UNITED STATES ARMY CORPS OF ENGINEERS

Missouri River Commercial Dredging Draft EIS

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Appendix D Air Quality and Climate Change Technical Information

PREPARED BY

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List of Acronyms

Capital Sand	Capital Sand Company, Inc.
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_{2s}	carbon dioxide equivalent
Con-Agg	Con-Agg of MO, L.L.C
EIS	environmental impact statement
g	gram(s)
GHG	greenhouse gas
Hermann Sand	Hermann Sand & Gravel, Inc.
Holliday Sand	Holliday Sand & Gravel Company, L.L.C.
HP	horsepower
J.T.R.	Jotori, Inc.
kW	kilowatt(s)
l/CD	cylinder displacement
Limited Leasing	Limited Leasing Company
LOMR	lower Missouri River
Master’s	The Master’s Dredging Company, Inc.
MDNR	Missouri Department of Natural Resources
N_20	nitrous oxide

NO_x	oxides of nitroxen
PM	particulate matter
Rau	Edward N. Rau Contractor Company
RIA	U.S. Environmental Protection Agency Regulatory Impact Analysis
RM	river mile
ROG	reactive organic gas
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

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APPENDIX D

Air Quality and Climate Change Technical Information

D.1 INTRODUCTION

The U.S. Army Corps of Engineers (USACE) has received permit applications from eight companies to dredge sand and gravel from selected locations between river mile (RM) 0.0 and RM 447.7 on the lower Missouri River (LOMR) for commercial uses. As part of its review of the permit applications, the USACE is preparing an environmental impact statement (EIS). The EIS examines the potential environmental impacts of the proposed dredging activities and any related actions.

As part of the environmental analysis, the potential effects of the Proposed Action and alternatives on air quality and climate change were examined. This appendix provides technical information in support of Section 3.16 in the Affected Environment chapter of the EIS, which describes existing air quality conditions, and Section 4.14, the analysis of air quality impacts and effects on climate change in the Environmental Consequences chapter of the EIS.

This technical appendix describes the methodology used to estimate criteria pollutant and greenhouse gas (GHG) emissions generated under the Proposed Action and alternatives, based on information received from the permit applicants. In addition, emissions factors and methodologies were obtained from the following previous studies: *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories* (ICF International 2009), the *Puget Sound Maritime Air Emissions Inventory* (Starcrest Consulting 2007), and the *2007 Good Movement Air Emissions Inventory at the Port of Houston* (Starcrest Consulting 2009).

As discussed in Section 4.14 in the EIS, the following three activities were considered:

- Dredging (removal of sand and gravel from the river bed and the transport of that material onshore),
- Onshore materials handling (use of earth-moving equipment to transport and process the dredged material) and sand plants, and
- Transportation of sand and gravel to local market areas.

This appendix describes the data and methods used to estimate emissions from these three activities and the procedures for estimating emissions from construction of new facilities. It also discusses why potential emissions generated by facility operations (e.g., fugitive dust from processed materials and air pollutants from the upkeep of offices and employee commute trips) were not quantified and were excluded from the impact analysis.

The following companies were assumed to operate under existing conditions: Capital Sand Company, Inc. (Capital Sand), Con-Agg of MO, L.L.C (Con-Agg), Hermann Sand & Gravel, Inc. (Hermann Sand), Holliday Sand & Gravel Company, L.L.C. (Holliday Sand), Jotori, Inc. (J.T.R.), and Limited Leasing Company (Limited Leasing). These companies, as well as two new applicants (The Master's Dredging Company, Inc. [Master's] and Edward N. Rau Contractor Company [Rau]), were assumed to operate under the Proposed Action and alternatives.

D.2 DREDGING

Primary emissions resulting from dredges and tug boats include reactive organic gases/volatile organic compounds (ROG/VOC), carbon monoxide (CO), oxides of nitrogen ($NO_{X)}$, particulate matter (PM), and GHGs emitted as engine exhaust. Information on engine horsepower, load factor, and hours of operation were provided by the majority of permit applicants. When companies did not supply complete information, assumptions were made using the most conservative scenarios so that potential emissions would not be underestimated. Tables D-1 and D-2 summarize the equipment used in the emissions modeling. The tables indicate where assumptions were made and how they were developed. Note that the operating information (e.g., hours of operation) presented below represents existing conditions unless otherwise noted.

Emission factors summarized in previous studies were used to quantify emissions from the dredge and tug boat engines identified in Tables D-1 through D-3 (ICF International 2009, Starcrest Consulting 2009). The use of a specific emissions factor is dependent upon engine power, model, year, and cylinder displacement (l/Cd). The U.S. Environmental Protection Agency (USEPA) has identified three categories of marine engines (Starcrest 2007):

- Category 1: 1–5 liters per l/Cd;
- Category 2: 5–30 liters per l/Cd; and
- Category 3: over 30 liters per l/Cd.

Marine engine standards are also broken down by engine year, where Tier 0 standards apply to engines 1999 and older, Tier 1 standards apply to engines constructed from 2000 to 2003, and Tier 2 standards apply to engines constructed from 2004 and 2007 (ICF International 2009). New Tier 3 and 4 standards will be required for engines constructed from 2009 to 2013 and after 2014, respectively (USEPA 2008). The emissions factors used in this analysis are organized by engine category and tier, as presented in Table D-4.

