Letter Health Consultation

Port Angeles Harbor
Evaluation of Exposure to Surface Sediments

Port Angeles, Clallam County, Washington

March 16, 2015

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

DOH 334-365 March 2015

Foreword

The Washington State Department of Health (DOH) prepared this health consultation in accordance with the Agency for Toxic Substances and Disease Registry (ATSDR) methodologies and guidelines. Health consultations are initiated in response to health concerns raised by community members or agencies about exposure to hazardous substances released into the environment. The health consultation summarizes our health findings and if needed, provides steps or actions to protect public health.

The findings in this report are relevant to conditions at the site during the time the report was written. It should not be relied upon if site conditions or land use changes in the future.

This report was supported by funds provided through a cooperative agreement with the ATSDR, U.S. Department of Health and Human Services. The findings and conclusions in these reports are those of the author(s) and do not necessarily represent the views of the ATSDR or the U.S. Department of Health and Human Services. This document has not been revised or edited to conform to agency standards.

Use of trade names is for identification only and does not imply endorsement by state or federal health agencies.

For additional information, please contact us at 1-877-485-7316 or visit our web site at www.doh.wa.gov/consults.

For persons with disabilities this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TDD/TTY call 711).

For more information about ATSDR, contact the CDC Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
OFFICE OF ENVIRONMENTAL HEALTH, SAFETY AND TOXICOLOGY
243 Israel Road SE • PO Box 47846 • Olympia, Washington 98504-7846
TDD Relay Service: 1-800-833-6388

March 16, 2015

Clallam County
Environmental Health Services
223 E 4th St #14
Port Angeles, WA 98362

Re: Letter Health Consultation
Port Angeles Harbor Sediments
Port Angeles, Clallam County, Washington

Dear Ms. Garcelon:

At the request of Clallam County Environmental Health Services, the Washington State Department of Health (DOH) evaluated the risk of recreational exposure to surface sediment for the Port Angeles Harbor site. The purpose of this document is to assess the health threat posed by exposure to hazardous substances in surface sediment at this site and recommend steps or actions to protect public health. Health consultations are initiated in response to health concerns raised by residents or agencies about exposure to hazardous substances. This letter health evaluation is limited to beach/intertidal sediments from Port Angeles Harbor and recreational exposures only. Recent sediment data available from Washington State Department of Ecology (Ecology) was used in the screening process.(1-3) Based on the evaluation of the sediment data, exposure to surface sediments is not expected to result in harmful human health effects. DOH has no public health recommendations for this site regarding exposure to sediments.

Background and Statement of Issues

Port Angeles Harbor is located in Clallam County, Washington. Historically, Port Angeles Harbor has supported wood products industries, recreational marinas, and boat industries.(4) Port Angeles Harbor was identified by Ecology, under the Toxics Cleanup Program's Puget Sound Initiative, for focused sediment cleanup and source control. Past and current commercial and industrial activities in Port Angeles Harbor include cargo handling, boat manufacturing, marina operations, plywood manufacturing, pulp and paper mills, fishing enterprises, and ferry services.

Hog fuel boilers (HFB) around Port Angeles were identified by Ecology as major contributors to dioxin present in soils. One operational HFB (Nippon Paper Industries) and three historical HFBs (Fibreboard, K-Ply, and Rayonier) exist around Port Angeles Harbor.(1) Nippon Paper

Industries currently employs over 200 employees and produces telephone directory paper to North American and Australian customers.(5) Rayonier Mills is a former pulp facility cleanup site located on the southeast end of the harbor. Ecology is planning the cleanup of this site under an agreed order.(6) K Ply, a former plywood mill also known as PenPly, is also under an Ecology agreed order.(7) In addition to cleanup sites around the harbor, there are combined sewer overflows (CSOs) from the City of Port Angeles that discharge into the harbor. Non-point source runoff from stormwater and residential/commercial land use also discharges from creeks that run into the harbor.(4) Harbor features (point and non-point sources) identified in the final report of the 2013 Port Angeles Harbor Sediment Dioxin Source Study Port Angeles Harbor (1) can be viewed in Figure 1, below.

