Exh. RXS-13

PSE Notice of Construction Application for Tacoma LNG (Excerpts) (5/22/2017)

(Publicly Available at https://pscleanair.gov/DocumentCenter/View/2684/PSE-TacomaLNG-NOCApplication?bidId=)

Notice of Construction Application
Supporting Information Report
Tacoma Liquefied Natural Gas Facility
Tacoma, Washington

May 22, 2017

Prepared for

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area HAP source. In addition, LNG storage associated with the Tacoma LNG Project will occur downstream of the point of custody transfer from the transmission company to the local distribution company (PSE). PSE operates no natural gas transmission facilities. For both of these reasons, this NESHAP does not apply.

3.5.4 Subpart JJJJJJ: National Emissions Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers Area Sources (Not Applicable)

NESHAP Subpart JJJJJJ applies to area source boilers combusting certain types of fuel. Boilers burning exclusively natural gas are exempt from coverage and process heaters are not within the definition of boilers. Therefore, the Tacoma LNG Project's two heaters and LNG vaporizer, which are exclusively gas-fired, are not subject to this NESHAP.

3.6 Toxic Air Pollutants and tBACT

As a new source, the Tacoma LNG Project is required to conduct a Toxic Air Pollutant (TAP) evaluation if maximum uncontrolled emissions of TAPs would be greater than the *de minimis* values identified in WAC 173-460-150, as adopted in Regulation III, Section 2.07. Each listed TAP has an established *de minimis* level, a Small-Quantity Emission Rate (SQER), and an Acceptable Source Impact Level (ASIL). If the TAP emission rate from a source is above its *de minimis* level and SQER, further determination of compliance with the ASIL is required.

Table 7 below shows the estimated TAP emission rate and *de minimis* value for each pollutant (further details on the emission calculations are provided in Section 2 and Appendix B). As shown in Table 5, emission estimates indicate that 12 TAPs require review for the Tacoma LNG Project under Chapter 173-460 WAC. Best Available Control Technology (BACT) for TAPs (tBACT) requirements are addressed in Section 4 and the ambient air quality assessment is addressed in Section 5.

Table 7: Project Emissions Compared to Small-Quantity Emission Rates

Pollutant	CAS Number	Averaging Period	Emission Rate	*De Minimis*[a]	SQER[a]	Review Required?
			(pounds per averaging period)			
3-Methylchloranthrene	56-49-5	Year	0.00061	0.00153	0.0305	--
7,12-Dimethylbenz(a)anthracene	57-97-6	Year	0.0054	0.000135	0.00271	Yes
Benzo(a)anthracene	56-55-3	Year	0.00061	0.0872	1.74	--
Benzene	71-43-2	Year	56	0.331	6.62	Yes
Benzo(a)pyrene	50-32-8	Year	0.00041	0.00872	0.174	--
Benzo(b)fluoranthene	205-99-2	Year	0.00061	0.0872	1.74	--
Benzo(k)fluoranthene	207-08-9	Year	0.00061	0.0872	1.74	--

Pollutant	CAS Number	Averaging Period	Emission Rate	*De Minimis*[a]	SQER[a]	Review Required?
			(pounds per averaging period)			
Chrysene	218-01-9	Year	0.00062	0.0872	1.74	--
Dibenz(a,h)anthracene	53-70-3	Year	0.00042	0.00799	0.16	--
Ethylbenzene	100-41-4	Year	3.1	3.84	76.8	--
Formaldehyde	50-00-0	Year	34	1.6	32	Yes
n-Hexane	110-54-3	24-hour	1.9	4.6	92	--
Hydrogen sulfide	7783-06-4	24-hour	0.26	0.0131	0.263	Yes
Indeno(1,2,3-cd)pyrene	193-39-5	Year	0.00069	0.0872	1.74	--
Naphthalene	91-20-3	Year	0.20	0.282	5.64	--
Toluene	108-88-3	24-hour	0.16	32.9	657	--
m-Xylene	108-38-3	24-hour	0.050	1.45	29	--
o-Xylene	95-47-6	24-hour	0.0084	1.45	29	--
p-Xylene	106-42-3	24-hour	0.050	1.45	29	--
Arsenic	--	Year	0.068	0.00291	0.0581	Yes
Beryllium	--	Year	0.0041	0.004	0.08	Yes
Cadmium	7440-43-9	Year	0.37	0.00228	0.0457	Yes
Cobalt	7440-48-4	24-hour	0.000075	0.000657	0.013	--
Copper	--	1-hour	3.2E-05	0.011	0.219	--
Lead and compounds	--	Year	0.17	10	16	--
Manganese	--	24-hour	0.00034	0.000263	0.00526	Yes
Mercury	7439-97-6	24-hour	0.00026	0.000591	0.0118	--
Selenium	--	24-hour	7.0E-05	0.131	2.63	--
Vanadium	7440-62-2	24-hour	0.0020	0.00131	0.0263	Yes
Carbon monoxide	630-08-0	1-hour	9.9	1.14	50.4	Yes
Nitrogen dioxide	10102-44-0	1-hour	3.0	0.457	1.03	Yes
Sulfur dioxide	7446-09-05	1-hour	3.0	0.457	1.45	Yes

[a] WAC 173-460-150

3.7 Chemical Accident Prevention (40 CFR 68) (Not Applicable)

Federal Risk Management Program requirements do not apply to LNG facilities that transport or store incident to such transport-regulated substances. As the EPA has explained:

> EPA has expressly provided that the RMP regulations do not apply to on-shore LNG facilities to the extent they transport or store incident to such transport regulated

Table B-2
Combusted Gas Characteristics
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Parameters	Natural Gas[a]	Flared Waste Gas[a]				
		Case 1	Case 2	Case 3	Case 4	Case 5
Heat Content (Btu/scf)	1,093	330	427	1,654	882	1,821
Density (lb/scf)	0.046	0.103	0.083	0.090	0.099	0.088
Sulfur Content (ppmw)	166	41	36	527	257	192
VOC Content (wt%)	NA	9.4%	14%	51%	25%	58%
Benzene Concentration ($\mu g/m^3$)[b]	2,980	2,980	2,980	2,980	2,980	2,980
Ethylbenzene Concentration ($\mu g/m^3$)[b]	144	144	144	144	144	144
m,p-Xylene Concentration ($\mu g/m^3$)[b]	986	986	986	986	986	986
o-Xylene Concentration ($\mu g/m^3$)[b]	165	165	165	165	165	165
Toluene Concentration ($\mu g/m^3$)[b]	2,570	2,570	2,570	2,570	2,570	2,570

Notes:

[a] Provided by CB&I.

[b] From "Natural Gas Analysis"; Environmental Partners, Inc.; February 3, 2014. Most hazardous air pollutants (HAPs) will go through with the heavy hydrocarbons, but the fraction is unknown. Therefore, we conservatively assume the waste gas has the full concentration of HAP.

