APPENDIX E
AIR QUALITY EMISSIONS CALCULATIONS

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Emissions Summary

	VOC	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO_2e
Alternative 1	11.15	33.74	174.72	0.20	5.73	5.56	20,175
Alternative 2	5.02	56.47	234.13	0.18	10.03	8.65	18,843
Alternative 1 & 3	13.52	49.18	190.48	0.27	21.63	5.90	31,011
Alternative 2 & 3	7.38	71.91	249.89	0.25	25.93	8.99	29,679

Emission Calculations for Alternative 1

Dump trucks
Bulldozers
Mobile generators
tractor scraper
loader

1,300,000 CY of sand truck cap 12 CY

Material	Source Location	One way distance (mi)	Total Round Trip Time (hrs)	CY19 Total # of trips	Computed Total time (hrs)	Total mi traveled
Sand transport by dump trucks	stockpile	3.25	0.75	108,333	81,250	704,167

	VOC lb/mile	CO lb/mile	NOx lb/mile	SO2 lb/mile	PM10 lb/mile	PM2.5 lb/mile	N2O lb/mile	CH4 lb/mile	CO2 lb/mile
Dump Trucks	1.59E-03	8.31E-03	3.78E-02	1.79E-05	1.60E-03	1.6E-03	1.06E-05	1.12E-05	4.21
	VOCs	**CO**	**NOx**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**N2O**	**CH4**	**CO2**
CY 2019	Ton	Ton	Ton	Ton	Ton	Ton	Ton	Ton	Ton
Dump Trucks	0.56	2.93	13.33	0.01	0.56	0.55	0.00	0.00	1,481.64
								CO2e in metric tons/year	**1,344**

Truck emission factors from MOVES

Equipment Usage	CY 19 Hours
Bulldozer	81,250
Wheel Tractor	54,167
Scraper	54,167
Loader	18,056
Gen Set	22,750

24 CY capacity
6 CY bucket capacity

CY 19 Equipment Emissions

Off-road Equipment	Hours of Operation	Engine HP	Load Factor	VOC g/hp-hr	CO g/hp-hr	NOx g/hp-hr	SO2 g/hp-hr	PM10 g/hp-hr	PM2.5 g/hp-hr	N2O g/gal	CH4 g/gal	CO2 g/hp-hr	BSFC lb/hp-hr
Bulldozer	81,250	215	0.59	0.31	0.75	4.00	0.005	0.13	0.13	0.22	0.58	530	0.367
Wheel Tractor	54,167	407	0.59	0.17	0.84	4.34	0.005	0.13	0.13	0.22	0.58	531	0.367
Scraper	54,167	290	0.59	0.31	0.75	4.00	0.005	0.13	0.13	0.22	0.58	530	0.367
Loader	18,056	262	0.59	0.31	0.75	4.00	0.005	0.13	0.13	0.22	0.58	530	0.367
Generator	22,750	13	0.43	0.44	2.16	4.44	0.005	0.27	0.27	0.22	0.58	589	0.408

	VOC	CO	NOx	SO2	PM10	PM2.5	N2O	CH4	CO2
	lb	lb	lb	lb	lb	lb	lb	lb	lb
Bulldozer	7,381	16,985	90,889	111	2,990	2,901	260	686	12,044,107
Wheel Tractor	5,040	24,159	124,312	140	3,774	3,661	328	865	15,212,802
Scraper	6,637	15,273	81,729	100	2,689	2,608	234	616	10,830,359
Loader	1,999	4,600	24,613	30	810	785	70	186	3,261,557
Generators	129	606	1,245	2	75	75	4	9	165,129
Tons/year:	**10.6**	**30.8**	**161.4**	**0.2**	**5.2**	**5.0**	**0.4**	**1.2**	**20,757**
								CO2e in metric tons/year	**18,830**

Emission factors and BFSC from Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition, USEPA 2010; Tier 2

Except for N2O and CH4 which are from Federal Greenhouse Gas Accounting and Reporting Guidance Technical Support Document, Revision 1, Page D-7. USEPA 2012.

