APPENDIX D

Air Quality Calculations

The major pollutants of concern, called "criteria pollutants," are carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), total suspended particulate matter less than or equal to 10 (PM10) and 2.5 (PM2.5) micrometers in aerodynamic diameter, and lead (Pb). USEPA has established National Ambient Air Quality Standards (NAAQS) for these pollutants, which are presented in table D.1.

A design value is a statistic that describes the air quality status of a given location relative to the level of the NAAQS. Design values are relevant because they provide baseline air quality levels for the given area. The most recently published design values based on current ambient monitoring levels (2022) for the SF Bay Area are compared to the federal or California ambient air quality standards (AAQS), whichever is more stringent, in Table D.2.

Table D.1 National Ambient Air Quality Standards and California Standards

	NAAQS			**California Standards**	
Pollutant	**Averaging Time**	**Primary/Secondary**	**Concentration**	**Averaging Time**	**Concentration**
CO	1 hour	Primary	35 ppm	1 hour	20 ppm
	8 hours	Primary	9 ppm	8 hours	9.0 ppm
Pb	Rolling 3-month period	primary and secondary[1]	0.15 µg/m3	30-day average	1.5 µg/m^3
NO_2	1 hour	Primary	100 ppb	1 hour	0.18 ppm
	1 year	primary and secondary[2]	53 ppb	Annual	0.030 ppm
O_3	8 hours	primary and secondary[3]	0.070 ppm	1-hour	0.09 ppm
				8-hour	0.070 ppm
$PM_{2.5}$	1 year	Primary	9.0 µg/m^3	1 year	12 µg/m^3
	1 year	Secondary	15.0 µg/m^3		
	24 hours	primary and secondary	35 µg/m^3		
PM_{10}	24 hours	primary and secondary	150 µg/m^3	24 hours	50 µg/m3
				1 year	20 µg/m3
SO_2	1 hour	primary[4]	75 ppb	1 hour	0.25 ppm
	3 hours	Secondary	0.5 ppm	24 hours	0.04 ppm

Sources: USEPA 2024, CARB 2024

[1] In areas designated non-attainment for the lead standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 micrograms per cubic meter as a calendar quarter average) also remain in effect.

[2] The level of the annual nitrogen dioxide standard is 0.053 part per million. It is shown here in terms of parts per billion for the purposes of clearer comparison to the 1-hour standard level.

[3] Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) ozone standards additionally remain in effect in some areas. Revocation of the previous (2008) ozone standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards. Additionally, some areas may have certain continuing implementation obligations under the prior revoked 1-hour (1979) and 8-hour (1997) O_3 standards.

[4] The previous sulfur dioxide standards (0.14 parts per million 24-hour and 0.03 part per million annual) will additionally remain in effect in certain areas: 1) Any area for which it is not yet one year since the effective date of designation under the current (2010) standards, and 2) any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved, and which is designated non-attainment under the previous sulfur dioxide standards or is not meeting the requirements of a State Implementation Plan (SIP) call under the previous sulfur dioxide standards (40 Code of Federal Regulations 50.4(3)). An SIP call is a USEPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the require NAAQS.

Key: µg/m3 = micrograms per cubic meter

CO = carbon monoxide
NO_2 = nitrogen dioxide
O_3 = ozone
Pb = lead
PM_{10} = particulate matter less than or equal to 10 microns
$PM_{2.5}$ = particulate matter less than or equal to 2.5 microns
ppb = parts per billion
ppm = parts per million
SO_2 = sulfur dioxide

Table D.2 Comparison of 2022 San Francisco Bay Area Design Values with Ambient Air Quality Standards

Pollutant	Averaging Time	Most Stringent AAQS	Maximum Design Values	% of AAQS
CO	1-hour	20 ppm (California)	1.9 ppm	10
	8-hour	9 ppm	1.1 ppm	12
O_3 (2015 standard)	8-hour	0.070 ppm	0.070 ppm	100
O_3 (2008 standard)	8-hour	0.075 ppm	0.070 ppm	93
$PM_{2.5}$	24-hour	35 µg/m^3	26 µg/m^3	74
	Annual	9 µg/m^3	8.2 µg/m^3	91

1 Data from USEPA's Air Quality System site, San Francisco-Arkansas Street, Site ID 060750005, located at 10 Arkansas Street, San Francisco, California.

Key: µg/m^3 = micrograms per cubic meter
AQQS = ambient air quality standards
CO = carbon monoxide
O_3 = ozone
PM_{10} = particulate matter less than or equal to 10 microns
$PM_{2.5}$ = particulate matter less than or equal to 2.5 microns
ppm = parts per million

Tab A. Summary

Comparison of Alternatives	VOC	NOx	PM10	PM2.5	CO2	CH4	N2O	CO2e
Baseline (No Action) Alternative	**9.55**	**178.50**	**6.18**	**5.93**	**18891.17**	**0.75**	**0.78**	**19,141**
Alternative 1	9.75	150.88	5.14	4.92	16884.27	0.81	0.68	17,107
Alternative 1 Net Change	**0.20**	**-27.62**	**-1.04**	**-1.01**	**-2006.90**	**0.06**	**-0.10**	**-2,034**
Alternative 2	8.43	171.82	6.04	5.81	17406.05	0.64	0.72	17,636
Alternative 2 Net Change	**-1.12**	**-6.68**	**-0.14**	**-0.12**	**-1485.12**	**-0.11**	**-0.06**	**-1,505**
Alternative 3	9.49	153.63	5.30	5.08	16665.43	0.77	0.67	16,885
Alternative 3 Net Change	**-0.06**	**-24.88**	**-0.88**	**-0.85**	**-2225.73**	**0.03**	**-0.10**	**-2,256**
Alternative 4	11.16	127.25	4.17	3.97	15944.94	0.99	0.62	16,155
Alternative 4 Net Change	**1.62**	**-51.25**	**-2.01**	**-1.96**	**-2946.23**	**0.24**	**-0.15**	**-2,986**