Table B-3
Potential Emissions from Vaporizer
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Emission Factor (lb/MMcf)	Potential Emissions	
		Hourly[a] (lbs/hr)	Annual[b] (tons/yr)
Criteria Pollutants			
$PM/PM_{10}/PM_{2.5}$	7.6 (1)	0.46	0.055
SO_2	15 [c]	0.9	0.11
NO_x	12 (2)	0.72	0.086
CO	40 (2)	2.4	0.29
VOCs	5.5 (1)	0.33	0.040
Lead	0.0005 (1)	3.0E-05	3.6E-06
Hazardous Air Pollutants/Toxic Air Pollutants			
Arsenic	2.0E-04 (3)	1.3E-08	1.4E-06
Benzene	2.1E-03 (3)	1.4E-07	1.5E-05
Beryllium	1.2E-05 (3)	7.9E-10	8.7E-08
Cadmium	1.1E-03 (3)	7.3E-08	8.0E-06
Chromium(total)	1.4E-03 (3)	9.2E-08	1.0E-05
Cobalt	8.4E-05 (3)	5.5E-09	6.1E-07
Copper	8.5E-04 (3)	5.6E-08	6.2E-06
Formaldehyde	7.5E-02 (3)	5.0E-06	5.4E-04
Hexane	1.8E+00 (3)	1.2E-04	1.3E-02
Lead	5.0E-04 (1)	3.3E-08	3.6E-06
Manganese	3.8E-04 (3)	2.5E-08	2.8E-06
Mercury	2.6E-04 (3)	1.7E-08	1.9E-06
Naphthalene	6.1E-04 (3)	4.0E-08	4.4E-06
Nickel	2.1E-03 (3)	1.4E-07	1.5E-05
Polycyclic Organic Matter	7.0E-04 (3)	4.6E-08	5.1E-06
2-Methylnaphthalene	*2.4E-05 (3)*	*1.6E-09*	*1.7E-07*
3-Methylchloranthrene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
7,12-Dimethylbenz(a)anthracene	*1.6E-05 (3)*	*1.1E-09*	*1.2E-07*
Acenaphthene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
Acenaphthylene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
Anthracene	*2.4E-06 (3)*	*1.6E-10*	*1.7E-08*
Benz(a)anthracene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
Benzo(a)pyrene	*1.2E-06 (3)*	*7.9E-11*	*8.7E-09*
Benzo(b)fluoranthene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
Benzo(g,h,i)perylene	*1.2E-06 (3)*	*7.9E-11*	*8.7E-09*
Benzo(k)fluoranthene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
Chrysene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
Dibenzo(a,h)anthracene	*1.2E-06 (3)*	*7.9E-11*	*8.7E-09*
Fluoranthene	*3.0E-06 (3)*	*2.0E-10*	*2.2E-08*
Fluorene	*2.8E-06 (3)*	*1.8E-10*	*2.0E-08*
Indeno(1,2,3-cd)pyrene	*1.8E-06 (3)*	*1.2E-10*	*1.3E-08*
Naphthalene	*6.1E-04 (3)*	*4.0E-08*	*4.4E-06*
Phenanathrene	*1.7E-05 (3)*	*1.1E-09*	*1.2E-07*
Pyrene	*5.0E-06 (3)*	*3.3E-10*	*3.6E-08*
Selenium	2.4E-05 (3)	1.6E-09	1.7E-07
Vanadium	2.3E-03 (3)	1.5E-07	1.7E-05
Toluene	3.4E-03 (3)	2.2E-07	2.5E-05
Total HAPs		**0.00012**	**0.014**

Calculations:

[a] Hourly Emissions (lb/hr) = [Maximum Heat Input (MMBtu/hr)] / [Fuel Heating Value (Btu/scf)] x [Emission Factor (lb/MMcf)]

[b] Annual Emissions (tons/yr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)] x [Operating Hours (hrs/yr)] / [2,000 lbs/ton]

Maximum Heat Input (MMBtu/hr) =	66	(4)
Fuel Heating Value (Btu/scf) =	1,093	(5)
Projected Hours of Operation (hrs/yr) =	240	(4)

[c] SO_2 Emission Factor (lb/MMcf) = [Natural Gas Density (lb/cf)] x [Sulfur Content (ppm)] / 10^6 x [2 g-SO_2/g-S] x [10^6 cf/MMcf]

Natural gas density (lb/cf) =	0.046	(5)
Sulfur Content of Fuel (ppmw) =	166	(5)

[d] Pollutant Emission Rate (lb/MMscf) = [Pollutant concentration by volume, dry basis (ppm_{dv})] x ([Maximum Fuel Usage (scf/hr)] x [Fuel Heating Value (Btu/scf)] x [Combustion Gas Generated (dscf/MMBtu)] x [Pollutant Molecular Weight (lb/lb-mole)] x [2.59×10^{-9} lb-mole/dscf per ppm] + [CO_2 Volume in Waste Gas (dscf/hr)]) x [20.9 / (20.9 - Percent Oxygen)]

Pollutant Concentration NO_X (ppm) =	9	(2)
Pollutant Concentration CO (ppm) =	50	(2)
Percent Oxygen =	3	(2)
Flue Gas Generated (dscf/MMBtu) =	8,710	(6)

Notes:

(1) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42.
(2) Vendor design specifications provided by CB&I.
(3) EPA. 1998b. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-3: Emission Factors for Speciated Organic Compounds from Natural Combustion. AP-42. Office of Air
(4) See rates in Table B-1.
(5) See fuel characteristics in Table B-2.
(6) NSPS Subpart D.

Table B-4
Case 1: Potential Emissions from Enclosed Ground Flare Burners
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Emission Factor (lb/MMBtu)			Potential Emissions	
				Hourly[a] (lbs/hr)	Annual[b] (tons/yr)
Criteria Pollutants					
$PM/PM_{10}/PM_{2.5}$	0.0075	lb/MMBtu	(1)	0.076	0.33
SO_2	8.4	lb/MMscf	[c]	0.26	1.1
NO_x	0.06	lb/MMBtu	(2)	0.61	2.7
CO	0.2	lb/MMBtu	(2)	2.0	8.9
VOCs	97	lb/MMscf	[d]	3.0	13
Lead	4.9E-07	lb/MMBtu	(1)	5.0E-06	2.2E-05
Hazardous Air Pollutants/Toxic Air Pollutants					
Arsenic	2.0E-07	lb/MMBtu	(3)	2.0E-06	8.7E-06
Benzene	1.7E-04	lb/MMBtu	[e]	1.7E-03	7.6E-03
Beryllium	1.2E-08	lb/MMBtu	(3)	1.2E-07	5.2E-07
Cadmium	1.1E-06	lb/MMBtu	(3)	1.1E-05	4.8E-05
Chromium(total)	1.4E-06	lb/MMBtu	(3)	1.4E-05	6.1E-05
Cobalt	8.2E-08	lb/MMBtu	(3)	8.4E-07	3.7E-06
Copper	8.3E-07	lb/MMBtu	(3)	8.5E-06	3.7E-05
Ethylbenzene	8.2E-06	lb/MMBtu	[e]	8.4E-05	3.7E-04
Formaldehyde	7.4E-05	lb/MMBtu	(3)	7.5E-04	3.3E-03
Hexane	1.8E-03	lb/MMBtu	(3)	1.8E-02	7.9E-02
Hydrogen sulfide	4.5E-02	lb/MMscf	[f]	1.4E-03	6.1E-03
Lead	4.9E-07	lb/MMBtu	(1)	5.0E-06	2.2E-05
Manganese	3.7E-07	lb/MMBtu	(3)	3.8E-06	1.7E-05
Mercury	2.5E-07	lb/MMBtu	(3)	2.6E-06	1.1E-05
Naphthalene	6.0E-07	lb/MMBtu	(3)	6.1E-06	2.7E-05
Nickel	2.1E-06	lb/MMBtu	(3)	2.1E-05	9.2E-05
Polycyclic Organic Matter	6.8E-07	lb/MMBtu	(3)	7.0E-06	3.1E-05
2-Methylnaphthalene	*2.4E-08*	*lb/MMBtu*	*(3)*	*2.4E-07*	*1.0E-06*
3-Methylchloranthrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
7,12-Dimethylbenz(a)anthracene	*1.6E-08*	*lb/MMBtu*	*(3)*	*1.6E-07*	*7.0E-07*
Acenaphthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
Acenaphthylene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
Anthracene	*2.4E-09*	*lb/MMBtu*	*(3)*	*2.4E-08*	*1.0E-07*
Benz(a)anthracene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
Benzo(a)pyrene	*1.2E-09*	*lb/MMBtu*	*(3)*	*1.2E-08*	*5.2E-08*
Benzo(b)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
Benzo(g,h,i)perylene	*1.2E-09*	*lb/MMBtu*	*(3)*	*1.2E-08*	*5.2E-08*
Benzo(k)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
Chrysene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
Dibenzo(a,h)anthracene	*1.2E-09*	*lb/MMBtu*	*(3)*	*1.2E-08*	*5.2E-08*
Fluoranthene	*2.9E-09*	*lb/MMBtu*	*(3)*	*3.0E-08*	*1.3E-07*
Fluorene	*2.7E-09*	*lb/MMBtu*	*(3)*	*2.8E-08*	*1.2E-07*
Indeno(1,2,3-cd)pyrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*1.8E-08*	*7.9E-08*
Naphthalene	*6.0E-07*	*lb/MMBtu*	*(3)*	*6.1E-06*	*2.7E-05*
Phenanathrene	*1.7E-08*	*lb/MMBtu*	*(3)*	*1.7E-07*	*7.4E-07*
Pyrene	*4.9E-09*	*lb/MMBtu*	*(3)*	*5.0E-08*	*2.2E-07*
Selenium	2.4E-08	lb/MMBtu	(3)	2.4E-07	1.0E-06
Toluene	1.5E-04	lb/MMBtu	[e]	1.5E-03	6.5E-03
Vanadium	2.3E-06	lb/MMBtu	(3)	2.3E-05	1.0E-04
m,p-Xylene	5.6E-05	lb/MMBtu	[e]	5.7E-04	2.5E-03
o-Xylene	9.4E-06	lb/MMBtu	[e]	9.6E-05	4.2E-04
Total HAPs				**0.023**	**0.10**