Table D-1 Dredge Equipment Assumptions for Existing Companies

Company	Dredge Name	Engine(s)	Engine HP	Engine Year	Load Factor (%)	Hours of Operation[a]
Capital Sand[b]	*Kathy Lee*	Caterpillar 3512[c]	1,150	1996	80	1,920
	Sandy K	Caterpillar C18	450	1987	60	
		Caterpillar 3412	450	1987	80	
	Rae Marie	Caterpillar 3412	450	2004	50	
		Caterpillar 3412	600	2004	65	
		Caterpillar 3406	450	2004	65	
Hermann Sand[d]	*Arl-501*	Cummins	335	2004	50	2,165
Holliday Sand	*Randolph*	EMD 16-645-E6[c]	1,200	2008	30	2,880
	Riverside	EMD 12-645E2	950	2004	38	2,720
	St. Joseph	John Deere 6125AFM	392	2006	30	1,520
J.T.R.	*Queenfish*	Cummins 1710	425	1986	100	974
	Mark V	Caterpillar 3408	455	1986	100	
	JTR	Caterpillar 3408	455	2002	100	
Limited Leasing	*St Charles*	Caterpillar 3406	365	1993	80[e]	2,165
	Traveler	Caterpillar 3406	365	1968	80[e]	
	Chesterfield	Caterpillar 3406	365	1971	80[e]	

Note: HP = Horsepower.

[a] Hours of operation were assumed to represent existing conditions. If permit applicants provided a range of operational hours, engine activity was based on the maximum number of operational hours to ensure that emissions were not underestimated.

[b] Capital Sand is contracted by Con-Agg to perform dredging operations. Capital Sand's fleet therefore was assumed to dredge the amounts requested by Con-Agg under the Proposed Action and alternatives.

[c] Engine horsepower greater than 1,000; Category 2 emissions factors were assumed (refer to Table D-3).

[d] Hermann Sand would be contracted by Rau to perform dredging operations. Hermann Sand's fleet therefore was assumed to dredge the amounts requested by Rau under the Proposed Action and alternatives.

[e] No information was provided. Default load factor was assumed (Starcrest 2009).

Source: Based on interviews with the companies conducted by the USACE for permitting purposes.

Table D-2 Dredge Equipment Assumptions for New Applicants

Company	Dredge Name	Engine(s)	Engine HP	Engine Year	Load Factor (%)	Hours of Operation[a]
Master's	Penny	Caterpillar D 398 TA	825	1990	50	4,209[b]
	Oklahoma	Caterpillar 3516 TA[c]	2,450	2005	50	4,676[b]
Rau[d]	--	--	--	--	--	--

Note: HP = Horsepower.

[a] Master's does not operate under existing conditions. Hours of operation therefore were assumed to represent conditions under the Proposed Action. Refer to Section D.2-1 for a discussion of operating conditions under the Proposed Action and alternatives.

[b] Master's does not operate under existing conditions. Hours of operation therefore were assumed to represent conditions under the Proposed Action. Refer to Section D.2-1 for a discussion of operating conditions under the alternatives.

[c] Engine horsepower greater than 1,000; Category 2 emissions factors were assumed.

[d] Rau does not operate dredging equipment.

Source: Based on interviews with the companies conducted by the USACE for permitting purposes.

Information on the distribution of Category 1 and 2 engines was not provided by the permit applicants. The Puget Sound Air Emissions Inventory indicates that 90 percent of all harbor craft engines are Category 1, and 10 percent are Category 2 (Starcrest 2007). Similarly, the 2007 Goods Movement Inventory conducted for the Port of Houston indicates that 89 percent of all engines are Category 1, and 9 percent are Category 2 (Starcrest 2009). Finally, the USEPA 2008 Regulatory Impact Analysis (RIA), which surveyed a higher number of inland tugs, found that 25 percent of vessels are Category 2 (ICF International 2009). Based on the equipment summarized in these documents and expected under the Proposed Action and alternatives, engines exceeding 1,000 horsepower (HP) were identified as Category 2. Under this assumption, 16 percent of the dredge engines and 22 percent of the tug engines were modeled using Category 2 emissions factors.

Table D-3 Tug Boat Equipment Assumptions

Company	Tug Name	Engine(s)	Engine HP	Engine Year	Activity: Upstream Empty Load Factor (%)	Upstream Empty Hours per Year[b]	Upstream Full Load Factor (%)	Upstream Full Hours per Year[b]	Downstream Empty Load Factor (%)	Downstream Empty Hours per Year[b]	Downstream Full Load Factor(%)	Downstream Full Hours per Year[b]	Trips per Day
Capital Sand[c]	*Marge 1*	(2) Caterpillar 3412	600	2004/2006	55	373[d]	60	496[d]	40	216[d]	60	280[d]	7
	Allison Marie	(3) Caterpillar 3412	600	2001/2002	50	373[d]	60	435[d]	40	216[d]	60	250[d]	
	Tarkio	(2) Caterpillar 3412	600	2006/2007	55	373[d]	60	559[d]	40	216[d]	60	280[d]	
Hermann Sand[e]	*Kathryn*	(2) Cummins N-14	880	2005	50	540	31[f]	573[g]	31[f]	264[g]	25	270	5
	Mel Sue	(2) NH 220 Cummins	400	1954	50	540	31[f]	573[g]	31[ef]	264[g]	25	270	
Holliday Sand	*Chouteau*	(2) Caterpillar C12	680	2006	55	581	70	756	20	423	35	454	14[j]
	Sibley	(2) Caterpillar 3406E	950	2006	55	581	70	756	20	423	35	454	
	Dakota	(2) Caterpillar 3412C[h]	1,040	N/A[i]	60	581	75	756	25	423	40	454	
	Fairfax	(2) Caterpillar 3412C[h]	1,300	2004	60	581	75	756	25	423	40	454	
	Edward Perry	(2) Caterpillar 3406	730	2009	83	816	100	907	45	454	63	242	
J.T.R.	*Barbara Sue*	(2) GM 8V-71	470	2000	100	367	100	918	80	154	50	261	5
	Shelby J	(2) 12V-71	680	2005		305		459	75	140	75	165	
	William Powell	(2) Cummins KTA19[h]	1,200	2001		206		367	75	121	50	140	

