U.S. Army Corps of Engineers
Charleston District

APPENDIX N

CHARLESTON HARBOR POST 45

CHARLESTON, SOUTH CAROLINA

Air Emission Inventory

03 October 2014

Air Emission Inventory and Assessment for the Charleston Harbor Navigation Improvement Project (Post 45)

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LIST OF ACRONYMS

BREAKBULK - Vessels that carry cargo in bags, boxes, crates, drums, barrels, and pallets.

CHE - Cargo handling equipment are top lifts, jockey trucks, cranes, etc.

COLD IRONING - Providing shore side electrical power to a vessel at berth while its main and auxiliary engines are turned off.

GHGs - Greenhouse gases are gases that trap heat in the atmosphere. Carbon Dioxide is the primary greenhouse gas emitted through human activities.

HAPs - Hazardous air pollutants (HAPs) or air toxics, those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects.

HOTELLING - When a vessel is securely moored or anchored in a port. Main engine is shut down with only auxiliary engines in operation.

NEI - The National Emissions Inventory (NEI) is a comprehensive and detailed estimate of air emissions of both Criteria and Hazardous air pollutants from all air emissions sources. The NEI is prepared every three years by the US EPA based primarily upon emission estimates and emission model inputs provided by State, Local, and Tribal air agencies for sources in their jurisdictions, and supplemented by data developed by the US EPA.

PANAMAX - Vessels that can pass the Panama Canal with the following approximate dimensions: 110 ft wide, 1,050 ft long, and 41.2 ft deep. These vessels can carry about 3000 TEU.

POST PANAMAX - Post Panamax (PPX) vessels that can pass the newly widened and deepened Panama Canal in late 2015 with the following dimensions: 161 ft wide, 1,200 ft long, and 50 ft deep. These vessels can carry up to 18,000 TEU.

PPX3 - Generation 3 Post Panamax vessels

PPX2 - Generation 2 Post Panamax vessels

PPX1 - Generation 1 Post Panamax vessels

RORO - Roll on Roll off vessel. Vessels that are designed to carry wheeled or tracked cargo (cars, tanks, etc.)

SCSPA - South Carolina State Port Authority

TEU - The twenty-foot equivalent unit is a unit of cargo capacity often used to describe the capacity of container vessels.

USACE - US Army Corps of Engineers

US EPA - Environmental Protection Agency

1.0 INTRODUCTION

An emission inventory is an accounting of the amount of pollutants discharged into the atmosphere. An emission inventory usually contains the total emissions for criteria pollutants, Hazardous Air Toxics (HAPs), and one or more specific greenhouse gases, originating from all source categories in a certain geographical area and within a specified time span.

Project Area

Charleston Harbor is located in Charleston, South Carolina, which lies approximately midway along the South Carolina coastline. It is approximately 140 statute miles southwest of the entrance to Cape Fear River, North Carolina and 75 statute miles northeast of the Savannah River. The Port of Charleston (see Figure 1) is a complex junction in the transportation of goods within the US and internationally. The port includes both public and privately-owned terminals and services a wide variety of vessel types and cargoes.

The publicly-owned South Carolina State Ports Authority (SCSPA) provides five modern, deepwater terminals:

- Union Pier,
- Columbus Street,
- Wando Welch,
- Veterans, and
- North Charleston.

Currently, the Wando Welch and North Charleston terminals are primarily used as container facilities. Union Pier, Columbus Street, and Veterans terminals are utilized primarily for Cruise Ships, Breakbulk/Bulk, and Roll-on / Roll-off facility (RORO) vessels.

SCSPA is building a new port facility on the south end of the former Charleston Naval Base in North Charleston (see Figure 1), which may open in 2018. The proposed Navy Base Terminal is designed exclusively for containerized cargo, will encompass approximately 288 acres, and will support cargo marshaling areas, processing areas, and handling facilities.

In addition to the SCSPA terminals, there are 12 privately-owned terminals in the Port of Charleston: Kinder Morgan ALID, Kinder Morgan KM-N, Kinder Morgan KM-1, Kinder Morgan KM-2, ALCO, BP/Amoco, Salmons-Shipyard River, Jacob's Engineering, Maybank, Army TC Dock (above grain terminal), Hess, and Nucor Steel.

Figure 1. Project Map (provided by SCSPA)

Assumptions

Under both the with and without project conditions, the Corps expects the Charleston Harbor SCSPA Terminals to reach build-out capacity in 2037 when the total number of TEUs processed through the terminal reaches 4.2 million. That capacity is the maximum number of containers that could reasonably be processed through the SCSPA Terminals in a year. That determination includes factors such as the size of the terminal, the number of gates that provide access to the property, the number and size of the berths, the number and size of the container cranes, the number of jockey trucks that move the containers within the terminal, how the containers are stacked, and the number of railroads that service the terminal and the frequency of those trains. It is anticipated that without deepening, more vessels will be required to transport the cargo that is expected to move through the port. With deepening, the total number of vessels decreases as vessels will be able to load more efficiently under the improved conditions.

The non-SCSPA or private terminals are expected to reach their build-out capacity in 2031. That build-out capacity for the non-SCSPA or private terminals is again defined as the limit of the total number of goods that can be processed through these terminals.

No increases in cargo are expected to occur as a result of the harbor deepening. As a result, the project would not affect the number of containers that move through the areas that surround the port. The economic benefits of the project would result from the use of larger, more cost-effective container ships, not an increase in the number of containers.

Related Studies

The SCSPA conducted an air emission inventory for all port related activity occurring in calendar year 2005 ((Moffat & Nichol 2008). That study, completed in September 2008, established the Port of Charleston's baseline emissions levels. Additionally, SCSPA has updated the 2005 baseline emission report to calendar year 2011 (Moffat & Nichol 2013). SCSPA's 2005 and 2011 completed air emission studies were used as a foundation for the Corps' Charleston Post 45 air emission inventory.

Charleston Post 45 Feasibility Study – Air Emission Inventory

The Corps has discussed completing an air emission inventory for the Charleston Post 45 port expansion feasibility study with representatives of the US Environmental Protection Agency (EPA) Region 4, SCSPA, and the SC Department of Health and Environmental Control (SC DHEC), Bureau of Air Quality. EPA requested the analysis be expanded to include (1) the emissions from landside equipment that service these vessels, (2) the air toxins and greenhouse gases emitted by both the vessels and the landside equipment, and (3) similar analyses associated with the privately-owned terminals in the harbor.

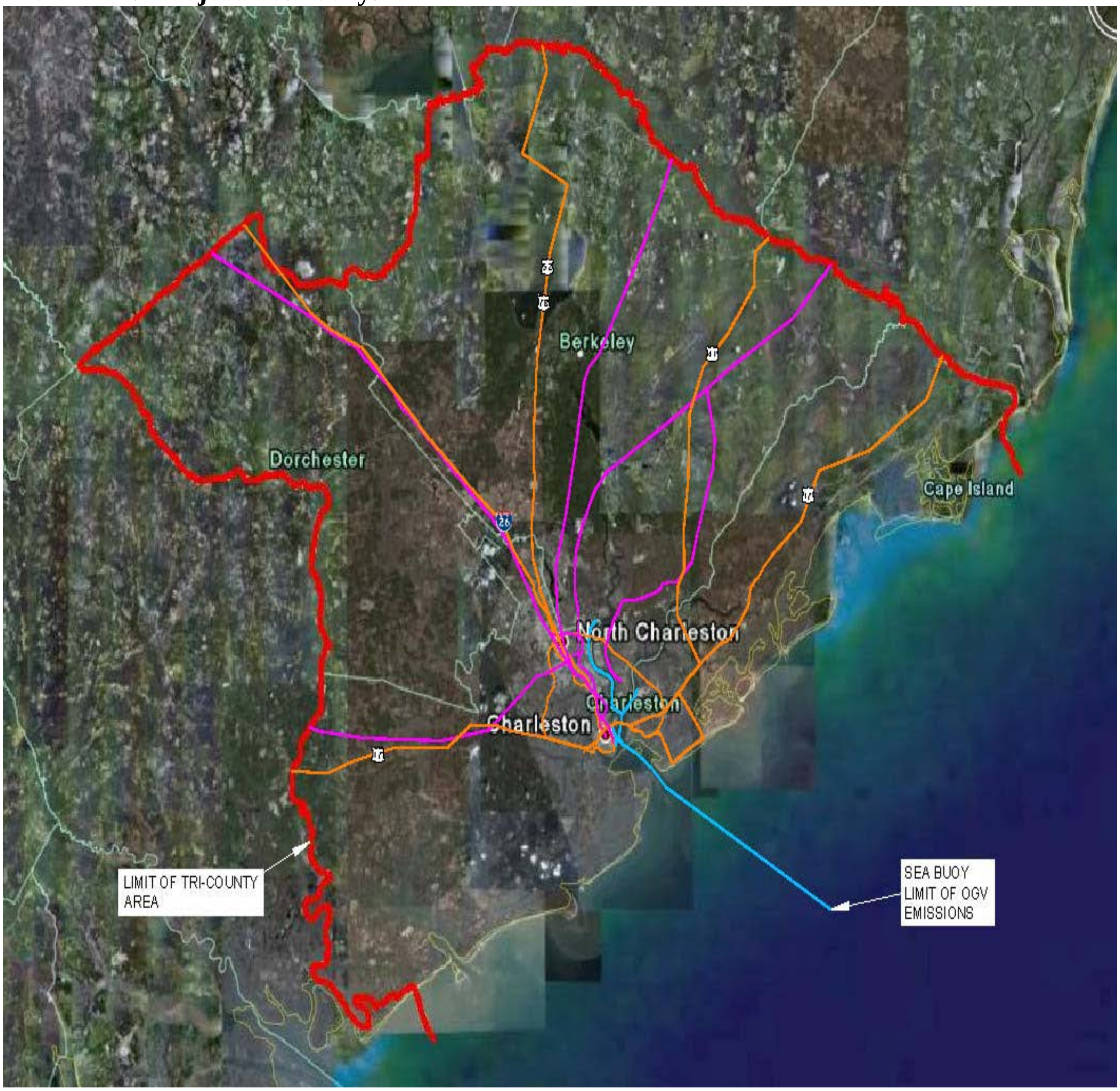
EPA requested a comprehensive air quality assessment of the Charleston Harbor to be able to place any expected increase in emissions resulting from the proposed harbor deepening in its proper context.

In addition to emissions occurring directly on SCSPA property, this inventory also includes emissions from non-SCSPA terminals at the port. This inventory includes private ships, cargo handling equipment (CHE), locomotives, and trucks that occur outside the SCSPA Port terminals but within the Charleston Tri-County area (i.e., Charleston, Berkeley, and Dorchester Counties). Figure 2 shows the boundary of the Tri-County project area. Ship emissions were included from the sea buoy which is located approximately 20 miles from the Charleston harbor entrance to the North Charleston Terminal, which is another 16 miles. The air emission inventories for the Ports of LA/Long Beach, Portland, Puget Sound (Ports of Seattle, Tacoma, and Everett), Savannah, and Houston had similar multi-county project boundaries.

In Chapter 1.5 Definition of Port Boundaries (USEPA 2009), EPA indicates that the landside boundary should be selected to include the first intermodal point and truck or rail distribution centers. The ocean side should generally include from where the pilots boards the ship for entry into the port (i.e., the sea buoy).

Moreover, the project area for the Charleston Harbor Post 45 air emission inventory is the same that was used for SCSPA air emission inventory's dated 2005 and 2011 (Moffatt & Nichol 2008 and 2013).

FIGURE 2. Project Boundary.



2.0 OBJECTIVE

The objective of this Charleston Post 45 air emission inventory is to expand SCSPA's 2005 and 2011 (Moffatt & Nichol 2008 and 2013) air quality analysis to the entire harbor to assess air quality impacts from the proposed harbor deepening. This assessment will evaluate the air emissions (including air toxics and greenhouse gases) from all cargo-carrying vessels and landside cargo handling equipment at the existing five SCSPA terminals and the twelve privately-operated terminals at the port. It will also compare these emissions for both the "With" the proposed deepening alternatives (i.e., -48/47, -48/48/, -50/47, -50/48, -52/47, and -52/48 foot depths) and "Without Project" (No Action) alternatives (i.e., -45 foot depth existing depth) for years 2011, 2022, 2027, 2032, and 2037.

The assessment does not include a detailed dispersion modeling assessment of these emissions or a risk-based assessment of the health effects associated with the proposed project. The primary focus of this analysis is a comparative assessment of the air emissions associated with the operation of the port before and after project implementation, in conjunction with consideration of the current status of air quality in the Charleston project area.

3.0 EXISTING CONDITIONS

Authority.

Section 118 (42 U.S.C. 7418) of the Clean Air Act Amendments (CAAA) of 1990 specifies that each department, agency, and instrumentality of the executive, legislative, and judicial branches of the Federal Government (1) having jurisdiction over any property or facility or (2) engaged in any activity resulting, or which may result, in the discharge of air pollutants, shall be subject to, and comply with, all Federal, State, interstate, and local requirements respecting the control and abatement of air pollution in the same manner, and to the same extent as any non-governmental entity. Section 176(c) (42 U.S.C. 7596(c)) requires that Federal agencies do not (1) engage in, (2) support in any way or provide financial assistance for, (3) license or permit, or (4) approve, any activity which does not conform to a State Implementation Plan (SIP).

Federal Regulatory Requirements.

Under the Clean Air Act of 1970 (42 U.S.C. §7401 et seq.), US EPA sets limits on certain air pollutants, including setting limits on how much can be in the air anywhere in the United States. This helps to ensure basic health and environmental protection from air pollution for all Americans. The Clean Air Act also gives US EPA the authority to limit emissions of air pollutants coming from sources like chemical plants, utilities, and steel mills. Individual states or tribes may have stronger air pollution laws, but they may not have weaker pollution limits than those set by US EPA.

Major amendments were added to the Clean Air Act in 1977 (CAAA 1977). The 1977 Amendments primarily concerned provisions for the Prevention of Significant Deterioration (PSD) of air quality in areas attaining the National Ambient Air Quality Standards (NAAQS). The CAAA 1977 also contained requirements pertaining to sources in non-attainment areas for NAAQS. Areas of the country where air pollution levels persistently exceed the national ambient air quality standards may be designated by US EPA as non-attainment. Both of these CAAA amendments (1970 and 1977) established major permit review requirements to ensure attainment and maintenance of the NAAQS.

Another set of major amendments to the Clean Air Act occurred in 1990 (CAAA 1990). The CAAA 1990 substantially increased the authority and responsibility of the federal government. New regulatory programs were authorized for control of acid deposition (acid rain) and for the issuance of stationary source operating permits. The national emissions standards for hazardous air pollutants (HAPs) were incorporated into a greatly expanded program for controlling toxic air pollutants. The provisions for attainment and maintenance of NAAQS were substantially modified and expanded. Other revisions included provisions regarding stratospheric ozone protection, increased enforcement authority, and expanded research programs.

<u>Toxic air pollutants</u>.

Toxic air pollutants are also known as hazardous air pollutants (HAPs), those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. US EPA is working with state, local, and tribal governments to reduce air toxics releases of 188 pollutants to the environment. Examples of toxic air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries. Examples of other listed air toxics include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds.

The Clean Air Act, which was last amended in 1990, requires US EPA to set National Ambient Air Quality Standards (40 CFR part 50) for six common air pollutants considered harmful to public health and the environment. These commonly found air pollutants (also known as "criteria pollutants") are found all over the United States. They are particle pollution (often referred to as particulate matter or PM), ground-level ozone (O_3), carbon monoxide (CO), sulfur oxides (SOx), nitrogen oxides (NOx), and lead (Pb). These pollutants can harm health and the environment, and cause property damage. Of the six pollutants, particle pollution and ground-level ozone are the most widespread health threats. US EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. The Clean Air Act identifies two types of national ambient air quality standards (NAAQS). *Primary standards* provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. *Secondary standards* provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. Table 3-1, below lists the US EPA’s primary and secondary standards for the six principal criteria pollutants as of October 2011. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air ($\mu g/m^3$).

Table 3-1 US EPA's PRIMARY AND SECONDARY STANDARDS FOR THE SIX PRINCIPLE CRITERIA POLLUTANTS AS OF OCTOBER 2011 (taken from http://www.epa.gov/air/criteria.html).

Pollutant [final rule cite]	Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (76 FR 54294, August 31, 2011)	Primary	8-hour	9 ppm	Not to be exceeded more than once per year
		1-hour	35 ppm	
Lead (75 FR 66964, November 12, 2008)	Primary and Secondary	Rolling 3 month average	0.15 ug/m^3 (1)	Not to be exceeded
Nitrogen Dioxide (75 FR 6474, Feb 9, 2010 and 61 FR 52852, Oct 8, 1996)	Primary	1-hour	100 ppb	98th percentile, averaged over 3 years
	Primary and Secondary	Annual	53 ppb (2)	Annual Mean
Ozone (73 FR 16436, March 27, 2008)	Primary and Secondary	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution (71 FR 61144, Oct 17, 2006) — $PM_{2.5}$	Primary and Secondary	Annual	12 ug/m^3	Annual mean, averaged over 3 years
		24-hour	35 ug/m^3	98th percentile, averaged over 3 years
PM_{10}	Primary and Secondary	24-hour	150 ug/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (75 FR 35520, Jun 22, 2010)	Primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
[38 FR 25678, Sept 14, 1973]	Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

NOTES for Table 3-1, above:

(1) Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

(2) The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

(3) Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

(4) Final rule signed June 2, 2010. The 1971 annual and 24-hour SO_2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved. As indicated in Table 1, above as of October 2011, US EPA's ozone standard is 75 ppb. Prior to the finalization of this table, US EPA had proposed to reduce the national ozone standard to 60 ppb (or less). In September 2011, the administration decided to rescind US EPA's recommendation and keep the 75 ppb standard

State Regulatory Requirements.

States are responsible for developing a State Implementation Plans (SIPs) for the prevention, control and abatement of air pollution according to NAAQS. A SIP is a collection of the regulations, programs and policies that a state will use to clean up polluted areas. The states must involve the public and industries through hearings and opportunities to comment on the development of each state plan. All state regulations referenced herein are part of the federally-approved State Implementation Plan (SIP) for South Carolina and have been submitted to US EPA for approval as part of the SIP.

Title V of the CAAA 1990 requires each state to institute a permit program that assesses fees based on annual air pollutant emissions. The SIP identifies how the State will attain and maintain the primary and secondary National Ambient Air Quality Standards (NAAQS) set forth in Section 109 of the Clean Air Act and 40 CFR 50.4 through 50.12 and which includes federally –enforceable requirements. Each State is required to have a SIP which contains control measures and strategies which demonstrate how each state will attain and maintain the NAAQS. SIP requirements applicable to all areas are provided in Section 110 of the Act. Part D of title I of the Act specifies additional requirements applicable to nonattainment areas, Section 110 and part D describe the elements of a SIP and include, among other things, emission inventories, a monitoring network, an air quality analysis, modeling, attainment demonstrations, enforcement mechanisms, and regulations which have been adopted by the State to attain or maintain NAAQS. EPA has adopted regulatory requirements which spell out the procedures for preparing, adopting and submitting SIPs and SIP revisions that are codified in 40 CFR part 51.

The proposed project is in compliance with Section 176 I of the Clean Air Act, as amended. Air quality in Charleston, Berkeley, and Dorchester Counties, South Carolina is designated as an "attainment area". South Carolina has a State Implementation Plan ("SIP") approved or promulgated under Section 110 of the CAA. However, for the following reasons, a Conformity Determination is not required:

a. Section 93.153 (b) states, "For Federal actions not covered by paragraph (a) of this section, a conformity determination is required for each pollutant where the total of direct and indirect emissions in a non-attainment or maintenance area (emphasis added by the writer) caused by a Federal action would equal or exceed any of the rates in paragraphs (b)(1) or (2) of this section." Since Charleston, Berkeley, and Dorchester Counties, South Carolina have been designated as an attainment area, a Conformity Determination is not required.

b. The direct and indirect emissions from the project fall below the prescribed de minimus levels (58 Fed. Reg. 93.153I(1)) and, therefore, no Conformity Determination would be required. Construction at the project site will take approximately four years, but will not be continuous (i.e., 7 days a week, 24 hours a day). The construction would also occur along the 16 miles of inner harbor and 20 miles of entrance channel, so air emissions would be quite dispersed. Even though the initial emissions may be slightly higher during construction activities, after the project is completed, the direct and indirect emissions should be lower since the project will increase navigational efficiency.

Greenhouse Gas Emissions.

Gases that trap heat in the atmosphere are called greenhouse gases (GHG). The four main GHG identified by US EPA (website at http://epa.gov/climatechange/ghgemissions/gases/co2.html) are:

Carbon dioxide (CO_2) enters the atmosphere through burning fossil fuels (coal, natural gas and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

Methane (CH_4) is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Nitrous oxide (N_2O) is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

Fluorinated gases: Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone depleting substances (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities (US EPA website at http://epa.gov/climatechange/ghgemissions/gases/co2.html). In 2010, CO_2 accounted for about 84% of all U.S. greenhouse gas emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle--both by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere. While CO_2 emissions come from a variety of natural sources, human-related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution.

The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, although certain industrial processes and land-use changes also emit CO_2.

On October 30, 2009, the U.S. Environmental Protection Agency (EPA) published a rule for the mandatory reporting of greenhouse gases (GHG) from large GHG emissions sources in the United States. Implementation of 40 CFR Part 98 is referred to as the Greenhouse Gas Reporting Program (GHGRP).

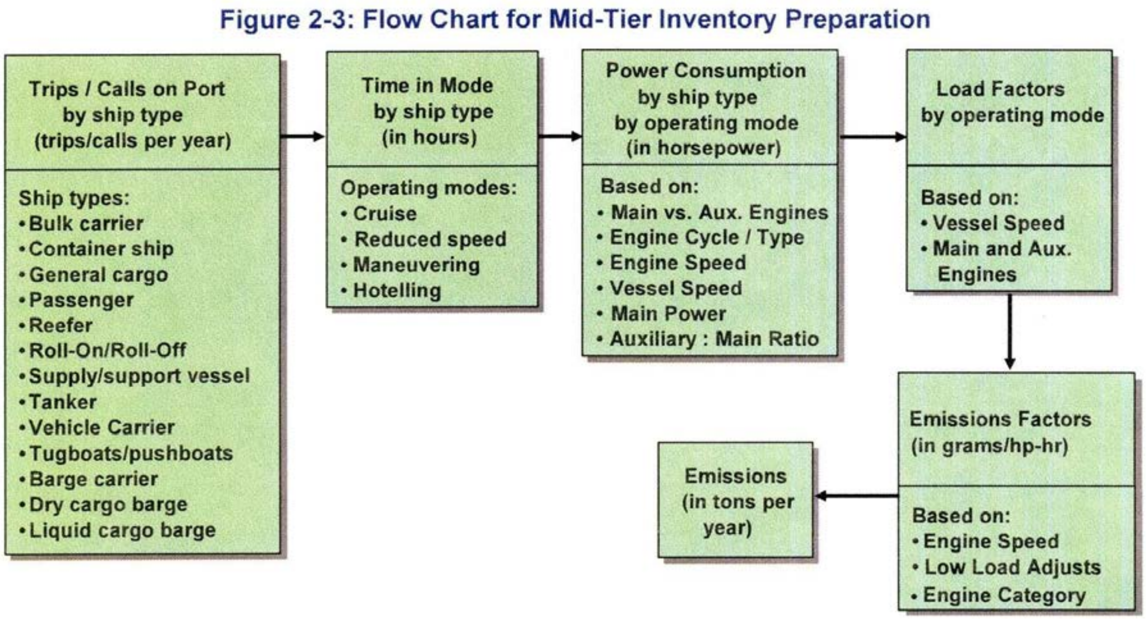
40 CFR part 98 applies to direct greenhouse gas emitters, fossil fuel suppliers, industrial gas suppliers, and facilities that inject CO_2 underground for sequestration or other reasons. In general, the threshold for reporting is 25,000 metric tons or more of carbon dioxide (CO_2) equivalent per year. Most small GHG sources fall below the 25,000 metric ton threshold for CO_2 and are not required to report GHG emissions to EPA (EPA 2009).

