APPENDIX Y

Estimated Criteria Pollutants, Noise, and GHG Emissions

ESTIMATED CRITERIA POLLUTANTS, NOISE, AND GHG EMISSIONS

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Table 1 Estimated Direct Criteria Pollutant Emissions from the Rail/Pipeline Scenario – CP Railway Route

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Storage Location (bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b,c]	Transport Distance, One Way (miles)[d]	Miles Traveled per Day, One Way[e]	On-terminal Line-haul Rail Activity per Day (hp-hr/day)[f]	Loaded Cargo[g] Fuel Efficiency (ton-miles/gal)	Loaded Cargo[g] Daily Fuel Use (gal/day)	Empty Cargo[h] Fuel Economy (miles/gal)	Empty Cargo[h] Daily Fuel Use (gal/day)	Criteria Pollutant Emissions (tons/year)[i] HC/VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$
WCS Extraction Site at Hardisty, Alberta to Rail Loading Terminals at Lloydminster, Saskatchewan (WCS)																	
Pipeline - connecting Hardesty to Lloydminster	730,000	NA	NA	NA	68.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting storage tanks to 7 terminals at Lloydminster	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks for all 7 terminals at Lloydminster	730,000	2,100,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	91.4	NA	NA	NA	NA	NA
Rail-Loading Terminals at Lloydminster, Saskatchewan to Storage Facility at Stroud, OK (WCS)																	
Rail terminal loading at Lloydminster	730,000	NA	NA	12.3	NA	NA	41,293	NA	NA	NA	NA	4.98	21.3	91.4	2.57	1.66	1.61
Rail - connecting Lloydminster to Stroud	730,000	NA	118,501	12.3	1,903	23,387	NA	480	469,807	0.14	167,050	1,601	6,833	29,360	825	534	518
Rail terminal unloading at Stroud	730,000	NA	NA	12.3	NA	NA	20,646	NA	NA	NA	NA	2.49	10.6	45.7	1.28	0.83	0.81
Pipeline - connecting storage tanks to 7 terminals at Stroud	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks for all 7 terminals at Stroud	730,000	2,100,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	103	NA	NA	NA	NA	NA
Storage Facilities at Stroud, OK to Storage Facility at Cushing, OK (WCS)																	
Pipeline - connecting Stroud to Cushing	730,000	NA	NA	NA	17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting off-loading terminals to storage tanks	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (11) 75,000 bbl tanks at the Cushing terminal	730,000	825,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	71.8	NA	NA	NA	NA	NA
Bakken Region to Rail Loading Terminal at Epping, ND (Bakken)																	
Truck - road connecting Bakken region to Epping	100,000	NA	14,259	25,677	50.0	1,283,847	NA	154	4,634	7.5	171,180	289	1,649	5,830	228	137	126
Storage tanks - (4) 75,000 bbl tanks at the Epping terminal	100,000	300,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.6	NA	NA	NA	NA	NA
Rail Loading Terminals at Epping, North Dakota to Storage Facility at Stroud, Oklahoma (Bakken)																	
Rail loading terminal at Epping	100,000	NA	NA	1.5	NA	NA	4,970	NA	NA	NA	NA	0.60	2.56	11.0	0.31	0.20	0.19
Rail - connecting Epping to Stroud	100,000	NA	14,259	1.5	1,347	1,993	NA	480	40,014	0.14	14,233	109	582	2,915	70.2	72.8	70.6
Rail unloading terminal at Stroud	100,000	NA	NA	1.5	NA	NA	2,485	NA	NA	NA	NA	0.30	1.28	5.50	0.15	0.10	0.10

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Storage Location (bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b,c]	Transport Distance, One Way (miles)[d]	Miles Traveled per Day, One Way[e]	On-terminal Line-haul Rail Activity per Day (hp-hr/day)[f]	Loaded Cargo[g]		Empty Cargo[h]		Criteria Pollutant Emissions (tons/year)[i]					
								Fuel Efficiency (ton-miles/gal)	Daily Fuel Use (gal/day)	Fuel Economy (miles/gal)	Daily Fuel Use (gal/day)	HC/ VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$
Storage Facilities at Stroud, Oklahoma to Storage Facility at Cushing, Oklahoma (Bakken)																	
Pipeline - connecting Stroud to Cushing	100,000	NA	NA	NA	17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting off-loading terminals to storage tanks	100,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (11) 75,000 bbl tanks at the Cushing terminal	100,000	825,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	25.5	NA	NA	NA	NA	NA
											Total	**2,310**	**9,100**	**38,259**	**1,127**	**747**	**717**

[a] Mass of crude transported per day was estimated based on volume of crude transported per day (bbl/day) and density of crude (7.73 lb/gal for dilbit and 6.79 lb/gal for Bakken crude).
[b] Number of train trips per day was estimated based on volume of crude transported per day (bbl/day), maximum volume per car (594 bbl/car for dilbit and 676 bbl/car for Bakken crude), and 100 cars per train.
[c] Number of truck trips per day was estimated based on volume of crude transported per day (bbl/day) and maximum payload for bulk tanker trucks (27 tons/truck).
[d] Transport distances (one way) for the rail routes were taken from the Final Supplemental EIS Section 5.1.2.2, Rail/Pipeline Scenario. Transport distance (one way) for the trucks was assumed to be 50 miles.
[e] Daily miles traveled estimated based on one-way transport distance and number of trips per day.
[f] On-terminal line-haul rail activity per day (hp-hr/day) was calculated based on the number of trains per day, number of locomotives per train (assumed three), hours at the terminal (assumed 1 hour for loading dilbit and Bakken crudes and 0.5 hour for unloading both crudes), average line-haul locomotive load factor of 28 percent (ICF 2009), and average locomotive horsepower (assumed 4,000 hp).
[g] Fuel efficiency for loaded long-haul locomotives (480 ton-miles/gal) was taken from Bureau of Transportation Statistics (BTS 2011), Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel efficiency for loaded bulk tanker trucks (154 ton-miles/gal or 6.5 gal/1,000 ton-miles) was taken from the National Research Council (NRC 2010). Daily fuel used was estimated based on transport distance (one way), fuel efficiency, and mass of crude transported per day.
[h] Fuel economy for empty long-haul locomotives (0.14 miles/gal) was taken from BTS 2011, Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel economy for empty bulk tanker trucks or Class 8b trucks (7.5 miles/gal) was taken from NRC 2010. Daily fuel used was estimated based on transport distance (one way), fuel economy, and mass of crude transported per day.
[i] Criteria pollutant emissions in tons per year were estimated based on emission factors in grams per gallon for cargo in transit and emission factors for idling activity (loading/unloading) at terminals in grams per horsepower-hour (g/hp-hr), daily diesel consumed, on-terminal line-haul rail activity per day, and 365 days of operation per year. Emissions of HC/VOCs for storage tanks were calculated using U.S. Environmental Protection Agency (USEPA) TANK 4.0.9d software assuming an external floating roof for each tank with a height of 48 feet. Criteria pollutant emission factors or standards for line-haul locomotives (remanufactured Tier 2) were taken from ICF International (ICF 2009). The line-haul locomotive emission factors were converted from g/hp-hr to grams per gallon using a conversion factor of 0.048 gal/hp-hr. Emission factors for the bulk tanker trucks or Class 8b trucks were taken from USEPA 2008. Emission factors for the bulk tanker trucks or Class 8b trucks were converted from grams per mile to grams per gallon using a fuel economy factor of 7.5 miles per gallon. SO_2 emission factors for both line-haul locomotives and bulk tanker trucks were calculated using a mass balance approach taking into account the molecular weight difference between SO_2 and sulfur and using a 500 ppm sulfur content (low sulfur diesel), 3,218 grams/gal diesel fuel density, and assuming 100% of fuel sulfur is converted to SO_2.

bbl = barrel, CO = carbon monoxide, CP = Canadian Pacific Railway, dilbit = diluted bitumen, g/hp-hr = grams per horsepower-hour, gal = gallon, hp-hr = horsepower-hour, HC = hydrocarbons, NA = not applicable, NOx = nitrogen oxides, $PM_{2.5}$ = particulate matter <2.5 microns, PM_{10} = particulate matter<10 micron, SO_2 = sulfur dioxide, VOC = volatile organic compounds, WCS = Western Canadian Select crude.

