VOLUME III: CHAPTER 12

MARINE VESSEL LOADING, BALLASTING, AND TRANSIT

Revised Final

January 2001

Prepared by:
Eastern Research Group, Inc.

Prepared for:
Area Sources Committee
Emission Inventory Improvement Program

DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

ACKNOWLEDGEMENT

This document was prepared for the Area Sources Committee of the Emission Inventory Improvement Program and for Charles Mann of the Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency. Members of the Area Sources Committee contributing to the preparation of this document are:

Kristin Abraham, West Virginia Department of Environmental Protection
Kwame Agyei, Puget Sound Air Pollution Control Agency
Ray Bishop, Oklahoma Department of Environmental Quality
Dan Brisko, New York State Department of Environmental Conservation
Orlando Cabrera-Rivera, Wisconsin Department of Natural Resources
Andy Delao, California Air Resources Board
Laurel Driver, Emission Factor and Inventory Group, U.S. Environmental Protection Agency
Mark Eastburn, Delaware Department of Natural Resources
Charles Mann, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency
Sally Otterson, Washington Department of Ecology
Kenneth Santlal, Massachusetts Department of Environmental Protection
Walter Simms, Maryland Department of the Environment
Jack Sipple, Delaware Department of Natural Resources and Environmental Control
Karla Smith-Hardison, Texas Natural Resources Conservation Commission
Angel Thompson, South Carolina Department of Health and Environmental Control
Lee Tooly, Emission Factor and Inventory Group, U.S. Environmental Protection Agency

Other reviewers contributing to this document are:

Allen Ellett, BP Oil Company
Rob Ferry, TGB Partnership
Tahir Khan, Chemical Emission Management Services

This page is intentionally left blank.

CONTENTS

CONTENTS (CONTINUED)

Section **Page**

TABLES

This page is intentionally left blank.

1

INTRODUCTION

This chapter is one of a series of documents developed to provide cost-effective, reliable and consistent approaches to estimating emissions for area source inventories. Multiple methods are provided in the chapters to accommodate needs of state agencies with different levels of available resources and skills; and different levels of needs for accuracy and reliability of their estimates. More information about the EIIP program can be found in Volume 1 of the EIIP series, *Introduction and Use of EIIP Guidance for Emissions Inventory Development.*

This chapter describes the procedures and recommended approaches for estimating emissions from marine vessel loading, ballasting, and transit. Section 2 of this chapter contains a general description of marine vessel loading, ballasting, and transit and an overview of available control technologies. Section 3 provides an overview of available emission estimation methods. Section 4 presents the preferred method for estimating emissions from these processes, and Section 5 of this series of documents usually presents alternative emission estimation techniques. For this source category, no alternative methods are known to exist, and Section 5 presents a brief discussion of this issue. Quality assurance issues and emission estimate quality indicators for the methods presented in this chapter are discussed in Section 6. Data coding procedures are discussed in Section 7. Section 8 is the reference section.

Throughout this chapter and other EIIP area source methods chapters, we stress that area source categories should be prioritized by the inventory planners so that resources can be spent on the source categories that are the largest emitters, most likely to be subject to regulations or are already subject to regulations, or require special effort because of some policy reason. Prioritization is particularly important for area source inventories, because in some cases, a difficult to characterize source category may contribute very little to overall emissions and attempting a high quality estimate for that source category may not be cost effective.

EIIP chapters are written for the state and local air pollution agencies, with their input and review. EIIP is a response to EPA's understanding that state and local agency personnel have more knowledge about their inventory area's activities, processes, emissions, and availability of information; and require flexible inventory methods to best use their sometimes limited resources. These EIIP area source chapters are written as a set of options presented to inventory professionals capable of using their own experience and judgement to apply the method that best fits their overall needs and constraints.

This page is intentionally left blank.

2

SOURCE CATEGORY DESCRIPTION

2.1 CATEGORY DESCRIPTION

Petroleum liquids are transported via ships and barges, and on-land transportation. The procedures discussed below relate to evaporative VOC emissions from marine transport of petroleum liquids. This category does not include exhaust emissions from fuel consumed by vessels while in transit or in port. Additional information about petroleum vessels can be found in *AP-42* (EPA, 1995), *AIRS Area and Mobile Source Category Codes* (EPA, 1999), and *Methodologies for Estimating Air Emissions from Three Non-Traditional Source Categories* (EPA, 1993).

2.2 PROCESS DESCRIPTION AND EMISSION SOURCES

In general, "petroleum liquids" include both crude oil and any refined petroleum product. Refined petroleum products conveyed to fuel marketing terminals and petrochemical industries via ships and barges include gasoline, kerosene, distillate oil, residual oil, jet fuel, and other petroleum-derived chemicals such as naphtha, mineral spirits, and asphalt.

For the purposes of this document, petroleum liquids are classified into groups which are represented by crude oil, gasoline, jet naptha, distillate oil/kerosene, or residual oil. Evaporative emissions from marine vessel operations result from three processes: loading, ballasting, and transit. These processes are described in more detail below and in *Methodologies for Estimating Air Emissions from Three Non-Traditional Source Categories*. Although there may be certain ports where loading large marine tankers results in emissions greater than 100 tons per year (tpy) at a given facility, Volatile Organic Compound (VOC) emissions in most ports do not exceed 100 tpy. Methods discussed in this chapter apply to area sources only. Emissions for point source facilities, such as petroleum refineries, should be calculated using more detailed methods. Petroleum vessel loading, ballasting and their associated emissions are typically concentrated in urban coastal areas and ports on inland waterways. Transit emissions are based on the amount of time that the vessel is in an area.

2.2.1 LOADING LOSSES (SHIPS/OCEAN VESSELS AND BARGES)

Loading losses occur as organic vapors in "empty" cargo tanks are displaced to the atmosphere by the liquid being loaded into the tanks. These vapors are a composite of vapors formed in three ways:

- Vapors which are formed in the "empty" tank by evaporation of residual product from previous loads;
- Vapors transferred to the tank from a vapor balance system that was used when the previous load was being unloaded; and
- Vapors generated in the tank as the new product is being loaded.

Loading losses are usually the largest source of evaporative emissions from petroleum vessels (EPA, 1996). This activity usually only occurs at refineries or at the terminal at the end of the pipeline where the product is loaded for distribution. However, petroleum liquids shipped in "super tankers" may be unloaded to barges or smaller ships in a harbor or bay to allow the larger tanker to enter shallower ports. In this situation called "lightering operations", vessel loading emissions occur along with ship transit and ballasting emissions. Barges (compartment depth 10 to 12 feet) exhibit higher emissions levels than ocean vessels which have greater compartment depth (approximately 40 feet).

2.2.2 BALLASTING LOSSES (SHIP/OCEAN VESSELS)

Ballasting losses are associated with the unloading of petroleum liquids at marine terminals and refinery loading docks from vessels which do not have segregated ballast tanks. It is common practice to load several cargo tank compartments with sea water after the cargo has been unloaded. This water, called "ballast," improves the stability of the empty tanker during the subsequent voyage. Ballasting emissions occur as vapor-laden air in the empty cargo tank is displaced to the atmosphere by ballast water being pumped into the tank. More often, the vessel being ballasted will be equipped with segregated ballasting tanks are ballasting will not result in emissions of VOC to the atmosphere. However, if the vessels being ballasted are not equipped with segregated ballasting tanks, then ballasting may range between 15 to 40 percent of the vessels' capacities (EPA, 1996).

2.2.3 TRANSIT LOSSES (SHIP/OCEAN VESSELS AND BARGES)

Transit losses are similar to breathing losses associated with petroleum storage. Transit loss is the expulsion of vapor from a vessel compartment through vapor contraction and expansion, which are the result of changes in temperature and barometric pressure. This loss may be

accompanied by slight changes in the level of the liquid in the tank due to liquid expansion or contraction due to the temperature change. Some ships are equipped with controls for these losses.

2.3 FACTORS INFLUENCING EMISSIONS

VOC emissions from petroleum vessel loading, ballasting, and transit are influenced by several factors. Emissions are a function of the physical and chemical characteristics of both previous and new cargos. Emissions are also a function of the vessel size. Many U.S. harbors are too shallow to receive large tankers. Instead, these tankers must remain outside the harbor area and off-load their cargo to smaller vessels in a process known as lightering. Since most lightering occurs more than 30 miles offshore, emissions from these operations are well dispersed before they reach the land. Lightering operations that occur outside the inventory study area may not need to be included in the inventory. Preparers of inventories should check with policymakers, modelers, or other inventory clients to determine whether it is necessary to include offshore lightering emissions. If lightering emissions do need to be included in an inventory, estimating the potential emissions from loading or ballasting will reflect the same processes as those discussed in Sections 2.2.1 and 2.2.2 of this chapter.

