United States Environmental Protection Agency
Air and Radiation
EPA420-R-99-019
September 1999

Commercial Marine Activity for Great Lake and Inland River Ports in the United States

Final Report

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Assessment and Modeling Division
Office of Mobile Sources
U.S. Environmental Protection Agency

Prepared for EPA by
ARCADIS Geraghty & Miller, Inc.

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COMMERCIAL MARINE ACTIVITY FOR GREAT LAKE AND INLAND RIVER PORTS IN THE UNITED STATES

Final Report

30 June 1999

PREPARED FOR

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Final Report

U.S. Environmental Protection Agency
Assessment & Modeling Division
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Ann Arbor, Michigan 48105

This report and the information and data described herein have been funded by the USEPA under Contract 68-C6-0068, Work Assignments 0-06, 1-05, and 2-01. It is being released for information purposes only. It may not reflect the views and positions of the USEPA on the topics and issues discussed, and no official endorsement by USEPA of the report or its conclusions should be inferred.

This report has not been peer reviewed.

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SECTION 1
INTRODUCTION TO COMMERCIAL MARINE ACTIVITY AT GREAT LAKE AND RIVER PORTS

This report is Volume II of a two volume report on commercial marine activity in the United States developed by ARCADIS Geraghty & Miller, Inc., for the U.S. Environmental Protection Agency (EPA), Office of Mobile Sources. This Volume addresses commercial marine activity at selected Great Lake and river ports. Volume I addressed commercial marine activity at selected deep-sea ports.

1.1 MARINE INVENTORY BACKGROUND

The purpose of this report is to present a basis for quantifying and qualifying operational characteristics of commercial marine activity at major Great Lake and river ports in the U.S. This report details work performed under work assignment (WA) 2-01, a continuation of WAs 0-06 and 1-05, of Contract 68-C6-0068, begun in fiscal year 1997 by ARCADIS Geraghty & Miller for the EPA. The activity profiles developed herein may be used to quantify emissions from Great Lake and river ports in the United States. EPA eventually plans to use data derived from these activity models as default inputs to EPA's NONROAD model.

As air emission inventories become more precise, it becomes necessary to chronicle all types of activities that could impact air quality. Because marine vessel emissions are believed to be a significant portion of the emission inventory, their operations and emissions must be better understood before the true impact of marine emissions on air quality can be assessed. Marine vessel activities have been investigated in the past, but in general these studies focused on only a few ports or made assumptions about all vessels based on data for only a few ship-types. This report will help EPA to assist state and local air pollution control agencies in forming a more precise picture of commercial marine activity at Great Lake and river ports, a large contribution to overall marine activity, and may help in devising incentive programs and regulations to reduce emissions from the marine sector.

1.2 DATA SOURCES FOR COMMERCIAL MARINE INVENTORIES

A set of ports were selected for detailed analysis in this report. These ports are referred to as Typical Great Lake Ports and Typical River Ports throughout this document. The Typical Ports are shown in Table 1-1. Data from these Typical Ports can then be used to define activity at other ports in the U.S. that are similar in nature to the Typical Ports.

In addition, ARCADIS Geraghty & Miller developed less detailed activity profiles (cumulative trips and tonnage organized by ship-type) for the Top 60 Great Lake and River Ports (LRPs) in the U.S. The LRP data can be used for applying Typical Port activity data to other of the LRPs.

Table 1-1. Typical Great Lake and River Ports

Typical Port	Waterways
Port of Cleveland, OH	Lake Erie
Burns Waterway Harbor, IN	Lake Michigan
Port of Cincinnati, OH	Ohio River
Metropolitan Port of St. Louis, MO	Mississippi River

Data on the Typical Great Lake Ports were available from Marine Exchanges and Port Authorities (MEPAs) associated with each Typical Great Lake Port as well as from the Census Bureau for foreign ships. All of the Typical Ports had detailed data available from the United States Army Corps of Engineers (USACE). This detailed data contained information on vessel movements, vessel characteristics, and vessel operators. The data sources, and a brief explanation of the data uses, are listed below. For a more detailed discussion of the data, refer to the sections referenced below and also to Appendix A.

- United States Army Corps of Engineers - The Waterborne Commerce Statistics Center of the United States Army Corps of Engineers (USACE) provided data used to develop total domestic trips and total domestic tonnages for the LRPs in the U.S. (see Section 2). The USACE also provided more detailed data on the Typical Ports allowing computation of individual vessel movements. (see Sections 3 and 4)
- *United States Bureau of Census (Census Bureau)* - Data provided on the Navigation Data Center Publications and U.S. Waterway Data CD by the Census Bureau were used to develop the total foreign trips and tonnages as well as individual foreign vessel movements for the Great Lake Ports. (see Sections 2 and 3) (Reference 1)
- *Marine Exchange/Port Authority (MEPA)* - Data were used to develop vessel hotelling time averages for the Great Lake Ports. (See Section 3)
- *Lloyds Maritime Information Service (LMIS)* - Data were provided from the Lloyds Register on vessel characteristics such as horsepower and engine speed. These data were matched with the vessel data from the MEPAs and Census Bureau for vessel characteristic summaries at the Great Lake Ports. (See Section 3)
- *Operator Data* - Information obtained through conversations with operators augmented the electronic data and allowed calculation of time-in-modes at the River Ports.
- *Port Series Reports* - Reports covering the principal U.S. coastal, Great Lakes, and ports are compiled and published by the Ports and Waterways Division, Water Resources Support Center, USACE. The

data in these reports were used in conjunction with pilot data to develop the detailed port data presented in each Typical Port section. (References 2 through 5)

- *Other data sources* - Other data sources such as the book "Know Your Ships" (Reference 6) and Internet Web Sites www.boatnerd.com (Reference 7) and www.lcaships.com (Reference 8) were invaluable for determining vessel characteristics and general operations for the Typical Great Lake Ports.

The data sources listed above were used to determine how each ship-type operates in each Typical Port, how many of each ship-type called on the Typical Port in the given year, and the characteristics of the ship-type. These data can be used to determine the emissions per ship-type for each mode of operation in the given year.

This report will determine the ship type categories to use as well as the values to use for the number of trips per year, the average time-in-mode, and the average rated horsepower. Other factors needed for determining emissions inventories, such as load factors and emission factors, are not discussed in this report.

1.3 APPROACH TO COMMERCIAL MARINE INVENTORIES

Our approach to the Great Lake and River component of the commercial marine inventory relies on a detailed analysis of a set of Typical Ports to be used in conjunction with less detailed data on the LRPs in the U.S. This approach provides a clear summary of the major U.S. ports as well as a more detailed analysis of the Typical Ports. The foundations of this approach are the activity profiles for the Typical Ports that give information on vessel equipment such as horsepower, speed, and age as well as information on vessel movements so that a modeler can determine how long each type of vessel commonly operates in each of several modes. These modes correspond to different engine loads and, thus, to different emission characteristics. In order to develop the activity profiles, this report does the following:

- Lists the Top 60 LRPs in the U.S. as determined by cargo tonnage for 1995 by the USACE
- Provides an inventory of the number of trips, by vessel type, at the Top 60 LRPs in the U.S. for 1995
- Provides an inventory of the tons of cargo handled, by vessel type, at each of the LRPs in the U.S. for 1995
- Provides Federal Information Processing Standard (FIPS)[1] codes for the LRPs in the U.S. Each county has a unique FIPS code, and the county names are also given for each county within a port's boundaries
- Provides detailed data, collected from the ports themselves, on vessel movements for four Typical Great Lake and River Ports for 1996

[1]FIPS codes are distinct, unique, numeric identification codes assigned to each county by the U.S. government.

- Provides vessel characterizations, by vessel type, for the Typical Ports including such equipment details as propulsion horsepower, capacity tonnage, and engine age (as available)
- Provides the time-in-mode for each vessel category
- Provides a methodology for allocating time-in-mode activity data from a Typical Port to a similar LRP

An activity scenario for each Typical Port is specified in terms of categories of vessels, number of vessels in each category for the given year (1996), and number of hours at each time-in-mode associated with cruising, reduced speed, maneuvering, and hotelling. The time-in-mode values developed for the Typical Great Lake Ports were based on actual activity information acquired directly from vessel operators and information obtained from the MEPAs. The time-in-mode values developed for the Typical River Ports were based on information acquired from vessel operators. The ship characteristics and time-in-mode data can be used to develop default operating time-in-modes for other LRPs based on similarities between a given LRP and a given Typical Port. This will yield a more easily obtained and more accurate estimate of vessel emissions for a wide range of ports than has been available in the past.

Because Great Lake ports and River ports are different from deep-sea ports as well as from each other, individual methodologies have been developed for Great Lake ports and for River ports. These are explained in detail in Sections 3 and 4.

By using trip and cargo tonnage data generated for the Top 60 LRPs and more detailed activity data generated for 4 Typical Ports, time-in-mode and vessel characteristics by ship-type can be determined for each of the 60 LRPs. Thus, a modeler could use either locally available time-in-mode characteristics unique to the port they wish to model or to use the default values from a Typical Port that most closely resembles the port to be modeled.

This report is intended for use by EPA in developing activity profiles for U.S. ports. These profiles will then be used with emission factors to develop emission profiles for LRPs. This report can also be used to facilitate data gathering and modeling efforts at the state and local levels by providing an understanding of the inputs EPA used in developing port emission profiles.

1.4 REPORT ORGANIZATION

This report presents data from four Typical Ports and the Top 60 LRPs. This report is organized into 5 sections. Section 1 is this introduction to the purpose and organization of the report. Section 2 is a presentation of the LRP data, data sources, and methodology for developing the data. Section 3 is a presentation of the Typical Great Lake Ports used in this study, operations in a Typical Great Lake Port, and a summary of the data. Section 4 is a presentation of the Typical River Ports used in this study, operation on the rivers, and a summary of the data. Section 5 provides recommendations for future work. References follows in Section 6. Appendix A gives descriptions for each field from each data source.

SECTION 2

TOP RIVER AND LAKE PORTS

2.1 PURPOSE

The data on the U.S. Great Lake and River Ports (LRPs) will be used to:

- Rank the Lake and River Ports as determined by 1995 cargo tonnage records
- Provide an inventory of the number of trips, by vessel type for 1995 at the LRPs
- Provide an inventory of the tons of cargo handled in 1995 by vessel type at each of the LRPs
- Determine county affiliations and federal county codes for the LRPs (for allocation purposes)
- Allow an estimation of activity at each of the LRPs when coupled with the information presented in Sections 3 and 4 for the Typical Ports.

2.2 DATA SUMMARIZED AND EXPLAINED

Before looking closely at the ship-types and the cargo tonnages, it is necessary to review the language of vessel movements. The terms most commonly used in this section are defined in Table 2-1. Trips, entrances, and clearances are terms used to denote a type of vessel movement to, from, or within a port/waterway area.

Table 2-1. Vessel movements described

Term	Definition
Port	A defined area of marine commerce within a navigable body of water. Ports have distinct boundaries but may be nearly 100 miles long in some instances. Port and waterway codes may be identical. They differ when a port is on a waterway which has more than one port. For instance, the Port of St. Louis is defined by port code 2310 and is located on waterways 6079 and 6080, but Burns Waterway Harbor is located on waterway 3739 and has no separate port code.
Waterway	A navigable body of water that may or may not have a port within it. Waterway codes and port codes are identical for some bodies of water (See "Port" above).
Entrance	When a vessel enters a port/waterway area. An entrance is recorded for a vessel entering the waterway and is analogous to one trip.
Clearance	When a vessel leaves a port/waterway area. A clearance is recorded for a vessel exiting the waterway and is analogous to one trip.
Trip	A trip is one entrance *or* one clearance from a USACE recognized port/waterway. A trip is a one-way movement. Trips may also occur *within* a port/waterway. Trips within a port are considered intraport and may be analogous to MEPA Area shifts (see Section 3.3). Trips and tonnages associated with intraport trips are included in the LRP summary tables.
Intraport	Movement within the boundaries of a port. For Great Lake and river ports, an intraport movement is comparable to a shift in a deep-sea port.

In some instances, the terms port and waterway can be used nearly interchangeably. In most cases, however, we are concerned with the traffic at the ports.

The data presented in this section were collected by the USACE and the Census Bureau. Data on domestic flag vessels were received from USACE and data on foreign flag vessels from the Census Bureau. Data received included trips and cargo tonnages for each port/waterway area in the U.S. recognized by the USACE. This trip and cargo data can be used separately or together to estimate ship traffic and activities in order to estimate emissions due to commercial marine vessel activity from port areas. For more detail on the relationship between Census Bureau data and USACE data as used in this report, see "Commercial Marine Activity Volume I: Deep-Sea Ports" by ARCADIS Geraghty & Miller, 1999 (hereafter Volume I).

There are a more limited number of ship-types involved with transportation at the LRPs than in the Deep-Sea Ports (DSPs). Table 2-2 of Volume I has descriptions of many general ship-types. Of those, there were no barge carrier, ferry or vehicle carrier trips or tons in 1995 at the Top 60 LRPs.

Table 2-2 presents a summary of all the trips and cargo tonnages for the LRPs in 1995. This table demonstrates how different criteria can result in different rankings of the LRPs and the significance of each ship-type. Intraport movements are included in the trip and tonnage totals of Tables 2-2 through 2-4. These intraport movements are a significant part of traffic on the river ports and have the same time-in-mode characteristics as a trip from an outside port. Intraport movements are an insignificant component of most of the Great Lake Ports. However, there are exceptions, such as the Port of Chicago, which have significant intraport movements. The activity profiles developed for the Typical Great Lake Ports may need to be revised for Great Lake Ports with significant intraport movements, as intraport movements would not normally have cruise or reduced speed zone time allotments.

Ship-types are abbreviated in Tables 2-2, 2-3, and 2-4 as follows:

BC = Bulk Cargo Carrier

BD = Dry-cargo Barge

BL = Liquid Cargo (Tanker) Barge

CS = Container Ship

GC = General Cargo

OT = Other, Unknown, or Undefined

PA = Passenger, Cruise and Excursion

RF = Reefer

RO = RORO and Ferry

SV = Supply/Support Vessel

TA = Tanker

TUG = Tugboat and Pushboat

UC = Unidentified Dry-cargo

Table 2-2. USACE trip and ton totals for the LRPs

Ship-Type	Trips		Tonnage	
	Lake	River	Lake	River
BC	16,420	-	212,348,453	-
BD	30,772	268,473	33,681,664	165,545,033
BL	8,821	44,941	9,761,536	42,739,741
CS	2	-	4,850	-
GC	1,484	9	1,719,198	-
OT	19	-	13,066	-
PA	3,759	559	7,929	128
RF	34	-	425,146	-
RO	4	-	8,414	-
SV	-	40	-	-
TA	2,539	-	1,811,986	-
TUG	23,972	140,204	-	-
UC	3,329	1,426	36,114,265	1,196
Grand Total	91,155	455,652	295,896,507	208,286,098

Table 2-3 and 2-4 present the LRPs ranked in order of net cargo tonnage recorded as sent/received by the port. Only the Top 60 LRPs as determined by the data from the USACE and Census Bureau are included in these tables. The top commercial DSPs are in the corresponding tables in Volume I. Table 2-3 presents the total number of trips per ship-type, and Table 2-4 presents the tons of cargo by ship-type. Table 2-5 presents Federal Information Processing Standard (FIPS) codes and corresponding county names for each of the LRPs.

2.3 DATA ORIGINS AND DETAILS

The number of vessels for each LRP were determined from two databases. One database, from the USACE Waterborne Commerce Statistics Center, records the port code, type of vessel, tons of cargo, number of trips per vessel type, and month of trip for domestic vessels. Port codes and waterway codes are assigned by USACE to all navigable waters in the U.S. As stated in Table 2-1, the port code is more specific and refers directly to a port or harbor area. The waterway code usually refers to a more general waterway area that often contains port or harbor areas. Knowledge of vessel type is important because there are distinct differences between operating characteristics and, therefore, between emissions of various types of vessels.

Included in the USACE files are data on foreign vessels. While USACE receives these data from the Census Bureau, they do not have permission to provide some details of foreign vessel traffic. USACE may only release the number of foreign entrances and clearances by a general ship-type description while reporting the annual foreign shipments in January , and the annual foreign receipts in December. Thus, another data source is needed in order to obtain detailed ship-type descriptions and monthly breakdowns of foreign vessel traffic.

Table 2-3. Top 60 Lake and River Ports, trips by ship-type for 1995

Rank	Port Name	R/L [a]	BC	BD	BL	CS	GC	OT	PA	RF	RO	SV	TA	TUG	UC	Grand Total
1	Port of Pittsburgh, PA	R	-	104,185	3,668	-	-	-	286	-	-	-	-	49,742	-	157,881
2	Duluth-Superior, MN & WI	L	1,808	63	6	-	84	-	-	5	-	-	670	64	566	3,265
3	Port of St. Louis, MO & IL	R	-	46,419	5,039	-	1	-	3	-	-	-	-	29,939	-	81,401
4	Port of Chicago, IL	L	690	21,739	5,964	-	10	-	1	-	-	-	166	12,523	120	41,213
5	Huntington, WV	R	-	29,154	5,769	-	-	-	-	-	-	-	-	18,595	-	53,518
6	Memphis, TN	R	-	13,888	4,748	-	2	-	4	-	-	-	-	1,893	-	20,535
7	Indiana Harbor, IN	L	679	638	1,504	-	1	-	-	-	-	-	961	2,671	92	6,546
8	Port of Detroit, MI	L	1,068	361	605	-	-	-	-	-	-	-	207	838	-	3,079
9	Cleveland Harbor, OH	L	1,344	229	145	-	11	-	2	-	-	-	48	685	186	2,650
10	Lorain Harbor, OH	L	1,061	35	-	-	12	-	-	-	-	-	-	46	37	1,191
11	Toledo Harbor, OH	L	763	80	212	2	26	-	-	-	-	-	65	346	423	1,917
12	Cincinnati, OH	R	-	12,419	2,824	-	-	-	220	-	-	-	-	3,341	-	18,804
13	Burns Waterway Harbor, IN	L	306	2,634	88	-	10	-	-	-	-	-	214	2,189	145	5,587
14	Presque Isle Harbor, MI	L	505	2	-	-	-	-	-	-	-	-	-	2	115	624
15	Ashtabula Harbor, OH	L	522	2	-	-	-	-	-	2	-	-	-	-	212	738
16	Gary Harbor, IN	L	325	1,350	-	-	-	-	-	-	-	-	88	1,089	17	2,869
17	Taconite Harbor, MN	L	339	41	-	-	-	-	-	-	-	-	-	41	-	421
18	Louisville, KY	R	-	8,864	4,034	-	-	-	-	-	-	-	-	2,238	-	15,136
19	Escanaba, MI	L	521	44	-	-	-	-	-	-	-	-	-	44	-	609
20	Stoneport, MI	L	696	32	-	-	-	-	-	2	-	-	-	29	66	825
21	Calcite, MI	L	612	51	-	-	-	-	-	-	-	-	-	46	164	873
22	Two Harbors, MN	L	317	34	-	-	-	-	-	-	-	-	-	35	-	386
23	Mount Vernon, IN	R	-	5,551	1,610	-	-	-	-	-	-	-	-	730	-	7,891
24	St. Clair, MI	L	378	6	53	-	-	19	-	-	-	-	5	42	26	529
25	Conneaut Harbor, OH	L	223	8	-	-	-	-	-	18	-	-	-	8	168	425
26	Vicksburg, MS	R	-	2,877	9,508	-	6	-	6	-	-	38	-	5,141	-	17,576
27	Port Inland, MI	L	457	111	-	-	-	-	-	-	-	-	-	109	31	708
28	St. Paul, MN	R	-	6,818	346	-	-	-	-	-	-	-	-	3,788	-	10,952
29	Victoria, TX	R	-	1,813	2,991	-	-	-	-	-	-	-	-	2,478	-	7,282
30	Silver Bay, MN	L	306	-	-	-	-	-	-	-	-	-	-	-	-	306
31	Port of Kansas City	R	-	15,983	132	-	-	-	-	-	-	-	-	15,728	-	31,843
32	Marine City, MI	L	162	-	-	-	-	-	-	-	-	-	-	-	-	162
33	Port of Nashville, TN	R	-	4,603	252	-	-	-	-	-	-	-	-	1,123	-	5,978
34	Sandusky Harbor, OH	L	183	9	-	-	-	-	8	7	-	-	-	9	517	733
35	Marblehead, OH	L	339	114	12	-	-	-	3,714	-	-	-	-	22	52	4,253
36	Milwaukee Harbor, WI	L	302	902	83	-	19	-	-	-	4	-	-	2,060	105	3,476
37	Port Dolomite, MI	L	299	75	-	-	-	-	-	-	-	-	-	71	27	472

Table 2-3. Top 60 Lake and River Ports, trips by ship-type for 1995 (continued)

Rank	Port Name	R/L [a]	BC	BD	BL	CS	GC	OT	PA	RF	RO	SV	TA	TUG	UC	Grand Total
38	Fairport Harbor, OH	L	256	36	-	-	576	-	-	-	-	-	-	35	35	938
39	Alpena Harbor, MI	L	492	2	-	-	-	-	-	-	-	-	4	1	41	540
40	Guntersville, AL	R	-	3,277	297	-	-	-	32	-	-	-	-	484	-	4,090
41	Chattanooga, TN	R	-	2,709	737	-	-	-	-	-	-	-	-	802	-	4,248
42	Green Bay Harbor, WI	L	215	1,801	6	-	-	-	-	-	-	-	14	16	-	2,052
43	Helena, AR	R	-	1,604	730	-	-	-	7	-	-	-	-	768	-	3,109
44	Monroe Harbor, MI	L	128	1	31	-	-	-	-	-	-	-	2	32	-	194
45	Greenville, MS	R	-	1,700	935	-	-	-	1	-	-	2	-	986	-	3,624
46	Port of Buffalo, NY	L	106	6	16	-	73	-	34	-	-	-	73	58	45	411
47	Muskegon Harbor, MI	L	170	37	10	-	-	-	-	-	-	-	-	33	16	266
48	Biloxi Harbor, MS	R	-	1,979	419	-	-	-	-	-	-	-	-	395	1,426	4,219
49	Drummond Island, MI	L	121	36	-	-	-	-	-	-	-	-	-	36	30	223
50	Charlevoix Harbor, MI	L	154	146	-	-	-	-	-	-	-	-	-	388	4	692
51	Tulsa, Port of Catoosa, OK	R	-	1,036	574	-	-	-	-	-	-	-	-	552	-	2,162
52	Buffington Harbor, IN	L	88	117	-	-	-	-	-	-	-	-	22	75	1	303
53	Minneapolis, MN	R	-	1,813	-	-	-	-	-	-	-	-	-	541	-	2,354
54	Ludington Harbor, MI	L	103	6	86	-	-	-	-	-	-	-	-	246	3	444
55	Huron Harbor, OH	L	87	-	-	-	-	-	-	-	-	-	-	20	30	137
56	Erie Harbor, PA	L	186	2	-	-	662	-	-	-	-	-	-	1	22	873
57	Grand Haven Harbor, MI	L	108	22	-	-	-	-	-	-	-	-	-	62	33	225
59	Washington, DC	R	-	1,041	122	-	-	-	-	-	-	-	-	144	-	1,307
60	Hempstead, NY	R	-	740	206	-	-	-	-	-	-	-	-	796	-	1,742
Grand Total			16,420	299,245	53,762	2	1,493	19	4,318	34	4	40	2,539	164,176	4,755	546,807

[a] R indicates a river port, L indicates a Great Lake Port.