Although there are various cleanup sites and environmental concerns around Port Angeles Harbor, recreational activities continue. During warmer summer months in particular, there are reports of activities such as beachcombing, wading in the water, rowing, and kayaking where people are exposed to intertidal sediments.(8) This letter health consultation will address concerns about recreational exposures to sediments by assessing human health risks from these exposures using recent sediment data made available by Ecology.(1-3)

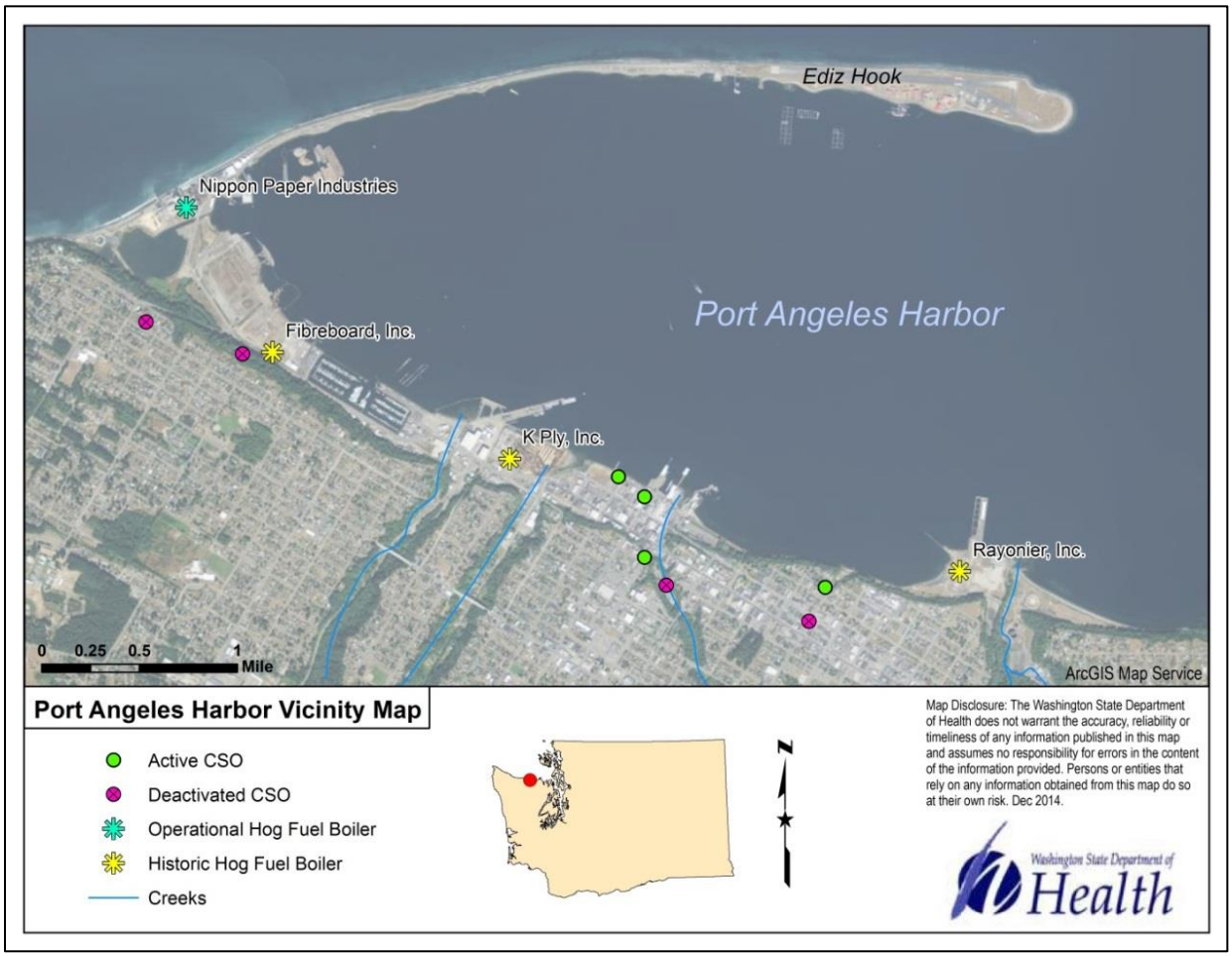

Figure 1: Port Angeles Harbor Vicinity Map with Point and Non-point Sources of Pollution, Clallam County, WA.