VOC emissions are also a function of the method of vessel loading. In splash loading, the fill pipe dispensing the cargo is lowered only partway into the cargo tank, resulting in higher turbulence during loading and subsequent high levels of vapor generation and loss. On the other hand, in submerged loading, the fill pipe extends almost to the bottom of the cargo tank, thus controlling liquid turbulence, and resulting in much lower vapor generation than encountered during splash loading.

2.4 CONTROL TECHNIQUES

The U.S. Coast Guard administers regulations (33 CFR, Part 157) that apply to all vessels exceeding 150 gross tons and are either documented under U.S. laws or are foreign vessels that transfer cargoes at ports subject to the jurisdiction of the U.S., or otherwise enter or operate in the navigable waters of the United States. The only exceptions are for foreign ships that are simply passing through U.S. waters or are exempt by the Port and Tanker Safety Act, as amended. The Coast Guard rule requires that all affected ships must have segregated ballast tanks, which should eliminate emissions from ballasting for these ships. Vessels unaffected by the regulation should be considered potential sources of ballasting emissions.

Many states require controls on vessel loading. State and local rules should be investigated before collecting other data for this category. Cases exist where companies have agreed to install

controls where none are required by Federal, state or local regulations. Inventory preparers should identify these instances.

Emissions from vessel loading can be controlled through loading practice or through control equipment. Submerged loading, in which the fill pipe opening is below the liquid surface level, reduces liquid turbulence and resulting vapor generation (EPA, 1996). Emissions from splash loading can also be reduced by restricting the loading rate until the fill pipe is submerged. This practice reduces the liquid turbulence during the splash loading portion of the load cycle.[1] When vessel loading is part of a lightering operation, vapor balancing may be used to transfer the vapor from the vessel being loaded to the vessel being unloaded. Emissions from vessel loading may also be controlled at terminals through vapor balance systems or with vapor control systems, such as carbon adsorption, refrigeration, or thermal destruction units.[1]

Controls for emissions from ballasting include using segregated non-contaminated ballast tanks, or placing the ballast between hulls on double-hulled ships (33 CFR, Part 157).

Emissions during transit can be reduced through the use of an inert gas system that maintains an inert gas atmosphere at a slight positive pressure in each tank to minimize emissions and reduce the risk of explosions.[1]

The use of any of these controls within the inventory area should be investigated before emissions are calculated.

[1] Personal communication between Allen Ellet, Senior Environmental Consultant, BP Oil Company, and L. Adams, Eastern Research Group Inc., February 1998.

3

OVERVIEW OF AVAILABLE METHODS

3.1 EMISSION ESTIMATION METHODOLOGIES

This document does not present an alternative method of estimating emissions from marine vessels carrying petroleum liquids. The preferred method can be used for any type of marine vessel, traffic classification, crude oil or refined petroleum product type, and any area of the United States served by marine vessels.

3.1.1 VOLATILE ORGANIC COMPOUNDS

The preferred method for estimating VOC emissions from marine vessel loading, ballasting, and transit is based on estimates of amount and type of products transported to or from the inventory area by waterways as well as the traffic classification (import, domestic, internal upbound, etc.). Fuels and other petroleum liquids transported are classified into five major product types of significantly different densities, vapor pressures, and physical compositions and the types of losses (emission points) expected from a specific operation are determined based on the traffic classification identified above. Inventory preparers with detailed information about the products being handled in their inventory area can use *AP-42* equations for estimation calculations, after activity data has been collected. VOC emissions are estimated by multiplying the throughput by the appropriate emission factors corresponding to the type of loss occurring in a specific traffic classification.

3.1.2 HAZARDOUS AIR POLLUTANTS

Hazardous air pollutant (HAP) emissions from this source are assumed to be proportional to the HAP vapor phase weight concentrations of the petroleum liquid for which the emissions are being calculated.

3.2 DATA NEEDS

3.2.1 DATA ELEMENTS

Several data sources are available on the movement of crude oil and other petroleum products; tonnage shipped and received; and capacities of refineries and bulk terminals at the national, regional, Petroleum Administration for Defense (PAD) District, state and local levels.

The minimum data elements needed to calculate emission estimates for marine vessel loading, ballasting, and transit are as follows:

- Petroleum liquids by traffic classification shipped[1] by type and volume aggregated by vessel type;
- Petroleum liquid by traffic classification received[2] by type and volume aggregated by vessel type;
- Petroleum liquid in transit through inventory area;
- Controls in place for all operations, and control effectiveness;
- Product type within each traffic classification;
- Information on transport situation (i.e., barge loading, ballasting, transit) inferred from the traffic classification; and
- Fraction of transit time spent in inventory area.

Traffic classifications will depend on the data source used. Examples used in this document are based on the publication *Waterborne Commerce of the United States*.[3]

As mentioned in Section 2 of this chapter, regulations administered by the U.S. Coast Guard require that large marine vessels control organic vapors from ballasting through measures such as segregated ballast tanks. As a result, ships affected by this rule do not need to be included in

[1] Traffic classification shipped: Materials classified as shipments or outbound are moved from the subject port to another location.

[2] Traffic classification received: Materials classified as receipts or inbound are moved from another location to the subject port.

[3] The publication can be obtained from the U.S. Army Corps of Engineers, New Orleans District, Waterborne Commerce Statistics Center, P.O. Box 61280, New Orleans, LA, 70161-1280. Tel. 504-862-1400; Waterborne commerce statistics may also be obtained on the internet from the Waterborne Commerce Statistics Center Wide World Web site at http://www.bts.gov/ntda/acewcsc/

estimates of emissions from ballasting. Ballasting emissions from smaller vessels will need to be investigated.

3.2.2 POINT SOURCE CORRECTIONS

Although there are certain ports where handling of crude oil and other petroleum products may result in large emissions, annual VOC emissions at most ports would not exceed 100 tons. As a result, emissions from marine vessel loading and other operations generally should be considered area sources. Some areas may have petroleum refineries where vessel loading operations have been accounted for as point sources. If so, the area source emissions estimating methodology should be designed to not double-count any sources that have been inventoried as point sources.

3.2.3 APPLICATION OF CONTROLS

Control techniques for loading, ballasting and transit are discussed in Section 2.4 of this chapter. Rules will vary by locale and the size of the terminal or vessel. Inventory preparers should investigate the rules in place in the inventory area, and determine if those rules apply to the smaller sources that make up an area source inventory. Air agencies, local port authorities, and marine vessel operators should be contacted about rules that apply in the inventory area. In addition to controls that are put in place because of rules, inventory preparers should identify instances of controls that are not required, but still used.

Air pollution control regulations in Louisiana and Pennsylvania require that marine loading facilities serving ships and/or barges loading crude oil, gasoline, or volatile organic compounds be equipped with a vapor collection system designed to collect the organic compounds vapors displaced from ships and/or barges during loading. The vapors are then processed by recovery and/or destruction systems such that uncontrolled emissions are reduced by at least 90 percent by weight. Pennsylvania air laws also require that by September 28, 1996, a minimum of 65 percent of the total volume of receipt of crude oil and gasoline during a specified period be delivered to a facility in vessels which do not ballast, such as barges, or in vessels which do not emit VOC when ballasted, such as tankers using segregated ballast tanks.

Chapter 1 of this volume, the *Introduction to Area Source Emission Inventory Development*, provides general guidance for determining and applying rule effectiveness (RE) for a source category. In addition, the EPA document *Procedures for Estimating and Applying Rule Effectiveness in Post-1987 Base Year Emission Inventories for Ozone and Carbon Monoxide State Implementation Plans* provides more detailed information on RE (EPA, 1989).

3.2.4 SPATIAL ALLOCATION

The preferred method estimates emissions from loading, ballasting, and transit at the study region level. Emissions from these operations are concentrated in coastal areas, areas surrounding the Great Lakes, and areas adjacent to ports on inland waterways.

3.2.5 TEMPORAL RESOLUTION

Seasonal Apportioning

Some emissions from loading, ballasting, and transit of petroleum liquids from marine vessels are expected to be spread evenly over time, while other emissions will exhibit seasonal variations. Crude oil activities are relatively stable throughout the seasons. However, seasonal variations are expected in gasoline shipments and in those areas where wintertime frozen waters make ports inaccessible, such as the Great Lakes region.

Alternatively, temporal allocation of vessel loading, ballasting, and transit emissions can be accomplished by (1) obtaining detailed monthly activity data for the port in question and applying these data to the estimation equation, or (2) by apportionment factors based on use of the various products. The second method would capitalize on data which should already exist from area/mobile source inventory efforts (e.g., monthly or seasonal allocation of motor fuel; consumption and/or vehicle miles traveled; home heating fuels; aircraft fuels, etc.).

VOC emissions from these marine vessel operations vary due to changes in temperature as well as vapor pressure. Equations are available that account for such variations. However, this source category generally accounts for a relatively small portion of the overall area inventory.

