Waterway Traffic Forecasts for the Upper Mississippi River Basin

Volume VI: Industrial Chemicals

Contract No. DACW72-90-D-003

Final Report

April 4, 1997

Submitted to:
Institute for Water Resources
U.S. Army Corps of Engineers

Submitted by:
Jack Faucett Associates

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Waterway Traffic Forecasts for the Upper Mississippi River Basin: Industrial Chemicals

1.0 Introduction

The purpose of this report is to forecast industrial chemical traffic on the Upper Mississippi River to the year 2050. For this study, the definition of the Upper Mississippi River includes the Illinois River and the Upper Mississippi River above its confluence with the Ohio River. The forecasts are predicated on barge and rail movements during the 1981-1992 time period and extended based on the OBER's Gross State Product (GSP) projections. In addition, this report surveys the principal production and demand areas for industrial chemicals and provides an analysis of the barge/rail modal split over the 1981-1992 time period.

Industrial chemical movements have maintained a consistent presence on the Upper Mississippi River. In 1992, 3.3 million tons of industrial chemicals traversed on the Illinois Waterway, 3.4 million tons moved on the Minneapolis to Missouri River segment of the Upper Mississippi, and 3.9 million tons traveled on the Missouri River to Ohio River link of the Upper Mississippi River. These movements accounted for 7.8%, 4.0%, and 3.4%, respectively, of the total traffic for each river segment. Exhibit 1 delineates the traffic direction and associated quantities for each of the chemical classifications for each of the three river segments. The data is provided for fifteen Waterborne Commerce Statistics Commodity codes at the four-digit level. The principal commodities shipped include alcohols, other hydrocarbons, sodium hydroxide, and metallic salts.

The chemical industry holds a strong and pervasive role in the U.S. economy. The United States chemical industry produces more than 60,000 chemical products derived from a broad selection of metals, minerals, coal, oil, natural gas, vegetable oils, animal fats, and other raw materials. The industries served by the chemical industry include the agricultural, construction, manufacturing, and service sectors. The chemical industry is generally characterized as competitive, international in scope, energy dependent, capital intensive, vertically integrated, and subject to cyclical market fluctuations. The chemical industry's share of U.S. GSP is presented in Exhibit 2. Between 1980 and 1992, this ranged from 1.6% to 1.9% and leveled off at approximately 1.75% after 1987.

Two classifications are used to identify chemical products: organic and inorganic. Organic chemistry connotes the chemistry of carbon compounds. Substances such as oil and natural gas contain hydrocarbons that form the backbone of final organic chemical outputs. Inorganic compounds are derived from any combination of the 107 natural elements of the earth, excluding carbon compounds. The industrial chemicals that comprise the majority of the volume on the Upper Mississippi River include alcohols (an organic compound), other hydrocarbons (organic), caustic soda (inorganic), and ammonia (inorganic). According to the Waterborne Commerce

Exhibit 1

1992 Industrial Chemical Traffic on the Upper Mississippi and Illinois Rivers by River Segment and Commodity (Thousands of Short Tons)

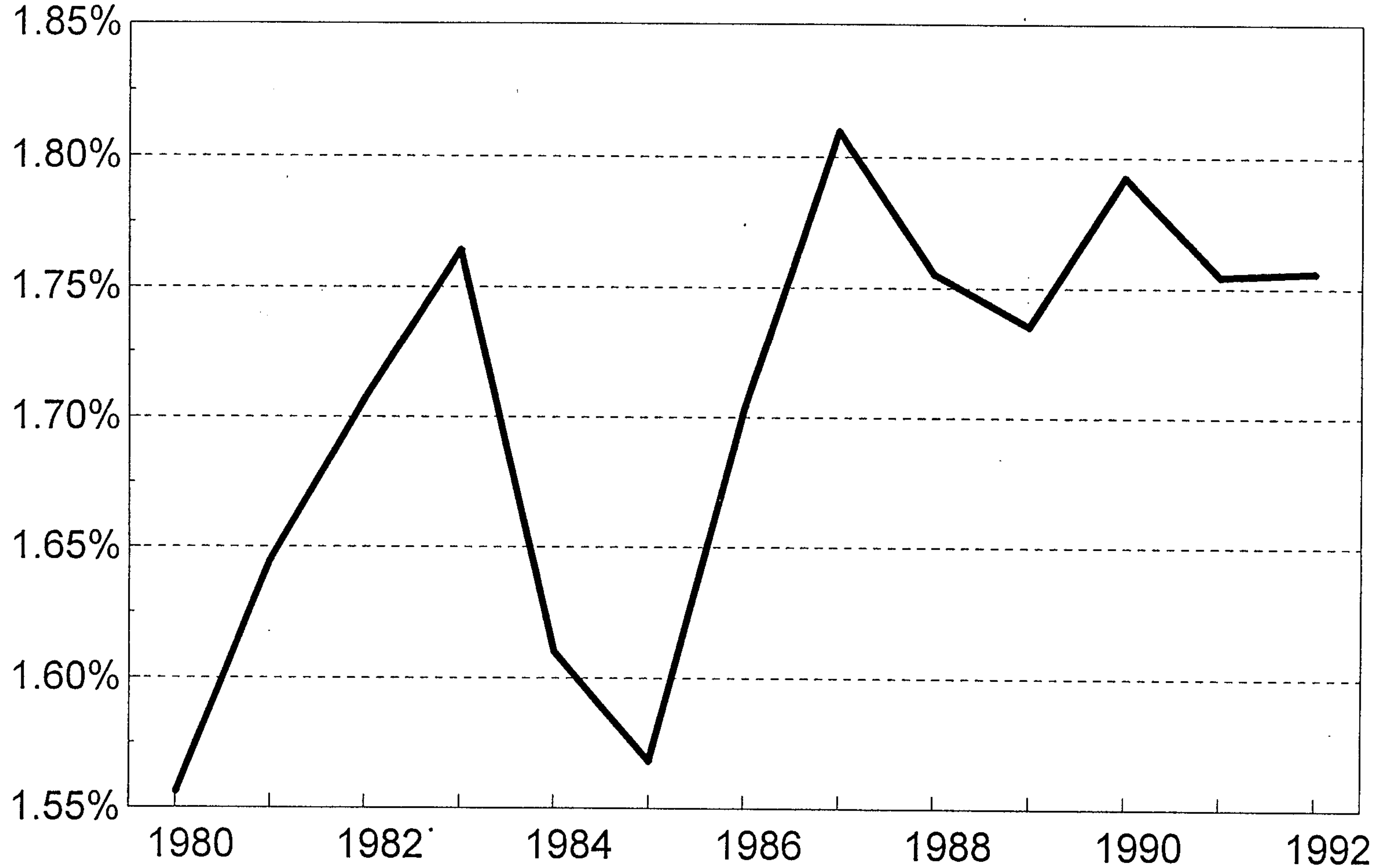
Illinois Waterway									
	Up				Down				
Commodity	Inbound	Outbound	Through	Intra	Inbound	Outbound	Through	Intra	TOTAL
alcohols	268	22	31	258	85	492	15	0	1,171
other hydrocarbons	798	0	46	4	6	8	4	4	871
sodium hydroxide	381	0	108	2	0	1	0	0	491
metallic salts	151	2	0	4	110	4	0	0	272
chem products nec.	138	0	9	1	0	20	0	0	168
organic comp. nec.	66	10	8	12	1	0	11	1	110
benzene & toluene	15	0	0	18	1	37	7	0	79
inorganic chem. nec.	46	3	6	0	0	5	0	0	60
inorg. elem. oxides	46	3	6	0	0	5	0	0	60
acyclic hydrocarbons	27	0	0	0	0	0	14	0	41
carboxylic acids	14	0	0	0	0	0	0	0	14
chemical additives	0	0	7	0	1	0	3	0	11
TOTAL	1,950	40	221	299	204	572	54	5	3,348

Upper Mississippi River: Minneapolis to Mouth of Missouri River									
	Up				Down				
Commodity	Inbound	Outbound	Through	Intra	Inbound	Outbound	Through	Intra	TOTAL
other hydrocarbons	63	0	842	0	0	0	13	0	918
alcohols	47	0	260	23	0	34	504	0	868
sodium hydroxide	134	0	500	0	0	11	1	0	646
metallic salts	44	0	146	6	0	34	4	24	258
benzene & toluene	74	0	8	0	3	105	42	5	236
chem products nec.	9	0	147	0	0	15	20	0	190
organic comp. nec.	0	0	74	0	0	0	11	0	85
chemical additives	69	0	7	0	3	0	0	0	78
inorg. elem. oxides	9	0	52	0	0	3	5	0	69
acyclic hydrocarbons	0	0	27	0	0	0	14	0	41
carboxylic acids	0	0	14	0	0	0	0	0	14
inorganic chem. nec.	0	0	7	0	0	0	0	0	7
nitrogen func. comp.	0	0	1	0	0	0	0	0	1
wood & resin chem.	0	0	1	0	0	0	0	0	1
TOTAL	449	0	2,084	29	6	202	614	29	3,412

Upper Mississippi River: Mouth of Missouri River to Mouth of Ohio River									
	Up				Down				
Commodity	Inbound	Outbound	Through	Intra	Inbound	Outbound	Through	Intra	TOTAL
other hydrocarbons	3	0	905	0	0	0	13	0	921
alcohols	58	0	316	0	78	0	456	0	908
sodium hydroxide	215	2	651	0	0	0	11	0	880
metallic salts	178	0	190	0	0	0	32	0	400
benzene & toluene	0	0	82	0	24	20	122	0	248
chem products nec.	4	0	155	0	0	3	35	0	198
organic comp. nec.	1	0	74	0	0	0	11	0	87
chemical additives	0	0	76	0	0	0	0	0	76
inorg. elem. oxides	3	1	62	0	0	0	8	0	75
acyclic hydrocarbons	0	0	27	0	0	0	14	0	41
sulphuric acid	0	0	0	0	0	24	0	0	24
carboxylic acids	0	0	14	0	0	1	0	0	16
inorganic chem. nec.	0	0	7	0	0	0	0	0	7
wood & resin chem.	0	1	0	0	0	0	0	0	1
nitrogen func. comp.	0	0	1	0	0	0	0	0	1
TOTAL	462	3	2,559	0	102	48	702	0	3,883

Exhibit 2

Industrial Chemicals GSP
(Percent of U.S. GSP)



Source: Bureau of Economic Analysis

Statistics Center (WCSC), these four product groups accounted for approximately 75% of the total industrial chemicals waterborne traffic on the Upper Mississippi River in 1992.

The report is divided into four main sections. The following section profiles the US industrial chemical industry. Section 3.0, a modal split analysis, looks at how industrial chemicals are transported between supply and demand areas. Section 4.0 presents forecasts of industrial chemical traffic on the Upper Mississippi River and Illinois Waterway.

2.0 Industrial Profiles of Alcohol and Sodium Hydroxide

The versatile nature of the industrial chemicals transported on the Upper Mississippi River precludes a detailed investigation of the supply and demand aspects for each of the fifteen chemical commodity groups. As mentioned above, the commodities produced by the chemical industry are used in a variety of industrial production stages and in many different industries. It is difficult, therefore, to both characterize the determinants of growth in the industry and specifically isolate specific sectors of the economy that are critical to the vitality of the chemical industry. In addition, individual industrial chemical commodity groups such as "metallic salts" and "other hydrocarbons" are rubrics for over thirty different types of chemical products making it difficult to characterize the supply and demand relationships for these groups. Two industrial chemical product groups that each accounted for more than 20% of the industrial chemical traffic on the Upper Mississippi River and are characterized by more easily identifiable supply and demand relationships included alcohols and sodium hydroxide. As shown in Exhibit 1, alcohols and sodium hydroxide accounted for over 44% of the industrial chemicals transported on the Upper Mississippi River in 1992. These two industrial chemical products are examined in detail in this report. The principal supply areas, principal demand regions, factors that influence demand, and other considerations are highlighted below.

2.1 Alcohols/Ethanol

2.1.1 Introduction

Among chemicals, alcohols comprise the largest commodity group accounting for approximately 25 percent of the total tonnage of chemicals transported on the upper Mississippi River. Commodity specialists and other experts assert that a substantially large share of the alcohols that move on the Upper Mississippi River System is ethanol which is primarily consumed as fuel for transportation. Ethanol is an alcohol that is generated either by the fermentation of biomass, or by the hydration of ethylene, a common chemical by-product of petroleum refining. Currently almost all ethanol production, 95 percent, is attributable to the fermentation of biomass. Although many biomass sources can serve as the feedstock for the production of ethanol, corn is the most commonly used because it is the least expensive, and most abundant source of starch in the U.S. In fact, more than 95% of ethanol production is derived from corn. Since corn production is concentrated in (and around) the states that comprise the study region, this area is the center of ethanol production in the nation.

2.1.2 Supply Regions/Production Facilities

As of January 1, 1995, U.S. ethanol plants had the capacity to produce 102,904 barrels of ethanol per day, according to the Department of Energy, Energy Information Administration (EIA). This volume is equivalent to 5.2 million tons (1.7 billion gallons) of ethanol production capacity per year. Almost all of this capacity is concentrated in the Mid-West and the eight largest plants comprise 87% of ethanol output. Ninety-seven percent of the nation's productive capacity is contained within the Petroleum Administration for Defense's second district, which is comprised of the five states within our study region, nine of the ten adjacent states to our study region, and Ohio. Moreover, of the facilities located within the second district, most of the productive capacity is located within the heart of our Study Area.

The EIA lists 38 separate companies who operate facilities producing ethanol. Only five of these companies operate more than one facility. These 46 facilities are listed in Tables 3-5 in Volume II of this study. Archer Daniels Midland Co. operates five facilities which together account for half of the total U.S. productive capacity. Two of their facilities have port access within our Study Area -- one along the Illinois Waterway at Peoria, IL; one along the Upper Mississippi at Clinton, IA. Other companies operate facilities along the waterway system in our study region, including: two plants in Pekin, IL, a plant in Keokuk, IA, and a plant in Muscatine, IA.

In 1994, Information Resources, Inc. compiled a list of ethanol production plants that either were already under construction or were on the drawing board at that time. If all of the proposed establishments are completed, it is estimated that 688 million gallons will be added to the U.S. ethanol production capacity over the next several years. The companies, locations, and annual capacities of the larger proposed facilities are presented in Exhibit 3. Note that some of these facilities may have recently been completed.

The Renewable Fuels Association estimated that in 1994, 1.5 billion gallons of ethanol was produced in the U.S. Table 3-4 in Volume II of this study shows how this production is distributed throughout the United States. As shown, the five Study Area states accounted for 68.3 percent of the total U.S. ethanol production in the 1994/95 marketing year. Illinois' share alone was over 40%.

Exhibit 3 Proposed Ethanol Production Facilities		
Company	**Location**	**Annual Capacity (Millions of gallons)**
Cargill	Blair, NE	80
Quadrex	Kearney, Central City, and Sutton, NE	75
Midwest Grain Products	Pekin, IL	60
North Carolina Ethanol, Ltd.	Faison, NC	60
Minnesota Corn Processors	Columbus, NE	50
Nebraska Energy, LLC.	Aurora, NE	30
Grain Processing Corp.	Muscantine, IA	30
American Ethanol Corp.	Great Falls, MT	30
High Plains Corp.	York, NE	30
Iowa Corn Millers	Denison, IA	28

Source: Information Resources, Inc., 1994.

2.1.3 Demand Regions/Principal Consumers of Ethanol

Analyses of ethanol markets can be found in documents which are dedicated to examining the status of alternative fuels for transportation. Fuel is the most important end use of ethanol, in terms of total volume of ethanol consumption. However, ethanol is sold for other end uses as well. Ethanol is used as an input in the production of various end-consumer products, including: cosmetics, toiletries, pharmaceuticals, mouthwash, and spirits. Ethanol is also used as an input for some intermediate chemical products, most notably acetaldehyde, which contributes to the production of numerous consumer goods, such as: plastics, paints, pharmaceuticals, and detergents.