Table 2 Estimated Direct Greenhouse Gas Emissions from the Rail/Pipeline Scenario – CP Rail Route

								Loaded Cargo[g]		Empty Cargo[h]		Greenhouse Gas Emissions[i] (tons/year)				Greenhouse Gas Emissions[i] (metric tons/year)
Transport and Storage Facilities	**Maximum Crude Volume Transported per Day, Throughput (bbl/day)**	**Crude Volume Stored per Storage Location (bbl)**	**Crude Mass Transported per Day (tons/day)[a]**	**Number of Trips per Day[b,c]**	**Transport Distance, One Way (miles)[d]**	**Miles Traveled per Day, One Way[e]**	**On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[f]**	**Fuel Efficiency (ton-miles/gal)**	**Daily Fuel Use (gal/day)**	**Fuel Economy (miles/gal)**	**Daily Fuel Use (gal/day)**	**CO_2**	**CH_4**	**N_2O**	**CO_2e**	**CO_2e**
WCS Extraction Site at Hardisty, AB to Rail Loading Terminals at Lloydminster, Saskatchewan (WCS)																
Pipeline - connecting Hardesty to Lloydminster	730,000	NA	NA	NA	68.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting storage tanks to 7 terminals at Lloydminster	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks for all 7 terminals at Lloydminster	730,000	2,100,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rail Loading Terminals at Lloydminster, Saskatchewan to Storage Facility at Stroud, OK (WCS)																
Rail loading terminal at Lloydminster	730,000	NA	NA	12.3	NA	NA	41,293	NA	NA	NA	NA	8,025	0.22	0.66	8,228	7,464
Rail - connecting Lloydminster to Stroud	730,000	NA	118,501	12.3	1,903	23,387	NA	480	469,807	0.14	167,050	2,615,260	106	21.2	2,624,235	2,380,668
Rail unloading terminal at Stroud	730,000	NA	NA	12.3	NA	NA	20,646	NA	NA	NA	NA	4,012	0.11	0.33	4,114	3,732
Pipeline - connecting storage tanks to 7 terminals at Stroud	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks for all 7 terminals at Stroud	730,000	2,100,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage Facilities at Stroud, OK to Storage Facility at Cushing, OK (WCS)																
Pipeline - connecting Stroud to Cushing	730,000	NA	NA	NA	17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting off-loading terminals to storage tanks	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (11) 75,000 bbl tanks at the Cushing terminal	730,000	825,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bakken Region to Rail Loading Terminal at Epping, ND (Bakken)																
Truck - road connecting Bakken region to Epping	100,000	NA	14,259	25,677	50.0	1,283,847	NA	154	4,634	7.5	171,180	721,981	29.3	5.86	724,459	657,219
Storage tanks - (4) 75,000 bbl tanks at the Epping terminal	100,000	300,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rail Loading Terminals at Epping, ND, to Storage Facility at Stroud, OK (Bakken)																
Rail loading terminal at Epping	100,000	NA	NA	1.5	NA	NA	4,970	NA	NA	NA	NA	966	0.03	0.08	990	898
Rail - connecting Epping to Stroud	100,000	NA	14,259	1.5	1,347	1,993	NA	480	40,014	0.14	14,233	222,767	9.04	1.81	223,531	202,784
Rail unloading terminal at Stroud	100,000	NA	NA	1.5	NA	NA	2,485	NA	NA	NA	NA	483	0.01	0.04	495	449

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Storage Location (bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b,c]	Transport Distance, One Way (miles)[d]	Miles Traveled per Day, One Way[e]	On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[f]	Loaded Cargo[g]		Empty Cargo[h]		Greenhouse Gas Emissions[i] (tons/year)				Greenhouse Gas Emissions[i] (metric tons/year)
								Fuel Efficiency (ton-miles/gal)	Daily Fuel Use (gal/day)	Fuel Economy (miles/gal)	Daily Fuel Use (gal/day)	CO_2	CH_4	N_2O	CO_2e	CO_2e
Storage Facilities at Stroud, OK to Storage Facility at Cushing, OK (Bakken)																
Pipeline - connecting Stroud to Cushing	100,000	NA	NA	NA	17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting off-loading terminals to storage tanks	100,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (11) 75,000 bbl tanks at the Cushing terminal	100,000	825,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
											Total	**3,573,494**	**145**	**30.0**	**3,586,052**	**3,253,216**

[a] Mass of crude transported per day was estimated based on volume of crude transported per day (bbl/day) and density of crude (7.73 lb/gal for dilbit and 6.79 lb/gal for Bakken crude).
[b] Number of train trips per day was estimated based on volume of crude transported per day (bbl/day), maximum volume per car (594 bbl/car for dilbit and 676 bbl/car for Bakken crude), and 100 cars per train.
[c] Number of truck trips per day was estimated based on volume of crude transported per day (bbl/day) and maximum payload for bulk tanker trucks (27 tons/truck).
[d] Transport distances (one way) for the rail routes were taken from the Final Supplemental EIS Section 5.1.2.2, Rail/Pipeline Scenario. Transport distance (one way) for the trucks was assumed to be 50 miles.
[e] Daily miles traveled was estimated based on one-way transport distance and number of trips per day.
[f] On-terminal line-haul rail activity per day (hp-hr/day) was calculated based on the number of trains per day, number of locomotives per train (assumed three), hours at the terminal (assumed 1 hour for loading dilbit and Bakken crudes and 0.5 hour for unloading both crudes), average line-haul locomotive load factor of 28% (ICF 2009), and average locomotive horsepower (assumed 4,000 hp).
[g] Fuel efficiency for loaded long-haul locomotives (480 ton-miles/gal) was taken from Bureau of Transportation Statistics (BTS 2011), Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel efficiency for loaded bulk tanker trucks (154 ton-miles/gal or 6.5 gal/1,000 ton-miles) was taken from the National Research Council (NRC 2010). Daily fuel used was estimated based on transport distance (one way), fuel efficiency, and mass of crude transported per day.
[h] Fuel economy for empty long-haul locomotives (0.14 miles/gal) was taken from BTS 2011, Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel economy for empty bulk tanker trucks (7.5 miles/gal) was taken from NRC 2010. Daily fuel used estimated based on transport distance (one way), fuel economy, and mass of crude transported per day.
[i] Greenhouse gas emissions in tons per year were estimated based on emission factors in kilograms per million British Thermal Units (kg/MMBtu), for cargo in transit and emission factors for idling activity (loading/unloading) at terminals in grams per horsepower-hour, daily diesel consumed (gal/day), high heating value of diesel (0.138 MMBtu/gal), on-terminal line-haul rail activity per day, and 365 days of operations per year. Greenhouse gas emission factors in kg/MMBtu were taken from 40 CFR 98 Subpart C, Table C-1 and C-2. Total greenhouse gases were estimated as CO_2 equivalents (CO_2e), accounting for 100-year global warming potentials of CO_2 (1), CH_4 (25) and N_2O (298).

bbl = barrel, CFR = Code of Federal Regulations, CH_4 = methane, CO_2 = carbon dioxide, CO_2e = CO_2 equivalents, CP = Canadian Pacific Railway, dilbit = diluted bitumen, gal = gallon, kg = kilogram, lb = pound, MMBtu = million British thermal units, hp = horsepower, hp-hr = horsepower-hour, N_2O = nitrous oxide, NA = not applicable, WCS = Western Canadian Select crude.

Table 3 Predicted Noise Levels at Closest Noise Sensitive Areas from the Rail/Pipeline Scenario – CP Rail Route

State	County	Pop. Density (people /mi²)[a]	Closest NSA Dist. to Railway (ft)[b]	Existing Ldn Noise Level (dBA)[c]	Volume of WCS Crude Transported per Day (bbl /day)	Daily train volume (trains /day)[d]	Day time (7am-10pm) hourly train volume (trains /hr)[e]	Night time (10pm-7am) train volume (trains /hr)[f]	Total Daytime Leq for Locomotives and Rail Cars (dBA)[g]	Total Night time Leq for Locomotives and Rail Cars (dBA)[g]	CP Rail Scenario Ldn at 50 feet (dBA)[g]	CP Rail Scenario Ldn at Closest NSA Plus Existing Ldn (dBA)[h]
North Dakota												
	Burke	1.8	162	60.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	70.2
	Ward	30.6	55	69.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	79.6
	Renville	2.8	540	49.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	59.7
	McHenry	2.9	145	61.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	71.1
	Pierce	4.3	175	59.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	69.5
	Wells	3.3	194	58.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	68.6
	Eddy	3.8	190	59.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	68.8
	Foster	5.3	166	60.1	730,000	12.3	7.7	4.6	75.3	73.1	79.9	70.0
	Griggs	3.4	226	57.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	67.3
	Steele	2.8	266	56.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	65.9
	Barnes	7.4	552	49.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	59.5
	Cass	84.9	39	72.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	82.5
	Richland	11.4	60	69.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.8
Minnesota												
	Clay	56.4	44	71.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	81.5
	Wilkin	8.8	79	66.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.4
	Traverse	6.2	313	54.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	64.5
	Grant	11	202	58.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	68.3
	Stevens	17.3	130	62.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.1
	Pope	16.4	447	51.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	61.4
	Swift	13.2	113	63.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.3
	Kandiyohi	53	68	67.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.7
	Chippewa	21.4	173	59.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	69.6
	Yellow Medicine	13.8	52	70.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.0
	Lyon	36.2	119	63.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.9
	Lincoln	11	443	51.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	61.4
	Pipestone	20.6	132	62.1	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.0
	Rock	20.1	175	59.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	69.5
South Dakota												
	Minnehaha	210	151	61.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	70.8
Iowa												
	Lyon	19.7	110	63.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.5
	Sioux	43.9	83	66.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.0
	Plymouth	29	56	69.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	79.4
	Woodbury	117.1	106	64.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.9
	Mills	34.4	125	62.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.4
	Fremont	14.6	102	64.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.2
Nebraska												
	Dakota	79.5	51	70.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.2
	Thurston	17.6	143	61.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	71.3
	Burt	14	97	64.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.6
	Dodge	69.4	63	68.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.4
	Saunders	27.7	70	67.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.5
	Cass	45.3	101	64.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.3