Tab B. Dredge Data

1 KW = 1.34102 HP, 453.59 g/lb

Sources: Federal Navigation Channels EA/EIR, Appendix B; 2015
CHC_CARB_Reported_Vessel_Data_2024-02-07
Appendix H 2021 Update to the Emission Inventory for Commercial Harbor Craft: Methodology and Results
Port Oakland 2020 Emissions Inventory Final Report
2020 Seaport Emissions Inventory: Update of Commercial Harbor Craft Emissions Memoranda, Ramboll, 2023
USACE DREDGE ESSAYONS _ Philadelphia District & Marine Design Center _ Fact Sheet Article View, 2012

Vessel Characteristics

Vessel	Engine Type	Number of Engines	Marine/Offroad Tier	HP (ea)	Load Factor	Emissions Factors (g/bhp-hr)								
						VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	BSFC
Essayons (Hopper)	Propulsion	2	Marine 2	4,640	0.4	0.11	1.49	6.21	0.23	0.22	506.68	0.002	0.02	159
	Ship Service	3	Marine 2	1,381	0.6	0.11	1.49	6.21	0.23	0.22	506.68	0.002	0.02	159
	600V Generators	4	Marine 2	4,358	0.6	0.11	1.49	6.21	0.23	0.22	506.68	0.002	0.02	159
Njord (Clamshell)	Main	1	Marine 1	2,934	0.4	0.28	1.09	4.28	0.125	0.115	529	0.026	0.02	159
	Aux	1	Offroad 4	280	0.6	0.07	1.00	0.27	0.01	0.009	531	0.007	0.02	159
	Aux	1	Offroad 4	280	0.6	0.07	1.00	0.27	0.01	0.009	531	0.007	0.02	159
Tender (Becky T) (Tugboat - Escort/Ship Assist)	Propulsion	2	Marine 3	350	0.2	0.82	3.73	3.99	0.08	0.078	670	0.073	0.02	159
	Aux	1	Offroad 3	162	0.3	0.81	3.73	3.8	0.09	0.087	670	0.073	0.02	159
	Aux	1	Offroad 1	25	0.3	0.81	2.78	7.31	0.319	0.31	587	0.073	0.02	185
Heidi Brusco (Disposal Trips) (Tugboat - Push/Tow)	Main	2	Marine 2	1,500	0.3	0.68	3.73	5.53	0.2	0.194	587	0.061	0.02	159
	Aux	1	Marine 3	161	0.4	0.81	3.73	5.1	0.22	0.213	670	0.073	0.02	159

NOTES: Essayons and Njord N20 emission factor from EPA Port Inventory (2020) equation 4.3
Essayons emission factors from EPA Port Inventory Appendix H
Njord used to represent clamshell dredging
Scow assumed for dredge material transport for clamshell dredging with 4500 CY capacity
Becky T represents tender for both dredging scenarios
Heidi Brusco is the tugboat used for scow transport for clamshell dredging

Disposal Transit and Tendering Time

For 1-hr Transit time	Emissions lb							
	VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O
Essayons (Hopper)–main	0.94	13.30	55.41	2.06	1.99	4519.66	0.02	0.20
Essayons (Hopper)–SS	0.54	7.72	32.17	1.19	1.16	2624.03	0.01	0.12
Essayons (Hopper)–gens	2.29	32.50	135.36	5.02	4.87	11040.83	0.04	0.49
Working Total	**3.78**	**53.53**	**222.93**	**8.27**	**8.02**	**18184.53**	**0.07**	**0.80**
Transit Total	**1.48**	**21.03**	**87.58**	**3.25**	**3.15**	**7143.70**	**0.03**	**0.32**
Njord (Clamshell)–main	0.79	3.07	12.07	0.35	0.32	1491.90	0.07	0.06
Njord (Clamshell)–aux	0.02	0.35	0.09	0.00	0.00	185.85	0.00	0.01
Njord (Clamshell)–aux	0.02	0.35	0.09	0.00	0.00	185.85	0.00	0.01
Working Total	**0.84**	**3.77**	**12.26**	**0.36**	**0.33**	**1863.61**	**0.08**	**0.08**
Tender (Becky T)–main	0.21	0.94	1.00	0.02	0.02	168.54	0.02	0.01
Tender (Becky T)–aux	0.10	0.45	0.46	0.01	0.01	80.88	0.01	0.00
Tender (Becky T)–aux	0.02	0.05	0.14	0.01	0.01	10.94	0.00	0.00
Working/Transit Total	**0.32**	**1.44**	**1.60**	**0.04**	**0.04**	**260.35**	**0.03**	**0.01**
Heidi Brusco (Disposal Trips)	1.50	8.24	12.22	0.44	0.43	1296.71	0.13	0.04
Heidi Brusco (Disposal Trips)—aux	0.11	0.49	0.67	0.03	0.03	87.99	0.01	0.00
Transit Total	**1.61**	**8.73**	**12.89**	**0.47**	**0.46**	**1384.70**	**0.14**	**0.05**

NOTES: Disposal transit time for Essayons, Becky T, and Heidi Brusco. Tender time applies to Becky T (representative for both clamshell and hopper dredging).