Daily Resolution

Vessel loading and unloading operations are assumed to occur on a daily basis, seven days a week.

3.3 PROJECTING EMISSIONS

The EIIP Projections Committee has developed a series of guidance documents containing information on options for forecasting future emissions. You can refer to these documents at http://www.epa.gov/ttn/chief/eiip/project.htm.

Projecting emissions from petroleum vessel loading, ballasting, and transit requires information on anticipated changes in demand for those products and prices, as well as changes in storage capacity at ports and harbors. If no information is available, the inventorying agency can assume no changes to the existing level of activities. Alternatively, historic activity at the ports in the inventory area would be the best source of data for projecting future vessel activity.

This page is intentionally left blank.

4

PREFERRED METHODS FOR ESTIMATING EMISSIONS

4.1 PREFERRED METHOD

The preferred method for estimating emissions from petroleum vessel loading, ballasting, and transit is described below. This method has limitations because the data that are needed are often not available. The method is intended to produce representative area source emissions estimates without requiring the expenditure of an unreasonable amount of resources to fill information gaps. However, it is recommended that, as a first step, inventory preparers identify controls that are in use in the area, and determine if emissions are primarily inventoried as part of the point source inventory. See Sections 2.4 and 3.2.3 of this chapter for more information about controls. Because some controls may eliminate emissions from certain processes and vessels altogether, data collection can be reduced to only those vessels and processes that are actually creating emissions. The steps of the methodology are as follows:

4.1.1 DETERMINATION OF AMOUNT OF PETROLEUM LIQUIDS TRANSPORTED TO OR FROM THE INVENTORY REGION

Determine the amount and type of petroleum liquids transported to or from the inventory region by waterway. The publication *Waterborne Commerce of the United States*[1] can be used to obtain data on the movements of commodities and vessels at individual ports and harbors and on individual waterways and canals of the United States. Both foreign and domestic commerce are included. Other sources of potentially useful information are the *Petroleum Supply Annual*,[2] *Petroleum Storage and Transportation* (DOE, 1989), publications from the U.S. Maritime

---

[1] The publication can be obtained from the U.S. Army Corps of Engineers, New Orleans District, Waterborne Commerce Statistics Center, P.O. Box 61280, New Orleans, LA, 70161-1280. Tel. 504-862-1400; Waterborne commerce statistics may also be obtained on the internet from the Waterborne Commerce Statistics Center Wide World Web site at http://www.bts.gov/ntda/acewcsc/

[2] The *Petroleum Supply Annual* can be obtained from the Energy Information Administration (EIA), Department of Energy, Washington, DC; refer to the EIA web site at http://www.eia.doe.gov.

Administration (U.S. Maritime Administration, 1985), and the *Petroleum Terminal Encyclopedia*.[3] Estimates of percentage of each fuel type carried by each type of vessel are available from National or Regional Petroleum Administrations for Defense district, or the state.

The New Orleans District Data Request Office of the U.S. Army Corps of Engineers also handles special requests (at a cost), for water commerce statistics such as port- and harbor-specific information regarding shipping and receiving operations. Available data include the following:

- Crude oil and other petroleum products shipped and received at each harbor aggregated by fuel and type of vessel (i.e., tankers versus barges);
- Refinery receipts of crude oil and petroleum products by type of vessel; and
- Refinery shipments of crude oil and petroleum products by type of vessel.

In some cases, only one shipping company ships specific products to and from certain locations. If the Data Request Center were to reveal the tonnage for each product shipped, the Confidential Business Information for that particular company may be compromised. In this situation the Data Request Center prefers to submit the data as lump sum totals without specifying the tonnage to each destination.

4.1.2 IDENTIFICATION OF EMISSION POINTS

Use Table 12.4-1 to identify the emission points for each traffic classification. Determine emission points for all petroleum commodity types. Additional traffic classifications may exist. Classifications listed here represent the most likely emission process assignments. Table 12.4-1 is based on the following assumptions:

- All traffic involves transit emissions;
- Loading (ship, vessel, barge) emissions only result from export, shipment, and outbound traffic;
- Ballasting emissions only result from import and receipts traffic where the return voyage requires balancing;
- Through traffic results only in transit emissions; and

[3] A periodic report from Salsby/Wilson Press, Houston, Texas; also available at http://www.opisnet.com/terminal.htm

- Barge loading emissions result only from exports and shipments traffic in shallower waterways (e.g. internal, lakeside waterways). Inventory preparers should investigate the use of barges and ships in their area.

The emission points presented in Table 12.4-1 are defined based on the traffic type definitions presented in the U.S. Army Corps of Engineers' *Waterborne Commerce of the United States*. Definitions of the traffic classifications can be found in that document. Loading operations (ship/vessel loading and barge loading) occur when the commodity is moved from the subject port to another port or location. Other traffic is assumed to be either traffic that has originated from another port or location and represents an unloading operation, or through traffic that does not stop at the port/waterway. One exception to this rule is intra-port or intra-waterway traffic which is loaded and unloaded in the subject waterway.

Unloading operations do not result in emissions from the vessel itself. Unloading operations only result in emissions counted as part of this source category if ballasting into non-segregated cargo tanks occurs to the vessel being unloaded. Otherwise the emissions that result due to the loading of the receiving tank or truck are counted as the source category covering emissions from loading tanks or trucks. Unless the receiving vessel is another marine vessel, loading of the tank or truck would not be considered marine loading and would not be part of this area source category.

4.1.3 CLASSIFICATION OF PETROLEUM PRODUCTS BY FUEL TYPE

Classify the petroleum liquids transported in the inventory region into five fuel type classifications using Table 12.4-2. If inventory data quality objectives require more detailed emission estimates, the inventory preparer may want to use the equations for calculating emissions from *AP-42*, Section 5.2, Transportation and Marketing of Petroleum Liquids, and portions of *AP-42*, Section 7.1, Liquid Storage Tanks, including Table 7.1-2, Properties of Selected Petroleum Liquids. The equations in *AP-42* require considerably more data collection than the data collection discussed in this chapter. The inventory preparer may want to consider the costs and benefits of using the more detailed approach, and may want to use the *AP-42* equations on a small subset of products that will most make the most significant improvement to the overall estimate, and use the emission factors presented here for the remaining products.

TABLE 12.4-1

EMISSION POINTS FOR PETROLEUM VESSEL TRAFFIC CLASSIFICATIONS

Traffic Classification[a]	Ship/Ocean Vessel Loading	Barge Loading[b,c]	Ballasting[c]	Transit
Foreign Imports			X	X
Foreign Exports	X			X
Foreign Intratransit Merchandise				X
Foreign Through Upbound				X
Foreign Through Downbound				X
Canadian Exports	X[d]	X[d]		X
Canadian Imports			X[d]	X
Canadian Through Upbound				X
Canadian Through Downbound				X
Coastwise Receipts			X	X
Coastwise Shipments	X			X
Coastwise Through Upbound				X
Coastwise Through Downbound				X
Lakewise Receipts			X	X
Lakewise Shipments		X		X
Internal Receipts			X	X
Internal Shipments		X		X
Internal Inbound Upbound			X	X
Internal Inbound Downbound			X	X
Internal Outbound Upbound		X		X
Internal Outbound Downbound		X		X
Internal through Upbound				X
Internal through Downbound				X
Internal Intra-waterway Upbound		X	X	X
Internal Intra-waterway Downbound		X	X	X
Internal Intraport		X	X	X
Intra-territory Shipments		X		X
Intra-territory Receipts			X	X

[a] These classifications are used in the *Waterborne Commerce of the United States*, U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, New Orleans, LA.
[b] Barges may not be used at all ports by the indicated traffic classification.
[c] Inventory preparers should research ballasting practices in their area to identify the traffic classifications where ballasting actually occurs.
[d] Inventory preparers should research the use of barges and ships in their area.

TABLE 12.4-2

PRODUCT TYPE CLASSIFICATIONS FOR COMMON PETROLEUM VESSEL COMMODITIES[a]

Petroleum Vessel Commodity	Product Type Classification
Crude petroleum	Crude oil
Gasoline	Gasoline
Kerosene	Distillate oil
Distillate fuel oil	Distillate oil
Residual fuel oil	Residual oil
Lube oil and greases	Distillate oil
Petro. jelly and waxes	Distillate oil
Naphtha and solvents	Jet naphtha
Asphalt, tar, and pitch	Residual oil
Petroleum coke	Residual oil
Liquid natural gas	Gasoline
Petroleum products not elsewhere classified	Jet naphtha

[a] These classifications were determined by approximately matching the density, vapor pressure, and physical composition of the commodities to the five product types. The product types match available AP-42 emission factors.

An example of how data from the *Waterborne Commerce* document can be compiled for one large waterway is shown in Example 12.4-1.