State	County	Pop. Density (people /mi^2)[a]	Closest NSA Dist. to Railway (ft)[b]	Existing Ldn Noise Level (dBA)[c]	Volume of WCS Crude Transported per Day (bbl /day)	Daily train volume (trains /day)[d]	Day time (7am-10pm) hourly train volume (trains /hr)[e]	Night time (10pm-7am) train volume (trains /hr)[f]	Total Daytime Leq for Locomotives and Rail Cars (dBA)[g]	Total Night time Leq for Locomotives and Rail Cars (dBA)[g]	CP Rail Scenario Ldn at 50 feet (dBA)[g]	CP Rail Scenario Ldn at Closest NSA Plus Existing Ldn (dBA)[h]
Missouri												
	Atchison	10.4	73	67.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.1
	Holt	10.6	86	65.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.7
	Andrew	40	151	61.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	70.8
	Buchanan	218.6	67	68.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.8
	Platte	212.6	50	70.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.4
	Clay	558.6	798	46.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	56.3
	Jackson	1115.3	1600	40.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	50.3
Kansas												
	Wyandotte	1039	60	69.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.8
	Johnson	1149.6	45	71.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	81.3
	Miami	57	75	67.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.9
	Linn	16.3	53	70.1	730,000	12.3	7.7	4.6	75.3	73.1	79.9	79.9
	Bourbon	23.9	110	63.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.5
	Crawford	66.4	86	65.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.7
	Cherokee	36.8	111	63.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.5
Oklahoma												
	Ottawa	67.6	52	70.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.0
	Craig	19.7	119	63.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.9
	Rogers	128.6	110	63.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.5
	Tulsa	1058.1	87	65.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.6
	Creek	73.6	57	69.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	79.2
	Lincoln	36	242	56.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	66.7

[a] Population density was taken from U.S. Census Bureau data for 2010 (U.S. Census Bureau 2012).
[b] Closest noise sensitive area (NSA) distance to railway was obtained from aerial photography/maps.
[c] Existing noise levels were estimated based on the proximity of the NSA to existing railway noise; estimation methodology is described in U.S. Department of Transportation (USDOT) 2006.
[d] Daily train volume was estimated from volume of WCS crude transported per day, maximum volume of WCS crude per car (594 bbl/car of dilbit), and 100 cars per train unit.
[e] Daytime hourly train volume was estimated based on a daytime period from 7am to 10pm (i.e., 15 hours per day).
[f] Nighttime hourly train volume was estimated based on a nighttime period from 10pm to 7am (i.e., 9 hours per day).
[g] Total daytime and nighttime Leq for locomotives and rail cars, and the Canadian Pacific Rail Scenario Ldn at 50 feet were calculated using the methodology described in USDOT 2006 for a commuter rail system. The noise calculations assumed three diesel powered locomotives per train unit with a speed of 40 miles per hour, and 100 cars per train unit.
[h] Canadian Pacific Rail Scenario plus existing Ldn levels were calculated using the typical logarithmic equation for combining noise levels: 10Log(10^(Existing Noise/10) + 10^(Canadian Pacific Scenario Noise/10)).

bbl = barrel, CP = Canadian Pacific Railway, dBA = decibels on the A-weighted scale, ft = feet, hr = hour, Leq = equivalent continuous sound level, Ldn = day-night sound level, mi = miles, NSA = Noise Sensitive Area, WCS = Western Canadian Select.

Table 4 Predicted Noise Levels at Closest Noise Sensitive Areas from the Rail/Pipeline Scenario – CN Rail Route

State	County	Pop. density (people /mi²)[a]	Closest NSA Distance to Railway (ft)[b]	Existing Ldn Noise Level (dBA)[c]	Volume of WCS Crude Trans-ported per Day (bbl/ day)	Daily train volume (trains/ day)[d]	Day time (7am-10pm) hourly train volume (trains/ hr)[e]	Night time (10pm-7am) train volume (trains/ hr)[f]	Total Day time Leq for Locomotives and Rail Cars (dBA)[g]	Total Night time Leq for Locomotives and Rail Cars (dBA)[g]	CN Rail Scenario Ldn at 50 ft (dBA)[g]	CN Rail Scenario Ldn at Closest NSA Plus Existing Ldn (dBA)[h]
Minnesota												
	Roseau	9.3	69	67.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.6
	Lake of the Woods	3.1	216	57.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	67.7
	Koochiching	4.3	92	65.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.1
	St Louis	32	132	62.1	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.0
	Carlton	41.1	195	58.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	68.6
	Pine	21.1	137	61.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	71.6
	Kanabec	31.1	278	55.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	65.5
	Isanti	86.8	86	65.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.7
	Anoka	782.1	120	63.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.8
	Hennepin	2081.7	65	68.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.1
	Ramsey	3341.7	77	66.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.6
	Dakota	709	88	65.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.5
	Rice	129.4	151	61.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	70.8
	Steele	85.1	143	61.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	71.3
	Freeborn	44.2	65	68.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.1
Wisconsin												
	Douglas	33.9	141	61.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	71.4
Iowa												
	Worth	19	107	64.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.8
	Cerro Gordo	77.7	58	69.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	79.1
	Franklin	18.4	91	65.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.2
	Hardin	30.8	95	65.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.8
	Story	156.3	116	63.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.1
	Polk	750.5	117	63.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.0
	Warren	81.1	73	67.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.1
	Marion	60.1	47	71.1	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.9
	Lucas	20.7	87	65.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.6
	Wayne	12.2	67	68.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.8
Missouri												
	Mercer	8.3	110	63.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.5
	Grundy	23.6	184	59.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	69.1
	Livingston	28.5	1600	40.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	50.3
	Daviess	15	1371	41.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	51.6
	Caldwell	22.1	103	64.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.1
	Ray	41.3	99	64.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.5
	Clay	558.6	128	62.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.2
	Jackson	1115.3	123	62.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.6
Kansas												
	Johnson	1149.6	83	66.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.0
	Miami	57	156	60.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	70.5
	Linn	16.3	234	57.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	67.0
	Anderson	14	284	55.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	65.3
	Allen	26.7	96	64.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.7
	Neosho	28.9	75	67.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.9
	Labette	33.5	129	62.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.2
Oklahoma												
	Craig	19.7	113	63.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.3
	Mayes	63	108	63.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.7

State	County	Pop. density (people /mi²)[a]	Closest NSA Distance to Railway (ft)[b]	Existing Ldn Noise Level (dBA)[c]	Volume of WCS Crude Trans-ported per Day (bbl/ day)	Daily train volume (trains/ day)[d]	Day time (7am-10pm) hourly train volume (trains/ hr)[e]	Night time (10pm-7am) train volume (trains/ hr)[f]	Total Day time Leq for Locomotives and Rail Cars (dBA)[g]	Total Night time Leq for Locomotives and Rail Cars (dBA)[g]	CN Rail Scenario Ldn at 50 ft (dBA)[g]	CN Rail Scenario Ldn at Closest NSA Plus Existing Ldn (dBA)[h]
	Wagoner	130.1	63	68.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.4
	Tulsa	1058.1	87	65.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.6
	Creek	73.6	57	69.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	79.2
	Lincoln	36	242	56.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	66.7

[a] Population density was taken from U.S. Census Bureau data for 2010 (U.S. Census Bureau 2012).
[b] Closest NSA distance to railway was obtained from aerial photography/maps.
[c] Existing noise levels were estimated based on the proximity of the NSA to existing railway noise; estimation methodology is described in USDOT 2006.
[d] Daily train volume was estimated from volume of WCS crude transported per day, maximum volume of WCS crude per car (594 bbl/car of dilbit), and 100 cars per train unit.
[e] Daytime hourly train volume was estimated based on a daytime period from 7am to 10pm (i.e., 15 hours per day).
[f] Nighttime hourly train volume estimated based on a nighttime period from 10pm to 7am (i.e., 9 hours per day).
[g] Total daytime and nighttime Leq for locomotives and rail cars, and the Canadian National Rail Scenario Ldn at 50 feet were calculated using the methodology described in USDOT 2006 for a commuter rail system. The noise calculations assumed three diesel powered locomotives per train unit with a speed of 40 miles per hour, and 100 cars per train unit.
[h] Canadian National Rail Scenario plus existing Ldn levels were calculated using the typical logarithmic equation for combining noise levels: 10Log(10^(Existing Noise/10) + 10^(Canadian National Scenario Noise/10)).

bbl = barrel, CN = Canadian National Railway, dBA = decibels on the A-weighted scale, ft = feet, hr = hour, Ldn = day-night sound level, Leq = equivalent continuous sound level, mi = miles, NSA = Noise Sensitive Area, WCS = Western Canadian Select crude.

Table 5 Estimated Direct Criteria Pollutant Emissions from the Rail/Tanker Scenario – Non-Tanker Portion