Dredging Activity

Vessel	Dredge Rate Average	Units	max load CY
Essayons (Hopper)	2,688	CY/hr	6,423
Njord (Clamshell)	257	CY/hr	

NOTES: 43,000 CY/day
2,688 CY/hr for a 16-hr day excluding disposal transit time

Engine use during dredging activity — 100,000 CY basis

Vessel	Engine Type	Number of Engines	MY/Tier	HP	Load Factor[1]	Hrs of Operation
Essayons (Hopper)	Propulsion	2	Tier 2	4640	0.44	–
Essayons (Hopper)	Ship Service	3	Tier 2	1207	0.57	–
Essayons (Hopper)	Pump	2	Tier 2	4640	0.57	–
Essayons (Hopper)	600 V	2	Tier 2	–	–	–
Paula Lee (Clamshell)	Dredge	1	–	1200	0.42	–
Paula Lee (Clamshell)	Generator	1	–	890	0.1	–
Paula Lee (Clamshell)	Deck	1	–	300	0.8	–
Paula Lee (Clamshell)	Deck winch	4	–	300	0.31	–
Tugboat (Becky T)	Propulsion	2	2017/3	1800	0.1	–
Tugboat (Becky T)	Aux	1	2018/3	–	–	–
Tugboat (Becky T)	Aux	1	2003/1	–	–	–

1. updated with CARB values 2021

Engine use during transits — 100,000 CY basis

Vessel	Engine Type	Number of Engines	HP	Load Factor[1]	Hrs of Operation
Essayons (Hopper)	Propulsion	2	4640	0.1	–
Essayons (Hopper)	Ship Service	3	1207	0.6	–
Essayons (Hopper)	Pump	2	4640	0.8	–
Paula Lee (Clamshell)	Dredge	1	1200	0.42	–
Paula Lee (Clamshell)	Generator	1	890	0.1	–
Paula Lee (Clamshell)	Deck	1	300	0.8	–
Paula Lee (Clamshell)	Deck winch	4	300	0.31	–
Tugboat (Becky T)	Propulsion	2	1800	0.1	–
Tugboat (Becky T)	Aux	1	–	–	–
Tugboat (Becky T)	Aux	–	–	–	–

1. updated with CARB values 2021

Tab C. Alternatives Calculations

Baseline Alternative—No Action

Analyzed dredge CY for this Alternative:	2,650,000	
% Clamshell Contribution:	69%	1,835,000 CY
% Hopper Contribution:	31%	815,000 CY

Placement Sites	In-bay Placement [1]		Nearshore Strategic Placement [2]		Potential Future Nearshore Strategic Placement [3]		Ocean Placement [2]		Deep Ocean Disposal [1]		Upland (sponsor provided) [3]		Non-aquatic Direct Placement [3]	
Baseline Alternative-No Action (range)	**30%**	**40%**	**5%**	**15%**	**0%**	**0%**	**0%**	**10%**	**45%**	**55%**	**0%**	**10%**	**0%**	**0%**
Average	35%	927,500	12%	318,000	0%	0	4%	106,000	48%	1,272,000	1%	26,500	0%	0
Max transit distance one-way	41.2	–	5.2	–	4.8	–	1.5	–	63.5	–	3.2	–	64.3	–

Dredging Type
1. Both
2. Hopper only
3. Clamshell only

Dredge Method	Volume Dredged (CY)	Dredging Duration hrs	Emissions Tons								
			VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
Clamshell	1,835,000	7,140	4.13	18.62	49.47	1.42	1.31	7582.61	0.38	0.31	7,684
Hopper	815,000	303	0.62	8.33	34.05	1.26	1.22	2796.76	0.02	0.12	2,834
–	–	**Total Baseline Dredging Emissions**	**4.75**	**26.95**	**83.52**	**2.67**	**2.53**	**10,379.37**	**0.40**	**0.43**	**10,518**

Placement Site	Dredge Volume CY	Max Distance nm	RT Distance nm	Speed knots	Time hours	Number of Trips	Emissions Tons								
							VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
In-Bay placement–clamshell	642,250	41.2	82.4	8	10.3	143	1.18	6.42	9.47	0.35	0.34	1017.78	0.11	0.03	1,031
In-Bay placement–hopper	285,250	41.2	82.4	8	10.3	44	0.34	4.81	20.03	0.74	0.72	1633.87	0.01	0.07	1,656
Nearshore strategic placement	318,000	5.2	10.4	8	1.3	50	0.05	0.68	2.82	0.10	0.10	229.89	0.00	0.01	233
Potential future nearshore strategic placement	0	4.8	9.6	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Ocean placement	106,000	1.5	3	8	0.4	17	0.00	0.07	0.27	0.01	0.01	22.11	0.00	0.00	22
Deep Ocean Disposal–clamshell	880,800	63.5	127	8	15.9	196	2.50	13.56	20.02	0.73	0.71	2151.32	0.22	0.07	2,179
Deep Ocean Disposal–hopper	391,200	63.5	127	8	15.9	61	0.72	10.17	42.34	1.57	1.52	3453.57	0.01	0.15	3,499
Upland (sponsor provided)	26,500	3.2	6.4	8	0.8	6	0.00	0.02	0.03	0.00	0.00	3.26	0.00	0.00	3
Non-aquatic direct placement	0	64.3	128.6	8	16.1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total transit emissions for Baseline	–	–	–	–	–	–	**4.79**	**35.72**	**94.98**	**3.51**	**3.40**	**8511.79**	**0.35**	**0.34**	**8,623**

Total Baseline Dredging Envelope Emissions

VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
9.55	62.67	178.50	6.18	5.93	18,891.17	0.75	0.78	19,141

