

3. INITIAL EVALUATION

This section presents the initial evaluation and assessment of contamination in the study area. The objective of this section is to enable the reader to organize and understand the previous investigations conducted at the facility so as to identify further data gaps and needs during the RI/FS.

3.1 SUMMARY OF PREVIOUS INVESTIGATIONS

Prior studies have been identified and reviewed to identify contaminants associated with the site, and their potential routes of exposure. The investigations reviewed within this section are not meant to be a compilation of all information related to the former Rayonier Mill Site. The investigations discussed below provide the best data for identifying chemicals of potential concern, locations of the chemicals, and exposure pathways. The single largest study of the former Rayonier Mill Site to date was performed by E&E during 1997/98 as part of EPA's hazard scoring effort. Because these data were collected under quality control guidelines consistent with state and federal cleanup regulations, and because they were collected recently, the following sections focus primarily on information from this investigation. Other investigations, performed by various agencies, and noted during the scoping phase of the RI, are also included.

3.1.1 Marine Sediments

Investigations have been conducted to assess possible effects of wastewater discharges on local marine biota, water quality and sediment quality near the former Rayonier Mill Site (Foster Wheeler Environmental, 1997). In May and June 1993, sediment quality was evaluated near the diffuser of the extended outfall (CH2M HILL, 1994a,b). This investigation showed that trace metal quantities were substantially lower than their respective sediment management standards (SMSs) and also indicated that there was low potential for sediment contamination by organic chemicals adjacent to the diffuser. Two more recent and comprehensive evaluations of sediment have been performed: EPA conducted an expanded site investigation report (E&E, 1998), which evaluated the presence of priority pollutants in sediments from Port Angeles Harbor, and Rayonier conducted sampling in the log pond where EPA was unable to collect samples during the ESI due to wood debris. The ESI sampling and subsequent data analyses were performed as a preliminary assessment to determine if further investigation was warranted. Thus, the sampling and data analyses methodologies followed EPA guidance on preliminary assessment and site investigations (PA/SIs). The sections below focus on EPA's ESI data as they are the most recent and extensive data set.

3.1.1.1 Summary of the EPA Expanded Site Investigation

Sediments were sampled at 69 locations in Port Angeles Harbor and adjacent waters in the Strait of Juan de Fuca (Figure 3-1). In addition to these locations, sediments were sampled at three background stations in Dungeness Bay, a protected, nonurbanized area approximately 15 miles east of Port Angeles Harbor (Figure 3-2). At 49 of the harbor stations, sediment samples were analyzed for priority pollutants except CDDs and CDFs. Samples from 20 harbor stations and the 3 background locations were analyzed for all of the priority pollutants (148 chemicals), which included CDDs and CDFs (Figure 3-3). Critical sediment habitat parameters that are often used in the interpretation of sediment chemistry and biological data were omitted from the final report. These include sediment grain size, total organic carbon, ammonia, and sulfides. Total organic carbon was later provided in correspondence to Ecology by NOAA and is provided here in Table 3-1.

Table 3-2 summarizes the reported EPA data for 75 chemicals that were analyzed at the 69 sample sites located in the harbor and the straits and for the three reference stations in Dungeness Bay.

All of the chemicals noted in Table 3-2 were found in at least one sample, and most were found in more than half of the samples. With the exception of antimony, beryllium, selenium, and silver, the frequency of detection for inorganic chemicals was greater than 20 percent. Organic chemicals with detection frequencies greater than 20 percent included the following:

- Two SVOCs (4-methylphenol, retene)
- Aroclor 1260
- Eight low molecular weight polycyclic aromatic hydrocarbon (LPAH) compounds
- Ten high molecular weight polycyclic aromatic hydrocarbon (HPAH) compounds
- Five CDD congeners
- Three CDF congeners
- Dibenzofuran (which is not chlorinated)

The Washington State SMSs provide sediment quality standards (SQS) and cleanup screening levels (CSL), which are numerical criteria for 47 chemicals or compound groups (this includes the designations total benzofluoranthenes, LPAH, HPAH, and total PCBs which are composites of several chemicals). Table 3-2 provides a comparison of the EPA 1998 data summary with both the SQS and CSL for those chemicals with criteria. For some



Figure 3-1. Sediment Sampling Locations in Port Angeles Harbor and the Strait of Juan de Fuca



Figure 3-2. Background Sediment Sampling Locations in Dungeness Bay



Figure 3-3. Sediment Sampling Locations in Port Angeles Harbor and the Strait of Juan de Fuca for Chlorinated Dibenzodioxins and Chlorinated Dibenzofurans

Organic chemicals, the SQS and CSL criteria are expressed as organic carbon normalized values (i.e., mg chemical/kg sediment organic carbon).

Table 3-1. Total organic carbon concentrations in sediment samples collected during the EPA ESI Investigation.

Station ID	% Total Organic Carbon		Station ID	% Total Organic Carbon
SD01	8.91		SD40	1.36
SD02	6.84		SD41	1.84
SD03	9.58		SD42	3.03
SD04	5.54		SD43	2.04
SD05	7.4		SD44	0.541
SD06	7.45		SD45	1.28
SD07	4.48		SD46	1.97
SD09	6.9		SD47	0.552
SD10	4.11		SD48	0.521
SD11	3.43		SD50	0.395
SD12	5.54		SD54	0.328
SD13	4.8		SD55	0.521
SD14	3.67		SD56	0.711
SD15	1.9		SD57	0.437
SD16	1.76		SD58	0.481
SD17	3.88		SD59	0.722
SD18	2.71		SD60	0.596
SD19	2.96		SD61	0.525
SD20	4.22		SD62	0.476
SD21	1.84		SD63	0.334
SD22	2.45		SD64	0.602
SD23	2.38		SD65	0.401
SD24	1.08		SD66	0.545
SD25	0.227		SD67	0.785
SD26	1.41		SD68	0.628
SD28	1.91		SD69	1.66
SD29	1.74		SD70	0.91
SD30	4.82		SD71	2.65 ³
SD32	3.07 ²		SD72	4.39
SD33	1.32		SD80	2.09
SD34	1.5		SD81	1.24
SD35	1.66		SD82	0.24
SD36	1.46		SD83	0.129
SD37	0.759		SD84	1.35
SD38	3.9		SD85	0.098
SD39	0.776		SD86	0.633

² This data was missing from the data provided by NOAA and thus interpolated from the adjacent stations.

Table 3-2. Summary of Chemicals Detected in Sediment Samples Collected from Port Angeles Harbor.

Chemical	No. Samples	Detection Frequency	Non-Detected Values		Detected Values		Sediment Management Standards	
			Min.	Max.	Min.	Max.	SQS ^b	CSL ^c
<i>Inorganic Chemicals (ppm DW)</i>								
Aluminum	68	100.0%	--	--	5,720	24,100	--	--
Antimony	68	5.9%	0.64	2.4	0.9	9.9	--	--
Arsenic^d	68	83.8%	0.73	6.3	1.4	66	57	93
Barium	68	100.0%	--	--	6.9	53	--	--
Beryllium	68	13.2%	0.25	0.81	0.25	1.5	--	--
Cadmium	68	92.6%	1.5	1.6	0.54	5.8	5.1	6.7
Calcium	68	100.0%	--	--	2,530	45,600	--	--
Chromium	68	100.0%	--	--	11	54	260	270
Cobalt	68	100.0%	--	--	2.8	16	--	--
Copper	68	100.0%	--	--	4.7	419	390	390
Iron	68	100.0%	--	--	9,580	39,500	--	--
Lead	68	100.0%	--	--	2.2	54	450	530
Magnesium	68	100.0%	--	--	3,440	17,900	--	--
Manganese	68	100.0%	--	--	106	420	--	--
Mercury	68	72.1%	0.05	0.16	0.01	1.4	0.41	0.59
Nickel	68	100.0%	--	--	13	45	--	--
Potassium	68	100.0%	--	--	679	4,330	--	--
Selenium	68	11.8%	0.64	2.4	0.93	3.6	--	--
Silver	68	2.9%	0.21	0.81	0.48	1.2	6.1	6.1
Sodium	68	100.0%	--	--	3,720	33,700	--	--
Thallium	68	42.6%	0.74	2.4	0.77	3	--	--
Vanadium	68	100.0%	--	--	21	88	--	--
Zinc	68	100.0%	--	--	21	669	410	960
<i>Volatile Organic Chemicals (ppb DW)</i>								
2-Butanone	68	1.5%	5.70	33.60	21.10	21.10	--	--
2-Propanone	68	7.4%	5.70	41.80	17.40	109.00	--	--
Carbon disulfide	68	1.5%	5.70	33.60	38.40	38.40	--	--
Methane, dichloro	68	1.5%	5.70	33.60	12.20	12.20	--	--
Toluene	68	1.5%	5.70	33.60	18.00	18.00	--	--
<i>Semivolatile Chemicals (ppb DW)</i>								
2,4,6-Trichlorophenol	67	1.5%	142.00	593.00	69.30	69.30	--	--
4-Methylphenol	67	52.2%	70.80	283.00	66.60	1250.00	670	670
9H-Carbazole	67	11.9%	14.20	132.00	18.00	628.00	--	--
Benzoic acid	67	3.0%	142.00	593.00	154.00	354.00	650	650
Dibenzofuran ^c	67	58.2%	5.9E-04	1.4E-02	8.3E-04	2.8E-01	15	58
Phenol	67	11.9%	70.80	297.00	78.70	182.00	420	1200
Retene	67	67.2%	70.80	244.00	65.30	2660.00	--	--

Table 3-2. Summary of Chemicals Detected in Sediment Samples Collected from Port Angeles Harbor. (Continued)

Chemical	No. Samples	Detection Frequency	Non-Detected Values		Detected Values		Sediment Management Standards	
			Min.	Max.	Min.	Max.	SQS ^b	CSL ^c
<i>Pesticides and Polychlorinated Biphenyls (ppm OC)</i>								
P,P'-DDD	67	11.9%	0.05	1.71	0.10	0.33	--	--
PCB 1242	67	3.0%	0.48	17.05	1.30	2.98	--	--
PCB 1254	67	7.5%	0.48	17.05	1.33	7.10	--	--
PCB 1260	67	25.4%	0.48	17.05	1.01	5.48	--	--
Total PCBs	67	28.4%	0.5	17	1	10	12	65
<i>Low Molecular Weight Polyaromatic Hydrocarbons (LPAHs) (ppm OC)</i>								
9H-Fluorene	67	62.7%	0.68	13.95	0.55	492	23	79
Acenaphthene	67	50.7%	0.59	13.95	0.57	315	16	57
Acenaphthylene	67	38.8%	0.39	13.95	0.55	65	66	66
Anthracene	67	73.1%	0.88	13.95	0.56	268	220	1200
Naphthalene	67	86.6%	2.98	16.04	0.79	75	99	170
Naphthalene, 1-methyl-	67	41.8%	0.39	13.95	0.65	40	--	--
Naphthalene, 2-methyl-	67	83.6%	2.66	13.95	0.55	57	38	64
Phenanthrene	67	97.0%	2.98	4.91	2.04	4,917	100	480
Total LPAH	67	100.0%	--	--	2.83	6,081	370	780
<i>High Molecular Weight Polyaromatic Hydrocarbons (HPAHs)(ppm OC)</i>								
Benzo(a)anthracene	67	70.1%	1.94	13.95	0.66	345	110	270
Benzo(a)pyrene	67	68.7%	0.61	13.95	0.70	125	99	210
Benzo(b)fluoranthene	67	76.1%	2.24	13.95	0.83	411	--	--
Benzo(ghi)perylene	67	52.2%	0.61	13.95	0.55	53	31	78
Benzo(k)fluoranthene	67	61.2%	0.61	13.95	0.69	196	--	--
Chrysene	67	74.6%	2.24	15.76	1.07	854	110	460
Dibenzo(a,h)anthracene	67	3.0%	0.39	13.95	9.73	24	12	33
Fluoranthene	67	95.5%	2.98	5.21	2.62	6,250	160	1200
Indeno(1,2,3-cd)pyrene	67	38.8%	0.59	13.95	0.45	63	34	88
Pyrene	67	94.0%	2.98	5.21	2.97	3,496	1000	1400
Total Benzofluoranthenes	67	100.0%	--	--	0.83	607	230	450
Total HPAH	67	100.0%	--	--	2.98	11,817	960	5300
<i>Dioxin (CDDs)(ppm OC)</i>								
1,2,3,4,6,7,8-HpCDD	20	90.0%	1.4E-03	1.6E-03	7.9E-04	8.3E-03	--	--
1,2,3,4,7,8-HxCDD	20	5.0%	1.1E-05	1.2E-03	4.0E-04	4.0E-04	--	--
1,2,3,6,7,8-HxCDD	20	55.0%	6.4E-05	1.1E-03	7.1E-05	6.8E-04	--	--
1,2,3,7,8,9-HxCDD	20	50.0%	3.5E-05	1.1E-03	3.1E-05	7.5E-04	--	--
1,2,3,7,8-PeCDD	20	5.0%	8.7E-06	1.6E-03	2.4E-04	2.4E-04	--	--
2,3,7,8-TCDD	20	30.0%	3.0E-06	5.8E-04	3.8E-05	7.2E-05	--	--
HpCDDs (total)	20	100.0%	--	--	1.8E-03	2.3E-02	--	--
HxCDDs (total)	20	85.0%	9.6E-04	2.4E-03	5.3E-04	1.2E-02	--	--
OCDD	20	95.0%	7.6E-03	7.6E-03	4.2E-03	9.2E-02	--	--
PeCDDs (total)	20	75.0%	6.7E-05	1.6E-03	4.0E-05	7.2E-03	--	--
TCDDs (total)	20	90.0%	7.9E-05	5.8E-04	2.9E-04	1.0E-02	--	--