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Storage Location (million bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b,c]	Transport Distance, One Way (miles)[d]	Miles Traveled per Day, One Way[e]	On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[f]	Loaded Cargo[g]		Empty Cargo[h]		Criteria Pollutant Emissions (tons/year)[i]					
								Fuel Efficiency (ton-miles/gal)	Daily Fuel Use (gal/ day)	Fuel Economy (miles/ gal)	Daily Fuel Use (gal/ day)	HC/ VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$
WCS Extraction Site at Hardisty, Alberta to Rail Loading Terminals at Lloydminster, Saskatchewan (WCS)																	
Pipeline - connecting Hardesty to Lloydminster	730,000	NA	NA	NA	68	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting storage tanks to 7 terminals at Lloydminster	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks for all 7 terminals at Lloydminster	730,000	2.10	NA	NA	NA	NA	NA	NA	NA	NA	NA	91.4	NA	NA	NA	NA	NA
Rail Loading Terminals at Lloydminster, Saskatchewan to New Marine Terminal at Prince Rupert, British Columbia (WCS)																	
Rail terminal loading at Lloydminster	730,000	NA	NA	12.3	NA	NA	41,293	NA	NA	NA	NA	4.98	21.3	91.4	2.57	1.66	1.61
Rail - connecting Lloydminster to Prince Rupert	730,000	NA	118,501	12.3	1,069	13,136	NA	480	263,887	0.14	93,831	900	3,838	16,491	463	300	291
Rail terminal unloading at Prince Rupert	730,000	NA	NA	12.3	NA	NA	20,646	NA	NA	NA	NA	2.49	10.6	45.7	1.28	0.83	0.81
Storage tanks - (28) 75,000 bbl tanks for 7 rail terminals at Prince Rupert	730,000	2.10	NA	NA	NA	NA	NA	NA	NA	NA	NA	91.4	NA	NA	NA	NA	NA
Pipeline - connecting storage tanks to 7 terminals at Prince Rupert	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (14) 496,000 bbl tanks for the marine terminal at Prince Rupert	730,000	6.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	36.9	NA	NA	NA	NA	NA
Bakken Region to Rail Loading Terminal at Epping, North Dakota (Bakken)																	
Truck - road connecting Bakken region to Epping	100,000	NA	14,259	25,677	50	1,283,847	NA	154	4,634	7.5	171,180	289	1,649	5,830	228	137	126
Storage tanks - (4) 75,000 bbl tanks at the Epping terminal	100,000	0.30	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.6	NA	NA	NA	NA	NA
Rail Loading Terminals at Epping, North Dakota to Storage Facility at Stroud, Oklahoma (Bakken)																	
Rail terminal loading at Epping	100,000	NA	NA	1.5	NA	NA	4,970	NA	NA	NA	NA	0.60	2.56	11.0	0.30	0.20	0.19
Rail - connecting Epping to Stroud	100,000	NA	14,259	1.5	1,347	1,993	NA	480	40,014	0.14	14,233	109	582	2,915	70.2	72.8	70.6
Rail terminal unloading at Stroud	100,000	NA	NA	1.5	NA	NA	2,485	NA	NA	NA	NA	0.30	1.28	5.50	0.15	0.10	0.10

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Storage Location (million bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b,c]	Transport Distance, One Way (miles)[d]	Miles Traveled per Day, One Way[e]	On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[f]	Loaded Cargo[g] Fuel Efficiency (ton-miles/gal)	Loaded Cargo[g] Daily Fuel Use (gal/ day)	Empty Cargo[h] Fuel Economy (miles/ gal)	Empty Cargo[h] Daily Fuel Use (gal/ day)	Criteria Pollutant Emissions (tons/year)[i] HC/ VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$
Storage Facilities at Stroud, Oklahoma to Storage Facility at Cushing, Oklahoma (Bakken)																	
Pipeline (existing) - connecting Stroud to Cushing	100,000	NA	NA	NA	17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline – connecting off-loading terminals to storage tanks	100,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (11) 75,000 bbl tanks at the Cushing terminal	100,000	0.83	NA	NA	NA	NA	NA	NA	NA	NA	NA	25.5	NA	NA	NA	NA	NA
											Total	**1,562**	**6,105**	**25,390**	**765**	**513**	**490**

[a] Mass of crude transported per day was estimated based on volume of crude transported per day (bbl/day) and density of crude (7.73 lb/gal for dilbit and 6.79 lb/gal for Bakken crude).
[b] Number of train trips per day was estimated based on volume of crude transported per day (bbl/day), maximum volume per car (594 bbl/car for dilbit and 676 bbl/car for Bakken crude), and 100 cars per train.
[c] Number of truck trips per day was estimated based on volume of crude transported per day (bbl/day) and maximum payload for bulk tanker trucks (27 tons/truck).
[d] Transport distances (one way) for the rail routes were taken from the Final Supplemental EIS Section 5.1.2.2, Rail/Pipeline Scenario, with the exception of the connection from Lloydminster to Prince Rupert, which is from ICF 2012, Exhibit 9, p. 16. Transport distance (one way) for the trucks was assumed to be 50 miles.
[e] Daily miles traveled were estimated based on one-way transport distance and number of trips per day.
[f] On-terminal line-haul rail activity per day (hp-hr/day) was calculated based on the number of trains per day, number of locomotives per train (assumed three), hours at the terminal (assumed 1 hour for loading dilbit and Bakken crudes and 0.5 hour for unloading both crudes), average line-haul locomotive load factor of 28% (ICF 2009), and average locomotive horsepower (assumed 4,000 hp).
[g] Fuel efficiency for loaded long-haul locomotives (480 ton-miles/gal) was taken from Bureau of Transportation Statistics (BTS 2011), Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel efficiency for loaded bulk tanker trucks (154 ton-miles/gal or 6.5 gal/1,000 ton-miles) was taken from National Research Council (NRC 2010). Daily fuel used was estimated based on transport distance (one way), fuel efficiency, and mass of crude transported per day.
[h] Fuel economy for empty long-haul locomotives (0.14 miles/gal) was taken from BTS 2011, Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel economy for empty bulk tanker trucks (7.5 miles/gal) was taken from NRC 2010. Daily fuel used was estimated based on transport distance (one way), fuel economy, and mass of crude transported per day.
[i] Criteria pollutant emissions in tons per year were estimated based on emission factors in grams per gallon for cargo in transit and emission factors for idling activity (loading/unloading) at terminals in grams per horsepower-hour, daily diesel consumed, on-terminal line-haul rail activity per day, and 365 days of operation per year. Emissions of HC/VOCs for storage tanks were calculated using USEPA TANK 4.0.9d software assuming an external floating roof for each tank with a height of 48 feet. Criteria pollutant emission factors or standards for line-haul locomotives (remanufactured Tier 2) were taken from *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*, Chapter 5 Rail and Heavy-duty Trucks, April 2009 (ICF 2009). The line-haul locomotive emission factors were converted from g/hp-hr to grams per gallon using a conversion factor of 0.048 gal/hp-hr. Emission factors for the bulk tanker trucks or Class 8b trucks were taken from USEPA's *Average In-Use Emissions from Heavy-Duty Trucks*, October 2008 (USEPA 2008). Emission factors for the bulk tanker trucks or Class 8b trucks were converted from grams per mile to grams per gallon using a fuel economy factor of 7.5 miles per gallon. SO_2 emission factors for both line-haul locomotives and bulk tanker trucks were calculated using a mass balance approach taking into account the molecular weight difference between SO_2 and sulfur and using a 500 ppm sulfur content (low sulfur diesel), 3.218 grams/gal diesel fuel density, and assuming 100% of fuel sulfur is converted to SO_2.

bbl = barrel, CO = carbon monoxide, dilbit = diluted bitumen, g = grams, gal = gallon, HC = hydrocarbon, hp-hr = horsepower-hour, lb = pound, NA = not applicable, NOx = nitrogen oxides, $PM_{2.5}$ = particulate matter <2.5 microns, PM_{10} = particulate matter<10 micron, ppm = parts per million, SO_2 = sulfur dioxide, VOC = volatile organic compound, WCS = Western Canadian Select crude.

Table 6 Estimated Direct Criteria Pollutant Emissions from the Rail/Tanker Scenario – Tanker Portion

					Propulsion Engine[d,e]		Auxiliary Engines[d]				Criteria Pollutant Emissions (tons/year)[h]					
Transport and Storage Facilities	**Maximum Crude Volume Transported per Day, Throughput (bbl/day)**	**Number of Trips per Day[a]**	**Transport Distance, One Way (miles)[b]**	**Fuel Type[c]**	**Total Max. Power Rating (kW)**	**Engine Load Factor**	**Total Max. Power Rating (kW)**	**Engine Load Factor**	**Speed (miles/hr)[f]**	**Activity (hours/trip)[g]**	**HC/VOC**	**CO**	**NOx**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
New Marine Terminal at Prince Rupert, British Columbia to Texas Gulf Coast – Return Trip (Houston/Port Arthur) (WCS)																
Tankers[i] (loaded) - RSZ leaving Prince Rupert	730,000	0.83	110	MDO	9,400	0.23	1,985	0.28	10.4	10.7	4.66	10.7	130	39.1	4.61	4.22
Tankers (loaded) – ECA cruise zone connecting Prince Rupert to Houston/Port Arthur	730,000	0.83	309	MDO	9,400	0.83	1,985	0.24	15.5	19.9	27.1	60.2	725	218	25.8	23.6
Tankers (loaded) - non-ECA cruise zone connecting Prince Rupert to Houston/Port Arthur	730,000	0.83	6,354	IFO 380	9,400	0.83	1,985	0.24	15.5	409	556	1,238	15,805	12,700	1,610	1,486
Tankers (loaded) - RSZ entering Houston/Port Arthur	730,000	0.83	40.6	MDO	9,400	0.23	1,985	0.28	10.4	3.92	1.72	3.94	47.7	14.4	1.70	1.55
Tankers - hoteling at Houston/Port Arthur	730,000	0.83	0	MDO	9,400	0	1,985	0.26	0	48.0	3.29	9.05	114	34.9	4.03	3.70
Tankers (ballast) - RSZ leaving Houston/Port Arthur	730,000	0.83	40.6	MDO	9,400	0.23	1,985	0.28	10.4	3.92	1.72	3.94	47.7	14.4	1.70	1.55
Tankers (ballast) - ECA cruise zone connecting Houston/Port Arthur to Prince Rupert	730,000	0.83	309	MDO	9,400	0.83	1,985	0.24	16.1	19.2	26.1	58.1	699	210	24.9	22.8
Tankers (ballast) - non-ECA cruise zone connecting Houston/Port Arthur to Prince Rupert	730,000	0.83	6,354	IFO 380	9,400	0.83	1,985	0.24	16.1	395	536	1,194	15,240	12,247	1,553	1,433
Tankers (ballast) - RSZ entering Prince Rupert	730,000	0.83	110	MDO	9,400	0.23	1,985	0.28	10.4	10.7	4.66	10.7	130	39.1	4.61	4.22
Tankers - hoteling at Prince Rupert	730,000	0.83	0	MDO	9,400	0	1,985	0.26	0	48.0	3.29	9.05	114	34.9	4.03	3.70
										Total	**1,165**	**2,598**	**33,052**	**25,553**	**3,235**	**2,984**