Table D-3 Tug Boat Equipment Assumptions

					Activity								
					Upstream Empty		Upstream Full		Downstream Empty		Downstream Full		
Company	Tug Name	Engine(s)	Engine HP	Engine Year	Load Factor (%)	Hours per Year[b]	Load Factor (%)	Hours per Year[b]	Load Factor (%)	Hours per Year[b]	Load Factor(%)	Hours per Year[b]	Trips per Day
Limited Leasing	*Atlas*	(3) Luggar L6140[g]	1,500	1962	31[f]	275	31[f]	367	31[f]	184	31[f]	275	10[k]
	Janet	(2) Detroit 8V71	460	1979		367		551		275		367	
	Joanne	(2) Detroit 8V71	460	1982		367		551		275		367	
	Leona	(2) Detroit 12V71	660	1956		275		367		184		275	
	Patricia	(2) Detroit 12V71	660	1959		275		367		184		275	
	Piasa	(2) Detroit 12V71	660	1959		275		367		184		275	

Note: HP = Horsepower.

a Master's does not use tugs to transport dredged materials to shore.

b Hours were assumed to represent existing conditions and were calculated according to the following formula: (hours per day) X (days per year) X (number of trips per tug) where the hours per day were provided by the permit applicants, days per year were assumed to be 216 (unless otherwise noted), and number of trips per tug were assumed to equal the number of trips per day divided by the number of tugs. The annual number of operating days (216) is based on dredging occurring 5 days per week from March to December (see Chapter 2).

c Capital Sand's fleet was assumed to dredge amounts requested by Con-Agg.

d Number of operational days per year was assumed to be 160 per information supplied by Capital Sand.

e Hermann Sand's fleet was assumed to dredge amounts requested by Rau under the Proposed Action and alternatives.

f Default load factor (Starcrest 2009).

g Information was not supplied by the permit applicant. Hours represent an average of the information provided by all applicants listed in the table.

h Engine horsepower greater than 1,000; Category 2 emissions factors were assumed (see Table D-3).

i Not available; no information received.

j Based on seven barges being unloaded per shift, with two shifts per day.

k Based on 10 barges being unloaded per day, assuming that one barge requires one tug trip.

Source: Based on interviews with the companies conducted by the USACE for permitting purposes.

Table D-4 Emissions Factors for Dredge and Tug Boat Engines (grams/kilowatt-hour [g/kW-hr])

Engine Power (kW)	VOC	NO_X	CO	PM	SO_2[a]	CO_2	N_2O	CH_4
Tier 0 Engines								
37	0.27	11	2	0.9	0.21	690	0.02	0.09
75	0.27	10	1.7	0.4	0.21	690	0.02	0.09
130	0.27	10	1.5	0.4	0.21	690	0.02	0.09
225	0.27	10	1.5	0.3	0.21	690	0.02	0.09
450	0.27	10	1.5	0.3	0.21	690	0.02	0.09
560	0.27	10	1.5	0.3	0.21	690	0.02	0.09
1,000	0.27	13	2.5	0.3	0.21	690	0.02	0.09
Category 2	0.5	13.2	1.1	0.72	0.21	690	0.02	0.09
Tier 1 Engines								
37	0.27	9.8	2	0.9	0.21	690	0.02	0.09
75	0.27	9.8	1.7	0.4	0.21	690	0.02	0.09
130	0.27	9.8	1.5	0.4	0.21	690	0.02	0.09
225	0.27	9.8	1.5	0.3	0.21	690	0.02	0.09
450	0.27	9.8	1.5	0.3	0.21	690	0.02	0.09
560	0.27	9.8	1.5	0.3	0.21	690	0.02	0.09
1,000	0.27	9.8	2.5	0.3	0.21	690	0.02	0.09
Category 2	0.5	9.8	1.1	0.72	0.21	690	0.02	0.09
Tier 2 Engines								
37	0.27	6.8	5	0.4	0.21	690	0.02	0.09
75	0.27	6.8	5	0.3	0.21	690	0.02	0.09
130	0.27	6.8	5	0.3	0.21	690	0.02	0.09
225	0.27	6.8	5	0.3	0.21	690	0.02	0.09
450	0.27	6.8	5	0.3	0.21	690	0.02	0.09
560	0.27	6.8	5	0.3	0.21	690	0.02	0.09
1,000	0.27	6.8	5	0.3	0.21	690	0.02	0.09
Category 2	0.5	9.8	5	0.72	0.21	690	0.02	0.09

Notes:

CH4 = Methane.
CO = Carbon monoxide.
CO_2 = Carbon dioxide.
kW = Kilowatt.
N_2O = Nitrous oxide.
NO_X = Oxides of nitrogen.
PM = Particulate matter.
SO_2 = Sulfur dioxide.
VOC = Volatile organic compounds.

[a] Based on U.S. Environmental Protection Agency emission standard of 500 parts per million sulfur content of marine diesel fuel. Calculated using the following equation: (500 grams S/1,000,000 grams fuel) X (210 grams fuel/kW-hour) X (2 grams SO_2/grams S).

Sources: ICF International 2009, Clean Air Task Force n.d.

The following equation was used to calculate emissions from each of the engines identified in Tables D-1 through D-3 (ICF International 2009, Starcrest 2009). Because the emissions factors summarized in Table D-4 are in grams/kilowatt-hour (g/kW-hour), the engine HP ratings provided by the permit applicants were converted to kilowatts, assuming that one HP is equal to 0.746 kilowatt. It was assumed that all engines would use off-road diesel fuel.

$$E = (kW) \times (Activity) \times (EF) \times (LF) \times (\# ENG)$$

Where:

E	=	Emissions, grams per year
kW	=	Kilowatts (one HP is equal to 0.746 kilowatt)
Activity	=	Activity, hours per year
EF	=	Engine emissions factor (see Tables D-1 through D-3)
LF	=	Engine load factor
# ENG	=	Number of vessel engines (see Tables D-1 through D-3)

The calculated emissions (in grams per year) were converted to tons per year by dividing emissions by the conversion factor, which is 907,184 grams/ton. Emissions for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) were converted to metric tons, assuming that 1 ton is equal to 0.907 metric ton.