Alternative 1. Beneficial Use–Diversion from Deep Ocean Disposal

Analyzed dredge CY for this Alternative	2,650,000	
% Clamshell Contribution	71%	1,892,121 CY
% Hopper Contribution	29%	757,879 CY

Placement Sites	In-Bay Placement[1]		Nearshore Strategic Placement[2]		Potential Future Nearshore Strategic Placement[3]		Ocean Placement[2]		Deep Ocean Disposal[1]		Upland (Sponsor Provided)[3]		Non-aquatic Direct Placement[3]	
Alt 1 (range)	35%	55%	5%	15%	0%	0%	0%	10%	10%	40%	0%	10%	5%	20%
Average	42%	1,113,000	12%	318,000	0%	0	4%	106,000	35%	927,500	1%	26,500	6%	159,000
Max transit distance one-way	41.2	–	5.2	–	4.8	–	1.5	–	63.5	–	3.2	–	64.3	–

Dredging Type
1. Both
2. Hopper only
3. Clamshell only

Dredge Method	Volume Dredged (CY)	Dredging Duration hrs	Emissions Tons								
			VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
Clamshell	1,892,121	7,362	4.26	19.20	51.01	1.46	1.35	7818.65	0.39	0.32	7,924
Hopper	757,879	282	0.58	7.75	31.66	1.17	1.14	2600.74	0.01	0.11	2,635
Total Alternative 1 Dredging Emissions			**4.84**	**26.95**	**82.67**	**2.63**	**2.48**	**10,419.39**	**0.41**	**0.43**	**10,559**

Placement Site	Dredge Volume CY	Max Distance nm	RT Distance nm	Speed knots	Time hours	Number of Trips	Emissions Tons								
							VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
In-Bay placement–clamshell	911,080	41.2	82.4	8	10.3	202	1.68	9.10	13.44	0.49	0.48	1443.80	0.15	0.05	1,462
In-Bay placement–hopper	201,920	41.2	82.4	8	10.3	31	0.24	3.40	14.18	0.53	0.51	1156.57	0.00	0.05	1,172
Nearshore strategic placement	318,000	5.2	10.4	8	1.3	50	0.05	0.68	2.82	0.10	0.10	229.89	0.00	0.01	233
Potential future nearshore strategic placement	0	4.8	9.6	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Ocean placement	106,000	1.5	3	8	0.4	17	0.00	0.07	0.27	0.01	0.01	22.11	0.00	0.00	22
Deep Ocean Disposal–clamshell	778,632	63.5	127	8	15.9	173	2.21	11.99	17.70	0.65	0.63	1901.77	0.20	0.06	1,926
Deep Ocean Disposal–hopper	148,868	63.5	127	8	15.9	23	0.27	3.87	16.11	0.60	0.58	1314.23	0.01	0.06	1,332
Upland (sponsor provided)	26,500	3.2	6.4	8	0.8	6	0.00	0.02	0.03	0.00	0.00	3.26	0.00	0.00	3
Non-aquatic direct placement	159,000	64.3	128.6	8	16.1	35	0.46	2.48	3.66	0.13	0.13	393.24	0.04	0.01	398
Total transit emissions for Alternative 1	–	–	–	–	–	–	**4.91**	**31.61**	**68.20**	**2.51**	**2.43**	**6464.87**	**0.40**	**0.25**	**6,548**

Total Alternative 1 Dredging Envelope Emissions

VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
9.75	58.55	150.88	5.14	4.92	16,884.27	0.81	0.68	17,107

Alternative 2. Beneficial Use—Regional Optimization

Analyzed dredge CY for this Alternative	2,650,000	
% Clamshell Contribution	52%	1,366,245
% Hopper Contribution	48%	1,283,755

Placement Sites	In-Bay Placement[1]		Nearshore Strategic Placement[2]		Potential Future Nearshore Strategic Placement[3]		Ocean Placement[2]		Deep Ocean Disposal[1]		Upland (Sponsor Provided)[3]		Non-aquatic Direct Placement[3]	
Alt 2 (range)	50%	60%	5%	15%	0%	0%	0%	10%	0%	10%	0%	10%	20%	30%
Average	56%	1,484,000	12%	318,000	0%	0	4%	106,000	0%	0	1%	26,500	27%	715,500
Max transit distance one-way	41.2	–	5.2	–	4.8	–	1.5	–	63.5	–	3.2	–	64.3	–

Dredging Type
1. Both
2. Hopper only
3. Clamshell only

Dredge Method	Volume Dredged (CY)	Dredging Duration hrs	Emissions Tons								
			VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
Clamshell	1,366,245	5,316	3.08	13.86	36.84	1.05	0.97	5645.62	0.28	0.23	5,721
Hopper	1,283,755	478	0.98	13.13	53.63	1.98	1.92	4405.34	0.02	0.19	4,464
Total Alternative 2 Dredging Emissions			**4.06**	**26.99**	**90.46**	**3.04**	**2.90**	**10,050.96**	**0.31**	**0.42**	**10,185**