Table 2-4. Top 60 Lake and River Ports, tonnage by ship-type for 1995

Rank	Port Name	R/L [a]	BC	BD	BL	CS	GC	OT	PA	RF	RO	SV	TA	TUG	UC	Grand Total
1	Port of Pittsburgh, PA	R	-	59,181,271	3,531,651	-	-	-	-	-	-	-	-	-	-	62,712,922
2	Duluth-Superior, MN & WI	L	35,251,727	971,765	8,284	-	608,991	-	-	69,273	-	-	91,015	-	8,089,024	45,090,079
3	Port of St. Louis, MO & IL	R	-	26,781,810	5,897,501	-	-	-	-	-	-	-	-	-	-	32,679,311
4	Port of Chicago, IL	L	6,101,138	17,137,750	5,442,921	-	22,388	-	-	-	-	-	274,525	-	1,153,627	30,132,350
5	Huntington, WV	R	-	21,349,882	6,915,849	-	-	-	-	-	-	-	-	-	-	28,265,731
6	Memphis, TN	R	-	10,332,453	5,970,642	-	-	-	-	-	-	-	-	-	-	16,303,095
7	Indiana Harbor, IN	L	11,266,916	1,488,782	2,239,545	-	1,945	-	-	-	-	-	89,551	-	674,386	15,761,125
8	Port of Detroit, MI	L	13,589,436	761,008	698,825	-	-	-	-	-	-	-	620,028	-	-	15,669,297
9	Cleveland Harbor, OH	L	12,019,713	1,554,374	270,307	-	29,249	-	-	-	-	-	177,671	-	1,501,766	15,553,079
10	Lorain Harbor, OH	L	14,515,815	328,479	-	-	5,467	-	-	-	-	-	-	-	114,523	14,964,284
11	Toledo Harbor, OH	L	7,604,955	351,877	322,682	4,850	72,272	-	-	-	-	-	187,426	-	5,530,436	14,074,499
12	Cincinnati, OH	R	-	10,127,942	2,950,144	-	-	-	-	-	-	-	-	-	-	13,078,086
13	Burns Waterway Harbor, IN	L	6,820,626	1,527,771	91,936	-	27,236	-	-	-	-	-	25,164	-	1,809,673	10,302,406
14	Presque Isle Harbor, MI	L	8,250,539	57,133	-	-	-	-	-	-	-	-	-	-	1,791,750	10,099,422
15	Ashtabula Harbor, OH	L	6,569,580	57	-	-	-	-	-	34,538	-	-	-	-	3,406,054	10,010,229
16	Gary Harbor, IN	L	7,637,237	2,068,560	-	-	-	-	-	-	-	-	3,354	-	283,208	9,992,359
17	Taconite Harbor, MN	L	8,620,330	627,031	-	-	-	-	-	-	-	-	-	-	-	9,247,361
18	Louisville, KY	R	-	4,557,255	4,442,027	-	-	-	-	-	-	-	-	-	-	8,999,282
19	Escanaba, MI	L	7,737,833	741,595	-	-	-	-	-	-	-	-	-	-	-	8,479,428
20	Stoneport, MI	L	7,125,554	330,530	-	-	-	-	-	33,671	-	-	-	-	978,000	8,467,755
21	Calcite, MI	L	5,934,910	585,986	-	-	-	-	-	-	-	-	-	-	1,859,996	8,380,892
22	Two Harbors, MN	L	7,141,452	1,123,932	-	-	-	-	-	-	-	-	-	-	-	8,265,384
23	Mount Vernon, IN	R	-	6,130,521	2,109,194	-	-	-	-	-	-	-	-	-	-	8,239,715
24	St. Clair, MI	L	6,153,051	64,912	36,688	-	-	13,066	-	-	-	-	9,176	-	128,387	6,405,280
25	Conneaut Harbor, OH	L	2,776,685	220,301	-	-	-	-	-	248,892	-	-	-	-	2,376,495	5,622,373
26	Vicksburg, MS	R	-	1,941,307	3,290,186	-	-	-	-	-	-	-	-	-	-	5,231,493
27	Port Inland, MI	L	4,569,546	106,723	-	-	-	-	-	-	-	-	-	-	374,003	5,050,272
28	St. Paul, MN	R	-	4,456,951	314,057	-	-	-	-	-	-	-	-	-	-	4,771,008
29	Victoria, TX	R	-	2,034,914	2,589,278	-	-	-	-	-	-	-	-	-	-	4,624,192
30	Silver Bay, MN	L	4,348,458	-	-	-	-	-	-	-	-	-	-	-	-	4,348,458
31	Port of Kansas City	R	-	4,050,173	208,686	-	-	-	-	-	-	-	-	-	-	4,258,859
32	Marine City, MI	L	3,850,333	-	-	-	-	-	-	-	-	-	-	-	-	3,850,333
33	Port of Nashville, TN	R	-	3,340,089	408,889	-	-	-	-	-	-	-	-	-	-	3,748,978
34	Sandusky Harbor, OH	L	887,715	2,400	-	-	-	-	716	38,771	-	-	-	-	2,606,398	3,536,000
35	Marblehead, OH	L	2,838,254	265,134	13,453	-	-	-	2,143	-	-	-	-	-	398,970	3,517,954
36	Milwaukee Harbor, WI	L	1,659,048	327,940	232,256	-	43,015	-	-	-	8,414	-	-	-	994,916	3,265,588
37	Port Dolomite, MI	L	2,455,796	519,206	-	-	-	-	-	-	-	-	-	-	286,856	3,261,858

Table 2-4. Top 60 Lake and River Ports, tonnage by ship-type for 1995 (continued)

LRP Rank	Port Name	R/L [a]	BC	BD	BL	CS	GC	OT	PA	RF	RO	SV	TA	TUG	UC	Grand Total
38	Fairport Harbor, OH	L	2,056,975	365,871	-	-	91,412	-	-	-	-	-	-	-	427,085	2,941,343
39	Alpena Harbor, MI	L	2,604,507	-	-	-	-	-	-	-	-	-	12,328	-	149,882	2,766,717
40	Guntersville, AL	R	-	2,623,790	142,323	-	-	-	128	-	-	-	-	-	-	2,766,241
41	Chattanooga, TN	R	-	1,897,795	627,582	-	-	-	-	-	-	-	-	-	-	2,525,377
42	Green Bay Harbor, WI	L	1,538,824	745,982	14,918	-	-	-	-	-	-	-	31,206	-	-	2,330,930
43	Helena, AR	R	-	963,237	1,001,345	-	-	-	-	-	-	-	-	-	-	1,964,582
44	Monroe Harbor, MI	L	1,792,744	-	120,959	-	-	-	-	-	-	-	6,209	-	-	1,919,912
45	Greenville, MS	R	-	1,185,025	700,259	-	-	-	-	-	-	-	-	-	-	1,885,284
46	Port of Buffalo, NY	L	616,321	47,546	31,441	-	581,213	-	-	-	-	-	282,029	-	313,984	1,872,534
47	Muskegon Harbor, MI	L	1,628,417	20,298	-	-	-	-	-	-	-	-	-	-	175,902	1,824,617
48	Biloxi Harbor, MS	R	-	1,428,647	309,613	-	-	-	-	-	-	-	-	-	1,196	1,739,456
49	Drummond Island, MI	L	1,045,235	357,634	-	-	-	-	-	-	-	-	-	-	203,209	1,606,078
50	Charlevoix Harbor, MI	L	979,061	581,212	-	-	-	-	5,070	-	-	-	-	-	18,844	1,584,187
51	Tulsa, Port of Catoosa, OK	R	-	821,129	710,748	-	-	-	-	-	-	-	-	-	-	1,531,877
52	Buffington Harbor, IN	L	1,097,077	317,208	-	-	-	-	-	-	-	-	2,304	-	30,450	1,447,039
53	Minneapolis, MN	R	-	1,299,922	-	-	-	-	-	-	-	-	-	-	-	1,299,922
54	Ludington Harbor, MI	L	871,258	32,842	237,321	-	-	-	-	-	-	-	-	-	8,531	1,149,952
55	Huron Harbor, OH	L	955,802	-	-	-	-	-	-	-	-	-	-	-	131,415	1,087,217
56	Erie Harbor, PA	L	716,368	-	-	-	236,011	-	-	-	-	-	-	-	104,348	1,056,727
57	Grand Haven Harbor, MI	L	719,217	49,825	-	-	-	-	-	-	-	-	-	-	192,147	961,189
59	Washington, DC	R	-	654,715	204,829	-	-	-	-	-	-	-	-	-	-	859,544
60	Hempstead, NY	R	-	386,205	414,938	-	-	-	-	-	-	-	-	-	-	801,143
Grand Total			212,348,453	199,226,697	52,501,277	4,850	1,719,198	13,066	8,057	425,146	8,414	-	1,811,986	-	36,115,461	504,182,605

[a] R indicates a river port, L indicates a Great Lake port.

Table 2-5. County and FIPS codes for the Top 60 LRPs

Rank	Port Name	R/L [a]	County	FIPS code
1	Port of Pittsburgh, PA	R	Allegheny	42003
2	Duluth-Superior, MN & WI	L	Saint Louis/Douglas	27137/54047/55031
3	Port of St. Louis, MO & IL	R	Saint Louis City/ Saint Louis/Jefferson St. Charles/Monroe/St. Clair/Madison	29510/29189/29099 29183/17133/17163/17119
4	Port of Chicago, IL	L	Cook	17031
5	Huntington, WV	R	Cabell/Wayne/Lawrence	54011/54099/39087
6	Memphis, TN	R	Shelby/Crittenden	47157/05035
7	Indiana Harbor, IN	L	White County	18181
8	Port of Detroit, MI	L	Wayne	26163
9	Cleveland Harbor, OH	L	Cuyahoga	39035
10	Lorain Harbor, OH	L	Lorain	39093
11	Toledo Harbor, OH	L	Lucas	39095
12	Cincinnati, OH	R	Hamilton/Kenton/Campbell	39061/21117/21037
13	Burns Wwy Harbor, IN	L	Porter	18127
14	Presque Isle Harbor, MI	L	Presque Isle	26141
15	Ashtabula Harbor, OH	L	Ashtabula	39007
16	Gary Harbor, IN	L	Lake	18089
17	Taconite Harbor, MN	L	Itasca	27061
18	Louisville, KY	R	Jefferson/Floyd/Harrison	21111/18043/18061
19	Escanaba, MI	L	Delta	26041
20	Stoneport, MI	L	Presque Isle	26141
21	Calcite, MI	L	Presque Isle	26141
22	Two Harbors, MN	L	Lake	27075
23	Mount Vernon, IN	R	Posey/Henderson	18129/21101
24	St. Clair, MI	L	Saint Clair	26147
25	Conneaut Harbor, OH	L	Ashtabula	39007
26	Vicksburg, MS	R	Warren/Madison	28149/22065
27	Port Inland, MI	L	Interlochen in Grand Traverse	26055
28	St. Paul, MN	R	Washington/St. Croix/Pierce	27163/55109/55093
29	Victoria, TX	R	Victoria/Goliad	48469/48175
30	Silver Bay, MN	L	Lake	27075
31	Port of Kansas City	R	Jackson/Clay/Platte Johnson/Wyandotte	26095/29047/29165 20091/20209
32	Marine City, MI	L	Saint Clair	26147
33	Port of Nashville, TN	R	Davidson	47037
34	Sandusky Harbor, OH	L	Erie	39043
35	Marblehead, OH	L	Ottawa	39123
36	Milwaukee Harbor, WI	L	Northampton	37131

Table 2-5. County and FIPS codes for the Top 60 LRPs (continued)

Rank	Port Name	R/L [a]	County	FIPS code
37	Port Dolomite, MI	L	Mackinac	26097
38	Fairport Harbor, OH	L	Lake	39085
39	Alpena Harbor, MI	L	Alpena	26007
40	Guntersville, AL	R	Marshall	1095
41	Chattanooga, TN	R	Hamilton	47065
42	Green Bay Harbor, WI	L	Brown	55009
43	Helena, AR	R	Phillips/Coahoma/Tunica	05107/28027/28143
44	Monroe Harbor, MI	L	Monroe	26115
45	Greenville, MS	R	Washington/Chicot	28151/05017
46	Port of Buffalo, NY	L	Erie	36029
47	Muskegon Harbor, MI	L	Muskegon	26121
48	Biloxi Harbor, MS	R	Harrison	28047
49	Drummond Island, MI	L	Chippewa	26033
50	Charlevoix Harbor, MI	L	Charlevoix	26029
51	Tulsa, Port of Catoosa, OK	R	Tulsa	40143
52	Buffington Harbor, IN	L	Brunswick in Lake	18089
53	Minneapolis, MN	R	Hennepin/Ramsey	27053/27123
54	Ludington Harbor, MI	L	Mason	26105
55	Huron Harbor, OH	L	Fresno	06019
56	Erie Harbor, PA	L	Erie	42049
57	Grand Haven Harbor, MI	L	Ottawa	26139
58	Port of Hopewell, VA	R	Hopewell City	51670
59	Washington, DC	R	Prince Georges	24033
60	Hempstead, NY	R	Queens, Nassau	36081/36059

[a] R indicates a river port, L indicates a Great Lake port

To obtain more detailed ship-type descriptions and monthly breakdowns for foreign vessel traffic, data on the "U.S. Waterway Data CD-ROM" made available by the Census Bureau's Bureau of Transportation Statistics was used. The fields available in this database include vessel name, month in which the data were recorded, port/waterway entered or cleared, international classification by ship-type (ICST) code, flag of registering country, waterway schedule to indicate the next or last port visited, net registered tons, and draft. The data on the CD-ROM are gathered from the Census Bureau who collects the data from U.S. Customs entrance clearance forms.

Both the foreign and domestic vessel files had port/waterway codes to define what port was being entered or cleared. There is a master list of waterways recognized by the USACE on the Waterway CD-ROM. This list was used to query the foreign and domestic databases and to break the data down into the LRPs. The LRPs were ranked by the most cargo tonnage (combination of shipments and receipts) for the calendar year 1995. Table 2-7 in the Volume I report presents the corresponding Vessel Type Classification and Construction codes (VTCC) used to identify domestic ship-types and International Classification by Ship-Type codes (ICST) used to identify foreign ship-types. The match between the VTCC and ICST codes in Table 2-7 comes from the USACE CD-ROM from the Waterborne Transportation Lines of the United States (WTLUS).

SECTION 3
TYPICAL GREAT LAKE PORTS

3.1 INTRODUCTION TO TYPICAL PORTS

The purpose of these Typical Port data are to allow determination of actual commercial marine vessel movements on the Great Lake ports of Cleveland and Burns Waterway Harbor. These two ports are considered by this report to be Typical Great Lake Ports and were chosen to use as models for extrapolating vessel characteristics and movements at other Great Lake ports. Included in this section are detailed data on these ports and a methodology allowing the data for these Typical Great Lake Ports to be used with the more general data in Section 2 to estimate commercial marine vessel movements at other Great Lake ports. The data on the Typical Great Lake Ports are from 1996 and were obtained from a variety of sources as will be explained in detail in Section 3.2. The data on the Typical Great Lake Ports will be used to:

- Calculate the total number of trips to and from locations within each Typical Great Lake Port
- Calculate the total number of trips by Lakers and Salties
- Determine vessel characteristics for the various ship-types stopping at each Typical Great Lake Port
- Determine modes of similar speed and operating characteristics
- Calculate the average time each ship-type is operating in these modes

The two Typical Great Lake Ports were chosen because they represent different barge-type distributions and because they were able to provide electronic data. Both ports are mid-sized Great Lake ports, with Cleveland ranked 9th by tonnage in the Top 60 LRPs and Burns Waterway Harbor ranked 13th.

The following information is presented in this section. Section 3.2 presents a general overview of the data sources used to determine operations at the ports. Section 3.3 presents a general overview of time-in-mode calculations. Section 3.4 presents operating information common to the Typical Great Lake Ports. Section 3.5 presents detailed data on the Port of Cleveland. Section 3.6 presents detailed data on Burns Waterway Harbor. This section concludes with Section 3.7, a methodology to use the Typical Great Lakes Port data with the general Great Lakes data presented on the Top 60 LRPs in Section 2.

3.2 DATA SOURCES

Four primary sources of data were used to determine trips and time-in-mode for the two Typical Great Lake Ports. These include USACE, Census Bureau, MEPA, and LMIS. The first dataset, obtained from the USACE, gave detailed trip data on domestic trips to the ports of Burns Waterway Harbor and Cleveland. Information within this database included vessel name, vessel type, engine horsepower, shipping port and dock, receiving port and dock, travel code, unloading equipment, year built, capacity and net rated tons. This dataset was used to determine trips and shifts for domestic ships, tugs, and barges calling on and leaving the two

Typical Ports.

The second dataset used was the data provided by the U.S. Bureau of Census on the Navigation Data Center Publications and U.S. Waterway CD. These data gave detailed trip data on foreign vessels that stopped at the ports of Burns Waterway Harbor and Cleveland. Data included in this dataset were ship name, flag, vessel type, and net rated tons. These data were used to determine trips to and from the two Typical Ports by foreign ships. The third dataset was provided by the Marine Exchange or Port Authority (MEPA). This included at least ship name, date and time the ship arrived at the port and date and time the ship left the port. This was used to determine hotelling times.

The fourth dataset was provided by LMIS on ship characteristics. This was matched with both the Census Bureau and MEPA datasets to provide detailed ship information. Sea-speed, engine type, engine speed and DWT ratings were determined using LMIS data for similar ship-types and information from the book "Know Your Ships 1996". Barge types and capacities were determined from USACE data and "Know Your Ships 1996". Ship-type information was determined from the vessel type construction and characteristics (VTCC) codes in the USACE datasets and from "Know Your Ships 1996". Maneuvering time was determined using the distance from the breakwater to the dock at which the vessel left or arrived.

In addition to the aforementioned data sources, information about ship activity was obtained from calling various operators of Lake vessels and pilots used to guide foreign vessels through the lakes. In addition, information published by the Lake Carriers Association and an educational web site at www.boatnerd.com provided valuable information on ship characteristics. Further details on the datasets can be found in Appendix A.

3.3 CALCULATION OF TIME-IN-MODE

Time-in-modes associated with the major engine operating characteristics are needed to calculate emission inventories due to commercial marine activity. Four separate time-in-modes were calculated for all ships entering and leaving the two Typical Great Lake Ports: cruise, reduced speed zone (RSZ), maneuvering, and hotelling. Definitions of these four time-in-modes are given in Table 3-1.

As this study details ship activity within a Great Lake port and not the Great Lakes themselves, travel on shipping lanes in the Great Lakes were excluded from this study. As most shipping lanes are over 10 miles from the breakwater of any port, cruise time-in-modes were treated as starting 10 miles from the breakwater and continuing for 7 nautical miles. Cruise times for all vessels that entered or cleared the breakwater were determined using the sea-speed or service speed of the vessel. Cruise is assumed to occur at 85 to 90 percent of maximum continuous rating (MCR). Intraport vessel movements do not have cruise times. Cruise times for each vessel entering or clearing one of the Typical Great Lake Ports were calculated using Equation 3.1.

Cruise (hrs/trip) = 7 nautical miles / Service Speed (knots) (3.1)

Table 3-1. Time-in-mode descriptions for vessel movements in Typical Great Lake Ports

Summary Table Field	Description
Cruise (hrs/trip)	Time at sea-speed measured from 10 miles outside of the breakwater to 3 miles outside of the breakwater. The breakwater is the geographic marker for the change from the open lake to the port.
Reduced Speed Zone (RSZ) (hrs/trip)	Time during which the vessel slows from sea-speed to 4 knots. This occurs during the last 3 miles before entering the port. It also occurs upon leaving the port when the vessel increases speed from 4 knots to sea-speed over a distance of 3 miles.
Maneuver (hrs/trip)	Time at dead slow or reverse. Dead slow is usually from 2 to 4 knots. All ships are at maneuvering speed while within the port boundaries except for excursion vessels which tend to operate at a RSZ of 6 to 7 knots for most of the 2 hour excursion within the port boundaries. Maneuvering for excursion vessels is only to get into and out of the dock and is considered to be 0.4 hours for the total trip.
Hotelling (hrs/call)	Hotelling is the time at a dock when the vessel is operating auxiliary engines only. Auxiliary engines are operated at some load conditions the entire time the vessel is manned, but peak loads will occur after the propulsion engines are shut down either because the auxiliary engines are responsible for onboard power or because they are being used to power off-loading equipment, or both.