D.2.1 Dredging Scaling Factors

Emissions from dredging activities are highly dependent on the number, type, and age of the dredging equipment, as well as the intensity (e.g., the hours of activity and distance of tug trips) of the dredging operation. Because this information is not available for each alternative, the rate at which emissions are affected by changing dredging amounts is currently unknown. For the purposes of this analysis, emissions generated by dredging activities were assumed to be proportional to permitted sand and gravel amounts, on a ton-for-ton basis. In other words, a 50-percent increase in dredging amounts, relative to existing conditions, was assumed to correspond to a 50-percent increase in dredging emissions.

The following sections describe the methodology used to estimate dredging emissions under the Proposed Action and alternatives. The reader is directed to Tables D-1 through D-3 for information on the dredger and tug boat equipment assumed in the analysis. Note that this information is presented by company, rather than by river segment. Consequently, emissions were calculated for each company and then apportioned by river segment for use in the impact analysis. Figure D-1 illustrates the steps taken to estimate dredging emissions.

D.2.1.1 Emissions Calculations for Existing Companies

Existing emissions generated by Capital Sand, Con-Agg, Hermann Sand, Holliday Sand, J.T.R., and Limited Leasing were calculated using the information summarized in Section D.2. To determine emissions generated by these companies under the Proposed Action and alternatives, existing emissions were multiplied by the percent change in sand and gravel amounts between existing conditions and the alternative in question (see Table D-5). For example, under the Proposed Action, permitted tonnage would increase by 74 percent in the Jefferson City segment. Existing dredging emissions generated by companies operating in the Jefferson City segment were multiplied by 1.74 to obtain dredging emissions for the Proposed Action.

D.2.1.2 Emissions Calculations for Master's and Rau

Master's and Rau are the only companies not part of existing conditions that would be permitted under the Proposed Action and alternatives. The methodology used for Table D-5 was not used to estimate emissions for these companies because it is based on existing dredging amounts by river segment. Separate scaling factors therefore were used to estimate emissions generated by the two proposed companies.

The emissions calculated for Master's and Rau using the information listed in Tables D-1 through D-3 were assumed to represent conditions under the Proposed Action because these companies do not operate under existing conditions. The estimated dredging emissions calculated for Master's and Rau were used as a basis for estimating dredging emissions under Alternatives A, B, and C. More specifically, calculated emissions under the Proposed Action were scaled by the percent change in dredging amounts between the Proposed Action and each of the alternatives in order to determine emissions associated with these companies for each alternative (see Tables D-5 and D-6). As for existing companies, this approach assumes that emissions generated by dredging activities would be proportional to permitted sand and gravel amounts.

Table D-5 Scaling Factors for Emissions Generated by Existing Companies

Segment	Existing Dredging[a]	Proposed Action		No Action Alternative		Alternative A		Alternative B		Alternative C	
		Dredging [b]	% Change	Dredging [b]	% Change	Dredging [b]	% Change	Dredging [b]	% Change	Dredging [b]	% Change
St. Joseph	326,928	1,150,000	251.76	0	-100.00	350,000	7.06	860,000	163.05	330,000	0.94
Kansas City	2,658,831	4,060,000	52.70	0	-100.00	540,000	-79.96	1,230,000	-53.74	2,660,000	0.04
Waverly	677,987	1,005,600	48.32	0	-100.00	500,000	-26.25	1,140,000	68.14	680,000	0.30
Jefferson City	1,578,858	2,750,000	74.18	0	-100.00	430,000	-72.77	980,000	-37.93	1,580,000	0.07
St. Charles	1,649,326	4,384,400	165.81	0	-100.00	370,000	-77.57	840,000	-49.07	1,650,000	0.04
Total[b]	6,891,930	13,350,000	93.70	0	-100.00	2,190,000	-68.22	5,050,000	-26.73	6,900,000	0.12

[a] Represents average annual dredging for the last 5 years (2004–2008). See Table 2.4-1 in the main volume.

[b] Values represent sand and gravel amounts requested by the existing companies under the Proposed Action and alternatives. In other words, amounts requested by Masters and Rau, the two new dredgers (see Table 2.2-1 in Chapter 2), have been removed from the segment totals.

Table D-6 Scaling Factors for Emissions Generated by New Companies

Company/Segment	Proposed Dredging Amount	No Action Alternative		Alternative A		Alternative B		Alternative C	
		Dredging Amount	% Change	Dredging Amount	% Change	Dredging Amount	% Change	Dredging Amount	% Change
Master's/Kansas City	1,000,000	0.00	-100.00	133,005	-86.70	302,956	-69.70	731,527	-26.85
Rau/St. Charles	100,000	0.00	-100.00	8,439	-91.56	19,159	-80.84	37,633	-62.37

D.2.1.3 Dredging Percentages by River Segment

Three companies—Capital Sand, Hermann Sand, and Holliday Sand—would operate in more than one segment (see Table 2.2-1 in the EIS). Emissions generated by these four applicants were apportioned by segment using the breakdown of annual dredging amounts by river segment summarized in Table 2.2-5 in the EIS because emissions were calculated for a company's entire fleet and information on the operational location of individual dredges and tugs is not available. Emissions calculated for these companies were multiplied by the percentage of each company's total requested permit amounts expected to occur in each segment. For example, Hermann Sand has requested a permit for 1,000,000 tons per year. One-half of this amount is expected to be dredged in the Jefferson City segment, and the remaining one-half in the St. Charles segment. It was assumed therefore that one-half of the emissions calculated for Hermann Sand would occur in the Jefferson City segment and the remaining one-half would occur in the St. Charles segment.