Data and emission calculations for all air emission sources at the Charleston Harbor, which includes criteria pollutants, HAPs, and greenhouse gases, are found in Chapter 6.

4.0 METHODOLOGY FOR DETERMINING AIR EMISSIONS

The US Environmental Protection Agency's (EPA's) Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, Final Report, dated April 2009 provided the framework to determine all air emissions at the Port of Charleston. The expanded analysis followed a Mid-Tier approach described as Figure 2-3 in EPA's guidance document (located on page 2-20) and shown in the following flow chart taken from that report:

Figure 3 US EPA Flow Chart for Mid-Tier Air Emission Inventory Preparation (USEPA 2009)



The analysis followed EPA's overall evaluation process. In general, air emissions are calculated by determining the size of the engine, the amount of time the engine is used, the load upon the engine, and the emission rate for that type of pollutant. There are many details which can affect the final calculated value, including age of the engine and the type of fuel that it burns.

Specific Tasks

The first step to develop an air emission inventory using EPA's Mid-Tier approach (in Figure 3) is to estimate the vessel types and calls per year at the port. The Commodity and Fleet Forecasts developed by the Mobile District, USACE, SCSPA, and the Harbor Pilots provided the number and types of vessels calling at the port for the No Action Alternative or baseline depth (i.e., -45 foot depth) and alternative depths (i.e., -48, -50, and -52 foot depths) for the years 2022 to 2037.

Vessels - The CESAM Fleet Forecast (See Appendix C of the final FR/EIS) provided the numbers and types (Post Panamax (Generation III, II, and I), Panamax, and Sub-Panamax) of vessels calling at the port terminals for different depths for the years 2022 to 2037. The air emissions for each different vessel engine size (includes both main and auxiliary engines working under various loads at different times with different fuels) for all depths and years were then calculated using EPA's Mid-Tier Approach (USEPA 2009). Harbor craft (tugs, etc.) and dredging operations (includes both maintenance and deepening work) emissions were also calculated (USEPA 2009).

Land Based Equipment- The air emissions for all land based operations (Cargo Handling Equipment (CHE), trucks going into and out of the terminals, terminal jockey trucks, trains, cranes, top lifts, etc.) using different fuels for all 17 terminals (i.e., 5 SCSPA and 12 private terminals) were also calculated using the formula's and methods discussed in US Environmental

Protection Agency's (EPA's) "**Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, Final Report, dated April 2009.** SCSPA provided equipment data and usage for its land-based operations at Union Pier, Columbus Street, Wando Welch, Veterans/Navy Base, and North Charleston Terminals.

Calculation of Hazardous Air Toxics (HAPs) - Once all vessel and land-based emissions for the 17 terminals at the Port of Charleston were calculated for all depths and years, then the Corps calculated the amount of air toxics emitted for these depths and years. Air Toxics are generally determined as a ratio of criteria pollutants (i.e., PM10 or VOC, etc) discharged. The Corps obtained information from the EPA's National Inventory Model (NMIM) Source Classification Code (SCC) "SCC Toxics" database table provided by EPA, Region 5 concerning the ratios of specific air toxics to other physical parameters. These ratios are displayed in the spreadsheet in Attachment A (available upon request).

Calculation of Greenhouse Gases (GHGs) - According to EPA (2009), "*While the majority of greenhouse gas emissions from ships are CO2, additional GHG emissions include methane (CH4) and nitrous oxide (N2O). Emission factors for various engine types listed in Table 2-13 (found in EPA 2009) are taken from the IVL 2004 update.42 To estimate CO2 equivalents, CH4 emissions should be multiplied by 21 and N2O emissions should be multiplied by 310*". Chapter 7 and the spreadsheet in Attachment A show the estimated GHGs emissions for Charleston Post 45 project.

Private Terminals - This expanded air emission assessment builds upon SCSPA's 2005 and 2011 (Moffatt & Nichol 2008 and 2013) Port Emission Inventory. Information was also obtained on vessels which call at the non-SCSPA or private terminals from the USACE, Charleston District. That information consisted of the number and type of vessels which call at each of the private terminals in the harbor. Details were obtained for the landside equipment associated with cargoes moving through the non-SCSPA terminals. Those details include not only the number and type of equipment, but also the specific model number, its engine size, fuel type, age, and annual use rate. The analysis used detailed information when it was accessible, but more general information when detailed data was not available. That approach follows the EPA Best Practices guidance.

All detailed air emission calculations are found in the spreadsheet in Attachment A.

5.0 BASELINE AND ESTIMATED FLEET FORECAST FOR THE PORT OF CHARLESTON

The SC State Ports Authority (Moffatt & Nichol 2013), USACE Charleston District, and USACE, Mobile District developed the following Tables 5-1 and 5-2, which serves as the baseline for the emission inventory and assessment. The information within these tables was developed by interviewing the SCSPA, harbor pilots and reviewing their traffic logs.

TABLE 5-1 2011 BASELINE EXISTING 45-FOOT DEPTH SCSPA TERMINALS

	Container	Breakbulk/Bulk/RORO	Cruise Ship	Total
Vessel #'s	1,288	290	88	1,666

Table 5-2 2011 BASELINE EXISTING 45-FOOT DEPTH NON-SCSPA TERMINALS

	Tankers	Breakbulk/Bulk	RORO	Total
Vessel #'s	159	42	35	236

Currently at the Port of Charleston, the existing navigation channel has an authorized depth of -45 feet. For this air emission analysis, the Corps used 2011 as the baseline. The Corps then looked at the following seven (7) alternatives: -45/45 or No Action Alternative, 48/47, 48/48, 50/47, 50/48, 52/47, and 52/48, where the first number represents the authorized depth of Segments 1 and 2 (inner harbor areas) and the second number represents the reach between the New Navy Base Terminal and the North Charleston Terminal). Detailed descriptions of the alternatives are provided in the Feasibility Report and Environmental Impact Statement. For this analysis, the Corps assumed that the project would be deepened to these depths from 2019 to 2022, the modifications to the Panama Canal may be completed in late 2015, and that the end of the 50-year project life was 2072. At 2037, the capacity of the port would be reached. This means that between 2037 and 2072, no increase in emissions and no additional growth occur in commodities or annual vessel numbers. No additional vessels could load/off-load at the port each year between 2037 and 2072. Table 5-3 below shows the Corps' estimated fleet forecast for all years (i.e., 2022 to 2037) and at various depths (i.e., -45/45 or No Action Alternative, 48/47, 48/48, 50/47, 50/48, 52/47, and 52/48).

Table 5-3 Summary of Container Vessel Calls for SCSPA Terminals at the Port of Charleston (for all years and all depths)

DEPTH ALTERNATIVES	PPX3	PPX2	PPX1	Panamax	Sub Panamax	TOTAL VESSELS
45/45	480	1,564	1,734	4,826	876	9,480
48/47	471	1,539	1,707	4,107	871	8,695
48/48	480	1,564	1,650	4,221	876	8,791
50/47	471	1,534	1,702	4,018	871	8,596
50/48	480	1,564	1,635	4,132	876	8,687
52/47	471	1,533	1,697	3,984	871	8,556
52/48	480	1,564	1,627	4,104	876	8,651

Notes: PPX3, PPX2, and PPX1 are defined as Post Panamax Generation 3, 2, and 1, respectively. The No-Action Alternative is the existing -45/45 foot depth.

Note: The forecasted number of vessels and the associated emissions do not consistently decrease progressively (i.e., depth alternatives 48/47, 50/47, and 532/47) from top to bottom through the tables and illustrations. This is due to the fact that the range of alternatives forecasted includes multiple depths for two separate sets of segments. For example, an apparent inconsistency exists where the depths for Segments 1 and 2 transition from 48 feet to 50 feet at the same time the depth for Segment 3 transitions from 48 feet to 47 feet. The increase in the total number of vessels at that (and similar) transitions occurs where the forecasted impact of decreasing the depth of Segment 3 exceeds the impact of increasing the depths of Segments 1 and 2.

Table 5-4 below shows the estimated number of General Cargo (Breakbulk, RORO, bulk, and tanker) vessels arriving at the 12 non-SCSPA (private) terminals in the Port of Charleston for all depths (i.e., -45 (Baseline), -48, -50, and -52 foot) and all years:

Table 5-4 Summary of Vessel Calls for non-SCSPA (Private) Terminals at the Port of Charleston

	2022	2027	2031	2072
Tanker	208	237	262	262
RORO	309	352	390	390
Breakbulk/bulk	190	215	238	238
Cruise Ship	104	104	104	104
TOTAL	811	908	994	994

Notes: All vessels arriving at the non-SCSPA or private terminals were estimated with one exception. SCSPA provided the numbers of Cruise Ships arriving at the Union Pier terminal. However, the number of Cruise Ships arriving at Union Pier Terminal (which is owned and operated by SCSPA) is not included in CESAM's Fleet Forecast and will not change due to the proposed deepening of the harbor. The number of vessels arriving at these non-SCSPA or private terminals also will not change over time or over depth. Lastly, the vessel calls for the non-SCSPA terminals reach capacity in 2031. Thus, there is no additional increase in air emissions or vessel numbers from 2031 to 2072 for the non-SCSPA terminals.

The vessel numbers and types taken from the Fleet Forecast (see Appendix C of the final IFR/EIS) found within the above tables (Tables 5-1, 5-2, 5-3, and 5-4) were used through-out this emission inventory.

6.0 CALCULATIONS OF EMISSIONS THE PORT OF CHARLESTON IN 2011

This report summarizes the analyses that the Corps performed. The intent is for the report to (1) summarize the information that was obtained and used in the analyses, and (2) provide sufficient information to understand the analyses that were conducted. Section 6 provides a detailed description of how the Corps calculated the air emissions for the Port of Charleston in 2011 or the baseline year. The same air emission calculations for years 2022, 2027, 2032, and 2037 were completed and the results are found within Section 7.0 and the spreadsheet in Attachment A.

6.01 2011 Harbor Fleet

Detailed information was collected on the fleet of deep-draft vessels which call at the Port of Charleston. SCSPA and USACE, Charleston District reviewed the logs of the Harbor Pilots for various years through 2011 and used it to generate this information. This information was then used in both the economic and air quality evaluations.

For this air quality evaluation, the Corps took the SCSPA and Harbor Pilots information and calculated the number and types of vessels that call at the different terminals. This information is summarized in Table 6-1, below.

Table 6-1 2011 Vessel Calls by Type and Location

Vessels	Total Harbor	Wando Welch	Columbus Street	North Charleston	Veterans	Union Pier	Non-SCSPA Terminals
Container	1288	890	6	392	NA	NA	NA
Bulk/Breakbulk/RORO	367	NA	225	2	28	35	77
Tanker	159	NA	NA	NA	NA	NA	159
Cruise	88	NA	NA	NA	NA	88	NA
Total	1,902	890	231	394	28	123	236

NOTE: A small number of other vessels called at Charleston in 2011. They were excluded from the analysis due to their small number and unpredictability of their calls.

6.02 Transit Time

The Harbor Pilots provided the Corps with information on the time it takes to move vessels in the harbor. The Pilots separated the typical transit into time spent in three different modes of operations: Reduced Speed (9-12 knots), Maneuvering (5-8 knots), and Docking. The Corps used this information to calculate average transit times to the various terminals.

The Pilots stated that generally the transit times for Bulk, Breakbulk and RO/RO vessels were the same since they have similar engine size and handling characteristics. Table 6-2 summarizes the typical transit times:

Table 6-2 2011 Transit time by Vessel Type (Minutes)

	Reduced Speed Zone (9 to 12 knots)	Maneuvering (5 to 8 knots)	Docking
Tanker	**90**	**44**	**30**
Container	**90**	**60**	**30**
Bulk/Breakbulk/RO/RO	**90**	**56**	**30**
Cruise Ship	**90**	**25**	**30**

The durations reflect the time the Harbor Pilots spent on the vessels. This covers the time when they meet the vessel at the sea buoy to the dock.

6.03 Container Vessels at SC State Ports Authority (SCSPA) Terminals

Using the information above, one can begin to calculate air emissions from various sources within the harbor. The first category to be discussed is the Panamax Container vessels that call at the SCSPA terminals. In general, the Corps followed the methodology described in EPA's 2009 Best Practices Report.

In summary, air emissions are calculated by determining the size of the engine (in kW or kilowatts), the amount of time the engine is used, the load upon the engine, and the emission rate for that type of pollutant. This procedure is shown below:

EMISSIONS PER TRANSIT	=	ENGINE KW	X	LOAD FACTOR	X	TRAVEL TIME	X	EMISSION RATE

For the first type of information needed – **"Engine kW"** – the Corps started with information described earlier on the fleet of vessels that call at Charleston. Using that information, EPA's 2009 Best Practices Report can be consulted to obtain information on the typical sizes for the propulsion and auxiliary engines. The information in Table 6-3 was obtained from that EPA report:

Table 6-3 Engine Size by Vessel Type

VESSEL TYPE	MAIN PROPULSION ENGINE kW	TOTAL AUXILIARY ENGINE kW
Bulk	8,000	1,776
Container	30,900	6,800
Cruise	39,600	11,000
RO/RO	11,000	2,850
Tanker	9,400	1,985

All vessels in Table 6-3 emissions were calculated using the same formula mentioned above. In order to reduce duplication only the steps in calculating emissions for Panamax Container vessels is shown in more detail below.

For Panamax Container vessels, the following Engine kW values in Table 6-4 were used:

Table 6-4 Panamax Container Engine Values

VESSEL TYPE	MAIN PROPULSION ENGINE kW	TOTAL AUXILIARY ENGINE kW
Panamax Container	30,900	6,800

The next type of information needed is the **"Load Factor"**. The load factor accounts for how hard the engine is working at that time. Therefore, the emission calculations use the durations for the various modes of operation that were discussed earlier in this document. An additional category was used called "Hotelling" to capture the emissions that occur while a vessel is docked and loading or unloading cargo.

The load factors vary by the size of the Container vessel being considered. This required separate calculations to be performed for three sizes of containerships that call at the port: Post-Panamax, Panamax, and Sub-Panamax. This load factor values which were used were taken from EPA's Best Practices Report dated 2009.

The main engine load factors are found in Table 6-5:

Table 6-5 Main Engine Load Factors

	Panamax
Reduced Speed Zone	12%
Maneuvering	3%
Slow / Dead Slow	3%
Docking	3%
Hotelling	0%

Different load factors in Table 6-6 are used for the auxiliary engines on these vessels.

Table 6-6 Auxiliary Engine Load Factors

	Auxiliary Engines
Reduced Speed Zone	25%
Maneuvering	50%
Slow / Dead Slow	50%
Docking	50%
Hotelling	17%

The third type of information needed is called the **"Travel Time"** shown in Table 6-7. The travel time for Container vessels arriving at the Wando Welch Terminal were taken from discussions with the harbor pilots and are shown below. **Note: This is provided as an example. The travel time to the other terminals in the Port of Charleston is different than Wando Welch and are found in the spreadsheets in Attachment A.**

Table 6-7 Travel Time for Wando Welch Terminal

MODE	LOCATION	TIME (Hours)
Full Maneuvering (Reduced Speed Zone)	Pilots' Station (Charlie) to Buoy 22	1.5
Slow / Dead Slow	Buoy 22 to Custom House Reach	0.41
Full Maneuvering (Reduced Speed Zone)	Custom House Reach to Wando Welch	0.33
Docking (Maneuvering)	Dock	0.5
Hotelling (average time)	Dock	10

The fourth type of information needed is called the **"Emission Rate"**. An emission rate is the rate at which a particular pollutant is discharged by a given engine. The emission rates used in this analysis for vessel engines were taken from EPA's Best Practices Report dated 2009. For main propulsion engines, we selected emission rates for Slow Speed Diesel engines using Marine Residual Oil (RO) fuel. The Charleston Harbor Pilots stated that all Ocean Going Vessels calling at the port use Residual Oil (RO) fuel. For the Auxiliary Engines, we also used the emission rates for engines using RO fuel.

Those selected emission rates found in Table 2-9: Emission Factors for OGV Main Engines, g/kWh (USEPA 2009) on page 2-14 and Table 2-16, Auxiliary Engine Emission Factors, g/kWh (USEPA 2009) on page 2-19. The emissions are nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), particulate matter 10 and 2.5 microns (PM10 and PM2.5), sulfur dioxide (SO2), and carbon dioxide (CO_2). Table 6-8 provides this information.

Table 6-8 Engine Emission Factors for RO Fuel (Grams/kW-Hour)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Main Propulsion Engine	18	1.4	0.6	1.42	1.31	10.29	620.62
Auxiliary Engines	14.7	1.1	0.4	1.44	1.32	11.98	722.54

Using those emission rates and information described previously for the other three required inputs (Engine power (kW), Load Factor, and Travel Time), one can calculate the emissions for individual Panamax Vessels arriving at the Port of Charleston.

To allow separation of air emissions while vessels are docked (hotelling), separate calculations were performed for inbound transits, Hotelling, and Outbound transits for each individual Panamax Vessel arriving at the port.

The results from these calculations for each individual Panamax Vessel for Inbound transits, Hotelling, and Outbound transits are shown in the Tables 6-9 and 6-13:

Table 6-9 Main Engine Emissions In-Bound Transits (Tons Per Transit)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Panamax	0.1887	0.0236	0.0132	0.0174	0.0153	0.1066	6.3607

Table 6-10 Auxiliary Engine Emissions (Tons Per Transit)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Panamax	0.1084	0.0081	0.003	0.0106	0.0097	0.0884	5.3299

Since EPA Region IV expressed concerns about emissions from Containerships while they are docked, separate calculations for emissions that occur from the auxiliary engines during that period were performed. This allows one to evaluate the potential value of cold-ironing of Container vessels in this harbor. Those calculations are summarized in Table 6-11 as follows:

Table 6-11 Hotelling Emissions, Auxiliary Engine Emissions Only (Tons Per Vessel)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Panamax	0.2302	0.0172	0.0063	0.0225	0.0207	0.1876	11.3132

The total emissions from Container vessels in the Port of Charleston in transit and docked were calculated and are summarized in Table 6-12:

Table 6-12 Total Emissions of Container Vessels, includes Hotelling (Tons per vessel)*

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Panamax	0.8244	0.0806	0.0385	0.0787	0.0707	0.5775	34.6946

*The formula was: Inbound plus outbound emissions plus hotelling equals total emissions per vessel per call.

These emissions were multiplied by the number of Container vessels that call at the port. The number of vessels was obtained from forecasts generated for the Economic Analysis. For 2011, 1,288 Container vessels called at Charleston, resulting in 2,576 transits (inbound, hotelling, and outbound) through the harbor. All of these vessels called at the SCSPA Columbus Street, North Charleston, and Wando Welch Terminals.

Using those 2011 vessel numbers, the air emissions of the Panamax Containerships that call at the Columbus Street, North Charleston, and Wando Welch Terminals over their entire vessel transit (In-bound, Hotelling, Out-bound for Main and Auxiliary Engines) were calculated. The results are shown in Table 6-13:

Table 6-13 Summary of Panamax Container Vessel Emissions Calling at Charleston for 2011 at the -45 foot depth (Total Tons)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
TOTAL	1248.79	141.42	84.26	152.16	136.71	1171.92	66,543.76

Additional container emission calculations are located in the SCSPA tab in the spreadsheet in Attachment A.

6.04 Tugs

Tugs are used to assist each vessel that moves through the harbor, with the exception of Cruise Ships arriving/departing at the SCSPA Union Pier terminal. According to Moran Towing and McAllister Towing (as well as the Harbor Pilots), Cruise Ships use their bow thrusters to dock and undock. Tugs are used to dock/undock all other vessels. On October 23, 2012, representatives from SCSPA and the Corps obtained information and discussed usage with the two companies that own and operate tugs in the Port of Charleston. Both Moran Towing and McAlister Towing own tugs with the following characteristics shown in Table 6-14:

Table 6-14 Tug Characteristics

	Main Engine (HP)	# of Auxiliary Engines	Auxiliary Engine (kW)
Moran Towing			
1	5,100	2	65
1	2,500	2	75
1	6,140	2	99
McAlister Towing			
1	5,140	2	99
1	4,000	2	99
2	3,000	2	99

The horsepower rating for each tug for both main and auxiliary engines were converted to kW. Additionally, the tugs owned and operated by Moran and McAlister Towing averaged the following hours in 2011 and load factors as indicated in Table 6-15:

Table 6-15 Average Hours of Operation in 2011

# of Tugs	Average Hours/Year	ME kW	Load Factor	# of Aux Engines	kW of Aux	Load Factor
1	3,600	4,578.67	0.85	2	99	0.56
1	3,173	3,840.35	0.85	2	99	0.56
1	3,100	3,803.13	0.85	2	65	0.56
1	2,733	2,982.80	0.85	2	99	0.56
2*	2,204	2,237.10	0.85	2	99	0.56
1	2,500	1,864.28	0.85	2	75	0.56

* Total hours used for two tugs.

During the discussion with the tug owners, Moran and McAlister indicated that all seven tugs have Category 2 marine engines, their main engines displacement is 11.6 liters per cylinder, and the age of their engines are Tier 2, 2004 to 2007. In 2011, all seven tugs use ULSD fuel or 15 ppm sulfur fuel. Additionally, all tugs are "cold ironed" at their respective docks.

Both Moran and McAlister stated that it takes 2 tugs to dock and undock vessels. On average, the time required to dock a vessel is about 1.5 hours (includes 1 hour warm up of main and auxiliary engines), undocking is about 0.5 hours.

The Corps used the average hours of operation found in Table 6-15, above. The USEPA formula that was used to calculate tug emissions for all eight tugs is found on page 3-12 in Section 3.7 entitled Emission Determination (USEPA Guidelines dated April 2009). This emission formula included both main and auxiliary engines, load factors, activity use (hours), and the criteria pollutant factor. The formula is described in Section 6.03.

The fuel emission factors were taken from Table 3-8 (page 3-10) USEPA Current Methodologies in Preparing Mobile Source Port Related Emission Inventories, Final Report, April 2009. The emission factors were also fuel corrected for ULSD (15 ppm sulfur) Table 3-9 (page 3-10) in USEPA 2009. Table 6-16 shows the emission factors used for all seven tugs:

Table 6-16 Tug Emission factors

Pollutant	Tug Main Engine Emission Factor (g/kW-hr)	Tug Auxiliary Engine Emission Factor (g/kW-hr)
NOx	9.80	9.80
CO	1.10	1.10
VOC	0.50	0.50
PM_{10}	0.62	0.62
$PM_{2.5}$	0.60	0.60
SO_2	0.01	0.01
CO_2	690.00	690.00

On average it takes about 1 hour for each tug to "warm up" and 30 minutes for two tugs to dock/undock each vessel at the port. In 2011 there were 1288 panamax container vessels that docked/undocked. The load factors were taken from Table 3-3 (USEPA 2009), and reflected in calculated emissions found in Table 6-17. **Note: McAlister Towing owns two tugs with identical main engine rating of 2237.10 kW. Within Table 6-17, the emissions for these tugs were doubled.**

Table 6-17 Docking/Undocking Emissions for all seven tugs at the Port of Charleston (2011)

Main Engine (kW)	Total NO_x Emissions (ton)	Total CO Emissions (ton)	Total HC Emissions (ton)	Total PM10 Emissions (ton)	Total PM2.5 Emissions (ton)	Total SO2 Emissions (ton)	Total CO2 Emissions (ton)
4,578.67	0.1535	0.0172	0.0078	0.0097	0.0094	0.0001	10.8083
3,840.35	0.1138	0.0128	0.0058	0.0072	0.0070	0.0001	8.0117
3,803.13	0.1095	0.0123	0.0056	0.0069	0.0067	0.0001	7.7079
2,982.80	0.0765	0.0086	0.0039	0.0048	0.0047	0.0001	5.3856
2,237.10	0.0466	0.0052	0.0024	0.0029	0.0029	0.0000	3.2806
1,864.28	0.0439	0.0049	0.0022	0.0028	0.0027	0.0000	3.0930
Total	0.5438	0.0610	0.0276	0.0344	0.0333	0.0004	38.2871

Additional tug emission calculations are located in the Tugs tab in the spreadsheet in Attachment A.