The National Corn Growers Association estimates that approximately 300 million gallons (less than 20%) of ethanol was used for non-fuel purposes. While non-fuel uses of ethanol are significant markets for the industry, little information is available about the demand outlook for ethanol for these non-fuel uses.

<u>Geographical Distribution of Ethanol Consumers</u>

In a recently completed report by Information Resources International, a comparison of ethanol blends and gasoline fuel uses was presented for the month of June 1995. The data are delimited by individual state and Petroleum Administration for Defense (PAD) District and reveal that ethanol blend fuel consumption in June accounted for 8.7% of the 1995 annual production of fuel.

It is reasonable to assume that both the percent utilization of the ethanol blends of the total fuel market and the share of ethanol blend of the US total are representative of the spring, summer and fall months of the year. During the winter months, EPA prohibits the sale of non-oxygenated fuel in Carbon Monoxide Nonattainment Areas. Exhibit 4 below summarizes the gasoline and ethanol blend utilization for each PAD district and the states comprising the Study Area.

Exhibit 4
Ethanol Blend Consumption by Geographic Region: June 1995

Geographic Region	% of Regional Fuel Consumption	% of U.S. Ethanol Blend Consumption
PAD I (Eastern - Atlantic U.S.)	3.3	13.2
PAD II (Midwestern U.S.)	17.3	59.6
PAD III (Southwestern U.S.)	3.8	5.9
PAD IV (North-central U.S.)	9.6	3.8
PAD V (Western - Pacific U.S.)	8.4	17.6
Study Area (IL,IA,MO,MN,WI)	25.4	34.6

Source: Information Resources, Inc., 1995.

Despite the dispersed potential markets for ethanol, most ethanol is consumed close to the center of production. Of the 96 trillion Btu of ethanol burned in 1994, 70 percent was burned in the Midwest Census region, according to the EIA's Annual Energy Review. The same source reveals that almost no ethanol was consumed in the Northeast Census region. The Annual Energy Review also shows that between 1981 and 1994 ethanol consumption grew from 7 billion to 96 billion BTU. From 1981 to 1989 ethanol consumption grew rapidly in both the South and the Midwest. Since 1989, ethanol consumption continued to increase in the Midwest, but fell substantially in the South.

Exogenous Determinants of Ethanol Demand

Environmental concerns and favorable tax subsidies to the ethanol industry are two important factors that affect the demand for ethanol. Although the prospects for non-fuel markets for ethanol are not well documented, the prospects for fuel markets for ethanol are the focus of considerable attention. This interest in the fuel markets for ethanol is driven by environmental concerns, and concomitant legislation/regulation pertaining to the burning of petroleum fuels to power motor vehicles. Ethanol can play an important role in ameliorating air pollution emissions from vehicular operations. It can be used in different ways to provide cleaner burning fuel than traditional unleaded gasolines: 1) ethanol can be used as the primary ingredient in a blend with gasoline in a fuel such as E-85 (85 percent ethanol 15 percent gasoline) for engines which are specially designed to burn E-85, 2) ethanol can be used as an additive (or oxygenate) to gasoline (10 percent ethanol 90 percent gasoline), or 3) ethanol can be used as an input to ethyl-tertiary-butyl-ether which in turn can be added to gasoline as an oxygenate. Although all of these fuels burn more cleanly than gasoline, only the ethanol-gasoline (gasohol) mixture is currently employed on a significant scale.

Even though gasohol burns more cleanly than traditional gasoline, it is more expensive to produce, and thus, gasohol would not be competitive against gasoline in a free market without intervention. However, government has intervened in this market with the goal of providing clean air. As a result of the Clean Air Act Amendments of 1990, the U.S. Environmental Protection Agency established National Ambient Air Quality Standards for six common pollutants. Furthermore, the EPA identified locations which did not meet these standards, and mandated that states, with regions which do not attain air quality standards, develop implementation plans by which the standards will be met. Moreover, the EPA requires specific programs for locations which exceed standards for specific pollutants.

The EPA has classified 40 locations throughout the continental United States as moderate to serious level Carbon Monoxide Nonattainment Areas. The EPA requires that gasoline stations in these areas sell only oxygenated fuel during four winter months, the season during which carbon monoxide emissions become trapped in the ambient air. Since ethanol increases the oxygen content of fuel, these 40 locations are potential markets for ethanol. Geographically, almost half of these areas are located in valleys between coastal mountain ranges and the Sierra Nevadas and the Cascades; i.e. they are aligned along the west coast ranging up to 200 miles inland. A smaller concentration of these areas are located within the most populous cities along the Rocky Mountains, especially Denver and St. Lake City. A third concentration is along the Northeast corridor which spans from Boston to Washington, D.C. Only two Carbon Monoxide Areas are located within our Study Area: Minneapolis-St. Paul, MN and Duluth, MN.

The EPA has classified ten locations within the U.S. as extreme or severe Ozone Nonattainment Areas. The EPA requires that motor fuel retailers in these areas switch from traditional gasoline to reformulated gasoline on a year-round basis. This requirement creates potential demand for ethanol in these locations. These ten locations are concentrated in three regions of the country. Three cities are located along the Northeast corridor, two are located along Lake Michigan within our study zone, and four are located in Southern California. Houston is the final severe ozone nonattainment area. In addition to these ten locations, the EPA has also identified 43 serious and moderate ozone nonattainment areas throughout the country. Although these areas are not required to participate in the reformulated gasoline program, they may "opt into" the program, and thus these areas also represent potential pockets of demand for ethanol. A large percentage of these locations include the major cities which comprise the I-95, I-85 corridor from Bar Harbor Maine to Atlanta Georgia. Additional concentrations of these nonattainment areas include the industrial mid-west from Charleston, WV to Detroit, MI; cities surrounding Lake Michigan, and areas in proximity to the San Francisco Bay.

These government requirements do not guarantee that ethanol makers will be assured large markets for ethanol. This uncertainty stems from the fact that oxygenates other than ethanol can be blended with gasoline to form oxygenated and reformulated fuels. Ethanol's largest competitor in this regard is Methyl-Tertiary-Butyl-Ether (MTBE) which is derived from methane, and/or methanol. MTBE is price competitive with ethanol, but MTBE has certain physical characteristics which make it superior to ethanol. MTBE has a lower Reid Vapor Pressure than ethanol and thus it is less volatile. More importantly, however, MTBE is capable of being mixed with gasoline in a refinery, and shipped to vendors via pipeline. Ethanol, on the other hand, will separate from gasoline if it is shipped by pipeline. Thus, ethanol can only be transported to the vendor in a much less efficient fashion. For this reason, MTBE is often preferred over ethanol as an oxygenate. Ethanol producers have managed to maintain a competitive position against MTBE because of a favorable tax structure which provides sales tax breaks for users of ethanol.

As of January 1, 1995, the U.S. had more than twice the MTBE production capacity as ethanol production capacity. Almost 90 percent of the production of MTBE is concentrated along the gulf coast in Texas and Louisiana.

The Ethanol Export Market

A final market for ethanol is exports. Most of U.S. ethanol exports is delivered to Brazil. Brazil pioneered the conversion of transportation fuel from petroleum products to ethanol and currently is the leading consumer of ethanol as a transportation fuel. Today, 40 percent of the cars in Brazil operate on pure ethanol, and the remaining 60 percent use a 22 percent ethanol blend with gasoline. Although Brazil produces most of the ethanol it consumes, in 1990, they imported 330,000 tons of U.S. ethanol. Most of these exports are shipped by barge from the Mid-West through the inland waterway system to the Gulf Coast. From the Gulf Coast, ethanol is moved by vessel to Brazil.

Logistical Considerations and Ethanol

Domestic purchasers of fuel ethanol are operators of tank farms. These organizations are classified as bulk terminals and bulk stations, and they are located throughout the country in order to store petroleum products and distribute them to retailers. Some fuel ethanol is purchased directly by refineries which distribute gasoline directly to retailers. Ethanol is moved from producer to the tank farms and refineries by barge, rail and truck. Ethanol is not moved by the cheapest form of transportation, pipeline, because it may be exposed to water. Ethanol's incompatibility with pipeline transportation increases its cost relative to substitutes for ethanol. Once ethanol reaches its destination, the tank farm, it is generally stored separately from the gasoline with which it will be blended before sale to retailers. Often ethanol is blended with gasoline only during its final movement from the tank farm to the retailer. This delay ensures that the two substances do not separate. However, this process makes ethanol less convenient than MTBE which can be moved by pipeline, and mixed and stored with gasoline at the refinery or tank farm.

2.1.4 Prospects for Increased Ethanol Production

The outlook for ethanol production is uncertain. The supply of feedstock is assured, as is the demand for transportation fuels. However, ethanol's competitive position against other transportation fuels is unpredictable, because it is contingent on political outcomes more than technological and economic outcomes. The current tax subsidies that ethanol receives makes ethanol competitive with MTBE as an oxygenate in markets in the Mid-West. These tax subsidies were originally awarded to the ethanol industry under the auspicious that it bolsters reliance on domestic over foreign fuel resources. However, these tax subsidies are not necessarily permanent. Moreover, the ethanol industry's political clout is waning since the recent loss of a court decision over the language of clean air legislation which would have required the use of ethanol. Even more importantly, the most significant and influential organization within the ethanol industry -- Archer, Daniels, Midland (ADM) -- which controls 50 percent of the industry, is under an ongoing investigation for price fixing in many of its markets. Although the ethanol market is not currently a subject of that investigation, this probe may cost ADM a good deal of political capital which weakens its position to perpetuate the favorable governing atmosphere which the ethanol industry enjoys.

On the other hand, increasing government requirements for cars to burn cleaner fuels generates increasing demand for oxygenates. Also government incentives both for the development of alternatively fueled vehicles (AFV) and for the establishment of alternatively fueled vehicle fleets also could create increased demand for fuel ethanol. As of 1994, the U.S. EIA reports that more than 500 vehicles in the U.S. are fitted to burn ethanol-gasoline blends in which ethanol is the principal fuel (E-85, or E-95). Five hundred vehicles do not consume a relatively substantial volume of ethanol; however, if this fleet grows, then ethanol AFVs could represent a substantial market for ethanol. Another potential market for fuel ethanol is as feedstock for ETBE, an oxygenate which shares many of the favorable characteristics of MTBE. Currently ETBE is more costly to produce than MTBE and only a small volume of ETBE is produced in the U.S. However, if technological improvements for ETBE production make the manufacturing of ETBE more cost efficient, then ETBE could become a significant fuel additive.

Aside from the regulatory climate, and technological advancements, the other important component for the demand for ethanol is the expected size of the U.S. fleet of vehicles. Using this information, several agencies/organizations have generated forecasts for the use of ethanol as a fuel. Currently, the Argonne National Laboratory, is working to generate forecasts for U.S. ethanol consumption. Their findings are expected by December, 1996.

2.1.5 Anticipated Demand for Ethanol

With the rescission of the Renewable Oxygenated Standard (ROS), it is likely that ethanol production will not increase appreciably over the next five to ten years. At the federal level, the use of ethanol is encouraged through a subsidy issued to blenders of ten percent ethanol motor fuel. Other states including Illinois, Iowa, Minnesota, and Missouri offer tax incentives to producers of ethanol. Although there exists a paucity of ethanol production forecasts, rudimentary forecasts provided by USDA indicate that ethanol production will plateau at 1.6 billion gallons nationwide by the turn of the century.

2.2 Sodium Hydroxide

2.2.1 Introduction

Sodium hydroxide, also known as caustic soda, is an industrial inorganic chemical -- SIC code 28123. Together with chlorine, the two commodities comprise 80 percent of the value of shipments within the alkalies and chlorine industry. As indicated in Exhibit 1, sodium hydroxide accounted for 14.7% of the industrial chemical traffic on the Illinois Waterway, 18.9% on the Minneapolis to Missouri River segment, and 22.7% on the Missouri River to Ohio River segment. Ninety-nine percent of the tonnage of sodium hydroxide originated below Cairo and either terminated in the Study Area or passed through the Study Area. Specifically, 38 percent of the total shipments of sodium hydroxide terminated along the Illinois Waterway, 17 percent terminated along the Mississippi above St. Louis, 27 percent terminated along the Mississippi between Cairo and St. Louis, and 15 percent passed through the entire system into the Great Lakes.

The U.S. Army Corps of Engineers maintains records on all piers, wharfs, and docks in their Port Series Reports. The Port Series database records 18 facilities within the Study Area that receive caustic soda (or sodium hydroxide) as part of their primary purpose. One-third of these facilities are located in the port of Chicago. Three additional facilities are located within the Illinois waterway system along the Des Plaines River. Only two facilities are listed for the segment between St. Louis and Cairo, one in St. Louis, and one in Madison County, Illinois. Seven facilities are listed for the segment between Minneapolis and St. Louis: three in Iowa, (in Clinton, Muscatine, and Scott counties); three in Minnesota (all in Ramsey County) and one along the Black River in La Crosse County, Wisconsin.

2.2.2 Location of Production Facilities and Production Data

The two main ingredients in the production of sodium hydroxide are salt water and electricity. Production occurs in areas where these inputs are in ample supply. Salt is an abundant mineral which is easily obtained. However, salt extraction is localized in focal regions because of facility of removal. U.S. centers of salt production include: Kansas, Louisiana, New York, Texas, Utah and Ohio. Of these areas Louisiana leads production with more than 14 million tons of salt produced in 1990, more than 35 percent of the total national production.

The production of sodium hydroxide is also intimately linked to the production of chlorine. The two commodities are the output of electrolysis of salt water which divides salt water, or brine, into a gaseous component, chlorine, and a liquid component, sodium hydroxide. According to the Bureau of Census, sodium hydroxide and chlorine were respectively the 7th and 8th leading chemical products produced in 1991 in terms of total tonnage. Through the 1980s the volume of sodium hydroxide production grew at an average annual rate of 1.4 percent.

The U.S. Census of Manufactures reports that sodium hydroxide production was eleven million metric tons in 1992. The Census provides data for three states: Georgia, Louisiana, and Washington. Together these states account for almost half of the total U.S. production of sodium hydroxide. Louisiana is the leading state in terms of production, with 38.6% percent of total production of sodium hydroxide. From 1989 to 1992, the average yearly increase in total U.S. production of sodium hydroxide was 2.2%.

More revealing, the 1990 Minerals Yearbook lists the 41 U.S. facilities that are primarily engaged in the production of chlorine and sodium hydroxide. Seventeen of these facilities are located in the Gulf Coast states of Alabama, Louisiana, and Texas and account for more than 88 percent of total U.S. productive capacity. Only one small facility is located within the Study Area; however, this producer is located in Green Bay, WI along Lake Michigan, not along the inland waterway system. Two small facilities are located in states which abut the Study Area: including a facility in Mt. Vernon, Indiana, and one in Wichita, Kansas.

The 1992 Census of Manufactures reveals an interesting trend in the production of chlorine and sodium hydroxide. Whereas the value of shipments of chlorine declined rapidly between 1987 and 1992, the value of shipments of sodium hydroxide increased over that period. The reason for these divergent trends is explained in the 1990 Minerals Yearbook. The value of shipments of chlorine has declined rapidly because of increased regulatory attention to the use of chlorine especially in the making of pulp, paper and paper products. The use of chlorine in these production processes has lead to the introduction of dioxin into environmental systems, thus increasing the risk of cancer to the proximate populations (human and animal).

Regulatory action has increased the cost of using chlorine. Pulp and paper producers have increasingly employed chlorine substitutes such as hydrogen peroxide, and sodium chlorate to replace the function of chlorine in the production stream. Since these substitutions also have driven up the costs of producing virgin pulp and paper, this trend has lead to increased usage of recycled products. Thus, the demand for chlorine has declined, and the value of chlorine has declined accordingly. The decline in the demand for chlorine has had the latent effect of increasing the value of sodium hydroxide without increasing its demand. Since supply of sodium hydroxide is linked to the production of chlorine, any declines in the production of chlorine reduces the relative supply of sodium hydroxide. The reduced supply of sodium hydroxide (relative to its demand growth) naturally leads to increased value of the product. This market dynamic accounts for the value of shipments of chlorine declining while the value of shipments of sodium hydroxide increases. Thus, data from the Census of Manufactures reveals that from 1985 to 1990 neither the amount of sodium hydroxide produced relative to the amount of chlorine produced (approximately 1.05) nor the total volume of sodium hydroxide produced (approximately 11 million tons) varied appreciably.