Table 3-2. Summary of Chemicals Detected in Sediment Samples Collected from Port Angeles Harbor. (Continued)

Chemical	No. Samples	Detection Frequency	Non-Detected Values		Detected Values		Sediment Management Standards	
			Min.	Max.	Min.	Max.	SQS ^b	CSL ^c
<i>Furan (CDFs) (ppm OC)</i>								
1,2,3,4,6,7,8-HpCDF	20	75.0%	7.9E-05	8.3E-04	1.3E-04	8.5E-04	--	--
2,3,7,8-TCDF	20	85.0%	8.8E-05	3.3E-04	1.3E-05	2.7E-04	--	--
HpCDFs (total)	20	85.0%	2.3E-04	8.5E-04	2.6E-04	4.9E-03	--	--
HxCDFs (total)	20	60.0%	4.2E-05	6.4E-04	1.9E-04	1.2E-03	--	--
OCDF	20	70.0%	2.9E-04	1.3E-03	4.4E-04	1.3E-02	--	--
PeCDFs (total)	20	70.0%	3.8E-05	1.2E-03	6.8E-05	1.1E-03	--	--
TCDD-TEQ	20	100.0%	--	--	1.4E-05	4.6E-04	--	--
TCDFs (total)	20	90.0%	8.8E-05	3.3E-04	1.3E-04	4.1E-03	--	--

^a Units expressed in mg/kg dw (PPM DW), ug/kg dw (PPB DW), or in mg/kg organic carbon (PPM OC). Chemicals normalized for organic carbon content include those from Station SD-83 where TOC was less than 0.02%.

^b The Sediment Quality Standard (SQS) corresponds to the "no effects" level, which is a sediment quality goal for Washington State sediments.

^c The Cleanup Screening Level (CSL) corresponds to the "minor adverse effects" level, which is used as an upper regulatory level for source control and cleanup decision making (WAC 173-204-320;520).

^d Chemicals and values above SMS are indicated in **bold** type.

^e Data presented are in ppm OC

Overall, 22 chemicals or compound groups were above either the SQSs or the CSLs at 12 locations in Port Angeles Harbor (Figure 3-4). Half of these locations (SD01, SD04, SD06, SD11, and SD12) are in the western end of the harbor and are not close to past discharges from the former Rayonier Mill Site. Chemicals that exceed SQSs at the western end of the harbor are inorganic chemicals: arsenic, cadmium, copper, mercury, and zinc. Six stations (SD36, SD42, SD43, SD59, SD81, and SD82) near the former Rayonier Mill Site or the extended outfall were above the sediment management standards for the following 16 chemicals or compound groups:

- Semivolatile organic chemicals—4-methylphenol
- Low molecular weight PAHs—Fluorene, acenaphthene, anthracene, 2-methylnaphthalene, phenanthrene, and total LPAHs
- High molecular weight PAHs—Benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, pyrene, total benzofluoranthenes and total HPAHs

Stations SD42, SD43, and SD59 were above SMS values for a single compound (4-methylphenol). Sediment concentrations of 4-methylphenol at these locations exceeded the CSL. Station 81 exceeded the CSL for 4-methylphenol and the SQS for acenaphthene.

Station Location	No. Chemicals > SMS	Arsenic	Cadmium	Copper	Mercury	Zinc	4-Methylphenol	9H-Fluorene	Acenaphthene	Anthracene	Naphthalene, 2-methyl-	Phenanthrene	Total LPAH	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(ghi)perylene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene	Indeno(1,2,3-cd)pyrene	Pyrene	Total Benzofluoranthenes	Total HPAH	
SD01	3		■		●	■																		
SD04	3	■	■	●																				
SD05	1				●																			
SD06	1				■																			
SD11	1				■																			
SD12	1				●																			
SD36	4														■	■			■				■	
SD42	1						●																	
SD43	1						●																	
SD59	1						●																	
SD81	2						●	■																
SD82	16						●	●	■	■	■	●	●	●	■	▲	●	▲	●	▲	●	●	●	●

■ 1X to 1.5X SQS
 ▲ >1.5X SQS
 ● Exceeds SQS & CSL



Figure 3-4. Sediment Sample SQS or CSL Exceedance in Port Angeles Harbor

Station SD36 was above the SMS for four HPAHs and station SD82 was above SMS values for five LPAHs and ten HPAHs.

Table 3-2 summarizes the information provided by EPA both electronically and in the final ESI report (EPA 1998) at the time this document was drafted. Other data were also collected by EPA, but parameters that were analyzed for and never detected in any sample by EPA were not summarized in the ESI report (EPA 1998). These raw data were found in the raw analytical laboratory reports (i.e., Form 1s) that were appended to the ESI report. These raw data sheets were reviewed for stations located in the vicinity of the Rayonier facility and at background locations (i.e., stations SD 28- SD86). Table 3-3 lists the parameters that have not been detected but do have associated SMS criteria and notes the percentage of samples where the reported detection limit exceeded the criteria. Of the 15 parameters with SMS criteria, 14 had detection limits that exceeded criteria in at least one sample location. Appendix A in this report provides a discussion of these chemicals and the rationale for not including them as part of the COPC list in sediments.

Table 3-3. A summary of those chemicals that are noted in the WA State Sediment Management Standards, analyzed by EPA during the 1997 investigation, but not summarized for in the ESI report published in 1998.

Chemical	DL > SQS (% of stations)	DL > CSL (% of stations)
<i>Ionizable Organic Compounds</i>		
2-Methylphenol	100	96
2,4-Dimethyl phenol	100	96
Pentachlorophenol	98	0
<i>Chlorinated Benzenes</i>		
1,2-Dichlorobenzene	98	98
1,4-Dichlorobenzene	93	58
1,2,4-Trichlorobenzene	100	100
Hexachlorobenzene	98	93
<i>Phthalate Esters</i>		
Dimethyl phthalate	4	4
Diethyl phthalate	4	0
Di-n-butyl phthalate	0	0
Butyl benzyl phthalate	82	4
Bis(2-ethylhexyl)phthalate	13	9
Di-n-octyl phthalate	44	0
<i>Miscellaneous</i>		
Hexachlorobutadiene	91	69
N-nitrosodiphenylamine	51	51

DL = Reported detection limit

SQS = Sediment Quality Standard

CSL = Cleanup Screening Level

3.1.1.2 Subsequent Log Pond Investigation

During late September and early October of 2000, Foster Wheeler and Marine Taxonomic Services performed a dive survey of the central area of the log pond. This area was not sampled during EPA's expanded site investigation (ESI) due to sunken logs, that were removed after the EPA investigation. Thus, six samples were collected for chemical analysis in the central area of the log pond (Figure 3-5). Each sample (except for X6) was a composite of two grab samples, comprised of two adjacent locations. Grabs were taken from the surficial (0-6 in.) sediments, except for locations X6 which was a single grab from subsurface sediments approximately 6-12 in. deep. Composite samples noted in Figure 3-5 were analyzed for selected semivolatiles (PAHs and phenols), resin and fatty acids, dioxins/furans, selected metals (As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn) and conventionals (grain size, TOC, ammonia nitrogen and total sulfide). In addition, single grab samples from nine locations were analyzed for TOC only (Figure 3-6).

Table 3-4 summarizes the chemical concentrations found in the log pond. Based on comparisons to WA State SMS, most of the chemicals were below levels of concern. The exception to this was a value of 690 reported for the coelution of 3- and 4-methylphenol, compared to a standard for 4-methylphenol of 670 for both the SQS and the CSL. Due to interferences, the two forms of methylphenol could not be distinguished by the laboratory, and thus were reported as a sum of both compounds. Since the exceedance is marginal, it is unlikely the concentration of 4-methylphenol alone exceeded the standard. The maximum lead value of 450 ppm-bw detected at station X6 was at, but did not exceed the SQS value for lead. No criteria exist in the SMS for resin acids and guiacols, and few criteria exist in the literature. A brief review of the literature values suggest the levels observed were not at levels posing significant effects, but specific evaluations and conclusions are left to the remedial investigation effort and report which will include a series of bioassays for evaluating not only the effects of these chemicals, but potential synergistic effects among all chemicals. Site-specific background concentrations for dioxin at the Olympic View Resource Area in Commencement Bay were similar and ranged from 83 to 728 ppt OC (Pentec Environmental 2001). No SMS criteria exist for evaluating dioxin, and a site specific risk assessment is planned which includes the collection of marine organisms to quantify risks related to the presence of this chemical at this location.

The presence of elevated OC levels in the log pond makes final conclusions difficult for screening chemicals of concern. Thus, this data was not used for that interpretation. The high levels of organic carbon can attract and bind higher levels of organic chemicals; thus, elevating the chemical concentrations relative to nearby sediment that have less OC levels. While this elevation may be accounted for numerically by normalizing the OC



Figure 3-5. Composite sampling locations where sediment was collected from the log pond.



Station locations are approximate.

Figure 3-6. Sampling locations where Total Organic Carbon (TOC) was analyzed.

Table 3-4. Summary of analyte concentrations detected in subsequent samples from the log pond.

Analyte Name	No. of Samples	Undetected		Detected		SMS	
		Min	Max	Min	Max	SQS	CSL
<i>Conventionals (ppm-bulk weight)</i>							
Ammonia as Nitrogen	6	--	--	49.8	104	--	--
Ammonium as Nitrogen	6	--	--	78	78	--	--
<i>Dioxins and furan s(ppt Organic Carbon)</i>							
1,2,3,4,6,7,8-HpCDD	6	--	--	1139.78	10721.65	--	--
1,2,3,4,6,7,8-HpCDF	6	--	--	242.47	1166.67	--	--
1,2,3,4,7,8,9-HpCDF	6	--	--	16.89	62.26	--	--
1,2,3,4,7,8-HxCDD	6	--	--	29.03	166.97	--	--
1,2,3,4,7,8-HxCDF	6	--	--	50.00	169.61	--	--
1,2,3,6,7,8-HxCDD	6	--	--	114.52	390.50	--	--
1,2,3,6,7,8-HxCDF	6	--	--	22.04	71.49	--	--
1,2,3,7,8,9-HxCDD	6	--	--	68.82	333.48	--	--
1,2,3,7,8,9-HxCDF	6	5.86	5.86	3.49	13.57	--	--
1,2,3,7,8-PeCDD	6	--	--	26.88	143.89	--	--
1,2,3,7,8-PeCDF	6	1.08	4.07	--	--	--	--
2,3,4,6,7,8-HxCDF	6	--	--	36.33	89.14	--	--
2,3,4,7,8-PeCDF	6	--	--	45.16	148.87	--	--
2,3,7,8-TCDD	6	9.28	9.28	7.53	39.37	--	--
2,3,7,8-TCDF	6	--	--	36.02	124.89	--	--
OCDD	6	--	--	9960.94	72010.31	--	--
OCDF	6	--	--	809.28	10980.39	--	--
2,3,7,8-TCDD (TEQ)	6	--	--	106.45	385.07	--	--
<i>High Molecular Weight Polyaromatic Hydrocarbons (HPAHs) (ppm Organic Carbon)</i>							
Benz(a)anthracene	6	1.45	1.76	1.76	14.02	110	270
Benzo(a)pyrene	6	1.39	1.76	0.88	5.43	99	210
Benzo(b)fluoranthene	6	1.45	1.76	1.47	6.79	--	--
Benzo(g,h,i)perylene	6	0.74	3.39	--	--	31	78
Benzo(k)fluoranthene	6	1.45	1.76	1.32	5.42	--	--
Chrysene	6	--	--	2.04	19.91	110	460
Dibenz(a,h)anthracene	6	0.735	3.393	--	--	12	33
Fluoranthene	6	--	--	3.78	23.53	160	120
Indeno(1,2,3-cd)pyrene	6	0.735	3.39	--	--	34	88
Total HPAHs	6	--	--	10.75	92.76	960	5300
Pyrene	6	--	--	3.49	17.65	1000	1400
<i>Inorganics (ppm-bulk weight)</i>							
Arsenic	6	--	--	5.5	9.4	57	93
Cadmium	6	--	--	0.98	2.13	5.1	6.7
Chromium	6	--	--	19.6	31.8	260	270
Copper	6	--	--	23.4	63.7	390	390
Lead	6	--	--	28.4	450	450	530
Nickel	6	--	--	15.6	33.5	--	--
Selenium	6	1.16	1.16	1.6	2.7	--	--