6.05 Other Deep-Draft Vessel Types

The distribution of vessel calls in 2011 by type is summarized in Table 6-18 as follows:

Table 6-18 2011 Vessel Calls at the Port of Charleston

	Total Harbor
Container	1,288
Bulk/ Breakbulk/ RO/RO	332
RORO	35
Tanker	159
Cruise Ships	88
Total	1,902

Those totals do not include some vessels which called at the port in 2011 because they appeared to be infrequent calls (one call per vessel type in that year) or were barges. Although Container vessels dominate the Charleston Harbor fleet (1,288 of 1,902 vessels in 2011), numerous other types of vessels also call at the port. Those include Bulk, Breakbulk, Tanker, and RO/RO vessels. The Corps performed separate calculations of emissions from those vessels because they generally have different engine configurations than Container vessels. The emission calculation process followed the same procedure as stated for containerships:

EMISSIONS PER TRANSIT = ENGINE HORSEPOWER X LOAD FACTOR X TRAVEL TIME X EMISSION RATE

Typical engine power (kW) for the various types of vessels was taken from Table 2-4 on page 2-7 of EPA's 2009 Best Practices Report and is shown in Table 6-19 below:

Table 6-19 Total Engine Power (Taken from EPA's 2009 Best Practices Report)

VESSEL TYPE	Main PROPULSION ENGINE (kW)	AUXILIARY ENGINE (kW)	AUXILIARY ENGINE (#)	TOTAL AUXILIARY POWER (kW)
Bulk*	8,000	612	2.9	1,775
Container	30,900	1,889	3.6	6,800
Cruise	39,600	2,340	4.7	10,998
General Cargo	9,300	612	2.9	1,775
RORO	11,000	983	2.9	2,851
Reefer	9,600	975	4	3,900
Tanker	9,400	735	2.7	1,985

* Since EPA's description of Bulk and Breakbulk vessels are so similar and information could not be readily found for emissions from main engines of Breakbulk vessels, the Corps used the emission rates for Bulk vessels. Since the engine size and emissions are different for the Main Propulsion Engine and Auxiliary Engines, the Corps performed separate calculations for both of those engine types.

The Load Factor for main propulsion engines OGV were obtained from the Table 2-15 on page 2-18 of the USEPA 2009 report and are shown in Table 6-20.

Table 6-20   Main Engine Load Factors (Taken From USEPA 2009)

Emissions	RSZ (12% Low Load Factor)	MANEUVERING (3% Low Load Factor)	DOCKING (3% Low Load Factor)	HOTELLING (Main Engine Shut Down)
NOx	1.14	2.92	2.92	0.00
CO	1.64	6.46	6.46	0.00
HC	1.76	11.68	11.68	0.00
PM10	1.24	4.33	4.33	0.00
PM2.5	1.20	4.20	4.20	0.00
SO2	1.18	2.49	2.49	0.00
CO2	1.17	2.44	2.44	0.00

Load Factors for auxiliary engines were obtained from EPA's 2009 Best Practices Report (page 2-12) and shown in Table 6-21.

Table 6-21 Auxiliary Engine Load Factors

Ship Type	Cruise	RSZ	Maneuver	Hotel
Auto Carrier	0.15	0.3	0.45	0.26
Bulk Carrier *	0.17	0.27	0.45	0.1
Container Ship	0.13	0.25	0.48	0.19
Cruise Ship	0.8	0.8	0.8	0.64
General Cargo	0.17	0.27	0.45	0.22
Miscellaneous	0.17	0.27	0.45	0.22
OG Tug	0.17	0.27	0.45	0.22
RORO	0.15	0.3	0.45	0.26
Reefer	0.2	0.34	0.67	0.32
Tanker	0.24	0.28	0.33	0.26

* Since EPA's description of Bulk and Breakbulk vessels are so similar and information could not be readily found for emissions from main engines of Breakbulk vessels, we used the emission rates for Bulk vessels.

Travel time was based on information provided by SCSPA from discussions with the Harbor Pilots. Differences in time between the vessel types are primarily the result of the different destinations (docking location). That information is summarized in Table 6-22:

Table 6-22 Travel Time (minutes)

VESSEL TYPE	REDUCED SPEED ZONE	MANEUVERING	DOCKING
Container	90	60	30
Bulk	90	56	30
Breakbulk	90	48	30
Tanker	90	44	30
RO/RO	90	30	30

The emission rates were obtained from the USEPA 2009 report. Those rates are shown in Table 6-23:

Table 6-23 Emission Rates (g/kW-hr)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Main Propulsion Engine	18.00	1.40	0.60	1.42	1.31	10.29	620.62
Auxiliary Engines	14.70	1.10	0.40	1.44	1.32	11.98	722.54

Combining this information, one can calculate the emissions per transit for each of the vessel types (including Tugs). The results of those calculations are in Table 6-24:

Table 6-24 2011 Total Emissions for all Vessels Calling at both SCSPA and non-SCSPA Terminals in the Port of Charleston.

Vessels	Total NOx Emissions (ton/call	Total CO Emissions (ton/call	Total HC Emissions (ton/call	Total PM10 Emissions (ton/call	Total PM2.5 Emissions (ton/call	Total SO2 Emissions (ton/call	Total CO2 Emissions (ton/call
Container (1,288)	1,248.79	141.42	84.26	152.16	136.71	1,171.92	66,543.76
Tanker (159)	45.74	5.00	2.69	5.74	5.13	45.55	2,535.33
RORO (35)	13.37	1.38	0.72	1.62	1.45	12.95	728.33
Breakbulk / Bulk (332)	57.03	6.85	3.93	7.62	6.78	59.74	3,263.09
Cruise Ship (88)	239.50	20.82	9.15	25.49	23.16	208.36	12,225.12
TOTAL (1,902)	1,604.42	175.47	100.75	192.64	173.24	1,498.52	85,295.64

Additional vessel emission calculations are located in the SCSPA and non-SCSPA tabs in the spreadsheet in Attachment A.

6.06 Maintenance Dredging of the Existing -45 foot depth channels

Dredges commonly operate in the harbor to maintain suitable depths for deep-draft vessels in both the navigation channel and the berths. The Corps of Engineers maintains the navigation channel, while the berth owners are responsible for maintaining depths at the berths. The berth maintenance operations are of a smaller scale than those to maintain the navigation channel. The berth owners may use a crane with a clamshell bucket, a tug dragging apparatus to perform agitation dredging, or a small dredge. This analysis includes only emissions from the Corps dredges because those operations use larger equipment and are conducted for longer periods of time than are the berth maintenance operations. Therefore, they are expected to result in more air emissions than those used to maintain the berths.

The Corps reviewed its records of recent dredging contracts to obtain information on the dredging it conducted. The most recent dredging records (2011) were used to identify the typical dredge and supporting equipment for the inner harbor dredging. This information is shown in Table 6-25:

Table 6-25 Equipment Used for the Harbor Channel Dredging 2011

	Engine Size (Horsepower)	Yearly Use	Hours of Use
Pipeline Dredge & Support	1,700.00	0.47	3,045.60
Clamshell Dredge & Support	5,000.00	0.25	1,620.00
Hopper Dredge	8,000.00	0.13	810.00

The Corps assumed that one Tug Tender Boat was used to support the operations for both the pipeline and clamshell dredge. Based on the 2003 Port of Houston report, we assumed that support boat had a 1,100 HP engine. We also assumed it operated for 18 hours per day.

The Corps selected an average dredge engine Load Factor of 75 percent. This value was averaged from two sources reported in the Port of Houston's 2003 report titled "Improvement to the Commercial Marine Vessel Inventory in the Vicinity of Houston, Texas". Engine Load factors for dredge tug tender were averaged from values obtained from EPA's Best Practices Report for an Assist Tugboat and a Dredge Tender. Because the District's data showed information on the amount of time that a booster pump was used, we used a 100 percent Load Factor over that entire duration.

Emission rates for NOx, VOC and CO were taken from 2003 Port of Houston report for the dredge, tug support, and booster pump engines. These rates were higher for those parameters than values contained in EPA's 2009 Best Practices report. Emission rates for other parameters (HC, PM10 and SO2), some of which were not reported for Houston, were taken from that EPA report. Information on engine load factors was obtained from EPA's Best Practices Report.

The hours of use with the engine size, load factor and the emission rates were used to produce emission totals by pollutant type for the four different types of equipment. The calculations followed a variation of the standard procedure:

EMISSIONS FROM EACH EQUIPMENT TYPE = ENGINE HORSEPOWER X LOAD FACTOR X TIME OF USE X EMISSION RATE

The Hopper Dredge emission rate was taken from the Port of New York/New Jersey Marine Vessel Emission Inventory dated April 2003. At that time, the green house gas CO_2 was not provided for the hopper dredge emission rate. The summary of those calculations is provided in Table 6-26:

Table 6-26 Summary Table for 2011 Maintenance Dredging Emissions (Ton/year)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Pipeline Dredge	124.48	23.94	2.59	2.87	2.79	6.03	6,607.26
Hopper Dredge	30.60	5.68	0.23	0.73	0.66	8.98	NA
Clamshell Dredge	90.88	17.48	1.89	2.10	2.03	4.40	4,823.82
TOTAL	245.97	47.10	4.70	5.70	5.49	19.42	11,431.08

Additional maintenance dredging emission calculations are located in the dredging tab in the spreadsheet in Attachment A.

6.07 Landside Equipment at Non-*SCSPA* (Private) Terminals

The Corps analyzed emissions from equipment used on the land to load and unload cargoes at the non-SCSPA terminals in the harbor. Detailed information was not readily available for the equipment used at the various private terminals. The Corps reviewed the air inventories that had been prepared for other harbors to identify a harbor which most reflected the types of vessels and cargoes which are handled at the Port of Charleston. The ports of Seattle and Tacoma were identified as being most similar to Charleston. In 2002, the total tonnage handled by the ports is shown in Table 6-27:

Table 6-27 2002 Total Tonnage

Seattle	19.6 million
Tacoma	20.6 million
Charleston	19.0 million

As in Charleston, both Seattle and Tacoma possess container, bulk, breakbulk, RO/RO, and tanker terminals.

The Corps utilized information on these two ports from the April 2007 report titled “Puget Sound Maritime Air Emissions Inventory”. That report describes air emissions from various sources, including landside equipment, for several terminals in Puget Sound. The number of vessel movements by vessel type was obtained for the two Puget Sound ports, as was the emission quantity by source (Cargo Handling Equipment (CHE), fleet vehicles, etc) and pollutant.

The Corps calculated an average emission rate per vessel for each pollutant type for each port. Those values were blended to produce an average emission rate per vessel for each pollutant type for use at the Port of Charleston. For CO and SO2, emission rates closer to those from the Port of Seattle because 30 percent of the vessels calling at the Port of Tacoma are auto carriers or

RO/RO. Such vessels make only limited calls at Charleston, so the values from Seattle should be more representative of the fleet in Charleston.

Using the Puget Sound report, the following information summarizes the emissions from the two ports for three categories of air emission sources -- Cargo Handling Equipment (CHE), Heavy Duty Vehicles, and Fleet Vehicles. These types of equipment load, unload, and move cargoes at a terminal (Table 6-28).

Table 6-28 Summary of Landside Emissions (2005 Data)

	NOx	VOC	CO	SO2	PM10	PM2.5	CO2
	-------------------------------- Tons per Year --------------------------------------						
Seattle	718	78	806	71	40	38	66,553
Tacoma	638	45	277	8	35	34	66,899
	----------------------------- Pounds per Vessel ---------------------------------						
Seattle	612.6	66.6	687.7	60.6	34.1	32.4	56,786
Tacoma	609.7	43	264.7	7.6	33.4	32.5	63,926
Blended Average	611.1	54.8	581	50	33.8	32.5	60,356

To use this information, one must then know the number of vessels that call at Charleston. That information was presented previously, but is repeated here in Table 6-29:

Table 6-29 2011 Vessel Calls by Type and Location

Vessels	Total Harbor	SCSPA Terminals	Non-SCSPA Terminals
Container	1288	1288	NA
Bulk/ Breakbulk/ RORO	332	290	42
Tanker	159	NA	159
RO/RO	35		35
Cruise Ships	88	88	NA
Total	1902	1666	236

The table shows that there were 236 vessels that called at non-SCSPA terminals in 2011. Using those vessels numbers and the emission rates, one can quantify the 2011 air emissions by pollutant source from the landside equipment used at non-SCPA terminals in Charleston. Again, that equipment is comprised of Cargo Handling Equipment, Heavy Duty Vehicles, and Fleet Vehicles. The summary of those calculations is provided in Table 6-30:

Table 6-30 NON-SCSPA 2011 LANDSIDE EQUIPMENT

ESTIMATED	Total NOx Emissions (ton/year)	Total CO Emissions (ton/year)	Total HC Emissions (ton/year)	Total PM10 Emissions (ton/year)	Total PM2.5 Emissions (ton/year)	Total SO2 Emissions (ton/year)	Total CO2 Emissions (ton/year)
	72.11	68.56	6.43	3.99	3.93	5.9	7,122.02

6.08 Landside Equipment at SCSPA Terminals

A detailed analysis of SCSPA's CHE and their emissions are found in the SCSPA (2013). The following information is taken from SCSPA (2011).

Cargo handling equipment emissions were calculated for equipment exceeding 25 hp using EPA's NONROAD 2008 emissions model and the equipment list and 2011 operating hours provided by SCSPA. A summary of the equipment list and operating hours is provided in Table 6-31 below. Emissions calculations were performed for each piece of equipment. Fuel types included diesel and liquid propane gas (LPG).

Table 6-31 Summary of SCSPA Cargo Handling Equipment (taken from Table 4-1 CHE Summary by terminal, SCSPA 2013)

Equipment Type	Number	Avg hp	Avg hrs	Total hrs	Avg Model Year	Avg Age
Columbus Street Terminal						
Container Handler, Full	6	271	72	433	1997	14
Crane, RTG	3	558	148	443	1999	12
Backhoe/Tractor	6	90	258	1,550	1997	14
Forklift	48	112	176	8,426	1998	13
North Charleston Terminal						
Container Handler, Full	24	293	1,069	25,653	1999	12
Crane, RTG	10	558	1,852	18,522	1996	15
Container Handler, Empty	5	231	1,497	7,486	2004	7
Forklift	20	89	637	12,737	1997	14
Assumed Avg Hostler	19	164	2,800	53,508	2009	3
Union Pier Terminal						
Forklift	19	76	312	5,924	1999	12
Wando Welch Terminal						
Container Handler, Full	18	279	2,026	36,467	1998	13
Crane, RTG	30	535	1,254	37,628	2004	7
Container Handler, Empty	12	218	1,544	18,528	2001	10
Forklift	35	101	305	10,679	1993	18
Assumed Avg Hostler	9	173	2,800	24,730	2011	0
Veterans Terminal						
Backhoe/Tractor	1	262	604	604	1994	17
Forklift	8	130	410	3,279	1994	17

Source: SCSPA data

The NONROAD model runs were accomplished through the use of detailed spreadsheets using the EPA NONROAD 2008 model input files and various lookup functions to:

- Assign the proper Tier for an engine based on its model year and engine size (hp).
- Assign the proper brake specific fuel consumption and zero hour emission factors based on the engines' SCC, horsepower range and Tier. These emission factors have the transient adjustment factors built into them based on the SCC to take into account the transient nature of various engine applications.
- Assign the proper NONROAD load factor based on the SCC.
- Calculate the proper deterioration factor based on assumed hours on the engine (age multiplied by NONROAD's median annual hours for that SCC), the median life hours at full load for that SCC and the appropriate shape factor. Deterioration factors account for the fact that engines generally emit more as they get older up to a certain point, at which time it is assumed the engine is rebuilt with fresh rings, etc.
- Calculate SO2 emission factors based on the brake specific fuel consumption and assumed fuel sulfur content as given by NONROAD depending on the year of analysis. Note that all CHE at the Port of Charleston is fueled by ultra-low sulfur (15 ppm) diesel fuel so the NONROAD inputs were revised to reflect this.
- Adjust the PM emission factors based on the variance between the sulfur content in the fuel and the assumed sulfur content upon which the NONROAD emission factor is based.

The end result is a calculation of emissions for each piece of equipment. The general equation for the emissions calculation is:

Emissions = (Installed hp) x (Annual hours of operation) x (Load factor) x (Adjusted emission factor)

The above emissions equation is applied for each individual pollutant included in the inventory. The calculated SCSPA CHE emissions are summarized in Section 6.09.

6.081 Trucks Calling at SCSPA Terminals

A detailed analysis of SCSPA's Heavy Duty Vehicles and their emissions are found in the SCSPA (2013). The following information is taken from SCSPA (2011).

Emissions were calculated for a total of nearly 1.7 million truck trips and forty-three million vehicle miles including the number of truck trips associated with the movement of containerized cargo as well as the reported number of Breakbulk truck trips at each terminal. Truck and rail trips associated with RO/RO cargo that were not included in the reported breakbulk truck trips are not included in this inventory. The containerized cargo truck trips are by far the dominant component of truck trips and truck emissions, representing over 98% of the estimated vehicle miles traveled. Given the relative throughput volumes of container to ro-ro cargo, excluding ro-ro truck and rail trips is not expected to have a significant impact on total emissions estimates.

The number of truck trips for 2011 was provided by SCSPA for each terminal, as shown in Table 6-32.

6-32 Count of Truck Visits by terminal

Terminal	Number of Truck Visits
Columbus Street	202
North Charleston	317,524
Wando Welch	511,779
Union Pier	0
Veterans	4,145

The number of each type of truck trip was calculated for each terminal based on the 2011 throughput at each terminal. The appropriate distances were applied for each truck trip type at each terminal. The results indicate that 1.659 million truck trips generated slightly under 43 million vehicle miles traveled.

Emission rates for over the road trucks were developed using EPA's MOVES 2010b modeling software. They were calculated in pounds per mile for diesel fuel combination short-haul trucks and are based on selected road types. Emission factors for trucks vary widely by model year. MOVES 2010b provides a default distribution of model years based on the year of analysis. The default model year distribution was used since no better data were available. For 2011, the vehicle model years ranged from 1981 to 2011.

The calculated SCSPA Truck emissions are summarized in Section 6.09.

6.082 Locomotives

A detailed analysis of SCSPA's Locomotives and their emissions are found in the SCSPA (2013). The following information is taken from SCSPA (2011).

Locomotive hours for both switcher and line-haul locomotives associated with work at the Port of Charleston terminals were included in this analysis. Line-haul locomotives move freight long distances and switcher locomotives move rail cars around a rail yard. Locomotive hours and engine information for switchers operating at the Port's terminals were provided to the SCSPA by SCPR. Line haul locomotive hours were estimated for the percentage of containerized port cargo or other project cargo that entered or left the Port through the nearby NS or CSX intermodal rail yards. Line haul locomotive activity was developed based on the number of trains of a given length needed to accommodate the estimated rail cargo throughput. Line haul emissions are split between off-terminal operations and on-terminal operations.

Line haul emissions are based on the estimated number of trains per year, assumed average rail speed and distance to the Tri-County boundary. None of the locomotive activities (idling, switching or cargo handling) within the local NS or CSX intermodal terminals were included in this inventory. Switcher locomotive horsepower is based on the engine information provided to the SCSPA by the SCPR. Line haul locomotive characteristics are based on typical line-haul locomotives currently in use by NS and CSX to move freight into/out of their local Charleston intermodal yards.

Locomotive emission factors are based on a detailed analysis of the 1998 Locomotive Emission Standards Regulatory Support Document in combination with the updated emission factors included in the EPA Fact Sheet “Emission Factors for Locomotives,” published in April 2009. The procedure for determining load factors for locomotives is different from that used for other sources. The current practice in the literature is to calculate a load factor for each of ten engine settings (dynamic braking, idling, and eight notch positions). Composite load factors are developed based on a percentage of time in each notch for typical switching and line haul activity. All SCPR switcher engines and NS or CSX line-haul engines operating at their local yards or at the Port’s terminals in 2011 used ultra-low sulfur diesel.

The calculated SCSPA Locomotive emissions are summarized in Section 6.09.

6.09 Summary of 2011 Baseline Emissions for the Port of Charleston

Summary results for the 2011 emissions inventory are presented in this section. The 2011 baseline emission (Table 6-33) include the following: SCSPA terminals, non-SCSPA (private) terminals, tugs, land based emissions (CHE, Trucks, Locomotives, etc), and maintenance dredging of the harbor. The emission inventory includes criteria pollutants and greenhouse gases (CO2). Both air toxics and additional greenhouse gases are discussed in the following sections.

Table 6-33 2011 Baseline Emissions for the Port of Charleston (ton/year)

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
OCEAN GOING VESSELS	1,604.42	175.47	100.75	192.64	173.24	1,498.52	85,295.64
TUGS	223.24	26.28	22.66	29.65	18.97	0.16	25,783.69
LAND BASED OPERATIONS (CHE, Trucks, Rail, etc.)	769.47	265.93	40.32	35.61	34.49	6.74	7,122.02
MAINTENANCE DREDGING	245.97	47.10	4.70	5.70	5.49	19.42	11,431.08
TOTALS	2,843.11	514.77	168.43	263.60	232.19	1,524.84	129,632.43

6.10 Air Toxics (HAPs)

In addition to the criteria pollutants that are traditionally evaluated when one discusses air emissions, there are also numerous other compounds which are emitted. Some of those are classified as “air toxics” or hazardous air pollutants (HAPs).

Air Toxics are generally determined as a ratio of pollutants discharged. The emission rates are a proportion of other parameters such as VOC, PM10, gallons or miles. The Corps obtained information from the NMIM "SCC Toxics" database table provided by EPA, Region 5 concerning the ratios of specific air toxics to other physical parameters. These ratios are displayed in Tables 6-34, below.

The 28 toxics which have been identified in the highest quantity in emission inventories prepared for other ports -- and their relationship to other calculated pollutants -- are shown in Tables 6-34, below.

The Corps calculated emissions of air toxics at the Port of Charleston (includes all 17 terminals, land based operations, dredging, OGVs, etc.) for the 28 air toxics in the 2011 base year by quantity. The following formula was used to covert HC to VOC, VOC = 1.005 HC. The total VOC’s (tons/year) was 169.27 and PM10 (tons/year) was 263.60 (see Table 6-33). All of these air toxic quantities are shown below in Table 6-34.

Table 6-34 Summary of Air Toxic Emissions for the Port of Charleston – 2011

	AIR TOXIC		AIR TOXIC RATIOS TAKEN FROM NMIM "SCC TOXICS" DATABASE"	AIR TOXICS For Port In 2011 (TONS / YEAR)
1	Ethyl Benzene	VOC	0.0031001	0.5248
2	Styrene	VOC	0.00059448	0.1006
3	1,3-Butadiene	VOC	0.0018616	0.3151
4	Acrolein	VOC	0.00303165	0.5132
5	Toluene	VOC	0.014967	2.5334
6	Hexane	VOC	0.0015913	0.2694
7	Anthracene	PM10	0.00000043	0.0001
8	Propionaldehyde	VOC	0.0118	1.9974
9	Pyrene	PM10	0.0000029	0.0008
10	Xylene	VOC	0.010582	1.7912
11	Benzo(g,h,i)perylene	PM10	0.00000019	0.0001
12	Indeno(1,2,3,c,d)pyrene	PM10	0.000000079	0
13	Benzo(b)fluoranthene	PM10	0.00000049	0.0001
14	Fluoranthene	PM10	0.000017	0.0045
15	Benzo(k)fluoranthene	PM10	0.00000035	0.0001
16	Acenaphthylene	PM10	0.000084	0.0223
17	Chrysene	PM10	0.0000019	0.0005
18	Formaldehyde	VOC	0.118155	20
19	Benzo(a)pyrene	PM10	0.00000035	0.0001
20	Dibenzo(a,h)anthracene	PM10	2.90E-09	0
21	2,2,4-Trimethylpentane	VOC	0.00066	0.1117
22	Benz(a)anthracene	PM10	0.00000071	0.0002
23	Benzene	VOC	0.020344	3.4436
24	Acetaldehyde	VOC	0.05308	8.9848
25	Acenaphthene	PM10	0.0001	0.0265
26	Phenanthrene	PM10	0.00026	0.0689
27	Fluorene	PM10	0.0001	0.0265
28	Naphthalene	PM10	0.00046	0.1219

6.11 Greenhouse Gases (GHGs)

Green house gases are discussed within the US Environmental Protection Agency, Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, Final Report, April 2009. The following information was taken from this document (USEPA 2009):

Carbon dioxide (CO2), the primary greenhouse gas associated with combustion of diesel (and other fossil fuels), accounted for about 96 percent of the transportation sector's global warming potential-weighted GHG emissions for 2003. Methane (CH4) and nitrous oxide (N2O) together account for about 2 percent of the transportation total GHG emissions in 2003. Both of these gases are released during diesel fuel consumption (although in much smaller quantities than CO2) and are also affected by vehicle emissions control technologies.