2.2.3 Principal Consumers of Sodium Hydroxide

The U.S. Chemical Manufacturers Association (CMA) provides a distribution of output of sodium hydroxide. According to their findings, 52 percent of total production is consumed by the chemical manufacturing industry, 23 percent is consumed by the pulp and paper manufacturing industry, 6 percent is consumed by the petroleum industry, 6 percent is consumed by the soap and detergent manufacturing industry, 5 percent by the textile manufacturing industry, 4 percent by aluminum manufacturing industry, and the rest is consumed by miscellaneous industries.

The 1992 Census of Manufactures indicates that establishments which constitute SIC classification Soaps and Other Detergents (2841) consumed 470.3 thousand tons of sodium hydroxide for that year. The states which comprise the Study Area produce a significant amount of the output within this classification. Together, Illinois, Wisconsin, Minnesota, and Missouri account for about 15 percent of this industry's total number of establishments. Among these four states, Illinois and Missouri are the two leaders in this industry. Nationally, Illinois and Missouri are the third and twelfth leading states by number of establishments[1].

Petroleum Refiners

Petroleum Refiners, SIC classification 2911, consumed 344 thousand tons of sodium hydroxide in 1992 according to the Census of Manufactures. The states which comprise the Study Area contain 11 of the nations 232 petroleum refining establishments. Seven of these facilities are in Illinois which is the fourth largest state in this industry in terms of employment and value of shipments.

Industrial Organic Chemicals

Industries in the Industrial Organic Chemical SIC classifications consumed a great deal of caustic soda. Industries in SIC 2869 (industrial organic chemicals not elsewhere classified) consumed 1,399 thousand tons of sodium hydroxide in 1992. This industry is well represented in the Study Area. Just over 10 percent of the nation's establishments in SIC 2869 are located in the five state Study Area. Again, Illinois is the largest producer in this industry of the states in the Study Area. Nationally, Illinois is the fourth largest producer in this industry, in terms of value of shipments.

1 Missouri is the fifth leading state by value of shipments

Pulp, Paper, and Paperboard

Manufacturers producing pulp (SIC 2611), paper (SIC 2621), and paperboard (SIC 2631) are especially important customers for the caustic soda producers. They respectively consumed 689 thousand tons, 1,383 thousand tons, and 718 thousand tons of caustic soda in 1992. The 1992 Census of Manufactures reported that, in descending order, Wisconsin, Maine, Alabama, Washington, and Louisiana were the leading paper producers in terms of value of shipments. Wisconsin is the nation's leading state in terms of paper production, with more facilities, greater employment, and a larger share of shipments than any other state. Wisconsin ships fourteen percent of the nation's paper, in terms of value. However, the Wisconsin production facilities are not located near the Upper Mississippi River. Rather, many of the facilities are located near Lake Michigan, on the other side of the state from the inland waterway system. Aside from Wisconsin, Minnesota and Illinois are the only other states in the Study Area that contain paper producing mills. Although the industry in these states is not as large as the industry in Wisconsin, some facilities in these states are in closer proximity to the inland waterway system.

The 1994 Lockwood Post Directory of Pulp and Paper mills provides maps which show several facilities in Illinois which appear to be along the Illinois Waterway. This directory also shows both a pulp and a paper mill in Fort Madison Iowa along the Mississippi River. As for pulp mills, the Census of Manufactures data show that of our study states, only Wisconsin has any facilities operating. Finally, among paperboard mills, the area is less significant nationally. The Census of Manufactures records some activity in this industry in our Study Area. Moreover, this activity is more evenly distributed among our five states than is activity in pulp or paper production.

Inorganic Chemicals, NEC

A final industry which is a significant consumer of sodium hydroxide is the catchall industrial inorganic chemicals not elsewhere classified. Facilities within this classification (SIC 2819) consumed 977.8 thousand tons of caustic soda in 1992. This industry is represented in the Study Area, although not strongly. Less than 5 percent of the nation's production in this industry occurs in this Study Area. Of the production which does occur in the Study Area, most is concentrated in Illinois.

3.0 Modal Split Analysis

3.1 Approach

In 1992, fifteen industrial chemical commodity classifications (4-digit WCSC code) moved on the Upper Mississippi River System These chemical products are used in a wide range of industries and in a diverse geographic area. Performing a modal split analysis for this commodity presents unique challenges due to its widespread use in many different industries and the significant geographic diversity of industrial chemicals originating and/or destinating in the Study Area.

Industrial chemical transportation analysts characterize commodity movements on a national geographic level. There has been limited analytical research that has investigated modal choice among shippers of industrial chemicals. Several factors are important in determining the choice of mode including transportation rates, location of commodity, distance, and waterway channel accessibility. It is difficult to assign a weight to isolate the factors that determine modal choice for the industrial chemical shippers on the Upper Mississippi for the reasons described above. Other peripheral issues that are becoming more critical in determining choice of mode include manufacturing processes predicated on just-in-time production methods. Rail has been more readily able to meet the demands of these methods.

The approach used in this study to examine the modal split for industrial chemicals on the Upper Mississippi River System entails ascertaining whether shifts in modal split may be ascribed to 1) changes in the geographical distribution of receipts and shipments over time and/or 2) increases in rail movements accompanied by either less than proportionate increases, or absolute decreases in barge movements. For purposes of this study, modal split is measured as the barge tonnage divided by the sum of the rail and barge tonnage for a particular origin-destination pair. The applicable time period of study is 1981-1992. The analysis of the historical and existing modal split for industrial chemicals is conducted at the state-level: Further, the analysis is divided into two segments: industrial chemicals 1) originating from and 2) destinating into the five-state Study Area, for a total of ten individual analyses.

The two files that are used to construct the modal split data include the Waterborne Commerce Statistics Center (WSCS) barge data and the confidential rail Waybill data. Origins and destinations for both rail and barge were developed at the BEA level and then aggregated to the state level. For each of the five Study Area states, the modal split for each state that transported industrial chemicals (via barge or rail) for any one year in the 1981-1992 time period was calculated. These calculations served as the foundation for performing the modal split analysis.

Additionally, for each study area state and traffic direction, (e.g., industrial chemicals destinating in Illinois) the percentage of barge and rail movements shipped to/received from other states was computed (e.g., the percentage of total movements destinating in Illinois that originated in state X) for the 1981-1992 time period. These computations help to identify relevant shifts in supply and demand locations. Such shifts are an important aspect of this analysis because they can result in different utilizations of transportation modes.

Changes in modal split for a particular region may be attributed to factors unrelated to channel accessibility or comparative transportation cost. For example, it may be discovered that the industrial chemicals moving in and out of the Study Area are being increasingly served by areas that are either more accessible or less accessible to barge transportation. The modal split analysis conducted for this study will examine these geographical factors for each of the five Study Area states.

3.2 Modal Split: Industrial Chemicals Destinating in Study Area States

The following analysis reveals that the total quantity of industrial chemicals destinating in each of the five states has grown steadily over the past ten years while the movements of barge tons have remained relatively steady. Each of these five states is analyzed in more detail below.

Illinois

Of the five states comprising the Study Area, Illinois was the leading recipient of industrial chemicals transported by barge and rail between 1981 and 1992. Exhibit 5 shows that approximately eleven million tons (barge plus rail) of industrial chemicals destinated in Illinois in 1992; three million tons were barge movements. Barge's share of industrial chemicals destinating in Illinois exhibits a general downward trend from 1981 to 1992, depicted in Exhibit 6. The total quantity (barge plus rail) of industrial chemicals destinating in Illinois steadily increased after 1985 (8.5 million tons to 11.3 million tons) while barge traffic increased at a more moderate rate (2.6 million tons to 3.3 million tons). The states that were the principal shippers of industrial chemicals into the Study Area included Illinois, Louisiana, Texas, and Utah. Together these states accounted for 64% of the industrial chemicals received by barge and rail in Illinois.

Louisiana and Texas shares of Illinois industrial chemical receipts both declined over the 1981-1992 time period. Utah, a state that serves the Study Area exclusively by rail, noticeably gained share over the 1981-1992 time period. This shift would account for some of the decline in barge's share of industrial chemicals destinating in Illinois.

Over the study period, barge lost share to rail on many of the routes from states that ship industrial chemicals into Illinois (with the exception of intra-state movements). Most notably, the barge's share of Illinois' industrial chemical receipts originating in Louisiana decreased from 76% to 50%; receipts originating in Texas also began to exhibit a relatively higher dependence on rail as barge's share of Texas-to-Illinois movements decreased from 40% to 34%. Barge also lost share to rail on movements originating in Kentucky, Missouri, and West Virginia.

In summary, an examination of the modal split for industrial chemicals destinating in Illinois indicates that although the quantity of these commodities has been increasing, barge's share of this tonnage has been decreasing. This implies that additional tonnage (or incremental demand for transportation services) moving into Illinois is being served by rail.

Exhibit 5

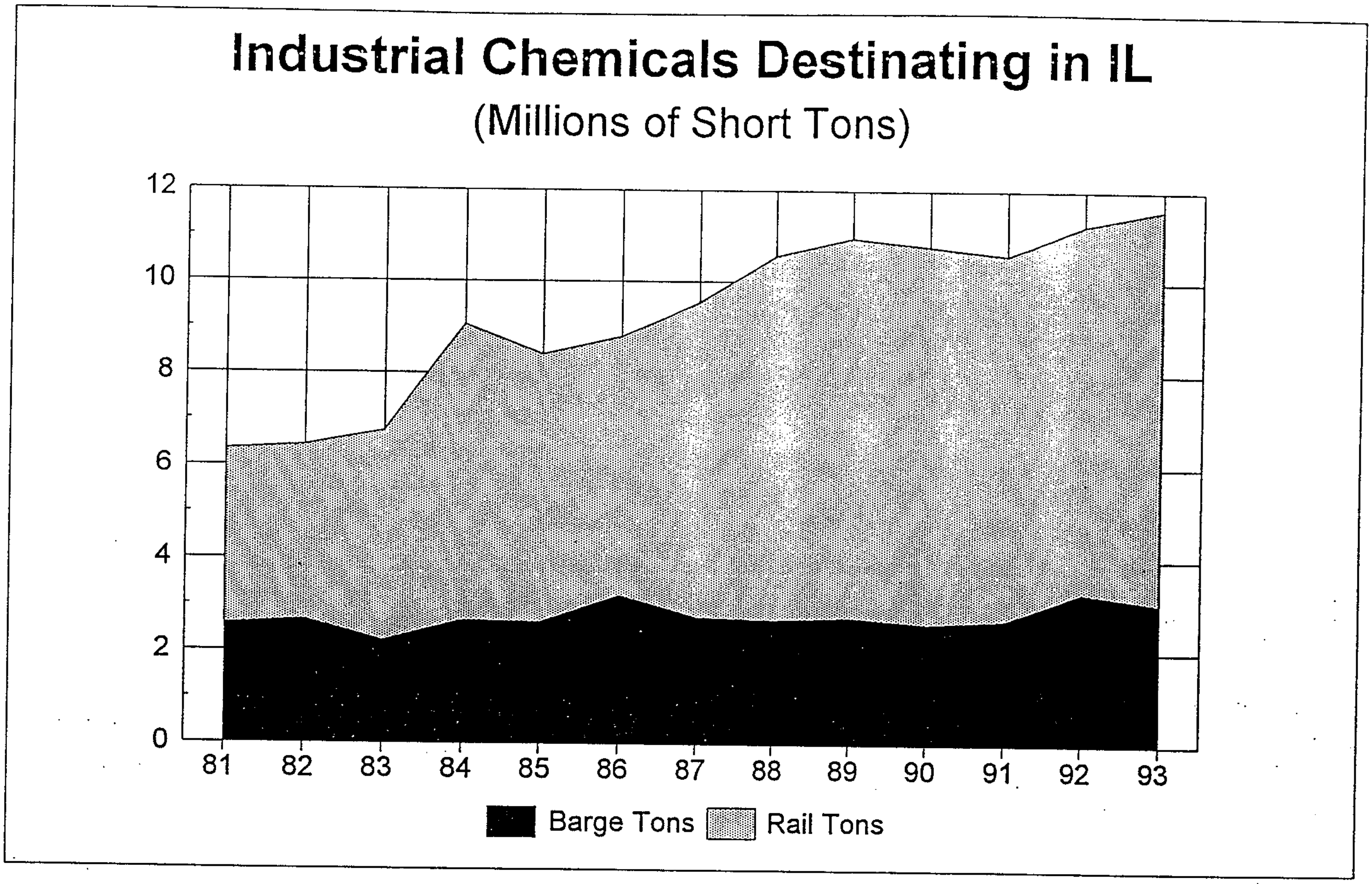
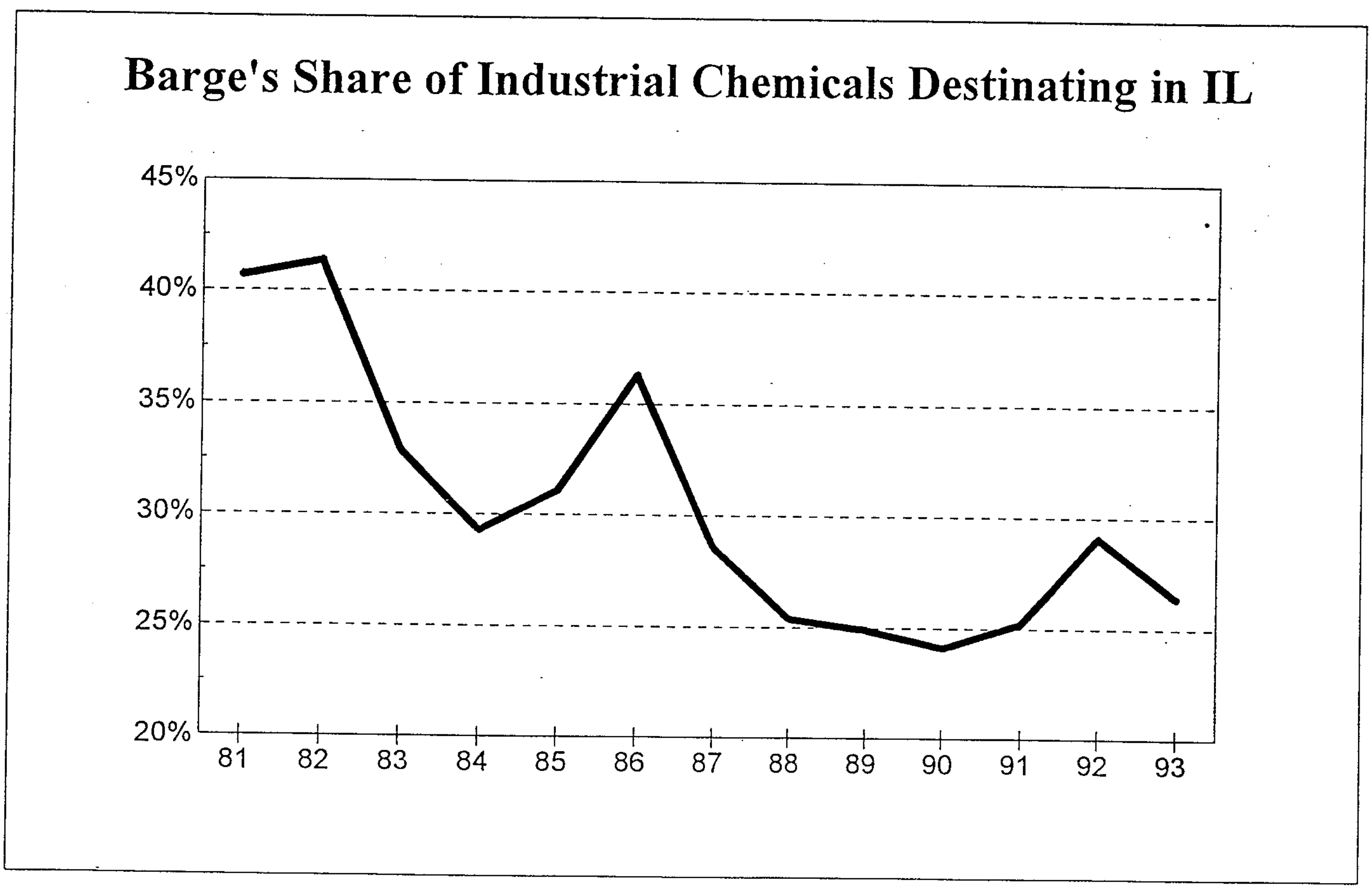


Exhibit 6



Iowa

Exhibit 7 indicates that the quantity of waterborne industrial chemicals destinating in Iowa hovered around 200,000 tons during the 1981-1989 time period but fell to approximately 100,000 tons afterwards. The amount of total tons (barge and rail) increased from 881 thousand in 1981 to 1.5 million in 1992, exhibiting a moderately steady upward trend, although not as pronounced as Illinois. Incoming barge tons of industrial chemicals decreased from 224 thousand in 1981 to 105 thousand in 1992.