Table 3-4. Summary of analyte concentrations detected in subsequent samples from the log pond. (Continued)

Analyte Name	No. of Samples	Undetected		Detected		SMS	
		Min	Max	Min	Max	SQS	CSL
Silver	6	--	--	0.11	0.28	6.1	6.1
Zinc	6	--	--	45.2	99.6	410	960
<i>Low Molecular Weight Polyaromatic Hydrocarbons(ppm Organic Carbon)</i>							
Acenaphthene	6	--	--	0.16	0.95	16	57
Acenaphthylene	6	0.14	0.17	0.14	0.22	66	66
Anthracene	6	--	--	0.53	4.52	220	1200
Fluorene	6	--	--	0.31	1.13	23	79
Total LPAHs	6	--	--	3.63	7.6	370	780
Naphthalene	6	--	--	0.268	1.176	99	170
Phenanthrene	6	--	--	1.52	4.11	100	480
<i>Resin Acids and Guaiacols (ppm-bulk weight)</i>							
12-Chlorodehydroabietic Acid	6	4.4	6.1	--	--	--	--
14-Chlorodehydroabietic Acid	6	4.4	6.1	--	--	--	--
3,4,5-Trichloroguaiacol	6	4.4	6.1	--	--	--	--
9,10-Dichlorostearic Acid	6	4.4	6.1	--	--	--	--
Abietic Acid	6	5.2	5.2	6.7	37	--	--
Dehydroabietic Acid	6	--	--	12	48	--	--
Dichlorodehydroabietic Acid	6	4.4	6.1	--	--	--	--
Isopimaric Acid	6	4.4	6.1	5.8	8.6	--	--
Linoleic Acid	6	4.4	6.1	4.7	4.7	--	--
Oleic Acid/Linolenic Acid	6	4.4	6.1	11	13	--	--
Pimaric Acid	6	4.4	6.1	4.6	4.6	--	--
Tetrachloroguaiacol	6	4.4	6.1	--	--	--	--
<i>Semivolatiles(ppb-bulk weight)</i>							
3- and 4-Methylphenol Coelution	6	--	--	120	690	670	670
Dibenzofuran ^a	6	--	--	0.2	0.77	15	58
Phenol	6	27	30	31	84	420	1200
2,4-Dimethylphenol ^b	6	100	200	--	--	29	29
2-Methylphenol ^b	6	70	90	--	--	63	63
Pentachlorophenol	6	79	110	--	--	360	690

^a Dibenzofuran is expressed as ppm OC

^b The detection limits presented in Table 3-4 are based upon the routine method reporting limits provided by the laboratory, not the method detection limits (MDLs). Reporting limits are considered practical quantitation limits, which are generally 3- to 10-times higher than the MDLs. Actual levels the laboratory are able to detect are the MDLs, which are at least 30 ug/kg for 2-methylphenol and at least 50 ug/kg for 2,4-dimethylphenol.

concentrations, the data sets for some chemical, which the SMS criteria are based on do not include sediments with similarly high levels of OC. And although the binding of organic contaminants by the high levels of organics carbon may limit the bioavailability and water concentrations of the chemicals and thereby reduce the levels of toxicity and bioavailability,

this level of evaluation and discussion is best performed during the remedial investigation after site specific bioassays and organisms have been collected.

3.1.2 Marine Biota

Port Angeles Harbor is located in the city of Port Angeles, Clallam County, Washington along the north coast of the Olympic Peninsula adjacent to the Strait of Juan de Fuca. Many activities occur in Port Angeles that undoubtedly influence the marine environment in Port Angeles Harbor. These activities have raised concern regarding the chemicals that may enter into the marine environment and subsequently be accumulated by biota inhabiting the harbor. As a result of these concerns, four investigations have been conducted to evaluate chemical residues in tissues of marine biota. These are:

- EPA, 1991. Dioxin and furan concentrations in Puget Sound Crabs
- EPA, 1992. National Study of Chemical Residues in Fish
- Rayonier, 1995. Port Angeles Bioaccumulation Study
- Ecology and Environment (under contract by EPA), 1998. Rayonier Pulp Mill Expanded Site Inspection, TDD: 97-06-0010, Prepared for EPA Region 10 - Superfund Technical Assessment and Response Team (START), October 1998. Expanded Site Investigation

Further investigations are planned to be implemented, and this section provides the basis for that planning by reviewing the existing information relative to screening indices to aide in focusing future efforts. Of the four studies noted above, three focused on dioxins and furans and the fourth led by Ecology and Environment evaluated a suite of dioxins and furans, semivolatiles including pesticides and polychlorinated biphenyls, and inorganics. The chemical levels found are reported and discussed below by chemical class.

3.1.2.1 Inorganic Chemicals

Only data collected by E&E (1998), under the direction of EPA, were analyzed for inorganic chemicals. Three composite samples of geoduck (*Panope abrupta*) and three composite samples of red rock crab (*Cancer productus*) were collected from Port Angeles Harbor (Figure 3-7). All of the 13 analytes sampled were detected in the biota tissues except antimony, beryllium, and thallium (Tables 3-5 and 3-6). Arsenic in both geoduck and red rock crab exceeded EPA's arsenic risk-based criteria (RBCs). Arsenic concentrations in marine biota showed a wide range of values. Crustacean tissues sold for human consumption and collected in United States coastal waters usually contain 3 to 10 ppm (USFWS 1988). The concentration of arsenic found in red rock crabs sampled in Port



Figure 3-7. Marine Biota Sampling Locations in Port Angeles Harbor and at the Reference Area Near Dungeness Spit

Table 3-5. Summary of Chemicals Analyzed in Geoducks from Port Angeles Harbor.							
Analyte	# of Samples	Detection Frequency ¹	Minimum NonDetect	Maximum Nondetect	Minimum Detected	Maximum Detected	EPA RBC ²
Dioxins and Furans (pg/g)							
1,2,3,4,6,7,8-HpCDD	3	0%	1	1	--	--	--
1,2,3,4,6,7,8-HpCDF	3	0%	1	1	--	--	--
1,2,3,4,7,8,9-HpCDF	3	0%	1	1	--	--	--
1,2,3,4,7,8-HxCDD	3	0%	1	1	--	--	--
1,2,3,4,7,8-HxCDF	3	0%	1	1	--	--	--
1,2,3,6,7,8-HxCDD	3	0%	1	1	--	--	--
1,2,3,6,7,8-HxCDF	3	0%	1	1	--	--	--
1,2,3,7,8,9-HxCDD	3	0%	1	1	--	--	--
1,2,3,7,8,9-HxCDF	3	0%	1	1	--	--	--
1,2,3,7,8-PeCDD	3	0%	1	1	--	--	--
1,2,3,7,8-PeCDF	3	0%	1	1	--	--	--
2,3,4,6,7,8-HxCDF	3	0%	1	1	--	--	--
2,3,4,7,8-PeCDF	3	0%	1	1	--	--	--
2,3,7,8-TCDD	3	0%	0.2	0.2	--	--	--
2,3,7,8-TCDF	3	67%	0.48	0.48	0.27	0.57	0.21
OCDD	3	100%	--	--	3.4	7.9	21
OCDF	3	33%	2	2	60	60	21
2,3,7,8-TCDD (TEQ) ³	--	--	--	--	0.03	0.06	0.021
Inorganics (mg/kg)							
Aluminum	3	100%	--	--	26.5	92.3	1.35E+03
Antimony	3	0%	0.05	0.05	--	--	--
Arsenic	3	100%	--	--	1.74	4.57	2.10E-03
Barium	3	100%	--	--	0.3	0.682	9.50E+01
Beryllium	3	33%	0.004	0.004	0.0056	0.0056	2.70E+00
Cadmium	3	100%	--	--	0.144	0.48	6.76E-01
Calcium	3	100%	--	--	320	1500	--
Chromium	3	100%	--	--	0.21	0.49	6.80E+00
Cobalt	3	100%	--	--	0.037	0.553	8.11E+01
Copper	3	100%	--	--	3.43	7.43	5.41E+01
Iron	3	100%	--	--	245	911	--
Lead	3	100%	--	--	0.214	1.05	--
Magnesium	3	100%	--	--	529	714	--
Manganese	3	100%	--	--	1.59	29.9	1.90E+02
Mercury	3	67%	0.05	0.05	0.054	0.054	1.40E-01
Nickel ³	3	100%	--	--	0.227	0.457	2.70E+01
Potassium	3	100%	--	--	2680	2820	--
Selenium	3	100%	--	--	0.48	0.824	6.76E+00
Silver	3	100%	--	--	0.116	0.467	6.76E+00
Sodium	3	100%	--	--	2880	4210	--
Thallium	3	0%	0.05	0.05	--	--	--
Vanadium	3	100%	--	--	0.31	1.58	9.46E+00
Zinc	3	100%	--	--	12.1	24.2	4.06E+02
Pesticides and PCBs (µg/kg)							
4,4'-DDD	3	0%	2	2	--	--	--
4,4'-DDE	3	100%	--	--	0.25	0.49	9.30E+00
4,4'-DDT	3	0%	2	2	--	--	--
Aldrin	3	0%	2	2	--	--	--

Analyte	# of Samples	Detection Frequency ¹	Minimum NonDetect	Maximum Nondetect	Minimum Detected	Maximum Detected	EPA RBC ²
alpha-BHC	3	100%	--	--	28	38	5.01E-01
Aroclor 1016	3	0%	20	20	--	--	--
Aroclor 1221	3	0%	39	40	--	--	--
Aroclor 1232	3	0%	39	40	--	--	--
Aroclor 1242	3	0%	20	20	--	--	--
Aroclor 1248	3	0%	20	20	--	--	--
Aroclor 1254	3	0%	20	20	--	--	--
Aroclor 1260 ³	3	100%	--	--	2.8	5.9	1.58E+00
beta-BHC ³	3	100%	--	--	12	15	1.75 ^E +00
Carbazole	3	0%	36	39.9	--	--	--
Chlordane (tech)	3	0%	20	20	--	--	--
delta-BHC	3	100%	--	--	1.2	1.6	--
Dieldrin	3	0%	2	2	--	--	--
Endosulfan sulfate	3	0%	2	2	--	--	--
Endosulfan I	3	0%	2	2	--	--	--
Endosulfan II	3	0%	2	2	--	--	--
Endrin	3	0%	2	2	--	--	--
Endrin aldehyde	3	0%	2	2	--	--	--
Endrin ketone	3	0%	2	2	--	--	--
gamma-BHC ³	3	100%	--	--	2.6	4	2.43E+00
Heptachlor	3	0%	2	2	--	--	--
Heptachlor epoxide	3	0%	2	2	--	--	--
Isophorone	3	0%	36	39.9	--	--	--
Methoxychlor	3	0%	3.9	4	--	--	--
Toxaphene	3	0%	59	60	--	--	2.87E+00
Semivolatile Compounds (µg/kg)							
1,2,4-Trichlorobenzene	3	0%	36	39.9	--	--	--
1,2-Dichlorobenzene	3	0%	36	39.9	--	--	--
1,2-Diphenylhydrazine	3	0%	36	39.9	--	--	--
1,3-Dichlorobenzene	3	0%	36	39.9	--	--	--
1,4-Dichlorobenzene	3	0%	36	39.9	--	--	--
1-Methylnaphthalene	3	0%	36	39.9	--	--	--
2,2'-Oxybis(1-chloropropane)	3	0%	36	39.9	--	--	--
2,4,5-Trichlorophenol	3	0%	36	39.9	--	--	--
2,4,6-Trichlorophenol	3	0%	36	39.9	--	--	--
2,4-Dichlorophenol	3	0%	36	39.9	--	--	--
2,4-Dimethylphenol	3	0%	36	39.9	--	--	--
2,4-Dinitrophenol	3	33%	720	798	783	783	2.70E+03
2,4-Dinitrotoluene	3	0%	180	199	--	--	--
2,6-Dinitrotoluene	3	0%	180	199	--	--	--
2-Chloronaphthalene	3	0%	36	39.9	--	--	--
2-Chlorophenol	3	0%	36	39.9	--	--	--
2-Methylnaphthalene	3	0%	36	39.9	--	--	--
2-Methylphenol	3	0%	36	39.9	--	--	--
2-Nitroaniline	3	0%	180	199	--	--	--
2-Nitrophenol	3	0%	72	79.8	--	--	--
3,3'-Dichlorobenzidine	3	0%	72	79.8	--	--	--
3-Nitroaniline	3	0%	39.1	72	--	--	--
4,6-Dinitro-2-methylphenol	3	0%	360	399	--	--	--