In addition to the GHGs, another climate forcing pollutant of concern is elemental carbon.

On Page 2-16 of EPA 2009, the following information is found for marine diesel engines in OGVs: To estimate CO2 equivalents, CH4 emissions should be multiplied by 21 and N2O emissions should be multiplied by 310. Therefore, to estimate CH4 and N20, CO2 should be divided by 21 and 310, respectively. Since C02 =CH4 X 21 and CO2=N20 X 310. **CH4=CO2 / 21 and N20 = CO2 / 310.**

On Page 3-11 of EPA 2009, the following information is found for diesel commercial marine vessels: In addition to the greenhouse gas emission factors discussed above, it is possible to estimate elemental carbon emission factors from EPA's SPECIATE4 model for emissions of PM2.5. For diesel harbor craft, the diesel commercial marine vessel (SCC 2280002000) sector is appropriate. That sector is assigned an emission fraction of 77.12% elemental carbon. That is: EFEC = 77.12% x 97% x EFPM10 after adjusting the PM10 emission factor for fuel sulfur. **Elemental Carbon equals .7712 X 0.97 X PM10 implies that Carbon = 0.7712 * 0.97 * PM10**

The Corps estimated the GHGs for all marine diesel vessels within the 17 terminals in the Port of Charleston for all depths. Marine diesel vessels include OGVs, tugs, pipeline and hopper dredges, etc. Table 6-35 provides this GHGs information.

Table 6-35 Estimated Greenhouse Gases for all Vessels in 2011 (tons/year) for -45 foot depth

Year	# of Vessels	CO_2	N_20	CH_4	Carbon
2011	1902	122,510.41	395.19	5,833.83	170.55

7.0 AIR EMISSIONS CALCULATED FOR THE PROPOSED DEEPENING ALTERNATIVES AND ANALYSIS

The objective of this Air Inventory and Assessment was to thoroughly evaluate the air impacts expected from the proposed harbor deepening. Additional sources were included that provided a better understanding of the air emissions resulting from normal operations within the port. A total of 10 sources of emissions were evaluated in this inventory, shown in Table 7-1.

Table 7-1 Sources of Emissions Within the Port of Charleston

Container Vessels	**SCSPA Cargo Handling Equipment**	**Maintenance Dredging**
Non-Container Vessels	**Landside Equipment at Non-SCSPA Terminals**	**Dredging During Deepening**
Tugs	**SCSPA Fleet Vehicles**	**Locomotives**
Trucks		

The inventory identified the air emissions from those various sources. The calculated 2011 Port of Charleston emission tonnages was shown in the previous section 6.0. The various contributions from the different air emission sources for years 2022, 2027, 2032, and 2037 are discussed in the remainder of this section and the detailed calculations are found in the enclosed spreadsheets in Attachment A. Within this section, the USACE refers frequently to the spreadsheet found in Attachment A, particularly the tabs found along the bottom of the spreadsheet. Each tab represents a particular emission calculation for the inventory.

Also keep in mind the following project scenario: The proposed deepening of the harbor may start in 2019 and be completed in 2022. The CESAM fleet forecast starts in 2022 and ends in 2037. In 2037, the Port reaches capacity with 4.2 million TEUs and from 2037 to the end of the 50-year project life in 2072 **no increase in vessels numbers are projected**. The Port reaching its cargo capacity in 2037 also means that the **air emissions remain constant (or do not increase) from 2037 to 2072**. CESAC has estimated that the private (non-SCSPA) vessels arriving at the private terminals reaches capacity in 2031, which means from 2031 to 2072 the air emissions for the private vessels remain constant. Lastly the private vessel numbers are the same for any depth alternative because they are not dependent on the proposed harbor deepening. Only the larger container vessels (Post Panamax Generations 1, 2, and 3) would benefit from the proposed harbor deepening.

The forecasted number of vessels with their associated emissions does not consistently increase progressively through the tables and figures. This is due to the fact that the range of alternatives forecasted includes multiple depths for two separate sets of segments. For example, an apparent inconsistency exists where the depths for Segments 1 and 2 transition from 48 feet to 50 feet at the same time the depth for Segment 3 transitions from 48 feet to 47 feet. The increase in the total number of vessels at that (and similar) transitions occurs where the forecasted impact of decreasing the depth of Segment 3 exceeds the impact of increasing the depths of Segments 1 and 2.

Also looking at the air emission tables in this section, the year 2022 emissions for all depth alternatives (i.e., -48/47, -48/48/, -50/47, -50/48, -52/47, and -52/48 foot) some of the criteria pollutants are slightly higher than the existing -45/45 foot depth or No Action Alternative <u>because the final year of deepening is 2022 and these deepening emissions are added to all depth alternatives</u>. Since the No-Action Alternative (-45/45 depth) does not contain any dredging emissions for deepening of the harbor, <u>the emissions are slightly lower than all of the depth alternatives</u>. However, the No Action Alternative does include the yearly O&M maintenance dredging emissions.

Emissions calculated for the Port of Charleston within this inventory are very conservative since not all emissions are generated within the various port terminals or within the City of Charleston. The calculated and estimated emissions in this inventory extend from the entrance channel (including a three mile long extension) to the North Charleston Terminal on the Cooper River, a total distance of about 36 miles. The extended/deepened entrance channel is about 20 miles long. From the entrance to the harbor to the North Charleston Terminal, the lower and upper harbor channels are approximately 16 miles in length. The majority of the deepening emissions for the entrance channel as well as transient emissions for vessels arriving and/or departing the harbor would occur offshore (some beyond the 3 mile territorial waters of the United States) and are not likely to contribute to air pollution in Charleston Harbor and/or the project area.

Future emissions at the Port of Charleston would also be improved by further reducing diesel fuel consumption by either technology or operational use, resulting in improved air quality. The new Post Panamax Generation 3 vessels (i.e., Triple E MAERSK), would have a capacity of 18,000 TEUs but because of their more efficient engines and slower cruising speeds would emit 50% less CO2 per container. The main innovations in the Triple E are two ‘ultra-long stroke’ engines, an innovative efficient shape and advanced waste heat recovery system saving up to 10% of main engine power. Since the Triple E would cruise at a slower speed (average about 16 to 19 knots), which means that the slower the ship sails, the less fuel it burns.

New technology such as electric rubber tired gantry (RTGs) cranes, upgrading diesel RTG engines from older Tier 0 and Tier 1 to newer Tier 4, retrofitting switch locomotives with automatic stop/start units to decrease idling, use of alternative fuels such as Biofuels, Natural Gas, or Propane would further reduce future air emissions at the Port of Charleston. EPA could also promulgate new regulatory requirements further reducing criteria pollutant emissions within the port. For example: EPA has reduced Sulfur content in OGV fuel from 2.7% (27,000 ppm) in 2011 to 0.10% (1,000 ppm) in 2015. Figures 7-1 and 7-2 graphically depicts and Table 7-2 shows the significant reduction in Sulfur (SO2) emissions, PM10, and PM2.5 emissions from 2011 to 2022. Further reductions in NOx emissions for OGV in years 2016, 2022, 2027, and 2037 are subject to the regulatory requirements pursuant to Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL Annex VI).

Air Emissions at SCSPA’s Terminals

The seven (7) alternatives for the project are: The Project Without (No-Action or the existing -45/45 depth) and the With Project Deepening Alternatives (-48/47 depth, -48/48 depth, -50/47 depth, -50/48 depth, -52/47 depth, and -52/48 depth). The existing depth of the Port of

Charleston is 45 feet. The No-Action or Project Without Alternative is the -45/45 depth. That means that over the life of the project (2022 to 2072), the No-Action Alternative **does not** deepen the harbor. The 2014 CESAM Fleet Forecast (Attachment A) estimated that more vessels will be required to handle the cargo for the No-Action Alternative (-45 foot depth) than any other alternative. The No-Action Alternative would be considered the worst case scenario in terms of the greatest amount of air emissions (i.e., criteria pollutants, HAPs, and GHGs) generated in the project area. Figures 7-1, 7-2, 7-3, 7-5, 7-8, and 7-10 graphically depicts the No-Action or existing -45/45 depth alternative. In comparison to the No-Action Alternative, Figure 7-4 shows the estimated air emissions for the NED plan (-50/48 depth) in 2037. Figure 7-4a shows the estimated air emissions for the Locally Preferred Plan (LPP) alternative, which is -52/48 foot depth.

On several occasions USEPA Region IV requested the Corps to calculate the air emissions at each SCSPA terminal in order to determine the impact to the adjacent neighborhoods. Table 7-2 shows the estimated air emissions for the No-Action Alternative (-45/45 foot depth). A large portion of these estimated emissions at each terminal are mainly from hotelling vessels. The emissions in Table 7-2 also include any land based equipment (CHE, trucks, trains, etc.) used to load/unload and transport the cargo at each terminal. Figures 7-5, 7-6, and 7-7 graphically shows all of the emissions (in tons/year) for all terminals for the No-Action (45/45), NED plan 50/48, and the LPP 52/48 foot depth alternatives.

Additionally Figures 7-8, 7-9,7-9a, and 7-10 graphically shows the percent of the criteria pollutants (i.e., NOx, CO, HC, PM10, PM2.5, and SO2 in the total port emissions for No Action Alternative (-45/45) in 2011 and 2037, the NED plan (-50/48) in 2037 and the LPP alternative -52/48 in 2037. Table 7-2 shows the summary of all terminal emissions for the NO-ACTION or the -45 foot depth alternative for 2011, 2022, 2027, 2032, and 2037.

Additionally Table 7-2a shows the summary of all terminal emissions for the NED plan or the 50/48 foot depth alternative for years 2022, 2027, 2032, and 2037. Table 7-2b shows the summary of all terminal emissions for the LPP or the -52/48 foot depth alternative. Comparing Tables 7-2, 7-2a, and 7-2b, it is apparent that the No-Action (-45/45 depth) emissions (in tons/year) are significantly greater than the NED (-50/48 foot depth) emissions and the LPP (-52/48 foot depth) emissions for all criteria pollutants and greenhouse gases (CO2). What this means is that if the Port of Charleston is not deepened (or remains at the existing -45 foot depth), the overall terminal emissions would be significantly greater than if the port is deepened to -50/48 or the -52/48 foot depth. Therefore both the NED plan (-50/48 foot depth) or the LPP plan (-52/48 foot depth) would not adversely impact air quality in the Port of Charleston and adjacent areas.

The following sections go into greater detail on how the USACE reached these conclusions that the Charleston Post 45 NED Plan (-50/48 foot depth) and the LPP plan (-52/48 foot depth) would have significantly less emissions (i.e., criteria pollutants, HAPs, and GHGs) within the project area than the existing NO-ACTION (existing -45/45 foot depth) alternative. Additionally, reviewing air emission data from nearby industrial sources (Table 7-7) and from the 2011 USEPA NEI (Table 7-5), the overall air emissions from the Charleston Harbor is minor in comparison to these sources.

Table 7-2 Summary of all Terminal Emissions for the No-Action Alternative (-45 foot depth).

Alternatives	Years	Terminals	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Baseline 45 ft	2011	North Charleston	406.90	133.85	20.23	24.10	22.75	90.70	12,222.37
Baseline 45 ft	2011	Navy/Veterans	166.39	96.45	12.36	9.44	9.01	16.24	7,742.03
Baseline 45 ft	2011	Columbus Street and Union Pier	171.77	30.44	6.78	15.62	14.46	108.44	6,536.85
Baseline 45 ft	2011	Wando Welch	739.24	207.72	33.90	44.47	41.99	173.38	17,191.31
No Action 45 ft	2022	North Charleston	551.10	200.40	30.42	22.84	21.98	13.78	18,257.68
No Action 45 ft	2022	Navy/Veterans	463.13	171.40	28.75	17.07	16.31	20.35	29,492.77
No Action 45 ft	2022	Columbus Street and Union Pier	72.52	9.65	3.36	1.59	1.51	3.39	5,574.44
No Action 45 ft	2022	Wando Welch	969.03	307.36	50.21	39.83	38.43	18.26	24,922.67
No Action 45 ft	2027	North Charleston	611.79	232.13	35.71	26.57	25.56	16.66	22,354.14
No Action 45 ft	2027	Navy/Veterans	469.40	199.97	34.20	20.13	19.23	24.63	35,936.81
No Action 45 ft	2027	Columbus Street and Union Pier	73.00	9.77	3.38	1.61	1.53	3.39	5,574.44
No Action 45 ft	2027	Wando Welch	1,061.24	354.51	58.30	46.01	44.39	21.68	29,798.82
No Action 45 ft	2032	North Charleston	667.60	263.14	40.74	30.18	29.03	19.27	26,000.59
No Action 45 ft	2032	Navy/Veterans	496.91	233.48	41.45	23.99	22.91	30.79	45,484.57
No Action 45 ft	2032	Columbus Street and Union Pier	39.62	9.88	3.40	1.63	1.55	3.39	5,574.44
No Action 45 ft	2032	Wando Welch	1,158.27	402.11	66.55	52.26	50.41	25.28	34,963.44
No Action 45 ft	2037	North Charleston	730.55	278.83	44.22	32.86	31.61	20.44	27,839.92
No Action 45 ft	2037	Navy/Veterans	514.67	239.35	42.66	24.91	23.79	30.80	45,484.57
No Action 45 ft	2037	Columbus Street and Union Pier	40.09	10.00	3.42	1.65	1.57	3.39	5,574.44
No Action 45 ft	2037	Wando Welch	1,279.01	434.10	73.15	57.53	55.49	27.33	38,137.71

Table 7-2a. Summary of all Terminal Emissions for the NED Plan or -50/48 foot depth.

ALTERNATIVE	YEAR	TERMINALS	NOx	CO	HC	PM10	PM2.5	SO2	CO2
50/48	2022	North Charleston	546.70	199.84	30.21	22.75	21.90	13.56	17,903.92
	2027	North Charleston	605.64	231.01	35.30	26.39	25.39	16.24	21,650.30
	2032	North Charleston	661.68	261.66	40.20	29.94	28.81	18.71	25,070.37
	2037	North Charleston	723.75	277.13	43.60	32.58	31.34	19.79	26,770.18
	2022	Navy/Veterans	458.40	170.80	28.53	16.97	16.22	20.12	29,112.31
	2027	Navy/Veterans	458.65	198.01	33.49	19.81	18.93	23.88	34,706.96
	2032	Navy/Veterans	461.56	224.63	38.23	22.55	21.54	27.41	39,928.00
	2037	Navy/Veterans	501.66	236.09	41.48	24.38	23.29	29.56	43,438.83
	2022	Columbus Street and Union Pier	72.52	9.65	3.36	1.59	1.51	3.39	5,574.44
	2027	Columbus Street and Union Pier	52.42	9.77	3.38	1.61	1.53	3.39	5,574.44
	2032	Columbus Street and Union Pier	39.62	9.88	3.40	1.63	1.55	3.39	5,574.44
	2037	Columbus Street and Union Pier	40.09	10.00	3.42	1.65	1.57	3.39	5,574.44
	2022	Wando Welch	961.46	306.40	49.86	39.67	38.28	17.89	24,313.78
	2027	Wando Welch	1,055.22	353.41	57.90	45.83	44.22	21.27	29,110.96
	2032	Wando Welch	1,153.04	400.80	66.07	52.04	50.21	24.78	34,141.62
	2037	Wando Welch	1,271.91	432.32	72.50	57.24	55.22	26.65	37,022.30

Table 7-2b. Summary of all Terminal Emissions for the LPP Plan or -52/48 foot depth.

ALTERNATIVE	YEAR	TERMINALS	NOx	CO	HC	PM10	PM2.5	SO2	CO2
52/48	2022	North Charleston	546.43	199.81	30.20	22.75	21.89	13.55	17,882.22
	2027	North Charleston	605.64	231.01	35.30	26.39	25.39	16.24	21,650.30
	2032	North Charleston	661.89	261.71	40.22	29.95	28.81	18.73	25,102.70
	2037	North Charleston	723.47	277.06	43.58	32.57	31.33	19.77	26,727.03
	2022	Navy/Veterans	458.62	170.83	28.54	16.97	16.22	20.13	29,129.73
	2027	Navy/Veterans	457.89	197.88	33.44	19.78	18.91	23.83	34,620.33
	2032	Navy/Veterans	460.90	224.47	38.17	22.52	21.52	27.35	39,824.07
	2037	Navy/Veterans	500.56	235.81	41.38	24.33	23.24	29.45	43,265.57
	2022	Columbus Street and Union Pier	72.52	9.65	3.36	1.59	1.51	3.39	5,574.44
	2027	Columbus Street and Union Pier	52.42	9.77	3.38	1.61	1.53	3.39	5,574.44
	2032	Columbus Street and Union Pier	39.62	9.88	3.40	1.63	1.55	3.39	5,574.44
	2037	Columbus Street and Union Pier	40.09	10.00	3.42	1.65	1.57	3.39	5,574.44
	2022	Wando Welch	961.06	306.34	49.84	39.67	38.28	17.87	24,281.33
	2027	Wando Welch	1,054.94	353.36	57.88	45.82	44.21	21.25	29,078.52
	2032	Wando Welch	1,152.70	400.71	66.04	52.03	50.19	24.75	34,087.34
	2037	Wando Welch	1,271.57	432.24	72.47	57.22	55.20	26.62	36,968.04

Figure 7-1. Which Shows all 2011 Air Emissions at the Existing -45/45 foot Depth (all units tons/year). Note that the SO2 emissions for OGV are almost as great as NOx. Fuel is RO with 2.7% (27,000 ppm) Sulfur and 18.10 gm/kW-hr NOx.

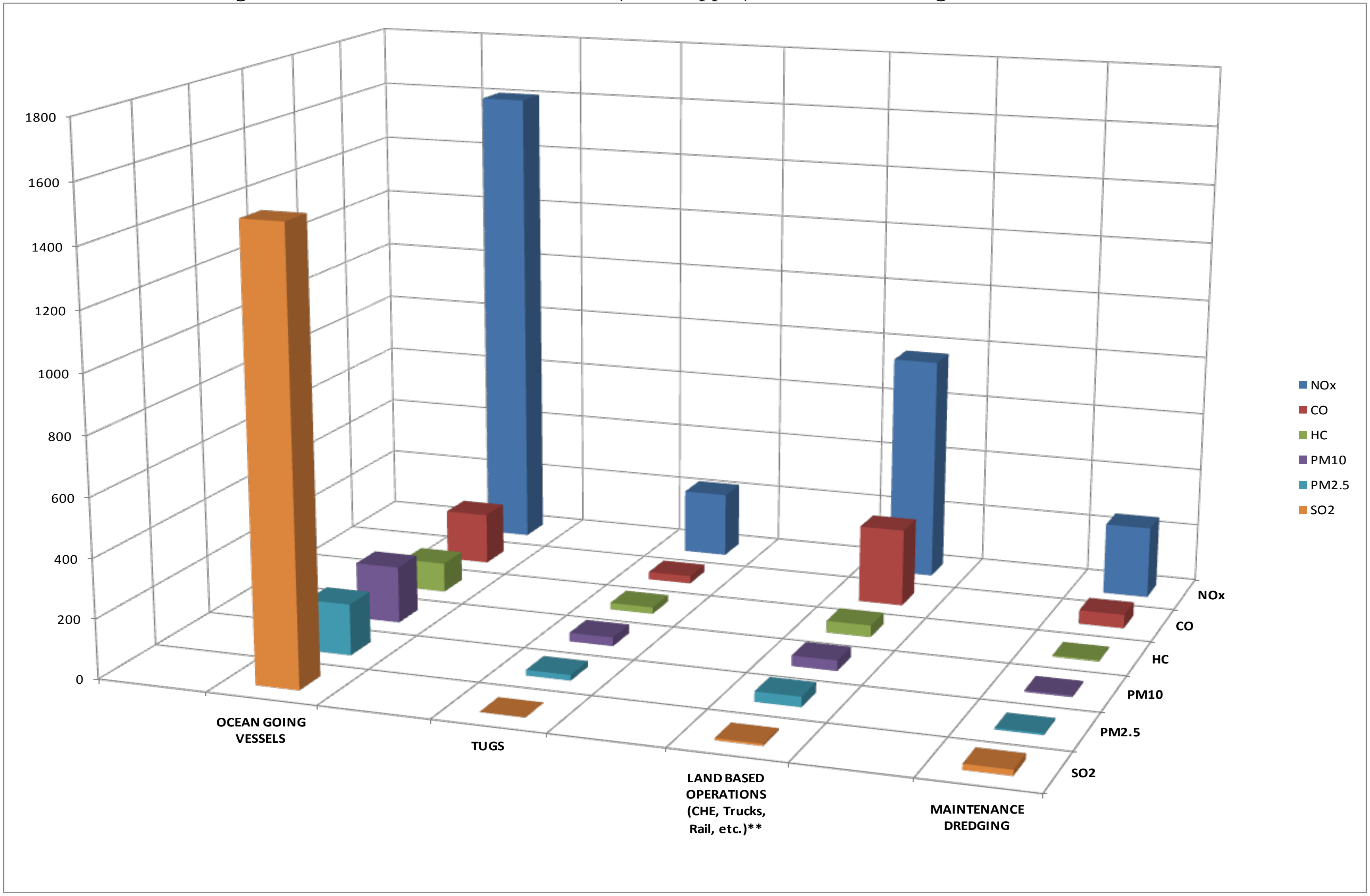


Figure 7-2. Depicts all of the 2022 Air Emissions at the existing -45/45 foot depth No-Action Alternative (tons/year). Note the NOx and SO2 emissions for OGVs have been reduced since OGV fuel is 10.78 gm/kW-hr NOX and 0.10% (1,000ppm) Sulfur. US EPA Regulatory requirement for Sulfur content changed from 2.7% (27,000 ppm) in 2011 to 0.10% (1,000 ppm) in 2015.

