APPENDIX E

Shell Puget Sound Refinery (PSR) Rail Unloading Facility
Greenhouse Gas Emissions Methods

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The greenhouse gas (GHG) emissions associated with crude-by-rail transport were estimated for the entire rail route. The route is assumed to originate in Williston, North Dakota, with full tank cars proceeding across northern Montana, and entering Washington State just east of Spokane. Note that alternate return routes to the mid-continent or locations other than Williston are likely, but the differences in estimated GHG emissions are not of a magnitude that would substantially change those provided in this environmental impact statement (EIS).

In addition to estimating GHG emissions from locomotive fuel combustion, this analysis considered the GHG reduction that would result from replacing Alaska North Slope crude oil transported by marine vessel for the equivalent amount of oil proposed to be brought to the Shell PSR by unit trains. For the purpose of this analysis, marine vessels are assumed to transport crude oil from Valdez, Alaska, to the Shell PSR, a travel distance by ship of approximately 1,400 miles. Through conversations with Shell PSR, the Washington State Departmenyt of Ecology (Ecology) discovered that approximately 60 percent of the crude oil on each marine vessel shipment from Alaska is delivered to the refinery. Therefore, 40 percent of the GHG emissions from the transport of crude oil by marine vessel are accounted for by other customers that the marine vessels visit. That means only 60 percent of the GHGs emitted by each marine vessel transport is assumed to be the responsibility of the Shell PSR. Therefore, the Shell PSR can take credit only for 60 percent of the GHGs emitted by marine vessels when compared with the amount of GHGs emitted by locomotives transporting crude. This is an important point. If Shell were to assume 100 percent of the marine vessel emissions, the net change in GHG emissions would appear to be less than what Shell can actually take credit for.

The calculations of GHGs for this effort were based on fuel consumption by locomotives and marine vessels, which is the most common and most extensively used approach in GHG estimations. Additionally, this approach was used in other environmental permitting documents prepared by Ecology such as the Westway Terminal and Imperium Terminal EISs. Several data imputs were used to calculate the amount of fuel that is or would be combusted in transporting crude oil to the Shell PSR. Table E-1 lists the data inputs for locomotive transport of crude oil and Table E-2 lists the data inputs for marine vessel transport of crude oil. Table E-3 shows the total GHGs for transport of crude oil by locomotive and marine vessel and also provides the net change in GHGs that would result from the shift in the delivery method.

Table E-1 Locomotive GHG Emissions Data Inputs

Data Input	Full Train	Empty Train
Barrels per tank car	714.3	--
Pounds – oil per tank car	210,004	--
Pounds - empty tank car weight	79,500	65,300
Pounds - total tank car weight	289,504	65,300
Tons - total tank car weight	144.75	32.7
Number of tank cars	102	102
Trailing tons weight	14,764.71	3,330
Tons per locomotive	200	200
Locomotives per unit train	4	4
Tons per train	15,565	4,130
Gross-ton-miles per gallon	954	954
Gallons per mile	16.3	4.3
Pounds - CO_2 per gallon	22.5	22.5
Pounds - CO_2 per mile	367.0	97.4
Tons - CO_2 per mile	0.18	0.05
Trip distance(miles)	1,449	1,302

Note: CO_2 = carbon dioxide

Table E-2 Marine Vessel (Panamax Class) GHG Emissions Data Inputs

Data Input	Value
API	38.76
Specific gravity	0.831
Nominal capacity, barrels	500,000
Tare (empty) light displacement, tons	14,800
Tare (empty) light displacement, pounds	29,600,000
Crude load, barrels	500,000
Crude Tanker % full	100%
Crude oil weight, short tons	72,691
Crude tanker deadweight tonnage, short tons	80,767
Crude tanker loaded displacement, short tons	95,567.3
One-way trip, miles	1,408
Full tanker, inbound, ton-miles	134,558,768
Empty tanker, outbound, ton-miles	20,838,400
Oil tankers per year	76
Total gross ton-miles per year	11,774,900,914
Residual Fuel Oil combusted in all ships, gallons per year	8,627,898

Note: CO_2 = carbon dioxide

Source: Shell 2016

Table E-3 CO_2 Emissions from Crude Oil Transport and Net Change

Emissions Source	Affected Route	Annual CO_2 Emissions (metric tons/year)
Rail Locomotives	Williston, ND, to Anacortes, WA	93,211
Oil Tanker Ships	Valdez, AK, to Anacortes, WA	48,224
Net Change (Increase)	"Global"	44,987

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