Analyte	# of Samples	Detection Frequency ¹	Minimum NonDetect	Maximum Nondetect	Minimum Detected	Maximum Detected	EPA RBC ²
4-Bromophenyl phenyl ether	3	0%	36	39.9	--	--	--
4-Chloro-3-methylphenol	3	0%	36	39.9	--	--	--
4-Chloroaniline	3	0%	36	39.9	--	--	--
4-Chlorophenyl phenyl ether	3	0%	36	39.9	--	--	--
4-Methylphenol	3	0%	36	39.9	--	--	--
4-Nitroaniline	3	0%	72	79.8	--	--	--
4-Nitrophenol	3	0%	180	199	--	--	--
Acenaphthene	3	0%	39.1	72	--	--	--
Acenaphthylene	3	0%	36	39.9	--	--	--
Aniline	3	0%	36	39.9	--	--	--
Anthracene	3	0%	36	39.9	--	--	--
Benz(a)anthracene	3	0%	36	39.9	--	--	--
Benzidine	3	0%	360	399	--	--	--
Benzo(a)pyrene	3	0%	36	39.9	--	--	--
Benzo(b)fluoranthene	3	0%	72	79.8	--	--	--
Benzo(g,h,i)perylene	3	0%	180	199	--	--	--
Benzo(k)fluoranthene	3	0%	36	39.9	--	--	--
Benzoic acid	3	0%	39.1	1270	--	--	--
Benzyl alcohol	3	0%	36	39.9	--	--	--
Bis(2-chloroethoxy) methane	3	0%	36	39.9	--	--	--
Bis(2-chloroethyl) ether	3	0%	36	39.9	--	--	--
Bis(2-ethylhexyl) phthalate	3	0%	72	79.8	--	--	--
Butyl benzyl phthalate	3	0%	72	79.8	--	--	--
Caffeine	3	0%	36	39.9	--	--	--
Chrysene	3	0%	36	39.9	--	--	--
Dibenz(a,h)anthracene	3	0%	180	199	--	--	--
Dibenzofuran	3	0%	36	39.9	--	--	--
Diethyl phthalate	3	0%	360	398	--	--	--
Dimethyl phthalate	3	0%	36	39.9	--	--	--
Di-n-butyl phthalate	3	0%	180	3340	--	--	--
Di-n-octyl phthalate	3	0%	360	399	--	--	--
Fluoranthene	3	0%	36	39.9	--	--	--
Fluorene	3	0%	36	39.9	--	--	--
Hexachlorobenzene	6	50%	36	39.9	0.58	0.62	1.97E+00
Hexachlorobutadiene	3	0%	36	39.9	--	--	--
Hexachlorocyclopentadiene	3	33%	180	196	199	199	9.46E+03
Hexachloroethane	3	0%	36	39.9	--	--	--
Indeno(1,2,3-cd)pyrene	3	0%	180	199	--	--	--
Naphthalene	3	0%	36	39.9	--	--	--
Nitrobenzene	3	0%	36	39.9	--	--	--
N-Nitrosodimethylamine	3	0%	36	39.9	--	--	--
N-Nitrosodi-n-propylamine	3	0%	36	39.9	--	--	--
N-Nitrosodiphenylamine	3	0%	36	39.9	--	--	--
Pentachlorophenol	3	0%	180	199	--	--	--
Phenanthrene	3	0%	39.1	72	--	--	--

Table 3-5. Summary of Chemicals Analyzed in Geoducks from Port Angeles Harbor.
(continued)

Analyte	# of Samples	Detection Frequency ¹	Minimum NonDetect	Maximum NonDetect	Minimum Detected	Maximum Detected	EPA RBC ²
Phenol	3	0%	36	39.9	--	--	--
Pyrene	3	0%	36	39.9	--	--	--
Pyridine	3	100%	--	--	133	409	1.35E+03
Retene	3	0%	36	39.9	--	--	--

¹ Detection frequency calculations did not incorporate rejected samples.² Risk-based screening concentrations were derived from EPA 1998.³ These chemicals exceed EPA's risk based screening concentrations**Table 3-6.** Summary of Chemicals Evaluated in Red Rock Crab Reported by EPA (1998).

Chemical Name	# of Sample	# Undetected	Detection Frequency ¹	Minimum NonDetect	Maximum NonDetect	Minimum Detected	Maximum Detected	EPA RBC
Dioxins and Furans (pg/g)								
1,2,3,4,6,7,8-HpCDD	3	3	0%	1	1	--	--	--
1,2,3,4,6,7,8-HpCDF	3	3	0%	1	1	--	--	--
1,2,3,4,7,8,9-HpCDF	3	3	0%	1	1	--	--	--
1,2,3,4,7,8-HxCDD	3	3	0%	1	1	--	--	--
1,2,3,4,7,8-HxCDF	3	3	0%	1	1	--	--	--
1,2,3,6,7,8-HxCDD	3	3	0%	1	1	--	--	--
1,2,3,6,7,8-HxCDF	3	3	0%	1	1	--	--	--
1,2,3,7,8,9-HxCDD	3	3	0%	1	1	--	--	--
1,2,3,7,8,9-HxCDF	3	3	0%	1	1	--	--	--
1,2,3,7,8-PeCDD	3	3	0%	1	1	--	--	--
1,2,3,7,8-PeCDF	3	3	0%	1	1	--	--	--
2,3,4,6,7,8-HxCDF	3	3	0%	1	1	--	--	--
2,3,4,7,8-PeCDF	3	3	0%	1	1	--	--	--
2,3,7,8-TCDD	3	3	0%	0.2	0.2	--	--	--
2,3,7,8-TCDF ³	3	1	67%	0.2	0.2	0.58	0.68	0.21
OCDD	3	3	0%	2	2	--	--	--
OCDF	3	--	100%	--	--	2.1	2.4	21
2,3,7,8-TCDD (TEQ) ³	--	--	--	--	--	0.002	0.07	0.021
Inorganics (mg/kg)								
Aluminum	3	--	100%	--	--	4.38	4.96	1.35E+03
Antimony	3	3	0%	0.05	0.05	--	--	--
Arsenic ³	3	--	100%	--	--	5.5	11.2	2.10E-03
Barium	3	--	100%	--	--	0.12	0.24	9.50E+01
Beryllium	3	3	0%	0.004	0.004	--	--	--
Cadmium	3	--	100%	--	--	0.176	0.39	6.76E-01
Calcium	3	--	100%	--	--	4660	7170	--
Chromium	3	--	100%	--	--	0.15	0.18	6.80E+00
Cobalt	3	--	100%	--	--	0.077	0.105	8.11E+01
Copper	3	--	100%	--	--	7.38	8.21	5.41E+01
Iron	3	--	100%	--	--	10.7	12.8	--
Lead	3	--	100%	--	--	0.012	0.018	--

Table 3-6. Summary of Chemicals Evaluated in Red Rock Crab Reported by EPA (1998).
(continued)

Chemical Name	# of Sample	# Undetected	Detection Frequency ^{1/}	Minimum NonDetect	Maximum Nondetect	Minimum Detected	Maximum Detected	EPA RBC
Magnesium	3	--	100%	--	--	774	977	--
Manganese	3	--	100%	--	--	0.443	1.23	1.90E+02
Mercury	3	1	67%	0.05	0.05	0.044	0.055	1.40E-01
Nickel	3	--	100%	--	--	0.176	0.422	2.70E+01
Potassium	3	--	100%	--	--	2710	3290	--
Selenium ³	3	--	100%	--	--	0.69	1.23	6.76E+00
Silver	3	--	100%	--	--	0.157	0.191	6.76E+00
Sodium	3	--	100%	--	--	4070	5650	--
Thallium	3	3	0%	0.05	0.05	--	--	--
Vanadium	3	--	100%	--	--	0.199	0.739	9.46E+00
Zinc	3	--	100%	--	--	47.6	61.9	4.06E+02
Pesticides and PCBs (ug/kg)								
4,4'-DDD	3	3	0%	1.9	2	--	--	--
4,4'-DDE	3	--	100%	--	--	0.52	2	9.28E+00
4,4'-DDT	3	3	0%	1.9	2	--	--	--
Aldrin	3	3	0%	1.9	2	--	--	--
Alpha-BHC ³	3	--	100%	--	--	1.2	1.3	5.01E-01
Aroclor 1016	3	3	0%	19	20	--	--	--
Aroclor 1221	3	3	0%	38	40	--	--	--
Aroclor 1232	3	3	0%	38	40	--	--	--
Aroclor 1242	3	3	0%	19	20	--	--	--
Aroclor 1248	3	3	0%	19	20	--	--	--
Aroclor 1254	3	3	0%	19	20	--	--	--
Aroclor 1260 ³	3	--	100%	--	--	4.8	22	1.58E+00
Beta-BHC	3	3	0%	1.9	2	--	--	--
Delta-BHC	3	3	0%	1.9	2	--	--	--
Carbazole	3	3	0%	37.7	38.8	--	--	--
Chlordane (tech)	3	3	0%	19	20	--	--	--
Dieldrin	3	3	0%	1.9	2	--	--	--
Endosulfan I	3	3	0%	1.9	2	--	--	--
Endosulfan II	3	3	0%	1.9	2	--	--	--
Endosulfan sulfate	3	3	0%	1.9	2	--	--	--
Endrin	3	3	0%	1.9	2	--	--	--
Endrin aldehyde	3	3	0%	1.9	2	--	--	--
Endrin ketone	3	3	0%	1.9	2	--	--	--
Heptachlor	3	3	0%	1.9	2	--	--	--
Heptachlor epoxide	3	3	0%	1.9	2	--	--	--
Isophorone	3	3	0%	37.7	38.8	--	--	--
Lindane (gamma-BHC)	3	3	0%	1.9	2	--	--	--
Methoxychlor	3	3	0%	3.8	4	--	--	--
Toxaphene	3	3	0%	58	60	--	--	--
Semivolative Compounds (ug/kg)								
1,2,4-Trichlorobenzene	3	3	0%	37.7	38.8	--	--	--
1,2-Dichlorobenzene	3	3	0%	37.7	38.8	--	--	--
1,2-Diphenylhydrazine	3	3	0%	37.7	38.8	--	--	--
1,3-Dichlorobenzene	3	3	0%	37.7	38.8	--	--	--
1,4-Dichlorobenzene	3	3	0%	37.7	38.8	--	--	--

Table 3-6. Summary of Chemicals Evaluated in Red Rock Crab Reported by EPA (1998).
(continued)