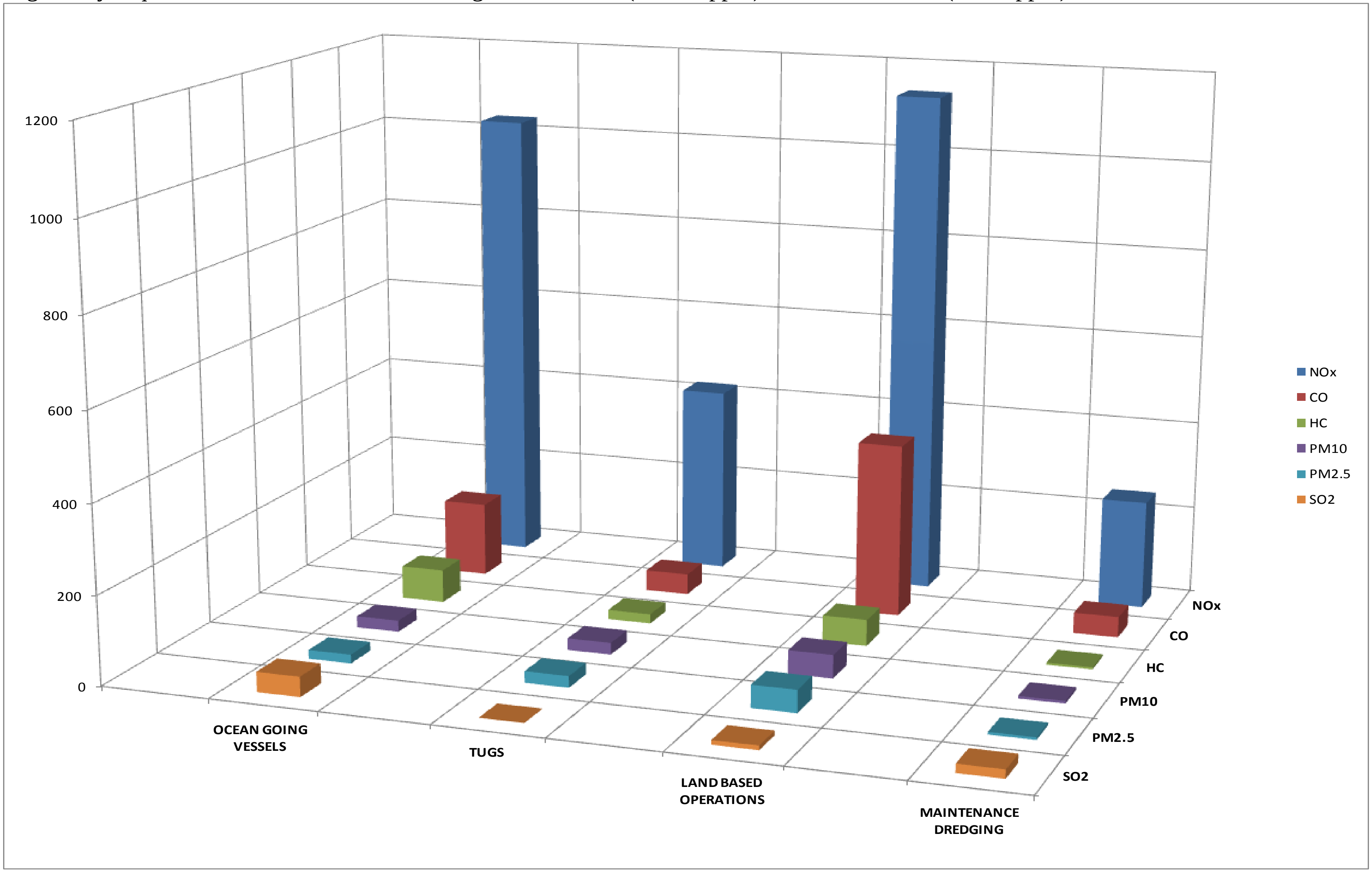


Figure 7-3. 2037 Air Emissions for the -45/45 foot depth No Action Alternative (all units in tons/year).

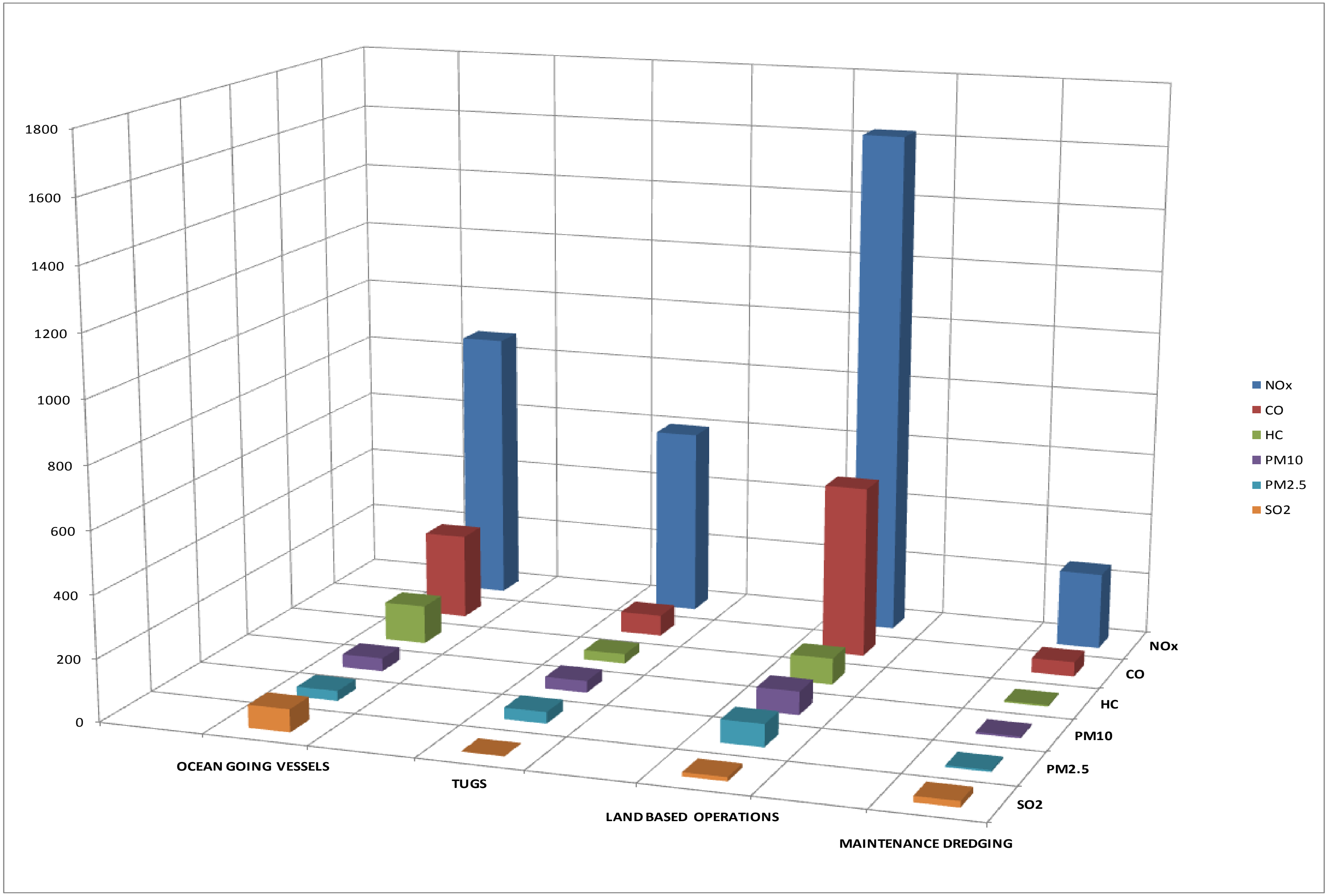


Figure 7-4. 2037 Air Emissions for NED Plan or Alternative -50/48 depth (all units in tons/year)

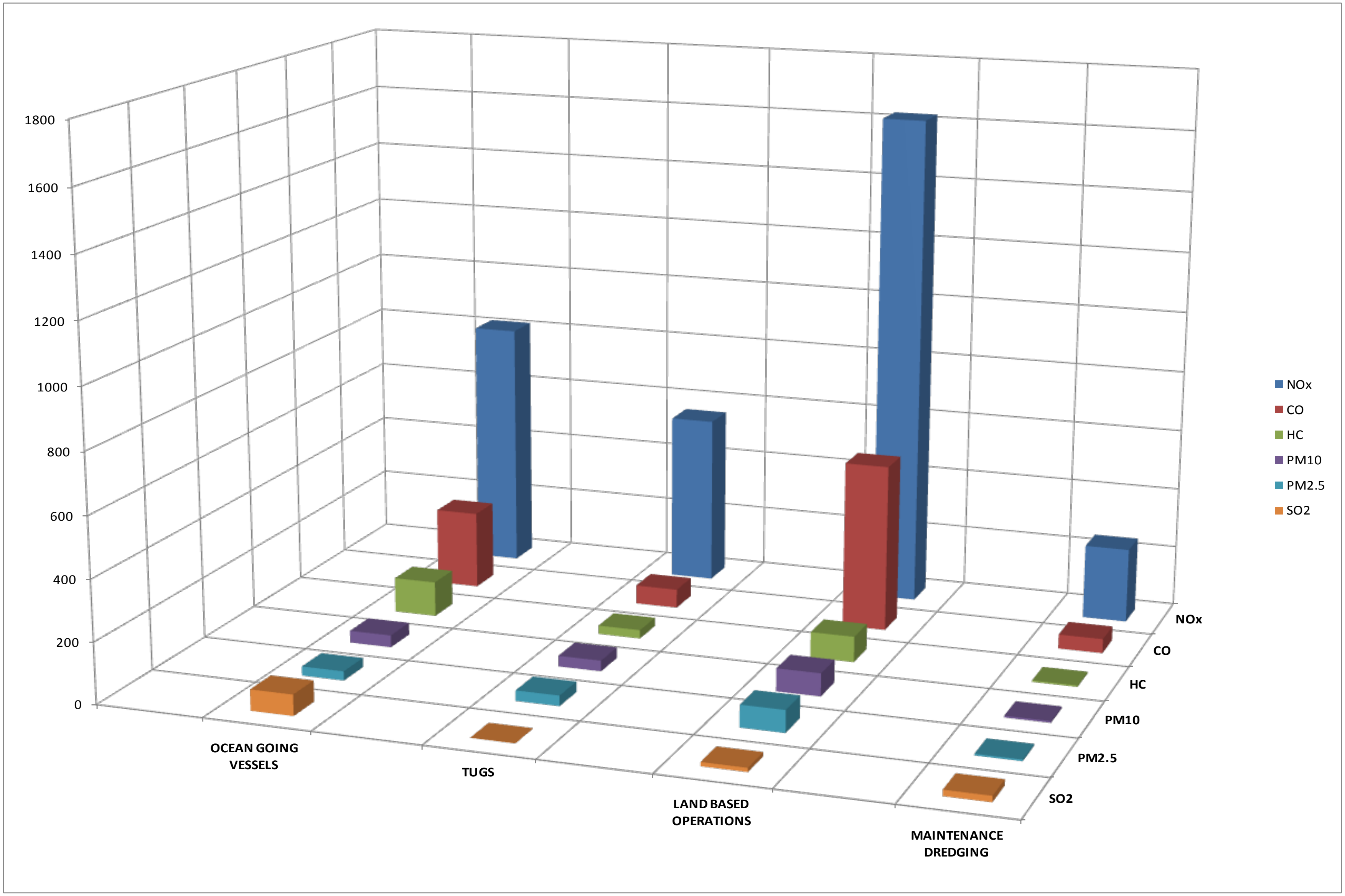


Figure 7-4a. 2037 Air Emissions for LPP Plan or Alternative -52/48 depth (all units in tons/year)

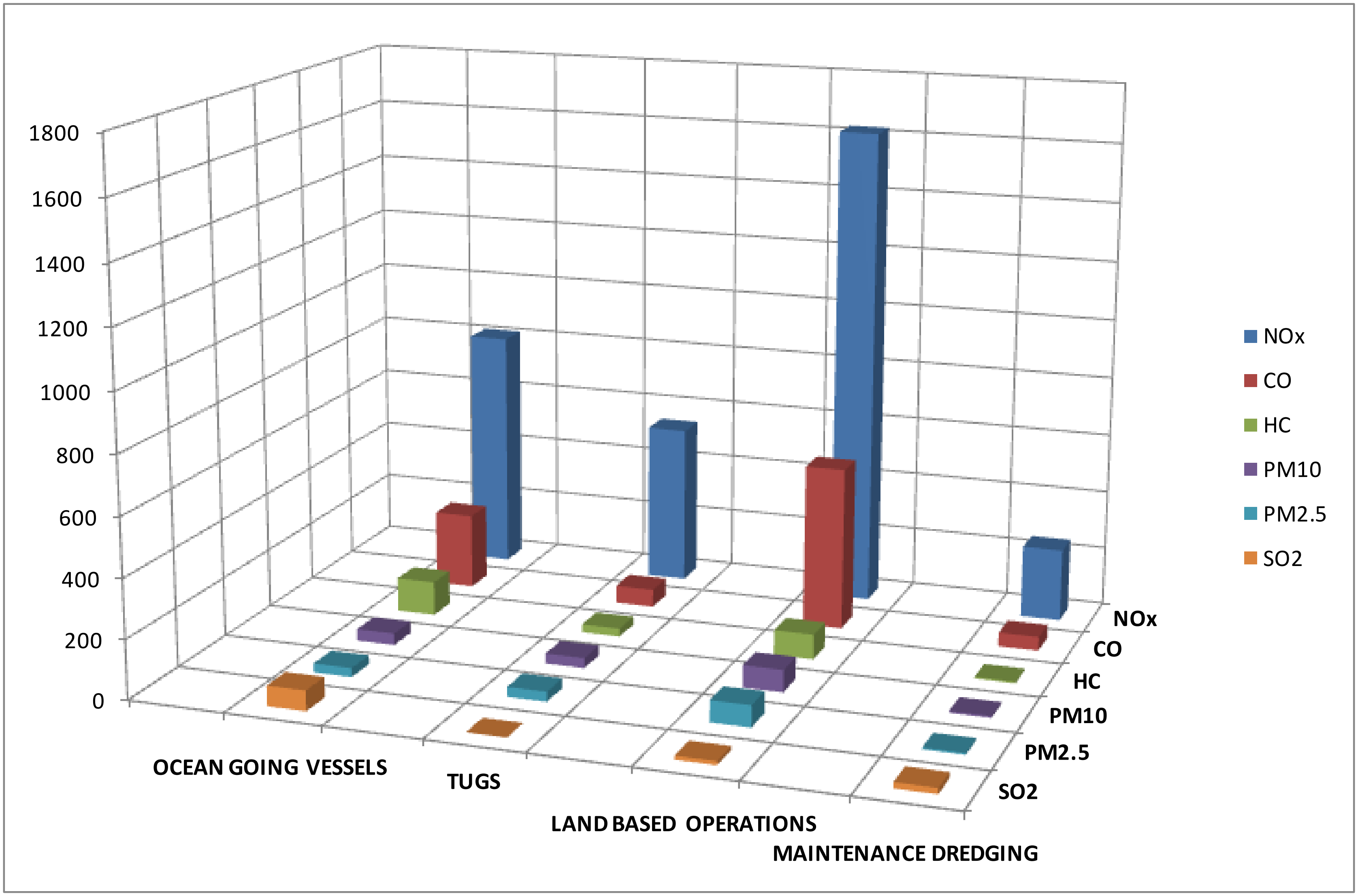


Figure 7-5. Summary of all Terminal Emissions for the No Action -45/45 foot depth Alternative (units in tons/year).

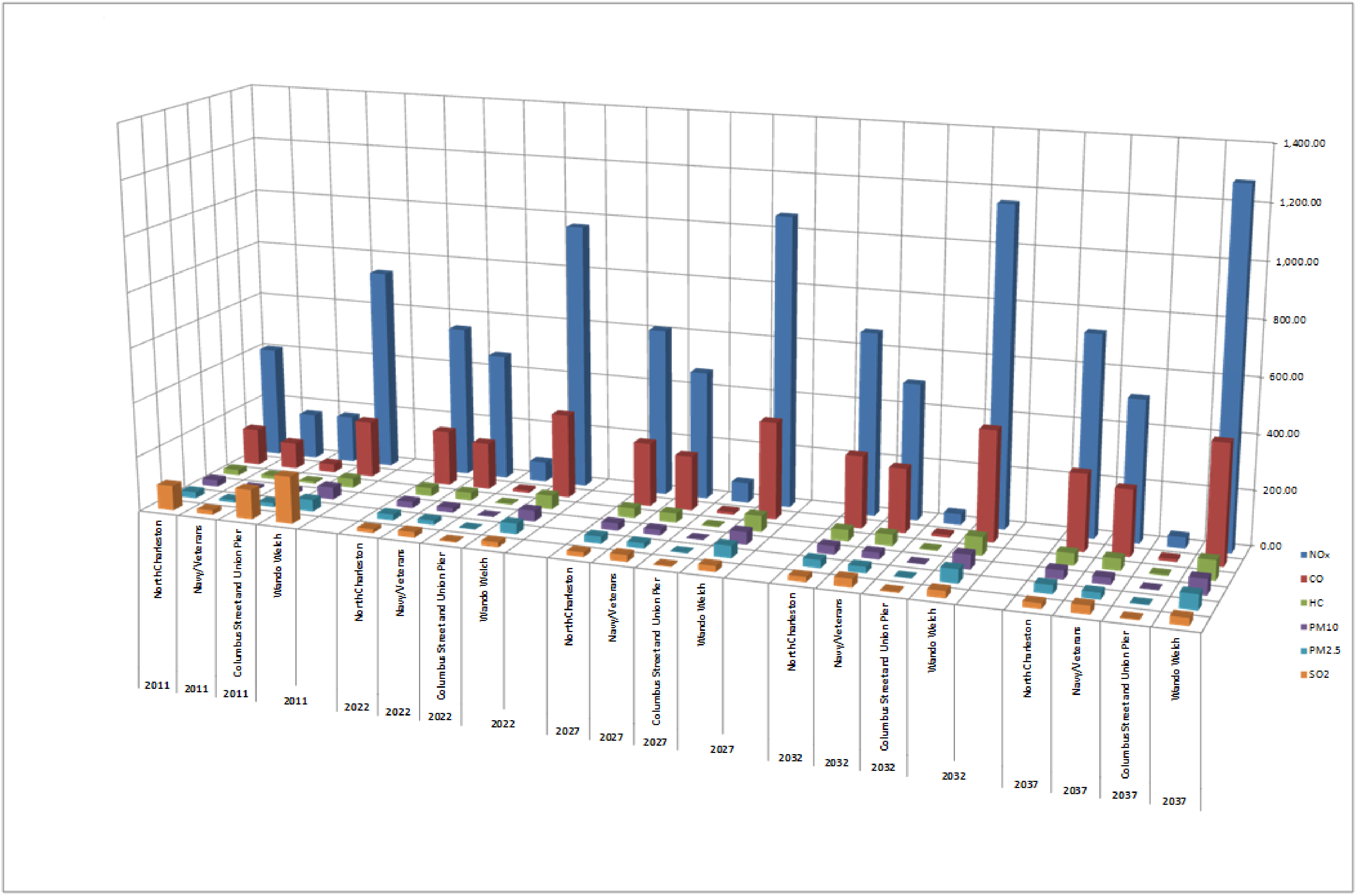


Figure 7-6. Summary of all Terminal Emissions for the NED (-50/48-foot depth) Alternative (units in tons/year)

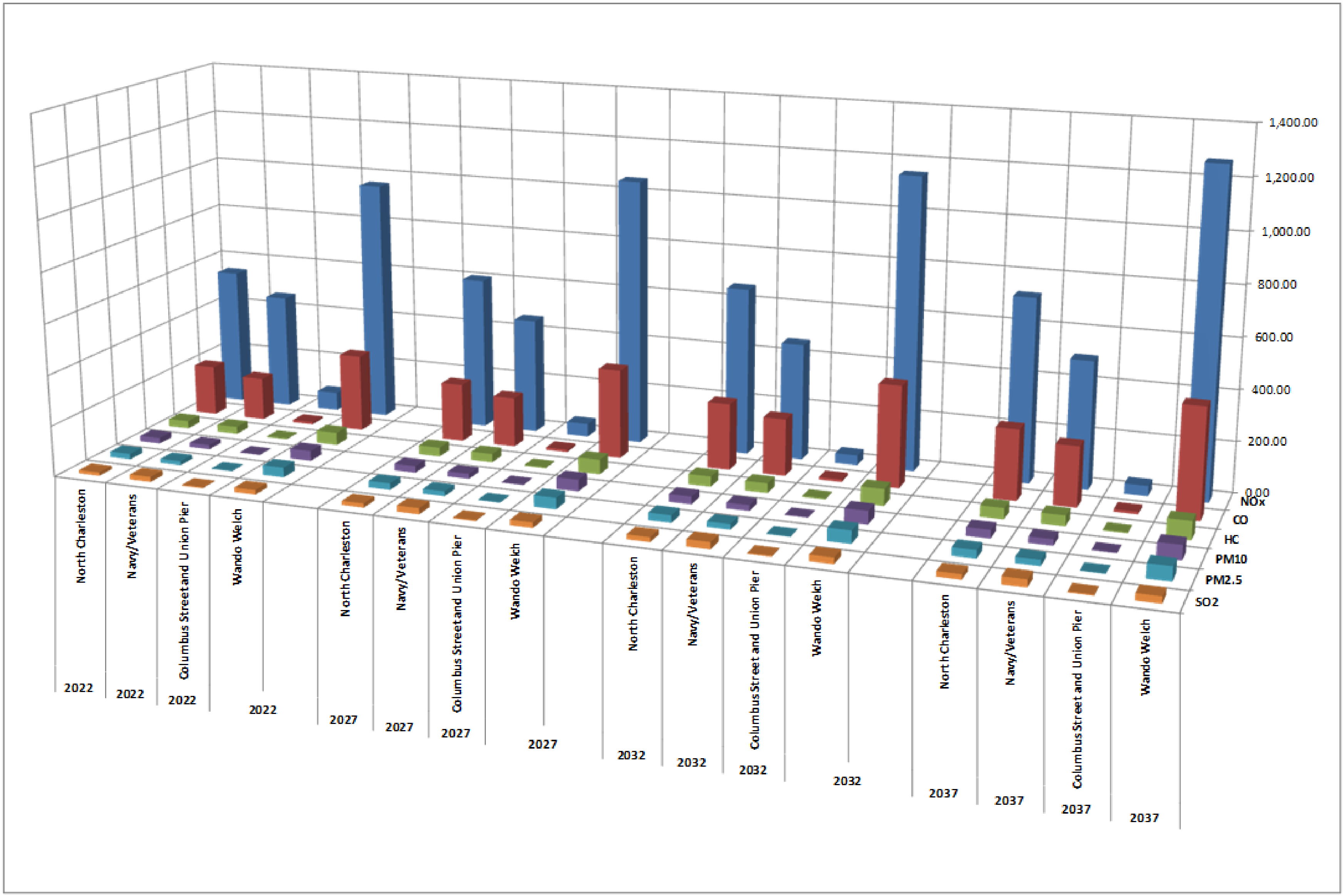


Figure 7-7. Summary of all Terminal Emissions for the LPP (-52/48-foot depth) Alternative (units in tons/year)

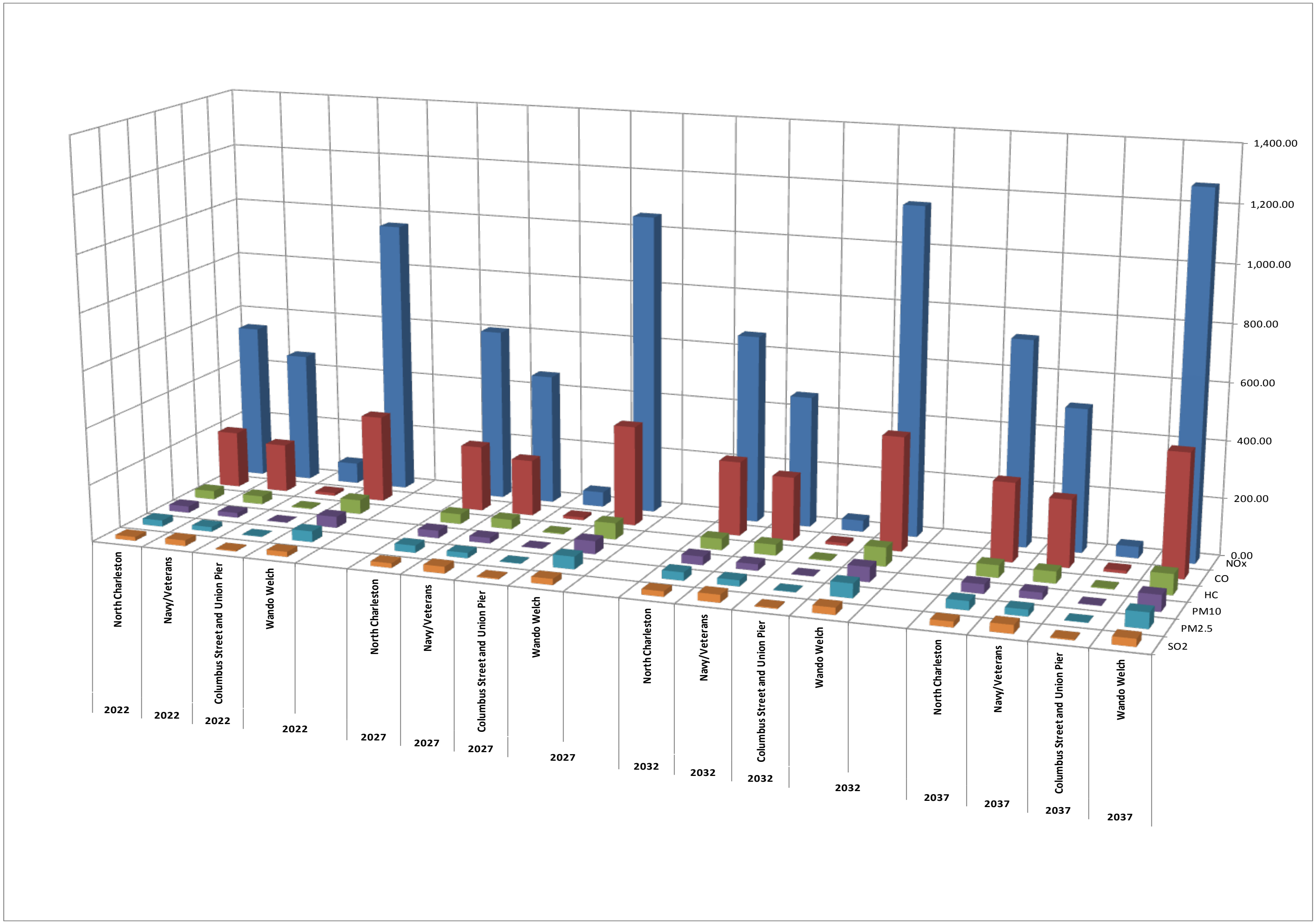


Figure 7-8. 2011 NO-Action (-45/45 foot depth) Alternative percent of total emissions by criteria pollutants.