Calculations:

[a] Hourly Emissions (lb/hr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)]

[b] Annual Emissions (tons/yr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)] x [Operating Hours (hrs/yr)] / [2,000 lbs/ton]

Heat Input (MMBtu/hr) =	10	(4)
Projected Hours of Operation (hrs/yr) =	8,760	(4)
Maximum Gas Flow (scf/hr) =	30,833	(4)

[c] SO_2 Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [64 g-SO_2/32 g-S] x [Destruction Efficiency (%)] x [10^6 cf/MMcf]

Gas Density (lb/cf) =	0.103	(5)
Sulfur Content of Gas (ppmw) =	41	(5)
Destruction Efficiency (%) =	99%	(2)

[d] Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [VOC Content (wt%)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

VOC Concentration (wt%) =	9.4%	(5)

[e] Emission Factor (lb/MMBtu) = [Gas Density (lb/cf)] x [Pollutant Concentration (µg/m^3)] / [453.6 g/lb] / [10^6 µg/g] / [35.31 ft^3/m^3] / [Natural Gas Heating Value (Btu/scf)] x [1 - Destruction Efficiency (%)] x [10^6 Btu/MMBtu]

Benzene Concentration (µg/m^3) =	2,980	(5)
Ethylbenzene Concentration (µg/m^3) =	144	(5)
m,p-Xylene Concentration (µg/m^3) =	986	(5)
o-Xylene Concentration (µg/m^3) =	165	(5)
Toluene Concentration (µg/m^3) =	2,570	(5)
Natural Gas Heating Value (Btu/scf) =	1,093	(5)

[f] H_2S Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [34 g-H_2S/32 g-S] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Notes:

(1) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42. Office of Air Quality Planning and
(2) Vendor design specifications provided by CB&I.
(3) EPA. 1998b. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-3: Emission Factors for Speciated Organic Compounds from Natural Combustion. AP-42. Office of Air Quality Planning and Standards, US
(4) See rates in Table B-1.
(5) See fuel characteristics in Table B-2.

Table B-5
Case 2: Potential Emissions from Enclosed Ground Flare Burners
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Emission Factor (lb/MMcf)			Potential Emissions: Hourly[a] (lbs/hr)	Potential Emissions: Annual[b] (tons/yr)
Criteria Pollutants					
$PM/PM_{10}/PM_{2.5}$	0.0075	lb/MMBtu	(1)	0.019	0.081
SO_2	6.0	lb/MMscf	[c]	0.035	0.15
NO_X	0.06	lb/MMBtu	(2)	0.15	0.65
CO	0.2	lb/MMBtu	(2)	0.50	2.2
VOCs	118	lb/MMscf	[d]	0.69	3.0
Lead	4.90E-07	lb/MMBtu	(1)	1.2E-06	5.3E-06
Hazardous Air Pollutants/Toxic Air Pollutants					
Arsenic	2.0E-07	lb/MMBtu	(3)	4.9E-07	2.1E-06
Benzene	1.7E-04	lb/MMBtu	[e]	4.2E-04	1.9E-03
Beryllium	1.2E-08	lb/MMBtu	(3)	2.9E-08	1.3E-07
Cadmium	1.1E-06	lb/MMBtu	(3)	2.7E-06	1.2E-05
Chromium(total)	1.4E-06	lb/MMBtu	(3)	3.4E-06	1.5E-05
Cobalt	8.2E-08	lb/MMBtu	(3)	2.1E-07	9.0E-07
Copper	8.3E-07	lb/MMBtu	(3)	2.1E-06	9.1E-06
Ethylbenzene	8.2E-06	lb/MMBtu	[e]	2.0E-05	9.0E-05
Formaldehyde	7.4E-05	lb/MMBtu	(3)	1.8E-04	8.0E-04
Hexane	1.8E-03	lb/MMBtu	(3)	4.4E-03	1.9E-02
Hydrogen sulfide	3.2E-02	lb/MMscf	[f]	1.9E-04	8.2E-04
Lead	4.9E-07	lb/MMBtu	(1)	1.2E-06	5.3E-06
Manganese	3.7E-07	lb/MMBtu	(3)	9.3E-07	4.1E-06
Mercury	2.5E-07	lb/MMBtu	(3)	6.3E-07	2.8E-06
Naphthalene	6.0E-07	lb/MMBtu	(3)	1.5E-06	6.5E-06
Nickel	2.1E-06	lb/MMBtu	(3)	5.1E-06	2.2E-05
Polycyclic Organic Matter	6.8E-07	lb/MMBtu	(3)	1.7E-06	7.5E-06
2-Methylnaphthalene	*2.4E-08*	*lb/MMBtu*	*(3)*	*5.9E-08*	*2.6E-07*
3-Methylchloranthrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
7,12-Dimethylbenz(a)anthracene	*1.6E-08*	*lb/MMBtu*	*(3)*	*3.9E-08*	*1.7E-07*
Acenaphthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
Acenaphthylene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
Anthracene	*2.4E-09*	*lb/MMBtu*	*(3)*	*5.9E-09*	*2.6E-08*
Benz(a)anthracene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
Benzo(a)pyrene	*1.2E-09*	*lb/MMBtu*	*(3)*	*2.9E-09*	*1.3E-08*
Benzo(b)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
Benzo(g,h,i)perylene	*1.2E-09*	*lb/MMBtu*	*(3)*	*2.9E-09*	*1.3E-08*
Benzo(k)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
Chrysene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
Dibenzo(a,h)anthracene	*1.2E-09*	*lb/MMBtu*	*(3)*	*2.9E-09*	*1.3E-08*
Fluoranthene	*2.9E-09*	*lb/MMBtu*	*(3)*	*7.3E-09*	*3.2E-08*
Fluorene	*2.7E-09*	*lb/MMBtu*	*(3)*	*6.8E-09*	*3.0E-08*
Indeno(1,2,3-cd)pyrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*4.4E-09*	*1.9E-08*
Naphthalene	*6.0E-07*	*lb/MMBtu*	*(3)*	*1.5E-06*	*6.5E-06*
Phenanathrene	*1.7E-08*	*lb/MMBtu*	*(3)*	*4.2E-08*	*1.8E-07*
Pyrene	*4.9E-09*	*lb/MMBtu*	*(3)*	*1.2E-08*	*5.3E-08*
Selenium	2.4E-08	lb/MMBtu	(3)	5.9E-08	2.6E-07
Toluene	1.5E-04	lb/MMBtu	[e]	3.7E-04	1.6E-03
Vanadium	2.3E-06	lb/MMBtu	(3)	5.6E-06	2.5E-05
m,p-Xylene	5.6E-05	lb/MMBtu	[e]	1.4E-04	6.1E-04
o-Xylene	9.4E-06	lb/MMBtu	[e]	2.3E-05	1.0E-04
Total HAPs				**0.006**	**0.02**

