertainty in exposure data: LOAEL-based HQ < 1.0 if empirical juvenile chinook salmon stomach contents data from the LDW are used to estimate exposure, instead of estimating exposure based on ingestion of benthic invertebrates Uncertainty in effects data: high uncertainty in the lowest TRV because selection of next higher TRV would result in LOAEL-based HQ < 1.0, all salmonid-specific studies for cadmium with NOAELs result in NOAEL-based HQs less than 0.01	no
	English sole	6.1	1.2	Uncertainty in exposure data: low uncertainty (LDW-collected benthic invertebrate tissue samples) Uncertainty in effects data: high uncertainty in the lowest TRV because selection of next higher TRV would result in LOAEL-based HQ < 1.0; all other NOAELs and LOAELs were orders of magnitude higher than the selected LOAEL	no
	Pacific staghorn sculpin	5.2	1.0	Uncertainty in exposure data: low uncertainty (LDW-collected shiner surfperch and benthic invertebrate tissue samples) Uncertainty in effects data: high uncertainty in the lowest TRV because selection of next higher TRV would result in LOAEL-based HQ < 1.0; all other NOAELs and LOAELs were orders of magnitude higher than the selected LOAEL	no