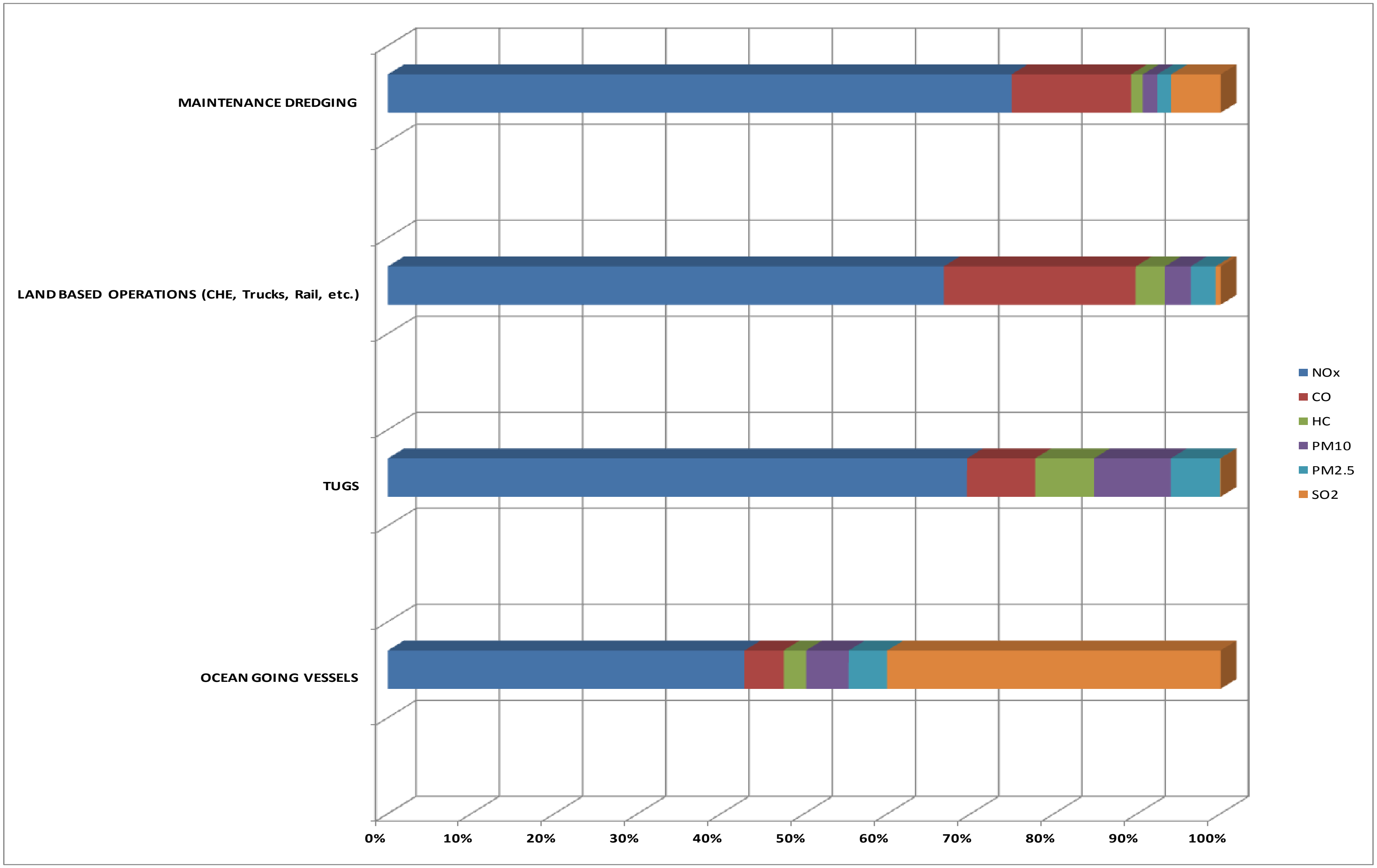


Figure 7-9. The NED Plan (-50/48 depth) Alternative percent emissions by criteria pollutants in 2037.

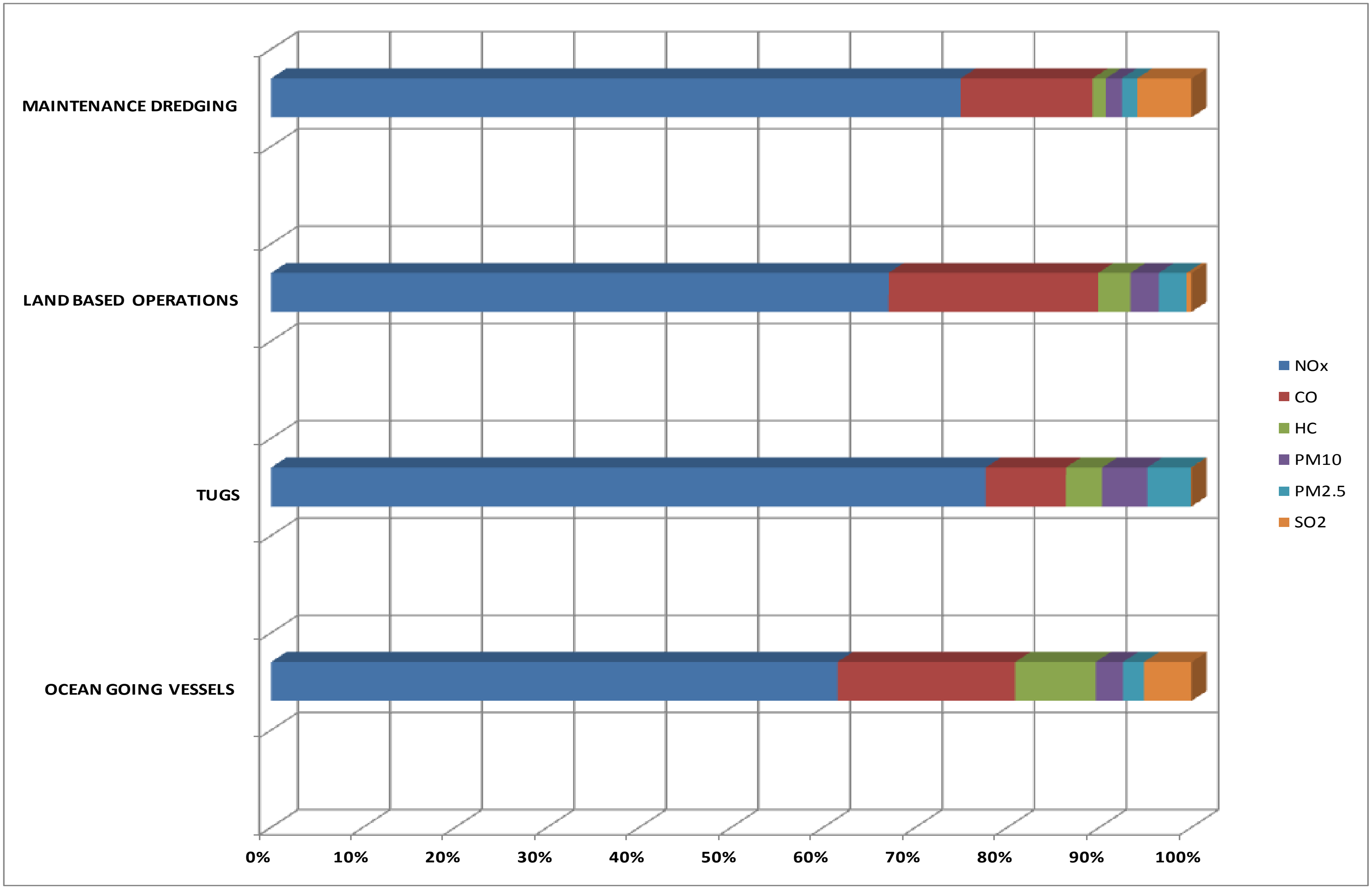


Figure 7-9a. The LPP Plan (-52/48 depth) Alternative percent emissions by criteria pollutants in 2037

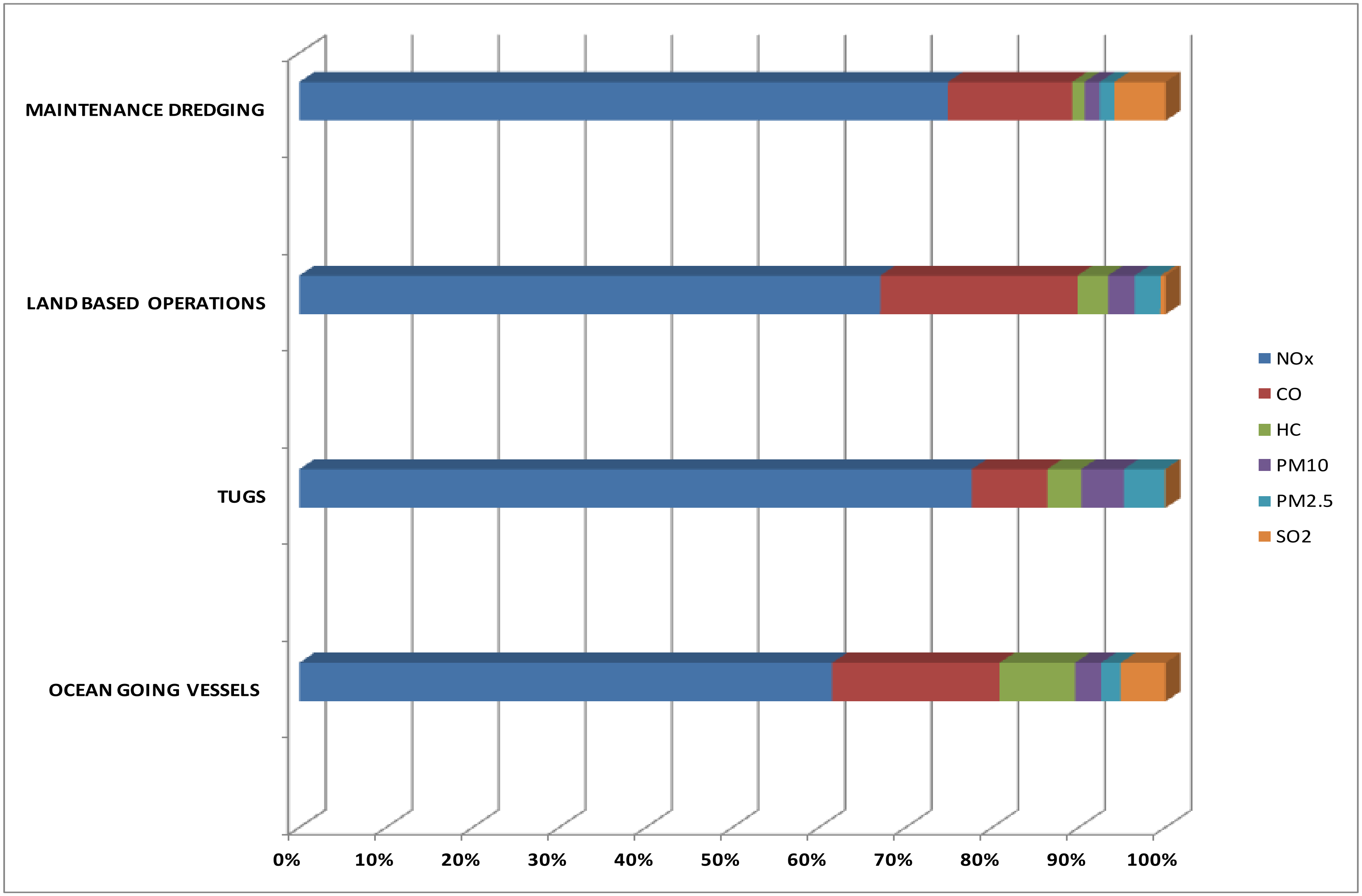
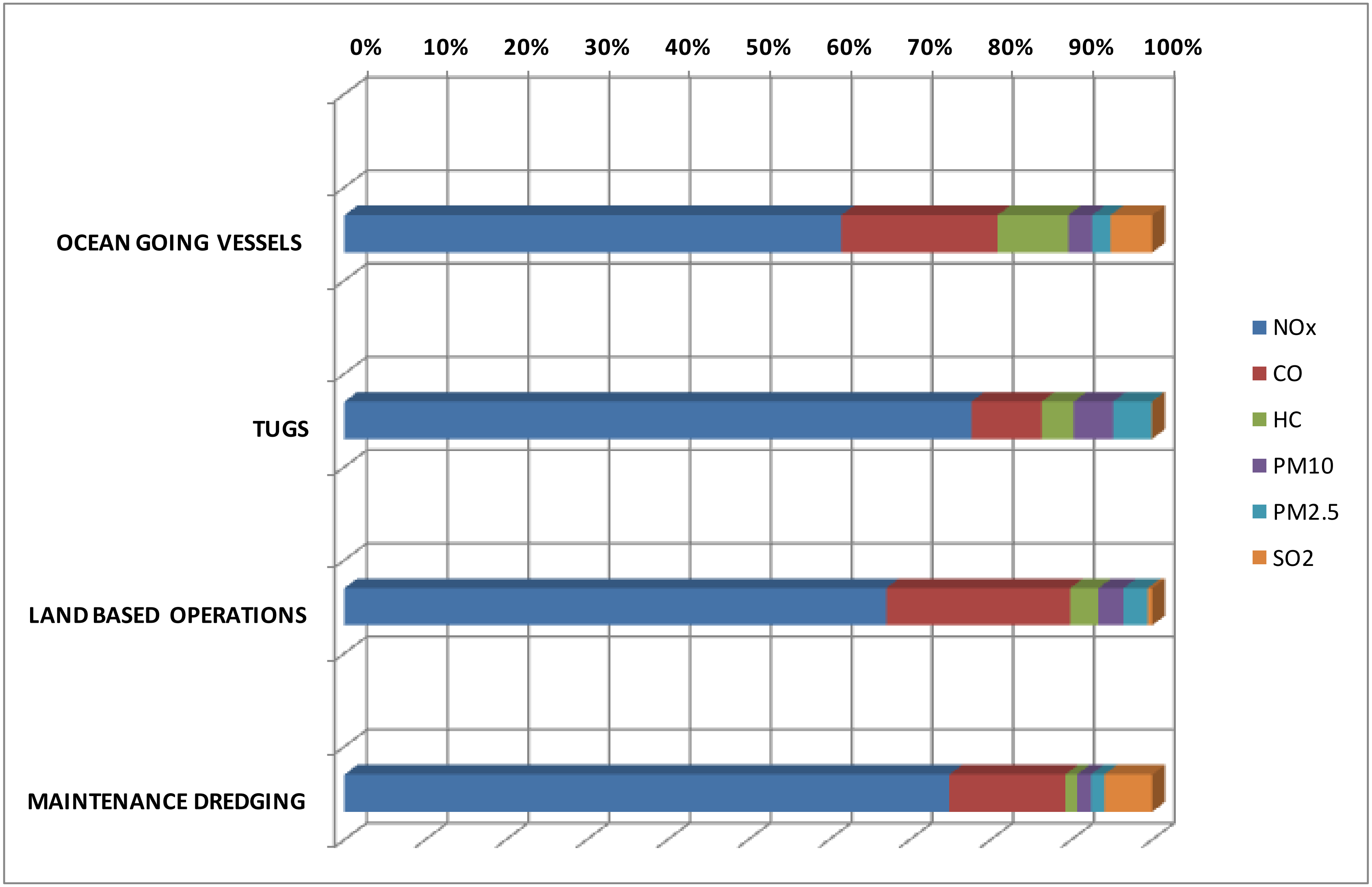


Figure 7-10. The No-Action (-45/45 foot depth) Plan emissions showing percent of criteria pollutants in 2037



Land Based Air Emissions at SCSPA Terminals

Table 6-33 provides the land based emissions for 2011 at the Port of Charleston. Land based emissions would include terminal Cargo Handling Equipment (CHE) (cranes, top lifts, jockey trucks, etc.), trucks, and trains. Table 7-3 shows the land based emissions at the SCSPA terminals and the percent of the land based operations to the total emissions for 2011 (Moffat & Nichol 2013).

Table 7-3. 2011 Baseline and Land Based Equipment

	NOx	CO	HC	PM10	PM2.5	SO2
CHE	114.40	62.40	9.60	7.80	7.60	0.20
Trucks	540.76	128.67	21.89	22.23	21.56	0.64
Trains	42.20	6.30	2.40	1.60	1.50	0.00
Total 2011 Port Emissions	2,843.11	514.77	168.43	263.60	232.19	1,524.84
% of Total						
CHE	4.0%	12.1%	5.7%	3.0%	3.3%	0.0%
Trucks	19.0%	25.0%	13.0%	8.4%	9.3%	0.0%
Trains	1.5%	1.2%	1.4%	0.6%	0.6%	0.0%

These 2011 emissions for CHE, Trucks, and Trains were used as a baseline for the years 2022 to 2037. The USACE projected these 2011 SCSPA land based air emissions by using a growth factor that is provided by USEPA (2009), which is found in Table 1-2 on page 1-10. This annual growth factor was multiplied by the emissions found in Table 7-15 and used for the 2022 to 2037 years. The SCSPA CHE tab in the spreadsheet in Attachment A shows the results of this projection.

Air Emissions at non-SCSPA's (Private) Terminals

CESAC provided estimates for the number of non-SCSPA (private) vessels arriving at the Port of Charleston. According to this forecast, the non-SCSPA terminals reach capacity in 2031 (not 2037 as indicated in the Container Fleet Forecast provided by CESAM). That means for the years 2031 to the end of the 50-year project life (2072), there is no increase in the number of vessels calling on non-SCSPA terminals. Therefore emissions also remain constant from 2031 to 2072 for these non-SCSPA terminals (Table 7-4).

Table 7-4 provides the emissions for the non-SCSPA (private) terminals in the Port of Charleston for 2022, 2027, and 2031.

YEARS	NOx	CO	HC	PM10	PM2.5	SO2	Total CO2
2022	106.62	101.36	9.51	5.89	5.66	8.72	10,529.91
2027	122.31	116.27	10.91	6.76	6.50	10.01	12,078.95
2031	137.99	131.19	12.31	7.63	7.33	11.29	13,627.99

Comparison of Emissions at the Port with Emissions in Project Area

This section also attempts to place the emissions calculated for the Port in a larger perspective, primarily by comparing them to emissions from the entire project area. The project area was described in Section 1 of this inventory. The Charleston Tri-County area is defined as Charleston, Berkeley, and Dorchester Counties. Figure 2 shows the boundary of the Tri-County project area.

Table 7-5 shows the total air emissions for the tri-county area, which is taken from the US EPA National Emission Inventory (NEI) dated 2011. The EPA 2011 NEI is the most recent version.

Table 7-5. EPA 2011 NEI emissions in the project area.

Criteria Pollutants 2011 US EPA SC NEI	Total NOx Emissions (ton)	Total CO Emissions (ton)	Total VOC Emissions (ton)	Total PM10 Emissions (ton)	Total PM2.5 Emissions (ton)	Total SO2 Emissions (ton)	Total CO2 Emissions (ton)
Berkeley	14,838.50	111,463.61	52,233.82	12,306.76	5,817.71	21,182.46	1,438,643.95
Charleston	16,428.82	80,925.41	42,149.29	8,703.06	3,801.00	3,758.78	2,870,628.26
Dorchester	5,301.45	31,288.88	30,261.99	4,922.92	1,707.46	1,501.68	870,386.57
TOTAL	36,568.76	223,677.89	124,645.10	25,932.75	11,326.17	26,442.92	5,179,658.78

Table 7-6 provides the percentage of all emissions for various years calculated for all alternatives (found in Table 7-15) and compared to the EPA 2011 NEI.

Please Note: The forecasted number of vessels and the associated emissions do not consistently increase progressively through the Table 7-6. This is due to the fact that the range of alternatives forecasted includes multiple depths for two separate sets of segments. For example, an apparent inconsistency exists where the depths for Segments 1 and 2 transition from 48 feet to 50 feet at the same time the depth for Segment 3 transitions from 48 feet to 47 feet. The increase in the total number of vessels at that (and similar) transitions occurs where the forecasted impact of decreasing the depth of Segment 3 exceeds the impact of increasing the depths of Segments 1 and 2.

Also looking at the air emission table7-6, below, the year 2022 emissions for all depth alternatives (i.e., -48/47, -48/48/, -50/47, -50/48, -52/47, and -52/48 foot) some of the criteria pollutants are slightly higher than the -45/45 foot depth or No Action Alternative <u>because the final year of deepening is 2022 and these deepening emissions are added to all depth alternatives</u>. Since the No-Action Alternative (-45/45 depth) does not contain any dredging emissions for deepening of the harbor, <u>the emissions are slightly lower than all of the depth alternatives</u>. However, the No Action Alternative does include the yearly O&M maintenance dredging emissions.

Table 7-6 Percentage of all emissions calculated for all alternatives and compared to the EPA 2011 NEI.