Calculations:

[a] Hourly Emissions (lb/hr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)]

[b] Annual Emissions (tons/yr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)] x [Operating Hours (hrs/yr)] / [2,000 lbs/ton]

Heat Input (MMBtu/hr) =	2.5	(4)
Projected Hours of Operation (hrs/yr) =	8,760	(4)
Maximum Gas Flow (scf/hr) =	5,833	

[c] SO_2 Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [64 g-SO_2/32 g-S] x [Destruction Efficiency (%)] x [10^6 cf/MMcf]

Gas Density (lb/cf) =	0.083	(5)
Sulfur Content of Gas (ppmw) =	36	(5)
Destruction Efficiency (%) =	99%	(2)

[d] Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [VOC Content (wt%)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

VOC Concentration (wt%) =	14%	(5)

[e] Emission Factor (lb/MMBtu) = [Gas Density (lb/cf)] x [Pollutant Concentration (µg/m^3)] / [453.6 g/lb] / [10^6 µg/g] / [35.31 ft^3/m^3] / [Natural Gas Heating Value (Btu/scf)] x [1 - Destruction Efficiency (%)] x [10^6 Btu/MMBtu]

Benzene Concentration (µg/m^3) =	2,980	(5)
Ethylbenzene Concentration (µg/m^3) =	144	(5)
m,p-Xylene Concentration (µg/m^3) =	986	(5)
o-Xylene Concentration (µg/m^3) =	165	(5)
Toluene Concentration (µg/m^3) =	2,570	(5)
Natural Gas Heating Value (Btu/scf) =	1,093	(5)

[f] H_2S Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [34 g-H_2S/32 g-S] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Notes:

(1) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42. Office of Air Quality Planning and

(2) Vendor design specifications provided by CB&I.

(3) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42. Office of Air Quality Planning and

(4) See rates in Table B-1.

(5) See fuel characteristics in Table B-2.

Table B-6
Case 3: Potential Emissions from Enclosed Ground Flare Burners
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Emission Factor (lb/MMcf)			Potential Emissions	
				Hourly[a] (lbs/hr)	Annual[b] (tons/yr)
Criteria Pollutants					
$PM/PM_{10}/PM_{2.5}$	0.0075	lb/MMBtu	(1)	0.26	1.1
SO_2	94	lb/MMscf	[c]	2.0	8.5
NO_x	0.06	lb/MMBtu	(2)	2.1	9.1
CO	0.2	lb/MMBtu	(2)	6.9	30
VOCs	459	lb/MMscf	[d]	9.6	42
Lead	4.90E-07	lb/MMBtu	(1)	1.7E-05	7.4E-05
Hazardous Air Pollutants/Toxic Air Pollutants					
Arsenic	2.0E-07	lb/MMBtu	(3)	6.8E-06	3.0E-05
Benzene	1.7E-04	lb/MMBtu	[e]	5.9E-03	2.6E-02
Beryllium	1.2E-08	lb/MMBtu	(3)	4.1E-07	1.8E-06
Cadmium	1.1E-06	lb/MMBtu	(3)	3.7E-05	1.6E-04
Chromium(total)	1.4E-06	lb/MMBtu	(3)	4.7E-05	2.1E-04
Cobalt	8.2E-08	lb/MMBtu	(3)	2.8E-06	1.2E-05
Copper	8.3E-07	lb/MMBtu	(3)	2.9E-05	1.3E-04
Ethylbenzene	8.2E-06	lb/MMBtu	[e]	2.8E-04	1.2E-03
Formaldehyde	7.4E-05	lb/MMBtu	(3)	2.5E-03	1.1E-02
Hexane	1.8E-03	lb/MMBtu	(3)	6.1E-02	2.7E-01
Hydrogen sulfide	5.0E-01	lb/MMscf	[f]	1.0E-02	4.6E-02
Lead	4.9E-07	lb/MMBtu	(1)	1.7E-05	7.4E-05
Manganese	3.7E-07	lb/MMBtu	(3)	1.3E-05	5.6E-05
Mercury	2.5E-07	lb/MMBtu	(3)	8.8E-06	3.8E-05
Naphthalene	6.0E-07	lb/MMBtu	(3)	2.1E-05	9.0E-05
Nickel	2.1E-06	lb/MMBtu	(3)	7.1E-05	3.1E-04
Polycyclic Organic Matter	6.8E-07	lb/MMBtu	(3)	2.4E-05	1.0E-04
2-Methylnaphthalene	*2.4E-08*	*lb/MMBtu*	*(3)*	*8.1E-07*	*3.6E-06*
3-Methylchloranthrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
7,12-Dimethylbenz(a)anthracene	*1.6E-08*	*lb/MMBtu*	*(3)*	*5.4E-07*	*2.4E-06*
Acenaphthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
Acenaphthylene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
Anthracene	*2.4E-09*	*lb/MMBtu*	*(3)*	*8.1E-08*	*3.6E-07*
Benz(a)anthracene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
Benzo(a)pyrene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.1E-08*	*1.8E-07*
Benzo(b)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
Benzo(g,h,i)perylene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.1E-08*	*1.8E-07*
Benzo(k)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
Chrysene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
Dibenzo(a,h)anthracene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.1E-08*	*1.8E-07*
Fluoranthene	*2.9E-09*	*lb/MMBtu*	*(3)*	*1.0E-07*	*4.4E-07*
Fluorene	*2.7E-09*	*lb/MMBtu*	*(3)*	*9.5E-08*	*4.1E-07*
Indeno(1,2,3-cd)pyrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.1E-08*	*2.7E-07*
Naphthalene	*6.0E-07*	*lb/MMBtu*	*(3)*	*2.1E-05*	*9.0E-05*
Phenanathrene	*1.7E-08*	*lb/MMBtu*	*(3)*	*5.7E-07*	*2.5E-06*
Pyrene	*4.9E-09*	*lb/MMBtu*	*(3)*	*1.7E-07*	*7.4E-07*
Selenium	2.4E-08	lb/MMBtu	(3)	8.1E-07	3.6E-06
Toluene	1.5E-04	lb/MMBtu	[e]	5.1E-03	2.2E-02
Vanadium	2.3E-06	lb/MMBtu	(3)	7.8E-05	3.4E-04
m,p-Xylene	5.6E-05	lb/MMBtu	[e]	1.9E-03	8.5E-03
o-Xylene	9.4E-06	lb/MMBtu	[e]	3.2E-04	1.4E-03
Total HAPs				**0.077**	**0.34**