Placement Site	Dredge Volume CY	Max Distance nm	RT Distance nm	Speed knots	Time hours	Number of Trips	Emissions Tons								
							VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
In-Bay placement–clamshell	765,097	41.2	82.4	8	10.3	170	1.41	7.64	11.28	0.41	0.40	1212.46	0.13	0.04	1,228
In-Bay placement–hopper	718,903	41.2	82.4	8	10.3	112	0.86	12.12	50.48	1.87	1.82	4117.77	0.02	0.18	4,172
Nearshore strategic placement	318,000	5.2	10.4	8	1.3	50	0.05	0.68	2.82	0.10	0.10	229.89	0.00	0.01	233
Potential future nearshore strategic placement	0	4.8	9.6	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Ocean placement	106,000	1.5	3	8	0.4	17	0.00	0.07	0.27	0.01	0.01	22.11	0.00	0.00	22
Deep Ocean Disposal–clamshell	0	63.5	127	8	15.9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Deep Ocean Disposal–hopper	0	63.5	127	8	15.9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Upland (sponsor provided)	26,500	3.2	6.4	8	0.8	6	0.00	0.02	0.03	0.00	0.00	3.26	0.00	0.00	3
Non-aquatic direct placement	715,500	64.3	128.6	8	16.1	159	2.06	11.16	16.47	0.60	0.58	1769.59	0.18	0.06	1,792
Total transit emissions for Alternative 2	–	–	–	–	–	–	**4.38**	**31.68**	**81.35**	**3.00**	**2.91**	**7355.09**	**0.33**	**0.29**	**7,451**

Total Alternative 2 Dredging Envelope Emissions

VOC	CO	NOx	PM10	PM2.5	CO2	CH4	N2O	CO2e
8.43	58.67	171.82	6.04	5.81	17,406.05	0.64	0.72	17,636

Alternative 3. Beneficial Used—Cost Sharing

Analyzed dredge CY for this Alternative	2,650,000	
% Clamshell Contribution	62%	1,644,650
% Hopper Contribution	38%	1,005,350

Placement Sites	In-Bay Placement[1]		Nearshore Strategic Placement[2]		Potential Future Nearshore Strategic Placement[3]		Ocean Placement[2]		Deep Ocean Disposal[1]		Upland (Sponsor Provided)[3]		Non-aquatic Direct Placement[3]	
Alt 3 (range)	35%	45%	5%	15%	0%	0%	0%	10%	0%	10%	0%	10%	35%	45%
Average	40%	1,060,000	12%	318,000	0%	0	4%	106,000	0%	0	1%	26,500	43%	1,139,500
Max transit distance one-way	41.2	–	5.2	–	4.8	–	1.5	–	63.5	–	3.2	–	64.3	–

Dredging Type
1. Both
2. Hopper only
3. Clamshell only

Dredge Method	Volume Dredged (CY)	Dredging Duration hrs	Emissions Tons								
			VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
Clamshell	1,644,650	6,399	3.70	16.68	44.34	1.27	1.17	6796.05	0.34	0.28	6,887
Hopper	1,005,350	374	0.77	10.28	42.00	1.55	1.51	3449.97	0.02	0.15	3,496
Total Alternative 3 Dredging Emissions			**4.47**	**26.97**	**86.34**	**2.82**	**2.68**	**10,246.01**	**0.36**	**0.43**	**10,383**

Placement Site	Dredge Volume CY	Max Distance nm	RT Distance nm	Speed knots	Time hours	Number of Trips	Emissions Tons								
							VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
In-Bay placement–clamshell	657,860	41.2	82.4	8	10.3	146	1.21	6.57	9.70	0.35	0.34	1042.52	0.11	0.04	1,056
In-Bay placement–hopper	402,140	41.2	82.4	8	10.3	63	0.48	6.78	28.24	1.05	1.02	2303.40	0.01	0.10	2,334
Nearshore strategic placement	318,000	5.2	10.4	8	1.3	50	0.05	0.68	2.82	0.10	0.10	229.89	0.00	0.01	233
Potential future nearshore strategic placement	0	4.8	9.6	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Ocean placement	106,000	1.5	3	8	0.4	17	0.00	0.07	0.27	0.01	0.01	22.11	0.00	0.00	22
Deep Ocean Disposal–clamshell	0	63.5	127	8	15.9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Deep Ocean Disposal–hopper	0	63.5	127	8	15.9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Upland (sponsor provided)	26,500	3.2	6.4	8	0.8	6	0.00	0.02	0.03	0.00	0.00	3.26	0.00	0.00	3
Upland direct placement	1,139,500	64.3	128.6	8	16.1	253	3.27	17.77	26.23	0.96	0.93	2818.24	0.29	0.10	2,854
Total transit emissions for alternative 3	–	–	–	–	–	–	**5.02**	**31.88**	**67.29**	**2.48**	**2.40**	**6419.42**	**0.41**	**0.24**	**6,502**

Total Alternative 3 Dredging Envelope Emissions

VOC	CO	NOx	PM10	PM2.5	CO2	CH4	N2O	CO2e
9.49	58.85	153.63	5.30	5.08	16,665.43	0.77	0.67	16,885

Alternative 4. Beneficial Use—Maximized

Analyzed dredge CY for this Alternative	2,650,000	
% Clamshell Contribution	85%	2,263,327
% Hopper Contribution	15%	386,673

Placement Sites	In-Bay Placement[1]		Nearshore Strategic Placement[2]		Potential Future Nearshore Strategic Placement[3]		Ocean Placement[2]		Deep Ocean Disposal[1]		Upland (Sponsor Provided)[3]		Non-aquatic Direct Placement[3]	
Alt 4 (range)	0%	10%	5%	15%	5%	15%	0%	10%	0%	10%	0%	10%	65%	75%
Average	6%	159,000	12%	318,000	9%	238,500	0%	0	0%	0	1%	26,500	71%	1,881,500
Max transit distance one-way	41.2	–	5.2	–	4.8	–	1.5	–	63.5	–	3.2	–	64.3	–