Alternatives	Year	Vessel Numbers	NOx	CO	HC	PM10	PM2.5	SO2	CO2
45-foot depth	2011	1,902	7.77%	0.23%	0.14%	1.02%	2.05%	5.77%	2.50%
	2022	2,712	7.76%	0.29%	0.13%	0.43%	0.90%	0.28%	2.41%
	2027	3,102	8.01%	0.34%	0.15%	0.49%	1.04%	0.33%	2.85%
	2032	3,515	8.30%	0.38%	0.18%	0.56%	1.18%	0.37%	3.27%
	2037	3,860	9.13%	0.42%	0.20%	0.62%	1.30%	0.40%	3.60%
	Year	Vessel Numbers	NOx	CO	HC	PM10	PM2.5	SO2	CO2
48/47-foot depth	2022	2,624	8.22%	0.31%	0.13%	0.44%	0.93%	0.35%	2.54%
	2027	2,938	7.81%	0.33%	0.15%	0.48%	1.01%	0.32%	2.73%
	2032	3,270	8.07%	0.38%	0.17%	0.54%	1.14%	0.35%	3.09%
	2037	3,570	8.86%	0.41%	0.19%	0.60%	1.26%	0.38%	3.40%
	Year	Vessel Numbers	NOx	CO	HC	PM10	PM2.5	SO2	CO2
48/48-foot depth	2022	2,604	8.69%	0.32%	0.13%	0.45%	0.96%	0.42%	2.67%
	2027	2,951	7.84%	0.33%	0.15%	0.48%	1.02%	0.32%	2.74%
	2032	3,316	8.11%	0.38%	0.17%	0.55%	1.15%	0.36%	3.13%
	2037	3,629	8.92%	0.41%	0.19%	0.60%	1.26%	0.39%	3.44%
	Year	Vessel Numbers	NOx	CO	HC	PM10	PM2.5	SO2	CO2
50/47-foot depth	2022	2,620	8.22%	0.31%	0.13%	0.44%	0.93%	0.35%	2.54%
	2027	2,917	7.81%	0.33%	0.15%	0.48%	1.01%	0.32%	2.73%
	2032	3,242	8.07%	0.38%	0.17%	0.54%	1.14%	0.35%	3.09%
	2037	3,524	8.86%	0.41%	0.19%	0.60%	1.26%	0.38%	3.40%
	Year	Vessel Numbers	NOx	CO	HC	PM10	PM2.5	SO2	CO2
50/48-foot depth	2022	2,601	8.67%	0.32%	0.13%	0.45%	0.96%	0.42%	2.66%
	2027	2,928	7.81%	0.33%	0.15%	0.48%	1.01%	0.32%	2.73%
	2032	3,283	8.08%	0.38%	0.17%	0.54%	1.14%	0.35%	3.10%
	2037	3,583	8.87%	0.41%	0.19%	0.60%	1.26%	0.38%	3.41%
	Year	Vessel Numbers	NOx	CO	HC	PM10	PM2.5	SO2	CO2
52/47-foot depth	2022	2,616	9.06%	0.33%	0.13%	0.47%	0.99%	0.47%	2.78%
	2027	2,909	7.78%	0.33%	0.15%	0.48%	1.01%	0.31%	2.71%
	2032	3,231	8.03%	0.37%	0.17%	0.54%	1.14%	0.35%	3.06%
	2037	3,507	8.80%	0.41%	0.19%	0.59%	1.25%	0.38%	3.36%
	Year	Vessel Numbers	NOx	CO	HC	PM10	PM2.5	SO2	CO2
52/48-foot depth	2022	2,597	8.20%	0.31%	0.13%	0.44%	0.93%	0.35%	2.53%
	2027	2,921	7.84%	0.33%	0.15%	0.48%	1.02%	0.32%	2.74%
	2032	3,276	8.11%	0.38%	0.17%	0.55%	1.15%	0.36%	3.13%
	2037	3,567	8.92%	0.41%	0.19%	0.60%	1.26%	0.39%	3.44%

As indicated in Table 7-6, the port is a minor contributor of NOx, HC, VOC, CO, PM10, PM2.5, SO2, and CO2 for all seven alternatives when compared to the EPA 2011 NEI.

Additionally, within the project area there are a number of major industries and electrical coal fired steam plants that produce a significant amount of emissions in the project area.

Table 7-7 shows the Major Air Emissions Sources within the project area for 2011. This information was provided by Mr. Chad Wilbanks with the Emissions Inventory, SC Bureau of Air Quality, SC DHEC on 13 May 2013.

Table 7-7. Major Air Emission Sources within the project area for 2011.

Permit No	Name	NOx	CO	HC	PM10	PM2.5	SO2	CO2
0420-0006	SCE&G WILLIAMS	1,543.42	264.10	31.54	557.72	332.63	606.94	2,677,525.00
0420-0030	SANTEE COOPER CROSS GENERATING STATION	5,426.12	10,480.16	90.55	1,165.66	1,019.65	9,163.79	15,435,446.00
0560-0008	KAPSTONE CHARLESTON KRAFT LLC	951.69	5,075.41	631.24	357.94	316.16	1,080.47	2,110.60
0560-0164	MEADWESTVACO SC LLC SPECIALTY CHEMICALS	20.42	22.09	102.21	11.33	0.96	3.18	17,314.32
0560-0244	COGEN SOUTH	2,019.96	410.28	41.60	140.02	122.03	801.20	1,071,144.00
0740-0002	SCE&G CANADYS	2,656.47	973.71	20.35	2,282.38	1,807.43	15,631.60	1,528,405.00
0900-0002	GIANT CEMENT CO	472.79	1,111.37	39.38	244.06	152.21	330.16	541,477.60
1140-0005	SANTEE COOPER WINYAH GENERATING STATION	2,768.88	557.38	66.77	769.01	632.02	3,510.24	5,781,214.00

Emissions from New Work Dredging

The proposed Port of Charleston Harbor Deepening would be a major construction project requiring large equipment to be used over a substantial period of time. The estimated construction period may be about four years from 2019 to 2022. Additionally, the total deepening emissions would not take place in one year but over 4 years. The proposed deepening would need to comply with all dredging windows (Threatened and Endangered Species, etc), which means that the deepening would not take place 365 days out of each year. The proposed construction methods and dredging windows are fully described in Section 4.0 in the DEIS. The emissions expected from the new work dredging for the proposed harbor deepening project were calculated and are shown in Table 7-8 below and compared to EPA's 2011 NEI for the project area.

Table 7-8 Summary of New Work Dredging Emissions (Tons) Compared to EPA's 2011 NEI

	Annualized Total Dredging Emissions from 2019 to 2022*						
	52 Depth						
	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Dredging Emissions	766.4596	146.4807	14.0930	17.8075	17.0640	70.7161	33,406.7643
US EPA 2011 NEI	36,568.7632	223,677.8898	124,645.0983	25,932.7489	11,326.1705	26,442.9246	5,179,658.7814
Percent of Total	2.10%	0.07%	0.01%	0.07%	0.15%	0.27%	0.64%
	50 Depth						
	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Dredging Emissions	631.5283	120.7413	11.7072	14.6663	14.0648	56.5156	27,905.1511
US EPA 2011 NEI	36,568.7632	223,677.8898	124,645.0983	25,932.7489	11,326.1705	26,442.9246	5,179,658.7814
Percent of Total	1.73%	0.05%	0.01%	0.06%	0.12%	0.21%	0.54%
	48 Depth						
	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Dredging Emissions	458.3516	87.6798	8.5927	10.6382	10.2128	39.2554	20,634.9544
US EPA 2011 NEI	36,568.7632	223,677.8898	124,645.0983	25,932.7489	11,326.1705	26,442.9246	5,179,658.7814
Percent of Total	1.25%	0.04%	0.01%	0.04%	0.09%	0.15%	0.40%
	*Includes all pipeline, hopper, and clamshell dredges.						

As indicated in Table 7-8, the constructions emissions generated to deepen the port channels is insignificant when compared to the overall project area.

The timing of the construction (number of dredges working at the same time) is not firm at this time, so a precise calculation of the emissions per year cannot be made. The percentages shown above assume an equal distribution of the emissions over a four-year construction period. One item to remember is that a good deal of the new work dredging would be performed in the entrance channel. The extended entrance channel starts approximately 20 miles east of the harbor entrance. With the prevailing winds being west to east, emissions from dredging the entrance channel would likely not add measurably to pollutant concentrations as dredging the inner harbor or other emissions in project area.

Emissions of Air Toxics (HAPs)

The quantity of air toxics were calculated using the air toxic ratios taken from the NMIM "SCC Toxics" database table, which was provided by US EPA, Office of Transportation and Air Quality Ann Arbor, Michigan. The Corps then multiplied these air toxic ratios by either the total VOC or PM10 emissions for each alternative. The results of these calculations are found in Appendix B (spreadsheet HAPs (Air Toxics)) tab.

Emissions of air toxics were calculated at the Port of Charleston (includes all 17 terminals, land based operations, dredging, OGVs, etc.) for the 28 air toxics in the 2011 base year, and project years 2022, 2027, 2032, and 2037 by quantity and compared them to the reported 2011 EPA NEI air toxic emission. The 2011 EPA NEI HAPS for the project area is found in Table 7-9 below.

The Port of Charleston is a small insignificant subset of the air emissions generated when compared to the entire project area. With or without the harbor deepening, the amount of HAPs would increase until the port reaches capacity in 2037 with 4.2 million TEUs.

Fewer transits are required from large ships to carry the same amount of cargo when compared to small ships. Therefore, the proposed harbor deepening – which would allow larger vessels to regularly use the harbor – would result in lower emissions of air toxics than would the fleet that can use the present 45-foot deep authorized channel.

Table 7-10 depicts the percentage of HAPs generated from the Total Port Emissions for the No-Action Alternative (-45 foot depth) and the LPP (-52/48 foot depth) alternative compared to the HAPs in the EPA 2011 NEI.

Table 7-9 EPA 2011 NEI HAPs for the Project Area.

Hazardous Air Pollutants (HAPs)	Acetaldehyde (tons)	Benzene (tons)	Formaldehyde (tons)	Hexane (tons)	Naphthalene (tons)	Phenol (tons)	Styrene (tons)	Xylenes (tons)
Berkeley	512.98	214.27	894.70	155.19	4.51	7.31	41.24	258.27
Charleston	382.93	247.00	660.89	359.14	11.69	15.01	10.99	456.60
Dorchester	284.42	76.61	449.49	90.67	4.41	0.58	67.81	88.68
TOTAL	1,180.32	537.88	2,005.08	605.00	20.61	22.91	120.03	803.55

Table 7-10 Comparison of HAPs generated from the Total Port Emissions for the No-Action Alternative (-45 foot depth) and the LPP (-52/48 foot depth) alternative to the EPA 2011 NEI

NO-ACTION ALTERNATIVE (-45/45 PROJECT DEPTH) Percent of HAPs from the Port Compared to the 2011 USEPA NEI					
HAPS	2011	2022	2027	2032	2037
Styrene	0.08%	0.08%	0.09%	0.11%	0.12%
Hexane	0.04%	0.04%	0.05%	0.06%	0.06%
Xylene	0.22%	0.21%	0.25%	0.29%	0.32%
Formaldehyde	1.00%	0.95%	1.13%	1.29%	1.44%
Benzene	0.64%	0.61%	0.72%	0.83%	0.92%
Acetaldehyde	0.76%	0.73%	0.86%	0.99%	1.10%
Naphthalene	0.59%	0.25%	0.29%	0.33%	0.36%
52/48 ALTERNATIVE Percent of HAPs from the Port Compared to the 2011 USEPA NEI					
HAPS	2011	2022	2027	2032	2037
Styrene	NA	0.08%	0.09%	0.10%	0.12%
Hexane	NA	0.04%	0.05%	0.06%	0.06%
Xylene	NA	0.22%	0.24%	0.28%	0.31%
Formaldehyde	NA	0.97%	1.09%	1.24%	1.38%
Benzene	NA	0.62%	0.70%	0.80%	0.89%
Acetaldehyde	NA	0.74%	0.83%	0.95%	1.05%
Naphthalene	NA	0.26%	0.28%	0.32%	0.35%

Greenhouse Gas Emissions (GHG)

While the majority of greenhouse gas emissions from ships are CO_2, additional GHG emissions include methane (CH_4) and nitrous oxide (N_2O). The EPA 2011 NEI inventory for the project area only includes CO_2 and it is found in Table 7-11:

Table 7-11 Provides the EPA 2011 NEI GHGs

Greenhouse Gases EPA 2011 NEI
Carbon Dioxide CO_2 (tons)
5,179,658.78

According to USEPA's Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, Ocean Going Vessels, ICF International, Final dated April 2009, on page 2-16, the following information is found:

While the majority of greenhouse gas emissions from ships are CO_2, additional GHG emissions include methane (CH4) and nitrous oxide (N2O). Emission factors for various engine types listed in Table 2-13 are taken from the IVL 2004 update 38. To estimate CO2 equivalents, CH4 emissions should be multiplied by 21 and N2O emissions should be multiplied by 310. Therefore, to estimate CH4 and N20, CO2 should be divided by 21 and 310, respectively. Since C02=CH4 X 21 and CO2=N20 X 310.

Therefore CH4 = CO2/21 and N2O = CO2/310.

On page 3-11 of this same document, it states:

In addition to the greenhouse gas emission factors discussed above, it is possible to estimate elemental carbon emission factors from the EPA's SPECIATE4 model for emissions of PM2.5. For diesel harbor craft, the diesel commercial marine vessel (SCC 2280002000) sector is appropriate. That sector is assigned an emission fraction of 77.12% elemental carbon. That is: EFEC = 77.12% x 97% x EFPM10 after adjusting the PM10 emission factor for fuel sulfur.

Therefore Elemental Carbon = 0.7712 x 0.97 x PM10.

These formulas were used to estimate the GHGs emissions for marine diesel vessels (i.e., OGVs, tugs, pipeline and hopper dredges) at all depths and years for all 17 terminals in the Port of Charleston. These GHGs estimates are shown in Table 7-12, below.

Table 7-12 Summary of GHGs Emissions for the Port of Charleston (tons/year).

Alternatives	Year	CO2	N20	CH4	Carbon
Baseline 45/45	2011	122,510.41	395.19	5,833.83	170.55
No-action 45/45	2022	114,531.60	369.46	5,453.89	43.33
No-action 45/45	2027	135,437.45	436.89	6,449.40	50.62
No-action 45/45	2032	155,501.64	501.62	7,404.84	57.87
No-action 45/45	2037	173,077.96	558.32	8,241.81	64.15
Alternatives	Year	CO2	N20	CH4	Carbon
48/47	2022	120,834.37	389.79	5,754.02	45.87
48/47	2027	129,213.11	416.82	6,153.01	48.34
48/47	2032	146,551.25	472.75	6,978.63	54.48
48/47	2037	162,648.01	524.67	7,745.14	60.17
Alternatives	Year	CO2	N20	CH4	Carbon
48/48	2022	120,260.40	387.94	5,726.69	45.60
48/48	2027	129,950.35	419.19	6,188.11	48.54
48/48	2032	148,247.27	478.22	7,059.39	55.16
48/48	2037	164,674.89	531.21	7,841.66	60.98
Alternatives	Year	CO2	N20	CH4	Carbon
50/47	2022	127,996.44	412.89	6,095.07	48.84
50/47	2027	128,430.50	414.29	6,115.74	48.03
50/47	2032	145,165.22	468.27	6,912.63	53.93
50/47	2037	160,831.12	518.81	7,658.62	59.47
Alternatives	Year	CO2	N20	CH4	Carbon
50/48	2022	127,423.73	411.04	6,067.80	48.57
50/48	2027	129,112.43	416.49	6,148.21	48.22
50/48	2032	147,016.72	474.25	7,000.80	54.68
50/48	2037	162,952.28	525.65	7,759.63	60.32
Alternatives	Year	CO2	N20	CH4	Carbon
52/47	2022	133,364.29	430.21	6,350.68	51.12
52/47	2027	128,208.83	413.58	6,105.18	47.94
52/47	2032	144,934.35	467.53	6,901.64	53.90
52/47	2037	160,187.22	516.73	7,627.96	59.22
Alternatives	Year	CO2	N20	CH4	Carbon
52/48	2022	132,741.72	428.20	6,321.03	50.83
52/48	2027	114,526.34	369.44	5,453.64	44.00
52/48	2032	145,910.88	470.68	6,948.14	54.02
52/48	2037	161,344.81	520.47	7,683.09	59.42

Note: The baseline 45/45 alternative in 2011 for Carbon emissions is 170.55 tons. The reason why carbon is so much greater in 2011 than other years is because carbon is calculated using PM10 emissions at the port. In 2011, at the baseline existing 45/45 alternative, OGVs are using the higher sulfur fuels (2.7% or 27,000 ppm Sulfur) and in later years they used lower sulfur fuels (0.1% or 1,000 ppm Sulfur). These lower sulfur fuels also reduce SO2, PM10, and PM2.5 emissions.

Lastly, the estimated Carbon Dioxide (CO_2) for the Port of Charleston was compared to the CO_2 found in the 2011 EPA NEI for the project area. Table 7-13 provides this information:

Table 7-13. Comparison of the Port CO2to the 2011 EPA NEI CO2 Emissions

SUMMARY TABLE					
Port Emissions as a Percent of 2011 USEPA NEI*	2011	2022*	2027	2032	2037
45-Foot Depth	2.37%	2.21%	2.61%	3.00%	3.34%
48/47-Foot Depth	NA	2.33%	2.49%	2.83%	3.14%
48/48-Foot Depth	NA	2.32%	2.51%	2.86%	3.18%
50/47-Foot Depth	NA	2.47%	2.48%	2.80%	3.11%
50/48-Foot Depth	NA	2.46%	2.49%	2.84%	3.15%
52/47-Foot Depth	NA	2.57%	2.48%	2.80%	3.09%
52/48- Foot Depth	NA	2.56%	2.21%	2.82%	3.11%

* NOTE: The 48/47, 48/48, 50/47, 50/48, 52/47, and 52/48 alternatives only have harbor channel deepening emissions in 2022.
That's why their percent of the 2011 NEI is higher than No Action Alternative.
Alternative 45 only has maintenance dredging for years 2011, 2022, 2027, 2032, 2037.

Conclusions

The USACE understands that the proposed Post Charleston 45 project will change the overall types of vessels arriving at the port. However, it is anticipated that without deepening, more, smaller and older vessels will be required to transport the same amount of cargo that is expected to move through the port. With deepening, the total number of vessels decreases as newer larger capacity vessels will be able to operate more efficiently under the improved depth conditions.

Under both the without (No-Action Alternative -45 foot depth) and with project conditions (-48, -50, and -52 foot depths alternatives), the Charleston Harbor SCSPA Terminals are expected to reach build-out capacity in 2037 when the total number of TEUs processed through the terminal reaches 4.2 million. That capacity is the maximum number of containers that could reasonably be processed through the SCSPA Terminals in a year.

No increases in cargo are expected to occur as a result of the harbor deepening. As a result, the project would not affect the number of containers that move through the areas that surround the port. The economic benefits of the project would result from the use of newer, larger, more cost-effective container ships, not an increase in the number of containers.

Air emissions (including criteria pollutants, air toxics and greenhouse gases) and vessel traffic would not be increased as a result of the proposed deepening. Therefore, the proposed harbor deepening would have no significant adverse impacts on the air quality of the Port of Charleston.

The following sections go into greater detail on how the USACE reached these conclusions.

Air Quality Standards of the Project Area

The project area (Charleston, Berkeley, and Dorchester Counties) is considered by EPA to be in an Attainment area since it meets the National Ambient Air Quality Standards, which are shown in Table 7-14 below:

Table 7-14 National Ambient Air Quality Standards

POLLUTANT	PRIMARY STANDARD	SECONDARY STANDARD
PM_{10}	150 ug/m^3 (24-hour)	Same
$PM_{2.5}$	35 ug/m^3 (24-hour)	Same
NO_X	0.1 ppm (1-hour) and 0.053 ppm annual	0.053 ppm annual
SO_2	0.075 ppm (1-hour)	0.5 ppm (3-hour)
CO	9 ppm (8-hour) and 35 ppm (1-hour)	Same
LEAD	0.15 ug/m^3	Same
OZONE	0.075 ppm (8-hour)	Same

EPA published information in February 2012 about air quality in the Port of Charleston project area in its "Latest Findings on National Air Quality, Status and Trends Through 2010" (USEPA 2012). In that document (Figure 8 on page 10), EPA stated that Charleston's 2010 Ozone level ranged from 0.060 to 0.075 ppm (4^{th} highest daily maximum 8-hour concentration). That is generally below the ozone standard of 0.075 ppm. Ground level ozone is formed when NOx and VOC react in the presence of sunlight. That document also reported that ozone levels had improved in Charleston from 2001 to 2010. The daily summer maximum 8-hour ozone concentrations between 2001 to 2010 decreased by 0.008 ppm or 16% (from Figure 9 in EPA's document). For a number of years EPA has indicated that they may promulgate a new ozone standard. The new ozone standard may be published in mid 2011. EPA had sought comments on setting the new ozone standard between 0.060 ppm and 0.070 ppm. In September 2011, the administration decided to rescind US EPA's recommendation and keep the 0.075 ppm standard (Personal Communication, September 12, 2011, Brad Newland, PE, Regional Supervisor, NC Division of Air Quality, Wilmington Field Office).

US EPA stated (USEPA 2012) that nationally both annual and 24 hour PM2.5 concentrations declined by 24 and 28 percent between 2001 and 2010. The annual and 24-hour concentration ranges for PM2.5 in Charleston, SC was from 3.1 to 12 (680 sites) and 16 to 35 (704 sites) microgram/$meter^3$. EPA also indicated that nationally PM10 concentrations declined by 29 percent between 2001 and 2010 (USEPA 2012). The 2010 PM10 concentrations (second maximum 24-hour) for Charleston, SC was a range from 2 to 54 (488 sites) microgram/$meter^3$.

These values indicate that the air quality in the Charleston, SC is within the National Ambient Air Quality Standards for Ozone, PM2.5, and PM 10.

The State Implementation Plan (SIP) identifies how the State will attain and maintain the primary and secondary National Ambient Air Quality Standards (NAAQS) set forth in Section

109 of the Clean Air Act and 40 CFR 50.4 through 50.12 and which includes federally – enforceable requirements. Each State is required to have a SIP which contains control measures and strategies which demonstrate how each state will attain and maintain the NAAQS. SIP requirements applicable to all areas are provided in Section 110 of the Act. Part D of title I of the Act specifies additional requirements applicable to nonattainment areas, Section 110 and part D describe the elements of a SIP and include, among other things, emission inventories, a monitoring network, an air quality analysis, modeling, attainment demonstrations, enforcement mechanisms, and regulations which have been adopted by the State to attain or maintain NAAQS. EPA has adopted regulatory requirements which spell out the procedures for preparing, adopting and submitting SIPs and SIP revisions that are codified in 40 CFR Part 51

The project is in compliance with Section 176 I of the Clean Air Act (CAA), as amended. Air quality in the project area (Charleston, Berkeley, and Dorchester Counties, South Carolina) is designated as an attainment area. South Carolina has a State Implementation Plan ("SIP") approved or promulgated under Section 110 of the CAA. However, for the following reason, a Conformity Determination is not required:

Section 93.153 (b) states, "For Federal actions not covered by paragraph (a) of this section, a conformity determination is required for each pollutant where the total of direct and indirect emissions in a non-attainment or maintenance area (emphasis added by the writer) caused by a Federal action would equal or exceed any of the rates in paragraphs (b)(1) or (2) of this section." Since the project area has been designated by South Carolina as an attainment area, a Conformity Determination is not required.

Table 7-15 Summary of all Pollutants (Tons/Year) for all Vessels and all Land Based Emissions for the 17 Terminals clearly shows that the air emissions (including Greenhouse Gases, i.e., CO_2) for the existing No Action Alternative depth of -45 foot is greater than the emissions for the LPP -52/48 foot depth in all years from 2027 to 2037. Table 7-15 also depicts the project future condition analysis that the air emissions for the No Action Alternative (-45 foot depth) are significantly greater than the deepened harbor.

Additionally, Table 7-15 indicates that since air toxics are ratios of either VOC or PM10, that the amount of air toxics discharged by the 17 terminals would be greater for the No Action Alternative than for the deepened harbor. There are less air emissions in the deepened harbor because fewer larger vessels (more heavily loaded) would be needed to transport the 4.2 million TEUs than the existing No Action Alternative depth of -45 foot. This does not mean that these larger vessels discharge less air pollutants than smaller vessels because they don't (see EPA 2009). Fewer larger vessels (more heavily loaded) would be needed to transport the 4.2 million TEUs in the deepened harbor than the No Action Alternative.