[a] Number of tanker trips per day was based on volume of crude transported per day (bbl/day) and maximum volume per Suezmax vessel light-loaded to traverse Panama Canal (884,000 bbl/tanker for crude oil) from the Final Supplemental EIS Section 5.1.2.2, Rail/Pipeline Scenario.
[b] Transport distances (one way) for the tankers were derived from Poten & Partners 2012 using 1/2 the average round-trip distance from Prince Rupert to the Houston and Port Arthur marine terminals via the Panama Canal. North American Emission Control Areas (ECAs) were assumed to include reduced speed zones (RSZs) surrounding each port. RSZ information for Houston/Port Arthur was from ICF 2009, Table 2-18, Matched Ports and Regions; RSZ for Prince Rupert Harbor was estimated using the average of all North Pacific port RSZs.
[c] Fuel types were from Poten & Partners 2012, pg. 6. ECA areas mandate the use of low-sulfur marine fuel (marine diesel oil, MDO) using auxiliary engines. During cruising in non-ECA areas, tankers use main propulsion engines and intermediate fuel oil (IFO 380).
[d] Engine power ratings and load factors were from ICF 2009, Table 2-4 and Table 2-7.
[e] Propulsion engine RSZ load factors were calculated using the following equation from ICF 2009, pg. 2-11: Load Factor = (actual speed/maximum speed)^3. Maximum speed was calculated using the assumption from ICF 2009 that cruise speed is an average of 94% maximum speed.
[f] Tanker speeds were from Poten & Partners 2012, Appendix A. Knots (nautical miles per hour) were converted to miles per hour by multiplying by a factor of 1.15 miles/nautical mile.
[g] Activity (duration) was calculated using tanker speed and distance traveled per trip. Hoteling data were from Poten & Partners 2012, Appendix A.
[h] Criteria pollutant emissions in tons per year were calculated using the following equation from ICF 2009, pg. 2-1: Emissions = Power Rating x Load Factor x Activity Hours x Emission Factor. Emission factors for propulsion engine were taken from ICF 2009, Table 2-9, and for auxiliary engine from ICF 2009, Table 2-16. Residual oil (RO) emission factors were used for IFO 380. Tankers are Suezmax vessels with a carrying capacity of 884,000 bbl for travel through the Panama Canal.
[i] Tankers are Suezmax vessels with a carrying capacity of 884,000 bbl for travel through the Panama Canal. Excluded potential lightering that would use smaller vessels (Afromax) at Houston/Port Arthur.

bbl = barrel, CO = carbon monoxide, ECAs = North American emission control areas, EIS = Environmental Impact Statement, HC = hydrocarbon, hr = hour, ICF = ICF International, IFO = intermediate fuel oil, kW = kilowatt, MDO = marine diesel oil, NOx = nitrogen oxides, $PM_{2.5}$ = particulate matter <2.5 microns, PM_{10} = particulate matter<10 micron, RO = residual oil, RSZs = reduced speed zones, SO_2 = sulfur dioxide, VOC = volatile organic compound, WCS = Western Canadian Select crude.

Table 7 Estimated Direct Greenhouse Gas Emissions from the Rail/Tanker Scenario – Non-Tanker Portion

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Location (million bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b,c]	Transport Distance, One Way (miles)[d]	Miles Traveled per Day, One Way[e]	On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[f]	Loaded Cargo[g] Fuel Efficiency (ton-miles/gal)	Loaded Cargo[g] Fuel Use (gal/day)	Empty Cargo[h] Fuel Economy (miles/gal)	Empty Cargo[h] Fuel Use (gal/day)	Greenhouse Gas Emissions[i] (tons/year) CO_2	Greenhouse Gas Emissions[i] (tons/year) CH_4	Greenhouse Gas Emissions[i] (tons/year) N_2O	Greenhouse Gas Emissions[i] (tons/year) CO_2e	Greenhouse Gas Emissions[i] (metric tons/year) CO_2e
WCS Extraction Site at Hardisty, Alberta to Rail Loading Terminals at Lloydminster, Saskatchewan (WCS)																
Pipeline – connecting Hardesty to Lloydminster	730,000	NA	NA	NA	68	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline – connecting storage tanks to 7 terminals at Lloydminster	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks at Lloydminster	730,000	2.10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rail Loading Terminals at Lloydminster, Saskatchewan to New Marine Terminal at Prince Rupert, British Columbia (WCS)																
Rail terminal loading at Lloydminster	730,000	NA	NA	12.3	NA	NA	41,293	NA	NA	NA	NA	8,025	0.22	0.66	8,228	7,464
Rail – connecting Lloydminster to Prince Rupert	730,000	NA	118,501	12.3	1,069	13,136	NA	480	263,887	0.14	93,831	1,468,971	59.6	11.9	1,474,012	1,337,203
Rail terminal unloading at Prince Rupert	730,000	NA	NA	12.3	NA	NA	20,646	NA	NA	NA	NA	4,012	0.11	0.33	4,114	3,732
Storage tanks – (28) 75,000 bbl tanks for 7 rail terminals at Prince Rupert	730,000	2.10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline – connecting storage tanks to 7 terminals at Prince Rupert	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (14) 496,000 bbl tanks at Prince Rupert	730,000	6.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bakken Region to Rail Loading Terminal at Epping, North Dakota (Bakken)																
Truck – road connecting Bakken region to Epping	100,000	NA	14,259	25,677	50	1,283,847	NA	154	4,634	7.5	171,180	721,180	29.3	5.86	724,459	657,219
Storage tanks - (4) 75,000 bbl tanks at the Epping terminal	100,000	0.30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rail Loading Terminals at Epping, North Dakota to Storage Facility at Stroud, Oklahoma (Bakken)																
Rail terminal loading at Epping	100,000	NA	NA	1.5	NA	NA	4,970	NA	NA		NA	966	0.03	0.08	990	898
Rail – connecting Epping to Stroud	100,000	NA	14,259	1.5	1,347	1,993	NA	480	40,014	0.14	14,233	222,767	9.04	1.81	223,531	202,784
Rail terminal unloading at Epping	100,000	NA	NA	1.5	NA	NA	2,485	NA	NA	NA	NA	483	00.01	0.04	495	449

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Location (million bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b,c]	Transport Distance, One Way (miles)[d]	Miles Traveled per Day, One Way[e]	On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[f]	Loaded Cargo[g] Fuel Efficiency (ton-miles/gal)	Loaded Cargo[g] Fuel Use (gal/day)	Empty Cargo[h] Fuel Economy (miles/gal)	Empty Cargo[h] Fuel Use (gal/day)	Greenhouse Gas Emissions[i] (tons/year) CO_2	Greenhouse Gas Emissions[i] (tons/year) CH_4	Greenhouse Gas Emissions[i] (tons/year) N_2O	Greenhouse Gas Emissions[i] (tons/year) CO_2e	Greenhouse Gas Emissions[i] (metric tons/year) CO_2e
Storage Facilities at Stroud, Oklahoma to Storage Facility at Cushing, Oklahoma (Bakken)																
Pipeline (existing) – connecting Stroud to Cushing	100,000	NA	NA	NA	17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline – connecting offloading terminals to storage tanks	100,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (11) 75,000 bbl tanks at the Cushing terminal	100,000	0.83	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
											Total	**2,427,204**	**98.3**	**20.7**	**2,435,829**	**2,209,750**

[a] Mass of crude transported per day was estimated based on volume of crude transported per day (bbl/day) and density of crude (7.73 lb/gal for dilbit and 6.79 lb/gal for Bakken crude).
[b] Number of train trips per day was estimated based on volume of crude transported per day (bbl/day), maximum volume per car (594 bbl/car for dilbit and 676 bbl/car for Bakken crude), and 100 cars per train.
[c] Number of truck trips per day was estimated based on volume of crude transported per day (bbl/day) and maximum payload for bulk tanker trucks (27 tons/truck).
[d] Transport distances (one way) for the rail routes were taken from the Final Supplemental EIS Section 5.1.2.2, Rail/Pipeline Scenario, with the exception of the connection from Lloydminster to Prince Rupert, which is from ICF 2012, Exhibit 9, pg. 16. Transport distance (one way) for the trucks was assumed to be 50 miles.
[e] Daily miles traveled were estimated based on one-way transport distance and number of trips per day.
[f] On-terminal line-haul rail activity per day (hp-hr/day) was calculated based on the number of trains per day, number of locomotives per train (assumed three), hours at the terminal (assumed 1 hour for loading dilbit and Bakken crudes and 0.5 hour for unloading both crudes), average line-haul locomotive load factor of 28% (ICF 2009), and average locomotive horsepower (assumed 4,000 hp).
[g] Fuel efficiency for loaded long-haul locomotives (480 ton-miles/gal) was taken from Bureau of Transportation Statistics (BTS 2011), Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel efficiency for loaded bulk tanker trucks (154 ton-miles/gal or 6.5 gal/1,000 ton-miles) was taken from the National Research Council (NRC 2010). Daily fuel used was estimated based on transport distance (one way), fuel efficiency, and mass of crude transported per day.
[h] Fuel economy for empty long-haul locomotives (0.14 miles/gal) was taken from BTS 2011, Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel economy for empty bulk tanker trucks (7.5 miles/gal) was taken from NRC 2010. Daily fuel used was estimated based on transport distance (one way), fuel economy, and mass of crude transported per day.
[i] Greenhouse gas emissions in tons per year were estimated based on emission factors in kilograms per million British thermal units for cargo in transit and emission factors for idling activity (loading/unloading) at terminals in grams per horsepower-hour, daily diesel consumed (gal/day), high heating value of diesel (0.138 MMBtu/gal), on-terminal line-haul rail activity per day, and 365 days of operations per year. Greenhouse gas emission factors were taken from 40 CFR 98 Subpart C, Table C-1 and C-2. Total greenhouse gases were estimated as CO_2 equivalents (CO_2e), accounting for 100-year global warming potentials of CO_2 (1), CH_4 (25) and N_2O (298).

bbl = barrel, BTS = Bureau of Transportation Statistics, CFR = Code of Federal Regulations, CH_4 = methane, CO_2 = carbon dioxide, CO_2e = CO_2 equivalents, dilbit = diluted bitumen, EIS = Environmental Impact Statement, gal = gallon, hp-hr = horsepower-hour, ICF = ICF International, lb = pound, MMBtu = million British thermal units, N_2O = nitrous oxide, NA = not applicable, NRC = National Research Council, WCS = Western Canadian Select.