At about 3 miles from the breakwater, the vessel begins to slow down in order to pass the breakwater at approximately 4 knots. Reduced speed zone (RSZ) times for vessels that entered or cleared the breakwater were determined from the average between sea-speed and 4 knots and were expected to last 3 nautical miles. The calculations give all vessels an average of 3 miles to slow from sea-speed to 4 knots. In actual operations, larger vessels may require more distance and time at RSZ to slow to maneuvering speed. RSZ is assumed to occur at about 60% MCR. RSZ time for each vessel was calculated using Equation 3-2 for all vessels entering or clearing one of the Typical Great Lake Ports. Tug sea-speed was assumed to be 12 knots based upon information gathered from tug operators.

RSZ (hrs/trip) = 3 nautical miles * 2 / (Sea-Speed + 4) knots (3.2)

The third time-in-mode is maneuvering. It is the final leg of the journey into the port estimated to occur at 2 to 4 knots depending upon the waterway, direction, and ship-type. Different estimations of maneuvering time were made for each Typical Great Lake Port. Maneuvering occurs at approximately 20 to 30% MCR. Details on maneuvering calculations for Cleveland and Burns Waterway Harbor are in Sections 3.5.2 and 3.6.2 respectively.

Hotelling time was determined from the time and date a ship arrived in the port to the time and date it left the port. These details on individual vessel operations were received from the MEPAs. Details on hotelling calculations for each Typical Great Lake Port can be found in Section 3.5.3 for Cleveland and Section 3.6.3 for Burns Waterway Harbor.

3.4 GENERAL OPERATIONS AT TYPICAL GREAT LAKE PORTS

There are several ship-types common to the Great Lakes. Most Great Lake ports have a combination of Lakers and Salties as well as a substantial amount of barge traffic. Commercial passenger vessels used for brief excursions are also common.

Lakers are dry-cargo ships that operate only on the Great Lakes and have self-unloading equipment. Most Lakers are bulk carriers or cement carriers. Salties are foreign flag ships entering and leaving the Great lakes using the St. Lawrence Seaway. Salties may include bulk dry-cargo, general cargo, tankers, and container ship-types.

Barge traffic falls into two categories: flat-bottomed river barges (scows) that enter the Great Lakes through the Ohio River near Chicago, Illinois. The river barges share 1-4 barges per tug and generally do not have self-unloading equipment. Notch barges are larger lake barges that are more common at Great Lake ports distant from Chicago. These frequently have self-unloading equipment.

Not included in any of the datasets used for this project are mooring tugs and dredges. Both operate within the harbor boundaries. Generally, only Salties use mooring tugs to assist in docking, but some Lakers also will need mooring help under certain conditions. According to operators on the Great Lakes, the rule of thumb is that ships with bow thrusters need one mooring tug, while those without bow thrusters often require two tugs. Generally Lakers have bow thrusters and Salties do not. Salties are often required to pick up a Great Lake pilot who is familiar with the specific section of the Lakes and the vessel's destination port.

3.5 CLEVELAND, OHIO

Cleveland, Ohio is on the south shore of Lake Erie, at the mouth of the Cuyahoga River, approximately 176 statute[2] miles southwesterly by water from Buffalo, New York, and 96 statute miles easterly by water from Toledo, Ohio. The Port of Cleveland consists of a lakefront, breakwater-protected, outer harbor area, and an inner harbor consisting of the lower, deep draft section of the Cuyahoga River, and connecting Old River.

Table 3-2. Port Of Cleveland

LRP Rank	Typical Port	USACE Port Code
9	Cleveland, Ohio	3217

The approximate dimensions of the Outer Harbor are as follows: length of 5 miles along the Cleveland lakefront, a width of 1,600 to 2,400 feet, and an area of 1,300 acres. It is divided into an East and West Basin, formed by the East and West Breakwaters. The Outer Harbor has two entrances from Lake Erie: the main entrance is through a dredged channel between the outer ends of two converging breakwaters; the other entrance

[2] One statute mile is equivalent to 5280 feet. A nautical mile is equivalent to 1.15 statute miles

is at the east end of the East Basin between the breakwater and the shore.

The Inner Harbor includes the improved, lower 5.8 miles of the Cuyahoga River and about one mile of Old River, the former outlet of the Cuyahoga River. The Old River extends westward from a point about 0.4 mile above the mouth of the Cuyahoga River. The mouth of, and entrance channel to, the Cuyahoga River are in line with the main entrance to the Outer Harbor from the lake. The entrance channel is protected by 2 parallel piers placed 325 feet apart. The Cuyahoga River varies in width from 130 feet to 325 feet in straight sections and widens in the bends and in the turning basin where a width of 800 feet is available; the turning basin is located 4.8 miles above the mouth. No foreign flag ships use harbors on the Cuyahoga River.

Cleveland has four distinct seasons with strong modifying influences caused by Lake Erie. Prevailing winds are generally from the south. Summers are moderately warm and humid, winters are reasonably cold and cloudy with expectations of about 5 days with sub-zero temperatures. Precipitation varies from year to year, but is normally abundant and well distributed throughout the year with spring being the wettest season. Winds of 50 mph or greater are most frequent from April to August. Mean snowfall is about 45 inches in the west to more than 90 inches in the extreme east. The average earliest and latest dates of opening and closing of navigation for Salties are as follows:

	Opening	Closing
Earliest Date	March 21	December 20
Latest Date	April 8	December 30

Domestic Lakers use the port all year around. Coast Guard cutters may be used in the winter months to break up ice in the harbors and channels to allow passage by Lakers.

3.5.1 Data

The main datasets used to analyze ship activity for the Port of Cleveland were USACE, Census Bureau, and data available from the MEPA.

Census Bureau data together with LMIS data were used to determine trips and ship characteristics for foreign vessels. The Census Bureau data were matched to the LMIS data using ship name. Of the 614 records of ships that stopped at the Port of Cleveland, 287 matched directly with LMIS data. Another 118 related to barges, leaving 209 that were matched to similar ships based upon ship-type, DWT and date of build. Each record represented an entrance or clearance to the Port of Cleveland. It was assumed that all vessels in the Census Bureau dataset stopped or left from a central dock in the Outer Harbor.

MEPA data together with LMIS data were used to determine hotelling times for all vessels. Of the 154 records in the MEPA dataset, 132 matched directly with LMIS data by vessel name. The other 22 records were matched with LMIS data based upon ship type, DWT, flag, and date of build. While there were no domestic ship data in the MEPA dataset, the data did represent data on all the various ship-types except excursion vessels, tugboats and barges. Assumptions made for those ship-types are explained in Section 3.5.2.

3.5.2 Time-in-Mode Calculations

Cruise and RSZ time-in-modes for all vessels that entered or cleared the breakwater were determined as discussed in Section 3.3. Maneuvering times were calculated based upon ship-type and the direction on the Cuyahoga River. Salties typically stop at a central dock in the Outer Harbor. Maneuvering times for Salties were estimated to be 0.8 hours per trip. Lakers and tugboats travel down the Cuyahoga river to unload cargo. Because the Cuyahoga is too narrow for Lakers to turn around (except at the turning basin), they must be pushed back out the Cuyahoga river by tugboats. Assuming that the river current is negligible, maneuvering for Lakers is assumed to occur at 4 knots down the river (away from the breakwater) and at 2 knots up the river (towards the breakwater) with tug assist. Average maneuvering times for Lakers are shown in Table 3-3 for the various docks within the port of Cleveland. Tugboats are assumed to travel at 3 knots both up and down the river. In addition to the travel time to the dock discussed above, 0.5 hours are added to maneuver into or out of a dock. The maneuvering times in Table 3-3 include the 0.5 hours of maneuvering into or out of a dock.

Hotelling time for bulk carrier Salties and Lakers were calculated using the MEPA Hotelling time was calculated using Equation 3.3.

$$\textbf{Hotelling (hrs/call)} = (\text{ETD\_DATE} - \text{ETA\_DATE}) * 24 + (\text{ETD\_TIME} - \text{ETA\_TIME}) \qquad (3.3)$$

where

ETA_DATE = Estimated date of arrival at port

ETD_DATE = Estimated date of departure from port

ETA_TIME = Estimated time of arrival at port

ETD_TIME = Estimated time of departure from port

The MEPA dataset did not contain any information on tugs, excursion vessels, or barges. Estimates of hotelling time for those ship-types is discussed in Subsection 3.5.4.

3.5.3 Trip Activity

Summary tables for Lakers, Salties, and excursion vessels stopping at the Port of Cleveland are given in Table 3-4. Each trip is considered one way, either an entrance or clearance into or out of the port. The total time-in-mode for each ship-type can be achieved by multiplying the trips by the chosen time-in-mode category. For instance, the 219 trips recorded for Bulk Carrier, Salty times the average RSZ time of 0.3 hours gives a total RSZ time for all Salty Bulk Carriers that stopped at Cleveland of 65.7 hours per year. The abbreviation "ST" denotes that a steam turbine is used for the propulsion engine instead of a diesel engine. Because most of the Lakers go down the Cuyahoga River but Salties do not, Lakers tend to have larger maneuvering times. The use of mooring tugboats to push the Lakers up the river from the last dock, LTV Steel, to the turning basin also increases maneuvering time. This activity might be unique to the Port of Cleveland and should be taken into account when extrapolating the detailed data for Cleveland to other Great Lake ports. For ports without narrow rivers that prevent a Laker from turning, maneuvering times for Salties should be used for Lakers when allocating Cleveland time-in-mode data to other ports.

Loaded vessels sit deeper in the water and require more power than the same vessel would without cargo, thus emissions will be higher from loaded vessels. Table 3-5 shows the percent of trips by Lakers, Salties, and excursion vessels that are loaded. Lakers tend to be loaded for only 57% of the trips indicating that they travel to a port loaded and leave light or visa versa. Salties tend to enter and leave the port loaded.

Trips for tugboats and barges are shown in Table 3-6. Cruise, RSZ and maneuvering times for barges are not shown as barge emissions come from the tugboat which pushes them. While there is no direct way to tie specific barges to specific tugboats, several conclusions can be drawn from the comparison of tug and barge trips. First, there is an almost equal number of barge trips and tugboat trips, so one can assume that the tugboats recorded by USACE are nearly always pushing a barge and are not deployed "light" or without a barge. It can also be assumed from this one to one barge to tug ratio that one tug pushes one barge in the Cleveland area. Furthermore, only 44 % of return trips are loaded, and one can assume that the larger horsepower tugs are used to push larger capacity barges. This means that for a majority of the trips into and out of the harbor, the barge comes in loaded and leaves light or comes in light and leaves loaded. Based upon information obtained from the tugboat operators, the tugboat generally stays with the barge while loading or unloading. Mooring tug trips are not recorded by USACE.

3.5.4 Hotelling

Summary tables for hotelling times for all ship-types are given in Table 3-7. While the MEPA only provided data on foreign ships, hotelling times for domestic ships are expected to be similar. According to the Boatnerd website (http://www.oakland.edu/boatnerd/), "Most Lakers require around six hours in port loading or unloading; many self-unloaders are so highly evolved it often takes just one man at the controls to unload the entire vessel. The majority of Lakers are self-unloaders - able to discharge cargo without dockside equipment." The 7.4 hour average hotelling time for Lakers found in this study seems quite reasonable based upon the above statement.

Because they are not recorded by the MEPA, tug and barge hotelling times were not calculated using the MEPA data. It can be assumed that self-unloading barges would unload in 6 hours or less depending upon cargo capacity. Since a 20,000 ton ship takes approximately 6 hours to unload with self-unloading equipment, one might assume 20 minutes unloading for each 1,000 tons of capacity for a barge with self-unloading equipment. Barges without self-unloading equipment have no significant emissions and therefore hotelling time, but there may be hotelling time associated with the tugboat if it stays with the barge. Hotelling time for excursion vessels should be assumed to be one hour for most voyages, to allow for passenger loading and unloading and cleaning the boat after an excursion. Back-to-back cruises might have two hours of hotelling in between voyages. Tugboats do stay with the larger self-unloading barges thus hotelling time for both the barge and tug should be taken into account. Table 3-8 shows the percentage of trips by each ship-type and category that have self-unloading equipment.

Table 3-3. Laker maneuvering times for various docks in Port of Cleveland

Dock No.	Description	Miles from Breakwater	Maneuvering (hrs/trip)	
			Entering	Clearing
1	Cuyahoga River Bank	1.5	0.9	1.3
10	Consolidated Rail Corp.	1.2	0.8	1.1
29	Cleveland Breakwall	0.0	0.5	0.5
30	City of Cleveland	2.8	1.2	1.9
50	Ontario Stone Corp., Dock 1	0.8	0.7	0.9
107	Sand Products Corp.	1.4	0.9	1.2
115	International Salt Co.	1.7	0.9	1.4
160	Ontario Stone Corp., Dock 4	1.4	0.9	1.2
178	Lafarge Cement Corp.	1.7	0.9	1.4
195	Byerlite Dock - ARCO Chemicals	1.9	1.0	1.5
250	United Ready Mix Dock	2.1	1.0	1.6
275	Mid Continental Coal & Coke Co.	2.9	1.2	2.0
329	Cleveland Builders Supply, F Hill Dock	3.7	1.4	2.4
360	Clifton Concrete & Supply Co. Wharf	4.6	1.7	2.8
378	Cleveland Builders Supply, Dock 1	5.0	1.8	3.0
435	LTV Steel, Middle Dock	6.2	2.1	3.6
440	LTV Steel, Upper Dock	6.5	2.1	3.8
495	LTV Steel, Lower Dock	5.6	1.9	3.3
580	Ontario Stone Corp., Dock 2	4.0	1.5	2.5
590	Cleveland Builders Supply, Dock 2	3.7	1.4	2.4
598	River Dock, Inc.	3.2	1.3	2.1
673	Medusa Cement Co.	2.1	1.0	1.6
720	Cleveland Stevedore Co.	0.5	0.6	0.8
724	Cleveland MEPA	0.5	0.6	0.8
728	Pier 28	0.5	0.6	0.8
736	North Coast Cruises Landing	1.5	0.9	1.3

Table 3-4. Summary of trips for the Port of Cleveland for 1996

Ship-type	Stroke Type[a]	Category[b]	Trips	Year Built	DWT (tonnes)	Power (hp)	Sea-Speed (knots)	Engine (rpm)	Cruise (hrs/trip)	RSZ (hrs/trip)	Manuerver[c] (hrs/trip)
BULK CARRIER, SALTY	2	< 10,000	2	ND	8,186	6,200	14	ND	0.5	0.3	0.8
		10,000 - 20,000	23	ND	15,866	6,996	14	113	0.5	0.3	0.8
		20,000 - 30,000	134	1984	27,225	9,116	15	110	0.5	0.3	0.8
		> 30,000	60	1981	35,125	10,909	14	100	0.5	0.3	0.8
BULK CARRIER, SALTY Total			219	1983	28,022	9,358	14	109	0.5	0.3	0.8
BULK CARRIER, LAKER	2	10,000 - 20,000	39	1943	17,500	4,500	13	ND	0.5	0.3	0.8
		20,000 - 30,000	717	1977	26,830	7,098	13	750	0.5	0.3	2.4
		30,000 - 40,000	55	1974	37,107	7,087	13	ND	0.5	0.4	1.0
		> 40,000	37	1980	50,800	8,538	13	ND	0.5	0.3	0.9
	4	< 10,000	56	1959	7,686	4,303	14	ND	0.5	0.3	0.9
		10,000 - 20,000	350	1951	17,000	4,236	13	ND	0.5	0.3	2.0
		20,000 - 30,000	70	1973	21,303	5,503	14	ND	0.5	0.3	2.5
		30,000 - 40,000	16	1980	33,205	9,601	12	ND	0.6	0.4	0.8
	ST	10,000 - 20,000	106	1943	15,047	8,269	15	ND	0.5	0.3	0.9
BULK CARRIER, LAKER Total			1446	1967	23,445	6,308	13	750	0.5	0.3	2.0
CONTAINER SHIP, SALTY	2	< 10,000	4	ND	8,229	5,950	15	ND	0.5	0.3	0.8
	4	10,000 - 20,000	2	1995	10,187	7,382	16	500	0.4	0.3	0.8
CONTAINER SHIP, SALTY Total			6	1995	8,882	6,427	15	500	0.5	0.3	0.8
EXCURSION VESSEL	4	450	572	1981	ND	460	10	ND	0.0	2.0	0.4
		1000	748	1990	ND	850	12	ND	0.0	2.0	0.4
EXCURSION VESSEL Total			1320	1986	ND	655	11	ND	0.0	2.0	0.4
GENERAL CARGO, SALTY	2	< 10,000	2	ND	7,805	5,400	15	225	0.5	0.3	0.8
		10,000 - 20,000	6	1980	15,658	10,600	16	ND	0.4	0.3	0.8
	4	< 10,000	8	1963	7,251	3,391	12	550	0.6	0.4	0.8
		10,000 - 20,000	2	ND	17,154	6,000	14	ND	0.5	0.3	0.8
		20,000 - 30,000	2	ND	23,000	7,800	13	ND	0.5	0.4	0.8
GENERAL CARGO, SALTY Total			20	1972	12,394	6,456	14	442	0.5	0.3	0.8
TANKER, SALTY	2	< 10,000	5	1974	8,000	2,950	12	750	0.5	0.3	2.6
	4	10,000 - 20,000	12	1978	11,420	6,253	15	117	0.5	0.3	0.8
TANKER, SALTY Total			17	1976	10,280	5,152	14	328	0.5	0.3	1.4
Grand Total			**1665**	**1968**	**23,678**	**6,664**	**13**	**519**	**0.5**	**0.3**	**1.8**

[a] ST refers to steam turbine

[b] Category is dead weight tonnes for all ship types except excursion boats. Excursion boat category is passenger capacity.

[c] Hotelling times are found in Table 3-7.

Table 3-5. Percent of trips that are loaded by ship-type for the Port of Cleveland, 1996

Ship-type	Category [a]	% of trips loaded
BULK CARRIER, LAKER	< 10,000	93%
	10,000 - 20,000	43%
	20,000 - 30,000	59%
	30,000 - 40,000	54%
	> 40,000	62%
BULK CARRIER, SALTY	all	100%
CONTAINER SHIP, SALTY	all	100%
EXCURSION VESSEL	all	100%
GENERAL CARGO, SALTY	all	100%
TANKER, SALTY	< 10,000	50%
	10,000 - 20,000	92%

[a] Category is dead weight tonnes.

Table 3-6. Tugboat and barge trip summary for Port of Cleveland for 1996

Ship-type	Category[a]	Barge	Trips	Year Built	Sea-Speed (knots)	Cruise (hrs/trip)	RSZ (hrs/trip)	Maneuver (hrs/trip)	Cargo (tons)
TUGBOAT	2000	N/A	80	1930	12	0.5	0.4	1.8	N/A
	2400		254	1971	12	0.5	0.3	1.6	
	3000		30	1977	12	0.3	0.2	0.9	
	3600		70	1965	12	0.6	0.4	2.3	
	4000		6	1975	12	0.3	0.4	2.1	
	5000		27	1944	12	0.3	0.4	1.3	
	7000		8	1990	12	0.6	0.4	1.2	
TUGBOAT Total			475	1961	12	0.5	0.3	1.7	N/A
DRY-CARGO BARGE	< 2,000	Loaded	1	1983	N/A				382
	2,000 - 5,000	Light	15	1968	N/A				
		Loaded	66	1977					3,225
	5,000 - 10,000	Light	10	1937	N/A				
		Loaded	6	1937					7,996
	10,000 - 15,000	Light	33	1957	N/A				
		Loaded	32	1957					10,131
	15,000 - 20,000	Loaded	32	1978	N/A				2,816
	> 20,000	Light	25	1950	N/A				
		Loaded	47	1951					15,057
DRY-CARGO BARGE Total			267	1962	N/A				7,563
LIQUID CARGO BARGE	2,000 - 5,000	Light	37	1981	N/A				
		Loaded	49	1980	N/A				3,092
	5,000 - 10,000	Light	52	1969	N/A				
		Loaded	73	1968	N/A				5,063
LIQUID CARGO BARGE Total			211	1973	N/A				4,259
Grand Total			953	1964	12	0.5	0.3	1.7	6,239

[a] Category for Tugboats is actual engine power (hp). Category for barges is cargo capacity in tons.

Table 3-7. Average hotelling times by ship-type for calls on Port of Cleveland in 1996

Ship-type	DWT Category (tonnes)	Calls	Hotelling (hrs/call)
BULK CARRIER, SALTY	10,000 - 20,000	11	41.3
	20,000 - 30,000	75	69.3
	> 30,000	45	49.1
BULK CARRIER, SALTY Total		131	60.0
BULK CARRIER, LAKER	20,000 - 30,000	1	7.8
	> 30,000	1	7.0
BULK CARRIER, LAKER Total		2	7.4
CONTAINER SHIP, SALTY	< 10,000	1	24.7
	10,000 - 20,000	1	111.5
CONTAINER SHIP, SALTY Total		2	68.1
GENERAL CARGO, SALTY	< 10,000	9	55.1
	10,000 - 20,000	6	78.9
GENERAL CARGO, SALTY Total		15	64.6
PASSENGER, SALTY	all	2	30.5
TANKER, SALTY	all	1	29.0
Grand Total		**153**	**59.3**

Table 3-8. Percent of self-unloaders by ship-type for the Port of Cleveland, 1996

Ship-Type	DWT Category (tonnes)	Percent Self-Unloaders
BULK CARRIER, SALTY	all	0%
BULK CARRIER, LAKER	all	100%
CONTAINER SHIP, SALTY	all	0%
EXCURSION VESSELS	all	0%
GENERAL CARGO, SALTY	all	0%
TANKER, SALTY	< 10,000	100%
	10,000 - 20,000	8%
DRY-CARGO BARGE	< 5,000	0%
	5,000 - 10,000	100%
	10,000 - 20,000	0%
	> 20,000	100%
LIQUID CARGO BARGE	2,000 - 5,000	99%
	5,000 - 10,000	94%
TUGBOAT	all	0%

3.6 BURNS WATERWAY HARBOR, INDIANA

Burns Waterway Harbor is an artificial harbor constructed on the south shore of Lake Michigan, approximately 16 miles east of Indiana Harbor and 19 miles east of Chicago, Illinois. The 400-foot-wide entrance between the breakwaters extends from deep water in the lake to the 94-acre Outer Harbor. The East Harbor Arm and the West Harbor Arm are each 820 feet wide and have lengths of about 2,140 feet and 3,950 feet, respectively.