Example 12.4-1:

Data from Example Area A, an area where large amounts of petroleum liquids are handled, is listed in Appendix A as it is provided in the *Waterborne Commerce of the United States*. Shipments and receipts of commodities are listed by product type and traffic classification. Definitions of traffic classifications can be found in the *Waterborne Commerce* document. For an area source inventory, the information needs to be compiled first by traffic classifications representing similar processes, and then by product types that can be linked to existing emission factors. For this example, these steps are accomplished using a spreadsheet. The first step, shown in Table 12.4-3, is to enter the data into the spreadsheet so it can be sorted by traffic classification and product type.

Table 12.4-4 shows the data further combined into groups based on traffic classification and sorted by product types that will match *AP-42* emission factors. Table 12.4-1 can be used to match traffic classifications and AP-42 processes, e.g. ship loading or barge loading. Note that based on local information, only foreign and Canadian and coastwise receipt categories were subject to ballasting.

4.1.4 ESTIMATION OF TRANSIT EMISSIONS

For transit emissions, estimate the average time traffic is in the inventory area. Specific data may be difficult to obtain. The best resource for this information may be the local port authorities.

4.1.5 CORRECTION FOR POINT SOURCE EMISSIONS

It is possible for some marine loading operations, such as those at large petroleum refineries operating their own port, to be included in point source inventories. To make the double-counting correction, the material throughputs from specific point source SCCs should be totaled and subtracted from the total area source material transferred. Area source emissions should then be estimated based on this corrected material transferred amount.

If the point source material throughputs are not available, the correction can be made at the emissions level (subtract total emissions from specific point source SCCs from total area source emissions). Emissions from vessel loading/unloading operations at facilities such as petroleum refineries located in the inventory area should be deducted from the area source totals. Point source SCCs may include 40600231 through 40600259. Additional point source SCCs may exist, so the point source inventory should be carefully reviewed.

TABLE 12.4-3

EXAMPLE SPREADSHEET FOR AREA A[a]

Product Code	Commodity Name	AP-42 Product Type Class	Foreign & Canadian Total	Foreign & Canadian Imports	Foreign & Canadian Exports	Coastwise Total	Coastwise Receipts	Coastwise Shipments	Coastwise Through	Internal Total	Internal Inbound	Internal Outbound	Internal Through	Internal Intra
2100	Crude Petroleum	Crude	38,744	38,744	0	75	72	4	0	5,654	841	575	4,205	33
2211	Gasoline	Gasoline	518	0	518	1,654	21	1,633	0	5,294	626	940	3,536	192
2221	Kerosene	Distillate	0	0	0	0	0	0	0	290	0	131	159	0
2330	Distillate Fuel Oil	Distillate	20	12	8	322	83	239	0	4,494	570	1,398	2,484	72
2340	Residual Fuel Oil	Residual	232	72	160	144	59	85	0	5,613	541	1,947	2,920	205
2350	Lube Oil & Grease	Distillate	737	690	47	570	256	314	0	1,112	27	356	726	3
2410	Petro Jelly & Waxes	Distillate	0	0	0	0	0	0	0	56	0	0	56	0
2429	Naphtha & Solvents	Jet Naphtha	177	155	22	27	27	0	0	2,119	421	373	1,109	216
2430	Asphalt, Tar & Pitch	Residual	43	2	41	19	0	0	19	1,075	14	23	1,038	0
2540	Petroleum Coke	Residual	3,676	241	3,435	0	0	0	0	776	446	64	261	4
2640	Liquid Natural Gas	Gasoline	158	131	27	0	0	0	0	552	239	55	255	4
2990	Petroleum Prod, NEC	Jet Naphtha	0	0	0	7	0	7	0	624	101	226	284	15

[a] All commodity amounts in one thousand tons

TABLE 12.4-4

PROCESS/ PRODUCT CATEGORIES[a]

AP-42 Product Type Class	Product Code	Commodity Name	Ship loading		Barge Loading		Ballasting		Transit		
			Foreign & Canadian Exports	Coastwise Shipments	Internal Outbound	Internal Intra	Foreign & Canadian Imports	Coastwise Receipts	Foreign & Canadian Total	Coastwise Total	Internal Total
Crude	2100	Crude Petroleum	0	4	575	33	38,744	72	38,744	75	5,654
Distillate	2330	Distillate Fuel Oil	8	239	1,398	72	12	83	20	322	4,494
Distillate	2350	Lube Oil & Grease	47	314	356	3	690	256	737	570	1,112
Distillate	2221	Kerosene	0	0	131	0	0	0	0	0	290
Distillate	2410	Petroleum Jelly and Waxes	0	0	0	0	0	0	0	0	56
Gasoline	2640	Liquid Natural Gas	27	0	55	4	131	0	158	0	552
Gasoline	2211	Gasoline	518	1,633	940	192	0	21	518	1,654	5,294
Jet Naphtha	2990	Petroleum Prod., NEC	0	7	226	15	0	0	0	7	624
Jet Naphtha	2429	Naphtha & Solvents	22	0	373	216	155	27	177	27	2,119
Residual	2340	Residual Fuel Oil	160	85	1,947	205	72	59	232	144	5,613
Residual	2430	Asphalt, Tar and Pitch	41	0	23	0	2	0	43	19	1,075
Residual	2540	Petroleum Coke	3,435	0	64	4	241	0	3,676	0	776

[a] All commodity amounts in one thousand tons

4.1.6 ESTIMATION OF EMISSIONS FROM PETROLEUM VESSELS

Use the estimates of petroleum liquids, grouped by traffic classification and sorted by product types, and the emission factors in Table 12.4-5 to estimate total VOC emissions from petroleum vessels for each of the five types of petroleum liquids (p) at each emission point. It should be noted that these factors are for dispensed product at 60°F and can be adjusted for significantly different conditions using original derivation methods in *AP-42*. It should also be noted that some emission factors may not apply to a particular port, e.g., barge loading or ballasting, may not take place.

In Section 2.2.2 of this chapter, ballasting practices are discussed. If ballasting only occurs using segregated ballast tanks, it is not necessary to estimate ballasting emissions. However, if ballasting uses the empty cargo tank, emissions will occur, and must be calculated. Note that the calculation for ballasting emissions in the equation includes a correction term of 0.30. This correction term reflects the practice of loading a ship or barge at some fraction of capacity when ballasting. Emission estimates will be improved if local information about typical percentages can be located and used. The correction term presented here represents a conservative assumption.

Apply any control efficiency to the appropriate terms in Equation 12.4-1, or Equation 12.4-2 can be used to apply control efficiency.

$$PV_p = [(SOEF_p \times PP_{S,p}) + (BREF_p \times PP_{B,p}) + (BLEF_{p,U} \times 0.30 \times PP_{BL,p}) + (TREF_p \times PP_{T,p})] \div 2000 \quad (12.4\text{-}1)$$

where:

PV_p = Total VOC emissions from petroleum vessel loading, ballasting, and transit for each of the petroleum liquids (p) transported: crude oil, gasoline, kerosene, distillate oil, and residual oil (tons)

SOEFp = Ship/ocean vessel loading emission factor (pounds VOC per 1,000 gallons transferred)

$PP_{S,p}$ = Amount of petroleum liquid (p) loaded into ships and ocean vessels in the inventory region (1,000 gallons)

$BREF_p$ = Barge vessel loading emission factor (pounds VOC per 1,000 gallons transferred)

$PP_{B,p}$ = Amount of petroleum liquid (p) loaded into barges in the inventory region (1,000 gallons)

$BLEF_p$ = Ballasting emission factor (pounds VOC per 1,000 gallons water ballasted)

$PP_{BL,p}$ = Amount of petroleum liquid (p) unloaded from vessels that are ballasted (1,000 gallons)

$TREF_p$ = Vessel transit emission factor (pounds VOC per week per 1,000 gallons transferred)

$PP_{T,p}$ = Amount of petroleum liquid (p) transported by marine vessels in the inventory region (1,000 gallons)

TABLE 12.4-5

UNCONTROLLED VOC EMISSION FACTORS FOR PETROLEUM CARRYING MARINE VESSELS (EPA, 1996)

Petroleum Liquid	Ship/Ocean Vessel Loading (Pounds VOC per 1,000 gallons Transferred)	Barge Loading (Pounds VOC per 1,000 gallons Transferred)	Ballasting (Pounds VOC per 1,000 gallons Ballasted)[a]	Transit (Pounds VOC per week per 1,000 gallons Transported)
Crude Oil	0.61	1	1.1[b]	1.3
Gasoline[b]	1.8[b]	3.4[b]	0.8[b]	2.7[b]
Jet Naphtha/ Other	0.5	1.2	NA	0.7
Distillate Oil/Kerosene	0.005	0.012	NA	0.005
Residual Oil	4×10^{-5}	9×10^{-5}	NA	3×10^{-5}

[a] It may not be necessary to estimate ballasting emissions. See Section 3, of this chapter, Data Elements for discussion.
[b] These are *AP-42* "typical overall situation" factors; various additional factors related to specific types of service can be found in *AP-42*. In addition, AP-42 equations could be used, if necessary, to calculate emission factors for specific compounds, given values for true vapor pressures and average liquid molecular weights.