Discussion

Screening of Chemical Contaminants

Contaminants of concern (COCs) in sediments were determined by employing a screening process. Maximum sediment contaminant levels were screened against health-based soil comparison values. Several types of health-based comparison or SVs were used during this process. Comparison values such as the "cancer risk evaluation guide" (CREG) and "environmental media evaluation guide" (EMEG) offer a high degree of protection and assurance that people are unlikely to be harmed by contaminants in the environment. For chemicals that cause cancer, the comparison values represent levels that are calculated to increase the theoretical risk of cancer by about one in a million. In general, if a contaminant's maximum concentration is greater than its comparison value, then the contaminant is evaluated further.

Comparisons may also be made with legal standards such as the cleanup levels specified in the Washington State toxic waste cleanup regulation, the Model Toxics Control Act (MTCA). Legal standards may be strictly health-based or incorporate non-health considerations such as cost, practicality of attainment, or natural background levels.

Since people are generally not exposed to surface sediments from depths greater than 10 feet, screening was applied to sediments samples that are relevant to human exposures. These samples are comprised of surface sediment located up to 10 feet or less underwater and will be referred to as "beach/intertidal" sediment samples. To view screening of beach/intertidal sediments, see Appendix A – Preliminary Screening of Surface Sediments. Table 1, below, displays the COCs identified from preliminary screening. COCs will be further evaluated in an exposure assessment that incorporates human recreational activities and incidental ingestion, inhalation, and dermal absorption of these contaminants.

Table 1. Chemicals found in Beach/Intertidal Sediments Exceeding Health-based Comparison Values, Port Angeles Harbor, Clallam County, WA.

Contaminant	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
cPAH BaP-EQ	0.133	0.096	B2	CREG	Yes
Total Dioxin TEQ	0.000094	0.00005	B2	EMEG	Yes

CREG - ATSDR's Cancer Risk Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
cPAH BaP-EQ – carcinogenic polycyclic aromatic hydrocarbons benzo(a)pyrene-equivalents
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)

Exposure Assessment

There are many factors that determine whether an exposure will cause adverse health effects. Factors include the concentration of chemicals a person is exposed to, duration of exposure, how chemicals enter the person (through touching, eating, and/or breathing), other chemicals a person is exposed to, an individual's age, health and nutritional status.(9) An exposure assessment uses environmental data to estimate doses of chemicals people are exposed to and predicts the risk of non-cancer and cancer health effects, when applicable, for each chemical. Exposure assumptions for this site can be viewed in Appendix B – Exposure Assumptions and Equations. Non-cancer and cancer risk results can be viewed in Appendix C – Non-Cancer Exposure Assessment and Appendix D – Cancer Exposure Assessment.

There are no non-cancer health effects expected from recreational exposure to beach/intertidal sediments at Port Angeles Harbor. Cancer risk is predicted to be low (approximately five in a million).

Conclusions

There is no apparent public health hazard with recreational exposures to beach/intertidal surface sediments at Port Angeles Harbor.

Recommendations

DOH does not have any public health recommendations regarding exposure to sediments at this time. We appreciate this opportunity to assist you with these technical issues. Please contact Amy Leang at 360-236-3357 if you have any questions.

Sincerely,

Amy Leang/Lenford O'Garro
Site Assessments and Toxicology Section

Enclosures (4)

cc: Joanne Snarski, Department of Health

Appendix A – Preliminary Screening of Surface Sediments

Table A1. Beach/Intertidal Surface Sediment Screening with Health Comparison Levels, Port Angeles Harbor, Clallam County, WA.