Table 3-9. Burns Harbor Waterway

LRP Rank	Typical Port	USACE Port Code
13	Burns Waterway Harbor, IN	3739

Bethlehem Steel Corp. has a riparian[3] fill in Lake Michigan in the area immediately east of the harbor area and the west bulkhead of this riparian fill is the east limit of Burns Waterway Harbor. Midwest Steel Division of National Steel Corp. has a riparian fill in the lake immediately west of the port site. The West Harbor Arm is owned by National Steel Corp.

The climate in Burns Harbor is predominately continental, ranging from relatively warm in summer to relatively cold in winter. In the winter, there is sometimes snowfall that is light inland but locally heavy near the lakeshore. Most of Lake Michigan does not freeze during the winter, which enhances the effect of Lake Michigan on winter temperatures and lake-produced snowfall, even though the area and harbors are often ice-choked.

Lakers use the harbor throughout the year. Coast Guard cutters break the ice around the harbor during winter months. The average navigation season for Salties is April 1 to December 15. Prevailing wind direction varies by month as shown in Table 3-10.

Table 3-10. Prevailing wind direction for Burns Harbor

Month	Prevailing Wind	Month	Prevailing Wind
January	W	July	NW
February	SW	August	NW
March	NW	September	SW
April	NW	October	S
May	S	November	SW
June	W	December	SW

[3] Riparian = along the bank of the Lake

Burns Waterway Harbor and the other ports on Lake Michigan and Lake Huron have more unique barge traffic than other Great Lake ports. Most of the barge traffic at Burns Waterway Harbor are river barges that come up the Illinois River from as far south as the Lower Mississippi River. When river tows reach the mouth of the Illinois River near Chicago, the barges are left in a fleeting area for distribution to nearby Great Lake ports. The larger barges that are commonplace to other Great Lake ports, such as Cleveland, are rarely seen in Burns Waterway Harbor. Tugs from Burns Waterway Harbor will bring loaded barges from the fleeting area into Burns Waterway Harbor and then push other loaded or light barges from Burns Waterway Harbor back to the fleeting area to be carried back down the river. These barges are also pushed from Burns Waterway Harbor to other ports on Lake Michigan and Lake Huron, as well as other Great Lake ports.

3.6.1 Data

The main datasets used to analyze ship activity for Burns Waterway Harbor were obtained from USACE, Census Bureau, and the MEPA.

Census Bureau data together with LMIS data were used to determine trips and ship characteristics for foreign vessels. The Census Bureau data were matched to the LMIS data using ship name. Of the 221 records of ships that stopped at Burns Waterway Harbor, 112 matched directly with LMIS data. The remaining 109 were matched to similar ships based upon ship-type, DWT, and date of build. Each record represented an entrance or clearance to Burns Waterway Harbor. It was assumed that all vessels in the Census Bureau dataset stopped or left from a central dock in the International Harbor.

MEPA data together with LMIS data were used to determine hotelling times for all vessels. Of the 594 records in the MEPA dataset, 71 matched directly with LMIS data by name. Another 496 records related to barges. The remaining 27 self-propelled vessel records were matched with LMIS data based upon ship-type, DWT, flag, and date of build. While there was no domestic ship data in the MEPA dataset, it did contain data on most of the various ship-types except tankers and tugboats. Assumptions made for those ship-types are explained in Section 3.6.2.

3.6.2 Time-in-Mode Calculations

Cruise and RSZ times for all vessels that entered or cleared the breakwater were determined as discussed in Section 3.3. Maneuvering time was calculated based upon the distance from the breakwater to the dock at 4 knots plus 0.5 hour for maneuvering into or out of a dock. For all ship types, the maneuvering times in Table 3-11 were used. In actual operations, larger vessels may require more time for maneuvering.

Hotelling times were calculated directly from the MEPA dataset for all vessel types. The exceptions include dry-cargo barges, tankers, and tugboats. All of the dry-cargo barges that stopped at Burns Waterway Harbor in 1996 did not have any auxiliary equipment, thus they would have no associated emissions with hotelling. Most of the liquid-cargo barges, however, had diesel pumps for unloading and thus some emissions would be associated with hotelling for those barges. Due to the efficiency of tugboat deployment, tugboats in

Burns Waterway Harbor are continually in motion either picking up or delivering barges. Thus, no hotelling emissions are associated with tugboats. Tanker hotelling emissions were unavailable using the existing datasets. The average hotelling time of 29 hours found for tankers in Cleveland would be an acceptable estimation of hotelling at Burns Waterway Harbor. Hotelling times for all other ship-types were calculated using Equation 3.4.

Table 3-11. Average maneuvering times for various docks in Burns Waterway Harbor

Dock No.	Description	Miles from Breakwater	Maneuvering (hrs/trip)
1	Disposal Site	0.7	0.7
2	Burns Harbor Breakwater	0.0	0.5
410	National Steel Corp. Barge Dock	1.1	0.8
420	Indiana Port Commission Berth 15	1.3	0.8
510	Indiana Port Commission Berth 6	0.5	0.7
540	Indiana Port Commission Berths 2-4.	0.7	0.7
550	Indiana Port Commission Berth 1	0.8	0.7
560	Bethlehem Steel Corp.	0.5	0.6

Hotelling (hrs/call) = (Exit_Date - Entry_Date) * 24 + (Exit_Time - Entry_Time) (3.4)

where

Entry_Date = Date ship arrived at port

Exit_Date = Date ship departed from port

Entry_Time = Time ship arrived at port

Exit_Time = Time ship departed from port

3.6.3 Trip Activity

Summary tables for Lakers and Salties stopping at Burns Waterway Harbor are given in Table 3-12. Each trip is considered one way, either an entrance, clearance, or an intraport movement. The abbreviation "ST" indicates a steam turbine used for the propulsion engine. In all other instances a diesel engine is the propulsion source. All of the cruise, RSZ and maneuvering times were fairly similar for all ship types and categories for Burns Waterway Harbor due to the short distance from the breakwater to the docks. This port should be used to model other ports that are similar in geography.

Load on the propulsion engines increases as the weight of the vessel increases. Table 3-13 shows the percent of trips by Lakers and Salties that are loaded with cargo. Lakers tend to be loaded for only about 58% of the trips indicating that they travel to a port loaded and leave light or visa versa. Salties tend to enter and leave the port loaded.

Table 3-12. Summary of trips for Burns Waterway Harbor for 1996

Ship-type	Stroke type [a]	Category [b]	Trips	Year Built	DWT (tonnes)	Power (hp)	Sea-Speed (knots)	Engine (RPM)	Cruise (hrs/trip)	RSZ (hrs/trip)	Maneuver [c] (hrs/trip)
BULK CARRIER, LAKER	2	20,000 - 30,000	9	1973	24,827	8,531	13	750	0.5	0.4	0.7
		30,000 - 40,000	37	1974	34,925	7,108	13	ND	0.5	0.4	0.6
		> 40,000	162	1975	67,695	14,376	14	ND	0.5	0.3	0.6
	4	10,000 - 20,000	14	1952	17,978	4,800	13	ND	0.5	0.4	0.7
		20,000 - 30,000	6	1971	22,491	6,600	15	ND	0.5	0.3	0.7
		30,000 - 40,000	27	1979	32,908	9,541	12	ND	0.6	0.4	0.7
	ST	20,000 - 30,000	11	1953	23,627	8,886	16	ND	0.4	0.3	0.6
BULK CARRIER, LAKER Total			266	1973	52,630	11,753	14	750	0.5	0.3	0.6
BULK CARRIER, SALTY	2	10,000 - 20,000	4	1976	14,631	6,700	14	ND	0.5	0.3	0.7
		20,000 - 30,000	99	1973	27,329	8,839	13	219	0.5	0.3	0.7
		30,000 - 40,000	42	1982	32,449	10,132	14	105	0.5	0.3	0.7
	ST	20,000 - 30,000	20	1961	26,175	3,551	16	ND	0.4	0.3	0.7
BULK CARRIER, SALTY Total			165	1974	28,185	8,476	14	193	0.5	0.3	0.7
GENERAL CARGO, SALTY	2	< 10,000	8	1962	8,395	4,100	14	ND	0.5	0.3	0.7
		10,000 - 20,000	1	1982	16,467	11,200	16	150	0.4	0.3	0.7
	4	< 10,000	6	1979	5,785	3,667	12	ND	0.6	0.4	0.7
GENERAL CARGO, SALTY Total			15	1970	7,889	4,400	13	150	0.5	0.3	0.7
TANKER, SALTY	4	< 10,000	200	1973	7,500	400	14	720	0.5	0.3	0.6
Grand Total			646	1973	40,342	9,792	14	596	0.5	0.3	0.7

[a] ST refers to steam turbine
[b] Category is dead weight tonnes for all ship-types
[c] Hotelling times are found in Table 3-15

Table 3-13. Percent of trips that are loaded by ship-type

Ship-type	Category [a]	Percent loaded trips
BULK CARRIER, LAKER	10,000 - 20,000	50%
	20,000 - 30,000	77%
	30,000 - 40,000	72%
	> 40,000	51%
BULK CARRIER, SALTY	all	100%
CONTAINER SHIP, SALTY	all	100%
GENERAL CARGO, SALTY	all	100%
TANKER, SALTY	< 10,000	50%

[a] Category is in dead weight tonnes

Trips for tugboats and barges are shown in Table 3-14. Cruise, RSZ and maneuvering times for barges are not shown as the emissions come from the tugboat which pushes them. While there is no direct way to tie specific barges to specific tugboats, several conclusions can be drawn. First, there are almost 1.6 barge trips for each tugboat trip, indicating that tugboats push more than one barge at a time. Tugboat operators indicate that they can move from 2 to 4 barges at a time over the Great Lakes. It is assumed that the larger horsepower tugboats will push more barges. One can also see that about 56% of the barge trips are loaded, thus it is slightly more likely that loaded barges are moved into Burns Waterway Harbor and empty barges are pushed out. Based upon information obtained from the tugboat operators, the tugboat generally does not stay with the barge while it is loading or unloading. Tugs are dispatched so that they are constantly on the move. Mooring tug trips are not recorded by USACE.

3.6.4 Hotelling

Summary tables for hotelling times for all ship-types are given in Table 3-15. While the MEPA provided data on almost all the ships and barges that stopped at Burns Waterway Harbor, tankers and tugboats were not recorded by the MEPA. Tugboat hotelling emissions are negligible as tugboats are scheduled to maximize the ratio of hours operated to barges pushed. The hotelling time for tankers in Cleveland can be used as a default for Burns Waterway Harbor. When comparing Table 3-15 for Burns Waterway Harbor against Table 3-7 for Cleveland, Lakers hotel longer and Salties shorter at Burns Waterway Harbor. This might be due to the port configuration, unloading equipment at the harbor, or the type of cargo handled.

Table 3-16 shows the percentage of each ship-type that contained self-unloading equipment. Only the Lakers and liquid-cargo barges have unloading equipment, the rest of the ship-types have none.

Table 3-14. Tugboat and Barge trip summary for Burns Waterway Harbor, 1996

Ship-type	Category [a]	Barge	Trips	Year Built	Power (hp)	Sea-Speed (knots)	Cruise (hrs/trip)	RSZ (hrs/trip)	Maneuver (hrs/trip)	Cargo (tons)
TUGBOAT	< 1500	N/A	530	1963	1,264	12	0.6	0.4	0.6	
	1500 - 2500	N/A	356	1962	2,048	12	0.6	0.4	0.6	
	2500 - 3500	N/A	170	ND	2,600	12	0.6	0.4	0.6	N/A
	4000	N/A	8	ND	4,000	12	0.6	0.4	0.6	
	7000	N/A	2	1990	7,000	12	0.6	0.4	0.6	
TUGBOAT Total			1066	1963	1,637	12	0.6	0.4	0.6	N/A
DRY-CARGO BARGE	< 2000	Light	639	1980	N/A					
		Loaded	827	1979						1,475
DRY-CARGO BARGE Total			1466	1980	N/A					1,475
LIQUID-CARGO BARGE	< 2000	Light	24	1985	N/A					
		Loaded	24	1985						1,490
	2000 - 5000	Light	21	1966	N/A					
		Loaded	22	1966						2,686
LIQUID-CARGO BARGE Total			91	1976	N/A					2,062
Grand Total			2623	1977	1,637	12	0.6	0.4	0.6	1,509

[a] Category for tugboat is actual engine power (hp). Category for barges is cargo capacity in tons.

Table 3-15. Average hotelling times by ship-type for calls on Burns Waterway Harbor

Ship-type	Category [a]	Calls	Hotelling (hrs/call)
BULK CARRIER, LAKER	10,000 - 20,000	7	13.5
	20,000 - 30,000	7	17.9
	> 30,000	7	18.7
BULK CARRIER, LAKER Total		21	16.6
BULK CARRIER, SALTY	10,000 - 20,000	4	61.0
	20,000 - 30,000	43	43.2
	> 30,000	19	48.0
BULK CARRIER, SALTY Total		66	45.8
GENERAL CARGO, SALTY	< 10,000	10	26.3
	20,000 - 30,000	1	23.9
GENERAL CARGO Total		11	26.0
DRY-CARGO BARGE	< 2000	446	46.8
LIQUID CARGO BARGE	< 2000	23	52.9
	2000 - 5000	27	29.7
LIQUID CARGO BARGE Total		50	40.3
Grand Total		594	44.4

[a] Category is in dead weight tonnes.

Table 3-16. Percent of self-unloaders by ship-type

Ship-type	Percent Self-Unloaders
BULK CARRIER, SALTY	0%
BULK CARRIER, LAKER	100%
GENERAL CARGO, SALTY	0%
TANKER, SALTY	0%
DRY-CARGO BARGE	0%
LIQUID CARGO BARGE	100%
TUGBOAT	0%

3.7 METHODOLOGY FOR ALLOCATION TO OTHER GREAT LAKE PORTS

In Section 2 of this report, trips and tons for the various ship-types were presented for the Top 60 LRPs. In Section 3, two Typical Great Lake Ports were studied in detail, showing activity and time-in-mode for the various ship-types. In this subsection, a methodology is presented for determining time-in-modes at other Great Lake ports using the following steps:

Step 1: Determine the Like Port for the Modeled Port (i.e. which Typical Great Lake Port is most similar to the port to be modeled)

Step 2: Allocate undetermined dry-cargo trips

Step 3: Determine bulk carrier trips made by Lakers

Step 4: Adjust barge and tug trips as needed

Step 5: Allocate time-in-modes to the Modeled Port

Step 6: Adjust maneuvering time as needed

As an example, Lorain Harbor, Ohio, ranked 10th in the Top 60 LRPs shall be used as the Modeled Port.

3.7.1 Step 1: Determine Which Typical Great Lake Port Is Most Like The Port To Be Modeled

In order to determine which Typical Great Lake Port to use as the basis for allocation of time-in-modes, the modeler must determine which Typical Port the Modeled Port is most similar to. Several factors can be used to determine this, but the most distinguishing characteristic is the dominant type of barge traffic that is seen at the port.

As stated in Subsections 3.5 and 3.6, two different types of barge traffic are common to the Great Lakes. Cleveland has a majority of larger notch barges which have unloading equipment. Burns Waterway Harbor has a majority of river barges which have no unloading equipment. Only barges with unloading equipment will have emissions associated with hotelling time. Tugboats tend to stay with barges that have unloading equipment, thus hotelling time is likely to be significant for tugboats pushing these barges.

If more detailed information is not available directly from the Modeled Port, the modeler can use Table 3-17 to help determine the dominate barge-type at the Modeled Port. As can be seen from Table 3-17, ports like Chicago, Gary, and Port Inland all have dry-cargo barge tons per trip of less than 2,000 tons indicating river barges with no unloading equipment. Tugs may often push more than one river-type barge at a time. Thus a barge to tug ratio greater than 1 indicates a majority of river barge traffic These ports should use Burns Waterway Harbor as the Like Port for allocation of time-in-modes. Ports such as Lorain, Toledo, and Buffalo all have dry-cargo barge tons per trip greater than 2,000 tons and barge to tug ratios of less than 1.0 indicating large notch barges with self- unloading equipment. These ports should use Cleveland as the Like Port.

Other ports such as Duluth-Superior and St. Clair have dry-cargo barge tons per trip over 2,000 tons but barge per tug trips greater than 1.0. For lack of better information, the modeler should look at the liquid-cargo barge tons per trip as well. Since in both these cases, liquid-cargo barge tons per trip are under 2,000 tons, one might assume that tugboats might push several liquid-cargo barges but only one dry-cargo barge. In those cases Cleveland should be used as the Like Port for the dry-cargo barge trips with tugboats and the Burns Waterway Harbor as the Like Port for the liquid-cargo barges. Other ports such as Detroit and Marblehead do not have a dominant barge-type and would require further data before a Like Port could be chosen. Green Bay Harbor seems to be an anomaly that either overstates dry-cargo barge trips, or understates tugboat trips, or both.

Since Lorain Harbor is the Modeled Port, the above discussion shows that Cleveland should be used as the Like Port.

3.7.2 Step 2: Allocate Undetermined Dry Cargo Trips

Time-in-modes were not calculated for undetermined dry-cargo (UC) ships. UC ships can be bulk carrier (BC), container (CS), general cargo (GC), passenger (PA), refrigerated cargo (RF), or roll-on/roll-off

Table 3-17. Tug and barge ratios for the top Great Lake ports

LRP Rank	Port Name	Barge/Tug [a]	Tons/DCB [b]	Tons/LCB [c]
2	Duluth-Superior, MN & WI	1.1	15,425	1,381
4	Port of Chicago, IL	2.2	788	913
7	Indiana Harbor, IN	0.8	2,334	1,489
8	Port of Detroit, MI	1.2	2,108	1,155
9	Cleveland Harbor, OH	0.5	6,788	1,864
10	Lorain Harbor, OH	0.8	9,385	NBT
11	Toledo Harbor, OH	0.8	4,398	1,522
13	Burns Waterway Harbor, IN	1.2	580	1,045
14	Presque Isle Harbor, MI	1.0	28,567	NBT
15	Ashtabula Harbor, OH	NBT	NBT	NBT
16	Gary Harbor, IN	1.2	1,532	NBT
17	Taconite Harbor, MN	1.0	15,293	NBT
19	Escanaba, MI	1.0	16,854	NBT
20	Stoneport, MI	1.1	10,329	NBT
21	Calcite, MI	1.1	11,490	NBT
22	Two Harbors, MN	1.0	33,057	NBT
24	St. Clair, MI	1.4	10,819	692
25	Conneaut Harbor, OH	1.0	27,538	NBT
27	Port Inland, MI	1.0	961	NBT
30	Silver Bay, MN	NBT	NBT	NBT
32	Marine City, MI	NBT	NBT	NBT
34	Sandusky Harbor, OH	1.0	267	NBT
35	Marblehead, OH	5.7	2,326	1,121
36	Milwaukee Harbor, WI	0.5	364	2,798
37	Port Dolomite, MI	1.1	6,923	NBT
38	Fairport Harbor, OH	1.0	10,163	NBT
39	Alpena Harbor, MI	2.0	NBT	NBT
42	Green Bay Harbor, WI	112.9	414	2,486
44	Monroe Harbor, MI	1.0	NBT	3,902
46	Port of Buffalo, NY	0.4	7,924	1,965
47	Muskegon Harbor, MI	1.4	549	NBT
49	Drummond Island, MI	1.0	9,934	NBT
50	Charlevoix Harbor, MI	0.4	3,981	NBT
52	Buffington Harbor, IN	1.6	2,711	NBT
54	Ludington Harbor, MI	0.4	5,474	2,760
55	Huron Harbor, OH	NBT	NBT	NBT
56	Erie Harbor, PA	NBT	NBT	NBT
57	Grand Haven Harbor, MI	0.4	2,265	NBT
Grand Total		1.7	1,095	1,107

[a] Ratio of all barge trips to tug trips for port. NBT indicates no barge trips.

[b] Ratio of total dry-cargo barge tons to total dry-cargo barge trips for port.

[c] Ratio of total liquid-cargo barge tons to total liquid-cargo barge trips for port.

(RO) ship-types. UC trips should be allocated to each of the above-listed ship-types using the ratio of trips for each dry-cargo ship-type divided by the total of all the listed dry-cargo ship-type trips. In the example of Lorain Harbor, there were 1,061 BC, 12 GC or 1,083 defined dry-cargo trips and 37 UC trips in 1995 (from Table 2-3). The 37 UC trips can be allocated to the BC and GC ship-types as follows. Of all the defined dry-cargo ship trips, 1,061 out of 1,083 were bulk carrier trips and 12 out of 1,083 were general cargo trips. The 37 UC trips multiplied by 1,061 and divided by 1,083 trips equals 36 trips, which should be added to BC trips. The remaining trip should be added to GC trips. Thus the total BC trips for Lorain would be 1,097 and the total GC trips would be 13.

3.7.3 Step 3: Determine Bulk Carrier Trips Made By Lakers

As the hotelling time for Lakers that have self-unloading equipment is significantly shorter than hotelling time for Salties, bulk carrier trips determined in Subsection 3.7.2 should be broken into Laker and Salty trips. By using the information in Table 3-18, the modeler can allocate bulk carrier trips to Lakers and Salties.

As a result of the step described in Subsection 3.7.2, Lorain Harbor had 1097 bulk carrier trips in 1995. Using the percentages in Table 3-18, all 1097 trips were by Lakers.

3.7.4 Step 4: Adjust Barge and Tug Trips as Needed

For ports like Duluth-Superior where barge to tug ratios are higher than 1.0 and dry-cargo barge tons per trip exceed 2000 tons, a reallocation of tug trips should be made. In this case, the modeler should allocate one tug trip for each dry-cargo barge trip. The remaining tug trips should be allocated to the liquid-cargo barge trips. This will give a different barge to tug ratio for dry-cargo and liquid-cargo barges.