If controls exist, then control efficiency can be calculated:

$$PP_C = PP_U * (1 - CE/100) \quad (12.4\text{-}2)$$

where:

PP_C = Controlled emissions (tons)
PP_U = Uncontrolled emissions (tons)
CE = Control efficiency (%)

Data obtained from sources such as the *Waterborne Commerce of the United States* are typically provided in terms other than 1,000 gallons (Mgal) as is required in Equation 12.4-1 and must be converted. Equation 12.4-3 can be used to convert units from 1,000 ton (Mtons) to Mgal.

$$PP_V = (PP_m/d) * 2{,}000 \text{ lb/ton} * \text{Mgal}/1{,}000 \text{ gallons} * 1{,}000 \text{ tons/Mtons} \quad (12.4\text{-}3)$$

where:

PP_v	=	Amount of petroleum liquid (Mgal)
PP_m	=	Amount of petroleum liquid (Mtons)
d	=	Density of petroleum liquid; see Table 7.1-2 in AP-42 (lb/gallon)

Example 12.4-2 illustrates the calculations used to estimate emissions from tons of fuel.

Example 12.4-2

The inventory area had an annual throughput of gasoline from vessel loading, barge loading, and transit operations as indicated below:

Operation	Throughput (1,000 tons)
Vessel loading	2,178
Barge loading	1,191
Ballasting	152
Transit	8,176

Using the gasoline density factor found in AP-42, Table 7.1-2 (5.6 lb/gal), and Equation 12.4-3, the mass throughputs are converted to volumetric throughputs. Vessels loading throughputs are converted by:

$$PP_v = [2{,}178 \text{ Mtons}/(5.6 \text{ lb/gal})] * \frac{2{,}000 \text{ lb}}{\text{ton}} * \frac{\text{Mgal}}{1{,}000 \text{ gal}} * \frac{1{,}000 \text{ tons}}{\text{Mtons}}$$

The results of the calculation are shown below:

Conversion of Mass Throughputs to Volumetric Throughputs			
Operation	**Equation 12.4-1 Parameter**	**Throughput (Mtons)**	**Throughput (Mgal)**
Vessel loading	$PP_{S,gas}$	2,178	777,857
Barge loading	$PP_{B,gas}$	1,191	425,357
Ballasting	$PP_{BL,gas}$	1,213	54,286
Transit	$PP_{T,gas}$	8,176	2,920,000

Example 12.4-2 (Continued)

For vessel loading operations, 90 percent of the total throughput was loaded at terminals with a control system of 95 percent efficiency. According to the local port authorities, transit time in the inventory area is two days (2/7 of a week). Emissions for each emission point are calculated using Equation 12.4-1 and the emission factors from Table 12.4-5. In this example, emissions for each emission point are calculated separately and then totaled. Note that CE is applied to vessel loading emissions, and transit emissions are apportioned to two days per week by multiplying emissions by 2/7.

Vessel Loading emissions are calculated:

$$PV_{gas} = [1.8 \text{ lb VOC/Mgal} * 777{,}857 \text{ Mgal/yr}) * (0.10 + (0.9 * \left(1 - \frac{95}{100}\right)] \div 2{,}000 \text{ lb/ton}$$

$$= 102 \text{ tons/yr}$$

Barge Loading emissions are calculated:

$$PV_{gas} = [3.4 \text{ lb VOC/Mgal} * 425{,}357 \text{ Mgal/yr})] \div 2{,}000 \text{ lb/ton}$$

$$= 723 \text{ tons/yr}$$

Ballasting emissions are calculated:

$$PV_{gas} = [0.8 \text{ lb VOC/Mgal} * 54{,}286 \text{ Mgal/yr}) * 0.30] \div 2{,}000 \text{ lb/ton}$$

$$= 7 \text{ tons/yr}$$

Transit emissions are calculated:

$$PV_{gas} = (2.7 \text{ lb VOC/Mgal} * 2{,}920{,}000 \text{ Mgal/yr} * 2/7 \text{ wk}) \div 2{,}000 \text{ lb/ton}$$

$$= 1{,}128 \text{ tons/yr}$$

Example 12.4-2 (Continued)

Total VOC emissions are calculated as follows:

$$\text{Total VOC} = 102 \text{ tons/yr} + 723 \text{ tons/yr} + 7 \text{ tons/yr} + 1{,}128 \text{ tons/yr}$$

$$= 1{,}957 \text{ tons/yr}$$

Contributions from the point source inventory are 82 tons/yr VOC. The total VOC emissions in the area source inventory are:

$$1{,}957 \text{ tons/yr} - 82 \text{ tons/yr} = 1{,}875 \text{ tons/yr}$$

5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

No alternative methods are known to exist, nor are any necessary since the preferred method and data associated with it can be used for any type of vessel, any type of traffic, any type of fuel, and any area of the United States serviced by petroleum vessels.

This page is intentionally left blank.

6

QUALITY ASSURANCE/ QUALITY CONTROL

Data collection and handling for the marine vessel loading, ballasting, and transit source category should be planned and documented in the Quality Assurance Plan. In particular, material type assignments and emission estimation calculations should be reviewed as part of the QA/QC procedures. Refer to the discussion of inventory planning and QA/QC in Chapter 1, *Introduction to Area Source Emission Inventory Development*, of this volume, and the QA volume (VI) of the EIIP series.

6.1 EMISSION ESTIMATE QUALITY INDICATORS

One method is provided in this chapter for estimating emissions from marine vessel loading, ballasting, and transit. Data collection for this source category involves identifying the most suitable data source from those listed in Section 4 of this chapter, and compiling the information. Although data collection for this category can require a significant amount of effort, the quality of the activity data is high, and the effort required may be justified by the importance of the estimated emissions in areas where there is a significant amount of marine vessel loading, ballasting, and transit.

6.1.1 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

The Data Attribute Rating System (DARS) has been developed as a tool to rate emission inventories. A description of the system and the EIIP recommendations for its use can be found in Appendix F of EIIP Volume VI, *Quality Assurance Procedures.* The following discussion uses the DARS rating system as a way to compare the estimation approaches presented in this chapter and analyze their strengths and weaknesses.

The DARS scores for the preferred method are summarized in Table 12.6-1. A range of scores is provided to account for differences in the implementation of the method. Lower activity scores are shown for activity data that are not drawn from records collected specifically for the inventory area. This would be the case if specific product data are not available for the inventory area and the tonnage of each product loaded or unloaded in the inventory area must be apportioned from regional data. Higher DARS scores than those assigned in Table 12.6-1 could

be assigned if the equations from AP-42 are used, rather than emission factors that have been derived from the equations.

Lower emission factor scores reflect the necessary simplifications that must be made for an area source method. The first simplification is the use of emission factors developed from the equations provided in *AP-42*. Assumptions have been made concerning the fuel type vapor pressure and the molecular weight of vapors, which are addressed in the source specificity score, and average annual temperature, which is addressed in the spatial congruity score. The emission factor measurement scores will vary depending on whether the product is actually the product type for which the emission factor was developed, or a similar product that has been grouped into that product classification (see Table 12.4-1). Variability in local practices affect the spatial congruity score. Seasonal temperature differences and potential changes in equipment and filling practices since the latest update of the emission equations and parameters in *AP-42* affect the temporal congruity score.

TABLE 12.6-1

PREFERRED METHOD: DARS SCORES

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.3 - 0.5	0.9	0.27 - 0.45
Source Specificity	0.7 - 0.9	0.7 - 0.9	0.49 - 0.81
Spatial Congruity	0.5	0.7 - 1.0	0.35 - 0.5
Temporal Congruity	0.5	0.9 - 1.0	0.45 - 0.5
Composite Scores	0.5 - 0.6	0.80 - 0.95	0.39 - 0.57

6.1.2 SOURCES OF UNCERTAINTY

There are several sources of uncertainty in estimating emissions from this source category. When the method provided in this chapter is used, activity data are collected, the data may be apportioned to reflect activity in the inventory area, and amounts of some materials are grouped with similar material types into product classifications. Each of these steps will have some associated uncertainty, and the uncertainty cannot be quantified.

An additional source of uncertainty comes from using emission factors rather than equations that use a number of parameters. In this case, the sensitivity of the equations to different parameters could be quantified using typical sensitivity analysis techniques.

This page is intentionally left blank.