Table 8 Estimated Direct Greenhouse Gas Emissions from the Rail/Tanker Scenario - Tanker Portion

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Number of Trips per Day[a]	Transport Distance, One Way (miles)[b]	Fuel Type[c]	Propulsion Engine[d,e] Total Max. Power Rating (kW)	Propulsion Engine[d,e] Engine Load Factor	Auxiliary Engines[d] Total Max. Power Rating (kW)	Auxiliary Engines[d] Engine Load Factor	Speed (miles/hr)[f]	Activity (hours/trip)[g]	Greenhouse Gas Emissions[h] (tons/year) CO_2	(tons/year) CH_4	(tons/year) N_2O	(tons/year) CO_2e	(metric tons/year) CO_2e
New Marine Terminal at Prince Rupert, British Columbia to Texas Gulf Coast (Houston/Port Arthur) (WCS)															
Tankers[i] (loaded) – RSZ leaving Prince Rupert	730,000	0.83	110	MDO	9,400	0.23	1,985	0.28	10.4	10.7	6.37e3	0.039	0.30	6.46e3	5.86e3
Tankers (loaded) – ECA cruise zone connecting Prince Rupert to Houston/Port Arthur	730,000	0.83	309	MDO	9,400	0.83	1,985	0.24	15.5	19.9	3.55e4	0.22	1.70	3.60e4	3.27e4
Tankers (loaded) - non-ECA cruise zone connecting Prince Rupert to Houston/Port Arthur	730,000	0.83	6,354	IFO 380	9,400	0.83	1,985	0.24	15.5	409	7.66e5	4.50	34.9	7.76e5	7.04e5
Tankers (loaded) - RSZ entering Houston/Port Arthur	730,000	0.83	40.6	MDO	9,400	0.23	1,985	0.28	10.4	3.92	2.34e3	0.014	0.11	2.38e3	2.16e3
Tankers - hoteling at Houston/Port Arthur	730,000	0.83	0	MDO	9,400	0	1,985	0.26	0	48.0	5.69e3	0.033	0.26	5.76e3	5.23e3
Tankers (ballast) - RSZ leaving Houston/Port Arthur	730,000	0.83	40.6	MDO	9,400	0.23	1,985	0.28	10.4	3.92	2.34e3	0.014	0.11	2.38e3	2.16e3
Tankers (ballast) - ECA cruise zone connecting Houston/Port Arthur to Prince Rupert	730,000	0.83	309	MDO	9,400	0.83	1,985	0.24	16.1	19.2	3.43e4	0.21	1.64	3.47e4	3.15e4
Tankers (ballast) - non-ECA cruise zone connecting Houston/Port Arthur to Prince Rupert	730,000	0.83	6,354	IFO 380	9,400	0.83	1,985	0.24	16.1	394.6	7.39e5	4.34	33.6	7.49e5	6.79e5
Tankers (ballast) - RSZ entering Prince Rupert	730,000	0.83	110	MDO	9,400	0.23	1,985	0.28	10.4	10.7	6.37e3	0.039	0.30	6.46e3	5.86e3
Tankers - hoteling at Prince Rupert	730,000	0.83	0	MDO	9,400	0	1,985	0.26	0	48.0	5.69e3	0.033	0.26	5.76e3	5.23e3
										Total	**1.60e6**	**9.45**	**73.2**	**1.63e6**	**1.47e6**

[a] Number of tanker trips per day was based on volume of crude transported per day (bbl/day) and maximum volume per Suezmax vessel light-loaded to traverse Panama Canal (884,000 bbl/tanker for crude oil) from the Final Supplemental EIS Section 5.1.2.2, Rail/Pipeline Scenario.
[b] Transport distances (one way) for the tankers were derived from Poten & Partners 2012, Appendix A, using 1/2 the average round-trip distance from Prince Rupert to the Houston and Port Arthur marine terminals via the Panama Canal. North American Emission Control Areas (ECAs) were assumed to include reduced speed zones (RSZs) surrounding each port. RSZ information for Houston/Port Arthur from ICF 2009, Table 2-18: Matched Ports and Regions; RSZ for Prince Rupert Harbor was estimated using the average of all North Pacific port RSZs.
[c] Fuel types from Poten & Partners 2012, pg. 6. Emission control areas mandate the use of low-sulfur marine fuel (marine diesel oil, MDO) using auxiliary engines. During cruising in non-ECA areas, tankers use main propulsion engines and intermediate fuel oil (IFO 380).
[d] Engine power ratings and load factors were from ICF 2009, Table 2-4 and Table 2-7.
[e] Propulsion engine RSZ load factors were calculated using the following equation from ICF 2009, pg. 2-11: Load Factor = (actual speed/maximum speed)^3. Maximum speed was calculated using the assumption from ICF 2009 that cruise speed is an average of 94% maximum speed.
[f] Tanker speeds were from Poten & Partners 2012, Appendix A. Knots (nautical miles per hour) were converted to miles per hour by multiplying by a factor of 1.15 miles/nautical mile.
[g] Activity (duration) was calculated using tanker speed and distance traveled per trip. Hoteling data were from Poten & Partners 2012, Appendix A.
[h] Greenhouse gas emissions in tons per year were calculated using the following equation from ICF 2009, pg. 2-1: Emissions = Power Rating x Load Factor x Activity Hours x Emission Factor. Emission factors were taken from ICF 2009, Table 2-9 for CO_2 (propulsion engine), Table 2-16 for CO_2 (auxiliary engine), and Table 2-13 for CH_4 and N_2O (medium speed diesel, or MSD, engine type). Residual oil (RO) emission factors were used for IFO. Total greenhouse gases were estimated as CO_2 equivalents (CO_2e), accounting for 100-year global warming potentials of CO_2 (1), CH_4 (25) and N_2O (298).
[i] Tankers are Suezmax vessels with a carrying capacity of 884,000 bbl for travel through the Panama Canal. Excluded potential lightering that would use smaller vessels (Afromax) at Houston/Port Arthur.

bbl = barrel, CH_4 = methane, CO_2 = carbon dioxide, CO_2e = CO_2 equivalents, ECAs = North American emission control areas, EIS = Environmental Impact Statement, hr = hour, ICF = ICF International, IFO = intermediate fuel oil, kW = kilowatt, MDO = marine diesel oil, MSD = medium speed diesel, N_2O = nitrous oxide, RO = residual oil, RSZs = reduced speed zones, WCS = Western Canadian Select crude.

Table 9 Estimated Direct Criteria Pollutant Emissions from the Rail Direct to the Gulf Coast Scenario

								Loaded Cargo[f]		Empty Cargo[g]		Criteria Pollutant Emissions (tons/year)[h]					
Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Storage Location (bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b]	Transport Distance, One Way (miles)[c]	Miles Traveled per Day, One Way[d]	On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[e]	Fuel Efficiency (ton-miles/gal)	Daily Fuel Use (gal/day)	Fuel Economy (miles/gal)	Daily Fuel Use (gal/day)	HC/ VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$
WCS Extraction Site at Hardisty, Alberta to Rail Loading Terminals at Lloydminster, Saskatchewan (WCS); Bakken Region to Rail Loading Terminal at Epping, North Dakota (Bakken)																	
Pipeline - connecting Hardesty to Lloydminster	730,000	NA	NA	NA	68.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting storage tanks to 7 terminals at Lloydminster	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks for all 7 terminals at Lloydminster	730,000	2,100,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	91.4	NA	NA	NA	NA	NA
Truck - road connecting Bakken region to Epping	100,000	NA	14,259	25,677	50.0	1,283,847	NA	154	4,634	7.5	171,180	289	1,649	5,830	6.83	137	126
Storage tanks - (4) 75,000 bbl tanks at the Epping terminal	100,000	300,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.6	NA	NA	NA	NA	NA
Lloydminster, Saskatchewan to Port Arthur, Texas; Epping, North Dakota to Port Arthur, Texas																	
Rail terminal loading at Lloydminster (WCS)	730,000	NA	NA	12.3	NA	NA	41,293	NA	NA	NA	NA	4.98	21.3	91.4	2.57	1.66	1.61
Rail - connecting Lloydminster to Port Arthur (WCS)	730,000	NA	118,501	12.3	2,485	30,540	NA	480	613,489	0.14	218,140	2,091	8,923	38,339	1,077	697	676
Rail terminal unloading at Port Arthur (WCS)	730,000	NA	NA	12.3	NA	NA	20,646	NA	NA	NA	NA	2.49	10.6	45.7	1.28	0.83	0.81
Rail terminal loading at Epping (Bakken)	730,000	NA	NA	1.5	NA	NA	4,970	NA	NA	NA	NA	0.60	2.56	11.0	0.31	0.20	0.19
Rail – connecting Epping to Port Arthur (Bakken)	100,000	NA	14,259	1.5	1,916	2,834	NA	480	56,917	0.14	20,245	155	828	4,146	100	103	100
Rail terminal unloading at Port Arthur (Bakken)	730,000	NA	NA	1.5	NA	NA	2,485	NA	NA	NA	NA	0.30	1.28	5.50	0.15	0.10	0.10
											Total	**2,646**	**11,436**	**48,469**	**1,188**	**941**	**906**