D.2.1.4 Calculation of Tonnage Ratios

A breakdown of company dredging amounts by river segment under Alternatives A, B, and C is currently not available. Consequently, the ratio of dredged materials between companies in each river segment under the Proposed Action (as presented in Table 2.2-5 in the EIS) was used to determine tonnage estimates by company and river segment for the alternatives. This approach assumes that the breakdown of company dredging amounts will remain constant between the Proposed Action and alternatives. For example, the ratio of dredging amounts between Holliday Sand and Master's in the Kansas City segment is 3,060,000 to 1,000,000 for the Proposed Action (see Table 2.2-5 in the EIS). It therefore was assumed that Holliday Sand would dredge approximately 75 percent of the permitted tonnage in the St. Joseph segment under Alternatives A, B, and C.

D.2.1.5 Total Emissions by Company by River Segment

Once tonnage amounts by company and river segment were estimated for the Proposed Action and alternatives, total dredging emissions by river segment were calculated. This step was completed by multiplying the total emissions estimated for each company under the Proposed Action and alternatives by the percentage of each company's permitted dredging amount expected to occur in the river segments. For example, because 45.46 percent of all activities within the Jefferson City segment under the Proposed Action were associated with Herman Sand, emissions calculated for Hermann Sand under the Proposed Action were multiplied by 45.46 percent (see Table D-7) to determine the company's contribution to emissions in the Jefferson City Segment.

Table D-7 summarizes the dredging amounts under the Proposed Action requested by the companies in their permit applications, as well as the tonnage breakdown calculated for Alternatives A, B, and C (refer to Section D.2.1.4). Segment percentages used in this analysis are also presented.

D.2.1.6 Total Emissions by River Segment

When company emissions had been quantified, scaled, and appropriated among segments, total emissions generated by river segment were calculated for the Proposed Action and the alternatives. This was completed by summing the emissions produced by each company operating in each segment.

Figure D-1 illustrates the steps taken to estimate dredging emissions.

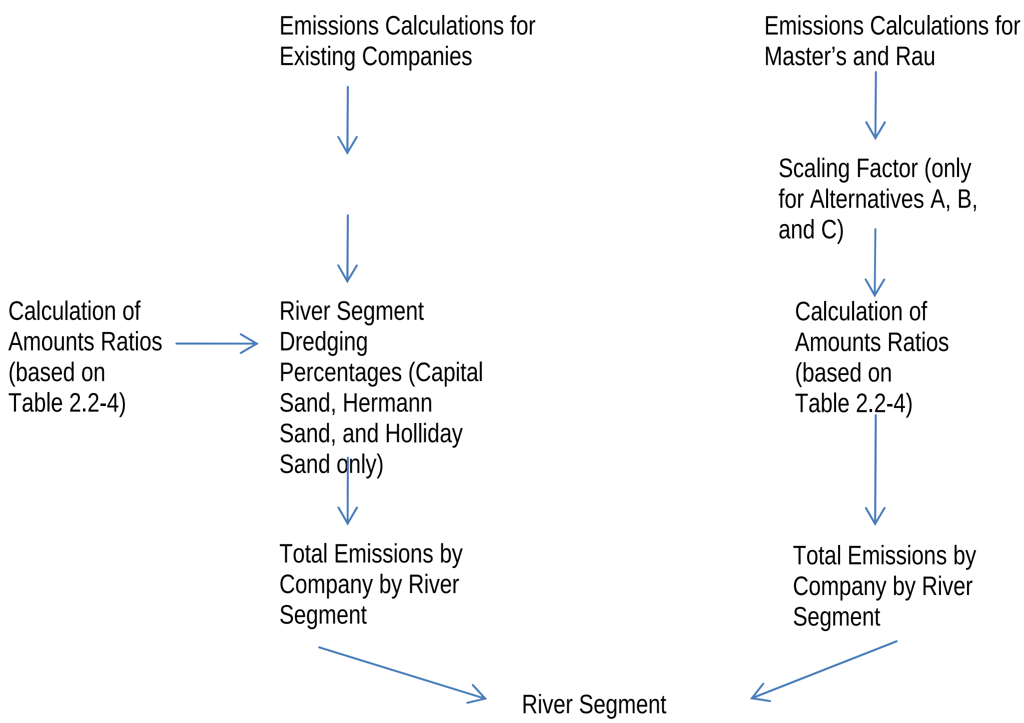

Figure D-1 Dredging Emissions Methodology

Table D-7 Dredging Breakdown by River Segment and Company Contribution Percentages

	Capital Sand[a]		Hermann Sand[b]		Holliday Sand	
Segment	Amount Requested (tons/year)	Percent of Company Total	Amount Requested (tons/year)	Percent of Company Total	Amount Requested (tons/year)	Percent of Company Total
Proposed Action[c]						
St. Joseph	--	--	--	--	1,150,000	25.28
Kansas City	--	--	--	--	3,060,000	67.26
Waverly	665,600	16.85	--	--	340,000	7.47
Jefferson City	2,250,000	56.96	500,000	45.46	--	--
St. Charles	1,034,400	26.19	600,000	54.55	--	--
Alternative A[d]						
St. Joseph	--	--	--	--	350,000	37.80
Kansas City	--	--	--	--	406,995	43.95
Waverly	330,947	42.98	--	--	169,053	18.26
Jefferson City	351,818	45.69	78,182	60.69	--	--
St. Charles	87,293	11.34	50,634	39.31	--	--
Alternative B[d]						
St. Joseph	--	--	--	--	860,000	39.59
Kansas City	--	--	--	--	927,044	42.67
Waverly	754,559	43.01	--	--	385,442	17.74
Jefferson City	801,818	45.70	178,182	60.79	--	--
St. Charles	198,179	11.30	114,953	39.22	-	-
Alternative C[d]						
St. Joseph	--	--	--	--	330,000	11.79
Kansas City	--	--	--	--	2,238,473	79.99
Waverly	450,088	21.11	--	--	229,912	8.22
Jefferson City	1,292,727	60.63	287,273	55.99	--	--
St. Charles	389,280	18.26	225,801	44.01	--	--

[a] Amounts include tonnage requested by Con-Agg.