Calculations:

[a] Hourly Emissions (lb/hr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)]

[b] Annual Emissions (tons/yr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)] x [Operating Hours (hrs/yr)] / [2,000 lbs/ton]

Heat Input (MMBtu/hr) =	34	(4)
Projected Hours of Operation (hrs/yr) =	8,760	(4)
Maximum Gas Flow (scf/hr) =	20,833	

[c] SO_2 Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [64 g-SO_2/32 g-S] x [Destruction Efficiency (%)] x [10^6 cf/MMcf]

Gas Density (lb/cf) =	0.090	(5)
Sulfur Content of Gas (ppmw) =	527	(5)
Destruction Efficiency (%) =	99%	(2)

[d] Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [VOC Content (wt%)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

VOC Concentration (wt%) =	51%	(5)

[e] Emission Factor (lb/MMBtu) = [Gas Density (lb/cf)] x [Pollutant Concentration ($\mu g/m^3$)] / [453.6 g/lb] / [10^6 $\mu g/g$] / [35.31 ft^3/m^3] / [Natural Gas Heating Value (Btu/scf)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Benzene Concentration ($\mu g/m^3$) =	2,980	(5)
Ethylbenzene Concentration ($\mu g/m^3$) =	144	(5)
m,p-Xylene Concentration ($\mu g/m^3$) =	986	(5)
o-Xylene Concentration ($\mu g/m^3$) =	165	(5)
Toluene Concentration ($\mu g/m^3$) =	2,570	(5)
Natural Gas Heating Value (Btu/scf) =	1,093	(5)

[f] H_2S Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [34 g-H_2S/32 g-S] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Notes:

(1) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42. Office of Air Quality Planning and
(2) Vendor design specifications provided by CB&I.
(3) EPA. 1998b. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-3: Emission Factors for Speciated Organic Compounds from Natural Combustion. AP-42. Office of Air Quality Planning and Standards, US
(4) See rates in Table B-1.
(5) See fuel characteristics in Table B-2.

Table B-7
Case 4: Potential Emissions from Enclosed Ground Flare Burners
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Emission Factor (lb/MMcf)			Potential Emissions	
				Hourly[a] (lbs/hr)	Annual[b] (tons/yr)
Criteria Pollutants					
$PM/PM_{10}/PM_{2.5}$	0.0075	lb/MMBtu	(1)	0.27	1.2
SO_2	50	lb/MMscf	[c]	2.0	8.9
NO_x	0.06	lb/MMBtu	(2)	2.1	9.4
CO	0.2	lb/MMBtu	(2)	7.1	31
VOCs	245	lb/MMscf	[d]	9.9	43
Lead	4.9E-07	lb/MMBtu	(1)	1.7E-05	7.7E-05
Hazardous Air Pollutants/Toxic Air Pollutants					
Arsenic	2.0E-07	lb/MMBtu	(3)	7.0E-06	3.1E-05
Benzene	1.7E-04	lb/MMBtu	[e]	6.1E-03	2.7E-02
Beryllium	1.2E-08	lb/MMBtu	(3)	4.2E-07	1.8E-06
Cadmium	1.1E-06	lb/MMBtu	(3)	3.8E-05	1.7E-04
Chromium(total)	1.4E-06	lb/MMBtu	(3)	4.9E-05	2.1E-04
Cobalt	8.2E-08	lb/MMBtu	(3)	2.9E-06	1.3E-05
Copper	8.3E-07	lb/MMBtu	(3)	3.0E-05	1.3E-04
Ethylbenzene	8.2E-06	lb/MMBtu	[e]	2.9E-04	1.3E-03
Formaldehyde	7.4E-05	lb/MMBtu	(3)	2.6E-03	1.1E-02
Hexane	1.8E-03	lb/MMBtu	(3)	6.3E-02	2.8E-01
Hydrogen sulfide	2.7E-01	lb/MMscf	[f]	1.1E-02	4.8E-02
Lead	4.9E-07	lb/MMBtu	(1)	1.7E-05	7.7E-05
Manganese	3.7E-07	lb/MMBtu	(3)	1.3E-05	5.8E-05
Mercury	2.5E-07	lb/MMBtu	(3)	9.1E-06	4.0E-05
Naphthalene	6.0E-07	lb/MMBtu	(3)	2.1E-05	9.3E-05
Nickel	2.1E-06	lb/MMBtu	(3)	7.3E-05	3.2E-04
Polycyclic Organic Matter	6.8E-07	lb/MMBtu	(3)	2.4E-05	1.1E-04
2-Methylnaphthalene	*2.4E-08*	*lb/MMBtu*	*(3)*	*8.4E-07*	*3.7E-06*
3-Methylchloranthrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
7,12-Dimethylbenz(a)anthracene	*1.6E-08*	*lb/MMBtu*	*(3)*	*5.6E-07*	*2.4E-06*
Acenaphthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
Acenaphthylene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
Anthracene	*2.4E-09*	*lb/MMBtu*	*(3)*	*8.4E-08*	*3.7E-07*
Benz(a)anthracene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
Benzo(a)pyrene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.2E-08*	*1.8E-07*
Benzo(b)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
Benzo(g,h,i)perylene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.2E-08*	*1.8E-07*
Benzo(k)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
Chrysene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
Dibenzo(a,h)anthracene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.2E-08*	*1.8E-07*
Fluoranthene	*2.9E-09*	*lb/MMBtu*	*(3)*	*1.0E-07*	*4.6E-07*
Fluorene	*2.7E-09*	*lb/MMBtu*	*(3)*	*9.8E-08*	*4.3E-07*
Indeno(1,2,3-cd)pyrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.3E-08*	*2.8E-07*
Naphthalene	*6.0E-07*	*lb/MMBtu*	*(3)*	*2.1E-05*	*9.3E-05*
Phenanathrene	*1.7E-08*	*lb/MMBtu*	*(3)*	*5.9E-07*	*2.6E-06*
Pyrene	*4.9E-09*	*lb/MMBtu*	*(3)*	*1.7E-07*	*7.7E-07*
Selenium	2.4E-08	lb/MMBtu	(3)	8.4E-07	3.7E-06
Toluene	1.5E-04	lb/MMBtu	[e]	5.2E-03	2.3E-02
Vanadium	2.3E-06	lb/MMBtu	(3)	8.0E-05	3.5E-04
m,p-Xylene	5.6E-05	lb/MMBtu	[e]	2.0E-03	8.8E-03
o-Xylene	9.4E-06	lb/MMBtu	[e]	3.4E-04	1.5E-03
Total HAPs				**0.080**	**0.35**

Calculations:

[a] Hourly Emissions (lb/hr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)]