7

DATA CODING PROCEDURES

The inventory preparer should check the EPA website (http://www.epa.gov/ttn/chief/) for the latest information (codes) available to characterize emission estimates from marine vessel loading, ballasting, and transit. A complete list of Source Classification Codes (SCC) can be retrieved at http://www.epa.gov/ttn/chief/codes/. Table 12.7-1 lists the applicable SCCs for marine vessel loading, ballasting, and transit.

Available codes and process definitions influence and help guide the preparation of emission estimates for this category. Data transfer formats should be taken into account when an inventory preparer plans for data collection, calculation, and inventory presentation. Consistent categorization and coding will result in greater continuity between emission inventories for use in regional and national scale analyses.

7.1 NECESSARY DATA ELEMENTS

If the category emissions data will be transferred to EPA for incorporation into the national criteria and toxics air pollutant inventory, specific data transfer formats are acceptable. The acceptable data transfer format(s) are described and available for download at http://www.epa.gov/ttn/chief/net/. The acceptable data transfer formats contain the data elements necessary to complete the data set for use in regional or national air quality and human exposure modeling. The inventory preparer should review the area source portion of the acceptable file format(s) to understand the necessary data elements. The EPA describes its use and processing of the data for purposes of completing the national inventory, in its Data Incorporation Plan, also located at http://www.epa.gov/ttn/chief/net/.

TABLE 12.7-1

AREA AND MOBILE SOURCE CATEGORY CODES FOR MARINE VESSEL LOADING, BALLASTING AND TRANSIT

Process Description	Source Category Code
Gasoline: Ship Loading -Cleaned and Vapor Free Tanks	40-60-002-31
Gasoline: Ocean Barges Loading	40-60-002-32
Gasoline: Barge Loading - Cleaned and Vapor Free Tanks	40-60-002-33
Gasoline: Ship Loading - Ballasted Tank	40-60-002-34
Gasoline: Ocean Barges Loading - Ballasted Tank	40-60-002-35
Gasoline: Ship Loading -Uncleaned Tanks	40-60-002-36
Gasoline: Ocean Barge Loading - Uncleaned Tanks	40-60-002-37
Gasoline: Barge Loading - Uncleaned Tanks	40-60-002-38
Gasoline: Tanker Ship - Ballasted Tank Condition	40-60-002-39
Gasoline: Barge Loading - Average Tank Condition	40-60-002-40
Gasoline: Tanker Ship - Ballasting	40-60-002-41
Crude Oil: Loading Tankers	40-60-002-43
Jet Fuel: Loading Tankers	40-60-002-44
Kerosene: Loading Tankers	40-60-002-45
Distillate Oil: Loading Tankers	40-60-002-46
Crude Oil: Loading Barges	40-60-002-48
Jet Fuel: Loading Barges	40-60-002-49
Kerosene: Loading Barges	40-60-002-50
Distillate Oil: Loading Barges	40-60-002-51
Crude Oil: Tanker Ballasting	40-60-002-53
Tanker/Barge Cleaning	40-60-002-59
Gasoline: Barge Loading - Ballasted	40-60-002-60
Not Classified	40-60-002-98
Not Classified	40-60-002-99

8

REFERENCES

EPA. 1995. *Compilation of Air Pollution Emission Factors - Volume 1: Stationary Point and Area Sources. Fifth Edition*, Supplements A-F, *AP-42*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. (GPO 055-000-00251-7). Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/)

EPA. 1993. *Methodologies for Estimating Air Emissions from Three Non-Traditional Source Categories: Oil Spills, Petroleum Vessel Loading and Unloading, and Cooling Towers*. U.S. Environmental Protection Agency, Office of Research and Development. EPA-600/R-93-063 (NTIS PB93-181592). Washington, DC.

EPA. 1999. *AIRS Point, Area, and Mobile Source Category Codes*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/scccodes.html)

EPA. 1989. *Procedures for Estimating and Applying Rule Effectiveness in Post-1987 Base Year Emission Inventories for Ozone and Carbon Monoxide State Implementation Plans*. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina.

DOE. 1989. *Petroleum Storage and Transportation, Volume II: System Dynamics*. Nation Petroleum Council, U.S. Department of Energy. Washington, DC.

U.S. Maritime Administration. 1985. *Domestic Waterborne Trade of the U.S.* U.S. Maritime Administration, Office of Domestic Shipping. Washington, DC.

This page is intentionally left blank.

Appendix A

Example Waterborne Commerce Data

Section Included: Gulf of Mexico to turning basins at West Port Arthur, Beaumont, and Orange, TX, about 85.8 miles; Adams Bayou Channel, about 1.6 miles; and Cow Bayou Channel, about 7 miles. Controlling Depth: Sabine Pass Channel, TX, 40 feet; Port Arthur, TX, 37 feet; Beaumont, TX, 39 feet; extension to Bethlehem Steel Shipyard, 32 feet; Orange, TX, 27 feet except channel around Harbor Island, 20 feet; Adams Bayou Channel, 9 feet; and Cow Bayou Channel, 8 feet. Project Depth: Sabine Pass Harbor, TX, 40 to 42 feet; Port Arthur, TX, 40 feet; Beaumont,TX, 40 feet except turning basin, 34 feet, and extension to Bethlehem Steel Shipyard, 30 feet; Orange, TX, 30 feet except channel around Harbor Island, 25 feet, Adams Bayou, 12 feet, and Cow Bayou, 13 feet, mean low tide.

Comparative Statement of Traffic
(thousand tons)

Year	Total	Year	Total
1986	75,943	1991	84,213
1987	79,742	1992	88,348
1988	89,091	1993	95,191
1989	96,564	1994	99,675
1990	90,819	**1995**	**103,254**

Freight Traffic, 1995
(thousand tons)

Commodity		Total	Foreign		Canadian	
			Imports	Exports	Imports	Exports
Total, all commodities		**49,124**	**40,724**	**8,178**	**167**	**55**
Total petroleum and petroleum products		**44,305**	**39,886**	**4,203**	**161**	**55**
Subtotal crude petroleum		**38,744**	**38,583**	----------	**161**	----------
2100	crude petroleum	38,744	38,583	----------	161	----------
Subtotal petroleum products		**5,562**	**1,303**	**4,203**	----------	**55**
2211	gasoline	518	----------	518	----------	----------
2330	distillate fuel oil	21	12	8	----------	----------
2340	residual fuel oil	232	72	160	----------	----------
2350	lube oil & greases	737	690	47	----------	----------
2429	naphtha & solvents	177	155	22	----------	----------
2430	asphalt, tar & pitch	43	2	41	----------	----------
2540	petroleum coke	3,676	241	3,380	----------	55
2640	liquid natural gas	158	131	27	----------	----------
Total chemicals and related products		**757**	**33**	**724**	----------	----------
Subtotal fertilizers		**12**	----------	**12**	----------	----------
3190	fert. & mixes nec	12	----------	12	----------	----------
Subtotal other chemicals and related products		**745**	**33**	**712**	----------	----------
3211	acyclic hydrocarbons	26	22	4	----------	----------
3212	benzene & toluene	44	----------	44	----------	----------
3219	other hydrocarbons	104	4	100	----------	----------
3220	alcohols	103	3	100	----------	----------
3240	nitrogen func. comp	10	----------	10	----------	----------
3260	organic comp. nec	25	3	22	----------	----------
3275	inorg. elem., oxides, & halogen salts	0	0	----------	----------	----------
3276	metallic salts	430	----------	430	----------	----------
3281	radioactive material	0	0	----------	----------	----------
3282	pigments & paints	0	----------	0	----------	----------
3285	perfumes and cleansers	0	----------	0	----------	----------
3286	plastics	0	0	0	----------	----------
3291	pesticides	0	----------	0	----------	----------
3297	chemical additives	1	----------	1	----------	----------
3298	wood & resin chem.	0	0	0	----------	----------