Chemical Name	# of Sample	# Undetected	Detection Frequency ^{1/}	Minimum NonDetect	Maximum Nondetect	Minimum Detected	Maximum Detected	EPA RBC
1-Methylnaphthalene	3	3	0%	37.7	38.8	--	--	--
2,2'-Oxybis	3	3	0%	37.7	38.8	--	--	--
2,4,5-Trichlorophenol	3	2	0%	37.7	38.8	--	--	--
2,4,6-Trichlorophenol	3	2	0%	37.7	38.8	--	--	--
2,4-Dichlorophenol	3	2	0%	37.7	38.8	--	--	--
2,4-Dimethylphenol	3	2	0%	37.7	38.8	--	--	--
2,4-Dinitrophenol	3	2	0%	753	775	--	--	--
2,4-Dinitrotoluene	3	3	0%	188	194	--	--	--
2,6-Dinitrotoluene	3	3	0%	188	194	--	--	--
2-Chloronaphthalene	3	3	0%	37.7	38.8	--	--	--
2-Chlorophenol	3	3	0%	37.7	38.8	--	--	--
2-Methylnaphthalene	3	3	0%	37.7	38.8	--	--	--
2-Methylphenol	3	2	67%	37.7	38.8	38.8	38.8	6.76E+04
2-Nitroaniline	3	3	0%	188	194	--	--	--
2-Nitrophenol	3	2	67%	75.3	77.5	77.7	77.7	2.70E+03
3,3'-Dichlorobenzidine	3	3	0%	75.3	77.7	--	--	--
3-Nitroaniline	3	3	0%	38.8	77.5	--	--	--
4,6-Dinitro-2-methylphenol	3	2	0%	377	388	--	--	--
4-Bromophenyl phenyl ether	3	3	0%	37.7	38.8	--	--	--
4-Chloro-3-methylphenol	3	3	0%	37.7	38.8	--	--	--
4-Chloroaniline	3	3	0%	37.7	38.8	--	--	--
4-Chlorophenyl phenyl ether	3	3	0%	37.7	38.8	--	--	--
4-Methylphenol	3	1	50%	37.7	37.7	23.6	23.6	6.76E+03
4-Nitroaniline	3	3	0%	75.3	77.7	--	--	--
4-Nitrophenol	3	2	0%	188	194	--	--	--
Acenaphthene	3	3	0%	38.8	77.5	--	--	--
Acenaphthylene	3	3	0%	37.7	38.8	--	--	--
Aniline	3	3	0%	37.7	38.8	--	--	--
Anthracene	3	3	0%	37.7	38.8	--	--	--
Benz(a)anthracene	3	3	0%	37.7	38.8	--	--	--
Benzidine	3	3	0%	377	388	--	--	--
Benzo(a)pyrene	3	3	0%	37.7	38.8	--	--	--
Benzo(b)fluoranthene	3	3	0%	75.3	77.7	--	--	--
Benzo(g,h,i)perylene	3	3	0%	188	194	--	--	--
Benzo(k)fluoranthene	3	3	0%	37.7	38.8	--	--	--
Benzoic acid	3	2	33%	873	888	804	804	5.41E+06
Benzyl alcohol	3	3	0%	37.7	38.8	--	--	--
Bis(2-chloroethoxy) methane	3	3	0%	37.7	38.8	--	--	--
Bis(2-chloroethyl) ether	3	3	0%	37.7	38.8	--	--	--
Bis(2-ethylhexyl) phthalate	3	3	0%	77.7	249	--	--	--
Butyl benzyl phthalate	3	3	0%	75.3	77.7	--	--	--
Caffeine	3	3	0%	37.7	38.8	--	--	--
Chrysene	3	3	0%	37.7	38.8	--	--	--
Dibenz(a,h)anthracene	3	3	0%	188	194	--	--	--
Dibenzofuran	3	3	0%	37.7	38.8	--	--	--
Diethyl Phthalate	3	3	0%	38.8	1550	--	--	--
Dimethyl Phthalate	3	3	0%	37.7	38.8	--	--	--

Table 3-6. Summary of Chemicals Evaluated in Red Rock Crab Reported by EPA (1998).
(continued)

Chemical Name	# of Sample	# Undetected	Detection Frequency ^{1/}	Minimum NonDetect	Maximum Nondetect	Minimum Detected	Maximum Detected	EPA RBC
Di-n-butyl Phthalate	3	3	0%	77.6	854	--	--	--
Di-n-octyl Phthalate	3	3	0%	377	388	--	--	--
Fluoranthene	3	3	0%	37.7	38.8	--	--	--
Fluorene	3	3	0%	37.7	38.8	--	--	--
Hexachlorobenzene	6	6	0%	1.9	38.8	--	--	--
Hexachlorobutadiene	3	3	0%	37.7	38.8	--	--	--
Hexachlorocyclopentadiene	3	2	0%	188	194	--	--	--
Hexachloroethane	3	3	0%	37.7	38.8	--	--	--
Indeno(1,2,3-cd)pyrene	3	3	0%	188	194	--	--	--
Naphthalene	3	3	0%	37.7	38.8	--	--	--
Nitrobenzene	3	3	0%	37.7	38.8	--	--	--
N-Nitrosodimethylamine	3	2	0%	37.7	38.8	--	--	--
N-Nitrosodi-n-propylamine	3	3	0%	37.7	38.8	--	--	--
N-Nitrosodiphenylamine	3	3	0%	37.7	38.8	--	--	--
Pentachlorophenol ³	3	2	33%	188	194	461	461	2.63E+01
Phenanthrene	3	3	0%	38.8	77.5	--	--	--
Phenol	3	2	33%	47	152	59.7	59.7	8.11E+05
Pyrene	3	3	0%	37.7	38.8	--	--	--
Pyridine ³	3	1	67%	77.7	77.7	860	4150	1.35E+03
Retene	3	3	0%	37.7	38.8	--	--	--

^{1/} Detection frequency calculations did not incorporate rejected samples.

^{2/} Risk-based screening concentrations were derived from EPA 1998.

^{3/} These chemicals exceed EPA's risk based screening concentrations.

Angeles Harbor ranged from 5.5 to 11.2 ppm. An arsenic level of 22 ppm was measured in red rock crab samples taken by EPA at the background site near Dungeness Spit.

Geoduck samples collected in Port Angeles Harbor ranged from 1.7 to 4.5 ppm. Arsenic concentrations in mollusc tissues tend to range lower than crustaceans and usually contain 2 to 5 ppm. (USFWS, 1988). This range is comparable to the levels found in the Port Angeles Harbor. An arsenic level of 4.2 ppm was measured in a geoduck sample taken for reference by EPA near Dungeness Spit.

Arsenic occurs in marine biota because of their natural ability to accumulate arsenic from seawater or food sources, and may not necessarily be due to localized pollution (Maher 1985). The great majority of arsenic in marine organisms exists as water-soluble and lipid soluble organoarsenicals that include arsenolipids, arsenosugars, and arsenobetaine. For most marine organisms, the primary form of arsenic is arsenobetaine. Arsenobetaine is viewed by most toxicologists from the Food and Drug administration as relatively nontoxic and not posing a risk to the consumer (Jelinek and Corneliussen, 1977). Because the EPA RBC for arsenic is based on a much more toxic, inorganic form of arsenic, and the

measurements of arsenic in crab tissue accounted for all forms of arsenic, the RBC is not an applicable screen and significantly overestimates any risk posed.

3.1.2.2 Pesticides and PCBs

Chemical analysis for the presence of 19 pesticides and 7 PCB mixtures was conducted as part of the 1998 EPA ESI. Two pesticides (4,4'-DDE and several forms of BHC), and one PCB (Aroclor 1260) were detected in crab and geoduck samples (Tables 3-5 and 3-6), but only BHC and Aroclor 1260 were detected at levels above EPA RBCs, while 4,4'-DDE was below the EPA RBC. Aroclors other than 1260 were not detected, but had detection limits above RBCs.

BHC is a synthetic chemical that exists in eight chemical forms (called isomers). The different isomers are named according to the position of the hydrogen atoms. One of these forms, gamma-BHC (commonly called lindane), was used as an insecticide on fruit, vegetable, and forest crops. It is still used in the United States and in other countries as a human medicine to treat head and body lice and scabies, a contagious skin disease caused by mites. Gamma-BHC has not been produced in the United States since 1977, although it is still imported into and is formulated here. Imported gamma-BHC is available in the United States for insecticide use as a dust, powder, liquid, or concentrate. It is also available as a lotion, cream, or shampoo to control scabies and head lice. Technical-grade BHC, a mixture of several chemical forms of BHC including alpha-BHC, was also once used as an insecticide in the United States and typically contained about 10 to 15 percent gamma-BHC as well as the alpha (a), beta (b), delta (d), and epsilon (e) forms of BHC.

The Agency for Toxic Substance and Disease Registry (ATSDR) has reviewed the levels of BHC as part of its toxicological profile series and concluded that it has become widely distributed and is detectable at low levels in many areas. As part of NOAA's Status and Trends Mussel Watch Program, conducted in the Gulf of Mexico, gamma-BHC was detected in 80 percent of the oyster samples collected in 1987 at levels ranging above the concentrations noted in Port Angeles Harbor (median, 1.20; range, less than 0.25 to 9.06 ppb) (Sericano et al., 1990). Concentrations of alpha-BHC ranged from 0.03 to 0.04 ppb, and it was found in fish from the southwestern and midwestern United States. An analysis of fish from the Upper Steele Bayou in Mississippi in 1988 indicated that beta-BHC concentrations ranged from not detected to 20,000 ppb in fish. Atlantic cod taken from relatively isolated stock in the southern Gulf of St. Lawrence showed declining tissue concentrations of alpha-BHC between 1977 (1,865 ppb) and 1985 (1,792 ppb).

The levels of alpha-BHC ranged higher in geoducks than red rock crabs. The highest concentration found in red rock crab was the reference sample collected from the

Dungeness Spit area. The highest level found in the geoducks sample was at the furthest east sampling station within the Harbor, but this was only slightly higher than the concentration found at Dungeness Spit reference samples.

Beta-, delta-, and gamma-BHC were also found in geoducks; whereas, delta-BHC was found in only one red rock crab (the reference sample). The pattern of concentrations are similar to those discussed above for alpha-BHC and do not suggest the former Rayonier Mill Site as the source.

Aroclor 1260 was detected in all of the tissue samples (Tables 3-5 and 3-6). PCBs are synthetic organic chemicals that contain 209 individual compounds (known as congeners) with varying harmful effects. PCBs are either oily liquids or solids. They enter the environment as mixtures containing a variety of individual components and impurities. The manufacture of PCBs stopped in the United States in October 1977 because of evidence that PCBs build up in the environment and cause harmful effects. Consumer products that may contain PCBs are old fluorescent lighting fixtures, electrical devices, appliances containing PCB capacitors, and hydraulic fluids.

The PCB levels observed during this study ranged from 1.5 to 22 ppb in red rock crab and from 1.4 to 5.9 ppb in geoduck samples. These levels are generally comparable to levels measured in similar organisms in areas with no known sources of contamination, suggesting that the levels found are influenced by global sources of PCBs rather than localized contamination. The crab and geoduck samples from Port Angeles Harbor contained higher concentrations of Aroclor 1260 than the reference samples collected near Dungeness Spit. The red rock crab collected near the former Rayonier Mill Site exhibited higher concentrations than the other samples.

Because of widespread use, PCBs have become ubiquitous in the environment and are detectable in most tissues of marine organisms. As part of the National Pesticide Monitoring Program, USFWS analyzed whole fish samples, collected nationwide, for PCB residues (Schmitt et al., 1985). Between 1980 and 1981, 315 composite samples of fish were collected from 107 stations nationwide. PCB residues were detected in 94 percent of all fish, and the geometric mean concentration of all aroclors was 0.53 ppb. An assessment of PCB levels in marine fish and shellfish is also available from the National Oceanic and Atmospheric Administration (NOAA) (1988). The mussel watch project reported that between 1990 and 1996 the average Total-PCB concentrations in whole mussel tissue collected from Cape Flattery was 6.63 ppb DW, with a range of 1.05 ppb to 16.29 ppb DW. During this same period, the average Total-PCB concentrations in mussels collected from Port Angeles Harbor was 27.69 ppb DW, with a range of 3.1 to 58.13 ppb DW. Background concentrations measured in crustaceans from the Arctic Ocean where no

known source of local contamination was present ranged from 480 to 3,000 ppb (Bidleman et al., 1989). Similarly, salmon collected from the Bering Sea and the Pacific Ocean had mean concentrations of 16 ppb. Molluscs (blue mussels) collected from 10 sites in coastal United States waters distant from any known source or known local contamination had total PCB concentrations ranging from 4 to 6 ppb dry weight (NOAA 1988).