[b] Annual Emissions (tons/yr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)] x [Operating Hours (hrs/yr)] / [2,000 lbs/ton]

Heat Input (MMBtu/hr) =	36	(4)
Projected Hours of Operation (hrs/yr) =	8,760	(4)
Maximum Gas Flow (scf/hr) =	40,417	

[c] SO_2 Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [64 g-SO_2/32 g-S] x [Destruction Efficiency (%)] x [10^6 cf/MMcf]

Gas Density (lb/cf) =	0.099	(5)
Sulfur Content of Gas (ppmw) =	257	(5)
Destruction Efficiency (%) =	99%	(2)

[d] Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [VOC Content (wt%)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

VOC Concentration (wt%) =	25%	(5)

[e] Emission Factor (lb/MMBtu) = [Gas Density (lb/cf)] x [Pollutant Concentration (µg/m^3)] / [453.6 g/lb] / [10^6 µg/g] / [35.31 ft^3/m^3] / [Natural Gas Heating Value (Btu/scf)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Benzene Concentration (µg/m^3) =	2,980	(5)
Ethylbenzene Concentration (µg/m^3) =	144	(5)
m,p-Xylene Concentration (µg/m^3) =	986	(5)
o-Xylene Concentration (µg/m^3) =	165	(5)
Toluene Concentration (µg/m^3) =	2,570	(5)
Natural Gas Heating Value (Btu/scf) =	1,093	(5)

[f] H_2S Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [34 g-H_2S/32 g-S] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Notes:

(1) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42. Office of Air Quality Planning and
(2) Vendor design specifications provided by CB&I.
(3) EPA. 1998b. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-3: Emission Factors for Speciated Organic Compounds from Natural Combustion. AP-42. Office of Air Quality Planning and Standards, US
(4) See rates in Table B-1.
(5) See fuel characteristics in Table B-2.

Table B-8
Case 5: Potential Emissions from Enclosed Ground Flare Burners
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Emission Factor (lb/MMcf)			Potential Emissions Hourly[a] (lbs/hr)	Potential Emissions Annual[b] (tons/yr)
Criteria Pollutants					
$PM/PM_{10}/PM_{2.5}$	0.0075	lb/MMBtu	(1)	0.28	1.2
SO_2	33	lb/MMscf	[c]	0.68	3.0
NO_x	0.06	lb/MMBtu	(2)	2.2	9.8
CO	0.2	lb/MMBtu	(2)	7.4	33
VOCs	505	lb/MMscf	[d]	10.3	45
Lead	4.90E-07	lb/MMBtu	(1)	1.8E-05	8.0E-05
Hazardous Air Pollutants/Toxic Air Pollutants					
Arsenic	2.0E-07	lb/MMBtu	(3)	7.3E-06	3.2E-05
Benzene	1.7E-04	lb/MMBtu	[e]	6.3E-03	2.8E-02
Beryllium	1.2E-08	lb/MMBtu	(3)	4.4E-07	1.9E-06
Cadmium	1.1E-06	lb/MMBtu	(3)	4.0E-05	1.8E-04
Chromium(total)	1.4E-06	lb/MMBtu	(3)	5.1E-05	2.2E-04
Cobalt	8.2E-08	lb/MMBtu	(3)	3.1E-06	1.3E-05
Copper	8.3E-07	lb/MMBtu	(3)	3.1E-05	1.4E-04
Ethylbenzene	8.2E-06	lb/MMBtu	[e]	3.1E-04	1.3E-03
Formaldehyde	7.4E-05	lb/MMBtu	(3)	2.7E-03	1.2E-02
Hexane	1.8E-03	lb/MMBtu	(3)	6.6E-02	2.9E-01
Hydrogen sulfide	1.8E-01	lb/MMscf	[f]	3.7E-03	1.6E-02
Lead	4.9E-07	lb/MMBtu	(1)	1.8E-05	8.0E-05
Manganese	3.7E-07	lb/MMBtu	(3)	1.4E-05	6.1E-05
Mercury	2.5E-07	lb/MMBtu	(3)	9.5E-06	4.2E-05
Naphthalene	6.0E-07	lb/MMBtu	(3)	2.2E-05	9.7E-05
Nickel	2.1E-06	lb/MMBtu	(3)	7.7E-05	3.4E-04
Polycyclic Organic Matter	6.8E-07	lb/MMBtu	(3)	2.5E-05	1.1E-04
2-Methylnaphthalene	*2.4E-08*	*lb/MMBtu*	*(3)*	*8.7E-07*	*3.8E-06*
3-Methylchloranthrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
7,12-Dimethylbenz(a)anthracene	*1.6E-08*	*lb/MMBtu*	*(3)*	*5.8E-07*	*2.6E-06*
Acenaphthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
Acenaphthylene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
Anthracene	*2.4E-09*	*lb/MMBtu*	*(3)*	*8.7E-08*	*3.8E-07*
Benz(a)anthracene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
Benzo(a)pyrene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.4E-08*	*1.9E-07*
Benzo(b)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
Benzo(g,h,i)perylene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.4E-08*	*1.9E-07*
Benzo(k)fluoranthene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
Chrysene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
Dibenzo(a,h)anthracene	*1.2E-09*	*lb/MMBtu*	*(3)*	*4.4E-08*	*1.9E-07*
Fluoranthene	*2.9E-09*	*lb/MMBtu*	*(3)*	*1.1E-07*	*4.8E-07*
Fluorene	*2.7E-09*	*lb/MMBtu*	*(3)*	*1.0E-07*	*4.5E-07*
Indeno(1,2,3-cd)pyrene	*1.8E-09*	*lb/MMBtu*	*(3)*	*6.6E-08*	*2.9E-07*
Naphthalene	*6.0E-07*	*lb/MMBtu*	*(3)*	*2.2E-05*	*9.7E-05*
Phenanathrene	*1.7E-08*	*lb/MMBtu*	*(3)*	*6.2E-07*	*2.7E-06*
Pyrene	*4.9E-09*	*lb/MMBtu*	*(3)*	*1.8E-07*	*8.0E-07*
Selenium	2.4E-08	lb/MMBtu	(3)	8.7E-07	3.8E-06
Toluene	1.5E-04	lb/MMBtu	[e]	5.5E-03	2.4E-02
Vanadium	2.3E-06	lb/MMBtu	(3)	8.4E-05	3.7E-04
m,p-Xylene	5.6E-05	lb/MMBtu	[e]	2.1E-03	9.2E-03
o-Xylene	9.4E-06	lb/MMBtu	[e]	3.5E-04	1.5E-03
Total HAPs				**0.083**	**0.36**

Calculations:

[a] Hourly Emissions (lb/hr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)]

[b] Annual Emissions (tons/yr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)] x [Operating Hours (hrs/yr)] / [2,000 lbs/ton]

Heat Input (MMBtu/hr) =	37	(4)
Projected Hours of Operation (hrs/yr) =	8,760	(4)
Maximum Gas Flow (scf/hr) =	20,417	

[c] SO_2 Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [64 g-SO_2/32 g-S] x [Destruction Efficiency (%)] x [10^6 cf/MMcf]

Gas Density (lb/cf) =	0.088	(5)
Sulfur Content of Gas (ppmw) =	192	(5)
Destruction Efficiency (%) =	99%	(2)

[d] Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [VOC Content (wt%)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

VOC Concentration (wt%) =	58%	(5)

[e] Emission Factor (lb/MMBtu) = [Gas Density (lb/cf)] x [Pollutant Concentration ($\mu g/m^3$)] / [453.6 g/lb] / [10^6 $\mu g/g$] / [35.31 ft^3/m^3] / [Natural Gas Heating Value (Btu/scf)] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Benzene Concentration ($\mu g/m^3$) =	2,980	(5)
Ethylbenzene Concentration ($\mu g/m^3$) =	144	(5)
m,p-Xylene Concentration ($\mu g/m^3$) =	986	(5)
o-Xylene Concentration ($\mu g/m^3$) =	165	(5)
Toluene Concentration ($\mu g/m^3$) =	2,570	(5)
Natural Gas Heating Value (Btu/scf) =	1,093	(5)

[f] H_2S Emission Factor (lb/MMcf) = [Gas Density (lb/cf)] x [S Content (ppmw)] / 10^6 x [34 g-H_2S/32 g-S] x [1 - Destruction Efficiency (%)] x [10^6 cf/MMcf]

Notes:

(1) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42. Office of Air Quality Planning and

(2) Vendor design specifications provided by CB&I.