Chemical	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	0.59	20	D	RMEG	No
Arsenic	9.9	15	A	EMEG	No
Barium	53	10,000	CN	EMEG	No
Cadmium	5.9	5	B1	EMEG	No
Chromium	40	50*		EMEG	No
Copper	61	500	D	IM EMEG	No
Lead	84.5	250	B2	MTCA	No
Mercury	0.59	15**	D	EMEG	No
Nickel	62	1,000		RMEG	No
Selenium	0.6				No
Silver	0.18	250	D	RMEG	No
Zinc	320	15,000	D	EMEG	No
Sulfide	1220	2800000* (H2S)		RSL	No
Ammonia	21.3	32,000 #			No
Diesel #2	110	2,000		MTCA	No
Motor Oil	370	2,000		MTCA	No
1-Methylnaphthalene	0.019				No
2-Methylnaphthalene	0.024	2,000		EMEG	No
Acenaphthene	0.034	3,000		RMEG	No
Acenaphthylene	0.019	3,000*		RMEG	No
Anthracene	0.043	15,000	D	RMEG	No
Fluorene	0.039	2,000	D	RMEG	No
Naphthalene	0.095	1,000	CN	RMEG	No
Phenanthrene	0.18	2,000*	D		No
Benzo(b)fluoranthene	0.12	2,000* 0.15	B2	RMEG RSL	No Yes (cPAH)
Benzo(k)fluoranthene	0.13	2,000* 1.5	B2	RMEG RSL	No Yes (cPAH)
Benzo(a)anthracene	0.089	2,000* 0.15	B2	RMEG RSL	No Yes (cPAH)
Benzo(a)pyrene	0.094	2,000* 0.096	B2	RMEG CREG	No Yes (cPAH)
Benzo(ghi)perylene	0.033	2,000*	D		No
Chrysene	0.14	2,000* 15	B2	RMEG RSL	No Yes (cPAH)
Dibenz(a,h)anthracene	0.019	2,000* 0.096**		RMEG CREG	No Yes (cPAH)

Table A1 continued

Chemical	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Fluoranthene	0.41	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.03	2,000* 0.15	B2	RMEG RSL	No Yes (cPAH)
Pyrene	0.029	1,500	D	RMEG	No
4-Methylphenol (p-Cresol)	0.37	3,000*	C	RMEG	No
Phenol	0.11	20,000	D	RMEG	No
2-Methylphenol (o-Cresol)	0.019	1,000*	C	RMEG	No
Pentachlorophenol	0.097	1.8	B2	CREG	No
Bis(2-ethylhexyl)phthalate	0.13	50	B2	CREG	No
Butyl benzyl phthalate	0.073	10,000	C	RMEG	No
Diethyl phthalate	0.019	40,000	D	RMEG	No
Di-n-butyl phthalate	0.019	5,000		RMEG	No
Dimethyl phthalate (1,4)*	0.019	5,000*		RMEG	No
Di-n-octyl phthalate	0.019	20,000		IM EMEG	No
4,4'-DDD	0.027	2.9	B2	CREG	No
4,4'-DDE	0.0058	2.1	B2	CREG	No
4,4'-DDT	0.017	2.1	B2	CREG	No
Aldrin	0.0021	0.041	B2	CREG	No
alpha-BHC	0.00077	0.11	B2	CREG	No
beta-BHC	0.0045	0.39	C	CREG	No
cis- Chlordane	0.00032	2*	KL	CREG	No
delta-BHC	0.0028	0.39*	C	CREG	No
Dieldrin	0.0012	0.044	B2	CREG	No
Endosulfan I	0.00051	100*		EMEG	No
Endosulfan II	0.0016				
Endosulfan Sulfate	0.0015				
Endrin	0.00066	15	D	EMEG	No
Endrin Aldehyde	0.0011	15*	D	EMEG	No
Endrin Ketone	0.0011				
gamma- Chlordane	0.0006	2*	KL	CREG	No
Heptachlor	0.00049	0.16	B2	CREG	No
Heptachlor Epoxide	0.0018	0.077	B2	CREG	No
Lindane	0.0022	15* (gamma BHC)	C	RMEG	No
Methoxychlor	0.0057	250	D	RMEG	No
Toxaphene	0.043	0.64	B2	CREG	No
Retene	0.2	15,000* Anthracene		RMEG	No