Load factors from Median Life, Annual Activity and Load Factor Values for Nonroad Engine Emissions Modeling, USEPA 2010

VOC correction from Conversion Factors for Hydrocarbon Emission Components, USEPA 2010

Wheel Tractor Scraper Engine and Capacity Ratings from Caterpillar 627H

BSFC = brake specific fuel consumption

Total Emissions

	VOC	CO	NOx	SO2	PM10	PM2.5	CO2e
Tons per Year	11.15	33.74	174.72	0.20	5.73	5.56	20,175

Emission Calculations for Alternative 2 1,300,000 CY of sand + 25% for loss 325000 1,625,000 Total CY
110 days

Material	Source Location	One way distance (mi)	Total Round Trip Time (hrs)	CY19 Total # of trips	Computed Total time (hrs)	Total mi traveled
Mobilization - supplies	Newport News	114	2.5	90	228	20,520
Tug & barge - mob supplies	Norfolk	100	40	10	400	2,000

	VOC lb/mile	CO lb/mile	NOx lb/mile	SO2 lb/mile	PM10 lb/mile	PM2.5 lb/mile	N2O lb/mile	CH4 lb/mile	CO2 lb/mile
Dump/Supply Trucks	1.59E-03	8.31E-03	3.78E-02	1.79E-05	1.60E-03	1.6E-03	1.06E-05	1.12E-05	4.21
	VOCs	**CO**	**NOx**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**N2O**	**CH4**	**CO2**
CY 2019	Ton	Ton	Ton	Ton	Ton	Ton	Ton	Ton	Ton
Dump/Supply Trucks	0.02	0.09	0.39	0.00	0.02	0.02	0.00	0.00	43.18
								CO2e in metric tons/year	**39**

Deliveries	**Engine HP**	**# Engines**	**Load Factor**	**VOC** g/hp-hr	**CO** g/hp-hr	**NOx** g/hp-hr	**SO2** g/hp-hr	**PM10** g/hp-hr	**PM2.5** g/hp-hr	**N2O** g/gal	**CH4** g/gal	**CO2** g/hp-hr	**BSFC** lb/hp-hr
Tugboat - propulsion	2000	2	0.85	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367
				VOC Ton	**CO** Ton	**NOx** Ton	**SO2** Ton	**PM10** Ton	**PM2.5** Ton	**N2O** Ton	**CH4** Ton	**CO2** Ton	
	Tugboat Annual Emissions (CY 19)			0.16	0.95	0.49	0.01	1.11	0.00	0.00	0.00	103.43	
											CO2e in metric tons/year	**94**	

Equipment Usage	CY 19 Hours
Derrick barge	240
Work barge	240
Work Tug	5,040
Bulldozer	9,600
Trailing Suction Dredge-propulsion	9,600
Trailing Suction Dredge - pumps	6,720

CY 19 Equipment Emissions

Off-road Equipment	**Hours of Operation**	**Engine HP**	**Load Factor**	**VOC** g/hp-hr	**CO** g/hp-hr	**NOx** g/hp-hr	**SO2** g/hp-hr	**PM10** g/hp-hr	**PM2.5** g/hp-hr	**N2O** g/gal	**CH4** g/gal	**CO2** g/hp-hr	**BSFC** lb/hp-hr
Derrick barge	240	2,500	0.85	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367
Work barge	240	1,000	0.85	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367
Work Tug	5,040	500	0.85	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367
Bulldozer	9,600	215	0.59	0.31	0.75	4.00	0.005	0.13	0.13	0.22	0.58	530	0.367
Trailing Suction Dredge-propulsion	9,600	4,000	0.4	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367
Trailing Suction Dredge - pumps	6,720	2,500	0.85	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367

1.053 VOC corr f

	VOC lb	CO lb	NOx lb	SO2 lb	PM10 lb	PM2.5 lb	N2O lb	CH4 lb	CO2 lb
Derrick barge	125	1,677	6,984	5	268	260	15	43	596,708
Work barge	50	671	2,794	2	107	104	6	17	238,683
Work Tug	523	7,043	29,334	21	1,127	1,093	64	182	2,506,174
Bulldozer	872	2,007	10,739	13	353	343	31	81	1,423,058
Trailing Suction Dredge-propulsion	3,752	50,504	210,348	152	8,081	7,838	458	1,304	17,971,443
Trailing Suction Dredge - pumps	3,488	46,953	195,558	141	7,512	7,287	426	1,212	16,707,826
Tons/year:	**4.4**	**54.4**	**227.9**	**0.2**	**8.7**	**8.5**	**0.5**	**1.4**	**19,721.9**
								CO2e in metric tons/year	**18,059**

Vessel emission factors from page 3-22 of Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder, USEPA 2008.