[b] Amounts include tonnage requested by Rau.

[c] Breakdown is based on Table 2.2-4 in the EIS. Values are based on the ratio of dredging amounts between companies in each segment.

[d] Values for J.T.R., Limited Leasing, and Master's Dredging are not shown as these companies operate in only one segment. Consequently, 100 percent of the emissions calculated for these companies were assumed to occur in their segment of operation.

D.3 MATERIALS HANDLING

The USEPA NONROAD2008 model was used to estimate emissions from materials-handling equipment operating at each of the onshore facilities identified in Figure 2.2-1 in the EIS. NONROAD is a USEPA-approved emissions model that calculates emission inventories (i.e., tons of pollutants) for user-specified off-road equipment in a given geographic area rather than emissions associated with specific equipment associated with a specific activity. For example, the model generates an emissions inventory for Missouri associated with certain equipment pieces that can be used to calculate equipment-specific emissions factors; the emissions inventory can then be used to generate emissions associated with this Project.

A detailed description of the type and amount of equipment was not provided by the permit applicants. Equipment estimates therefore were based on conversations with the Missouri Department of Natural Resources (MDNR) (Zeaman pers. comm.). For this analysis, one crane (399 HP), one dozer (357 HP), one crusher (300 HP), and four loaders (108 HP) were assumed to operate at each onshore facility.[1,2]

Emissions inventories for these four pieces of equipment were generated using NONROAD based on the following inputs: (1) geographic location: Missouri; (2) year: 2011; and (3) time period: typical weekday. Based on the inventories (i.e., the total emissions for each piece of equipment in Missouri) produced by NONROAD, emissions factors were calculated for each piece of equipment using the following equation.

$$EF = (Tons/Day) \times (1/Activity) \times (1/HP) \times LF$$

Where:

EF	=	Emissions factor, tons per horsepower-hour
Tons/Day	=	NONROAD emissions inventory for each pollutant
Activity	=	NONROAD output for activity (i.e. equipment use)
HP	=	NONROAD default for equipment horsepower
LF	=	Load factor (model default: crane 0.43, loader 0.21, dozer 0.59)

Table D-8 summarizes the calculated emissions factors. The emissions factors summarized in Table D-8 were multiplied by the company hours of operation and maximum horsepower of each piece of equipment in order to estimate emissions. Operating assumptions were based on information supplied by the permit applicants (see Table D-9). As a worst-case scenario, each piece of equipment was

1 While conveyors are common pieces of equipment, the MDNR indicated that most are electric powered and therefore do not produce direct emissions (Zeaman pers. comm.). Although operation of these conveyors would generate indirect GHG emissions through electricity usage, given the speculative nature of the amount of electricity consumed by individual conveyors, GHG emissions associated with these pieces of equipment were not quantified.

2 No equipment would operate at the Waldron (Master's) or Washington (Rau) facilities under existing conditions because they do not exist under existing conditions.

assumed to operate during the entire operating period. Note that the assumptions summarized in Table D-9 represent existing conditions, unless otherwise noted.

Table D-8 Emissions Factors for Materials-Handling Equipment (tons/horsepower-hour)

Equipment	VOC	NO_X	CO	PM_{10}[a]	CO_2[b]
Crane	3.17E-07	4.41E-06	9.38E-07	2.25E-07	6.30E-04
Crusher	3.16E-07	4.41E-06	9.34E-07	2.24E-07	6.17E-04
Dozer	3.81E-07	4.87E-06	1.68E-06	3.63E-07	8.19E-04
Loader	1.00E-06	4.44E-06	5.48E-06	8.36E-07	5.06E-04

Notes:

CH4 = Methane.
CO = Carbon monoxide.
CO_2 = Carbon dioxide.
NO_X = Oxides of nitrogen.
N_2O = Nitrous oxide.
$PM_{2.5}$ = Particulate matter less than 2.5 microns.
PM_{10} = Particulate matter less than 10 microns.
SO_2 = Sulfur dioxide.
VOC = Volatile organic compounds.

[a] NONROAD does not provide emission outputs for $PM_{2.5}$. An emissions factor therefore was not calculated. Instead, $PM_{2.5}$ emissions were assumed to equal 92 percent of PM_{10} emissions (SCAQMD 2006).

[b] NONROAD does not provide emission outputs for CH_4 and N_2O. An emissions factor therefore was not calculated. Instead, emissions were determined by scaling calculated CO_2 emissions by the ratio of CH_4/CO_2 and N_2O/CO_2 emissions expected per gallon of diesel fuel according to the Climate Action Registry (California Climate Action Registry 2009).

D.3.1 Materials-Handling Scaling Factors

Limited information is currently available on how implementation of the Proposed Action and alternatives would affect the operation and number of materials-handling equipment. As discussed above, the assumptions summarized in Table D-9 represent existing conditions, except in the case of Master's and Rau, where they represent conditions under the Proposed Action. emissions calculated for materials-handling equipment were scaled by the factors presented in Tables D-5 and D-6 because this analysis assumes that emissions are proportional to the amount of sand and gravel permitted, and the use of onshore equipment is required to process any sand and gravel removed from the river.