[a] Mass of crude transported per day was estimated based on volume of crude transported per day (bbl/day) and density of crude (7.73 lb/gal for dilbit and 6.79 lb/gal for Bakken crude).
[b] Number of train trips per day was estimated based on volume of crude transported per day (bbl/day), maximum volume per car (594 bbl/car of dilbit and 676 bbl/car of Bakken crude), and 100 cars per train.
[c] Transport distances (one way) for the rail routes were taken from the Final Supplemental EIS Section 5.1.2.4, Rail Direct to the Gulf Coast Scenario.
[d] Daily miles traveled were estimated based on one-way transport distance and number of trips per day.
[e] On-terminal line-haul rail activity per day (hp-hr/day) was calculated based on the number of trains per day, number of locomotives per train (assumed three), hours at the terminal (assumed 1 hour for loading dilbit and Bakken crudes and 0.5 hour for unloading both crudes), average line-haul locomotive load factor of 28% (ICF 2009), and average locomotive horsepower (assumed 4,000 hp).
[f] Fuel efficiency for loaded long-haul locomotives (480 ton-miles/gal) was taken from Bureau of Transportation Statistics (BTS 2011), Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Fuel efficiency for loaded bulk tanker trucks (154 ton-miles/gal or 6.5 gal/1,000 ton-miles) was taken from the National Research Council (NRC 2010). Daily fuel used was estimated based on transport distance (one way), fuel efficiency, and mass of crude transported per day.
[g] Fuel economy for empty long-haul locomotives (0.14 miles/gal) was taken from BTS 2011, Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009.
[h] Criteria pollutant emissions in tons per year were estimated based on emission factors in grams per gallon for cargo in transit and emission factors for idling activity (loading/unloading) at terminals in grams per horsepower-hour, daily diesel consumed, on-terminal line-haul rail activity per day, and 365 days of operation per year. Criteria pollutant emission factors or standards for line-haul locomotives (remanufactured Tier 2) were taken from ICF International (ICF 2009). The line-haul locomotive emission factors were converted from grams per horsepower-hour to grams per gallon using a conversion factor of 0.048 gal/hp-hr. SO_2 emission factors for the line-haul locomotives were calculated using a mass balance approach taking into account the molecular weight difference between SO_2 and sulfur and using a 500 ppm sulfur content (low sulfur diesel), 3,218 grams/gal diesel fuel density, and assuming 100% of fuel sulfur is converted to SO_2.

bbl = barrel, BTS = Bureau of Transportation Statistics, CO = carbon monoxide, dilbit = diluted bitumen, EIS = Environmental Impact Statement, gal = gallon, HC = hydrocarbons, hp-hr = horsepower-hour, ICF = ICF International, NA = not applicable, NOx = nitrogen oxides, NRC = National Research Council, $PM_{2.5}$ = particulate matter <2.5 microns, PM_{10} = particulate matter<10 micron, SO_2 = sulfur dioxide, VOC = volatile organic compounds, WCS = Western Canadian Select crude.

Table 10 Estimated Direct Greenhouse Gas Emissions from the Rail Direct to the Gulf Coast Scenario

Transport and Storage Facilities	Maximum Crude Volume Transported per Day, Throughput (bbl/day)	Crude Volume Stored per Storage Location (bbl)	Crude Mass Transported per Day (tons/day)[a]	Number of Trips per Day[b]	Transport Distance, One Way (miles)[c]	Miles Traveled per Day, One Way[d]	On-Terminal Line-haul Rail Activity per Day (hp-hr/day)[e]	Loaded Cargo[f] Fuel Efficiency (ton-miles/gal)	Loaded Cargo[f] Daily Fuel Use (gal/day)	Empty Cargo[g] Fuel Economy (miles/gal)	Empty Cargo[g] Daily Fuel Use (gal/day)	Greenhouse Gas Emissions[h] (tons/year) CO_2	Greenhouse Gas Emissions[h] (tons/year) CH_4	Greenhouse Gas Emissions[h] (tons/year) N_2O	Greenhouse Gas Emissions[h] (tons/year) CO_2e[i]	Greenhouse Gas Emissions[h] (metric tons/year) CO_2e[i]
WCS Extraction Site at Hardisty, Alberta to Rail Loading Terminals at Lloydminster, Saskatchewan (WCS); Bakken Region to Rail Loading Terminal at Epping, North Dakota (Bakken)																
Pipeline - connecting Hardesty to Lloydminster	730,000	NA	NA	NA	68.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline - connecting storage tanks to 7 terminals at Lloydminster	730,000	NA	NA	NA	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storage tanks - (28) 75,000 bbl tanks for all 7 terminals at Lloydminster	730,000	2,100,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Truck - road connecting Bakken region to Epping	100,000	NA	14,259	25,677	50.0	1,283,847	NA	154	4,634	7.5	171,180	721,981	29.3	5.86	724,459	657,219
Storage tanks - (4) 75,000 bbl tanks at the Epping terminal	100,000	300,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lloydminster, Saskatchewan to Port Arthur, Texas; Epping, North Dakota to Port Arthur, Texas																
Rail terminal loading at Lloydminster (WCS)	730,000	NA	NA	12.3	NA	NA	41,293	NA	NA	NA	NA	8,025	0.22	0.66	8,228	7,464
Rail - connecting Lloydminster to Port Arthur (WCS)	730,000	NA	118,501	12.3	2,485	30,540	NA	480	613,489	0.14	218,140	3,415,093	139	27.7	3,426,812	3,108,755
Rail terminal unloading at Port Arthur (WCS)	730,000	NA	NA	12.3	NA	NA	20,646	NA	NA	NA	NA	4,012	0.11	0.33	4,114	3,732
Rail terminal loading at Epping (Bakken)	100,000	NA	NA	1.5	NA	NA	4,970	NA	NA	NA	NA	966	0.026	0.080	990	898
Rail - connecting Epping to Port Arthur (Bakken)	100,000	NA	14,259	1.5	1,916	2,834	NA	480	56,917	0.14	20,245	316,868	12.9	2.57	317,955	288,444
Rail terminal unloading at Port Arthur (Bakken)	100,000	NA	NA	1.5	NA	NA	2,485	NA	NA	NA	NA	483	0.013	0.0040	495	449
											Total	**4,467,427**	**181**	**37.2**	**4,483,053**	**4,066,962**

[a] Mass of crude transported per day was estimated based on volume of crude transported per day (bbl/day) and density of crude (7.73 lb/gal for dilbit and 6.79 lb/gal for Bakken crude).
[b] Number of train trips per day was estimated based on volume of crude transported per day (bbl/day), maximum volume per car (594 bbl/car of dilbit and 676 bbl/car of Bakken crude), and 100 cars per train.
[c] Transport distances (one way) for the rail routes were taken from the Final Supplemental EIS Section 5.1.2.4, Rail Direct to the Gulf Coast Scenario. Transport distance (one way) for the trucks was assumed to be 50 miles.
[d] Daily miles traveled were estimated based on one-way transport distance and number of trips per day.
[e] On-terminal line-haul rail activity per day (hp-hr/day) was calculated based on the number of trains per day, number of locomotives per train (assumed three), hours at the terminal (assumed 1 hour for loading dilbit and Bakken crudes and 0.5 hour for unloading both crudes), average line-haul locomotive load factor of 28% (ICF 2009), and average locomotive horsepower (assumed 4,000 hp).
[f] Fuel efficiency for loaded long-haul locomotives (480 ton-miles/gal) was taken from Bureau of Transportation Statistics (BTS 2011), Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Daily fuel used estimated based on transport distance (one way), fuel efficiency, and mass of crude transported per day.
[g] Fuel economy for empty long-haul locomotives (0.14 miles/gal) was taken from BTS 2011, Table 4-17: Class I Rail Freight Fuel Consumption and Travel, Year 2009. Daily fuel used was estimated based on transport distance (one way), fuel economy, and mass of crude transported per day.
[h] Greenhouse gas emissions in tons per year were estimated based on emission factors in kilograms per million British Thermal Units (kg/MMBtu) for cargo in transit and emission factors for idling activity (loading/unloading) at terminals in grams per horsepower-hour, daily diesel consumed (gal/day), high heating value of diesel (0.138 MMBtu/gal), on-terminal line-haul rail activity per day, and 365 days of operations per year. Greenhouse gas emission factors in kg/MMBtu were taken from 40 CFR 98 Subpart C, Table C-1 and C-2.
[i] Total greenhouse gases were estimated as CO_2 equivalents (CO_2e), accounting for 100-year global warming potentials of CO_2 (1), CH_4 (25) and N_2O (298).

bbl = barrel, BTS = Bureau of Transportation Statistics, CFR = Code of Federal Regulations, CH_4 = methane, CO_2 = carbon dioxide, CO_2e = CO_2 equivalents, dilbit = diluted bitumen, EIS = Environmental Impact Statement, gal = gallon, hp-hr = horsepower-hour, ICF = ICF International, kg = kilogram, lb = pound, MMBtu = million British thermal units, N_2O = nitrous oxide, NA = not applicable, WCS = Western Canadian Select crude.