All vessels are presumed to use 2 propulsion engines, table lists total HP.

Off-road Equipment	Hours of Operation	Engine HP	Load Factor	VOC g/hp-hr	CO g/hp-hr	NOx g/hp-hr	SO2 g/hp-hr	PM10 g/hp-hr	PM2.5 g/hp-hr	N2O g/gal	CH4 g/gal	CO2 g/hp-hr	BSFC lb/hp-hr
Bulldozer	9,600	215	0.59	0.31	0.75	4.00	0.005	0.13	0.13	0.26	0.58	530	0.367
				VOC lb	**CO lb**	**NOx lb**	**SO2 lb**	**PM10 lb**	**PM2.5 lb**	**N2O lb**	**CH4 lb**	**CO2 lb**	
			Bulldozer	872	2,007	10,739	13	353	343	36	81	1,423,058	
			Tons/year:	**0.4**	**1.0**	**5.4**	**0.0**	**0.2**	**0.2**	**0.02**	**0.04**	**711.5**	
											CO2e in metric tons/year	**651**	

Total Emissions

	VOC	CO	NOx	SO2	PM10	PM2.5	CO2e
Tons per Year	5.02	56.47	234.13	0.18	10.03	8.65	18,843

Emission Calculations for Alternative 3

130 ft long
10 ft wide at top
8 ft depth
50 ft width at base assumed based on std breakwater design
21.5 ft width of long sides
31,200 CY volume of one breakwater - ends
2,000 CY volume of one breakwater end
33,200 CY Total volume of one breakwater
6 total
1 month construction period

rocks brought by water from Norfolk
1,500 tons ave barge capacity
15,000 Type 2 stone capacity for 1 barge
3,000 Type 3 stone capacity for 1 barge

Deposited using barge excavator
31,318 CY of Type 2 stone required for breakwater
325,061 Total Type 2 stones for 1 breakwater
22 barges to bring this number of Type 2 stone

Type 2 stone 150 - 299
Type 3 stone 500-1500

200 lb stone
2.3 ft long
0.78 ft wide
1.45 ft thickness type 2
0.10 CY volume of 1 Type 2 200 lb stone

1000 lb stone
3.7 ft long
1.25 ft wide
2.2 ft thickness
0.377 CY volume of 1 Type 3 1000 lb stone

35 stones for one 130 ft length
17 stones for one 21.5 ft width course
8 stones for 10 ft top width
40 stones for 50 ft base width
562 Total Type 3 stones for double row on top
1,209 Total Type 3 stones for double row on long sides
2,811 Total Type 3 stones for double row on bottom
413 Total Type 3 stones for ends
4,994 Total Type 3 stones for 1 breakwater
2 barges to bring this number of Type 3 stone
1,882 CY volume of Type 3 stone in 1 breakwater

Material	Source Location	One way distance (mi)	Total Round Trip Time (hrs)	CY19 Total # of trips	Computed Total time (hrs)	Total mi traveled
Tug & barge - riprap	Norfolk	100	40	140	5,601	28,003

Deliveries	Engine HP	# Engines	Load Factor	VOC g/hp-hr	CO g/hp-hr	NOx g/hp-hr	SO2 g/hp-hr	PM10 g/hp-hr	PM2.5 g/hp-hr	N2O g/gal	CH4 g/gal	CO2 g/hp-hr	BSFC lb/hp-hr
Tugboat - propulsion	2000	2	0.85	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367
				VOC Ton	**CO** Ton	**NOx** Ton	**SO2** Ton	**PM10** Ton	**PM2.5** Ton	**N2O** Ton	**CH4** Ton	**CO2** Ton	
	Tugboat Annual Emissions (CY 19)			2.21	13.30	6.86	0.07	15.56	0.01	0.10	0.29	11,139.61	
											CO2e in metric tons/year	**10,140**	