Unlike the locations of dredges and tugs, the locations of onshore facilities and associated materials-handling equipment are fixed and known. Therefore, emissions produced by companies permitted in more than one river segment did not require further calculations. Once the appropriate scaling factors were applied, total emissions estimates for each river segment were obtained by adding the emissions calculated for equipment operating at each onshore facility within the segment.

Table D-9 Materials-Handling Operating Assumptions

Company	Hours per year
Capital Sand	1,600[a]
Hermann Sand	2,160[b]
Holliday Sand	2,160[b]
J.T.R.	2,052[c]
Limited Leasing	2,160[b]
Master's	2,160[b, d]
Rau	2,160[d, e]

Notes:

[a] Based on a 10-hour work day and 160 work days per year. Assumed to represent existing conditions.

[b] Based on a 10-hour work day and 216 work days per year. Assumed to represent existing conditions, unless otherwise stated.

[c] Based on a 9.5-hour work day and 216 work days per year. Assumed to represent existing conditions.

[d] Hours assumed to represent conditions under the Proposed Action.

[e] No information was provided. The maximum number of hours provided by any one applicant was assumed as a worst-case scenario. Hours were assumed to represent conditions under the Proposed Action.

Source: Based on interviews with the companies conducted by the USACE for permitting purposes.

D.4 TRANSPORTATION OF SAND AND GRAVEL

Transportation of sand and gravel produces emissions of ROG/VOC, CO, NO_X, PM, and GHGs as vehicle exhaust. Emissions of these pollutants were estimated using emissions factors generated by the USEPA MOVES2010 model and information summarized in Sections 3.13 and 4.11 (Noise) and Section 3.12 (Economics and Demographics) in the EIS.

MOVES2010 calculates emissions factors for on-road vehicles based on user-specified vehicle types, time periods, geographical areas, and operating characteristics. All vehicles were assumed to be single-unit short-haul diesel trucks operating in the State of Missouri. Table D-10 summarizes the emissions factors used in this analysis.

Haul truck characteristics, such as number of trips and distance traveled, were based on information presented in Sections 3.12, 3.13, and 4.11 in the EIS. Table 3.13-6 and Tables 4.11-5 through 4.11-8 in the EIS summarize the estimated number of truck trips under existing conditions, the Proposed Action, and the alternatives. As discussed in Section 3.12, the market area served by sand plants along the Missouri River is within a 25-mile radius of the sand plant. It therefore was assumed that each of the trips summarized in Table 3.13-6 and Tables 4.11-5 through 4.11-8 were 25 miles.[3]

Table D-10 Emissions Factors for Vehicles Hauling Sand and Gravel (grams per kilometer for one single-unit short-haul diesel truck)

VOC	NO_X	CO	PM_{10}[a]	$PM_{2.5}$[a]	CO_2e
0.2018	2.5918	0.7546	0.1364	0.1221	0.2348

Notes:

CO = Carbon monoxide.
CO_2e = Carbon dioxide equivalent.
NO_X = Oxides of nitrogen.
$PM_{2.5}$ = Particulate matter less than 2.5 microns.
PM_{10} = Particulate matter less than 10 microns.
VOC = Volatile organic compounds.

Emissions factors include emissions from brakeware, tireware, and exhaust.

Emissions factors based on MOVES2010. The U.S. Environmental Protection Agency model MOVES2010 calculates emissions factors for on-road vehicles based on user-specified vehicle types, time periods, geographical areas, and operating characteristics. All vehicles were assumed to be single-unit short-haul diesel trucks operating in the State of Missouri.

The following equation was used to calculate emissions from sand and gravel hauling operations.

$$E = (\#\ of\ trips) \times (trip\ distance) \times (EF) \times (CON)$$

Where:

E = Emissions, tons per year
# of trips = Estimated truck deliveries per year (based on Table 3.13-6 and Tables 4.11-5 through 4.11-8 in the EIS)
Trip distance = 25 miles (40.23 kilometers)
EF = Emissions factor, grams/kilometer (see Table D-10)
CON = Conversion from grams to tons (907,184 grams is equal to 1 ton)

D.4.1 Materials-Handling Scaling Factors

As discussed above, haul truck characteristics for existing conditions, the Proposed Action, and the alternatives are provided in Section 3.13 in the EIS. Consequently, emissions generated by sand and gravel hauling operations were not scaled, as emissions could be independently calculated for each alternative.

[3] The 25-mile figure represents an approximation of the primary market area for construction material extracted from the Missouri River. Note that the market area, and thus haul trips, extends beyond 25-miles. However, this distance was assumed to represent the upper bound for shipping distance.

D.5 CONSTRUCTION EMISSIONS

Construction activities, which can generate fugitive dust and exhaust emissions, can result in substantial temporary impacts on local air quality (i.e., exceed state air quality standards for ozone, CO, PM_{10}, and $PM_{2.5}$). Such emissions result from earthmoving and use of heavy-duty equipment. Emissions can vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing weather.

Under the Proposed Action and Alternatives A, B, and C, Rau and Master's would construct a new sand plant. Rau's facility would be approximately 25.6 acres and would be located in Franklin County. Master's facility would be 20–60 acres and would be located in Platte County. In addition to these facilities, increased demand on alternate sources of sand and gravel may require construction of new or expanded facilities at alternate source locations. The size and number of these facilities are currently unknown.

Limited information is available on the schedule and types of equipment that would be used to construct the new facilities. This analysis therefore relies heavily on professional judgment and air quality model default values. Actual emissions may vary depending upon specific construction information.