Table A1 continued

Chemical	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
12-Chlorodehydroabietic Acid	0.096				
14-Chlorodehydroabietic Acid	0.096				
1-Phenanthrenecarboxylic acid	5				
9,10-Dichlorstearic Acid	0.096				
Abietic Acid	4.8				
Dehydroabietic Acid	3.2				
Dichlorodehydroabietic Acid	0.096				
Isopimaric Acid	1.4				
Linoleic Acid	0.79				No
Linolenic Acid	0.096				
Neoabietic Acid	0.68				
Oleic Acid	0.096				
Oleic- Linolenic Acid mixture	0.97				
Palustric Acid	0.64				
Pimaric Acid	0.096				
Sanaracopimaric Acid	0.096				
Isophorone	0.019	740	C	CREG	No
3,4,5-Trichloroguaiacol	0.019	15,000* (phenol)	D	RMEG	No
3,4,6-Trichloroguaiacol	0.02				
3,4-Dichloroguaiacol	0.02				
4, 5,6-Trichloroguaiacol	0.019				
4,5-Dichloroguaiacol	0.019				
4,6-Dichloroguaiacol	0.02				
4-Chloroguaiacol	0.02				
Guaiacol	0.019				
Tetrachloroguaiacol	0.02				
1,2,4-Trichlorobenzene	0.019	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.019	15,000		EMEG	No
1,3-Dichlorobenzene	0.019	1,000		IM EMEG	No
1,4-Dichlorobenzene	0.019	3,500		EMEG	No
Hexachlorobenzene	0.019	0.44	B2	CREG	No
Hexachlorobutadiene	0.019	9	C	CREG	No
2,4,5-Trichlorophenol	0.097	5000		RMEG	No
2,4,6-Trichlorophenol	0.097	64	B2	CREG	No
2,4-Dichlorophenol	0.097	150		RMEG	No
2,4-Dimethylphenol	0.019	1,000		RMEG	No
2,4-Dinitrophenol**	0.19	100		RMEG	No
2,4-Dinitrotoluene	0.097	100		EMEG	No
2,6-Dinitrotoluene	0.097	200		IM EMEG	No
2-Chloronaphthalene	0.019	4,000		RMEG	No
2-Chlorophenol	0.019	250		RMEG	No

Table A1 continued

Chemical	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
2-Nitroaniline	0.097	61		RSL	No
2-Nitrophenol	0.097	100**		RMEG	No
4,6-Dinitro-2-Methylphenol	0.19	200		IM EMEG	No
4-Chloro-3-Methylphenol	0.097	250***		RMEG	No
4-Chlorophenyl-phenyl ether	0.019	2,500*** biphenyl		RMEG	No
4-Nitroaniline	0.097	24		RSL	No
4-Nitrophenol	0.097	100**		RMEG	No
Carbazole	0.019	24			No
Nitrobenzene	0.019	100		RMEG	No
Hexachlorocyclopentadiene	0.097	37		RSL	No
N-Nitrosodi-n-propylamine	0.097	0.1	B2	CREG	No
N-Nitrosodiphenylamine	0.019	140	B2	CREG	No
4-Bromophenyl phenyl ether	0.019	2,500*** biphenyl		RMEG	No
2,2'-Oxybis[1-chloropropane]	0.019	4,500 1,2-Dichloropropane		EMEG	No
Bis(2-Chloroethoxy)methane	0.019	18		RSL	No
Bis(2-Chloroethy)Ether	0.019	0.21		RSL	No
Hexachloroethane	0.019	18		CREG	No
Dibenzofuran	0.041	78	D	RSL	No
Benzoic Acid	0.26	200,000	D	RMEG	No
Total PCBs	0.23	0.35		CREG	No
cPAH BaP-EQ	0.133	0.096			Yes
Total Dioxin TEQ	0.000094	0.00005	B2	EMEG	Yes