Duluth-Superior had 63 dry-cargo barge trips, 6 liquid-cargo barge trips and 64 tug trips. Assigning one dry-cargo barge trip to one tug trip leaves 6 liquid-cargo trips for one tug trip. If the tugs at this harbor are higher horsepower tugboats, they should be able to push 6 liquid barges without problem. By doing this, the modeler can better estimate the loads on the tugboat while pushing barges.

In the example of Lorain Harbor, there are no liquid-cargo barge trips, the dry-cargo barge tons per trip seem reasonable, and so does the ratio of barge trips to tug trips. In the case of Lorain Harbor, there are 35 dry-cargo barge trips and 46 tugboat trips, indicating that 11 trips or 24% of the tug trips are made without barges.

3.7.5 Step 5: Allocate Time-In-Modes To The Modeled Port

Cruise, RSZ and maneuvering times listed in the tables for the Typical Great Lake Ports are in hours per trip, while hotelling times are in hours per call. If the modeler desires to calculate time-in-modes (cruise, RSZ, and maneuver) for calls (an entrance and clearance) instead of trips, divide the trips by 2 and multiply the times-in-mode by 2. Hotelling can be directly applied from the Like Port to the Modeled Port without modification for all the various ship-types. In the case of Lorain Harbor, 1097 bulk carrier Laker trips, 35 dry-cargo barge trips, 13 general cargo trips and 46 tugboat trips were made in 1995. Time-in-modes were applied directly from Tables 3-4 and 3-6 for Cleveland and are shown in Table 3-19 for Lorain Harbor. Tugboat and dry-cargo barge hotelling times should be determined using the rule of thumb for self-unloading barges from Subsection 3.5.4 and the cargo tonnage per barge from Table 3-17, if the cargo tonnage per dry-cargo barge is over 2000 tons. Lorain Harbor has an average of 9,385 tons per barge, thus a hotelling time of 20 minutes per 1000 tons times 9.385 gives a hotelling time of 188 minutes or 3.1 hours. This should be applied to both the barges and the tugboats.

Table 3-18. Bulk carrier Laker and Salty percentage of trips for Great Lake ports

RL Rank	Port Name	Salty	Laker
2	Duluth-Superior, MN & WI	10%	90%
4	Port of Chicago, IL	27%	73%
7	Indiana Harbor, IN	0%	100%
8	Port of Detroit, MI	0%	100%
9	Cleveland Harbor, OH	15%	85%
10	Lorain Harbor, OH	0%	100%
11	Toledo Harbor, OH	15%	85%
13	Burns Waterway Harbor, IN	30%	70%
14	Presque Isle Harbor, MI	0%	100%
15	Ashtabula Harbor, OH	7%	93%
16	Gary Harbor, IN	1%	99%
17	Taconite Harbor, MN	0%	100%
19	Escanaba, MI	0%	100%
20	Stoneport, MI	0%	100%
21	Calcite, MI	0%	100%
22	Two Harbors, MN	0%	100%
24	St. Clair, MI	1%	99%
25	Conneaut Harbor, OH	0%	100%
27	Port Inland, MI	0%	100%
30	Silver Bay, MN	0%	100%
32	Marine City, MI	0%	100%
34	Sandusky Harbor, OH	0%	100%
35	Marblehead, OH	0%	100%
36	Milwaukee Harbor, WI	21%	79%
37	Port Dolomite, MI	0%	100%
38	Fairport Harbor, OH	3%	97%
39	Alpena Harbor, MI	0%	100%
42	Green Bay Harbor, WI	0%	100%
44	Monroe Harbor, MI	0%	100%
46	Port of Buffalo, NY	31%	69%
47	Muskegon Harbor, MI	0%	100%
49	Drummond Island, MI	0%	100%
50	Charlevoix Harbor, MI	0%	100%
52	Buffington Harbor, IN	0%	100%
54	Ludington Harbor, MI	9%	91%
55	Huron Harbor, OH	0%	100%
56	Erie Harbor, PA	2%	98%
57	Grand Haven Harbor, MI	0%	100%

Table 3-19. Allocation of ship activity to Lorain Harbor

Ship-type	Trips	Cruise (hrs/trip)	RSZ (hrs/trip)	Maneuver (hrs/trip)	Hotelling (hrs/call)
BULK CARRIER, LAKER	1,097	0.5	0.3	2.0	7.4
GENERAL CARGO, SALTY	13	0.5	0.3	0.8	64.6
TUGBOAT	46	0.5	0.3	1.7	3.1
DRY-CARGO BARGE	35	N/A	N/A	N/A	3.1

3.7.6 Step 6: Adjust Maneuvering Time as Needed

A comparison should be made between the Modeled Port and the Like Port distance from the breakwater to docking areas. These data can be obtained from the Port Series reports for the Modeled Port. If the distances are different, maneuvering times should be adjusted accordingly by the ratio of the distances. The easiest and most direct method is to determine the distance to the furthest dock for the Modeled Port and the Like Port. Since 0.5 hour of maneuvering time per trip is related to entering or clearing the dock, 0.5 hour needs to be subtracted from the total maneuvering time at the Like Port to determine the travel time from the breakwater to the average dock. The remaining maneuvering time should then be adjusted by multiplying it by the ratio of the distance to the furthest dock in the Modeled Port divided by the distance to the furthest dock in the Like Port. The 0.5 hour per trip should then be added back to the adjusted travel time to give the total maneuvering time per call for the Modeled Port.

In the case of Lorain, the furthest dock is about 2.8 miles down the Black River while the furthest dock for Cleveland is approximately 6.5 miles down the Cuyahoga River. Distances to various docks within ports can be determined from the Port Series Report published by the USACE. Subtracting 0.5 hour of maneuvering time per trip, the modeler calculates 1.5 hours of maneuvering time for Lakers. The maneuvering time should then be adjusted by multiplying it by the ratio of 2.8 miles divided by 6.5 miles giving an adjusted maneuvering travel time of 0.6 hour. Adding 0.5 hour of maneuvering for the time into or out of the dock, the modeler gets 1.1 hours of maneuvering for Lakers per trip. Similar adjustments for distance should be carried out for tugboats, dry-cargo barges, and liquid-cargo barges. Data indicate that Salties do not go down the river and thus the maneuvering times for Cleveland can be directly applied to all Salty ship-types. The final time-in-modes for Lorain Harbor are shown in Table 3-20.

Table 3-20. Final time-in-modes at Lorain Harbor

Ship-type	Trips	Cruise (hrs/trip)	RSZ (hrs/trip)	Maneuver (hrs/trip)	Hotelling (hrs/call)
BULK CARRIER, LAKER	1,097	0.5	0.3	1.1	7.4
GENERAL CARGO, SALTY	13	0.5	0.3	0.8	64.6
TUGBOAT	46	0.5	0.3	1.0	3.1
DRY-CARGO BARGE	35	N/A	N/A	N/A	3.1

SECTION 4

TYPICAL RIVER PORTS

4.1 INTRODUCTION TO TYPICAL RIVER PORTS

To continue our analysis of major commercial ports in the United States, we chose to acquire data on two inland river ports. The purpose of these data are to allow determination of actual commercial marine vessel movements on the inland waterways at the Port of St. Louis and the Port of Cincinnati. These two ports are considered Typical River Ports and will be examined in detail in this section. A methodology is also presented in Section 4.6 that allows data for these Typical River Ports to be used with the more general data in Section 2, Tables 2-3, 2-4, and 2-5 to estimate commercial marine vessel movements at other river ports. The data on the Typical River Ports is for 1996 and were obtained from the USACE Waterborne Commerce Statistics Center. The data will be used to:

- Calculate the total number of trips to and from locations within each Typical River Port
- Calculate the total number of trips passing, but not stopping at, each Typical River Port
- Determine vessel characteristics for tugboats and barges operating in and through each Typical River Port
- Determine modes of similar speed and operating characteristics
- Calculate the average time the tugs are operating in these modes

The Typical River Ports were chosen because they are large ports located on two of the most important rivers in the U.S. and because of the availability of lock data either within or on either side of the port. The Port of St. Louis has two locks located within its boundaries. Cincinnati has no locks located within its boundaries but has an up-river and a down-river lock with no other major ports located between the locks.

This section is organized with general data on the river ports in Section 4.2 and general information on time-in-modes of the river ports in Section 4.3. Information and data specific to the Port of St. Louis are in Section 4.4. Information and data specific to the Port of Cincinnati are in Section 4.5. Section 4.6 presents the methodology for using Typical River Port data with the rivers in the general Top 60 Lake and River Ports data.

4.2 GENERAL OPERATIONS ON RIVERS

Commercial traffic on rivers consists almost exclusively of tug and barge movements. There are some excursion vessels such as paddle boats, dinner cruises, or other entertainment-centered river traffic, but the majority of trips and vast majority of tonnage recorded by the USACE are centered around the tug/barge movements. The tug/barge combination is often referred to as a tow. The following is a discussion of excursion vessels, tugs, and barges.

Excursion vessels are passenger boats of all kinds which normally operate on repetitive routes that last a set length of time. Excursion vessels include cruise, passenger, and excursion ship-types. Each excursion boat usually has a cruise that lasts from one to several hours, returning and departing from the same port. A few excursion cruises may be overnight or several days and cover several ports. Excursion vessels will have only a short time at the dock between cruises and will rarely leave their auxiliary engines on for more than an hour of hotelling time at the dock. Gambling boats are likely to have large hotelling emissions from auxiliary engines, however they are expected to be a small percentage of the overall excursion vessel population and are not specifically addressed in this report.

There are different types of tugs and different types of barges that commonly operate on the rivers. Two main types are described as follows. The two main types of tugs are towboats and pushboats. A river tug or pushboat is generally a flat bottomed boat with a flat bow. The bow meets up against the flat stern of a river barge, the two are secured to each other, and the tug pushes the barge or barges up or down the river. In one variation, the pushboat has a rounded or pointed bow that fits in a notch on the stern of a barge (notch barge) and then commences to push the barge. Less commonly seen on the rivers are towboats. Unlike a pushboat, the hull of the towboat does not, generally speaking, touch the barge. Instead a long line passes between the towboat and the barge as the towboat pulls the barge forward. Towboats are more commonly used for ocean going barges and on the Great Lakes than they are in the rivers. Table 4-1 shows the relative percent of tow trips powered by towboats and by pushboats near the Typical River Ports. No distinction is made between operating characteristics of these vessels in the report and, in all other sections of the report, the propulsion boat of the tow is referred to as a tug.

Table 4-1. Percent of towboats and pushboats at the Typical River Ports

Port	Propulsion Source	Trips	% of Trips
St. Louis	Towboat	4,833	21%
	Pushboat	17,864	79%
Cincinnati	Towboat	4,000	25%
	Pushboat	12,000	75%

The two main types of barges are dry cargo and liquid cargo barges. Dry cargo barges include flat deck, open hopper, covered, and lash barges. Liquid cargo barges include single-hull, double-hull, and double-sided. Liquid cargo barges have an average of 40% greater cargo capacity and are an average of 15% longer and 30% wider than a dry cargo barge. There are variations within the liquid and dry cargo barge categories. Table 4-2 presents the barge-types and total number of trips near the ports of St. Louis and Cincinnati. These trip totals also include barges which passed the port without calling. However, it is very difficult to determine, using the existing data, any matches between specific tugs and specific barges on the river. Because tugs generally push several barges as part of a tow and the tow could be made of a combination of liquid and dry barges, it is not considered critical to this report to present barges in more defined ship-type categories in the summary tables.

Table 4-2. Detailed barge characteristics at the Typical River Ports

Barge Type	St. Louis Trips	Cincinnati Trips	Cap [a] (Ton)	NRT [b]	Length	Breadth	VTCC [c]	ICST [d]	Description
Dry Cargo	0	1,918	486 [e]	84	116	33	4A11	351	Passenger barge
Dry Cargo	231	48	407	204	62	31	4A52	344	Lash Barge
Dry Cargo	2,663	1,668	1557	590	184	30	4A47	341	Open Dry Cargo Barge
Dry Cargo	23,493	1,740	1618	758	195	35	4A48	342	Covered Dry Cargo Barge
Dry Cargo	17,411	47,711	1600	691	196	35	4A40	341	Open Hopper Barge
Dry Cargo	7,398	184	1464	806	206	40	4A43	343	Flat/Deck Barge
Dry Cargo	59,157	7,776	1596	905	196	35	4A41	342	Covered Hopper Barge
Liquid Cargo	4	6	1655	740	200	35	5F71	142	Double Hull Liquid Cargo Barge (unknown material)
Liquid Cargo	8,678	4,741	2290	1254	230	46	5A71	142	Double Hull Liquid Cargo Barge (steel)
Liquid Cargo	530	149	2440	1314	243	48	5A74	149	Other Liquid Cargo Barge
Liquid Cargo	662	1,359	3227	1318	232	48	5A70	141	Single Hull Liquid Cargo Barge
Liquid Cargo	512	858	2764	1369	264	53	5A72	143	Double Sided Liquid Cargo Barge

[a] Barge capacity in Tons, [b] Average Net Registered Tons, [c] Vessel Type Classification and Construction code, [d] International Classification by Ship-Type code, [e] Average Passenger Capacity

Barges are assembled into tows at fleeting areas. It is within the fleeting area that tows are made and broken down by harbor tugs and where the higher horsepower tug meets the completed tow for the trip up- or down-river. Barges are secured together according to their delivery destination. Sometimes the entire tow may be delivered to a fleeting area within a port and sometimes a harbor tug will meet the tow and remove one or more of the outermost barges while leaving the rest of the tow intact to continue its voyage.

Unlike deep-sea ports, a vessel passing through a river port does not necessarily stop at the port. However, the passage of this vessel will be an emission event for the surrounding port area. For example, a vessel leaving from Memphis, TN and destined for St. Paul, MN would pass through the Port of St. Louis. Likewise, a vessel leaving St. Louis, MO and destined for Pittsburgh, PA would pass through the Port of Cincinnati. Thus, traffic passing through a river port can be equally important as traffic calling on the port. Indeed, passing traffic is often more significant in tonnage and trips than the calling traffic as seen in the summary tables for the Typical River Ports. For this reason, the summary tables are broken out by passing and calling to indicate the characteristics of vessels that actually had the Typical River Port as their shipping or receiving port as separate from the characteristics of vessels that were passing through the port.

As mentioned above, there is no direct way to link a specific tug with a specific barge or set of barges using the USACE data. Lock Performance Monitoring System data were also consulted and the average barges per tug through the locks are presented in the sections on St. Louis and Cincinnati. To supplement these data, river operators were contacted and asked how tug horsepower related to the number of barges in a tow. The operators cited many different factors that affect this decision including weather, river stage (depth), river current, destination on the river, and Coast Guard Regulations. We were also told that the Coast Guard rule is 250 hp per barge but that the ratio might be higher or lower than that depending on the previously cited factors. In general, strong current requires more horsepower as shown in the example from one operator who stated that 3 barges carrying 20,000 barrels of oil each could be pushed by an 1,800 hp tug in the intracoastal waterway around the Gulf of Mexico, but that a 3,000 hp tug would be assigned to the same barges if they were destined for a port on the river. General guidelines for horsepower required per total tow tonnage as used by one operator are repeated in Table 4-3.

Table 4-3. Rules of thumb for computing maximum barge to tug ratios per tow

Tug HP Range	tons/hp	tons/barge [a]	hp/tug	barge/tug [b]
3,500 and above	5.7	1,610	4,200	15
1,500 - 3,500	5.3	1,610	3,000	10
< 1,500	6.6	1,610	1,200	5

[a] Average tons/barge includes 1550 tons for barge cargo, 100 tons for the empty barge NRT, and 10 tons for a fraction of the tug NRT.

[b] Barge per tug numbers are expected to be the upper limit of that tugs horsepower capacity. These are rule of thumb numbers only. Actual barges per tow should be expected to vary considerably.

4.3 CALCULATING TIME IN MODE

Unlike the commercial deep-sea ports, vessels moving within inland river ports have two primary modes of operation, river cruise and maneuvering. Hotelling is rarely seen on the river although some hotelling time is allocated to passenger/excursion vessels.

4.3.1 River Cruise

River cruise is considered to be the speed when traveling on the river which varies due to weather and river conditions, congestion in the river, and load on the tug. This speed will be slower in the vicinity of a port where congestion forces slower speeds, in bends where slower speeds allow more maneuvering time, going up-river where the current of the river reduces the relative speed of the boat, and at low river stages. River cruise will be faster going down-river in straight flowing, open water when the river is at a higher stage.

The river cruise speeds were adjusted for the river current. Data on river current was obtained from the regional office of the USACE for St. Louis and Cincinnati respectively. The velocity of the river will change depending on season, river stage, and whether it is a bend or straight section. The river is generally wide enough such that varying widths produce only small changes in the current speed. The average river velocity, given by the USACE regional office for St. Louis, varies from 1.5 to 8 miles per hour. An average of 2 mph was used in this report. For Cincinnati a range of 0.2 to 3 miles per hour was given and an average of 0.5 mph was used. When calculating river cruise time-in-mode, river current is added to the tug speed for downbound traffic and subtracted from the tug speed for upbound traffic to get the overall speed.

For excursion vessels, if the shipping mile and receiving mile are the same, a value of 2 hours for time at river cruise is recorded and factored into the average cruise time calculations.

4.3.2 Maneuvering

Maneuvering is calculated to take place when a tug maneuvers a barge into a dock or fleeting area or when a tow maneuvers through a lock. There are other times a tow may drop to a maneuvering speed within the port area such as to maneuver around a tight bend, to maneuver through a congested area, or as a precaution in unusually high river conditions or other inclement weather. Only maneuvering associated with movements into and out of docks, fleeting areas, or locks has been accounted for in this study.

4.3.3 Hotelling

Hotelling is the time the vessel is at dock with it's main propulsion engines shut down and the auxiliary engines still in operation. While hotelling can last many hours at deep-sea ports, it is rarely a significant event for vessels operating on the river. Tugs are deployed nearly constantly. Due to the efficiency of river operation, tugs are rarely at dock and virtually never traveling without any barges. They have two crews which keep the vessel in operation 24 hours a day. Tugs are most often refueled midstream so they do not even have hotelling time due to bunkering. Therefore, for a normal trip on the river, hotelling time is negligible.

No emissions are generally associated with barges, so time the barges spend in port is generally of little interest to the modeler. The exception to this would be for barges with self-unloading equipment or other equipment that requires power. A very small percentage, less than 0.5% of the liquid cargo barges at St. Louis have self-unloading equipment. These vessels are not discussed in any further detail and no extra hotelling time is included for them.

The time an excursion vessel is at port is rarely hotelling. As the term is used in this report, hotelling is time the vessel is at dock with it's main propulsion engines shut down and the auxiliary engines still in operation. Excursion vessels will have only a short time at the dock between cruises (if they are doing back to back cruises). This time between cruises may be up to an hour long, but the propulsion engines are generally running in the idle position during this time. If the vessel is done for the day, it will have up to an hour of hotelling while the crew cleans the vessel and readies it for the next day's operation. Then the vessel will be completely shut down for the night. For this reason, hotelling times for each excursion vessel can be considered to be 1 hour per trip.

4.4 PORT OF ST. LOUIS, MISSOURI AND ILLINOIS

The Metropolitan Port of St. Louis is located on the Mississippi River and is nominally located between miles 138.8 and 208.8 on the river. The port extends for 70 miles along both banks of the river and encompasses Jefferson, St. Louis, and St. Charles counties as well as the city of St. Louis on the right bank and Monroe, St. Clair, and Madison counties on the left bank. The city of St. Louis, MO is located on the right bank of the Mississippi River below its confluence with the Missouri River and approximately 175 miles above its confluence with the Ohio River. The Missouri River flows into the Mississippi River at mile 195, within the boundaries of the Port of St. Louis. Seven port authorities serve the area in and around the port. These are the: City of St. Louis Port Authority, Tri-City Regional Port District, Southwest Regional Port District, St. Charles County Port Authority, Jefferson County Port Authority, St. Louis County Port Authority, and the Southeast Missouri Regional Port Authority.

Table 4-4. Metropolitan Port of St. Louis

LRP Rank	Typical Port	Miles	USACE Port Code
4	Metropolitan Port of St. Louis	138.8 - 208.8	2310

The USACE is responsible for maintaining a minimum channel of 9 feet deep and 300 feet wide in the lower Mississippi River and a depth of 9 feet and minimum width of 200 feet starting at mile 191 (within the Port of St. Louis) with additional width in bends. Weather in the St. Louis area varies with four seasons and a modified continental climate. Freezing temperatures are not unusual in December, January, or February, however, the river traffic is rarely if ever impeded due to ice. Table 4-5 has prevailing wind directions as reported in the USACE Port Series report 70 from data compiled by the National Weather Service. All data were collected and averaged over a 32 year period. Heavy fog days occur less than 12 days per year and are those with 1/4 mile visibility or less.

Table 4-5. Weather data for the Port of St. Louis

Month	Prevailing wind direction	Month	Prevailing wind direction
Jan	NW	July	S
Feb	NW	Aug	S
Mar	WNW	Sep	S
April	WNW	Oct	S
May	S	Nov	WNW
June	S	Dec	S
Overall for the Year		S	

4.4.1 Locks of St. Louis

Two locks are located within the port. These are located at miles 185.5, for lock 27 at Granite City, IL, and mile 200.8, the Melvin Price lock at Alton , IL. Each of these locks has a main and an auxiliary lock. The main locks, with an available length of 1,200 feet are twice as long as the auxiliary locks and can accommodate larger tows. Lockage times through the main lock are longer than those through the auxiliary lock due, in part, to the larger volume of water transferred. Lock 27 is the first lock for vessels traveling up-river on the Mississippi River. Tows may be as large as 40 barges per tow on the lower Mississippi River but due to restrictions in lock capacity and river conditions, it is rare to see more than 15 barges per tow up-river of lock 27. Vessel passage data recorded at these locks differ not only because of traffic that may have stopped at or originated in St. Louis, but also due to traffic originating from or stopping at ports on the Missouri River. Table 4-6 gives the total counts and average barges per tow as reported by the Lock Performance Monitoring System for 1996 (Reference 9). These averages are through the lock and may or may not accurately reflect the average number of barges per tug on the river within the port itself.