The URBEMIS2007 (Version 9.2.4) and NONROAD2008 emissions models were used to estimate emissions from construction activities. URBEMIS2007 is an emissions model that analyzes construction-, area-, and mobile-source emissions from land use development projects. Based on a specific type of land use, URBEMIS can estimate construction exhaust and fugitive dust emissions based on default assumptions regarding construction types and numbers of construction equipment, equipment activity data (i.e., number of hours per day and the load factor), and earth disturbance. URBEMIS was developed for use in California because it takes into account fuel regulations and vehicle characteristics specific to the state. Emissions estimates generated by URBEMIS for construction equipment therefore were not used for this analysis because fuel regulations and emission control technologies are more stringent in California than in other parts of the United States. Instead, URBEMIS was used to estimate fugitive dust emissions and to develop an equipment inventory for construction activities. NONROAD2008 emissions factors then were used to calculate emissions from each of the equipment pieces identified by URBEMIS.

Table D-11 lists the assumptions used in the URBEMIS modeling for construction activities and the basis for those assumptions.

The assumptions in Table D-11 were input into the URBEMIS model, the result of which was the equipment inventory, which is listed in Table D-12. Construction of Master's and Rau's facilities would require use of the equipment identified in Table D-12 for each facility.

Table D-11 URBEMIS Modeling Assumptions for Construction Activities

	Assumption	Rationale
Property size (number of acres graded)	Master's: 60	Permit applicant
	Rau: 25.6	Permit applicant
Number of acres disturbed per day	25 percent of total property area	Model default
Building construction	1,000-square-foot general office building	GoogleEarth aerials of existing facilities and photographs supplied by permit applicants
Construction schedule[a]	Master's: site grading (3/1/2011 – 7/30/2011); building construction (7/15/2011 – 7/30/2011)	Professional judgment
	Rau: site grading (3/1/2011 – 5/15/2011); building construction (5/1/2011 – 5/15/2011)	Professional judgment

[a] Construction activities were assumed to take place 5 days per week.

Emission factors for the equipment inventory in Table D-12 were calculated from the NONROAD model using the equation identified in Section D-3. Table D-13 summarizes the calculated emissions factors. These factors were multiplied by the maximum horsepower of each piece of equipment and the total number of hours operating for the entire construction period (see Table D-11). Calculated emissions for construction equipment were then combined with fugitive dust emissions generated by URBEMIS to obtain a total emissions estimate for construction of each of the facilities.

D.6 FACILITY OPERATIONS

The primary emissions generated by sand and gravel facilities are fugitive dust from processed materials and air pollutants from the upkeep of offices, and employee commute trips. Dust emissions can occur during materials processing. Generally, these materials are wetted or moistened for handling, which suppresses dust emissions. All commercial dredging operations must also abide by MDNR Regulation 10 CSR 10.6.170 (see Table 3.16-9 in the EIS), which restricts fugitive dust emissions beyond the premises of origin. Consequently, implementation of the Proposed Action or alternatives is anticipated to result in negligible fugitive dust emissions. No further analysis is required.

Table D-12 URBEMIS Modeling Assumptions for Construction Equipment

Phase	Equipment	Number	Horsepower	Hours/Day
Site grading	Grader	1	174	8
	Dozer	1	357	8
	Tractor	2	108	7
	Water Truck	1	189	8
Building construction	Crane	1	399	4
	Forklift	2	145	6
	Tractor	1	108	8

Table D-13 Emissions Factors for Construction Equipment (tons/horsepower-hour)

Equipment	VOC	NO_X	CO	PM[a]	CO_2[b]
Grader	4.56E-07	5.57E-06	2.31E-06	1.05E-06	8.62E-04
Dozer	1.73E-05	2.21E-04	7.63E-05	1.65E-05	3.72E-02
Tractor	1.00E-06	4.44E-06	5.48E-06	8.36E-07	5.06E-04
Water truck	7.24E-07	9.09E-06	4.53E-06	1.13E-06	1.68E-03
Crane	3.17E-07	4.41E-06	9.38E-07	2.25E-07	6.30E-04
Forklift	3.22E-07	4.01E-06	1.57E-06	3.45E-07	5.31E-04

Notes:

CO = Carbon monoxide. CO_2 = Carbon dioxide. NO_X = Oxides of nitrogen.
PM = Particulate matter. VOC = Volatile organic compounds.

[a] NONROAD does not provide emissions outputs for $PM_{2.5}$. An emissions factor therefore was not calculated. Instead, $PM_{2.5}$ emissions were assumed to equal 92 percent of PM_{10} emissions (SCAQMD 2006.

[b] NONROAD does not provide emissions outputs for CH_4 and N_2O. An emissions factor therefore was not calculated. Instead, emissions were determined by scaling calculated CO_2 emissions by the ratio of CH_4/CO_2 and N_2O/CO_2 emissions expected per gallon of diesel fuel according to the Climate Action Registry (California Climate Action Registry 2009).

Upkeep of the commercial offices and natural gas combustion for heating are sources of additional air pollutants from onshore facilities. In addition, GHG emissions would be generated through electricity usage, water consumption, and wastewater production. Employee travel to and from the property also would generate criteria pollutants and GHG emissions through vehicle exhaust. These emissions would be minimal compared to those produced by other dredging activities. Moreover, in response to data requests posed by the USACE, several permit applicants indicated that operational changes would be minimal with implementation of the Proposed Action. It is therefore unlikely that changes in the level of permitted sand and gravel volumes would result in a substantial increase or decrease in operational activities. Consequently, office operations under the Proposed Action and alternatives would result in a negligible impact on air quality and climate change. No further analysis is required.

D.7 REFERENCES

D.7.1 Printed Literature

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D.7.2 Personal Communication

Zeaman, Bill. Chief, Non-Coal Unit. Missouri Department of Natural Resources, Jefferson City, Missouri. Email message to Laura Smith, ICF International. February 9, 2010.

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