Table 11 Predicted Noise Levels at Closest Noise Sensitive Areas from the Rail Direct to the Gulf Coast Scenario – Lloydminster, Saskatchewan to Port Arthur, Texas

State	County	Pop. Density (people /mi²)[a]	Closest NSA Dist. to Railway (ft)[b]	Existing Ldn Noise Level (dBA)[c]	Volume of WCS Crude Transported per Day (bbl /day)	Daily train volume (trains /day)[d]	Day time (7am-10pm) hourly train volume (trains /hr)[e]	Night time (10pm-7am) train volume (trains /hr)[f]	Total Daytime Leq for Locomotives and Rail Cars (dBA)[g]	Total Night time Leq for Locomotives and Rail Cars (dBA)[g]	Direct Rail to the Gulf Coast Scenario Ldn at 50 ft (dBA)[g]	Direct Rail to the Gulf Coast Scenario Ldn at Closest NSA Plus Existing Ldn (dBA)[h]
North Dakota												
	Burke	1.8	112	63.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.4
	Renville	2.8	521	50.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	60.0
	Ward	30.6	38	72.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	82.8
	McHenry	2.9	77	66.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.6
	Pierce	4.3	338	54.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	63.8
	Sheridan	1.4	177	59.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	69.4
	Wells	3.3	50	70.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.4
	Foster	5.3	64	68.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.2
	Stutsman	9.5	115	63.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	73.2
	Barnes	7.4	30	75.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	84.8
	Cass	84.9	332	54.1	730,000	12.3	7.7	4.6	75.3	73.1	79.9	63.9
	Ransom	6.3	100	64.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.4
	Richland	11.4	120	63.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.8
Minnesota												
	Wilkin	8.8	90	65.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.3
	Grant	11	27	75.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	85.7
	Douglas	56.5	96	64.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.7
	Stearns	112.2	48	70.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.7
	Pope	16.4	100	64.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	74.4
	Wright	188.5	60	69.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.8
	Kandiyohi	53	250	56.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	66.4
	Meeker	38.3	71	67.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	77.3
	Hennepin	2,081.7	25	76.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	86.4
	Dakota	709	30	75.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	84.8
	Scott	364.5	65	68.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.1
	Rice	129.4	27	75.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	85.7
	Steele	85.1	50	70.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.4
	Freeborn	44.2	40	72.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	82.3
Iowa												
	Worth	19	45	71.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	81.3
	Cerro Gordo	77.7	40	72.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	82.3
	Franklin	18.4	35	73.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	83.5
	Hardin	30.8	44	71.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	81.5
	Story	156.3	40	72.5	730,001	12.3	7.7	4.6	75.3	73.1	79.9	82.3
	Polk	750.5	72	67.4	730,002	12.3	7.7	4.6	75.3	73.1	79.9	77.2
	Marion	60.1	33	74.2	730,003	12.3	7.7	4.6	75.3	73.1	79.9	84.0
	Warren	81.1	100	64.5	730,004	12.3	7.7	4.6	75.3	73.1	79.9	74.4
	Lucas	20.7	34	73.9	730,005	12.3	7.7	4.6	75.3	73.1	79.9	83.7
	Wayne	12.2	41	72.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	82.1
Missouri												
	Mercer	8.3	52	70.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	80.0
	Grundy	23.6	30	75.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	84.8
	Daviess	15	260	56.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	66.1
	Livingston	28.5	203	58.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	68.2
	Caldwell	22.1	45	71.5	730,001	12.3	7.7	4.6	75.3	73.1	79.9	81.3
	Ray	41.3	20	78.5	730,002	12.3	7.7	4.6	75.3	73.1	79.9	88.3

State	County	Pop. Density (people /mi²)[a]	Closest NSA Dist. to Railway (ft)[b]	Existing Ldn Noise Level (dBA)[c]	Volume of WCS Crude Transported per Day (bbl /day)	Daily train volume (trains /day)[d]	Day time (7am-10pm) hourly train volume (trains /hr)[e]	Night time (10pm-7am) train volume (trains /hr)[f]	Total Daytime Leq for Locomotives and Rail Cars (dBA)[g]	Total Night time Leq for Locomotives and Rail Cars (dBA)[g]	Direct Rail to the Gulf Coast Scenario Ldn at 50 ft (dBA)[g]	Direct Rail to the Gulf Coast Scenario Ldn at Closest NSA Plus Existing Ldn (dBA)[h]
	Clay	558.6	43	71.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	81.7
	Jackson	1,115.3	83	66.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	76.0
Kansas												
	Johnson	1,149.60	62	68.7	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.5
	Miami	57	33	74.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	84.0
	Linn	16.3	40	72.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	82.3
	Anderson	14	288	55.4	730,000	12.3	7.7	4.6	75.3	73.1	79.9	65.2
	Allen	26.7	66	68.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.0
	Neosho	28.9	54	69.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	79.7
	Labette	33.5	15	81.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	90.8
Oklahoma												
	Craig	19.7	84	66.1	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.9
	Mayes	63	85	66.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.8
	Wagoner	130.1	129	62.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	72.2
	Muskogee	87.6	45	71.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	81.3
	McIntosh	32.7	87	65.8	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.6
	Pittsburg	35.1	90	65.5	730,000	12.3	7.7	4.6	75.3	73.1	79.9	75.3
	Atoka	14.5	102	64.4	730,001	12.3	7.7	4.6	75.3	73.1	79.9	74.2
	Bryan	46.9	66	68.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.0
Texas												
	Grayson	129.6	26	76.2	730,000	12.3	7.7	4.6	75.3	73.1	79.9	86.1
	Cooke	43.9	378	53.0	730,001	12.3	7.7	4.6	75.3	73.1	79.9	62.8
	Denton	754.3	16	80.5	730,002	12.3	7.7	4.6	75.3	73.1	79.9	90.3
	Tarrant	2,094.70	36	73.4	730,003	12.3	7.7	4.6	75.3	73.1	79.9	83.2
	Johnson	208.3	23	77.3	730,004	12.3	7.7	4.6	75.3	73.1	79.9	87.1
	Hill	36.6	42	72.1	730,005	12.3	7.7	4.6	75.3	73.1	79.9	81.9
	McLennan	226.5	45	71.5	730,006	12.3	7.7	4.6	75.3	73.1	79.9	81.3
	Falls	23.3	65	68.3	730,007	12.3	7.7	4.6	75.3	73.1	79.9	78.1
	Robertson	19.4	17	79.9	730,008	12.3	7.7	4.6	75.3	73.1	79.9	89.8
	Brazos	332.8	19	79.0	730,010	12.3	7.7	4.6	75.3	73.1	79.9	88.8
	Grimes	33.8	36	73.4	730,011	12.3	7.7	4.6	75.3	73.1	79.9	83.2
	Montgomery	437.5	57	69.4	730,012	12.3	7.7	4.6	75.3	73.1	79.9	79.2
	Hardin	61.3	78	66.7	730,013	12.3	7.7	4.6	75.3	73.1	79.9	76.5
	Liberty	65.3	60	69.0	730,000	12.3	7.7	4.6	75.3	73.1	79.9	78.8
	Waller	84.1	157	60.6	730,000	12.3	7.7	4.6	75.3	73.1	79.9	70.4
	Jefferson	287.9	29	75.3	730,000	12.3	7.7	4.6	75.3	73.1	79.9	85.1
	Harris	2,402.40	24	76.9	730,000	12.3	7.7	4.6	75.3	73.1	79.9	86.8

[a] Population density was taken from U.S. Census Bureau data for 2010 (U.S. Census Bureau 2012).
[b] Closest NSA distance to railway was obtained from aerial photography/maps.
[c] Existing noise levels were estimated based on the proximity of the NSA to existing railway noise; estimation methodology is described in U.S. Department of Transportation (USDOT 2006).
[d] Daily train volume was estimated from volume of WCS crude transported per day, maximum volume of WCS crude per car (594 bbl/car of dilbit), and 100 cars per train unit.
[e] Daytime hourly train volume was estimated based on a daytime period from 7am to 10pm (i.e., 15 hours per day).
[f] Nighttime hourly train volume estimated based on nighttime period being from 10pm to 7am (i.e., 9 hours per day).
[g] Total daytime and nighttime Leq for locomotives and rail cars, and the Rail Direct to the Gulf Coast Scenario Ldn at 50 feet were calculated using the methodology described in USDOT 2006 for a commuter rail system. The noise calculations assumed three diesel powered locomotives per train unit with a speed of 40 miles per hour, and 100 cars per train unit.
[h] Rail Direct to the Gulf Coast Scenario plus existing Ldn levels were calculated using the typical logarithmic equation for combining noise levels: 10Log(10^(Existing Noise/10) + 10^(Canadian Pacific Scenario Noise/10)).

bbl = barrel, dBA = decibels on the A-weighted scale, dilbit = diluted bitumen, ft = feet, hr = hour, Leq = equivalent continuous sound level, Ldn = day-night sound level, mi = miles, NSA = Noise Sensitive Area, WCS = Western Canadian Select.

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