3.1.2.3 Other Semivolatile Chemicals

Seventy-two semivolatile chemicals were analyzed in each of the four geoduck and four red rock crab samples. Four semivolatiles were detected in geoduck: 2,4-dinitrophenol, hexachlorobenzene, hexachlorocyclopentadiene, and pyridine. Five were detected in red rock crab: 4-methylphenol, benzoic acid, pentachlorophenol, phenol, and pyridine. Pyridine concentrations in both geoduck and red rock crab samples exceeded EPA's RBC. Pentachlorophenol in red rock crab also exceeded EPA's RBC (Tables 3-5 and 3-6).

Pyridine

Pyridine is a colorless liquid with an unpleasant smell. It can be made from crude coal tar or from other chemicals. Pyridine is used to dissolve other substances. It is also used to make many different products such as medicines, vitamins, food flavorings, paints, dyes, rubber products, adhesives, insecticides, and herbicides. Pyridine can also be formed from the breakdown of many natural materials in the environment. The source of the pyridine found in the biota tissues is not evident. The primary pathway of exposure to man-made sources is air, since pyridine does not typically accumulate in the tissues of animals. Pyridine is also a principal part of many of the base respiratory enzymes including the most abundant, diphosphopyridine nucleotide (DPN). Additionally, current research indicates pyridine-based enzymes are part of the complex mixtures of chemoreceptors that crustaceans use to sense their environment. Upon an organism's death, respiratory enzymes begin to break down, and the pyridine concentrations found may be a resulting breakdown product. Only one geoduck sample exceeded EPA's RBC. This was the sample collected from the reference area near Dungeness Spit. Since pyridine was elevated in reference samples and in one crab sample in the north end of the harbor, the data do not suggest these concentrations reflect a source related to harbor activities.

Pentachlorophenol

Pentachlorophenol is a manufactured chemical not found naturally in the environment. Pure pentachlorophenol occurs as a colorless crystal. The impure form is dark gray to brown dust, beads, or flakes. Pentachlorophenol was used as a biocide and wood preservative. It was one of the most heavily used pesticides in the United States. Only certified applicators can now purchase and use pentachlorophenol. It is still used in industry as a wood preservative for power line poles, railroad ties, cross arms, and fence posts. It is no longer

found in wood preserving solutions or insecticides and herbicides marketed for home and garden use.

Pentachlorophenol generally sticks to soil particles, but its movement in soils depends on the soil's acidity. Very little pentachlorophenol will evaporate into the air. It rapidly degrades in air and soils, but does not easily dissolve in water. In soils and surface waters, microorganisms break it down into other compounds. Pentachlorophenol has been found in fish, but tissue levels are usually low and temporally wide-ranging because pentachlorophenol breaks down in the body of organisms. Only one sample had any pentachlorophenol detected: the easternmost crab sample from Port Angeles Harbor. Since detection limits for the analyte were above the EPA's RBC, the data do not allow inferences regarding the magnitude of the problem or the potential sources.

3.1.2.4 Dioxins and Furans

Dioxin is the common name for a family of chemicals with similar properties and toxicity. Seventy-five different forms of dioxin exist, the most toxic being 2,3,7,8-TCDD. These chemicals are the unintended byproducts of industrial processes that involve chlorine or processes that burn chlorine-containing substances. Soils archived from preindustrial times have been evaluated and contain dioxin, suggesting some dioxin existed in the environment before industrial activities (Agency for Toxic Substances and Disease Registry, 1997). In addition, the fact that dioxins and furans have been distributed throughout the world and now occur throughout the environment, even in places distant from industry, is widely accepted by the scientific and regulatory community. The wide distribution of dioxins and furans, even in areas without industry, is exemplified by research noting levels of 2 to 37 ppt in lipid tissues sampled from polar bears inhabiting the arctic (Agency for Toxic Substances and Disease Registry, 1997), and adipose tissue levels exceeding 200 ppt (2,3,7,8-TCDD [TEQ]) by oceanic dwelling albatross (Jones et al., 1996). Thus, to determine if specific sources within regions have resulted in elevated concentrations and, thereby, additional public health risks, it is helpful to understand the background levels of dioxins that occur.

The concentration of dioxins distributed in fish species throughout the world varies by location and species. Species occupying higher levels in the food chain typically have higher concentrations than those that are lower in the food chain due to the proclivity for dioxin to concentrate in tissue—a process known as bioaccumulation. As part of the EPA dioxin assessment and reassessment programs, EPA sampled more than seven species of predatory, bottom-dwelling species of freshwater and anadromous fish from several areas throughout the country identified as background (EPA, 1992). The background concentration of dioxin in these fish ranged from below analytical detection limits to

3.02 ppt (2,3,7,8 TCDD [TEQ]). Based largely on this data, EPA used a value of 1.19 ppt 2,3,7,8 TCDD (TEQ) as the average exposure concentration resulting from ingestion of marine organisms nationally. The EPA data are comparable to those reviewed by Dr. Nelson Beyer of USFWS. He observed that 90 percent of the fish sampled at nonpolluted areas were found to have body burdens below 5 ppt (sum of all dioxin and furan congeners).

Four investigations have evaluated dioxin and furan concentrations in Port Angeles Harbor. Of these, one is not useful. EPA (1992a) evaluated a sample collected from a pen-reared Atlantic salmon filet raised on the southeastern portion of Ediz Hook. Since dioxin is primarily accumulated through the food chain, and the pen-reared salmon were fed commercial foods, the concentration of dioxins and furans in the tissues is more likely to represent exposure to the dioxin and furan levels in the commercial feed than dioxin and furan levels in Port Angeles Harbor. Additionally, the 1992 investigation did not evaluate all of the congeners, which are measured under current protocols. Thus, the data will underestimate 2,3,7,8-TCDD (TEQ) equivalencies.

In 1991, EPA published a study on crabs in the Puget Sound. As part of this study, six crab pots were placed in Port Angeles Harbor near the former Rayonier Port Angeles Mill. Dungeness Spit was selected as the reference area. Dungeness crab was not caught in sufficient quantities, so one composite sample of three male red rock crabs was evaluated in the Port Angeles Harbor. As part of the study, analyses of muscle tissue was only performed if significant levels of dioxins and furans (defined as greater than 7.5 ppt 2,3,7,8-TCDD (TEQ)) were found in the hepatopancreas. The level found in the crab hepatopancreas from Port Angeles Harbor did not meet this criterion so muscle tissue was not analyzed. Dungeness crab was collected in the reference area and analyzed. The hepatopancreas concentration of the reference area crabs was 2.0 ppt compared to 7.0 ppt in Port Angeles Harbor. In 1995, Rayonier was required by NPDES Permit obtained from the State of Washington to test for dioxin bioaccumulation in indigenous aquatic organisms near its deep water discharge into the Strait of Juan de Fuca. Three composite samples of Dungeness crab muscle tissue were collected near the diffuser and one composite sample was collected approximately five miles east of the diffuser, near Green Point. In general, the dioxin results are comparable to those found during the 1998 EPA ESI investigation. The dioxin congeners detected in at least one sample were OCDD, 1,2,3,4,6,7,8-HpCDD, and 2,3,7,8-TCDF. 2-3-7-8 TCDD (TEQ) concentrations ranged from 0.11 to 0.22 among the three near site samples, and was 0.11 at the reference station.

In 1998, EPA collected crab and geoduck samples from Port Angeles Harbor and Dungeness Spit and sampled muscle tissues for dioxin and furan levels. Three congeners were detected: OCDD, OCDF, and 2,3,7,8-TCDF. 2,3,7,8-TCDD (TEQ) concentrations

found in Red Rock Crab ranged from 0.002 to 0.07 ppt (Figure 3-1). Two samples exceed the EPA's RBC screening concentrations. None of the samples exceed the upper background concentration of 3.08 ppt (TEQ) identified in EPA's (1992a) national study of chemical residues in fish throughout the U.S. No dioxins were detected in the crab sample collected from Dungeness Spit. 2,3,7,8-TCDD (TEQ) concentrations found in geoduck samples ranged from 0.0359 to 0.065 ppt. These samples are all above the EPA screening RBCs. All of these samples were also above the geoduck sample collected near Dungeness spit, but below the upper limit noted previously during a national study. Since the dioxin levels found during the EPA 1998 investigation exceed screening levels, further investigation of the levels found would be helpful.

3.2 KNOWN AND EXPECTED CONTAMINANTS

On the basis of a compilation and examination of the background information and analytical data from the previous studies presented in Section 3.1, several categories of COPCs were identified as either known, or expected to be found in the near-surface soils, subsurface soils, marine sediments, groundwater, and marine biota. They are as follows:

- Toxic inorganics including arsenic, cadmium, chromium, lead, and mercury
- SVOCs, including PAHs
- Dioxins and furans
- PCBs
- Petroleum hydrocarbons

The following sections specifically identify and discuss the primary chemicals of concern (COCs). In general, these chemicals were identified by comparing the maximum levels of chemicals found in the various media during EPA's expanded site investigation and other relevant studies to screening levels available from Ecology and EPA for each medium. This approach is conservative and will, therefore, name found chemicals on site for the RI that will not require subsequent remediation efforts.

Chemicals noted in this section are the primary COCs on site. At times, however, due to lack of data or sampling opportunities, other chemicals may be evaluated and reported. These are specifically detailed in the SAP (Volume II).

All chemicals proposed for evaluation by matrix are summarized in Volume III, Tables 3-2 through 3-5.

3.2.1 Marine Sediments

As discussed in Section 3.1.4, substantial sampling and data analyses were performed as part of the preliminary assessment of the site to determine if further investigation was warranted.

The SMSs provide SQSs as numerical criteria for 47 chemicals or compound groups (this includes the designations total benzofluoranthenes, LPAH, and HPAH which are composites of several chemicals). Table 3-2 provides a comparison of a summary of the EPA 1997 to 1998 data with the SQSs. For some organic chemicals, the SQS criteria are expressed as organic carbon normalized values (i.e., mg chemical/kg sediment organic carbon). At Ecology's request, the SQS values were replaced with their respective bulk sediment chemistry concentrations for this evaluation (Barrick et al., 1988). Overall, 15 chemicals or compound groups were above the SQSs at 12 locations in Port Angeles Harbor (Figure 3-4). Half of these sampling stations (SD01, SD04, SD06, SD11, SD12) are located in the western end of the harbor and are not close to past discharges from the former Rayonier Mill Site. Chemicals that exceed SQSs at the western end of the harbor are inorganic: arsenic, cadmium, copper, mercury, and zinc. Six stations (SD36, SD42, SD43, SD59, SD81, and SD82) near the former Rayonier Mill Site or the extended outfall were above the SMSs for 10 chemicals or compound groups:

- SVOCs—4-methylphenol
- Low-molecular-weight PAHs—fluorene, acenaphthene, phenanthrene, and total LPAH
- High-molecular-weight PAHs—benzo(a)anthracene, chrysene, fluoranthene, pyrene, and total HPAH

These compounds are included as COPCs for the deep water outfall and dock.

The Washington State SQSs predominantly evaluate the chemical effects on marine invertebrates that inhabit the sediment. For chemicals that are bioaccumulative, such as dioxins and furans, concentrations that pose no effect on sediment-inhabiting invertebrates can pose risks to vertebrate animals that inhabit higher trophic levels (e.g., harbor seals or humans). Many of these bioaccumulative chemicals do not have an SQS promulgated and have no other criteria for screening based on concerns of higher trophic level exposure without a site-specific evaluation of risk. Thus, in addition to the COPCs noted above, data collected previously in marine biota were reviewed. Section 3.2.2 identifies those chemicals with a potential for accumulating in tissues and are also included as sediment COPCs.

Information for characterizing sediment quality in the log pond is limited. Therefore, sediment samples in the log pond will be analyzed for the full suite of SMS chemicals in addition to chemicals listed for the deep water outfall and dock.