(3) EPA. 1998b. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-3: Emission Factors for Speciated Organic Compounds from Natural Combustion. AP-42. Office of Air Quality Planning and Standards, US

(4) See rates in Table B-1.

(5) See fuel characteristics in Table B-2.

Table B-9
Potential Emissions from Enclosed Ground Flare Pilots
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Emission Factor (lb/MMcf)	Potential Emissions	
		Hourly[a] (lbs/hr)	Annual[b] (tons/yr)
Criteria Pollutants			
$PM/PM_{10}/PM_{2.5}$	7.6 (1)	0.0046	0.020
SO_2	15 [c]	0.009	0.040
NO_x	50 (2)	0.030	0.13
CO	84 (2)	0.050	0.22
VOCs	5.5 (1)	0.0033	0.014
Lead	0.0005 (1)	3.0E-07	1.3E-06
Hazardous Air Pollutants/Toxic Air Pollutants			
Arsenic	2.0E-04 (3)	1.2E-07	5.3E-07
Benzene	2.1E-03 (3)	1.3E-06	5.5E-06
Beryllium	1.2E-05 (3)	7.2E-09	3.2E-08
Cadmium	1.1E-03 (3)	6.6E-07	2.9E-06
Chromium(total)	1.4E-03 (3)	8.4E-07	3.7E-06
Cobalt	8.4E-05 (3)	5.0E-08	2.2E-07
Copper	8.5E-04 (3)	5.1E-07	2.2E-06
Formaldehyde	7.5E-02 (3)	4.5E-05	2.0E-04
Hexane	1.8E+00 (3)	1.1E-03	4.7E-03
Lead	5.0E-04 (1)	3.0E-07	1.3E-06
Manganese	3.8E-04 (3)	2.3E-07	1.0E-06
Mercury	2.6E-04 (3)	1.6E-07	6.8E-07
Naphthalene	6.1E-04 (3)	3.7E-07	1.6E-06
Nickel	2.1E-03 (3)	1.3E-06	5.5E-06
Polycyclic Organic Matter	7.0E-04 (3)	4.2E-07	1.8E-06
2-Methylnaphthalene	*2.4E-05 (3)*	*1.4E-08*	*6.3E-08*
3-Methylchloranthrene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
7,12-Dimethylbenz(a)anthracene	*1.6E-05 (3)*	*9.6E-09*	*4.2E-08*
Acenaphthene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
Acenaphthylene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
Anthracene	*2.4E-06 (3)*	*1.4E-09*	*6.3E-09*
Benz(a)anthracene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
Benzo(a)pyrene	*1.2E-06 (3)*	*7.2E-10*	*3.2E-09*
Benzo(b)fluoranthene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
Benzo(g,h,i)perylene	*1.2E-06 (3)*	*7.2E-10*	*3.2E-09*
Benzo(k)fluoranthene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
Chrysene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
Dibenzo(a,h)anthracene	*1.2E-06 (3)*	*7.2E-10*	*3.2E-09*
Fluoranthene	*3.0E-06 (3)*	*1.8E-09*	*7.9E-09*
Fluorene	*2.8E-06 (3)*	*1.7E-09*	*7.4E-09*
Indeno(1,2,3-cd)pyrene	*1.8E-06 (3)*	*1.1E-09*	*4.7E-09*
Naphthalene	*6.1E-04 (3)*	*3.7E-07*	*1.6E-06*
Phenanathrene	*1.7E-05 (3)*	*1.0E-08*	*4.5E-08*
Pyrene	*5.0E-06 (3)*	*3.0E-09*	*1.3E-08*
Selenium	2.4E-05 (3)	1.4E-08	6.3E-08
Vanadium	2.3E-03 (3)	1.4E-06	6.0E-06
Toluene	3.4E-03 (3)	2.0E-06	8.9E-06
Total HAPs		**0.0011**	**0.0050**

Calculations:

[a] Hourly Emissions (lb/hr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)]

[b] Annual Emissions (tons/yr) = [Maximum Fuel Usage (scf/hr)] x [1 MMscf/1,000,000 scf] x [Emission Factor (lb/MMcf)] x [Operating Hours (hrs/yr)] / [2,000 lbs/ton]

Maximum Fuel Usage (scf/hr) = 600 (4)

Projected Hours of Operation (hrs/yr) = 8,760 (4)

[c] SO_2 Emission Factor (lb/MMcf) = [Natural Gas Density (lb/cf)] x [Sulfur Content (ppm)] / 10^6 x [2 g-SO_2/g-S] x [10^6 cf/MMcf]

Natural gas density (lb/cf) = 0.046 (5)

Sulfur Content of Fuel (ppm) = 166 (5)

Notes:

(1) EPA. 1998b. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-2: Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion. AP-42.

(2) EPA. 1998a. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-1: Emission Factors for Nitrogen Oxides and Carbon Monoxide from Natural Gas Combustion. AP-42.

(3) EPA. 1998c. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 1.4, Table 1.4-3: Emission Factors for Speciated Organic Compounds from Natural Combustion. AP-42. Office of Air

(4) See rates in Table B-1.

(5) See fuel characteristics in Table B-2.

Table B-10
Fugitive Emissions from Equipment Leaks
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

EQUIPMENT INFORMATION (1)

Component	Phase	Fluid Serviced									VOC Emission Factors (3) (lb/hr per component)	LDAR Control Efficiency (4)
		Acid gas	Boil-Off Gas	Ethylene	Fuel Gas	Hydrocarbon Liquid	Liquefied Natural Gas	Mixed Refrigerant	Natural Gas	Untreated Natural Gas		
Valves	Gas/Vapor	39	9	12	36			112	185	30	0.00137	75%
	Light Liquid					33	244				0.00537	75%
Pump Seals	Light Liquid					1	4				0.0493	75%
Flanges/Connectors	Gas/Vapor	0	7	2	15			28	77	15	0.000559	30%
	Light Liquid					6	114				0.000559	30%
Compressor Seals	Gas/Vapor	0	2	0	0	0	0	1	1	0	0.0166	75%
Relief Valves	Gas/Vapor	3	0	1	3	1	19	8	9	2	0.0220	75%
Swivel Joints	Light Liquid						4				0.0493	75%