Table 4-6. Vessel counts and tonnage through locks in the Port of St. Louis

		tow		barge loaded		total barges		total tons		Barges/ tow		tons/barge	
		A [a]	M	A	M	A	M	A	M	A	M	A	M
Lock 27	up	865	3,022	1857	12,960	5,383	34,579	2,871	20,852	6	11	1,546	1,609
	dn	983	3,086	5193	30,717	6,015	34,009	8,173	47,588	6	11	1,574	1,549
Melvin Price	up	449	2,879	491	13,660	971	36,284	603	22,031	2	12	1,228	1,613
	dn	549	2,947	527	32,845	1,298	36,023	854	50,394	2	12	1,615	1,534

[a] A = Auxiliary Lock, M = Main lock. The main lock often has twice the capacity of the auxiliary lock.

4.4.2 Time-in-modes for St. Louis

The load on the tugs during river cruise is of interest to any modeler. The cruise speeds in this report account for load in three ways - tows with loaded and light barges, direction the tow is headed on the river, and the average barges/tug in the tow. Upbound tugs have higher loads, or slower speeds, than downbound tugs. Loaded barges are heavier and therefore sit lower in the water requiring more power to move, or moving slower, than a light barge.

For tows in and around St. Louis, 57% of the barges were loaded with cargo in 1996. In general, all loaded barges are considered loaded to capacity of 1,500 tons and all light barges carry no cargo tonnage. Information from phone conversations with tug and barge operators indicates that loaded barges are traveling (with no current and in an open river) at 8 mph and light barges are traveling at 10 to11 mph (full ahead). In a more congested area, the tugs are likely to run at 60% to 80% of their max power or less for an average speed of 5 to 6.5 for loaded barges and 6 to 8 mph for light barges (without adjusting for current). Thus, if 57% of the barges are loaded, we adjust the overall tug speeds to be 57% at 5.7 mph and 43% at 7 mph for an overall weighted average speed of 6.2 mph. Adjusting for current gives the results shown in Table 4-7.

In addition to the difference between loaded barges and light barges, there is the difference in load depending on the number of barges in a tow. On average, tugs under 1,500 hp are harbor tugs used for maneuvering 1 to 4 barges in and around the port. The larger tugs are used to transport the barges longer distances although they may also take part in maneuvering a barge into dock to facilitate the dispersal of the tow. An adjustment were made to the cruise speed of tugs <1,500 hp to account for their role in more congested areas by reducing their cruise speeds by 20% as shown in Table 4-7.

Table 4-7. Cruising and maneuvering, average speeds on the Mississippi River

Tug Power	Direction	Status	Cruise (mph)	Maneuver (mph)
>1500 hp	Upbound	Calling	4.2	2
		Passing	4.2	2
	Downbound	Calling	8.3	2
		Passing	8.3	2
< 1500 hp	Upbound	Calling	3.4	2
		Passing	3.4	2
	Downbound	Calling	6.6	2
		Passing	6.6	2

Although the speeds used in this report, as presented in Table 4-7, reflect accurate average speeds, the following anecdotal information may help modelers understand the variability in river cruising speeds. Anecdotal information from river operators suggests that other speeds may be common on the river and within the boundaries of the port. Anecdotal information from Cincinnati has 8 loaded liquid cargo barges pushed by

3800-5000 hp tugs at 8 mph using an estimated 80-85% of tug capacity. The same speed would be used for light barges leading to a lower load on the tug. Another operator said that speed through a port varies but 3-4 mph is considered no wake. All operators agreed that the pilot is responsible for the wake of his tow and any damage which it might cause. Loaded barges create more wake than light barges. Another operator gave an average of 8 mph loaded and 10-12 mph for light barges in still water (no current) when in straight water and non-congested areas.

Maneuvering is calculated to take place when a tug maneuvers a barge into a dock or fleeting area or when a tow maneuvers through a lock. Data from the operators indicates that on average, each lockage event takes one hour from initial slow down until the vessel is back up to speed again. This includes delays at the lock and is the same for upbound and downbound vessels. The average speed maneuvering into the lock is 1-2 mph. For the data summaries, maneuvering is associated with the USACE recorded tug trips and is considered to be 0.5 hours each to maneuver into or out of a dock and 1 hour from first slowdown to resumption of river cruise speed when going through a lock. As both lockages and calls on port are considered reasons for maneuvering, both calling and passing vessels have maneuvering time. Thus, vessels passing the Port of St Louis also have 1 hour of maneuvering time for each lock or a total of 2 hours of maneuvering. Depending on the miles traveled within the port, other vessels will also have an extra hour of maneuvering to account for each probable lockage.

Maneuvering for lockages were computed as follows. The two locks within the boundaries of the Port of St. Louis are located at miles 185.5 for lock 27 at Granite City, IL and mile 202.9, the Melvin Price lock at Alton, IL. For tows traveling upbound on the Mississippi River and received at mile 185.5 or less and for tows traveling downbound on the Mississippi River and received at mile 202.9 or greater, no locks are passed and no maneuvering time for lockages were computed. For tows shipped from or received to a mile on the Mississippi River between miles 185.5 and 202.9, each trip has one hour of maneuvering for lockages plus 0.5 hours to maneuver into a dock or fleeting area. For all other tows, each trip has 2 hours of maneuvering for lockages plus 0.5 hours to maneuver into a dock or fleeting area. Note, although 0.5 hours is considered an average time to maneuver into a fleeting area, one operator indicated that larger tows take 1 to 1.5 hours to maneuver into a fleeting area.

4.3.3 Summary Data for the Port of St. Louis

All data in Tables 4-8 through 4-10 were assembled from data received from the USACE Waterborne Commerce Statistics Center. Table 4-8 is the summary table for St. Louis tug movements and Table 4-9 is the summary of tug characteristics. Table 4-10 is the summary table for barge trips and tonnage. Table 4-11 summarizes the percent of barges loaded and light by barge type. Table 4-12 presents the summary of barge/tug ratios for trips and tonnages including all the St. Louis barges (including light) in the calculations.

Table 4-8. Tug movements in the Port of St. Louis

Status	Direction	HP Bin	Total Trips	% of Trips	Maneuver (hr/trip)	Cruise (hr/trip)
Calling	Downbound	0 - 750	544	2%	2.2	2.7
		751 - 1,500	1,544	7%	2.3	2.1
		1,501 - 3,000	613	3%	1.7	3.7
		3,000 - 5,000	4,015	18%	2.1	3.8
		5,000 - 8,000	730	3%	1.8	4.3
		>8,000	912	4%	2.2	4.3
	Downbound Total		8,358	37%	2.1	3.7
	Upbound	0 - 750	3,972	18%	1.0	4.5
		751 - 1,500	814	4%	1.2	5.0
		1,501 - 3,000	704	3%	1.2	6.5
		3,000 - 5,000	4,368	19%	1.7	7.5
		5,000 - 8,000	961	4%	1.0	8.4
		>8,000	1,033	5%	0.7	8.5
	Upbound Total		11,852	52%	1.4	7.4
Calling Total			20,210	89%	1.7	5.6
Passing	Downbound	0 - 750	4	0%	2.0	10.6
		751 - 1,500	76	0%	2.0	6.0
		1,501 - 3,000	81	0%	2.0	8.4
		3,000 - 5,000	628	3%	2.0	8.1
		5,000 - 8,000	239	1%	2.0	8.4
		>8,000	56	0%	2.0	8.4
	Downbound Total		1,084	5%	2.0	8.2
	Upbound	0 - 750	13	0%	2.0	20.6
		751 - 1,500	85	0%	2.0	14.4
		1,501 - 3,000	71	0%	2.0	16.7
		3,000 - 5,000	891	4%	2.0	16.3
		5,000 - 8,000	307	1%	2.0	16.7
		>8,000	36	0%	2.0	16.7
	Upbound Total		1,403	6%	2.0	16.4
Passing Total			2,487	11%	2.0	13.0
Grand Total			22,697	100%	1.8	7.0

Table 4-9. Tug characteristics in the Port of St. Louis

Status	Direction	HP Bin	Total Trips	NRT (Ton)	Avg. Engine Power (hp)	Date Of Build
Calling	Downbound	0 - 750	544	55	497	1968
		751 - 1,500	1,544	85	998	1971
		1,501 - 3,000	613	195	1,884	1966
		3,000 - 5,000	4,015	408	4,504	1971
		5,000 - 8,000	730	605	6,332	1978
		>8,000	912	817	8,992	1975
	Downbound Total		8,358	419	4,549	1972
	Upbound	0 - 750	3,972	44	559	1969
		751 - 1,500	814	85	1,050	1973
		1,501 - 3,000	704	184	1,855	1965
		3,000 - 5,000	4,368	408	4,413	1970
		5,000 - 8,000	961	610	6,319	1978
		>8,000	1,033	817	9,010	1975
	Upbound Total		11,852	433	4,641	1972
Calling Total			20,210	426	4,596	1972
Passing	Downbound	0 - 750	4	130	293	1962
		751 - 1,500	76	75	1,140	1978
		1,501 - 3,000	81	162	2,061	1968
		3,000 - 5,000	628	365	4,511	1974
		5,000 - 8,000	239	619	6,371	1982
		>8,000	56	753	8,527	1976
	Downbound Total		1,084	409	4,724	1975
	Upbound	0 - 750	13	79	541	1975
		751 - 1,500	85	91	1,169	1976
		1,501 - 3,000	71	145	2,093	1971
		3,000 - 5,000	891	388	4,712	1973
		5,000 - 8,000	307	648	6,362	1981
		>8,000	36	582	8,683	1983
	Upbound Total		1,403	431	4,911	1975
Passing Total			2,487	422	4,835	1975
Grand Total			22,697	425	4,640	1973

Table 4-10. Barge trips and cargo tonnage summary for St. Louis

Status	Direction	Barge Type	Trips	Tons
Calling	Downbound	Dry Cargo Barge	14,003	18,863,052
		Liquid Cargo Barge	2,052	2,459,163
	Downbound Total	All	16,055	21,322,215
	Upbound	Dry Cargo Barge	26,761	6,010,668
		Liquid Cargo Barge	2,238	2,817,515
	Upbound Total	All	28,999	8,828,183
Calling Total		All	45,054	30,150,398
Passing	Downbound	Dry Cargo Barge	36,646	51,309,023
		Liquid Cargo Barge	3,061	1,747,262
	Downbound Total	All	39,707	53,056,285
	Upbound	Dry Cargo Barge	32,972	15,657,937
		Liquid Cargo Barge	3,066	4,705,737
	Upbound Total	All	36,038	20,363,674
Passing Total		All	75,745	73,419,959
Grand Total		All	120,799	103,570,357

Table 4-13 is the summary table for excursion and other traffic on the river calling or passing the Port of St. Louis.

The date of build given in Table 4-9 for St. Louis tugs includes the date of rebuild for some of the tug vessels. A review of the data shows that approximately 5% of the 2,000 horsepower bin tugs and 2% of the 4,000 horsepower bin tugs have been rebuilt. There is no indication that the other horsepower categories have rebuilt engines. It was unknown at the time of writing if the data accurately presented the rebuilt indicator for all rebuilt engines.

Higher horsepower tugs push more barges. In order to estimate the maximum feasible barge/tug ratios, it is suggested to use the rule of thumb in Section 4.2. However, to determine the average load on each tug in Table 4-8, it is useful to know the overall average barge/tug ratio and the overall average tons/barge ratio (including light barges in the calculations). Table 4-12 presents these overall summaries.

Table 4-11. St. Louis barges, percent of total for light and loaded by barge type

Status	Direction	Cargo	Type	Trips	Tons
Calling	Downbound	Light	Dry Cargo Barge	2%	0%
			Liquid Cargo Barge	1%	0%
		Loaded	Dry Cargo Barge	10%	18%
			Liquid Cargo Barge	1%	2%
	Downbound Total	All	All	13%	21%
	Upbound	Light	Dry Cargo Barge	18%	0%
			Liquid Cargo Barge	1%	0%
		Loaded	Dry Cargo Barge	4%	6%
			Liquid Cargo Barge	1%	3%
	Upbound Total	All	All	24%	9%
Calling Total		All	All	37%	29%
Passing	Downbound	Light	Dry Cargo Barge	1%	0%
			Liquid Cargo Barge	2%	0%
		Loaded	Dry Cargo Barge	29%	50%
			Liquid Cargo Barge	1%	2%
	Downbound Total	All	All	33%	51%
	Upbound	Light	Dry Cargo Barge	18%	0%
			Liquid Cargo Barge	0%	0%
		Loaded	Dry Cargo Barge	9%	15%
			Liquid Cargo Barge	2%	5%
	Upbound Total	All	All	30%	20%
Passing Total			All	63%	71%
Grand Total			All	100%	100%

Table 4-12. Overall average barges per tug and tons per barge on the Mississippi River at St. Louis

Status	Direction	Barges/Tug [a]	Tons/Barge
Call	Downbound	2	1,328
	Upbound	2	304
Pass	Downbound	37	1,336
	Upbound	54	565

[a] The barge per tug ratios for passing vessels are higher than is actually seen on the river. This may be due to lack of reporting for tugs passing the port. LPMS reports an average of 10 barges per tug

The overall barge per tug ratios in Table 4-12 for vessels calling on St. Louis is synchronous with the anecdotal information received from the port. However, the passing barge to tug ratio is higher than the anecdotal information or the LPMS information would lead one to expect. It appears that the USACE data undercounts the number of tugs passing the port. One hypothesis that explains this undercounting would be if a tug pushed a tow of 15 or so barges up or down the river to the fleeting area. The tug then leaves the tow in the fleeting area, removes two to four barges from the tow, and pushes these barges into port at St. Louis. After depositing those barges, the tug picks up one to four barges and pushes them back to the fleeting area. These new barges may be introduced into the original tow or another tow. The tug then continues up or down the river with the larger tow. The reason for the undercounting of passing tugs comes because the barges in the tow that stopped in the fleeting area are considered as passing while the tug is considered calling.

Table 4-13. Excursion vessel summary on the Mississippi River at St. Louis

Status	Direction	Trips	Date of Build	Avg. Engine Power (hp)	NRT (ton)	Passenger Capacity	Cruise (hr)	Maneuver (hr)	Hotel (hr)
Calling	Downbound	5,031	1978	2,066	1,226	1,006	3.4	0.8	1.0
	Upbound	5,028	1977	2,026	1,135	1,027	3.4	0.8	1.0
Passing	Downbound	8	1975	2,348	1,997	343	14.0	0.5	1.0
	Upbound	3	1994	1,928	1,249	217	10.2	0.5	1.0

4.5 PORT OF CINCINNATI, OHIO

The Ohio River starts in Pittsburgh, Pa and flows in a generally west/southwest direction through the states of West Virginia, Kentucky, Ohio, Indiana, and Illinois. At Cairo, IL, the Ohio flows into the Mississippi. The Port of Cincinnati lies between miles 0 and 7 on the Licking River and between miles 483 to 516 on the Ohio River if the river miles are considered to increase from Cairo, IL to Pittsburgh, PA (C to P) or between miles 460 and 483 if the river miles are considered to increase from Pittsburgh, PA to Cairo, IL (P to C).

The reason for this ambiguity is that organizations which record data on the Port of Cincinnati seem to use two different numbering conventions to indicate miles on the river. Care must be taken as to which numbering convention is being used as the port of Cincinnati is nearly in the middle of the length of the Ohio River. Some numbering systems put mile 0 at Cairo, IL and mile 981 at Pittsburgh, PA (C to P) and others put mile 0 at Pittsburgh, PA and mile 981 at Cairo, IL (P to C). Lock Performance Monitoring System (LPMS) data uses P to C as does the USACE's Port Series Report. The detailed electronic data from the USACE data, however, uses C to P. Not only are the numbering conventions reversed in direction, but the C to P method has 10 more miles within the bounds of the Port of Cincinnati than does the P to C method. As the electronic data forms the basis of the summary tables, the C to P format is favored in this report and the Port of Cincinnati is treated as 33 miles long. Both numbering conventions will be presented here in the format of C to P (followed by P to C in parenthesis).

Table 4-14. Port of Cincinnati

LRP Rank	Typical Port	Miles on River	USACE Port Code
14	Port of Cincinnati	Ohio River, 483-516 (C to P) Ohio River, 460-483 (P to C) Licking River, 0-7	2335 2335 2345

There are no locks within the boundaries of the Port of Cincinnati. The closest upstream lock to Cincinnati is the Captain Anthony Meldahl at mile 544.8 (436.2) and the closest downstream lock is the Markland at mile 449.5 (531.5).

4.5.1 Time-in-mode calculations for Cincinnati

The load on the tugs during river cruise is of interest to any modeler. The cruise speeds in this report account for load in three ways - tows with loaded and light barges, direction the tow is headed on the river, and the average barges/tug in the tow. Upbound tugs have higher loads, or slower speeds, than downbound tugs. Loaded barges are heavier and therefore sit lower in the water requiring more power to more, or moving slower, than a light barge.

For tows in and around Cincinnati, 56% of the barges were loaded with cargo in 1996. In general, all loaded barges are considered loaded to capacity of 1,500 tons and all light barges carry no cargo tonnage. Information from phone conversations with tug and barge operators indicates that loaded barges are traveling, with no current and in an open river, at 8 mph and light barges are traveling at 9 to 10 mph. In a more congested area, the tugs are likely to run at a maximum of 60-80% of their max power to a minimum of engine idle for an average speed of 4 to 6 mph for loaded barges and 6 to 7 mph for light barges (without adjusting for current). Thus, if 56% of the barges are loaded, we adjust the overall tug speeds to be 56% at 5 mph and 44% at 6.5 mph for an overall average speed of 5.7 mph. Adjusting for a current of 0.5 mph gives the results shown in Table 4-15.

In addition to the difference between loaded barges and light barges, there is the difference in load depending on the number of barges in a tow. On average, tugs under 1,500 hp are harbor tugs used for maneuvering 1 to 4 barges in and around the port. The larger tugs are used to transport the barges longer distances although they may also take part in maneuvering a barge into dock to facilitate the dispersal of the tow. An adjustment was made to the cruise speed of tugs < 1,500 hp to account for their role in more congested areas by reducing their cruise speeds by 20% as shown in Table 4-15.

Table 4-15. Cruising and maneuvering, average speeds on the Ohio River

Tug Power	Direction	Status	Cruise (mph)	Maneuver (mph into dock)	Maneuver (mph on Licking R.)
>1,500 hp	Upbound	Calling	5.2	2	4
		Passing	5.2	0	4
	Downbound	Calling	6.2	2	4
		Passing	6.2	0	4
< 1,500 hp	Upbound	Calling	4.1	2	4
		Passing	4.1	0	4
	Downbound	Calling	4.9	2	4
		Passing	4.9	0	4

Anecdotal information from river operators suggests that other speeds may be common on the river and within the boundaries of the port. Information from Cincinnati has 8 loaded liquid cargo barges pushed by 3,800-5,000 hp tugs at 8 mph using an estimated 80-85% of tug capacity. The same speed would be used for light barges leading to a lower load on the tug. Another operator said that speed through a port varies but 3-4 mph is considered no wake. All operators agreed that the pilot is responsible for the wake of his tow and any damage which it might cause. Loaded barges create more wake than light barges. Another operator gave an average of 8 mph loaded and 10-12 mph for light barges in still water (no current) when in straight water and non-congested areas.

There are no locks within the boundaries of the Port of Cincinnati. Thus, no maneuvering time due to lockages is accounted for on the Ohio River near Cincinnati. Maneuvering time in Cincinnati is a default value of 0.5 hours for all trips and 1 hour for intraport trips.

4.5.2 Summary data for the Port of Cincinnati

All data in Tables 4-16 through 4-21 were assembled from data received from the USACE Waterborne Commerce Statistics Center. Table 4-16 is the summary table for Cincinnati tug movements. Table 4-17 is the summary table for Cincinnati tug characteristics. Table 4-18 is the percent of trips loaded and light for the barges. Table 4-19 presents barge trip and tonnage summary data. Table 4-20 present the overall averages for barges per tug and tons per barge in and around Cincinnati including light barges in the calculations. Table 4-21 is the summary table for all other traffic (excursion) calling or passing the Port of Cincinnati.