Some chemicals are associated with wood debris in the log pond and were not evaluated during the EPA ESI. These chemicals are included as COPCs:

- Resin and fatty acids
- Guaiacols

3.2.2 Marine Biota

As discussed in Section 3.1.5, four investigations were conducted to evaluate chemical residues in tissues of marine biota. These are as follows:

- Dioxin and Furan Concentrations in Puget Sound crabs, EPA, 1991b
- National Study of Chemical Residues in Fish, EPA, 1992a
- Port Angeles Bioaccumulation Study, Rayonier, 1995
- Rayonier Pulp Mill Expanded Site Inspection, TDD: 97-06-0010, prepared for EPA Region 10 - START, October 1998; Expanded Site Investigation, E&E (under contract by EPA), 1998

Of the four studies noted above, three focused on dioxins and furans. The fourth, led by E&E (1998), consisted of evaluating a suite of dioxins and furans; semivolatiles, including pesticides and polychlorinated biphenyls, and inorganics. Figure 3-7 depicts the locations of the marine biota samples collected during this study.

The results of the EPA ESI investigation indicated that 32 and 33 chemicals were detected in red rock crab and geoduck, respectively. Chemicals that were not detected in any samples and whose detection limits were adequate to permit evaluation were screened from the COPC list, unless noted below.

Some inorganic chemicals are considered to be trace, mineral nutrients by EPA (1989). Because humans and wildlife have a wide range of tolerance to these chemicals, EPA has not promulgated toxicological criteria and recommends that they be omitted from cleanup actions unless levels are substantially above typical background concentrations. These chemicals are not considered COPCs in any media:

- Calcium
- Magnesium

- Potassium
- Iron

As part of site investigation and screening procedures, EPA has developed RBCs for chemicals in seafood. These levels are intended to be used during the initial phases of a remediation project to identify chemicals that need further evaluation (EPA, 1998). As initial screening levels, the chemical concentrations developed are understood to be conservative. Significantly higher chemical concentrations typically are required before health effects are measurable, or remediation is required. A comparison of the chemicals detected in marine biota to these criteria identified the following chemicals as COPCs:

- Dioxins
- Furans
- Arsenic
- Cadmium
- BHC isomers
- PCBs
- Pentachlorophenol
- Pyridine

Because of the limited number of biota samples, additional chemicals that may have been associated with past site activities were evaluated based on the chemical's potential to bioaccumulate. For nonionic organic chemicals, the octanol water partition coefficient (K_{ow}) was used to evaluate bioaccumulation potential. A K_{ow} is a measure of a chemical's ability to partition to octanol and is correlated with the likelihood of the chemical to bioaccumulate within the food chain. Chemicals with $\log K_{ow}$ less than 4.0 show no bioaccumulation, even in four-tiered food chains (EPA 2000). For inorganic compounds, a literature review was performed to identify bioaccumulation potential. I. Pais and J. B. Jones, Jr. (1997) have published an extensive review and compilation of data on trace elements. In addition, ATSDR's toxicity profiles (ATSDR, 1997) review and document the bioaccumulation potential for many chemicals.

- Finally, chemicals that are known to be bioaccumulative and may have been associated with past mill site activities based on knowledge of site processes and previous detections are: Copper
- Lead

- Mercury
- Selenium
- Zinc
- Polycyclic Aromatic Hydrocarbons (PAHs)
- 4,4' DDE, DDT, and DDD

3.3 CONCEPTUAL SITE MODEL

The conceptual site model for the former Rayonier Mill Site identifies the primary contaminant sources, release mechanisms, transport mechanisms, secondary contaminant sources, potential pathways, and exposure routes. Existing chemical data, approximations of physical transport processes occurring at the former Rayonier Mill Site, and identification of potential human and ecological receptors associated with the former Rayonier Mill Site were used to develop the model. This model helped identify and explain the fate and transport behavior of the chemicals unique to the former Rayonier Mill Site. These data were used to identify the additional data needs that are the focus of this Work Plan.

The model first identifies the primary contaminant sources and then describes the release mechanism from the sources into the receiving environmental media. Using physical transport processes, the migration of potential contaminants through media and the subsequent release mechanisms are summarized. This results in the identification of potentially contaminated media to which receptors are most likely to be exposed (exposure media). Once the exposure media are identified, the specific human and ecological receptors are incorporated into the model, completing the exposure pathway.

The conceptual site model brings together multiple environmental and anthropogenic variables to formulate an understanding of the potential pathways of contaminant movement that may exist at the former Rayonier Mill Site. The model also brings together the physical descriptions of the environment, the extent of the potential contamination, the fate and transport processes, and the potential routes by which human and ecological receptors are exposed to contaminants. In general, the former Rayonier Mill Site model consists of sequential steps that trace potential contaminants from the primary sources to the final receptors (human and ecological).

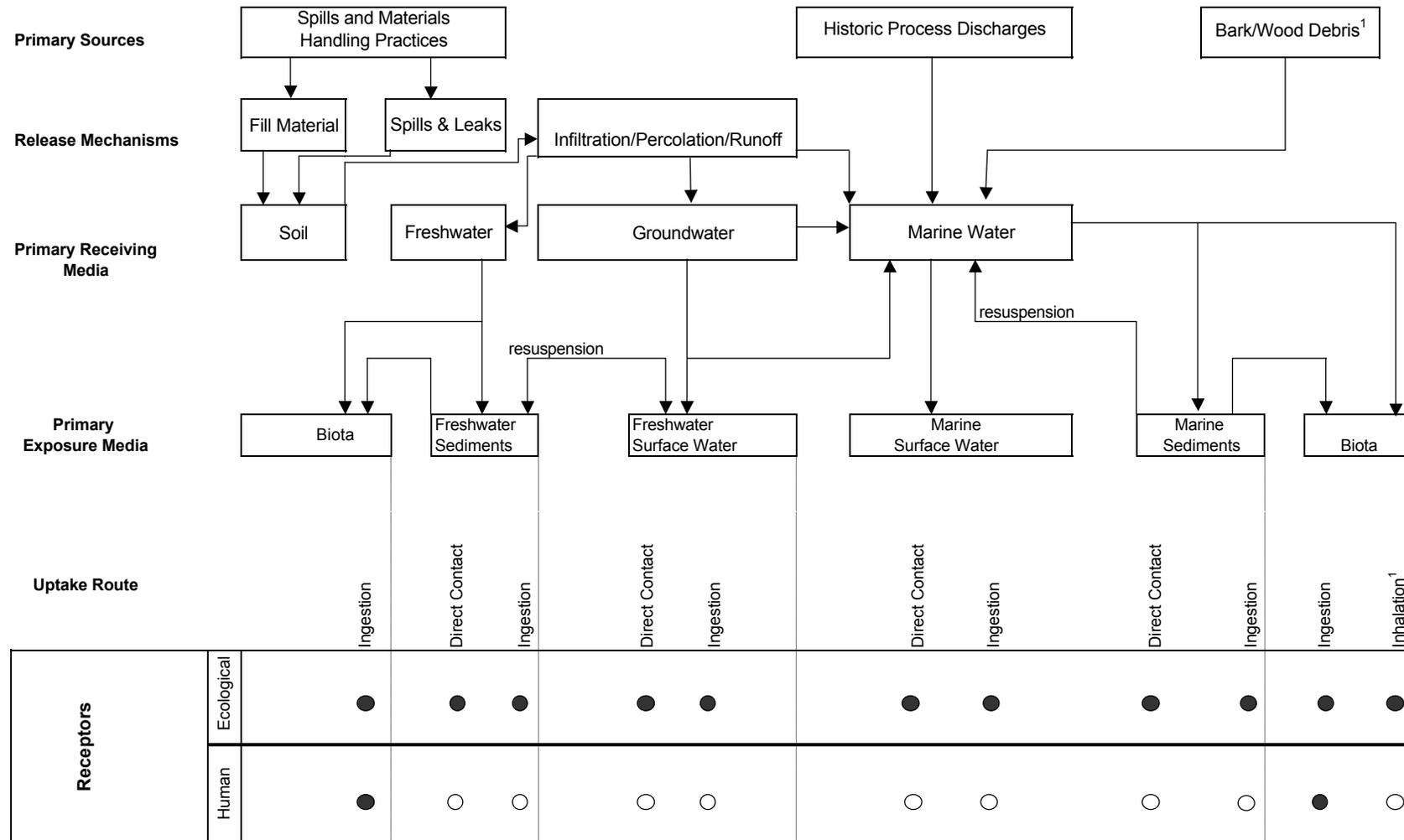
Figure 3-8 shows the uplands conceptual site model for the terrestrial portion of the former Rayonier Mill Site that includes both on-site and adjacent off-site areas. Figure 3-9 shows the marine conceptual site model for the aquatic portion of the former Rayonier Mill Site that includes Ennis Creek and Port Angeles Harbor.

3.3.1 Primary Contaminant Sources

As summarized in Section 2.1 above, the former Rayonier Mill Site used an acid sulfite process for the production of dissolving grade pulps. Wood chips were combined with fortified ammonium bisulfate cooking liquor produced in the acid plant and treated at high temperature and pressure in the digesters. The cellulose fibers (pulp) produced in the digesters were transferred to blow pits and then to red stock washers where the spent cooking liquor was recovered. The pulp was then sent to the bleach plant where chlorine, sodium hydroxide, hydrogen peroxide, sodium hypochlorite, and chlorine dioxide were used to remove noncellulose wood components. The pulp was then passed through several washers before being dried and packaged. The plant was powered by a recovery boiler, a hog fuel boiler, and two auxiliary power boilers that used hog fuel (wood waste), combustible solid process residues, and Bunker C fuel oil as energy sources. Before 1972, mill wastewater and stormwater were discharged directly into five nearshore outfalls in Port Angeles Harbor. After 1972, mill effluents were conveyed to primary and secondary treatment systems before being discharged into Port Angeles Harbor.

The primary sources for potential contaminants have been identified as originating from materials used or coincidentally produced at mill processes, including fuel and hydraulic oils, solvents, and mill process chemicals. Four potential sources have been identified:

- Ash from the boilers—The primary source of ash was the No. 6 hog fuel boiler air pollution control system, which generated fly ash. The chemical classes generally associated with hog fuel/wood waste ash are metals and dioxins/furans.
- Fuel oil leaks and spills from storage tanks, boiler and electrical power operations, and other activities—The chemical classes generally associated with fuel oil are petroleum hydrocarbons, SVOCs, metals, and PCBs.
- Gasoline, diesel, paint, and solvent leaks and spills from various workshops and process areas—The chemical classes associated with these sources are petroleum hydrocarbons, VOCs, SVOCs, and metal, especially lead.
- Bark and wood debris—Bark and wood debris have accumulated in log rafting areas in the log pond potentially causing an oxygen limiting condition.
- Historic process discharges.



- Primary Evaluation Pathway
- Secondary Evaluation Pathway

¹In addition to the effects of chemicals released by wood debris, the CSM also depicts concerns about impacts to biota resulting from the depletion of oxygen in surface and interstitial waters by the wood decomposition process.