As indicated in Exhibit 8, barge's share of industrial chemicals destinating in Iowa has consistently decreased since 1982. The origin of industrial chemicals destinating in Iowa also became more geographically dispersed over the time period. The five states (Iowa, Illinois, Louisiana, Missouri, and Texas) that served as the primary shippers of these commodities to Iowa accounted for 68% of the total movements in 1981 and only 52% of the total in 1992.

Shifts in the state origin of this commodity group provide one important explanation for the decline in barge's share of industrial chemicals destinating in Iowa. Five states increased their shares over the 1981-1992 time period: Florida, Kansas, Nebraska, Utah, and Wisconsin. Historically, flows of industrial chemicals between these states and Iowa have moved exclusively by rail. Conversely, four states that lost share in the eleven year time period regularly use barge transportation to ship industrial chemicals. These states include Iowa, Illinois, Louisiana, and Missouri. Although the underlying cause for this shift may be related to numerous factors including barge and rail rate competition, it appears that the industrial chemicals supplied to Iowa are being distributed from different locations in which barge transportation is not a viable mode.

For most of the state-to-state flows, barge's share of industrial chemicals destinating in Iowa also declined. In addition to Iowa's intra-state movements, Illinois and Louisiana have historically moved chemicals into Iowa by barge. Barge's share of Iowa intrastate movements decreased from 42% in 1981 to 18% in 1992. Barge's share of Iowa's industrial chemical receipts originating in Illinois and Louisiana decreased from 4% to 0% and 52% to 28%, respectively, over the same time period.

Exhibit 7

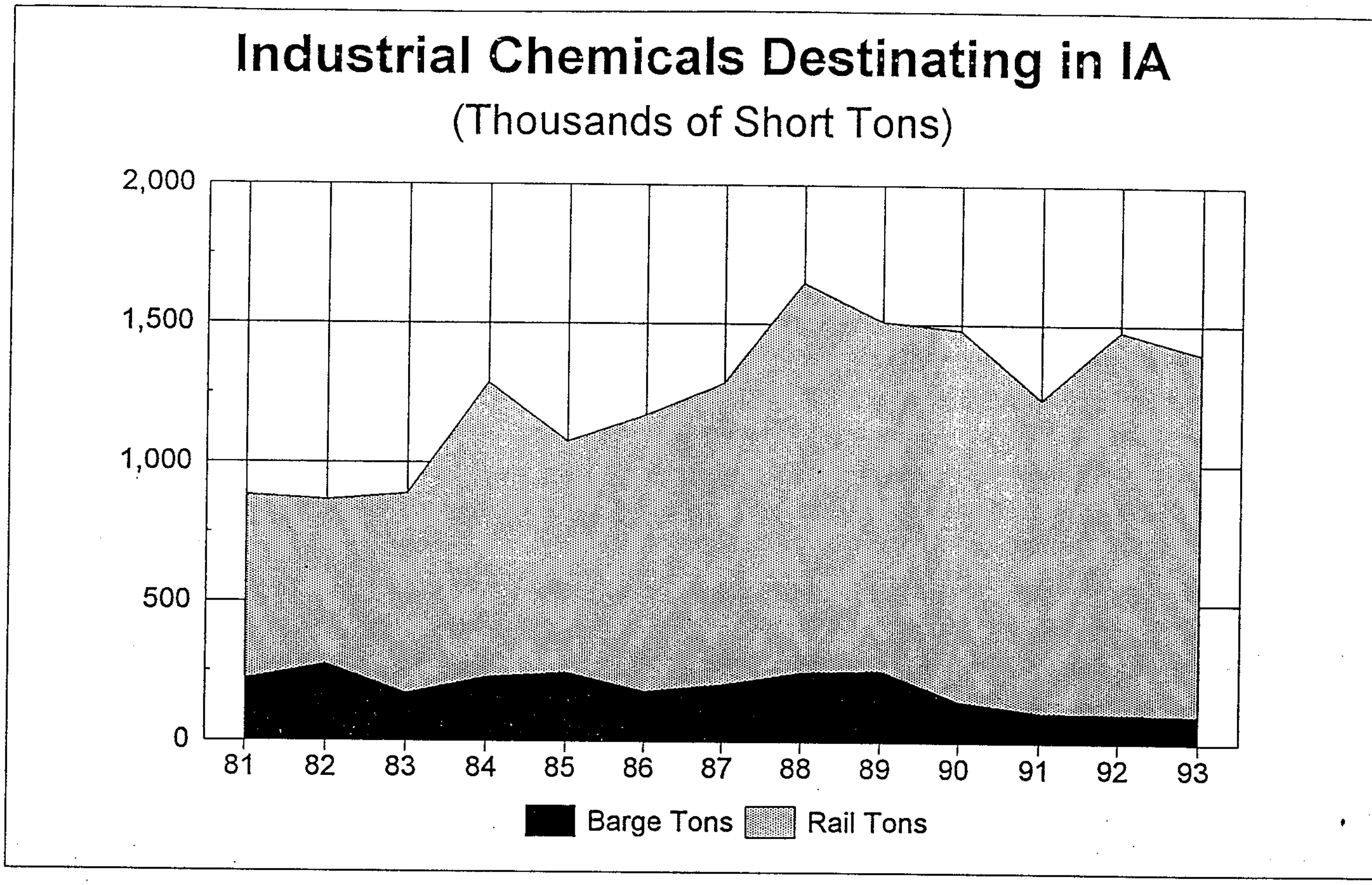
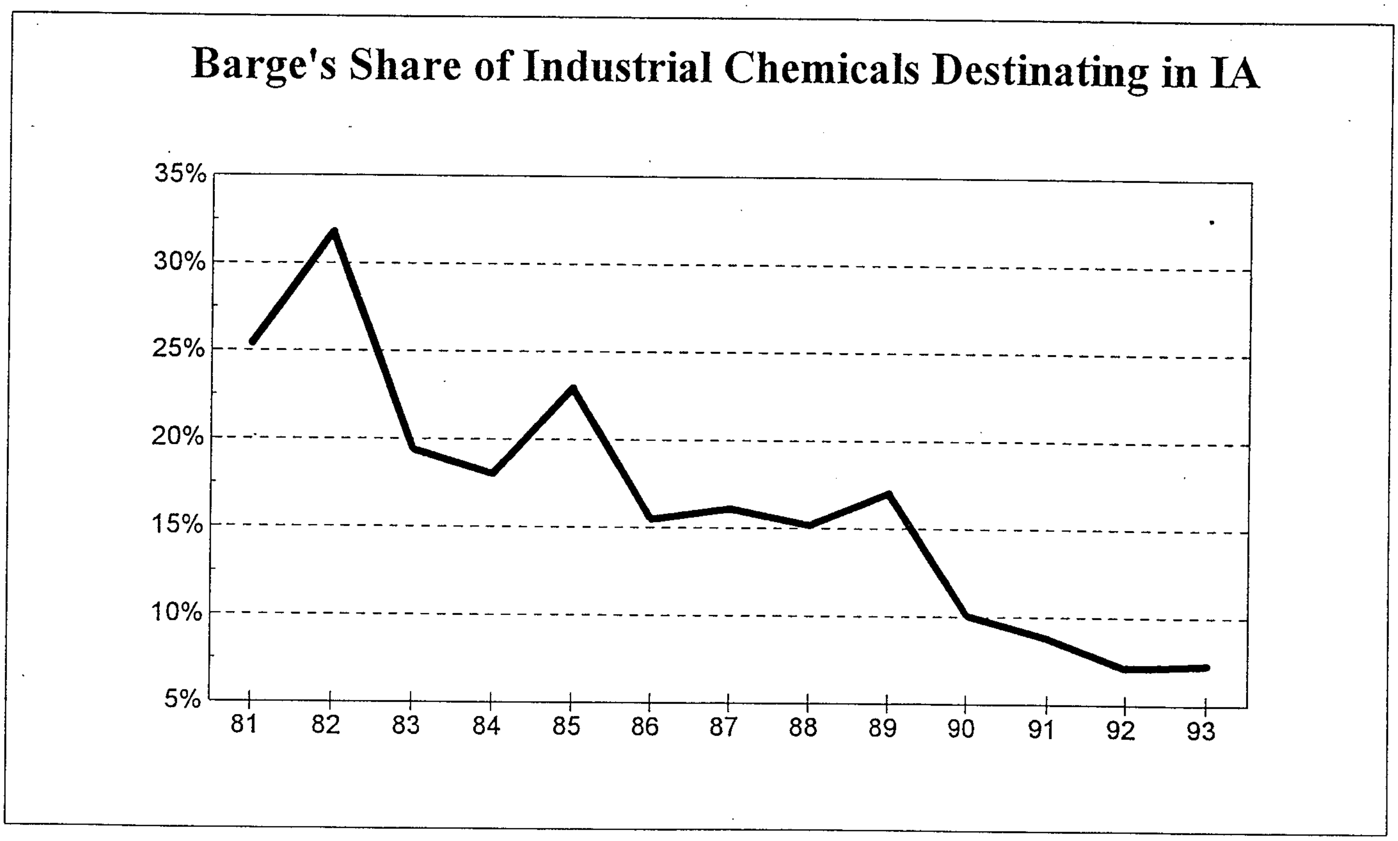


Exhibit 8



Minnesota

The historical modal split for industrial chemicals destinating in Minnesota in 1981-1992 displayed an analogous trend to that of Iowa (Exhibit 10). A dramatic decline in barge's share of inbound industrial chemicals occurred between 1981 (0.20) and 1984 (0.09). This decline was followed by more moderate reduction from 1985 (0.11) to 1992 (0.08). The main states that supply Minnesota with industrial chemicals include Iowa, Illinois, Louisiana, Michigan, Texas, and Utah. These state provided 82% of the industrial chemicals transported to Minnesota in 1981. By 1992, that share had fallen to 55%. Canadian origins also account for a significant amount of the industrial chemicals transported to Minnesota. In fact, the province of Alberta supplied 14% of the Minnesota's industrial chemicals in 1992.

Over the 1981-1992 time period, the total barge and rail movements of industrial chemicals destinating in Minnesota surged 113% (776,000 tons to 1.64 million tons). However, total barge tons decreased from 157,000 tons in 1981 to 124,000 tons in 1992. Most of this decline occurred before 1988. Exhibit 9 graphically portrays these trends.

Of those states transporting industrial chemicals into Minnesota, the states that lost share have historically used barge transportation whereas the states that gained share have principally used rail. Three states conspicuously lost share in the 1981-1992 time period: Iowa, Louisiana, and Michigan. Both Iowa and Louisiana have historically used barge transportation to serve Minnesota. The three states that noticeably gained share over the time period include Florida, Illinois, and South Dakota; virtually all of the industrial chemical movements originating in these three states and destinating in Minnesota move by rail.

In 1992, Texas and Louisiana accounted for approximately 300,000 tons (18%) of the total traffic destinating in Minnesota. In addition to Iowa, these two states were the primary origins of industrial chemicals moving by barge into Minnesota. Over the past several years, however, the barge's share of industrial chemicals destinating in Minnesota and originating in these two states has fallen dramatically. From 1981-1992, barge's share of industrial chemicals originating in Louisiana and destinating in Minnesota fell from 0.88 to 0.59. Likewise, barge's share of Minnesota receipts originating in Texas fell from 0.40 to 0.04. These findings suggest that additional tonnage shipped into Minnesota has primarily been served by rail. Not only has there been a shift in origins to states that predominantly use rail, but those states that have employed barge transportation are also using relatively more rail.