Equipment Usage	CY 19 Hours
Work Tug	960
Excavator	960

CY 19 Equipment Emissions

Off-road Equipment	Hours of Operation	Engine HP	Load Factor	VOC g/hp-hr	CO g/hp-hr	NOx g/hp-hr	SO2 g/hp-hr	PM10 g/hp-hr	PM2.5 g/hp-hr	N2O g/gal	CH4 g/gal	CO2 g/hp-hr	BSFC lb/hp-hr
Work Tug	960	2000	0.5	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367
Excavator	960	417	0.85	0.11	1.49	6.21	0.004	0.24	0.23	0.26	0.74	531	0.367

	VOC lb	CO lb	NOx lb	SO2 lb	PM10 lb	PM2.5 lb	N2O lb	CH4 lb	CO2 lb
Work Tug	234	3,156	13,147	9	505	490	29	81	1,123,215
Excavator	83	1,119	4,660	3	179	174	10	29	398,124
Tons/year:	**0.2**	**2.1**	**8.9**	**0.0**	**0.3**	**0.3**	**0.0**	**0.1**	**760.7**
CO2e in metric tons/year									**697**

Vessel emission factors from page 3-22 of Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder, USEPA 2008.

All vessels are presumed to use 2 propulsion engines, table lists total HP.

Total Emissions

	VOC	CO	NOx	SO2	PM10	PM2.5	CO2e
Tons per Year	2.37	15.44	15.76	0.08	15.90	0.34	10,836

average passenger vehicle					
404			grams of CO_2 per mile		
0.89			lb of CO_2 per mile		
CO_2e					
Tons/yr		45,333,824		miles	
Alt 1	20,175		3,942		cars driving 11,500 miles per year
40,578,601			miles		
Alt 2	18,059		3,529		cars driving 11,500 miles per year
69,682,638			miles		
Alt 3 - north wallops	31,011		6,059		cars driving 11,500 miles per year
66,689,595			miles		
Alt 3 - unnamed shoal	29,679		5,799		cars driving 11,500 miles per year

CY 2019

North Wallops Beach - sand coming from (Alternative 1) 200 acres
Offshore Shoal A - sand coming from (Alternative 2)
Nearshore Breakwaters Add to Alt 1 or Alt 2 and becomes Alt 3
Remove, store, replace sand fencing
Estimated distance from southern edge of borrow
area to northern edge of renourishment area 0.5 mi
Total distance from north to south of both areas 9 mi

Alternative 1 1,300,000 cubic yards of sand
Excavate sand to 2.35 feet 2 mi approx length of borrow area
tractor scraper with low pressure tires remove sand from beach
stockpile sand assume 0.25 mi from fill area
dump trucks would transport to fill area 6.5 mi approx length of renourishment area 3.25 mi is avg distance
bulldozers spread the sand 4 215 HP each 24 hr/day
ATVs
mobile generators for lighting
mobile fuel tanks

Alternative 2 1,625,000 cubic yards of sand
Equipment mobilization 30-45 days Dodge Island 4350 HP propulsion
discharge pipe (several miles) 3000 HP dredge pump power
productivity = 18,513 CY/day based on 2010 EIS
pump out buoys
multiple barges
tugboats 4000 HP X 2
derrick barge
crew transport vehicles
Onshore discharge lines trucked in and placed using loader or crane
onshore equipment
bulldozers
ATVs
mobile generators
mobile fuel tanks
suction hopper dredges self propelled 8000 HP assume 2 dredges 3 RT/day
pumping/jetting engines 5000 HP centrifugal pumps
mooring buoy placement using derrick barge 5000 HP 2 work barges 2000 HP 2 tender tu 1000 HP Placement and removal 12 hrs
17 14 hr dredging days
Dredge over a large area from unnamed Shoal A to mooring buoy 17 mi
length of pipeline to placement 2 mi
7-10 ft depth
hopper capacity 4000 CY actual capacity 3000 CY
booster pumps for moving sand from offload point to placement area

Alternative 3		combined with either 1 or 2
Type 1 stone =		0.75 to 2 tons
Type 2 stone =		150 to 500 pounds
	130	ft long
	10	ft high at crest
	100	ft apart
water depth		4 to 8 ft
	6	total

rock transport by rail
offloaded than moved by truck to staging location