CREG - ATSDR's Cancer Risk Evaluation Guide (child)
RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - data qualifier: The associated numerical result is an estimate
A - EPA: Human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
D - EPA: Not classifiable as to health carcinogenicity
RSL - EPA: Regional Screening Level
* Acenapthene RMEG value was used as a surrogate
* Fluoranthene RMEG value was used as a surrogate
** Benzo(a)pyrene CREG value was used as a surrogate
***Tributyltin oxide EMEG value was used as a surrogate
cPAH BaP-EQ – carcinogenic polycyclic aromatic hydrocarbons benzo(a)pyrene-equivalents
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
MTCA - Washington State Model Toxics Control Act
Maximum allowable ammonium bicarbonate is some food (baked goods, grains, snacks, and reconstituted vegetables)

Appendix B – Exposure Assumptions and Equations

Table B1: Exposure Assumptions for Oral, Dermal, and Inhalation Routes, Port Angeles Harbor, Clallam County, WA.

Parameter	Units	Age Group								
		Child 6 wks to <1 yr	Child 1 to <2 yr	Child 2 to <6 yr	Child 6 to <11 yr	Child 11 to <16 yr	Child 16 to <21 yr	Adults ≥21 yr	Adults 9 yrs Resident*	Adults 33 yrs Resident**
Concentration (C)	mg/kg (ppm)	Variable; maximum detected value								
Conversion Factor (CF)	kg/mg	0.000001; converts concentration from mg/kg								
Ingestion Rate (IR)	mg/day	60	100	100	100	100	100	50	50	50
Exposure Frequency (EF)	days/yr	90; approximates recreational activity for summer months								
Exposure Duration (ED)	yrs	0.88	1	4	5	5	5	12	9	33
Body Weight (BW)	kg	9.2	11.4	17.4	31.8	56.8	71.6	80	80	80
Surface Area (SA)	cm^2	3625	5300	7600	10800	15900	18400	19450	19450	19450
Averaging Time (AT)	days	321.2	365	1460	1825	1825	1825	4380	3285	12045
Cancer Averaging Time (AT)	days	28470 (equivalent to 78 years)								
Cancer Slope Factor (CSF)	$(mg/kg/day)^{-1}$	Variable								
24-Hr Absorption Factor (ABS)	unitless	Variable; PAHs - 0.13, Dioxin - 0.03, other inorganics - 0.01								
Oral Route Adjustment Factor (ORAF)	unitless	1; default								
Adherance Duration (AD)	days	1; default								
Adherance Factor (AF)	mg/cm^2	0.1						0.04		
Inhalation Rate (IHR)	m^3/day	8	5.4	10.1	12	15.2	16.3	14.7	14.7	14.7
Soil Matrix Factor (SMF)	unitless	1; default								
Particulate Emission Factor (PEF)	m^3/kg	600000000; model parameter default for 0% grass cover								

*Mean number of years an adult lives at one residence
** 95^{th} Percentile number of years an adult lives at one residence
ppm: parts per million; kg: kilogram; mg: milligram; yr: year; cm^2: centimeter squared
m^3: meters cubed; $(mg/kg/day)^{-1}$; inverse of milligram per kilogram per day

Exposure dose and cancer risk calculations:

Exposure assumptions given in Table B1 and B2 above were used with the following equations to estimate contaminant doses a person in each general age group would receive from recreational exposure to contaminants in beach/intertidal surface sediments. Doses were then used to calculate hazard quotients (See Appendix C). For carcinogenic contaminants of concern, cancer risk was also calculated in addition to hazard quotients.