Dredging Type
1. Both
2. Hopper only
3. Clamshell only

Dredge Method	Volume Dredged (CY)	Dredging Duration hrs	Emissions Tons								
			VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
Clamshell	2,263,327	8,807	5.10	22.96	61.02	1.75	1.61	9352.55	0.47	0.38	9,478
Hopper	386,673	144	0.29	3.95	16.15	0.60	0.58	1326.91	0.01	0.06	1,344
		Total Alt 4 Dredging Emissions	**5.39**	**26.92**	**77.18**	**2.34**	**2.19**	**10,679.46**	**0.48**	**0.44**	**10,823**

Placement Site	Dredge Volume CY	Max Distance nm	RT Distance nm	Speed Knots	Time Hours	Number of Trips	Emissions Tons								
							VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
In-Bay placement - clamshell	135,800	41.2	82.4	8	10.3	30	0.25	1.36	2.00	0.07	0.07	215.20	0.02	0.01	218
In-Bay placement - hopper	23,200	41.2	82.4	8	10.3	4	0.03	0.39	1.63	0.06	0.06	132.89	0.00	0.01	135
Nearshore strategic placement	318,000	5.2	10.4	8	1.3	50	0.05	0.68	2.82	0.10	0.10	229.89	0.00	0.01	233
Potential future nearshore strategic placement	238,500	4.8	9.6	8	1.2	37	0.04	0.19	0.29	0.01	0.01	30.85	0.00	0.00	31
Ocean placement	0	1.5	3	8	0.4	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Deep Ocean Disposal - clamshell	0	63.5	127	8	15.9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Deep Ocean Disposal - hopper	0	63.5	127	8	15.9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Upland (sponsor provided)	26,500	3.2	6.4	8	0.8	6	0.00	0.02	0.03	0.00	0.00	3.26	0.00	0.00	3
Upland direct placement	1,881,500	64.3	128.6	8	16.1	418	5.41	29.34	43.30	1.58	1.53	4653.38	0.49	0.16	4,712
Total transit emissions for Alternative 4	–	–	–	–	–	–	**5.77**	**31.98**	**50.07**	**1.83**	**1.78**	**5265.47**	**0.51**	**0.18**	**5,332**

Total Alternative 4 Dredging Envelope Emissions

VOC	CO	NOx	PM10	PM2.5	CO_2	CH4	N_2O	CO2e
11.16	58.89	127.25	4.17	3.97	15,944.94	0.99	0.62	16,155

Tab D. Baseline (No Action) Summary

Channel	Likely Dredge Method	Typical Dredging Cycle (years)	Average Volume Dredged per Episode (CY)
Inner Richmond Harbor	Clamshell	1	300,000
Napa River	Cutterhead-pipeline	6-11	110,000
Oakland – Inner and Outer Harbor	Clamshell	1	750,000
Petaluma River- across the flats	Clamshell	3	70,000
Petaluma River	Cutterhead-pipeline	4-7	150,000
Redwood City	Clamshell	1	180,000
San Rafael Creek	Clamshell	4-6	110,000
Suisun Bay Channel	Clamshell	Variable	165,000
Outer Richmond Harbor	Hopper	1	250,000
San Bruno	Hopper	23	30,000
San Francsico Harbor	Hopper	Variable	345,000
San Pablo Bay (Pinole Shoal)	Hopper	Variable	190,000

Likely Dredge Method	Average Volume Dredged per Episode (CY)	Percent of Total
Clamshell	**1,835,000**	**69%**
Hopper	**815,000**	**31%**
Total	**2,650,000**	**100%**

Tab E. Alternative 1. Beneficial Use–Diversion from Deep Ocean Disposal Summary

Channel	Likely Dredge Method	Typical Dredging Cycle (years)	Average Volume Dredged per Episode (CY)
Inner Richmond Harbor	Clamshell	1	300,000
Napa River	Cutterhead-pipeline	6-11	110,000
Oakland – Inner and Outer Harbor	Clamshell	1	750,000
Petaluma River- across the flats	Clamshell	3	70,000
Petaluma River	Cutterhead-pipeline	4-7	150,000
Redwood City	Clamshell	1	180,000
San Rafael Creek	Clamshell	4-6	110,000
Suisun Bay Channel	Clamshell	1	165,000
Outer Richmond Harbor	Hopper	1	210,000
San Bruno	Hopper	23	30,000
San Francsico Harbor	Hopper	1	345,000
San Pablo Bay (Pinole Shoal)	Hopper	1	150,000

Likely Dredge Method	Average Volume Dredged per Episode (CY)	Percent of Total
Clamshell	**1,835,000**	**71%**
Hopper	**735,000**	**29%**
Total	**2,570,000**	**100%**

Tab F. Alternative 2. Beneficial Use–Optimized Alternative Summary

Channel	Likely Dredge Method	Typical Dredging Cycle (years)	Average Volume Dredged per Episode (CY)
Napa River	Cutterhead-Pipeline	6-11	110,000
Oakland – Inner and Outer Harbor	Clamshell	1	540,000
Petaluma across the flats	Clamshell	3	70,000
Petaluma River	Cutterhead-pipeline	4-7	150,000
Redwood City	Clamshell	1	180,000
San Rafael Creek	Clamshell	4-6	110,000
Suisun Bay Channel (Suisun*, NY Slough, Bulls Head)	Clamshell	1	165,000
Inner Richmond Harbor	Hopper	1	300,000
Outer Richmond Harbor	Hopper	1	210,000
San Bruno	Hopper	23	30,000
San Francsico Harbor	Hopper	1	345,000
San Pablo Bay (Pinole Shoal)	Hopper	1	150,000
Oakland – Inner and Outer Harbor	Hopper	1	210,000