Exhibit 9

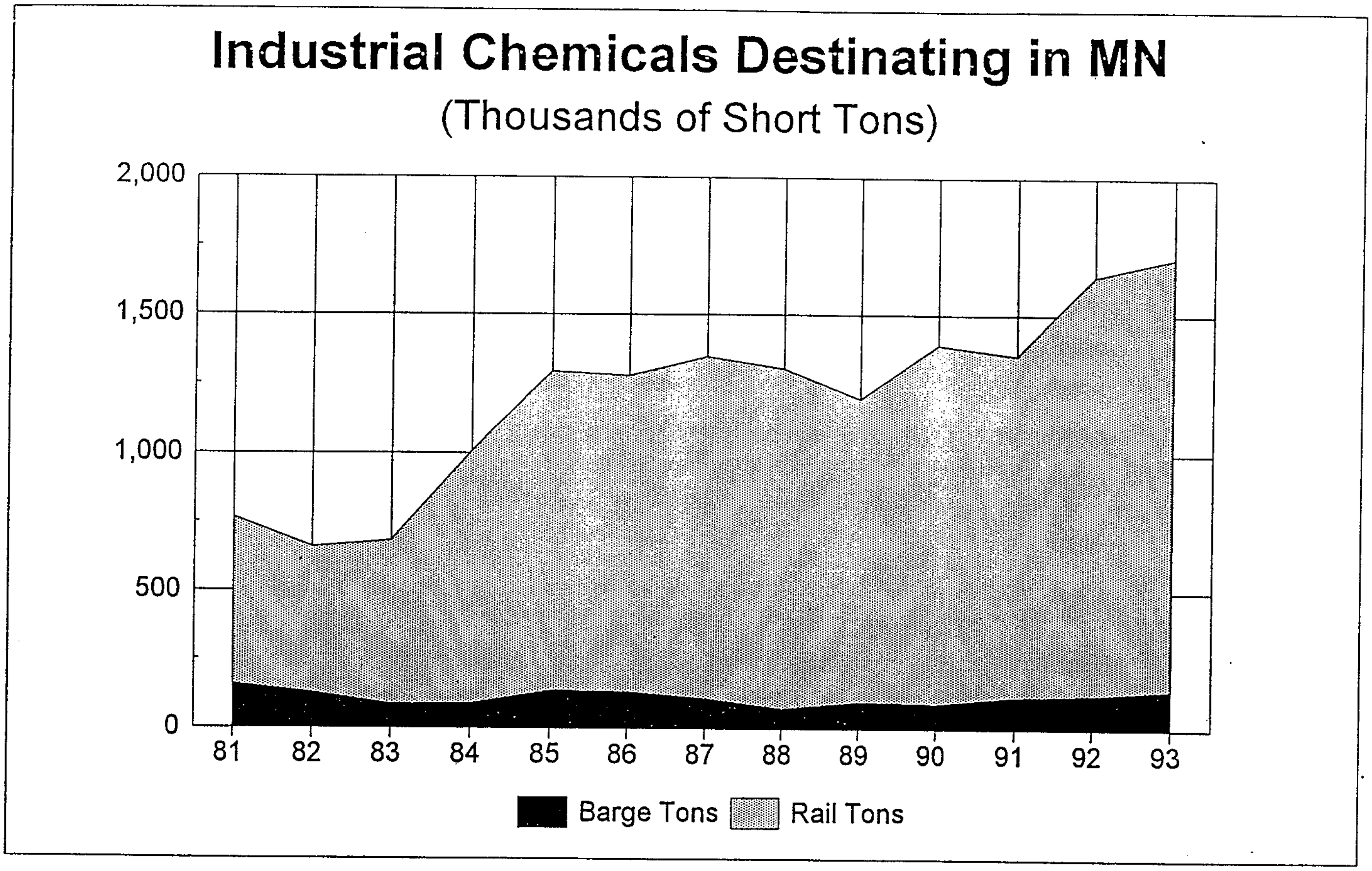
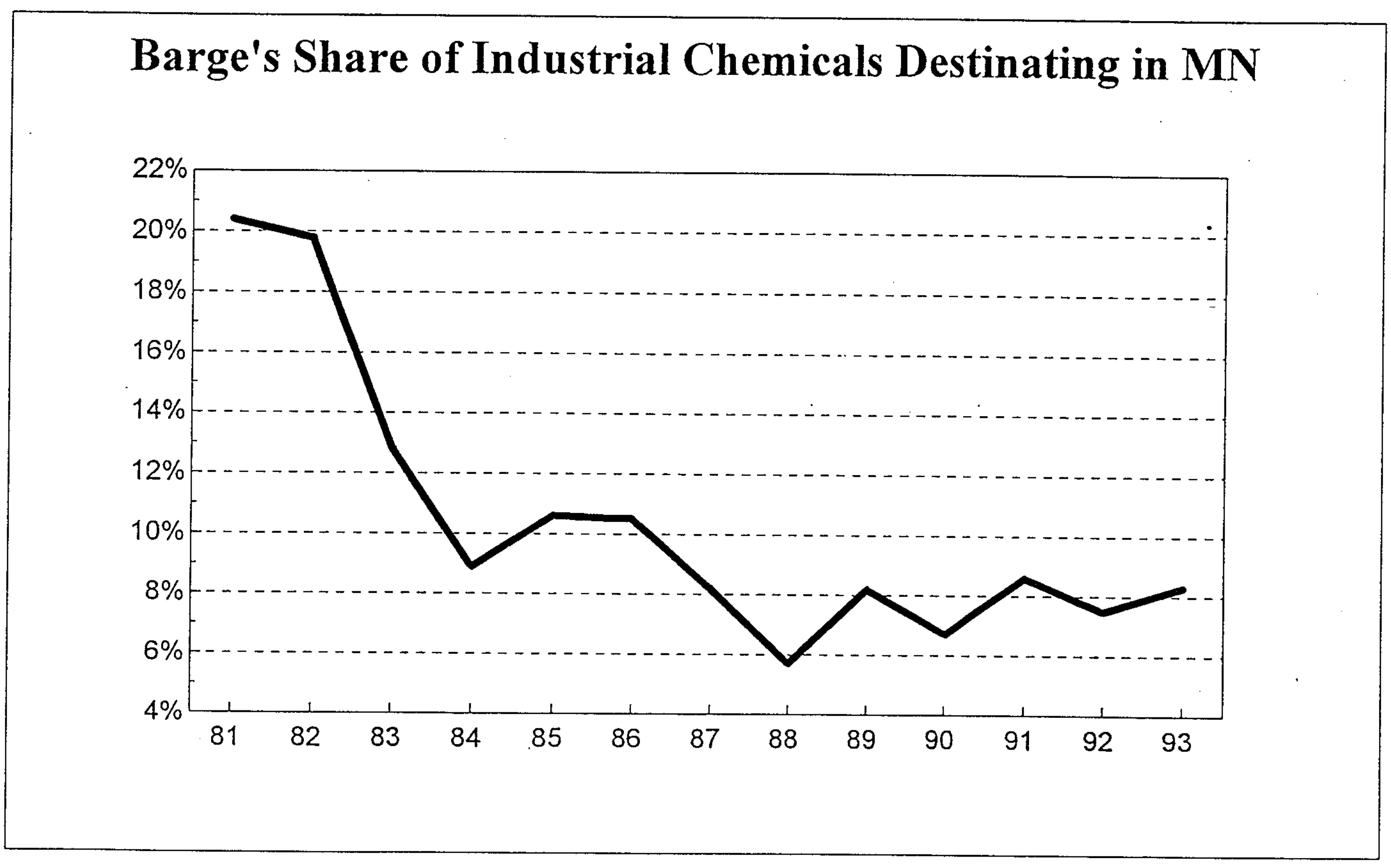


Exhibit 10



Missouri

Exhibit 11 graphically displays the historical total barge and rail movements destinating in Missouri. Both modes reveal an upward trend over the 1981-1991 time period: barge tons increased by 54% (from 471,000 tons to 727,000 tons) and total tons increased 76% (from 2.54 million tons to 4.48 million tons). However, total barge and rail tons asymptotically approach 4.75 million tons.

Barge's share of industrial chemicals destinating in Missouri exhibited a steady downward trend from 1981 (0.19) to 1986 (0.13). From 1986 to 1993, the share increased moderately: from 0.13 to 0.15. These trends are shown graphically in Exhibit 12.

The four main states that transport industrial chemicals to Minnesota include Illinois, Louisiana, Texas, and Utah. From 1981 to 1991, the combined share of these states increased from 49% to 62%, suggesting that the supply of these commodities is now more geographically concentrated.

Only a few discernible shifts in the state origins of industrial chemicals can provide insight into the factors contributing to the barge's increasing share of Missouri's industrial chemical receipts, observed from 1986-1991. Illinois and Utah both increased their share of Missouri's consumption of industrial chemicals while Missouri intrastate movements, and Oklahoma, lost share.

Additionally, the changes in modal splits for those states that have historically accounted for significant barge movements do not fully elucidate the reasons for the relatively greater use of barge witnessed between 1986 and 1991. Barge lost share to rail for movements originating in Kentucky, Missouri, and Texas; however, it moderately increased its share relative to rail for movements originating in West Virginia and Illinois.

Exhibit 11

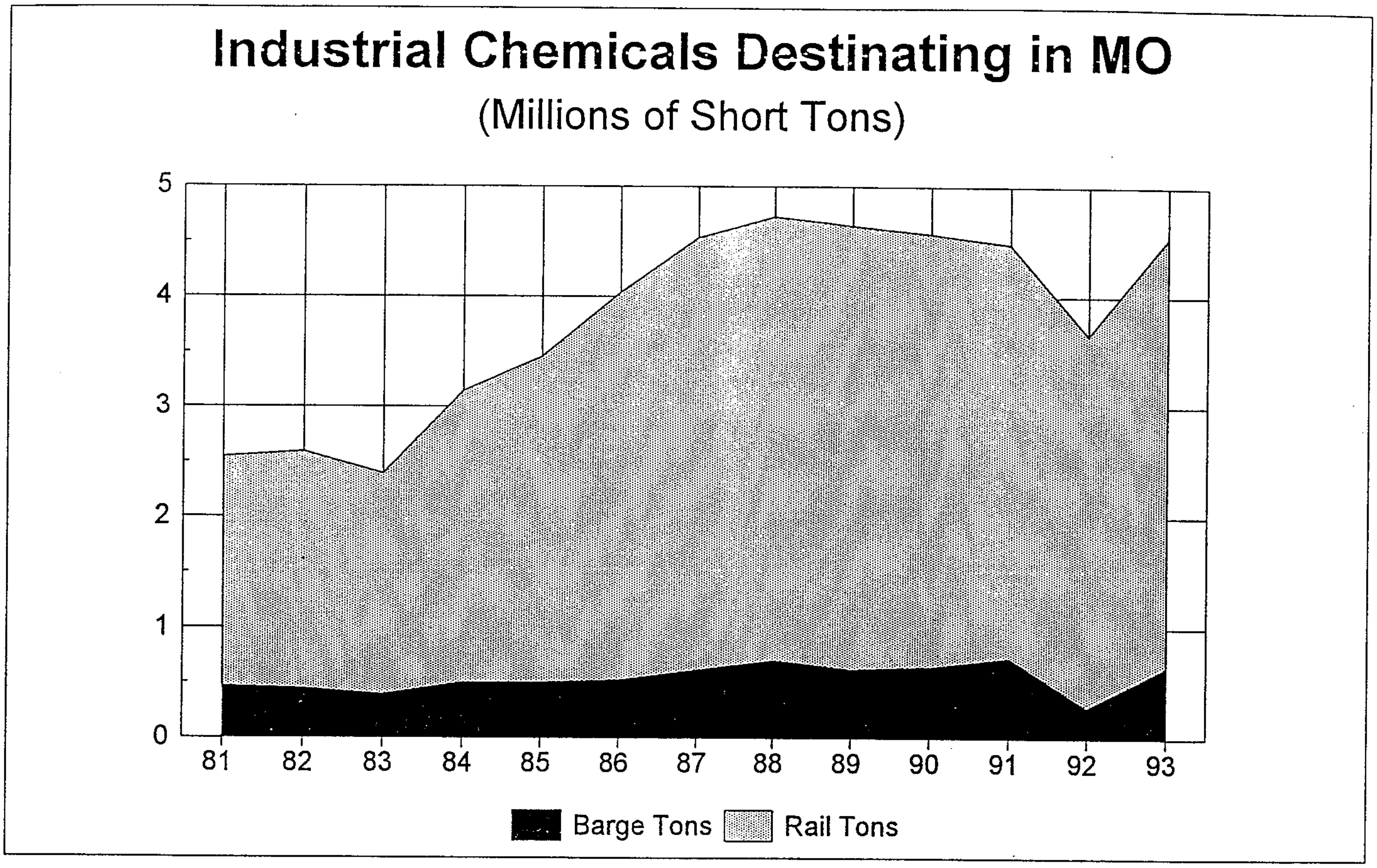
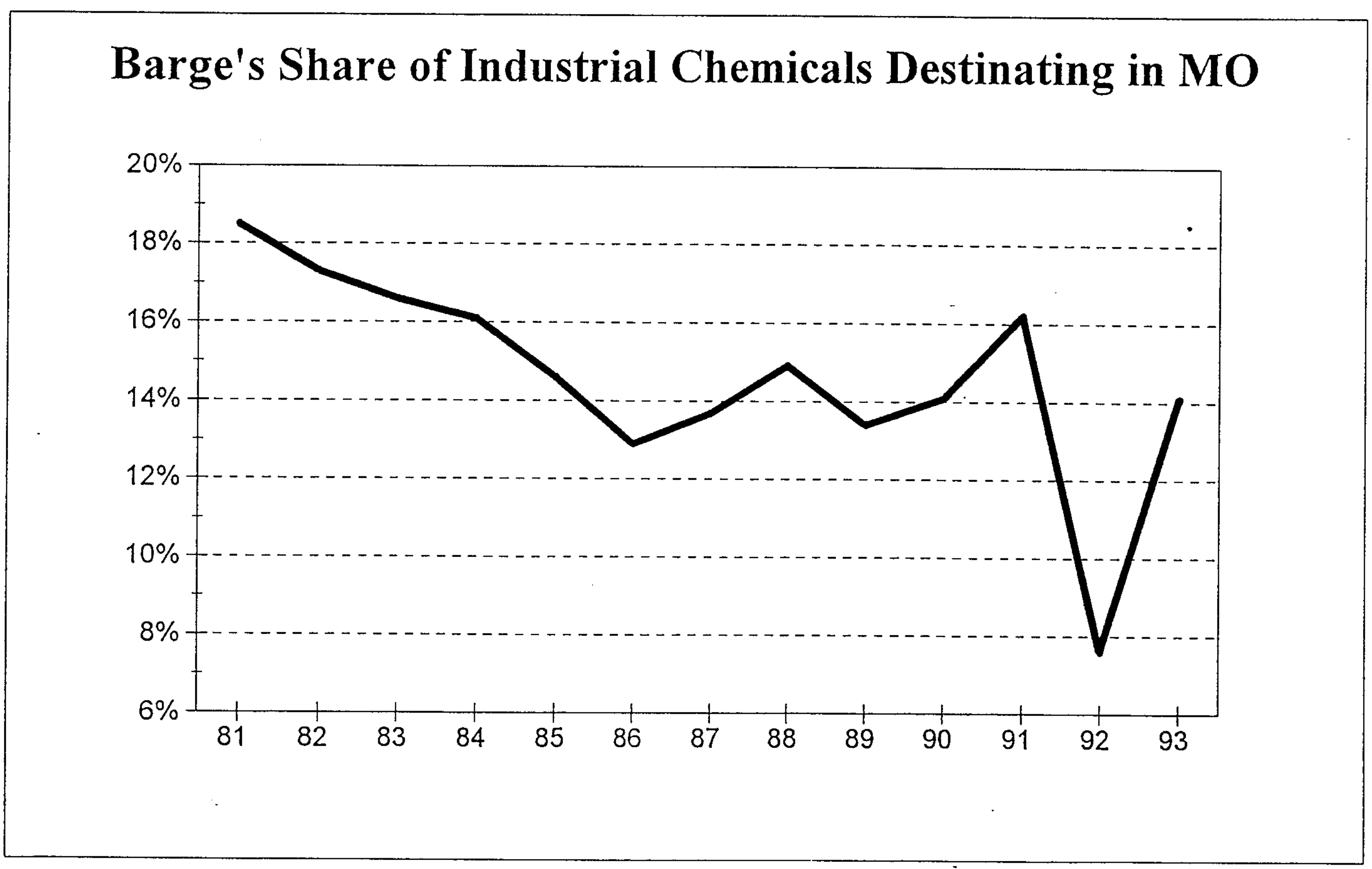


Exhibit 12



Wisconsin

Historically, barge transportation has not played an critical role in the movement of industrial chemicals into Wisconsin. Although the amount of industrial chemicals destinating in Wisconsin was the lowest of the five Study Area states, total movements of barge and rail tons increased by a marked 112% (702,000 tons to 1.49 million tons) between 1981 and 1992. Almost all of this growth can be attributed to increases in rail movements.

Louisiana was the only state that distributed industrial chemicals by barge to Wisconsin. Given this historical context, it is not likely that industrial chemical barge movements into Wisconsin will have a significant impact on Upper Mississippi River traffic over the next several years.