Table 4-16. Tug movements summary table for the Port of Cincinnati

Status	Direction	HP Bin	Trips	% Trips	Cruise (hr)	Maneuver (hr)
Calling	Downbound	0 - 750	392	2%	4.2	0.7
		751 - 1,500	796	5%	4.3	0.9
		1,501 - 3,000	191	1%	2.8	0.5
		3,000 - 5,000	559	4%	3.0	0.5
		5,000 - 8,000	57	0%	2.8	0.5
		>8,000	1	0%	3.8	0.5
	Downbound Total		1,996	13%	3.2	0.6
	Upbound	0 - 750	393	3%	4.3	0.8
		751 - 1,500	774	5%	5.4	0.8
		1,501 - 3,000	168	1%	3.5	0.5
		3,000 - 5,000	474	3%	3.7	0.5
		5,000 - 8,000	34	0%	3.4	0.5
		>8,000	1	0%	4.5	0.5
	Upbound Total		1,844	12%	3.9	0.6
Calling Total			3,840	24%	3.5	0.6
Passing	Downbound	0 - 750	57	0%	7.7	0.5
		751 - 1,500	3,014	19%	7.7	0.5
		1,501 - 3,000	555	4%	5.6	0.5
		3,000 - 5,000	2,101	13%	5.5	0.5
		5,000 - 8,000	277	2%	5.5	0.5
		>8,000	1	0%	5.5	0.5
	Downbound Total		6,005	38%	5.8	0.5
	Upbound	0 - 750	83	1%	8.2	0.5
		751 - 1,500	3,033	19%	8.2	0.5
		1,501 - 3,000	538	3%	6.6	0.5
		3,000 - 5,000	1,987	13%	6.6	0.5
		5,000 - 8,000	215	1%	6.6	0.5
		>8,000	1	0%	6.6	0.5
	Upbound Total		5,857	37%	6.8	0.5
Passing Total			11,862	76%	6.3	0.5
Grand Total			15,702	100%	5.8	0.5

Table 4-17. Tug characteristics summary table for the Port of Cincinnati

Status	Direction	HP Bin	Trips	NRT (ton)	Avg. Engine Power (hp)	Date of Build
Calling	Downbound	0 - 750	392	45	600	1973
		751 - 1,500	796	82	1,009	1972
		1,501 - 3,000	191	175	1,882	1967
		3,000 - 5,000	559	397	4,098	1969
		5,000 - 8,000	57	505	6,437	1979
		>8,000	1	602	8,200	1965
	Downbound Total		1,996	303	3,255	1970
	Upbound	0 - 750	393	43	589	1972
		751 - 1,500	774	81	965	1972
		1,501 - 3,000	168	173	1,812	1968
		3,000 - 5,000	474	405	4,151	1969
		5,000 - 8,000	34	540	6,342	1979
		>8,000	1	602	8,200	1965
	Upbound Total		1,844	305	3,205	1970
Calling Total			3,840	304	3,233	1970
Passing	Downbound	0 - 750	57	47	605	1974
		751 - 1,500	3,014	63	951	1970
		1,501 - 3,000	555	170	1,802	1972
		3,000 - 5,000	2,101	427	4,384	1972
		5,000 - 8,000	277	543	6,163	1981
		>8,000	1	602	8,200	1965
	Downbound Total		6,005	350	3,691	1972
	Upbound	0 - 750	83	42	606	1974
		751 - 1,500	3,033	62	948	1970
		1,501 - 3,000	538	170	1,803	1972
		3,000 - 5,000	1,987	429	4,352	1972
		5,000 - 8,000	215	555	6,126	1981
		>8,000	1	602	8,200	1965
	Upbound Total		5,857	345	3,590	1972
Passing Total			11,862	347	3,642	1972
Grand Total			15,702	339	3,561	1972

Table 4-18. Cincinnati Barges, percent of total for light and loaded by barge type

Status	Direction	Cargo	Barge Type	% Trips	% Ton
Calling	Downbound	Light	Dry Cargo Barge	4%	0%
			Liquid Cargo Barge	1%	0%
		Loaded	Dry Cargo Barge	11%	16%
			Liquid Cargo Barge	2%	6%
	Downbound Total		All	18%	22%
	Upbound	Light	Dry Cargo Barge	8%	0%
			Liquid Cargo Barge	2%	0%
		Loaded	Dry Cargo Barge	7%	9%
			Liquid Cargo Barge	2%	4%
	Upbound Total		All	18%	12%
Calling Total			All	37%	34%
Passing	Downbound	Light	Dry Cargo Barge	5%	0%
			Liquid Cargo Barge	0%	0%
		Loaded	Dry Cargo Barge	19%	35%
			Liquid Cargo Barge	2%	6%
	Downbound Total		All	27%	41%
	Upbound	Light	Dry Cargo Barge	21%	0%
			Liquid Cargo Barge	2%	0%
		Loaded	Dry Cargo Barge	13%	24%
			Liquid Cargo Barge	0%	1%
	Upbound Total		All	36%	25%
Passing Total			All	63%	66%
Grand Total			All	100%	100%

Table 4-19. Barge Summary for Cincinnati, OH

Status	Direction	Barge Type	Trips	Tons
Calling	Downbound	Dry Cargo Barge	8,287	8,015,952
		Liquid Cargo Barge	1,960	2,999,500
	Downbound Total	All	10,247	11,015,452
	Upbound	Dry Cargo Barge	8,415	4,359,134
		Liquid Cargo Barge	2,050	1,793,011
	Upbound Total	All	10,465	6,152,145
Calling Total		All	20,712	17,167,597
Passing	Downbound	Dry Cargo Barge	13,950	17,394,338
		Liquid Cargo Barge	1,481	2,934,547
	Downbound Total	All	15,431	20,328,885
	Upbound	Dry Cargo Barge	19,163	12,201,534
		Liquid Cargo Barge	1,406	358,540
	Upbound Total	All	20,569	12,560,074
Passing Total		All	36,000	32,888,959
Grand Total		All	56,712	50,056,556

Higher horsepower tugs push more barges. In order to estimate barge/tug ratios, it is suggested to use the rule of thumb in Section 4.2. However, to determine the average load on each tug in Table 4-16, it is useful to know the overall average barge/tug ratio and the overall average tons/barge ratio (including light barges in the calculations). Table 4-20 presents these overall summaries.

Table 4-20. Overall average barges per tug and tons per barge on the Ohio River at Cincinnati from USACE data (Tables 4-16 and 4-18)

Status	Direction	Barges/Tug	Tons/Barge
Call	Downbound	5	1,075
	Upbound	6	588
Pass	Downbound	3	1,317
	Upbound	4	611

Table 4-21. Excursion Vessels on the Ohio River at Cincinnati

Status	Direction	Passengers	Trips	Tons	Maneuver (hr)	Cruise (hr)
Calling	Downbound	Light	42	0	0.5	1.1
		Loaded	915	85,718	0.5	1.6
	Upbound	Light	44	0	0.5	3.3
		Loaded	913	85,873	0.5	4.9
Grand Total			1,914	171,591	0.5	2.9

No excursion vessels passing the Port of Cincinnati were reported by the USACE

4.6 METHODOLOGY - USING TYPICAL RIVER PORT DATA WITH TOP 60 LRP DATA

Operations on the rivers are significantly different from operations on the Great Lakes or at Deep Sea Ports. For this reason, a different methodology is needed to apply Typical River Port data to other river ports. In general, this methodology will apply the percentage of tug trips and barge trips and tonnages for the Typical Port to the total tug and total barge trips given in Section 2 for a port chosen to be the Modeled Port.

The Typical River Ports can be used with the general river data in Section 2 to develop more detailed vessel characteristics and movements at other river ports. The tug, barge, and excursion vessel data developed for the ports of St. Louis and Cincinnati can be used to model tug, barge, and excursion vessel movements at the other river ports by using the percent of total trips given in each of the Section 4 summary tables. If there is better information available from the port on the distributions of trips by horsepowers or on barge to tug ratios, that data should be used to supplement the default values in the summary table for the Typical Ports.

This methodology for river allocations pertains to barges, tugs, and passenger/excursion ship-types. Unidentified dry-cargo ship-types should, by default, be treated as excursion vessels. Other ship-types such as general cargo or bulk carrier may have a few trips for some ports. These can either be treated as a barge/tug combination or can use the methodology from the deep-sea port when determining their characteristics and time-in-modes.

There are seven main steps to use when applying the Typical River data to a general river port. Step 1 is to choose a general port from Section 2. This is the Modeled Port. Step 2 is to choose which Typical River Port to use. Step 3 is to summarize the trips and tonnage data for the Modeled Port. Step 4 is to calculate the time-in-modes of interest for the Modeled Port by applying the percentage of trips and tonnages in the summary tables (4-10 or 4-17). Step 5 is to adjust the cruising time for the port distance on the river. Step 6 is to adjust the maneuvering time for the presence of locks. Step 7 addresses how the data may be allocated to the county level. An example of how the default data from the Typical River Ports would be used with general data from a LRP (Section 2) follows.

4.6.1 Step 1: Choose a Modeled Port

This example will use Memphis, TN (LRP # 6) as the Modeled Port.

4.6.2 Step 2: Choose the Typical River Port

Choosing a Typical Port is at the discretion of the modeler. Some of the important factors to consider are:

- The presence or absence of locks in the Modeled Port
- The presence or absence of navigable tributary rivers within the Modeled Port
- The characteristics of the fleet and the barge to tug ratio at the Modeled Port
- The average river characteristics including current information if available for the Modeled Port.

Memphis Harbor has no locks within the boundaries of the port. In this way it is like Cincinnati. From the data in Section 2, Table 2-3 we find that Memphis is like many of the river ports in that virtually all of the traffic is barge and tug and that there are several times as many dry-cargo barge trips as liquid-cargo barge trips. Memphis Harbor has a section of the Wolf River within the boundaries of the port. In this way it is like Cincinnati. The overall barge to tug ratio from Table 2-3 is 18,632 to 1,893 or roughly 10 to 1. In this way Memphis, with its relatively high barge to tug ratio, is more like St. Louis. The main river for Memphis Harbor is the Mississippi below St. Louis and is likely to flow at 2 to 5 miles per hour. In this way, Memphis Harbor is more like St. Louis.

Thus, the data available from the river ports is similar enough such that a modeler can choose which Typical Port to use as Like Port for individual criteria if need be. The bulleted criteria indicate that for calculating the cruising time-in-mode, barge to tug ratios, and other vessel characteristics, use of St. Louis as the Like Port is likely to yield a better estimate of activity for Memphis. Likewise, using Cincinnati to estimate maneuvering time-in-mode (after correcting for river current) is likely to yield more accurate vessel movement data.

4.6.3 Step 3: Summarize Trip and Tonnage Data for the Modeled Port

From Section 2, Tables 2-3 and 2-4 we get the trip and tonnage data by ship-type for Memphis as shown below in Table 4-22.

Table 4-22. Trip and tonnage data for the Modeled Port, Memphis, TN

Ship-Type	Trip	Ton
Dry Cargo Barge	13,888	10,332,453
Liquid Cargo Barge	4,748	5,970,642
General Cargo	2	0
Passenger	4	0
Tug	1,893	0
Total	20,535	16,303,095

4.6.4 Step 4: Determine Trips and Tons for the Modeled Port Ship-Types

Using the percentages in the tug and barge summary tables (Table 4-8 and 4-11 for St. Louis), trips and tons can be calculated for any of the horsepower bins, calling or passing the port, upbound or downbound using Equation 4.1 (below). If details of tug horsepower distributions are available from the Modeled Port, calculating all of these categories may be necessary to determine emissions for the port. However, as we are assuming that the Modeled Port has a distribution of tug horsepowers similar to those in the Typical Port, only the overall trip and tonnage averages for the categories of upbound, downbound, calling and passing will be required to determine emissions. As there is currently no way to determine what tugs push loaded or light barges or which tugs push dry or liquid cargo barges, the barge trips and tons used in Equation 4.1 are totals including both loaded and light, dry and liquid cargo barges.

$$\mathbf{MP_{CT} = MP_{TT} * \%TP_{CT}} \qquad \mathbf{(4.1)}$$

Where:

MP_{CT} = Modeled Port category trips or tons (by vessel type)

MP_{TT} = Modeled Port total trips or tons (by vessel type)

$\%TP_{CT}$ = Percentage of Typical Port trips or tons (by vessel type and by category)

As an example, here are the calculations for the category of calling, downbound tugs. MP_{TT} from Table 4-22 is 1,893 and the $\%TP_{CT}$ for St. Louis from Table 4-8 is 37%. Thus,

$$\begin{aligned} MP_{CT} &= MP_{TT} * \%TP_{CT} \\ &= 1{,}893 * 37\% \\ &= 700 \end{aligned}$$

Thus the methodology estimates that there are 700 calling, downbound tug trips for Memphis. Table 4-23 has the results of these calculations for each category. The categories are abbreviated with DB for downbound and UB for upbound traffic.

Table 4-23. Step 4 results for the Modeled Port, Memphis, TN

Category	% Tugs [a]	Tug Trips [b]	% barge trips [c]	Barge Trips [b]	% barge tons [c]	barge tons [b]
Calling DB	37%	700	13%	2,423	21%	3,423,650
Calling UB	52%	984	24%	4,473	8%	1,304,248
Passing DB	5%	95	33%	6,150	51%	8,314,578
Passing UB	6%	114	30%	5,591	20%	3,260,619
Total	100%	1,893	100%	18,636	100%	16,303,095

[a] From Table 4-8, [b] From Equation 4-1, [c] From Table 4-11

The barge trips and tonnages found by the methodology in Step 4 will be significantly lower than those found if the modeler used the rule of thumb in Table 4-3. Application of the rule of thumb in Table 4-3 will result in barge trip numbers close to the upper limit of barge trips and tonnages that could be propelled by the recorded number of tugs in the Modeled Port. The rule-of-thumb is likely to give the upper limit of feasible barge trips rather than an estimation of actual trips. The numbers in Table 4-23 represent an estimation of the actual average barges and tonnage per tug and therefore give the modeler some indication of load on the tugs.

4.6.5 Step 5. Allocation of Cruise Time-in-mode to the Modeled Port

As stated in Step 2, more than one Like Port may be chosen to determine the time-in-mode and vessel characteristics of the Modeled Port. As cruise times are largely unaffected by locks and are dependent mainly on the length of the Modeled Port on the river and of the river current through the Modeled Port, St. Louis will be used as the Modeled Port for determining cruise time-in-mode at Memphis.

The Modeled Port distance along the river can be determined from the master dock file available from the USACE. This file presents the docks within each port, the waterway the dock is on, and the mile on the river for each dock. Thus the difference between the miles for the first dock and the last dock give a useful estimation of the length of the river port along the river. These data are also available for most of the perspective Modeled Ports from Port Series Reports published by the USACE and other sources. If the exact distance of the Modeled Port on the river is not available, the default distance can be the distance of the Modeled Port's namesake city along the river.

Cruise times are calculated by calculating the ratio of the Modeled Port's distance along the river and the Like Port's distance along the river and by adjusting for the Like Port's river current from the time-in-mode. Cruise times for excursion vessels are calculated using the same ratio. Equation 4.2 shows the calculations for cruise time-in-mode.

$$\mathbf{MP_{CT} = LP_{CT} * MP_{RD}/LP_{RD} * LP_{CS}/(LP_{CS} \, {}^{+}/_{-} \, LP_{RC} \, {}^{-}/_{+} \, MP_{RC})} \qquad \textbf{(4.2)}$$

Where:

MP_{CT}	=	Modeled Port cruise time-in-mode (hr/trip)
LP_{CT}	=	Like Port cruise time-in-mode. Data in Tables 4-8 and 4-13 or 4-16 and 4-21 depending on the Like Port.
MP_{RD}	=	Modeled Port distance along the river
LP_{RD}	=	Like Port distance along the river
LP_{CS}	=	Like Port cruise speed. Depends on direction. Data in Tables 4-7 or 4-15
LP_{RC}	=	Like Port river current (added for upbound vessels or subtracted for downbound)
MP_{RC}	=	Modeled Port river current (subtracted for upbound vessels or added for downbound)

Regardless of the vessel category (hp bin, direction, or status), the port of Memphis is approximately 30 miles long (MP_{RD} = 30 miles). The Like Port, St. Louis, is 70 miles long (LP_{RD} = 70 miles). The river current at Memphis is treated as an average of 3 miles per hour. As stated earlier, the current at St. Louis is treated as 2 miles per hour. An example of how Equation 4-2 would be applied to Memphis for the category of calling, upbound tugs follows:

$$MP_{CT} = LP_{CT} * MP_{RD}/LP_{RD} * LP_{CS}/(LP_{CS} {}^{+}/_{-} LP_{RC} {}^{-}/_{+} MP_{RC})$$

$$= 7.4 * 30/70 * 3.8 / (3.8 + 2 - 3)$$

$$= 3.7 * 0.43 * 1.4$$

$$= 4.3 \text{ (hr/trip)}$$

Note: Although the cruise speeds are broken into greater than and less than 1,500 tug horsepower categories in Tables 4-7 And 4-15, the use of these more specific cruise speeds is only useful if the allocation of horsepowers within the Modeled Port is known or needed. If a general estimation is required, the above and below 1500 hp categories should be averaged. For St. Louis this leads to the cruise speeds of 7.5 mph downbound and 3.8 mph upbound. Table 4-24 has the results of Step 5 calculations.

4-6.6 Step 6. Allocation of Maneuvering Time-in-mode to the Modeled Port

Maneuvering times are mainly dependent upon the presence of locks and of tributary rivers within the port. Memphis Harbor has a tributary river and no locks within the boundaries of the port. Thus, Cincinnati which also has a tributary river and no locks within its boundaries will be used as the Like Port.

If there are locks within the Modeled Port, maneuvering times should be adjusted based on the number of locks within the boundaries of the port. If a port has no locks, maneuvering times should be treated as 0.5 hours per each tug trip. If a port has two locks, the maneuvering times from St. Louis can be used without adjustment. If a port has 1 or 3 or more locks, an estimate of the maneuvering time can be made using the average maneuvering times for St. Louis (with 2 locks) and Cincinnati (with 0 locks). For example, the category of downbound calling tugs has 2.1 hours of maneuvering for St. Louis and 0.5 hours for Cincinnati. The difference between these maneuvering times is 1.6 hours and can be considered the maneuvering time associated with two locks for this category of vessel. For a 1 lock port, the average maneuvering time per lockage could be considered 1.6/2 or 0.8 hours and the total maneuvering time for tugs towing barges downstream would be 1.3 hours (0.8 + 0.5) in a single lock port. Maneuvering times for excursion vessels are calculated using the same methodology.

If there is a navigable tributary river within the Modeled Port, maneuvering times should also be adjusted for the time-in-mode on the tributary river. In Cincinnati, miles on the Licking River are considered maneuvering and calculated accordingly.

To conclude the example of the Modeled Port, Memphis has no locks and a tributary river and thus would use the maneuvering time-in-modes as calculated for Cincinnati. Table 4-24 shows the cruising and maneuvering times to use for Memphis calculated as discussed above.

Table 4-24. Cruise and maneuvering times in hours for the Modeled Port, Memphis

Category	Tug Cruise	Tug Maneuver	Excursion Cruise	Excursion Maneuver
Calling DB	1.4	0.6	1.3	0.5
Calling UB	4.3	0.6	2.0	0.5
Passing DB	3.1	0.5	5.3	0.5
Passing UB	9.5	0.5	5.9	0.5

4.6.7 Step 7: Allocation to counties

Emissions from ports will likely need to be allocated to counties. Many ports are large enough that their boundaries encompass more than one county. For example, the Port of St. Louis is located on both banks of the Mississippi River from mile 138 to mile 208 on the river. Thus the port encompasses the city of St. Louis counties of Jefferson, St. Louis, St. Charles, Monroe, St. Clair, and Madison. If emissions from ports will need to be allocated to the county level, trips or the various time-in-modes must be allocated to the county level. The following are some possible methods of allocating ship traffic to the various counties that are within the port.

Method 1. Equal distribution: Divide the total number of trips for the port by the total number of counties. This is the simplest method and gives a straight forward equal allocation of trips to each county.

Method 2. Distribution by coastline distance: Divide the coastline distance of the county by the total coastline of the port. This method seeks to allocate trips based on an actual geographic factor. Still a simple method but more complex and probably more accurate than Method 1.

Method 3. Distribution using average wind speed and direction. Get data on wind speeds and directions along the river. Allocate emissions to the counties downwind of the prevailing wind (either by Method 1 or 2). This method has varying degrees of complexity depending upon the detail of the meteorological data used to determine the prevailing winds. This could be used to change the allocation to ports on a seasonal basis. This method may be more or less accurate than Methods 1 or 2 depending on the constancy of the prevailing winds.

Method 4. Distribution by berth density: Determine the density of activity (by counting the total number of berthing facilities in each county), total the berthing facilities in the overall port, determine the fraction in each county and use that fraction to determine traffic distribution. This method assumes that areas with more piers, wharves, and docks (PWDs) should have more emissions allocated to them. The port series reports published by the USACE for most major U.S. ports have detailed descriptions of PWD locations. For this method to be accurate, the intensity of activity at the majority of PWDs would need to be similar.

An example of how Method 4 would be used on the Typical River Ports is shown in Table 4-25 and 4-26 below.

Table 4-25. Counties within the boundaries of the Port of St. Louis

from the USACE published Port Series Report 70, Revised 1990

County	State	Bank	Mile (AOR for Mississippi)	PWD #'s	# Docks	% of total
Jefferson	MO	R	138.8 - 161	148-158	11	8 %
St. Louis	MO	R	161 - 195.5	86 - 147	62	47 %
St. Charles	MO	R	195 - 208.8	0	0	0 %
Monroe	IL	L	138.8 - 171	13 - 17	5	4 %
St. Clair	IL	L	171 - 182	18 - 34	17	13 %
Madison	IL	L	182 - 208.8	35 - 68, 76-77	36	28 %

PWD = Piers, wharves, and docks.   AOR = actual on river

Table 4-26. Counties within the boundaries of the Port of Cincinnati from the USACE published Port Series Report 72, Revised 1991

County	State	Bank	Mile C to P (P to C)	PWD #'s	# Docks	% of total
Kenton	KY	L	516-483 (470 - 483)	12 - 19	8	24 %
Campbell	KY	L	516-516 (460 - 470)	20 - 24	5	15 %
Hamilton	OH	R	516-483 (460 - 483)	113 - 132	20	61 %

PWD = Piers, wharves, and docks.   AOR = actual on river   C to P = Cairo, IL to Pittsburgh, PA

Activity information developed for the port as a whole could be allocated to the county level using the percent of total numbers given in the above tables. Thus we would say that since 47% of the docks in the Metropolitan Port of St. Louis are in St. Louis County, 47% of the time-in-mode activity also takes place there.

However, the percent of total numbers do not necessarily reflect activity. They are merely a count of the piers, wharves, and docks in operation when these Port Series Reports were revised and updated. Some of the docks may be used infrequently, others several times a day. The data in Tables 4-25 and 4-26 do not determine frequency of use.