Likely Dredge Method	Average Volume Dredged per Episode (CY)	Percent of Total
Clamshell	**1,325,000**	**52%**
Hopper	**1,245,000**	**48%**
Total	**2,570,000**	**100%**

Tab G. Alternative 3. Beneficial Use–Cost Share Opportunity Summary

Channel	Likely Dredge Method	Typical Dredging Cycle (years)	Average Volume Dredged per Episode (CY)
Napa River	Cutterhead-Pipeline	6-11	110,000
Oakland – Inner and Outer Harbor	Clamshell	1	750,000
Petaluma Across the Flats	Clamshell	3	70,000
Petaluma River	Cutterhead-Pipeline	4-7	150,000
Redwood City	Clamshell	1	180,000
San Rafael Creek	Clamshell	4-6	110,000
Suisun Bay Channel (Suisun*, NY Slough, Bulls Head)	Clamshell	1	165,000
Inner Richmond Harbor	Clamshell	1	35,000
Outer Richmond Harbor	Clamshell	1	15,000
San Pablo Bay (Pinole Shoal)	Clamshell	1	10,000
Inner Richmond Harbor	Hopper	1	265,000
Outer Richmond Harbor	Hopper	1	195,000
San Bruno	Hopper	23	30,000
San Francsico Harbor	Hopper	1	345,000
San Pablo Bay (Pinole Shoal)	Hopper	1	140,000

Likely Dredge Method	Average Volume Dredged per Episode (CY)	Percent of Total
Clamshell	**1,595,000**	**62%**
Hopper	**975,000**	**38%**
Total	**2,570,000**	**100%**

Tab H. Alternative 4. Maximized Beneficial Use

Channel	Likely Dredge Method	Typical Dredging Cycle (years)	Average Volume Dredged per Episode (CY)
Inner Richmond Harbor	Clamshell	1	300,000
Napa River	Cutterhead-Pipeline	6-11	110,000
Oakland – Inner and Outer Harbor	Clamshell	1	750,000
Outer Richmond Harbor	Clamshell	1	210,000
Petaluma Across the Flats	Clamshell	3	70,000
Petaluma River	Cutterhead-Pipeline	4-7	150,000
Redwood City	Clamshell	1	180,000
San Pablo Bay (Pinole Shoal)	Clamshell	1	150,000
San Rafael Creek	Clamshell	4-6	110,000
Suisun Bay Channel (Suisun*, NY Slough, Bulls Head)	Clamshell	1	165,000
San Bruno	Hopper	23	30,000
San Francsico Harbor	Hopper	1	345,000

Likely Dredge Method	Average Volume Dredged per Episode (CY)	Percent of Total
Clamshell	**2,195,000**	**85%**
Hopper	**375,000**	**15%**
Total	**2,570,000**	**100%**

Tab I. Transit Distances Provided By USACE

Placement Site	Distance (nm)
Channel: Inner Richmond (clamshell)	
SF-DODS	59.2 Deep water ocean disposal sites
Montezuma	42.0 Upland BU
SF-11	8.5 In-bay
SF-9	18.9 In-bay
SF-10	11.0 In-bay
SF-11	12.1 In-bay
Channel: Napa River	
SF-9	17.0 In-bay
Imola Avenue	3.2 Upland site
Montezuma	37.1 Upland BU
Channel: Oakland (Inner and Outer)	
SF-DODS	57.1 Deep water ocean disposal sites
Montezuma	47.4 Upland BU
SF-11	5.4 In-bay
SF-9	24.3 In-bay
Emeryville Crescent nearshore	4.8 In-water nearshore
SF-10	16.5 In-bay
Channel: Petaluma River	
SF-10	18.9 In-bay
Shollenberger	3.2 Upland site
Montezuma	44.9 Upland BU
SF-11	21.6 In-bay
Channel: Redwood City	
Montezuma	64.3 Upland BU
Whale's Tail nearshore	2.8 In-water nearshore
SF-9	41.2 In-bay
SF-DODS	105.0 Deep water ocean disposal sites
SF-10	33.4 In-bay
Channel: San Rafael Creek	
SF-11	14.4 In-bay
Montezuma	37.0 Upland BU
SF-9	13.9 In-bay
SF-10	6.0 In-bay
SF-16	4.7 In-bay

Placement Site	Distance (nm)
Channel: Suisun Bay	
Montezuma	9.6 Upland BU
SF-11	37.6 In-bay
SF-10	22.0 In-bay
SF-11	9.4 In-bay
Channel: Outer Richmond	
Montezuma	38.9 Upland BU
SF-9	15.8 In-bay
SF-10	7.9 In-bay
Channel: San Bruno	
SF-DODS	63.5 Deep water ocean disposal sites
Montezuma	54.6 Upland BU
SF-11	11.8 In-bay
SF-9	31.5 In-bay
SF-10	23.6 In-bay
Channel: San Francisco Main Ship Channel	
SF-8	1.5 In-water ocean sites
SF-17	5.2 In-water ocean BU
Ocean Beach onshore	6.3
SF-10	4.7 In-bay
SF-9	3.2 In-bay
Channel: San Pablo Bay (Pinole Shoal)	
Montezuma	26.3 Upland BU
SF-11	20.3 In-bay

In-bay	SF-9, SF-10, SF-11, SF-16
In-water ocean BU	SF-17
In-water ocean sites	SF-8
Deep water ocean disposal sites	SF-DODs
Upland	Shollenberger Park (Petaluma River), Imola Avenue (Napa River)
Upland BU	Montezuma Wetlands, Cullinan Ranch
In-water nearshore strategic placement beneficial use sites	den Landing (Whale's Tail) Nearshore, Emeryville Crescent Nearshore