Exhibit 13

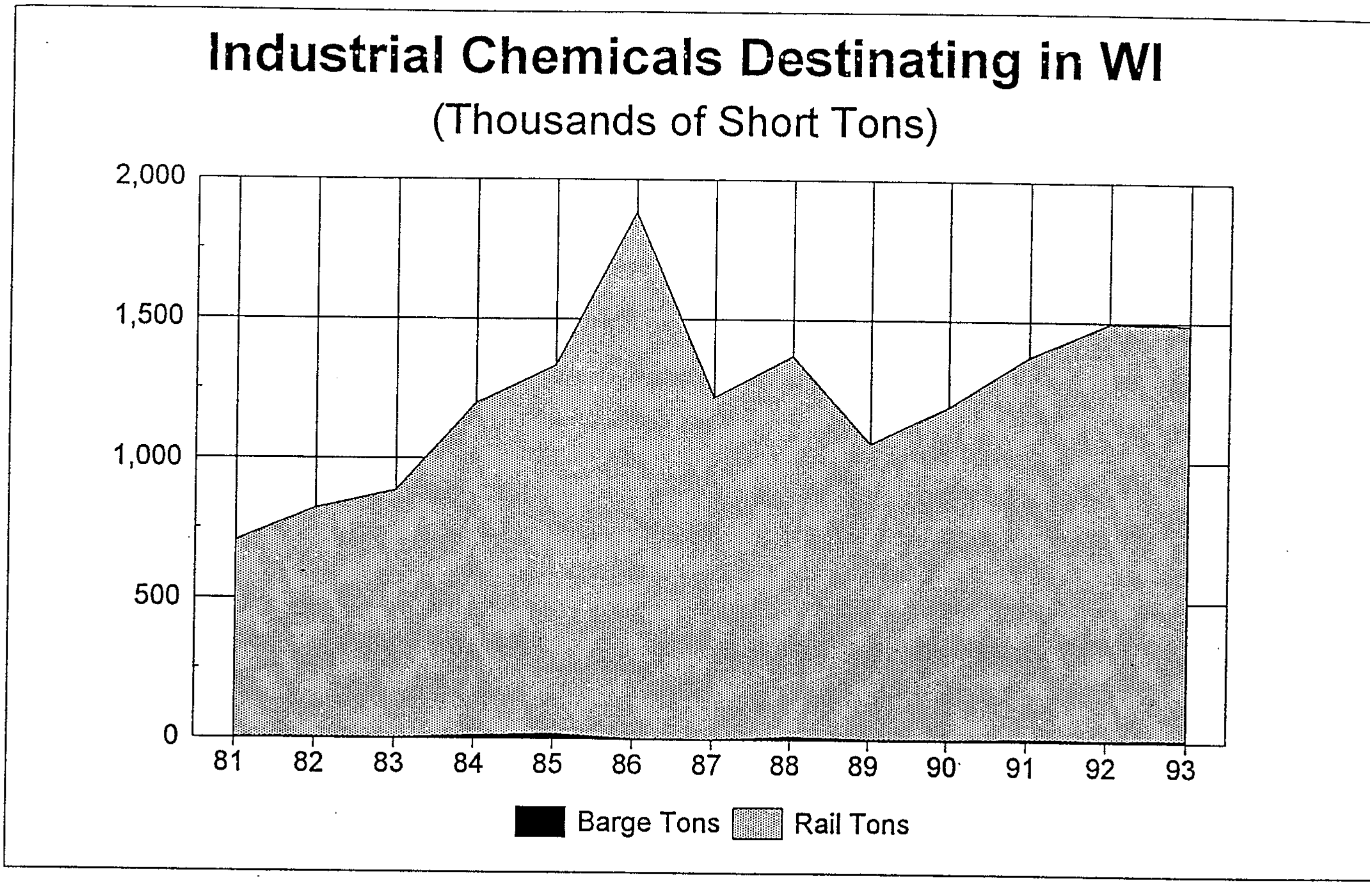
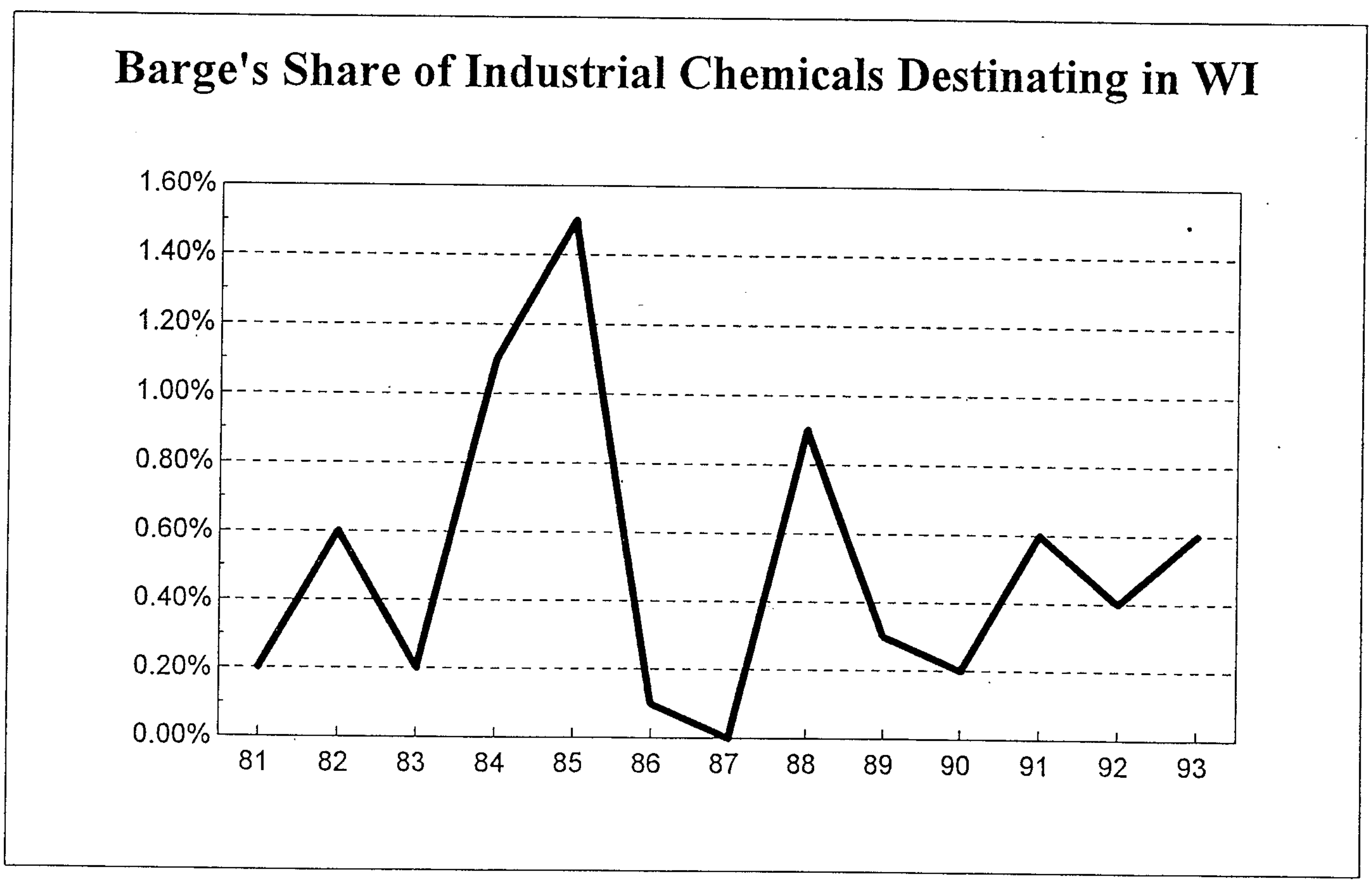


Exhibit 14



3.3 Modal Split: Industrial Chemicals Originating in the Study Area

To analyze the modal split for industrial chemicals originating in the Study Area, we applied a procedure similar to the one used for industrial chemicals destinating in the Study Area. First, each destination's share of industrial chemical shipments originating in the Study Area was calculated. We also calculated the mode split for each of these origin-destination pairings. Relative to the inbound movements discussed above, the industrial chemical movements originating in the Study Area were distributed to more geographic locations. For the inbound industrial chemical movements, four or five origin states accounted for more than 50% of the traffic. With the exception of Minnesota, outbound movements require the summation of the top six or seven destination states in order to muster more than 50% of the outbound traffic.

A state-specific analysis of industrial chemical movements originating in the Study Area is provided below. Again, the methodology parallels that of the previous section.

<u>Illinois</u>

Of the industrial chemical movements originating in the five-state Study Area, Illinois has had the largest share. Total tons of these commodities increased appreciably from 1981 to 1988 (2.38 million tons to 6.12 million tons) and more moderately from 1988 to 1992 (6.12 million tons to 6.41 million tons). Barge movements of industrial chemicals originating in Illinois grew from 373,000 tons in 1981 to 1.11 million tons in 1992. These movements can be seen in Exhibit 15.

As shown in Exhibit 16, barge's share of industrial chemicals originating in Illinois exhibited a volatile, upward trend between 1981 and 1992. The share rose from 0.14 to 0.17 over the twelve-year time period.

Industrial chemicals originating in Illinois are distributed to numerous locations. In fact, Illinois itself was the only state to receive more than 10% of its shipments on average.

New York and Ohio have typically received industrial chemicals from Illinois almost exclusively by barge; both saw increases in their shares of Illinois industrial chemical shipments. Changes in barge's share of Illinois industrial chemical shipments over the 1981-1992 time period were pronounced for three states: Illinois (0.31 to 0.58), Missouri (0.18 to 0.02), and Tennessee (0.02 to 0.47). The state-to-state movements of industrial chemicals from Illinois to Texas and Louisiana exhibited no discernible changes in mode split.

Exhibit 15

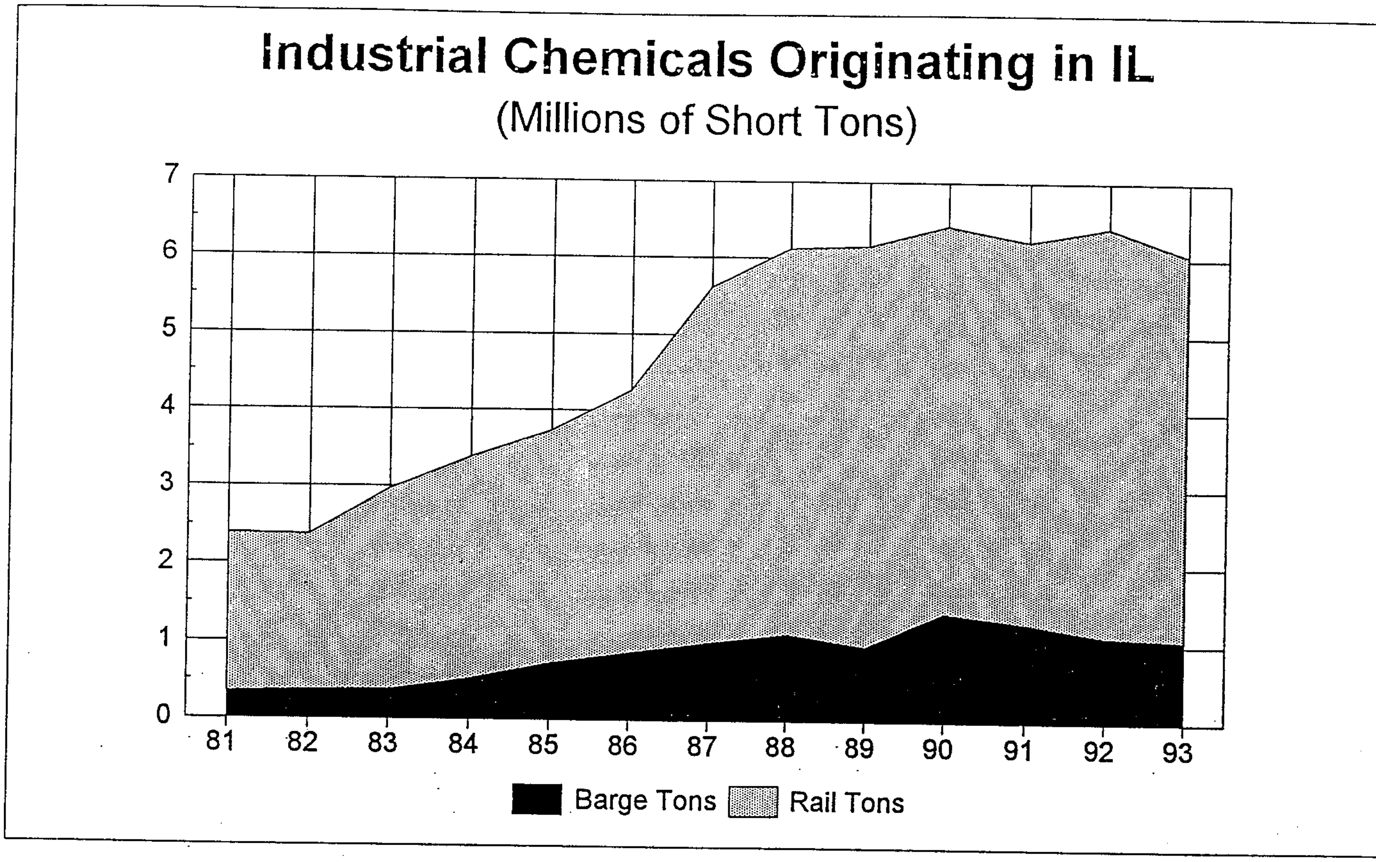
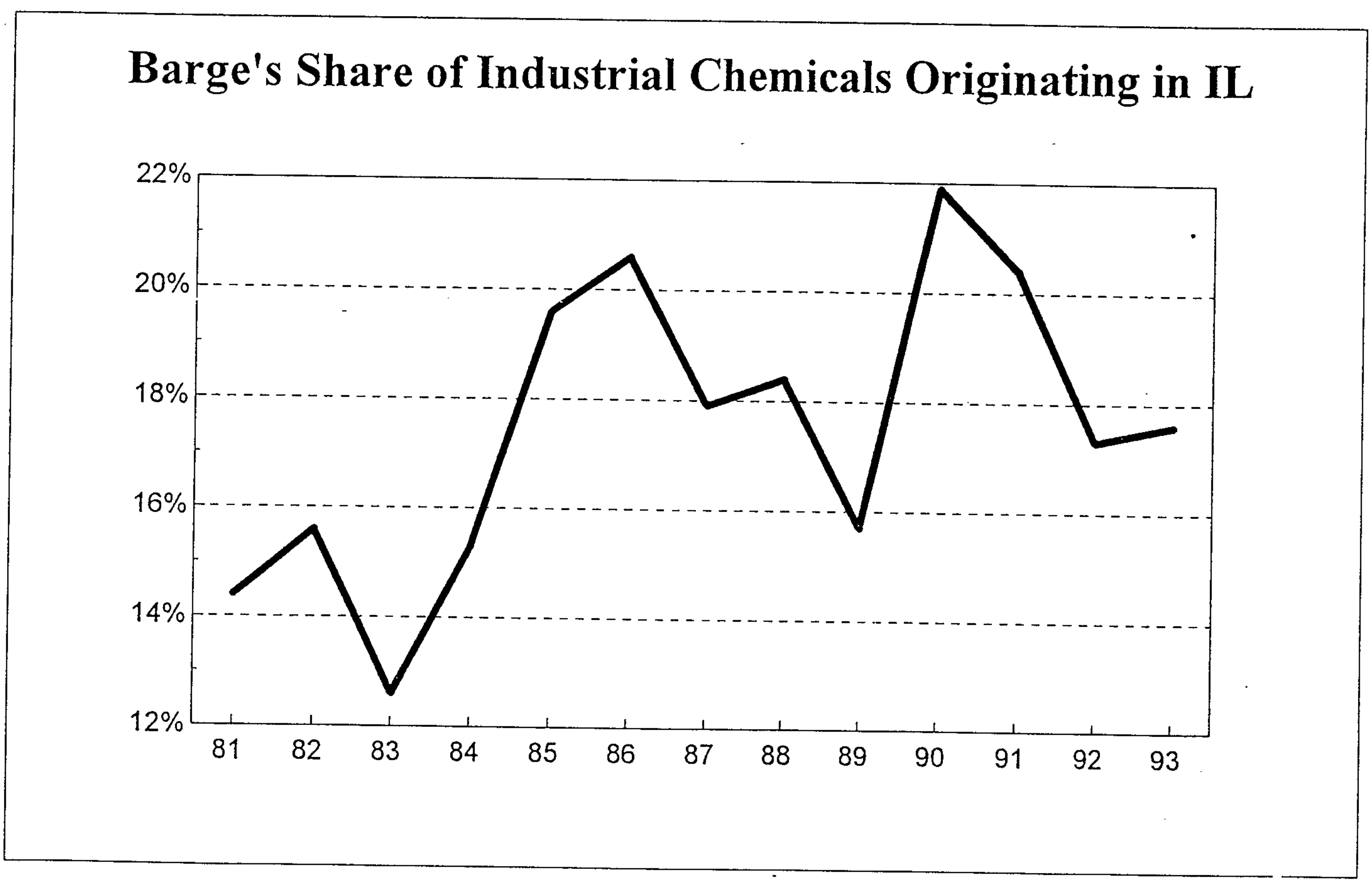


Exhibit 16



Iowa

As shown in Exhibit 18, barge lost share of Iowa's industrial chemicals shipments starting in the late 1980s and continuing through the early 1990s. Over the 1981-1992 period, barge movements originating in Iowa were relatively flat. Total barge and rail movements, however, increased by 48% over the same time period.

