

June 30, 2017

MEMORANDUM

To: Karen Huss, Sacramento Metropolitan Air Quality Management District
 From: John Grant, Tasko Olevski, Chris Lindhjem, and Lit Chan
 Subject: Harbor Craft, Dredge and Barge Emission Factor Tool

This memorandum describes the development of the Harbor Craft, Dredge and Barge Emission Factor Tool (hereafter referred to as the Calculator or Tool) including 1) a description of the emission calculation methodology and 2) references to California Air Resources Board (CARB) source data. This calculator enables users to estimate emissions rates for vessels used in dredging operations based on emission calculation methodology consistent with three California Air Resources Board (CARB) inventory databases: harbor craft emissions inventory database¹, crew and supply emissions inventory database², and barge and dredge emissions inventory database³.

Tool Functionality

At the request of and in collaboration with the District, the Tool has been developed by Ramboll Environ to provide a framework for federal, state, and local agencies to quickly estimate emission rates from these sources as part of California Environmental Quality Act (CEQA)/National Environmental Protection Act (NEPA) analysis and for reporting during project implementation.

A brief description of Tool content by spreadsheet tab is as follows:

Instructions: Instructions for Tool use.

Input: All information that the user will enter into the tool is contained in this tab. The user chooses a calendar year for which to estimate emissions and provides inputs for 1) main engines and 2) auxiliary engines.

MainEngineEmissRates: This tab summarizes the main engine emission rates for each entry in the main engine input table. The following data is presented for each engine and vessel:

- Vessel name
- Vessel number
- Location
- Vessel type
- Engine Model Year
- Engine Rated Power
- Engine Load factor
- Number of Engines

¹ https://www.arb.ca.gov/msei/california_harbor_craft_emissions_inventory_database_10072011.mdb

² https://www.arb.ca.gov/msei/california_crew_supply_emissions_inventory_database_10072011.mdb

³ https://www.arb.ca.gov/msei/california_barge_dredge_emissions_inventory_database_10072011.mdb

- Criteria air pollutant⁴ and greenhouse gas⁵ emission rates in pounds per hour (lb/hr) and grams per brake horsepower-hour (g/bhp-hr)

AuxEngineEmissRates: This tab contains output in a format similar to the “MainEngineEmissRates” tab with an additional column for auxiliary engine type.

VesselDesc: This tab includes brief descriptions of harbor craft vessel types.

Documentation: This tab documents calculator version information.

Calculations: This tab performs emission factor calculations based on user-provided inputs and CARB database emission factors and inputs.

CARB_EFs: This tab contains zero-hour emission factors and deterioration rates from CARB harbor craft inventories.

CARB_Defaults: This tab contains default and average engine characteristics available from CARB reference data for parameters such as engine load factor, useful life, engine rated power, and other parameters needed to estimate emission rates.

Data Sources and Methods

Emission rates are estimated according to CARB methodology and reference data (see Table 1).

Table 1. Reference data sources.

Input Description	Input Source(s)
Tool Tab: CARB_EFs	
Zero-Hour Emission Factors (ROG, CO, NO _x , PM ₁₀ , PM _{2.5}) Deterioration Factors (ROG, CO, NO _x , PM ₁₀ , PM _{2.5}) Fuel Correction Factors (NO _x , PM, ROG) Brake Specific Fuel Consumption	Harbor Craft Emissions Inventory Database ¹ , Crew And Supply Emissions Inventory Database ² , and Barge And Dredge Emissions Inventory Database ³
Tool Tab: CARB_Defaults	
Vessel Useful Life, Load Factor, and Average Annual Hours of Use	Harbor Craft Emissions Inventory Database ¹ , Crew And Supply Emissions Inventory Database ² , and Barge And Dredge Emissions Inventory Database ³
Greenhouse Gas Emission Factors (CO ₂ , CH ₄ , N ₂ O)	CARB Greenhouse Gas Inventory Documentation ⁶
Average Engine Age Average Engine Horsepower	Average Estimates from Harbor Craft Emissions Inventory Database ¹ , Crew And Supply Emissions Inventory Database ² , and Barge And Dredge Emissions Inventory Database ³

⁴ Particulate matter less than ten microns (PM₁₀), particulate matter less than 2.5 microns (PM_{2.5}), oxides of nitrogen (NO_x), reactive organic gases (ROG), carbon monoxide (CO), sulfur dioxide (SO₂)

⁵ Carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and carbon dioxide equivalents (CO₂e)

⁶ Documentation of California's 2000-2015 GHG Inventory: Water-borne : Intrastate : Harbor craft - Distillate, https://www.arb.ca.gov/cc/inventory/doc/doc_index.php

Main engine and auxiliary engine emission rates were developed in the “Calculations” tab as follows:

1. Estimate the deterioration factor (g/bhp-hr) for each engine according to the following equation.

$$DF_i = \frac{ZH_i \times D_i \times CHr}{UL}$$

where:

DF_i = Deterioration factor (g/bhp-hr) for pollutant (i).

ZH_i = Zero-hour emission factor (g/bhp-hr) for pollutant (i)

D_i = Fraction by which the zero hour emission factor increases at the end of the useful life of the equipment for pollutant (i)

CHr = Cumulative hours of operation (hours/engine)⁷

UL = Engine useful life (hours/engine)

2. Estimate the emissions rate in grams per brake horsepower-hour (g/bhp-hr) for each engine according to the following equation.

$$EF_i = (ZH_i + DF_i) \times FCF$$

where:

EF_i = Deteriorated emission factor (g/bhp-hr) for pollutant (i)

FCF = Fuel correction factor (unitless)

3. Estimate the emissions rate in pounds per hour (lb/hr) for each engine according to the following equation.

$$ER_i = EF_i * LF * HP / 453.6$$

where:

ER_i = Emission rate (lb/hr) for pollutant (i)

LF = Engine load factor (unitless)

HP = Engine rated power (horsepower)

453.6 = unit conversion factor (g/lb)

⁷ Consistent with CARB methodology, engine emission rates will be assumed to increase up to the engine useful life and remain constant thereafter.