SECTION 5
RECOMMENDATIONS

This section discusses further work required to quantify and qualify the commercial marine inventory at Great Lake and river ports in the United States. Some tasks must be completed before the default inputs for the NONROAD model can be developed. All of these recommendations are complimentary to the work already performed in this Work Assignment. Many of the recommendations are similar to those recommendations in Volume I of this report. The recommendations pertain to the following:

1. Characterization of mooring tug operation
2. Clearer definitions of barge types at Great Lake ports
3. Determination of emission factors
4. Update of the Top 60 LRPs to 1996
5. Auxiliary engine characterization
6. General understanding of inland river and Great Lake traffic
7. Commercial fishing vessels and activity
8. Dredging vessels and activities
9. Distances from the breakwater for Great Lake ports
10. Distance on the river for river ports
11. Electronic maps
12. Guidance document

Mooring tug operation on the Great Lakes, as well as at the Deep-Sea Ports, may account for a large percentage of the emissions that occur close to land. Unfortunately, neither the USACE nor the MEPAs regularly track mooring tug operations. It may be possible to apply a rule-of-thumb, based on ship-type, to determine the average number and time-in-mode for mooring tugs. It would be better to have actual data on mooring tugs and have these vessels tracked within the port.

The types of barges used at the Great Lake ports help determine barge per tug ratios and whether emissions are negligible during hotelling. Although it is possible to determine the number of dry and liquid cargo barges, and even to determine average capacity tonnages for the barges based on VTCC codes, the VTCC code alone is not enough to determine if the barges are river barges or the larger lake barges which would have self-unloading equipment and therefore hotelling emissions.

Emission factors will need to be applied to the time-in-mode data developed in this report if emissions are to be estimated for Great Lake and river operations. Lloyds Maritime has reports on fuel consumption and emission rates which could be used to calculate emission factors for the various time-in-modes for Salties, Lakers, tugs, and excursion vessels as used in the Great Lakes and rivers.

The Top 60 LRP data are from 1995 USACE data. The Typical Great Lake Port and Typical River Port data are from 1996. More agreement between these two datasets might be seen if the data were from the same years. We suggest purchasing 1996 data on all the United States Ports so that the Top 60 Lake and River Ports as well as the Top 95 Deep-Sea Ports may be updated to 1996 figures. Likewise, both the "Top Port" data and the "Typical Port" lake and river data can be updated to any given year if those data sets are purchased from USACE.

Auxiliary engines are on some liquid and dry cargo barges, some tugs, and most excursion vessels. Auxiliary engines are used for loading and unloading and power generation on the vessel. Lloyds Maritime Information Service (LMIS) have auxiliary engine data on about 22,000 engines. However, these auxiliary data are more likely to apply to deep-sea vessels than to the vessels operating on the Great Lakes and Rivers. The USACE has data on auxiliary equipment that could be used to determine the number of vessels with auxiliary engines. Further information could be obtained directly from fleet operators.

While this report details river and Great Lake traffic at two ports, general operations on the rivers and Great Lakes is not covered. There are substantial distances on the Mississippi and Ohio rivers that are not covered by ports and could be a significant emissions source. Using lock data and additional USACE data, we could present a more thorough picture of activity on the inland rivers. In addition, significant lake traffic occurs in the shipping lanes on the Great Lakes that is not characterized in our current study. This could also be a significant source of emissions that are transported to local non attainment areas that need to be characterized. With additional USACE data, we could also characterized general Great Lake traffic.

Fishing activity was investigated and several possible methodologies were discussed. Very few ports keep records on fishing boat activities. These most likely need to be determined from fishing boat operators and state departments of fish and game. Efforts were invested in contacting the Washington Department of Fish & Game which provided information on fishing licenses and tons of fish caught. Extrapolation of these data are difficult since tons of fish caught, as recorded by USACE, are given without distinguishing the type of fish. Also USACE only records these data for regions rather than ports. Furthermore, fishing license information is not specific or complete enough to detail vessel activity. More vessel oriented information is needed, however, to detail fishing vessel activity.

Some attempts were made to determine dredging activity from the USACE. USACE coordinates most of the dredging in ports and rivers. The LMIS data has some information on dredges and together with USACE data on dredging schedules at the Typical Ports, dredging activity could be characterized.

Although distances from the breakwater to the majority of docks within the Great Lakes is only a few miles and could be estimated, some port areas are more complex than others and information from these ports would allow determination of a more accurate distance. Some of the Great Lakes ports also have rivers within the boundaries of the port and more detailed information would be needed from the port to determine if vessels call on harbors on the river.

It would also be useful to obtain accurate miles on the river for each of the river ports. Many of these ports extend beyond the boundaries of the city for which they are named and common maps do not show these port boundaries. The Port Series Reports published by the USACE are very useful in determining the boundaries of the river ports as well as the counties located within the ports and the location of docks on the river. If allocation is to be made to the county level, it will be necessary to know, at a minimum, what percentage of docks lie within each county of the river ports.

Additional items to help the user of this report might include maps in electronic form that are imported into the document. Electronic maps focusing on the major geographic features of ports and waterways are not as readily available as street maps but through a combination of INTERNET map sites, cooperation with various Port Authorities, and scanning of available paper maps, maps showing the breakwater, ports, major geographic features and other reference points often referred to in this report could be obtained and included herein.

Furthermore, a guidance document should be written for air emission inventory modelers to assist them in obtaining marine activity information more specific to their port. As ARCADIS Geraghty & Miller searched for information on detailed vessel activities and port descriptions, it became apparent that a great deal of variability exits between ports as to what data are recorded at what level of completeness. A guidance document could greatly assist the Port Authorities in obtaining information relevant to the model.

ARCADIS Geraghty & Miller can provide all these services and would be happy to discuss these recommendations and future work with EPA.

SECTION 6

REFERENCES

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2 U.S. Army Corps of Engineers. *The Port of Milwaukee, Wisconsin and Port on Lake Michigan.* Port Series No. 48. Revised 1995.

3 U.S. Army Corps of Engineers. *The Port of Cleveland, Ohio.* Port Series No. 70. Revised 1992.

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6 LeLievre, Roger ed. *Know Your Ships, Guide to Boats and Boatwatching on the Great Lakes and St. Lawrence Seaway*. Marine Publishing Company. 1996. See web site http://www.knowyourships.com/

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9 United States Army Corps of Engineers/CEWRC Navigation Data Center. *Lock Performance Monitoring Data.* 1996

APPENDICES

APPENDIX A

DATA FIELDS DETAILED

A.13 CONFIDENTIAL USACE DATA FIELDS

Table A-1. ARC(WW) FILES (Cincinnati, St. Louis, Burns Harbor, Cleveland)

Field	Field Name	Type	Length	DESCRIPTION
1	LD_LT	TEXT	6	loaded or light
2	OPERATOR	TEXT	8	operator code (OPERATOR)
3	VESSEL	NUM	6	vessel code (VESSEL)
4	TRIPS	NUM	4	Number of trips (some are more than 1 – how can that be?)
5	VESS_TYPE	NUM	2	vessel type
6	SHIP_DATE	TEXT	6	shipping date (yymmdd)
7	SHIP_LOC	NUM	6	shipping location (LOCATION)
8	SHIP_DOCK	NUM	4	shipping dock (DOCKS)
9	SHIP_DRAFT	NUM	3	shipping draft
10	RECV_DATE	TEXT	6	receiving date (yymmdd) (may need to convert in DBASE or other
11	RECV_LOC	NUM	6	receiving location (LOCATION)
12	RECV_DOCK	NUM	4	receiving dock (DOCKS)
13	RECV_DRAFT	NUM	3	vessel draft upon reception into the dock
14	TRAFFIC	NUM	3	traffic code, 11 = oversears imports, 12 = overseas exports, 21 = imports from Canada, 22 = Exports to Canada, 30 = Coastwise, 40 = Lakewise, 50 = Internal, 70 = Intraport, 80 = Intraterritory, 90 = Ferry
15	SER_CODE	TEXT	2	service code, 1 = common carrier, 2 = exempt for hire, 3 = private, 9 = unknown
16	COMM_CODE	NUM	6	detail commodity code (COMMODITY)
17	TONNAGE	NUM	9	short tons (2,000 lb = 1 ton)
18	ALTERNATES	NUM	14	maximum of 7 alternates, 2 characters each, indicates the route of the vessel if different from the ‘standard’ route
19	SHIP_WW	NUM	5	shipping waterway *(port/waterway codes)*
20	SHIP_MILE	NUM	5	shipping mile
21	SHIP_PORT	NUM	5	shipping port
22	SHIP_ST	TEXT	2	shipping state
23	RECV_WW	NUM	5	receiving waterway *(port/waterway codes)*
24	RECV_MILE	NUM	5	receiving mile
25	RECV_PORT	NUM	5	receiving port
26	RECV_ST	TEXT	2	receiving state
27	CONT	TEXT	1	containerized indicator
28	AREAS	TEXT	3	Indicates which regions were in the trip. The same number can indicate 2 or more regions.
29	SUB_A1	TEXT	3	Indicates subareas traveled in region 1
30	SUB_A2	TEXT	3	Indicates subareas traveled for region 2
31	SUB_A3	TEXT	3	Indicates subareas traveled for region 3
32	SUB_A4	TEXT	3	Indicates subareas traveled for region 4

Table A-2 OPERATOR

Field	Field Name	Type	Length	Description
1	OPERATOR	NUM	6	Detail Operator code – 6 digit numerical
2	NAME	TEXT	62	Operator company name
3	ADDRESS	TEXT	25	street address
4	CITY	TEXT	20	city
5	ST	TEXT	2	state
6	ZIP	TEXT	10	ZIP
7	OWNER	TEXT	1	not implemented
8	OPER	TEXT	1	not implemented
9	TS OPER	TEXT	1	not implemented
10	SERVICE	TEXT	1	operator shipping service code, R = regulated, N = non-regulated
11	REPORT FREQ	TEXT	1	Operator reporting frequency, A = annual, M = monthly, Q = quarterly, S = semi annual
12	POC NAME	TEXT	20	contact person with NM or other 2 letter initial designation.
13	POC AREA CODE	NUM	3	POC area code
14	POC PHONE	TEXT	3	Phone number
15	FAX	TEXT	20	Fax number – and comments often blank
16	BEGIN DATE	DATE	6	Date record created
17	END DATE	DATE	6	Date record marked for deletion
18	LAST CHANGE	DATE	6	date record last changed
19	CLASS	TEXT	2	types of vessels operatord, 3 = cargo/bulk, 4 = towing, 5 = passengers, 6 = barges, 7 = tankers, 8 = towing/barges, 9 crew boats
20	SEA GOING	TEXT	2	Indicates an ocean going vessel

Table A-3. ALTERNATES

Field	Field Name	Type	Length	Description
1	ALTERNATE	NUM	2	alternate route
2	ALTERNATE NAME	TEXT	40	alternate name
3	REGION	TEXT	1	region alternate is in, 1 = Atlantic, 2 = Miss Valley/Gulf, 3 = Great Lakes, 4 = Pacific, 5 = Coastwise traffic
4	LINK	TEXT	5	link number alternate is in
5	ENTRY	TEXT	1	basis for alternate, C = contractor, O = O/D pairs, P = passengers

Tale A-4. LOCATION

Field	Field Name	Type	Length	Description
1	LOCATION	NUM	5	Location code (5-digit port code)
2	DISTRICT	NUM	2	engineering district code
3	LOCATION NAME	TEXT	138	location name
4	HMF	TEXT	4	harbor maintenance fee indicator
5	BEGIN DATE	DATE	11	Date record created
6	END DATE	DATE	11	Date record marked for deletion
7	AREA	NUM	4	areas used in Part V publication

Table A-5. COMMODITY

Field	Field Name	Type	Length	Description
1	COMMODITY	NUM	5	TOWS commodity code
2	COMMODITY NAME	TEXT	50	commodity name
3	COMM4	NUM	4	WCSC commodity code prior to 1990
4	PUB GROUP	NUM	4	publication commodity code
5	PDDB GROUP	NUM	5	public domain database commodity code
6	PMS GROUP	NUM	1	PMS commodity code
7	BEGIN DATE	DATE	11	date record created
8	END DATE	DATE	11	date record marked for deletion
9	LAST CHANGE	DATE	11	date record was last changed
10	HAZARD	TEXT	1	hazardous material based on USDOT
11	STCC	NUM	2	Standard Transportation Commodity Classification
12	EST GROUP	NUM	2	commodity groups used for estimating waterways

Table A-6. DOCKS

Field	Field Name	Type	Length	Description
1	LOCATION	NUM	5	5 digit port code
2	DOCK	NUM	3	dock code
3	FACILITY TYPE	TEXT	3	dock facility type: First character: D= dock, L = lock, J = junction, B = bridge, C = cargo handling facility, N = non-cargo handling facility, U = unverified port facilty, M = milepost, F = fleeting area, X = foreign, W = open water (ocean, rigs, fishing), O = other (harbor breakwater, dredging area, channel jetty and turning basin), R = recreational (foreign yachts) Second character: P = port facilities, null/blank = not official port facilities, D = dam
4	DOCK NAME	TEXT	50	official dock name
5	DOCK MILE	NUM	4	mile point on the waterway or channel
6	BANK	TEXT	1	bank (location of dock on river) C = center transfer, L = left bank, R = right bank
7	PORT	NUM	4	port code 4-digit
8	COUNTY	TEXT	3	county code
9	STATE	TEXT	2	dock state
10	LINK NUMBER	NUM	4	River link number
11	WTWY	NUM	4	waterway code *(useful to see if the waterway code and port code are different for any or most or none)*
12	BEA	NUM	4	Bureau of Economic Analysis Code
13	SMSA	NUM	4	Standard Metropolitan Statistical Area Code
14	PUB DOMAIN	NUM	2	Public Domain code for 26 regions
15	PORT EQUIVALENCE	NUM	4	Port Equivalence code
16	STATUS	NUM	2	dock status code
17	COMM CLASS	NUM	2	commodity class code
18	SHIPRECV	TEXT	1	shipping/receiving code: S = shipping only (not implemented), R = receiving only, B = both shipping and receiving
19	BEGIN DATE	DATE	11	Date record created
20	END DATE	DATE	11	Date record marked for deletion
21	LAST CHANGE	DATE	11	date record last changed
22	NTAR	NUM	3	National Transportation Analysis Region

Table A-7 VESSEL

Field	Field Name	Type	Length	Description
1	VESSEL	NUM	5	vessel code
2	REGION	TEXT	1	vessel region
3	NRT	TEXT	6	vessel net registered tonnage *(NRT = gross registered tonnage less an allowance for the space occupied by machinery, bunkers, water ballast and crew's quarters. Gross Registered Tonnage is a measure of the carrying capacity of the vessel. 100 cubic feet of capacity are equivalent to one gross ton*
4	VESSEL NAME	TEXT	24	vessel name
5	VESSEL NUMBER	TEXT	7	vessel number
6	COAST GUARD	TEXT	10	coast guard number
7	OPERATOR	TEXT	7	operator code
8	OWNER	NUM	7	vessel owner code (same codes as operator codes)
9	LAST OPERATOR	NUM	7	last reporting operator
10	REG_LENGTH	NUM	7	registered length of the vessel, 0-20,000
11	OVERALL LENGTH	NUM	7	0 – 20,000
12	REG_BREADTH	NUM	6	0 – 4,000
13	OVERALL BREADTH	NUM	6	0 – 4,000
14	HORSEPOWER	NUM	6	horsepower 0 - 150,000
15	CAP_REF	TEXT	1	capacity reference indicator: R = railroad cars, A = autos, C = containers, V = ?
16	CAP_TONS	NUM	8	capacity tons 0 – 50,000
17	CAP_PASS	NUM	4	passenger capacity
18	HFP	NUM	4	highest fixed point
19	REBUILT	TEXT	1	REBUILT INDICATOR
20	YEAR BUILT	YEAR	4	1900 – present
21	VESSEL TYPE	TEXT	4	VTCC code
22	EQUIPMENT_1	TEXT	16	cargo handling equipment 1
23	EQUIPMENT_2	TEXT	16	cargo handling equipment 2
24	STATE	TEXT	2	state code
25	BASE_1	TEXT	10	vessel operating base 1
26	BASE_2	TEXT	10	vessel operating base 2
27	SERIES 3	TEXT	1	series 3 indicator
28	SERIES 4	TEXT	1	series 4 indicator
29	SERIES 5	TEXT	1	series 5 indicator
30	TS OPERATOR	TEXT	7	TS Operator code
31	SUSPENSE	TEXT	1	vessel suspense code
32	FOREIGN EXCEP	TEXT	2	Foreign exemption code
33	STATUS	TEXT	1	vessel status code, A = active, G = group vessel code, F = foreign vessel
34	BEGIN DATE	DATE	11	Date record created
35	END DATE	DATE	11	Date record marked for deletion
36	LAST CHANGE	DATE	11	date record last changed
37	LOADED DRAFT	NUM	7	vessel loaded draft 1-99
38	LIGHT DRAFT	NUM	7	1-99
39	ICST	NUM	3	International Classification of Ships by Type
40	STATE ID	TEXT	14	state identification
41	LAST REPORT DATE	DATE	11	last reporting/receiving date for that vessel
42	YEAR REBUILT	YEAR	4	1990-present

A.2 DATA FROM LLOYDS MARITIME INFORMATION SERVICE

Table A-8. Lloyds Maritime Information Service fields and descriptions

LMIS Field	Description
Vessel	Current trading name of vessel
Ship Type - A	Ship type classification as defined for Lloyds Register Statistical Tables
Ship Type - B	More detailed ship type classification
Ship Type -C	Most detailed ship type classification
Lr No	The unique Lloyd's register identity number.
Steam Turbine	Number of steam turbines
Stroke Type	2 stroke, 4 stroke, or blank (for steam turbines)
DWT	Summer deadweight tonnage
BHP	Power in brake horsepower of new or refurbished engines
Speed	Service speed of the vessel
RPM	RPM at service speed
Consumption	Fuel consumption
DOB	Year in which the vessel was delivered to the fleet or last date of engine refurbishment
Ind	Ship status indicator
Ship Status	Description of ship status
Design	Name of company that manufactures the main propulsion engines
Designation	Engine designation
Recip - Kw	KW produced by the steam turbines
Gas Turb	Number of propulsion gas turbines on board
Flag	Flag of country where the vessel is registered
Best Address	Parent company where available, or manager, or owner.
LR number supplied	Yes indicates that this record was generated from a Lloyds registry number supplied by ARCADIS Geraghty & Miller to LMIS No indicates that this record was generated from a ship name only.

A.3 DATA FROM USACE AND CENSUS BUREAU TO GENERATE TOP 60 LRP TABLES

Table A-9. Army Corps of Engineers Data 1995 file and field data vessel movement data

Data Field	Description
acurrvld	File name for loaded receipts. These are vessels coming into port with cargo
acurrvlt	File name for light receipts. These are vessels coming into port without cargo
acurshld	File name for loaded shipments. These are vessels leaving the port with cargo
acurshlt	File name for light receipts. These are vessels leaving the port without cargo - These files are cargo specific so that the same vessel could be recorded several times in different files without double counting trips
USACE Field	**Description**
PCODE	Port code used by the COE to represent ports and waterways in the United States
PORT_NAME	Name of the port
SH_RC_DATE	Date of shipment receipt
TRAFFIC	Traffic code indicates the type of shipment or receipt by origin
VTYPE	Single digit vessel type code: 1 = Motor dry cargo and steam dry cargo 2 = Motor tanker and steam tanker 3 = Tug 4 = Barge - dry cargo 5 = Barge - tanker 6 = Other including yacht, sloop, schooner, sailboat, houseboat, rowboat, and
VESS_TYPE	Four digit vessel type construction and characteristics (VTCC) code
TONS	Tons shipped or received
TRIPS	One-way entrance or clearance from a PCODE

Source: Waterborne Commerce Statistics Center in New Orleans, LA

Table A-10. USACE Data on Foreign Ships from USWWCD and the Census Bureau.

Data Field	Description
STAT MONTH	Represents the month in which the vessel entrance or clearance was processed. The porcessin month is almost always the same month as the physical movement of the vessel
WTWY	Port or waterway code used by the COE to represent ports and waterways in the United States
VESS_NAME	Vessels full name up to 36 characters
ICST	International Classification of Ships by Type code indicates the ship type. If the ICST code is not available, the Census Bureau's 1 digit rig code is used as follows: 1 = Motor dry cargo and steam dry cargo 2 = Motor tanker and steam tanker 3 = Tug 4 = Barge - dry cargo 5 = Barge - tanker 6 = Other including yacht, sloop, schooner, sailboat, houseboat, rowboat, and research
FLAG	Vessel's flag of registry
WTWYSCHEDK	Indicates the vessel's last port of call for an "entrance" or the next port of call for a "clearance". If the port if foreign the field contains the port's 5 digit schedule K code. If it is domestic, it contains the COE's 4 digit port or waterway code.
PORT_IND	Indicates a domestic port by a "D" in the field. Otherwise the port is foreign
NRT	Net registered tonnage of the vessel
DRAFT	Indicates the vessel's draft in feet

Source: Data submitted to the Census Bureau by the Army Corps of Engineers for publication on the United States Waterway Data CD-ROM for 1995

A.4 DATA FROM BURNS WATERWAY HARBOR PORT AUTHORITY

Table A-11. Burns Waterway Harbor MEPA data

Data Field	Description
TENANT	The company that brought the ship into Burns Harbor
BARGE	Barge name and number. This field is blank if it is a ship
SHIP	Ship name. This field is blank if it is a barge.
VESSEL	Indicates whether the ship is a Laker, Salty, or Barge.
BERTH	Dock at which the vessel stopped.
IN	Date and time the vessel stopped at Burns Harbor
OUT	Date and time the vessel left Burns Harbor
COMMODITY	The commodity on the ship
CARGO TYPE	Type of cargo carried. This includes Bulk Metal, Dry Bulk (Dr/Bk), General, Grain, and Liquid Bulk (Li/Bk).
TONNAGE	Cargo tonnage

A.5 DATA FROM PORT OF CLEVELAND PORT AUTHORITY

Table A-12. Cleveland MEPA data

Data Field	Description
ETA (TIME)	Estimated time of arrival to Port of Cleveland
ETA (DATE)	Estimated date of arrival to Port of Cleveland
ETD (TIME)	Estimated time of departure from Port of Cleveland
ETD (DATE)	Estimated date of departure from Port of Cleveland
FLAG	Vessel's flag of registry
SHIP	Ship name
TONS	Cargo tonnage
LINE	Shipping line
AGENT	Shipping agent
PIER	First pier stopped at
PIER (#2)	Second pier stopped at