Total Dose from Sediment = Ingestion dose + Dermal dose + Inhalation dose

Ingestion Route

$$\text{Dose}_{\text{non-cancer}} = \frac{C \times CF \times IR \times EF \times ED}{BW \times AT_{non-cancer}}$$

$$\text{Cancer Risk} = \frac{C \times CF \times IR \times EF \times CPF \times ED}{BW \times AT_{cancer}}$$

Dermal Route

$$\text{Dermal Transfer (DT)} = \frac{C \times AF \times ABS \times AD \times CF}{ORAF}$$

$$\text{Dose}_{\text{non-cancer}} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{non-cancer}}$$

$$\text{Cancer Risk} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{cancer}}$$

Inhalation Route

$$\text{Dose}_{\text{non-cancer}} = \frac{C \times IR \times EF \times ED \times SMF \times (\frac{1}{PEF})}{BW \times AT}$$

$$\text{Cancer Risk} = \frac{C \times IR \times EF \times ED \times SMF \times CSF \times (\frac{1}{PEF})}{BW \times AT_{cancer}}$$

Appendix C – Non-Cancer Exposure Assessment

After the dose is calculated, it is compared to ATSDR Minimal Risk Levels (MRLs) or the EPA Reference Dose (RfD) when the MRL is not available. MRLs and RfDs are levels at which no adverse health effects are expected. Hazard quotients (HQs) are calculated to assess potential non-cancer health effects. When HQs are equal to or below 1, no adverse health effects are expected.

Table C1: Non-Cancer Exposure Doses and Hazard Calculations for Beach/Intertidal Surface Sediments, Port Angeles Harbor, Clallam County, WA.

Contaminant	Concentration (ppm)	Age Group	Estimated Dose (mg/kg/day)			Total Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient (Total Dose/MRL)
			Incidental Ingestion	Dermal Contact	Inhalation of Particulates			
cPAH BaP-EQ	0.133	Child 6 wks to < 1 yr	2.1E-07	1.7E-07	4.8E-11	3.8E-07	4.0E-01	9.5E-07
		Child 1 to < 2 yr	2.9E-07	2.0E-07	2.6E-11	4.9E-07		1.2E-06
		Child 2 to < 6 yr	1.9E-07	1.9E-07	3.2E-11	3.7E-07		9.4E-07
		Child 6 to < 11 yr	1.0E-07	1.4E-07	2.1E-11	2.5E-07		6.2E-07
		Child 11 to <16 yr	5.8E-08	1.2E-07	1.5E-11	1.8E-07		4.4E-07
		Child 16 to <21 yr	4.6E-08	1.1E-07	1.2E-11	1.6E-07		3.9E-07
		Adults ≥ 21 yr	2.0E-08	4.1E-08	1.0E-11	6.2E-08		1.5E-07
Total Dioxin TEQ	0.000094	Child 6 wks to < 1 yr	1.5E-10	2.7E-11	3.4E-14	1.8E-10	1.0E-09	0.18
		Child 1 to < 2 yr	2.0E-10	3.2E-11	1.8E-14	2.4E-10		0.24
		Child 2 to < 6 yr	1.3E-10	3.0E-11	2.2E-14	1.6E-10		0.16
		Child 6 to < 11 yr	7.3E-11	2.4E-11	1.5E-14	9.7E-11		0.10
		Child 11 to <16 yr	4.1E-11	1.9E-11	1.0E-14	6.0E-11		0.060
		Child 16 to <21 yr	3.2E-11	1.8E-11	8.8E-15	5.0E-11		0.050
		Adults ≥ 21 yr	1.4E-11	6.8E-12	7.1E-15	2.1E-11		0.021

cPAH BaP-EQ – carcinogenic polycyclic aromatic hydrocarbons benzo(a)pyrene-equivalents
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
ppm: parts per million; mg/kg/day: milligrams per kilogram body weight per day
*Agency for Toxic Substances and Disease Registry Minimal Risk Level (MRL)
Fluoranthene Intermediate Oral MRL used for PAHs – hepatic/liver health endpoint
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin Chronic Oral MRL used for Dioxin – developmental health endpoint

Appendix D – Cancer Exposure Assessment

Table D1: Cancer Risks Calculated for Beach/Intertidal Surface Sediments Exposure, Port Angeles Harbor, Clallam County, WA.