Figure 3-8. Conceptual Site Model for Aquatic Pathways

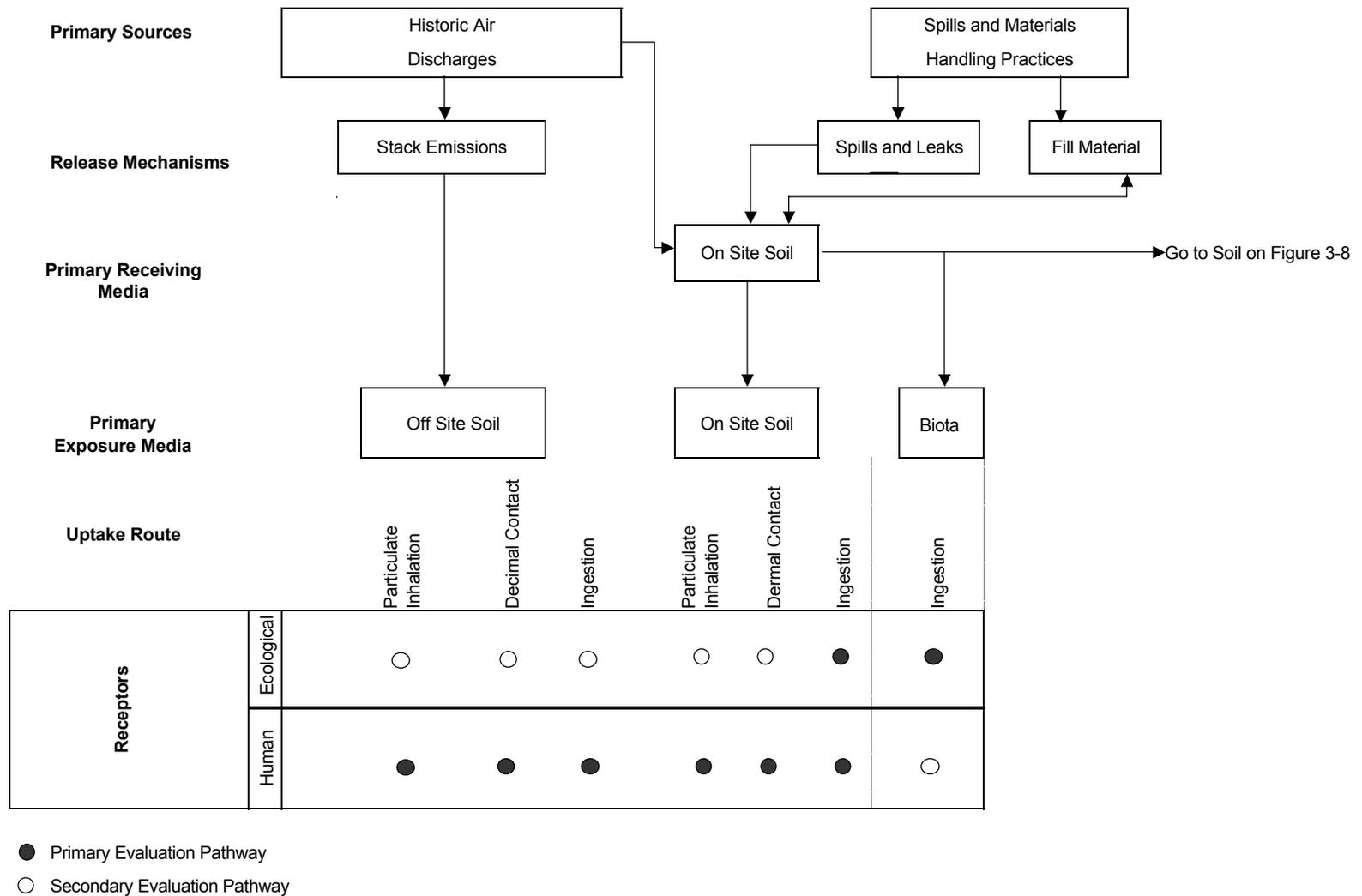


Figure 3-9. Conceptual Site Model for Soil Associated Pathways

Port Angeles is an important urban center on the Olympic Peninsula. It has attracted residential, commercial, and industrial development. A variety of potential sources exists within the area. These sources may have contributed to contamination of the terrestrial environment on the former Rayonier Mill Site and adjacent land and of Port Angeles Harbor. For example, stack emissions from other wood processing facilities in Port Angeles may be potential sources of dioxins/furans found in soils in the area, and discharges from industrial or municipal wastewater treatment facilities may have contributed to the presence of contaminants in Port Angeles Harbor.

3.3.2 Primary Release Mechanisms

The primary release mechanisms for contaminants potentially present on the terrestrial portion of the former Rayonier Mill Site include the following:

- Contaminated fill
- Accidental spills and leaks
- Stack emissions

Contaminants could have been released to the former Rayonier Mill Site by accidental spills of material during daily plant operations (e.g., dry chemicals, fuel, fly ash, and solvents) and by direct ash emissions from the exhaust stacks of the former Rayonier Mill Site boilers.

Particulates suspended in stack emissions precipitated onto soils located on the former Rayonier Mill Site and adjacent land.

For the aquatic portion of the former Rayonier Mill Site, the primary release mechanisms include the following:

- Accidental spills and leaks
- Stack emissions
- Discharge from permitted NPDES wastewater treatment system outfall (Port Angeles Harbor)
- Discharge from nearshore outfalls

Contaminants released onto the soil from accidental spills, leaks, and stack emissions could potentially migrate to Ennis Creek and Port Angeles Harbor through a variety of transport mechanisms. Five nearshore outfalls discharged mill effluent directly into Port Angeles Harbor at different times throughout the period of operations from 1930 to 1972. Primary effluent treatment was implemented in 1972 when the discharge was consolidated to one

deep-water outfall. Secondary effluent treatment was implemented in 1979 and continued until the plant closure in 1997.

3.3.3 Primary Transport Mechanisms

Primary transport mechanisms for contaminants potentially present at the former Rayonier Mill Site include the following:

- Air transport of stack emissions
- Volatilization and wind erosion of chemicals from soil
- Infiltration, percolation, and runoff of chemicals from soil

Particulate and gaseous stack emissions may be transported great distances from the source by the wind. Depending upon particulate sizes and weather conditions, particulate emissions tend to deposit on soil and surfaces of plants and buildings. Particulates that deposit on surfaces of plants and buildings may bind to the surfaces or be washed off by rain to accumulate in the soil.

Chemicals that accumulate in soils can migrate via several transport mechanisms. Chemicals vary in their water solubility and ability to bind with soil particles. Transport of chemicals in soils can occur via volatilization and wind erosion. Some of the chemicals potentially released at the former Rayonier Mill Site readily volatilize and disperse into ambient air. Wind erosion may disperse chemicals adsorbed onto soil particles into the atmosphere as dust. Transport of chemicals adsorbed onto surface soil particles may also occur during storm events through surface water runoff of entrained soil particles. These airborne and waterborne processes could transport chemicals beyond the boundaries of the former Rayonier Mill Site to surrounding land and surface waters.

Chemicals may also desorb from the soil particles into the runoff water and near-surface groundwater. Chemicals dissolved in the runoff water may migrate to Ennis Creek and Port Angeles Harbor. Chemical transport processes in the subsurface soil consist of diffusion and advection processes. These processes are, in part, governed by soil porosity, permeability, and the moisture content of the soils. The diffusion process is dominated by the partitioning of chemicals at the soil and water interface. Once dissolved in the groundwater, chemicals can migrate from the former Rayonier Mill Site into adjacent surface-water bodies. The hydraulic effect of the tidal action and the rewetting of the soil particles at the soil-water interface may cause chemicals, depending on their partitioning coefficient, to desorb from the soil particles at the water interface.

Depending on the permeability of the base material, potential subsurface chemicals that may have leached into the tidal zone influence region could be transported through the material

by tidal actions. While the diffusion process, governed by the partitioning of the chemicals at the soil and water interface, is potentially occurring, the transport mechanism is likely dominated by particle entrainment in the tidal water due to physical actions of tidal fluctuations. Thus, particles may be transported through the groundwater to a sediment-water interface in the intertidal zone. Tidal actions may cause the release of the soil particles from the fill matrix into the water. As a result of these mechanisms, chemicals (both dissolved and particulate forms) may be transported to the sediment-water interface of the harbor in the intertidal zone. Currently, this potential is significantly reduced because all stormwater is now collected and processed through the treatment system.

3.3.4 Secondary Sources

Based on the potential physical transport pathways present at the former Rayonier Mill Site, environmental media potentially affected by chemical releases from the former Rayonier Mill Site include air, surface and subsurface soils, near-surface groundwater, and sediments and surface waters in Ennis Creek and Port Angeles Harbor. These media can act as secondary sources that dynamically interact among themselves in terms of chemical migration. They can also act as sources for uptake of chemicals into plants and animals. Once a chemical is taken up by a plant or animal, it enters a food web where it can be transferred to animals at all trophic levels, including human. Chemicals that are highly bioaccumulative pose the greatest concern once they enter a food web.

3.3.5 Potential Pathway and Exposure Routes

Potential exposure routes for human and ecological receptors include the following:

- **Dermal Contact**—Dermal contact with soil on site is a primary route of exposure to current and future on-site workers. It is also a primary pathway of concern for off-site individuals at residences where chemicals were deposited as a result of airborne emissions. Vertebrate wildlife tend to have thick fur coats or feathers, which serve as barriers to chemicals that they contact in the soil. However, such wildlife spend a great deal of time grooming, and this leads to an increase in the potential for incidental soil ingestion as noted below.
- **Inhalation**—Suspended particulates from soil can be transported by air and inhaled by potential on-site and off-site receptors. Emissions of volatile chemicals from soil and groundwater (human receptors only) may also be transported as vapors by air, but are considered to be pathways of secondary concern because, in ambient conditions, such vapors are rapidly diluted and degraded.

- **Ingestion**—Accidental ingestion of chemicals in the soil on site, or in the soil that received particulates from stack emissions off site, and the ingestion of chemicals in terrestrial and marine tissue are primary routes of exposure to both human and wildlife receptors.

The following section describes specific exposure pathways of primary concern.

3.3.5.1 Exposure Pathways of Concern

Complete exposure pathways by which a study area can reach potential receptors include the following:

- *Historical Air Discharges*—Chemicals were emitted from the stacks on the former Rayonier Mill Site at various rates throughout the operations. Many of these chemicals (e.g., sulfur) were volatiles and rapidly dissipated to concentrations that would presently be undetectable in the environment. Other chemicals (e.g., dioxins) are much more persistent and are typically associated with the particulate phase of the emission. As these particulates are emitted, they settle or deposit into the surface soil both on and off site at differing rates according to particle size, wind speed, rainfall, and other environmental factors. Exposure to these chemicals via ingestion of soil, dermal contact with soil, and particulate inhalation, for both off-site and on-site human receptors, is a primary pathway. Because the off-site area is predominantly urban, exposure to ecological receptors is of secondary concern.
- *Spills and Materials Handling Practices*—During mill operations, various materials that were stored directly on unpaved portions of the former Rayonier Mill Site were handled, or were accidentally spilled into soil. Chemicals released as a result of storage practices and accidental spills would first enter either the surface or subsurface soil. Ingestion, dermal contact, and particulate inhalation of these chemicals are complete exposure pathways for on-site workers. Ecological receptors in the riparian and vegetated areas of the former Rayonier Mill Site are also potentially impacted by these exposure pathways.

Hydrophilic chemicals present in the soil are likely to be transported to the shallow groundwater at this site. Once in groundwater, the chemicals may be transported to freshwater in Ennis Creek or to saltwater in Port Angeles Harbor. The two water bodies are cold throughout the year and have restricted access. Human exposure dermally or through incidental ingestion is, therefore, unlikely to be significant. Dermal contact and incidental ingestion are, therefore, pathways of secondary concern. Dermal contact and ingestion of chemicals by wildlife inhabiting these

surface water bodies, as influenced by the groundwater, are primary exposure pathways for further consideration.

- *Marine Discharges*—During the mill operation, process discharges to the marine environment occurred in Port Angeles Harbor. These discharges contained chemicals, many of which were water-soluble. Dilution of chemicals in such a large volume of water would likely lower their concentration to levels that would no longer be detectable in the marine water or the sediments. Other chemicals primarily associated with the particulates in the process discharge may have settled into the sediments in the harbor. As noted above, because of the temperature of the harbor, human exposure to the marine water or the marine sediments is not a primary concern. Because of the salinity, ingestion is also not likely.

Exposure to the water and sediments by ecological receptors inhabiting the marine environment is a primary concern, both through direct contact with the two environmental matrices and as incidental ingestion. Chemicals that are lipophilic and reside in the sediments may accumulate in the various marine biota inhabiting the harbor. Consumption of these biota by both higher food chain ecological receptors and humans are exposure pathways of primary concern.

- *Wood and Bark Debris*—The area immediately next to the former Rayonier Mill Site, referred to as the log pond, was used for storing and rafting logs before processing. While rafted, bark and small slivers of wood would fall from the logs during wave action and be deposited on the sediments. Additionally, logs that became soaked with water would also sink to the bottom. As the wood debris, particularly bark, decomposes in the marine environment, it can be a source of persistent chemicals (e.g., tannin, lignin, resin, acid, guaiacol, and phenol), which, can have toxic effects on sediment-dwelling organisms at high concentrations. Additionally, nonpersistent chemicals such as ammonia and sulphur are also produced by the decomposition process. While these chemicals typically dissipate rapidly to levels not associated with toxic effects when exposed to the water column, interstitial levels can accumulate to pose a risk to sediment dwelling organisms. Since none of these chemicals is likely to be bioaccumulative, human health risks from wood debris are of secondary concern, but exposure pathways to sediment dwelling organisms in contact with and ingesting the sediments and the interstitial water in this area are of primary concern.