Substantial geographic dispersion characterizes the movements originating in Iowa. In 1992, Illinois, Minnesota, and Missouri were the leading recipients, respectively, of Iowa industrial chemical shipments. Three of the Study Area states exhibited marked decreases in their shares of Iowa industrial chemical shipments: Iowa, Minnesota, and Wisconsin. Both Illinois and Iowa saw their shares of Iowa shipments increase.

Barge lost some of its advantage to rail in two states, Iowa and Texas, that have consistently received industrial chemicals by barge . As indicated in the inbound movement discussion, barge's share of intra-Iowa movements decreased from 0.42 in 1981 to 0.18 in 1992. Likewise, barge's share of Iowa's industrial chemicals shipments destinating in Texas dipped to 0.13 in 1992 from 0.46 in 1981. The mode splits for Iowa shipments destinating in Illinois and Minnesota fluctuated but did not demonstrate any upward or downward trends.

Exhibit 17

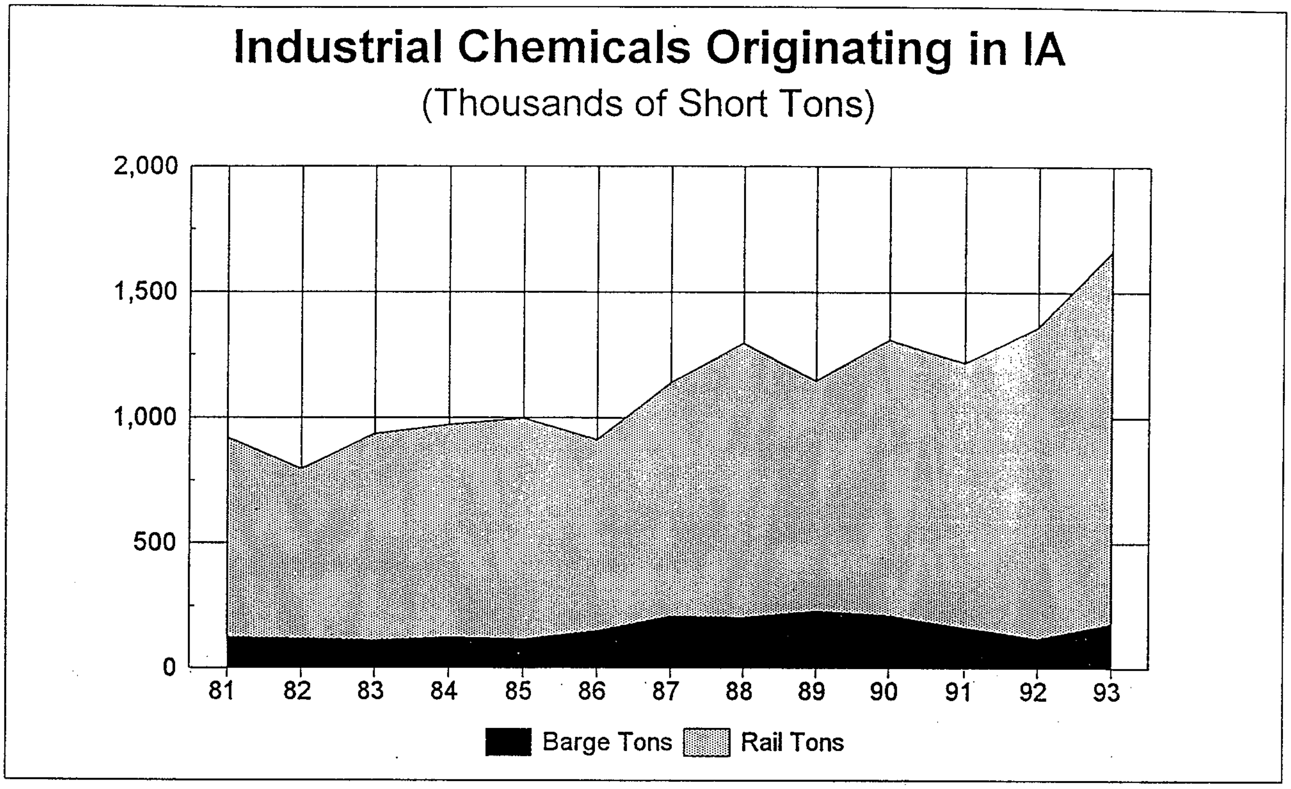
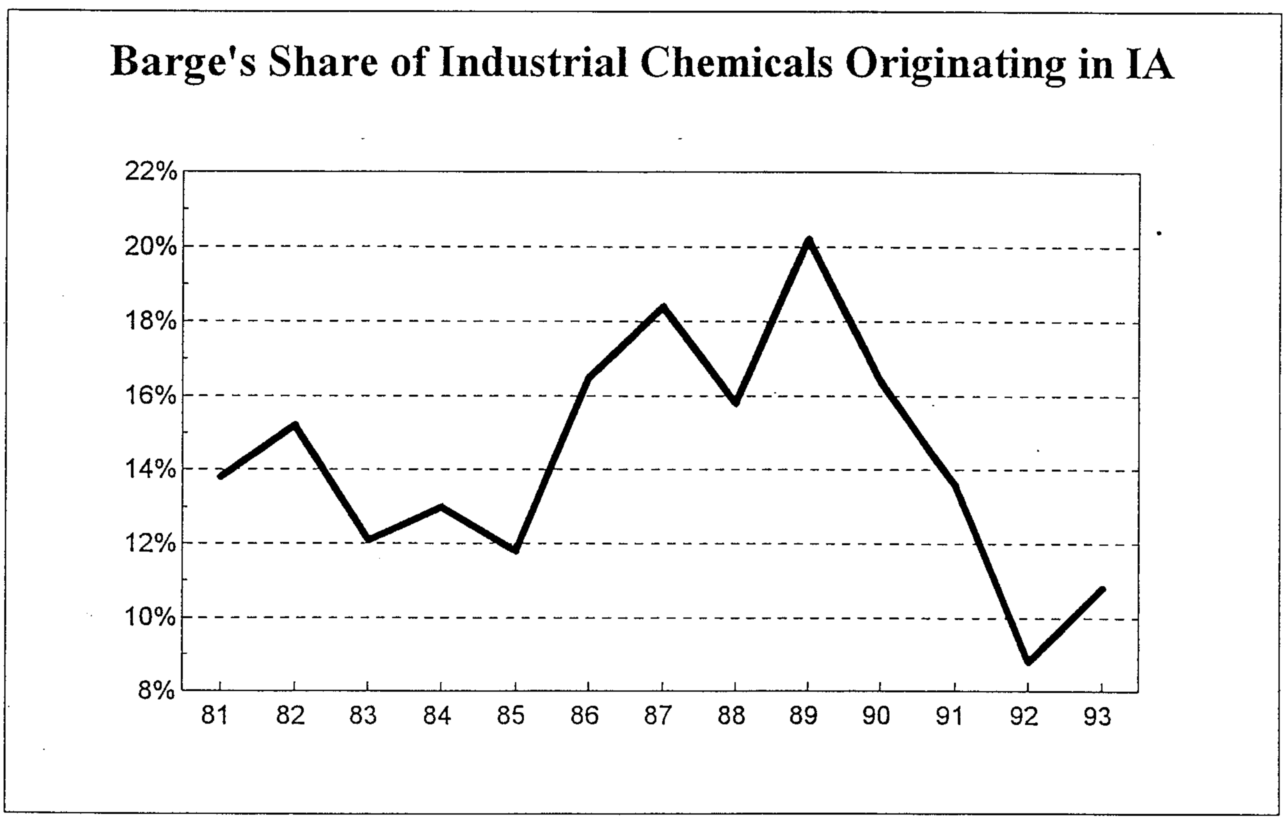


Exhibit 18



Minnesota

Iowa, Illinois, Michigan, and Wisconsin, are the primary areas that receive industrial chemicals from Minnesota. Combined these four states received 91% of Minnesota's industrial chemical shipments in 1992. Exhibit 19 indicates that total barge and rail shipments out of Minnesota increased substantially from 62,000 tons in 1981 to 263,000 tons in 1992, a 328% increase.

As demonstrated in Exhibit 20, barge's share of industrial chemicals originating in Minnesota fluctuated considerably from 1981-1992. No barge movements originated in Minnesota in 1991 and 1992.

The states that increased their share's of the shipments out of Minnesota are those that have typically been served by rail. The share of Minnesota's shipments destined for intra-state locations increased markedly between 1981 and 1992. Both Wisconsin and Illinois received relatively larger shares of Minnesota's industrial chemical shipments. Given the historically limited role that barge commerce has fulfilled in distributing industrial chemicals originating in Minnesota and the increasing reliance on transporting these commodities to surrounding states, it is reasonable to assume that the barge will continue to play a diminishing role in Minnesota's industrial chemical shipments.

Exhibit 19

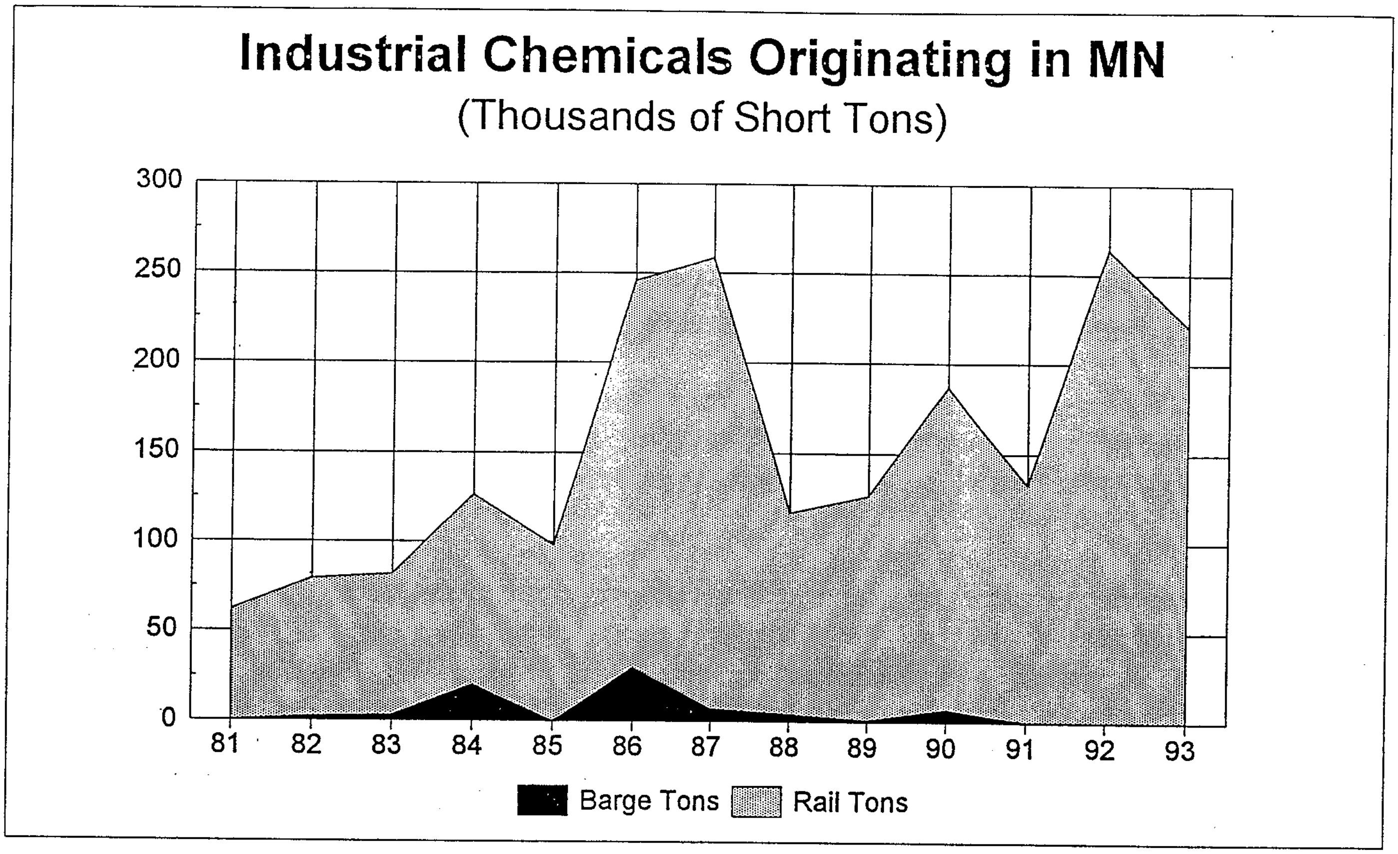
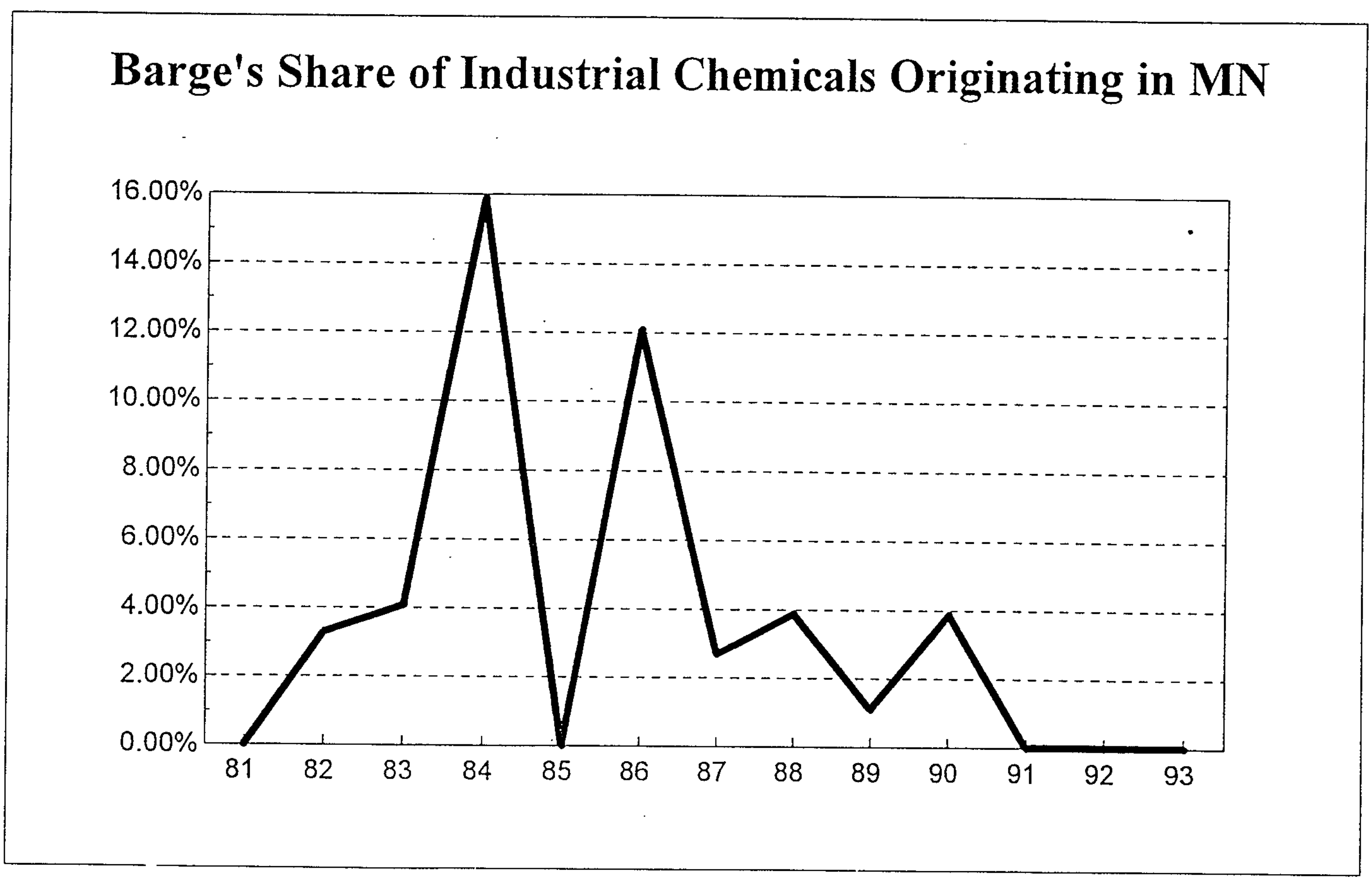


Exhibit 20



Missouri

Total barge and rail shipments increased consistently from 1981 (1.48 million tons) to 1987 (2.31 million tons) and then decreased to 2.10 million tons in 1992. Barge tons remained relatively steady from 1981 to 1987 (330,000 tons to 397,000 tons) and then dropped considerably to 136,000 tons in 1992. These data are graphed in Exhibit 21.