FLUID HAP/TAP CONTENT

Pollutant	Fluid								
	Acid gas	Boil-Off Gas	Ethylene	Fuel Gas	Hydrocarbon Liquid	Liquefied Natural Gas	Mixed Refrigerant	Natural Gas	Untreated Natural Gas
VOC Content (%wt) (1)	100%	100%	100%	100%	100%	100%	100%	100%	100%
n-Hexane (ppmw) (1)	70	5.7E-10		1,185	210,669	27		1,185	1,185
Hydrogen sulfide (ppmw) (1)	3,128	0.00035		22	0.010	0.21		22	166
Benzene (ppmw)[b]	4.0	4.0		4.0	4.0	4.0		4.0	4.0
Ethylbenzene (ppmw)[b]	0.20	0.20		0.20	0.20	0.20		0.20	0.20
m,p-Xylene (ppmw)[b]	1.3	1.3		1.3	1.3	1.3		1.3	1.3
o-Xylene (ppmw)[b]	0.22	0.22		0.22	0.22	0.22		0.22	0.22
Toluene (ppmw)[b]	3.5	3.5		3.5	3.5	3.5		3.5	3.5

Table B-10
Fugitive Emissions from Equipment Leaks
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

POTENTIAL EMISSIONS

Pollutant	Acid gas	Boil-Off Gas	Ethylene	Fuel Gas	Hydrocarbon Liquid	Liquefied Natural Gas	Mixed Refrigerant	Natural Gas	Untreated Natural Gas	Total
Hourly Emissions (lb/hr)										
VOCs	0.030	0.014	0.010	0.035	0.064	0.58	0.098	0.15	0.027	**1.0**
n-Hexane	2.1E-06	8.1E-18	0	4.1E-05	0.014	1.6E-05	0	1.7E-04	3.2E-05	**0.014**
Hydrogen sulfide	9.3E-05	4.9E-12	0	7.5E-07	6.61E-10	1.2E-07	0	3.2E-06	4.5E-06	**0.00010**
Benzene	1.2E-07	5.7E-08	0	1.4E-07	2.6E-07	2.3E-06	0	5.9E-07	1.1E-07	**3.6E-06**
Ethylbenzene	5.8E-09	2.7E-09	0	6.8E-09	1.3E-08	1.1E-07	0	2.9E-08	5.3E-09	**1.7E-07**
m,p-Xylene	4.0E-08	1.9E-08	0	4.6E-08	8.6E-08	7.7E-07	0	2.0E-07	3.6E-08	**1.2E-06**
o-Xylene	6.7E-09	3.2E-09	0	7.8E-09	1.4E-08	1.3E-07	0	3.3E-08	6.1E-09	**2.0E-07**
Toluene	1.0E-07	4.9E-08	0	1.2E-07	2.2E-07	2.0E-06	0	5.1E-07	9.5E-08	**3.1E-06**
Total HAPs	2.8E-07	1.3E-07	0	3.2E-07	6.0E-07	5.3E-06	0	1.4E-06	2.5E-07	**8.3E-06**
Annual Emissions (tpy)										
VOCs	0.13	0.062	0.046	0.15	0.28	2.5	0.43	0.64	0.12	**4.4**
n-Hexane	9.1E-06	3.5E-17	0	0.00018	0.060	6.9E-05	0	0.00076	0.00014	**0.061**
Hydrogen sulfide	0.00041	2.1E-11	0	3.3E-06	2.9E-09	5.3E-07	0	1.4E-05	2.0E-05	**0.00045**
Benzene	5.3E-07	2.5E-07	0	6.1E-07	1.1E-06	1.0E-05	0	2.6E-06	4.8E-07	**1.6E-05**
Ethylbenzene	2.6E-08	1.2E-08	0	3.0E-08	5.5E-08	4.9E-07	0	1.3E-07	2.3E-08	**7.6E-07**
m,p-Xylene	1.7E-07	8.2E-08	0	2.0E-07	3.8E-07	3.4E-06	0	8.6E-07	1.6E-07	**5.2E-06**
o-Xylene	2.9E-08	1.4E-08	0	3.4E-08	6.3E-08	5.6E-07	0	1.4E-07	2.7E-08	**8.7E-07**
Toluene	4.6E-07	2.1E-07	0	5.3E-07	9.8E-07	8.8E-06	0	2.2E-06	4.1E-07	**1.4E-05**
Total HAPs	1.2E-06	5.7E-07	0	1.4E-06	2.6E-06	2.3E-05	0	6.0E-06	1.1E-06	**3.6E-05**

Calculations:

[a] Hourly Emissions (lb/hr) = [Emission Factor (lb/hr per component)] x [Component Count] x [Pollutant Content (%wt)] x [1 - LDAR Control Efficiency (%)]

Annual Emissions (tpy) = [Emission Factor (lb/hr per component)] x [Component Count] x [Pollutant Content (%wt)] x [1 - LDAR Control Efficiency (%)] x [Hours of Operation (hrs/yr)] / [2,000 lb/ton]

Hours of Operation (hrs/yr) = 8,760

[b] Pollutant Concentration (ppmw) = [Pollutant Concentration ($\mu g/m^3$)] / [453.6 g/lb] / [10^6 $\mu g/g$] / [35.31 ft^3/m^3] / [Gas Density (lb/cf)] x 10^6

Benzene Concentration ($\mu g/m^3$) =	2,980	(5)
Ethylbenzene Concentration ($\mu g/m^3$) =	144	(5)
m,p-Xylene Concentration ($\mu g/m^3$) =	986	(5)
o-Xylene Concentration ($\mu g/m^3$) =	165	(5)
Toluene Concentration ($\mu g/m^3$) =	2,570	(5)
Natural Gas Density (lb/scf) =	0.046	(5)

Notes:

(1) Provided by CB&I.

(2) From "Natural Gas Analysis"; Environmental Partners, Inc.; February 3, 2014. Most HAPs will go through with the heavy hydrocarbons, but the fraction is unknown. Therefore, we assume each fluid has the full concentration of HAP to provide a conservative emissions estimate.

(3) Terminal/Depot factors from South Coast Air Quality Management District's "Guidelines for Fugitive Emissions Calculations" (June 2003). In this guidance, the District updated emissions factors that were identified in the EPA's "Protocol for Equipment Leak Emission Estimates (November 1995).

(4) Control effectiveness from Texas Commission for Environmental Quality (TCEQ) "Control Efficiencies for TCEQ Leak Detection and Repair Programs" (July 2011) for its 28M fugitive leak detection program.

(5) See fuel characteristics in Table B-2.

Table B-11
Project Emissions Summary
Puget Sound Energy – Liquefied Natural Gas Project
Tacoma, Washington

Pollutant	Vaporizer		Enclosed Ground Flare (Worst-case)		Fugitives		Total	
	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
Criteria Pollutants								
$PM/PM_{10}/PM_{2.5}$	0.46	0.055	0.28	1.2	--	--	**0.74**	**1.3**
SO_2	0.93	0.11	2.0	8.9	--	--	**3.0**	**9.0**
NO_x	0.72	0.086	2.3	9.9	--	--	**3.0**	**10**
CO	2.4	0.29	7.5	33	--	--	**9.9**	**33**
VOCs	0.33	0.040	10	45	1.0	4.4	**12**	**50**
Lead	3.0E-05	3.6E-06	1.9E-05	8.1E-05	--	--	**4.9E-05**	**8.5E-05**
Hazardous Air Pollutants	**0.00012**	**0.014**	**0.084**	**0.37**	**8.3E-06**	**3.6E-05**	**0.084**	**0.38**