Tab J. Changes in Placement Percent and Volume by Alternative

	In-bay Placement		Nearshore Strategic Placement		Potential Future Nearshore Strategic Placement		Ocean Placement		Deep Ocean Disposal		Upland (Sponsor-Provided)		Non-aquatic Direct Placement	
Baseline	35%	927,500	12%	318,000	0%	–	4%	106,000	48%	1,272,000	1%	26,500	0%	–
Alt 1	42%	1,113,000	12%	318,000	0%	–	4%	106,000	35%	927,500	1%	26,500	6%	159,000
Change	**7%**	**185,500**	**0%**	–	**0%**	–	**0%**	–	**-13%**	**(344,500)**	**0%**	–	**6%**	**159,000**
Alt 2	56%	1,484,000	12%	318,000	0%	–	4%	106,000	0%	–	1%	26,500	27%	715,500
Change	**21%**	**556,500**	**0%**	–	**0%**	–	**0%**	–	**-48%**	**(1,272,000)**	**0%**	–	**27%**	**715,500**
Alt 3	40%	1,060,000	12%	318,000	0%	–	4%	106,000	0%	–	1%	26,500	43%	1,139,500
Change	**5%**	**132,500**	**0%**	–	**0%**	–	**0%**	–	**-48%**	**(1,272,000)**	**0%**	–	**43%**	**1,139,500**
Alt 4	6%	159,000	12%	318,000	9%	238,500	0%	–	0%	–	1%	26,500	71%	1,881,500
Change	**-29%**	**(768,500)**	**0%**	–	**9%**	**238,500**	**-4%**	**(106,000)**	**-48%**	**(1,272,000)**	**0%**	–	**71%**	**1,881,500**

Tab K. Conversion of Total GHG Emissions from Short Tons to Metric Tonnes

Alternative	CO_2e	METRIC
Baseline (No Action) Alternative	**19,141**	**17,364**
Alternative 1–Dredge Operation Emissions	10,559	9,579
Alternative 1–Transit Emissions	6,548	5,941
Subtotal	17,107	15,519
Alternative 1 Net Change	**-2,034**	**-1,845**
Alternative 2–Dredge Operation Emissions	10,185	9,240
Alternative 2–Transit Emissions	7,451	6,759
Subtotal	17,636	15,999
Alternative 2 Net Change	**-1,505**	**-1,365**
Alternative 3–Dredge Operation Emissions	10,383	9,419
Alternative 3–Transit Emissions	6,502	5,899
Subtotal	16,885	15,318
Alternative 3 Net Change	**-2,256**	**-2,046**
Alternative 4–Dredge Operation Emissions	10,823	9,818
Alternative 4–Transit Emissions	5,332	4,838
Subtotal	16,155	14,656
Alternative 4 Net Change	**-2,986**	**-2,709**

SCC-GHG Alternative 4

Emission Year	2020 Dollars per Metric Ton			Metric ton/yr			Total Cost
	SC-CO2 2.5%	SC-CH4 2.5%	SC-N2O 2.5%	CO2	CH4	N2O	CO2e
2025	$130.00	$1,590.00	$39,972.00	-2946.23	0.24	-0.15	($388,781)
2026	$133.00	$1,657.00	$40,920.00	-2946.23	0.24	-0.15	($397,750)
2027	$136.00	$1,724.00	$41,868.00	-2946.23	0.24	-0.15	($406,718)
2028	$139.00	$1,791.00	$42,816.00	-2946.23	0.24	-0.15	($415,686)
2029	$141.00	$1,857.00	$43,764.00	-2946.23	0.24	-0.15	($421,709)
2030	$144.00	$1,924.00	$44,712.00	-2946.23	0.24	-0.15	($430,677)
2031	$147.00	$2,002.00	$45,693.00	-2946.23	0.24	-0.15	($439,648)
2032	$150.00	$2,080.00	$46,674.00	-2946.23	0.24	-0.15	($448,619)
2033	$153.00	$2,157.00	$47,655.00	-2946.23	0.24	-0.15	($457,590)
2034	$155.00	$2,235.00	$48,636.00	-2946.23	0.24	-0.15	($463,615)
						10−Year Total Estimated Cost Reduction	**($4,270,795)**

SCC−GHG Alternative 2

Emission Year	2020 Dollars Per Metric Ton			Metric ton/yr			Total Cost
	SC−CO2 2.5%	SC−CH4 2.5%	SC−N2O 2.5%	CO2	CH4	N2O	CO2e
2025	$130.00	$1,590.00	$39,972.00	-1485.12	-0.11	-0.06	($195,540)
2026	$133.00	$1,657.00	$40,920.00	-1485.12	-0.11	-0.06	($200,057)
2027	$136.00	$1,724.00	$41,868.00	-1485.12	-0.11	-0.06	($204,574)
2028	$139.00	$1,791.00	$42,816.00	-1485.12	-0.11	-0.06	($209,092)
2029	$141.00	$1,857.00	$43,764.00	-1485.12	-0.11	-0.06	($212,124)
2030	$144.00	$1,924.00	$44,712.00	-1485.12	-0.11	-0.06	($216,641)
2031	$147.00	$2,002.00	$45,693.00	-1485.12	-0.11	-0.06	($221,162)
2032	$150.00	$2,080.00	$46,674.00	-1485.12	-0.11	-0.06	($225,682)
2033	$153.00	$2,157.00	$47,655.00	-1485.12	-0.11	-0.06	($230,202)
2034	$155.00	$2,235.00	$48,636.00	-1485.12	-0.11	-0.06	($233,238)
						10−Year Total Estimated Cost Reduction	**($2,148,311)**