Commodity		Total	Foreign		Canadian	
			Imports	Exports	Imports	Exports
Total crude materials, inedible except fuels		**727**	**441**	**286**	----------	----------
	Subtotal forest products, wood and chips	**231**	**6**	**224**	----------	----------
4161	wood chips	224	----------	224	----------	----------
4170	wood in the rough	0	0	----------	----------	----------
4189	lumber	6	6	0	----------	----------
	Subtotal pulp and waste paper	**62**	----------	**62**	----------	----------
4225	pulp & waste paper	62	----------	62	----------	----------
	Subtotal soil, sand, gravel, rock and stone	**432**	**432**	----------	----------	----------
4322	limestone	30	30	----------	----------	----------
4331	sand & gravel	402	402	----------	----------	----------
Subtotal iron ore and scrap		**2**	**2**	----------	----------	----------
4420	iron & steel scrap	2	2	----------	----------	----------
	Subtotal non-ferrous ores and scrap	**0**	**0**	----------	----------	----------
4680	non-ferrous scrap	0	0	----------	----------	----------
	Subtotal other non-metal. min.	**0**	----------	**0**	----------	----------
4900	non-metal. min. nec	0	----------	0	----------	----------
	Total primary manufactured goods	**549**	**333**	**211**	**6**	----------
	Subtotal paper products	**22**	**0**	**21**	----------	----------
5120	paper & paperboard	21	0	21	----------	----------
5190	paper products nec	0	0	0	----------	----------
	Subtotal lime, cement and glass	**2**	**0**	**1**	----------	----------
5290	misc. mineral prod.	2	0	1		----------
	Subtotal primary iron and steel products	**313**	**304**	**4**	**6**	----------
5312	pig iron	2	1	0	----------	----------
5320	i&s primary forms	262	256	----------	6	----------
5330	i&s plates & sheets	1	1	----------	----------	----------
5360	i&s bars & shapes	3	----------	3	----------	----------
5370	i&s pipe & tube	1	0	1	----------	----------
5390	primary i&s nec	45	45	----------	----------	----------
	Subtotal primary non-ferrous metal products	**2**	**1**	**1**	----------	----------
5422	aluminum	1	**1**	0	----------	----------
5429	smelted prod. nec	0	----------	0	----------	----------
5480	fab. metal products	1	**0**	1		
	Subtotal primary wood products	**211**	**27**	**183**	----------	----------
5540	primary wood prod.	211	27	183	----------	----------
	Total food and farm products	**2,778**	**30**	**2,748**	----------	----------
	Subtotal grain	**1,733**	----------	**1,733**	----------	----------
6241	wheat	1,486	----------	1,486	----------	----------
6344	corn	0	----------	0	----------	----------
6442	rice	20	----------	20	----------	----------
6447	sorghum grains	227	----------	227	----------	----------
	Subtotal oilseeds	**513**	----------	**513**	----------	----------
6522	soybeans	513	----------	513	----------	----------
6590	oilseeds nec	0	----------	0	----------	----------
	Subtotal vegetable products	**15**	----------	**15**	----------	----------
6653	vegetable oils	1	----------	1	----------	----------
6654	vegetables & prod.	14	----------	14	----------	----------

Commodity		Total	Foreign		Canadian	
			Imports	Exports	Imports	Exports
Subtotal processed grain and animal feed		**507**	**27**	**480**	----------	----------
6746	wheat flour	385	----------	385	----------	----------
6747	grain mill products	95	----------	95	----------	----------
6782	animal feed, prep.	27	27	----------	----------	----------
Subtotal other agricultural products		**11**	**3**	**7**	----------	----------
6858	fruit juices	0	0	0	----------	----------
6871	coffee	3	3	----------	----------	----------
6885	alcoholic beverages	0	----------	0	----------	----------
6889	food products nec	8	1	7	----------	----------
6893	cotton	0	----------	0	----------	----------
Total all manufactured equipment, machinery and products		**8**	**2**	**6**	----------	----------
7110	Machinery (not elec)	3	1	2	----------	----------
7120	electrical machinery	3	0	2	----------	----------
7210	vehicles & parts	0	0	0	----------	----------
7220	air craft & parts	0	----------	0	----------	----------
7230	ships & boats	1	----------	1	----------	----------
7400	manufac. wood prod.	0	0	----------	----------	----------
7500	textile products	0	0	0	----------	----------
7600	rubber & plastic pr.	0	0	0	----------	----------
7900	manufac. prod. nec	0	0	0	----------	----------
Total unknown or not elsewhere classified		**0**	**0**	----------	----------	----------
9900	unknown or nec	0	0	----------	----------	----------
Ton-miles (x1000)		**123,373**		**42,846**		**0**
Foreign & Canadian			**80,527**		**0**	

Commodity		Total	Coastwise		
			Receipts	Shipment	Through Upbound
Total, all commodities		**3,949**	**576**	**3,346**	**27**
Total petroleum and petroleum products		**2,818**	**518**	**2,828**	**19**
Subtotal crude petroleum		**75**	**72**	**4**	----------
2100	crude petroleum	75	72	4	----------
Subtotal petroleum products		**2,743**	**446**	**2,278**	**19**
2211	gasoline	1,654	21	1,633	----------
2330	distillate fuel oil	322	83	239	----------
2340	residual fuel oil	144	59	85	----------
2450	lube oil & greases	570	256	314	----------
2429	naphtha & solvents	27	27		----------
2430	asphalt, tar & pitch	19	----------	----------	19
2990	petro. products nec	7	----------	7	----------
Total chemicals and related products		**1,059**	**4**	**1,050**	**5**
Subtotal other chemicals and related products		**1,059**	**4**	**1,050**	**5**
3212	benzene & toluene	31	4	26	----------
3219	other hydrocarbons	105	----------	105	----------
3220	alcohols	113	----------	113	----------

Commodity		Total	Coastwise		
			Receipts	Shipment	Through Upbound
3271	sulphur (liquid)	352	----------	352	----------
3274	sodium hydroxide	4	----------	----------	4
3276	metallic salts	12	0	10	1
3297	chemical additives	436	----------	436	----------
3299	chem. products nec	7	----------	7	----------
Total crude materials, inedible except fuels		**56**	**53**	**2**	**1**
	Subtotal soil, sand, gravel, rock and stone	**3**	----------	**1**	**1**
4338	soil & fill dirt	3	----------	1	1
	Subtotal iron ore and scrap	**53**	**53**	----------	----------
4420	iron & steel scrap	53	53	----------	----------
	Subtotal sulphur, clay and salt	**0**	----------	**0**	----------
4782	clay refrac. mat.	0	----------	0	----------
	Subtotal other non-metal. min.	**0**	----------	**0**	----------
4900	non-metal. min. nec	0	----------	0	----------
Total primary manufactured goods		**14**	**1**	**13**	----------
	Subtotal primary iron an steel products	**11**	----------	**11**	----------
5320	i&s primary forms	11	----------	11	----------
	Subtotal primary non-ferrous metal products	**3**	**1**	**1**	----------
5421	copper	1	1	----------	----------
5480	fab. metal products	1	----------	1	----------
Total all manufactured equipment, machinery and products		**2**	**0**	**0**	**1**
7110	machinery (not elec)	0	0	0	----------
7400	manufac. wood prod.	1	----------	----------	1
Ton-miles (x1000) Coastwise		**199,731**	**28,002**	**169,459**	**2,270**

Commodity		Total	Internal							
			Inbound		Outbound		Through		Intra	
			Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd
Total, all Commodities		**50,181**	**5,879**	**1,529**	**1,226**	**7,880**	**14,797**	**17,425**	**972**	**474**
Total coal		**107**	**1**	**1**	**48**	----------	**5**	**51**	----------	----------
1100	Coal lignite	8	1	----------	----------	----------	----------	7	----------	----------
1200	coal coke	99	----------	1	48	----------	5	44	----------	----------
Total Petroleum and Petroleum products		**27,660**	**2,935**	**860**	**994**	**5,096**	**7,360**	**9,673**	**510**	**231**
Subtotal crude petroleum		**5,654**	**841**	----------	**30**	**545**	**852**	**3,353**	**23**	**10**
2100	crude petroleum	5,654	841	----------	30	545	852	3,353	23	10

Commodity		Total	Internal							
			Inbound		Outbound		Through		Intra	
			Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd
Subtotal petroleum products		**22,006**	**2,094**	**860**	**964**	**4,551**	**6,508**	**6,320**	**487**	**222**
2211	gasoline	5,294	581	45	162	778	1,526	2,010	86	106
2221	kerosene	290	----------	----------	130	1	92	67	----------	----------
2330	distillate fuel oil	4,494	492	48	107	1,291	691	1,793	62	10
2340	residual fuel oil	5,613	483	58	290	1,657	1,863	1,057	198	7
2350	lube oil & greases	1,112	23	4	137	219	519	207	2	1
2410	petro. jelly & waxes	56	----------	----------	----------	----------	51	5	----------	----------
2429	naphtha & solvents	2,119	384	37	4	369	571	538	126	90
2430	asphalt, tar & pitch	1,075	11	3	1	22	767	271	----------	----------
2540	petroleum coke	776	8	438	64	----------	241	20	----------	4
2640	liquid natural gas	552	58	181	----------	55	124	131	----------	4
2990	petro. products nec	624	54	47	67	159	63	221	15	----------
Total chemicals and related products		**16,101**	**1,439**	**53**	**161**	**2,367**	**5,789**	**5,587**	**462**	**243**
Subtotal fertilizers		**741**	**1**	**0**	**----------**	**0**	**151**	**588**	**----------**	**----------**
3110	nitrogenous fert.	506	----------	----------	----------	----------	71	436	----------	----------
3120	phosphatic fert.	135	----------	----------	----------	----------	6	129	----------	----------
3130	potassic fert.	4	----------	0	----------	----------		3	----------	----------
3190	fert. & mixes nec	96	1	----------	----------	----------	---------- 75	20	----------	----------
Subtotal other chemicals and related products		**15,360**	**1,437**	**53**	**161**	**2,366**	**5,638**	**5,000**	**462**	**243**
3211	acylic hydrocarbons	1,084	386	----------	----------	5	134	559	----------	----------
3212	benzene & toluene	1,369	196	32	7	485	99	362	33	156
3219	other hydrocarbons	4,669	96	6	122	417	3,015	814	197	----------
3220	alcohols	2,559	119	2	1	564	589	908	33	43
3230	carboxylic acids	381	27	----------	----------	57	252	45	----------	----------
3240	nitrogen func. comp.	813	102	----------	----------	280	374	57	----------	----------
3260	organic comp. nec	602	57	----------	----------	3	242	299	----------	----------
3271	sulphur (liquid)	82	48	----------	----------	----------	5	30	----------	----------
3272	sulphuric acid	231	19	----------	----------	45	35	132	----------	----------
3273	ammonia	1,016	30	----------	----------	186	----------	800	----------	----------
3274	sodium hydroxide	970	40	----------	----------	29	352	549	----------	----------