Since the proposed harbor deepening is not expected to increase the number of vessels or total cargo moving through the port, no decrease in air quality would occur as a result of the project. Increases in air emissions at the port are expected over time as a result of growth in demand for goods that move through the port. With or without the deepening of the harbor, these increases in air emissions at the port may increase. Those increases would be independent of a harbor deepening project and may be reduced by future advances in technology, changes in fuel use, regulatory requirements, and other advancements that may lower emission rates.

Therefore, over the 50 year life of the project (from 2022 to 2072) the proposed deepening of the harbor will not interfere with the area attainment and maintenance of the NAAQS under Section 110 of the Clean Air Act and NAAQS maintenance plan requirements.

Table 7-15 Summary of All Port Emissions for all Alternatives (Tons/year). Note (1) all vessel numbers are provided by CESAC and CESAM.

Alternatives	Year	Vessel Numbers[1]	Depth (ft)	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Baseline	2011	1,902	45	2,843.11	514.77	168.43	263.60	232.19	1,524.84	129,632.43
No-action	2022	2,712	45	2,836.31	655.83	160.77	110.58	102.01	74.53	125,061.51
No-action	2027	3,100	45	2,926.68	758.13	189.98	128.02	117.67	86.14	147,388.23
No-action	2032	3,515	45	3,034.13	859.02	218.44	145.51	133.35	97.21	169,129.63
No-action	2037	3,860	45	3,340.02	939.98	243.22	160.79	147.03	105.87	186,705.95
48/47	2022	2,624	48/47	3,006.98	690.06	161.82	113.97	105.37	93.17	131,364.29
48/47	2027	2,938	48/47	2,857.70	744.75	183.98	125.02	114.95	83.48	141,292.06
48/47	2032	3,270	48/47	2,949.41	839.68	209.69	140.98	129.31	93.35	160,179.24
48/47	2037	3,570	48/47	3,240.77	917.49	233.01	155.46	142.30	101.40	176,276.00
48/48	2022	2,604	48/48	2,998.67	688.81	161.27	113.61	105.08	92.95	130,790.31
48/48	2027	2,951	48/48	2,865.54	746.32	184.69	125.29	115.24	83.84	142,029.31
48/48	2032	3,316	48/48	2,965.34	843.21	211.32	141.88	130.07	94.08	161,875.26
48/48	2037	3,629	48/48	3,260.27	921.78	234.99	156.55	143.24	102.25	178,302.88
50/47	2022	2,620	50/47	3,178.66	722.94	164.85	117.94	109.17	110.39	138,526.35
50/47	2027	2,917	50/47	2,848.90	743.08	183.22	124.61	114.60	83.14	140,509.45
50/47	2032	3,242	50/47	2,935.81	836.89	208.43	140.25	128.63	92.81	158,793.22
50/47	2037	3,524	50/47	3,224.00	913.63	231.25	154.52	141.51	100.59	174,459.11
50/48	2022	2,601	50/48	3,170.32	721.65	164.28	117.59	108.89	110.17	137,953.64
50/48	2027	2,928	50/48	2,856.05	744.54	183.88	124.86	114.86	83.48	141,191.38
50/48	2032	3,283	50/48	2,953.80	840.60	210.14	141.25	129.52	93.55	160,644.72
50/48	2037	3,583	50/48	3,244.12	918.11	233.32	155.66	142.47	101.50	176,580.27
52/47	2022	2,616	52/47	3,311.66	748.38	167.10	121.00	112.11	124.54	143,894.20
52/47	2027	2,909	52/47	2,846.36	742.65	183.01	124.49	114.49	83.05	140,287.78
52/47	2032	3,231	52/47	2,934.70	836.28	208.15	140.20	128.62	92.62	158,562.34
52/47	2037	3,507	52/47	3,217.97	912.26	230.62	154.19	141.22	100.31	173,815.21
52/48	2022	2,597	52/48	3,302.59	747.01	166.50	120.60	111.77	124.32	143,271.63
52/48	2027	2,921	52/48	2,846.08	743.20	183.27	124.28	114.31	83.36	140,434.29
52/48	2032	3,276	52/48	2,939.45	838.68	209.26	140.36	128.68	93.42	159,538.88
52/48	2037	3,567	52/48	3,224.27	915.22	232.01	154.47	141.33	101.22	174,972.80

Ongoing actions that improve air quality - EPA

EPA has issued new standards for diesel fuels that will result in less air pollution. Fuels used in non-road diesel, locomotives, and marine diesel engines transitioned from 5,000 ppm sulfur to 500 ppm in 2007, and to ultra low sulfur diesel (ULSD), which is 15 ppm in 2010.

For trucks calling at the SCSPA Terminals, the 15 ppm ULSD was used throughout the calculations because EPA indicates that the majority of trucks used the ULSD fuel since 2008. For all other equipment, the calculations include the effects of cleaner fuels on engine emission rates as those fuels become common in the Charleston area.

On March 14, 2007, EPA announced new emission standards for locomotives and marine diesel engines. For locomotives, the regulations apply to all diesel line-haul, passenger, and switch locomotives that operate extensively within the US, including new locomotives and re-manufactured locomotives. That would include the locomotives that service the SCSPA Terminals. For marine diesel engines, the regulations apply to new and re-manufactured commercial marine diesel engines above 600 kilowatt (kW) or 800 horsepower (hp) with displacement less than 30 liters per cylinder installed on vessels flagged or registered in the United States. EPA divides marine diesel engines into three categories for the purposes of their standards. Category 1 represents engines up to 7 liters per cylinder displacement. Category 2 includes engines from 7 to 30 liters per cylinder. Finally, Category 3 engines are those at or above 30 liters per cylinder. Category 3 engines are not included in this rule. They are typically used for propulsion on ocean-going vessels (OGV) and will be addressed in a separate EPA rulemaking.

Marine diesel engines covered by EPA's ruling are used in a variety of applications. Commercial propulsion applications range from fishing and tug boats to Great Lakes freighters. Recreational propulsion applications range from sailboats to super-yachts. Auxiliary power units range from small generator sets to large auxiliary engines on ocean-going vessels. This final group would be of most interest to the Port of Charleston. The effect of the ruling will be limited, as the marine engine component only applies to vessels flagged or registered in the United States. Most of the vessels that call at Charleston are registered in another country, so these new standards would not apply to them.

The March 2007 rule consists of three parts. First, there will be new standards for existing locomotives and marine diesel engines when they are remanufactured. They would also apply to newly manufactured locomotives. The standards take effect as soon as certified remanufacture systems are available, as early as 2008. Second, the rule sets near-term emission standards, referred to as Tier 3 standards, for newly-built locomotive and diesel marine engines. These standards reflect the application of currently available technologies to reduce engine emissions of PM and NOx and phase-in starting in 2009. The rule also creates new idle reduction requirements for new and remanufactured locomotives and establishes a new generation of clean switch locomotives, based on clean non-road diesel engine standards. Third, the final long-term emissions standards, referred to as Tier 4, apply to newly-built locomotives and marine diesel engines. These standards are based on the application of high-efficiency catalytic after-treatment technology and would phase-in beginning in 2014 for marine diesel engines and 2015 for locomotives. These standards are enabled by the availability of ultra-low sulfur diesel fuel with sulfur content capped at 15 parts per million. These marine Tier 4 engine standards apply only to commercial marine diesel engines above 600 kW (800 hp).

EPA estimates this final rule will result in PM reductions of about 90 percent and NOx reductions of about 80 percent from engines meeting these standards, compared to engines meeting the current standards. The standards would also yield sizeable reductions in emissions of HC, CO, and other air toxics.

On December 18, 2009, EPA finalized emission standards for new marine diesel engines with per-cylinder displacement at or above 30 liters (called Category 3 marine diesel engines) installed on US vessels. These emission standards are equivalent to those adopted in the amendments to Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL Annex VI). The emission standards apply in two stages—near-term standards for newly built engines will apply beginning in 2011; long-term standards requiring an 80 percent reduction in NOx emissions will begin in 2016. EPA also finalized a change to its diesel fuel program that will allow for the production and sale of 1,000 ppm sulfur fuel for use in Category 3 marine vessels. In addition, the new fuel requirements will generally forbid the production and sale of other fuels above 1,000 ppm sulfur for use in most U.S. waters, unless alternative devices, procedures, or compliance methods are used to achieve equivalent emissions reductions. EPA adopted further provisions under the Act to Prevent Pollution from Ships, especially to apply the emission standards to engines covered by MARPOL Annex VI that are not covered by the Clean Air Act, and to require that these additional engines use the specified fuels (or equivalents).

The final regulations also include technical amendments to EPA's motor vehicle and non-road engine regulations; many of these changes involve minor adjustments or corrections to our recently finalized rule for new non-road spark-ignition engines or adjustment to other regulatory provisions to align with this recent final rule.

According to this new standard, ocean-going vessels (OGV) within 200 miles of the USA are required to comply with the following:

Sulfur fuel standards will change in 2012 to 1% or 10,000 ppm S. In 2015 sulfur content will be reduced to 1,000 ppm or 0.10% sulfur. In 2016 NOx will be 3.0 g/kW-hr, no change in PM and SOx (since low sulfur fuel reduces these two pollutants), HC and CO are 2.0 g/kW-hr and 5.0 g/kW-hr respectively. No standards were developed for CO2.

In 2011, the Pilots in Charleston indicated that OGV are currently using RO. Years 2022, 2027, 2032, and 2037 have been revised to reflect the new US EPA NOx and Sulfur standards.

On January 22, 2010, EPA strengthened the health-based National Ambient Air Quality Standard (NAAQS) for nitrogen dioxide (NO2). The new standard will protect public health, including the health of sensitive populations – people with asthma, children and the elderly. EPA set a new 1-hour NO2 standard at the level of 100 parts per billion (ppb). This level defines the maximum allowable concentration anywhere in an area. It will protect against adverse health effects associated with short-term exposure to NOx, including respiratory effects that can result in admission to a hospital. In addition to establishing an averaging time and level, EPA also set a new "form" for the standard. The form is the air quality statistic used to determine if an area meets the standard. The form for the 1-hour NO2 standard is the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations.

EPA also retained, with no change, the current annual average NO2 standard of 53 ppb. EPA states that this suite of standards will protect public health by limiting people's exposures to short-term peak concentrations of NO2 – which primarily occur near major roads – and by limiting community-wide NO2 concentrations to levels below those that have been linked to respiratory-related emergency department visits and hospital admissions in the United States. To determine compliance with the new standard, EPA established new ambient air monitoring and reporting requirements for NO2. In urban areas, monitors are required near major roads, as well as in other locations where maximum concentrations are expected.

Additional monitors are required in large urban areas to measure the highest concentrations of NO2 that occur more broadly across communities. Working with the States, EPA will site a subset of monitors in locations to help protect communities that are susceptible and vulnerable to NO2-related health effects.

EPA is setting new requirements for the placement of new NO2 monitors in urban areas. These include:

Near Road Monitoring

At least one monitor must be located near a major road in any urban area with a population greater than or equal to 500,000 people. A second monitor is required near another major road in areas with either:

(1) population greater than or equal to 2.5 million people, or
(2) one or more road segment with an annual average daily traffic (AADT) count greater than or equal to 250,000 vehicles.

These NO2 monitors must be placed near those road segments ranked with the highest traffic levels by AADT, with consideration given to fleet mix, congestion patterns, terrain, geographic location, and meteorology in identifying locations where the peak concentrations of NO2 are expected to occur. Monitors must be placed no more than 50 meters (about 164 feet) away from the edge of the nearest traffic lane.

EPA estimates that the new NO2 monitoring requirements will result in a network of approximately 126 NO2 monitoring sites near major roads in 102 urban areas.

Community-Wide Monitoring

A minimum of one monitor must be placed in any urban area with a population greater than or equal to 1 million people to assess community-wide concentrations. An additional 53 monitoring sites will be required to assess community-wide levels in urban areas. Some NO2 monitors already in operation may meet the community-wide monitor siting requirements.

EPA expects to identify or designate areas not meeting the new standard, based on the existing community-wide monitoring network, by January 2012. New monitors must begin operating no later than January 1, 2013. When three years of air quality data are available from the new monitoring network, EPA intends to re-designate areas as appropriate. It may be January 1, 2016, before EPA has the required data to re-designate areas as appropriate.

The US Census Bureau defines the Charleston Metropolitan Statistical Area (MSA) as Charleston, North Charleston, and Summerville, SC. Between 2000 and 2010, the estimated population of the Charleston MSA grew from 293,000 to 334,353 an increase of 14 percent.

According to the South Carolina Department of Transportation (SCDOT) in 2010, no highways in the Charleston MSA had an AADT count greater or equal to 250,000 vehicles (SCDOT 2010).

Ongoing actions that improve air quality – SC State Ports Authority

The Port of New York/New Jersey completed an Emission Inventory Update in 2005 and found that emissions from their Cargo Handling Equipment (CHE) had dropped, even though the fleet had increased by 19 percent, their average operating hours had increased by 5 percent, and the total number of containers handled increased by 25 percent. The reductions were attributed to a modernization of the fleet and lower sulfur fuels. Their 2005 report explains that EPA found that newer engines produce less pollution, and as they replaced their fleet with newer models, the overall pollution levels would decrease. EPA's data is summarized in Table 7-16 as follows:

Table 7-16 NONROAD Emission Factors (Grams/HP-Hr)

Engine Tier	Year of Engine	NOx	PM10
Tier 2	2002 – 2004	4.9	0.15
Tier 1	1996 – 2001	6.9	0.25
Base	Pre-1996	10.9	0.49

NOTE: The Base emissions are estimated

Based on this information, engines manufactured today produce roughly half the NOx and PM10 emissions that engines did which were manufactured before 1996. One could expect similar decreases in emissions from Cargo Handling Equipment (CHE) in Charleston as the terminal operators modernize their equipment and begin to use the cleaner fuels.

Other SCSPA air initiatives include:

1) **Clean Truck Certification Program-** SCSPA requires that every truck that enters the container terminals to certify that it has an engine year of 1994 or newer. This insures that the oldest trucks do not become concentrated around port facilities.
2) **Truck Replacement-** SCSPA receives grants from the SCDHEC and USEPA to replace older diesel trucks with newer, cleaner models.
3) **Electrification and Equipment Upgrades-** SCSPA has upgraded all of the container cranes from diesel to electric power and all of the rubber tired gantry cranes (RTGs) are tier 3 engines or better. All forklifts on SCSPA terminals run on propane fuel. The

agricultural trainload facility was recently converted from tier 0 diesel engines to all electric service at the Wando Welch Terminal.

4) **Clean Construction**- All SCSPA construction contracts include language requiring tier 2 or better engines in all construction equipment.
5) **Clean Fuels**- SCSPA switched to ultra-low sulfur diesel 3 years before the federal mandate and has supported clean fuel standards at the international level for all ocean going vessels.
6) **Air Monitoring**- SCSPA operates real time air monitors at Wando Welch Terminal, Union Pier Terminal, and will soon monitor at the Navy Base Terminal construction site.

Two categories of activities in the Port of Charleston were found to have relatively minor or insignificant amounts of air emissions: Those two consist of (1) Maintenance Dredging performed by the Corps and (2) Tug operations. Those activities do not adversely affect the air quality in project area or at the Port.

The criteria pollutant NOx is emitted in the largest quantities in the port (Table 7-15). This pollutant comprises roughly 58 percent of the quantity of emissions among the criteria pollutants analyzed (HC, VOC, CO, NOx, PM10, PM2.5 and SO2).

Container vessels are the source of most air emissions among the various types of vessels that call at the port (see Figures 7-1 to 7-3). That is to be expected, as the port services more container vessels than any other vessel type.

Most of the air emissions at the Port result from the deep-draft vessels which call there as well as the land based operations (Table 7-15 and Figures 7-1 to 7-10). The tugs which guide those vessels were found to contribute much less pollutants than their land-based support operations. The reason being is that tugs are already using ULSD (15 ppm Sulfur) fuel and are "cold ironed' at the dock. Also the majority of the aerial cranes, CHE, trucks and trains are using ULSD (15 ppm Sulfur) fuel in the Port of Charleston.

It is apparent from the Corps' Fleet Forecast (see Appendix C of the final IFR/EIS), that the numbers of vessels expected to call on the Port of Charleston for years 2022, 2027, 2032, and 2037 will be substantially greater for the No-Action Alternative (-45/45 feet) than the maximum proposed depth of -52/48 feet (see Table7-15). In 2037, for the -45/45 and -52/48 foot depths, the numbers of vessels arriving in Charleston would change from 3860 to 3567 respectively. In 2037, the Fleet Forecast estimates 8% more vessels arriving in Charleston for the existing depth of – 45/45 feet than for the maximum proposed depth of -52/48 foot. More vessels calling on the Port for the existing -45 foot depth during this projected time (i.e., 2022 to 2037) would result in a greater amount of Criteria Pollutants, Air Toxics and Greenhouse Gases being discharged in project area. Those emissions would be reduced by a deeper harbor that would allow a fleet of larger vessels that each carries more cargo. The same cargo volumes could be moved through the port with fewer container ships. The table showing the Summary of all Emissions (i.e., Table 7-15) and mentioned throughout this document show this trend.

For the Land-Based Operations at SCSPA's Terminals (Table 7-3), trucks were found to produce the most air emissions, followed by CHE and trains. The trucks that bring containers to the port and take them to their US destination were found to be approximately 19% of the total NOx port air emissions. Trucks also contributed a larger percentage of CO (25 percent) to the emissions from the terminal (Table 7-3). Train emissions comprise less than 1.5 percent of all air emissions produced by the port.

While container ships are docked and being loaded/unloaded (referred to as Hotelling) at the SCSPA Terminals, they contribute less than 12% of the total emissions of the total port emissions. The emissions while Hotelling represent less than 12% of the emissions from the SCSPA Terminal (vessels, tugs, and landside CHE). With the proposed future EPA reductions in both NOx and Sulfur emissions for containerships, this percentage would be further reduced. Therefore, Hotelling is not a major contributor to the port's emissions.

When new work dredging to deepen the harbor is compared to the EPA 2011 NEI for the project area (Table 7-8), these emissions are less than 1.7 percent of the overall project area emissions. Remember that a large portion of those emissions would occur offshore while deepening the entrance channel and are not likely to contribute to air pollution in the City.

The Corps' calculations of 2011 emissions for the Port (Table 7-6) indicate that the Port when compared to the EPA 2011 NEI was not a substantial contributor of NOx (7.8 percent compared to the EPA 2011 NEI) emissions in the project area (Table 7-6). (It should be noted that some of the emissions the Corps calculated for the Port occur while ships move through the entrance channel located in the ocean east of the coastline.) The Port in 2011 contributes only minor amounts to emissions of SO2 (5.77 percent compared to the EPA 2011 NEI data), PM10 (1.02 percent compared to the EPA 2011 NEI data), PM2.5 (2.05 percent compared to the EPA 2011 NEI data), HC (0.14 percent compared to the EPA 2011 NEI data), VOC (0.14 percent compared to the EPA 2011 NEI data), and CO (0.23 percent compared to the EPA 2011 NEI data).

Emissions of NOx, SO2, and PM10/PM2.5 are likely to decrease as the terminal operators replace their equipment with newer engines that do not emit as much pollution and use the lower sulfur fuels mandated by EPA. The port's contributions to SO2 emissions are expected to decrease as a result of EPA's requirements for use of cleaner fuels. These new standards should substantially reduce SO2 emissions, as the SO2 content in the fuels used by non-road diesel, locomotives, and marine diesel engines transitioned from 500 ppm sulfur in 2007 to ultra low sulfur diesel (ULSD) -- which is 15 ppm -- in 2010. For Ocean-Going Vessels, EPA issued new emission standards in late 2009 for Category 3 marine diesel engines which will require an 80 percent reduction in NOx emissions beginning in 2016. EPA also adopted standards for engines covered by MARPOL Annex VI that require OGV within 200 miles of the US to use fuel with a maximum of 1% Sulfur (10,000 ppm) beginning in 2012 and 0.10% (1,000 ppm) beginning in 2015. Again, the port's contributions of NOx and SO2 emissions in the County should substantially decrease as a result of these new cleaner fuel requirements.

There are at least three ways in which these emissions could be further reduced. (1) The quality of the fuel could be improved. Cleaner fuels would result in lower air emissions. Since the containerships that call at Charleston are engaged in international trade and generally call at several US ports on its round-the-world transit, multi-national treaties may be needed to alter the fuel used by these international trading vessels. Congress and EPA are presently involved in this issue. (2) The second potential method is to reduce the dwell time for each vessel (time it spends at the dock). This is an issue that SCSPA continues to address, as it is a direct reflection of how well it serves its customers by providing quick turn-around times. Increases on cargo handling efficiency would allow reductions in the dwell time and, thereby, the air emissions occurring while at the dock. (3) The third potential method of reducing these emissions is through a process called "cold ironing". This process allows vessels to use electrical power from land while at the dock rather than its on-board auxiliary engines. Currently the Ports of Los Angeles, Long Beach, Oakland, and Seattle are using "cold ironing" at their terminals. Along the east coast, Port Everglades (Miami) is either in the process of looking into or has implemented this alternative.

Comparing the calculated port air toxic emissions for the No-Action Alternative (-45/45 depth) and the LPP (-52/48 depth) alternative to EPA's 2011 air toxic emissions, the Port is not a significant contributor of any air toxics in the project area (Table 7-10). The Port contributes minor amounts (less than or equal to 1%) of the County's totals for air toxics.

For the 50-year project life, the Port does not appear to be a significant emitter of Greenhouse Gases (Table 7-12). Port operations contribute less than a number of industries in the project area (Table 7-7).

More detailed analyses -- such as dispersion analyses to identify "hot spots" of pollution -- could be conducted. However, the Port is not a major contributor to the overall emissions in the project area. When coupled with the dispersed nature of many of those "Port" emissions along the 38-mile length of the navigation channel, the Corps concluded that such additional analyses are not warranted.

Future growth in cargo movements and accompanying air emissions are expected at Charleston. With or without the harbor deepening, these air emissions are expected to grow. Those increases would be the result of increasing demand for the goods which move through the port and not a result of a harbor deepening. Those higher total emission levels in the future would be lessened if larger container vessels are allowed to regularly call at the port. The expected future growth in total emission levels would be substantially reduced by the recently-mandated use of cleaner fuels.

Any of the proposed harbor deepening alternatives would reduce air emission levels in the Port of Charleston from what they would be with the present 45-foot navigation channel. The beneficial effect increases with the amount of deepening. Construction of a deeper channel would result in temporary increases in air emissions. However, since those temporary increases would be distributed along the length of the approximate 38-mile channel -- roughly a third of which is in the ocean on the entrance channel -- the overall effects of a harbor deepening project would be beneficial and not warrant mitigation.

Under both the without and with project conditions, the Corps expects the SCSPA Terminals to reach its build-out capacity near 2037 when the total number of TEUs processed through the terminal reaches 4.2 million. That capacity is the maximum number of containers that could reasonably be processed through the SCSPA Terminals in a year. That determination includes factors such as the size of the terminal, the number of gates that provide access to the property, the number and size of the berths, the number and size of the container cranes, the number of jockey trucks that move the containers within the terminal, how the containers are stacked within the terminal, and the number of railroads that service the terminal and the frequency of their trains. It is anticipated that without deepening, more vessels will be required to transport the cargo that is expected to move through the port. With deepening, the total number of vessels would decrease as vessels would be able to load more deeply under the improved conditions.

No increases in cargo are expected to occur as a result of the proposed harbor deepening. As a result, the project would not affect the number of containers that move through the areas that surround the port. The economic benefits of the project would result from the use of larger, more cost-effective container ships, not an increase in the number of containers. Noise, air emissions (including air toxics), and traffic would not be increased as a result of the proposed deepening. Therefore, the proposed harbor deepening would have no adverse landside impacts.

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ATTACHMENT A SPREADSHEETS CONTAINING ALL CALCULATIONS FOR THE PORT OF CHARLESTON AIR EMISSION INVENTORY[1]

[1] Available upon request