Contaminant	Concentration (ppm)	EPA Cancer Class	Slope Factor $(mg/kg/day)^{-1}$	Age Group	Increased Cancer Risk			Total Cancer Risk
					Incidental Ingestion	Dermal Contact	Inhalation	
cPAH BaP-EQ	0.133	B2	7.3	Child 6 wks to <1 yr	1.8E-08	1.4E-08	3.9E-12	3.1E-08
				Child 1 to <2 yr	2.7E-08	1.9E-08	2.4E-12	4.5E-08
				Child 2 to <6 yr	7.1E-08	7.0E-08	1.2E-11	1.4E-07
				Child 6 to <11 yr	4.8E-08	6.8E-08	9.7E-12	1.2E-07
				Child 11 to <16 yr	2.7E-08	5.6E-08	6.8E-12	8.3E-08
				Child 16 to <21 yr	2.1E-08	5.1E-08	5.8E-12	7.3E-08
				Adults 21 yr+	2.3E-08	4.7E-08	1.1E-11	7.0E-08
Total Dioxin TEQ	0.000094	B2	1.50E+05	Child 6 wks to <1 yr	2.6E-07	4.6E-08	5.7E-11	3.0E-07
				Child 1 to <2 yr	3.9E-07	6.2E-08	3.5E-11	4.5E-07
				Child 2 to <6 yr	1.0E-06	2.3E-07	1.7E-10	1.3E-06
				Child 6 to <11 yr	7.0E-07	2.3E-07	1.4E-10	9.3E-07
				Child 11 to <16 yr	3.9E-07	1.9E-07	9.9E-11	5.8E-07
				Child 16 to <21 yr	3.1E-07	1.7E-07	8.5E-11	4.8E-07
				Adults 21 yr+	3.3E-07	1.6E-07	1.6E-10	4.9E-07
Total Lifetime Cancer Risk								**5.1E-06**

Total Cancer Risk for Residential Adult (9 years at residence, mean): 5.2E-08 from cPAH BaP-EQ, 3.7E-07 from Total Dioxin TEQ
Total Cancer Risk for Residential Adult (33 years at residence, 95th percentile): 1.9E-07 from cPAH BaP-EQ, 1.3E-06 from Total Dioxin TEQ

cPAH BaP-EQ – carcinogenic polycyclic aromatic hydrocarbons benzo(a)pyrene-equivalents
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
ppm: parts per million; $(mg/kg/day)^{-1}$: inverse of milligrams per kilogram body weight per day
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)

References

(1) NewFields. Port Angeles Harbor Sediment Dioxin Source Study, Final Report. 2013.

(2) Ecology & Environment. Port Angeles Harbor Sediment Characterization Study, Port Angeles, Washington - Sediment Investigation Report. 2012.

(3) WindWard Environmental LLC. Former Rayonier Mill in Port Angeles Interim Action Report Volume II: Marine Data Summary Report. 2014.

(4) Dutch M, Long E, Kammin W, Redman S. Puget Sound Ambient Monitoring Program: Marine Sediment Monitoring Component - Final Quality Assurance Project and Implementation Plan. 31. 1998. Olympia, WA, Washington State Department of Ecology.

(5) Washington State Department of Ecology. Nippon Paper Industries USA, Co. Ltd. 2014. 12-23-2014.

(6) Washington State Department of Ecology. Rayonier Mill Cleanup Progress. 2014. 12-23-2014.

(7) Washington State Department of Ecology, National Oceanic and Atmospheric Administration. Sediment Quality in Puget Sound Year 3 - Southern Puget Sound. 2002.

(8) Jennifer Garcelon. Site Visit to Port Angeles Harbor with Clallam County Staff. 2015. 2-17-2015.

(9) Agency for Toxic Substances and Disease Registry (ATSDR). Public Health Assessment Guidance Manual (Update). 2005.