Commodity		Total	Internal							
			Inbound		Outbound		Through		Intra	
			Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd
3275	inorg. elem., oxides, & halogen salts	230	2	---	---	1	99	129	---	---
3276	metallic salts	61	---	5	0	4	10	42	---	---
3297	chemical additives	1,184	286	4	9	205	332	106	199	43
3298	wood & resin chem.	2	---	---	---	---	2	---	---	---
3299	chem. products nec	407	29	4	21	86	98	169	---	---
Total crude materials, inedible except fuels		**3,003**	**1,136**	**98**	**1**	**15**	**1,239**	**515**	**---**	**---**
Subtotal forest products, wood and chips		13	**0**	**---**	**---**	**---**	**3**	**9**	**---**	**---**
4110	rubber & gums	3	---	---	---	---	3	---	---	---
4189	lumber	2	0	---	---	---	---	2	---	---
4190	forest products nec	8	---	---	---	---	---	8	---	---
Subtotal soil, sand, gravel, rock and stone		**1,029**	**768**	**53**	**---**	**1**	**2**	**205**	**---**	**---**
4432	limestone	390	300	52	---	---	---	38	---	---
4323	gypsum	57	---	---	---	---	---	57	---	---
4327	phosphate rock	7	---	---	---	---	---	7	---	---
4331	sand & gravel	496	458	0	---	1	2	35	---	---
4335	waterway improve. mat	73	10	0	---	---	---	63	---	---
4338	soil & fill dirt	6	---	---	---	---	---	6	---	---
Subtotal iron ore and scrap		**558**	**363**	**---**	**---**	**5**	**140**	**50**	**---**	**---**
4410	iron ore	115	67	---	---	---	9	39	---	---
4420	iron & steel scrap	443	295	---	---	5	131	12	---	---
Subtotal marine shells		**68**	**---**	**43**	**---**	**---**	**---**	**25**	**---**	**---**
4515	marine shells	68	---	43	---	---	---	25	---	---
Subtotal non-ferrous ores and scrap		**1,119**	**3**	**---**	**---**	**---**	**1,067**	**49**	**---**	**---**
4650	aluminum ore	1,058	---	---	---	---	1,043	14	---	---
4670	manganese ore	51	3	---	---	---	19	29	---	---
4690	non-ferrous ores nec	11	---	---	---	---	5	6	---	---
Subtotal sulphur, clay and salt		**16**	**2**	**0**	**0**	**4**	**3**	**7**	**---**	**---**
4782	clay & refrac. mat.	16	2	0	0	4	3	7	---	---
Subtotal slag		**108**	**---**	**---**	**---**	**3**	**---**	**105**	**---**	**---**
4860	slag	108	---	---	---	3	---	105	---	---

Commodity		Total	Internal							
			Inbound		Outbound		Through		Intra	
			Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd
Subtotal other non-metal. min.		**91**	**0**	**2**	**1**	**2**	**23**	**63**	----------	----------
4900	non-metal min. nec	91	0	2	1	2	23	63	----------	----------
Total primary manufactured goods		**1,856**	**297**	**2**	**1**	**277**	**106**	**1,173**	----------	----------
Subtotal paper products		**14**	----------	**0**	----------	----------	----------	**14**	----------	----------
5110	newsprint	14	----------	----------	----------	----------	----------	14	----------	----------
5120	paper & paperboard	0	----------	0	----------	----------	----------	----------	----------	----------
Subtotal lime, cement and glass		**101**	**88**	**0**	**0**	**0**	**10**	**3**	----------	----------
5210	lime	3	----------	----------	----------	----------	----------	3	----------	----------
5220	cement & concrete	98	88	0	0	0	10	----------	----------	----------
Subtotal primary iron and steel products		**1,638**	**209**	**0**	**0**	**272**	**69**	**1,088**	----------	----------
5312	pig iron	281	206	----------	----------	----------	3	72	----------	----------
5315	ferro alloys	81	1	----------	----------	----------	9	70	----------	----------
5320	i&s primary forms	68	----------	----------	----------	15	5	48	----------	----------
5330	i&s bars & sheets	568	----------	----------	----------	----------	26	542	----------	----------
5360	i&s bars & shapes	274	----------	----------	----------	257	9	8	----------	----------
5370	i&s pipe & tube	246	1	0	0	----------	5	239	----------	----------
5390	primary i&s nec	121	----------	----------	----------	----------	12	109	----------	----------
Subtotal primary non-ferrous metal products		**97**	----------	**1**	----------	**4**	**27**	**64**	----------	----------
5421	copper	2	----------	----------	----------	----------	2	----------	----------	----------
5422	aluminum	1	----------	----------	----------	----------	----------	1	----------	----------
5429	smelted prod. nec	8	----------	----------	----------	----------	2	6	----------	----------
5480	fab. metal products	86	----------	1	----------	4	24	56		
Subtotal primary wood products		**5**	----------	----------	**1**	**1**	----------	**4**	----------	----------
5540	primary wood prod.	5	----------	----------	1	1	----------	4	----------	----------
Total food and farm products		**736**	**16**	**5**	**15**	**61**	**247**	**392**	----------	----------
Subtotal grain		**347**	----------	----------	----------	----------	**92**	**255**	----------	----------
6241	wheat	116	----------	----------	----------	----------	48	68	----------	----------
6344	corn	7	----------	----------	----------	----------	7	----------	----------	----------
6442	rice	200	----------	----------	----------	----------	24	176	----------	----------
6445	oats	11	----------	----------	----------	----------	----------	11	----------	----------
6447	sorghum grains	13	----------	----------	----------	----------	13	----------	----------	----------

Commodity		Total	Internal							
			Inbound		Outbound		Through		Intra	
			Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd
Subtotal oilseeds		**16**				**11**	**5**			
						11	5			
6522	soybeans	16								
Subtotal vegetable products		**9**					**6**	**3**		
6653	vegetable oils	3						3		
6654	vegetables & prod.	6					6			
Subtotal processed grain and animal feed		**28**		**4**	**13**	**3**	**5**	**4**		
		5				1	3			
6746	wheat flour	24		4	13	1	2	4		
6838	animal feed, prep.									
Subtotal other agricultural products		337	**16**	1	2	48	**139**	**130**		
							3			
6835	fish, prepared	3						8		
6838	tallow, animal oils	8					124	79		
6861	sugar	204					2	27		
6865	molasses	28					0	0		
6871	coffee	1								
6885	alcoholic beverages	11						11		
6887	groceries	0				0				
6888	water & ice	76	16	1	2	48		5		
6889	food products nec	7				0	4 7			
Total all manufactured equipment, machinery and products		**172**	**26**	**2**	**3**	**59**	**51**	**32**		
7110	machinery (not elec)	120	25	2	3	57	13	21		
7210	vehicles & parts	0				0				
7230	ships & boats	0						0		
7300	ordnance & access.	5					0	5		
7500	textile products	6					3	3		
7600	rubber & plastic pr.	16	1				15	1		
7900	manufac. prod. nec	25				2	20	2		

Commodity		Total	Internal							
			Inbound		Outbound		Through		Intra	
			Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd	Upbound	Downbnd
Total waste and scrap nec		**547**	**29**	**509**	**3**	**5**	**----------**	**1**	**----------**	**----------**
8900	Waste and scrap nec	547	29	509	3	5	----------	1	----------	----------
Ton-miles Internal (x100)		**3,033,660**	**159,544**	**32,842**	**25,880**	**139,905**	**1,194,804**	**1,456,126**	**17,674**	**6,713**
Tons All Traffic (x (1000)				**103,254**						
Ton-miles All Traffic (x 1000)				**3,356,592**						