The abatement in barge movements over the 1987-1992 resulted in a corresponding decline in barge's share of industrial chemicals originating in Missouri: from 0.22 in 1981 to 0.065 in 1992. As shown in Exhibit 22, the largest reduction occurred between 1986 and 1988.

A significant amount of geographic dispersion characterized the state destination of industrial chemicals originating in Missouri. The two states with the largest share of Missouri shipments, Pennsylvania and Texas, were the only states with shares greater than 10% in 1992. It is interesting to note that the states that gained share (California, Nebraska, and Pennsylvania) were principally served by rail whereas the states that lost share (Illinois, Louisiana, and Texas) have historically received relatively large quantities of industrial chemicals by barge. This observation helps elucidate the shift from barge to rail that occurred between 1986 and 1992.

Exhibit 21

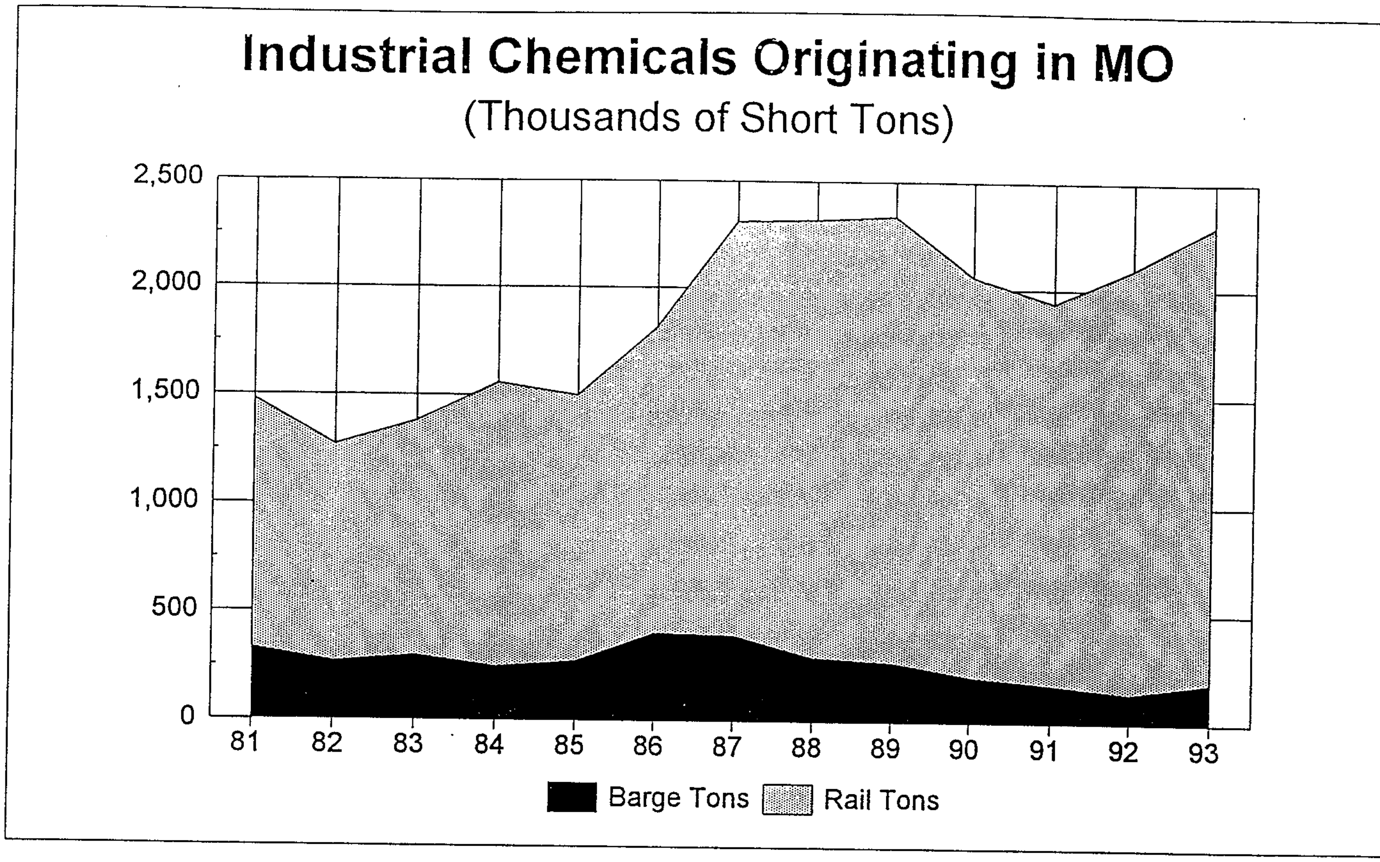
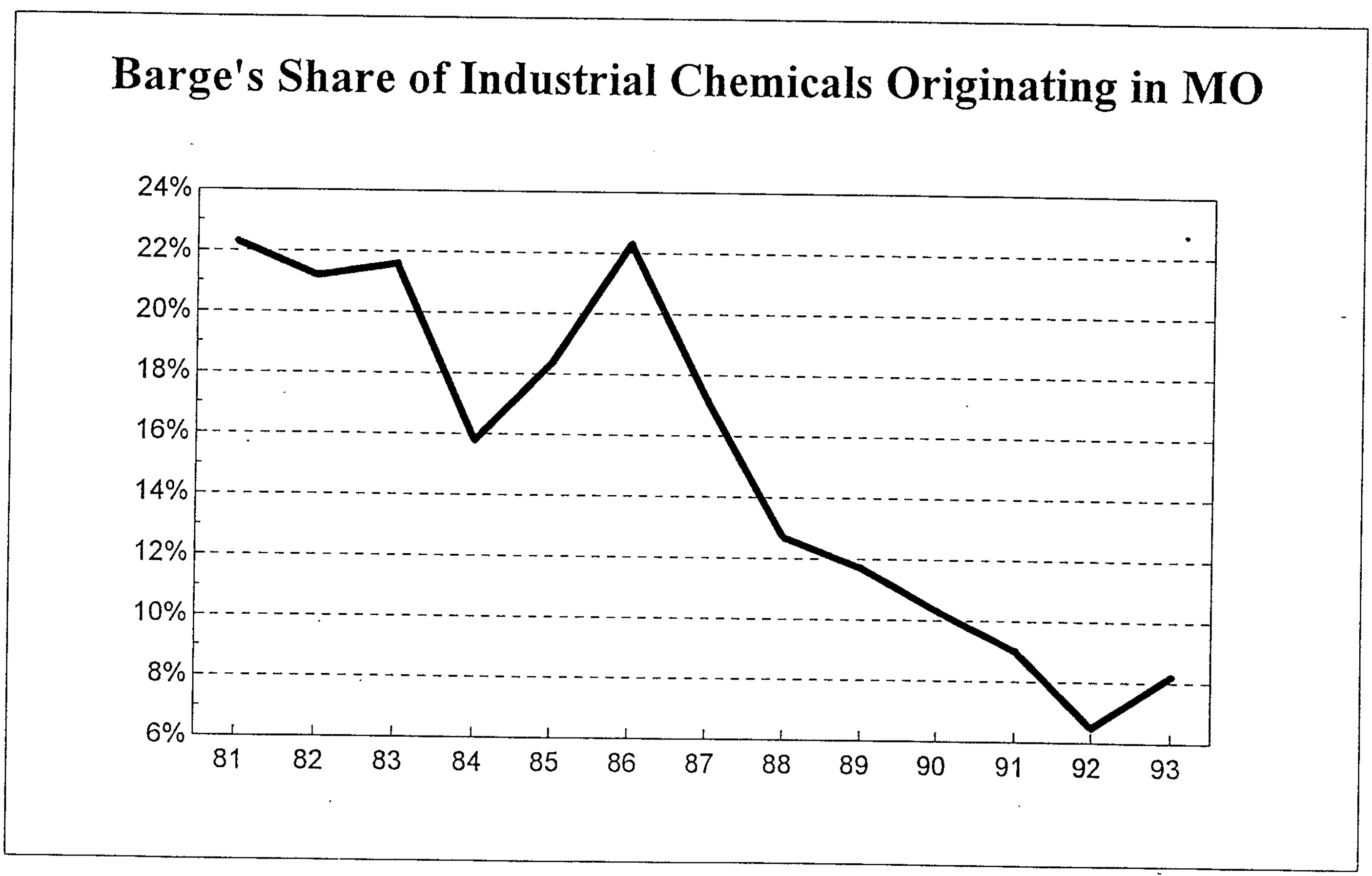


Exhibit 22



Wisconsin

Barge commerce has served an extremely limited role in transporting industrial chemicals originating in Wisconsin. Between 1981 and 1993, industrial chemical barge movements occurred only in two years, 1989 and 1990; in both years the tonnage was less than 3,000 tons. Total movements of rail and barge increased moderately from 173,000 tons in 1981 to 285,000 tons in 1992. Movements to Iowa and intra-Wisconsin movements comprised just under 50% of the total industrial chemical shipments originating in Wisconsin in 1992. It is not likely that barge commerce will re-emerge as a principal component of the movements of industrial chemicals originating in Wisconsin.

4.0 Waterway Traffic Forecasts

This section summarizes of the procedure used to project the volumes of industrial chemicals transported on the Upper Mississippi River. The procedure relies upon OBERs GSP projections at the state level for SIC two-digit industries.

The procedure was implemented independently for each state in the Study Area: i.e., projections in one state are independent of projections in another state. In addition, the procedure considers that traffic can both originate and destinate in each state and treats each case separately.

Traffic that Destinates in the Study Area

Destinating traffic was assumed to be driven by intermediate demand. Given this assumption, our goal was to take into account differences in projected growth rates across industries that exhibit different levels of demand (per unit of output) for industrial chemicals.

Rough estimates of intermediate demand were developed for the base period by multiplying an input-output coefficient by GSP for the corresponding industry. Industry shares of intermediate demand were then calculated and used to allocate total destinating tonnage (rail plus barge) to consuming industries. In the next step, each industry's assigned tonnage was divided by industry GSP to produce a tonnage/GSP ratio[2].

These tonnage/GSP ratios were computed for each year in the base period. We then examined the historical trends in these ratios and used regression analyses and other procedures to forecast them out into the future. Taking the product of the forecasted tonnage/GSP ratios and the OBERs industry GSP projections yielded forecasts of the total tonnage consumed by each industry in the state. The industry forecasts were summed to estimate the total amount of tonnage (barge plus rail) destinating in the state.

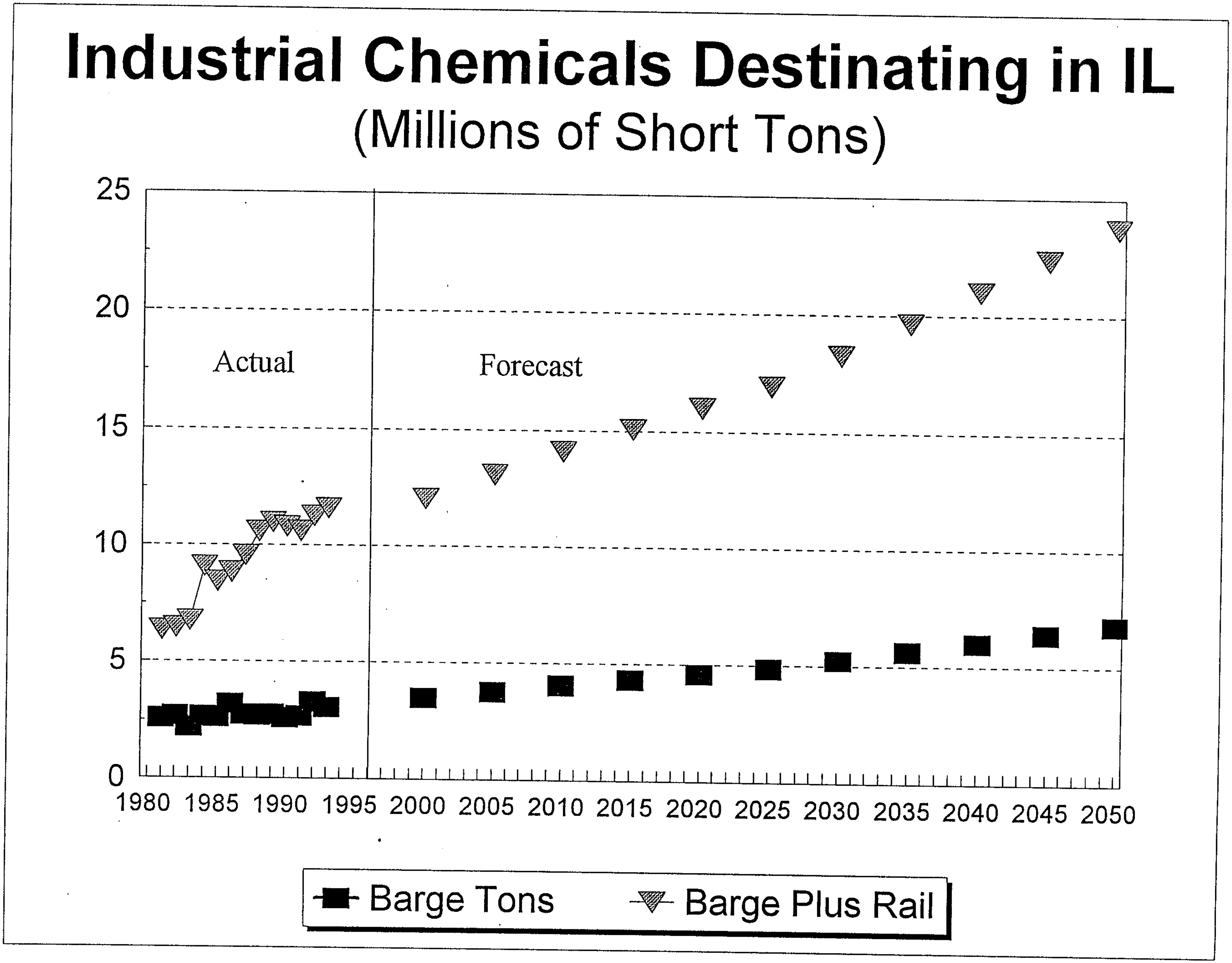
The total tonnage figures were then allocated to state origins. Base year origin shares were based upon actual commodity flow data (rail and barge). The shares were then adjusted according to expected changes in relative supply. We used OBERs GSP projections for the chemicals industry to make these adjustments. State level shares of U.S. chemical industry GSP were calculated for both the base year as well as each forecast year. Changes in the GSP shares were applied to the base year origin shares to make the adjustment for relative changes in supply. State-to-state commodity flows were produced by multiplying the new origin shares by the total tonnage destinating in the state.

[2] Note that this can only be done if total tonnage is used. For example, using only barge tonnage would lead to changes in the ratio induced by changes in modal split.

The next step entailed assigning each O-D flow to transportation modes. This was accomplished using average historical mode shares based upon 1989-1992 data. We chose to define the average mode shares using data from the latter part of the period because many of the state-to-state mode splits were characterized by downward trends. Using averages based upon the whole period typically resulted in barge forecasts that didn't mesh with data from the latter part of the period and were much higher than one would expect for the year 2000. Along these same lines, it should be noted that although holding the mode splits constant does ensure that relative transportation costs are also held constant, it also results in forecasts that are not true estimates of "what will be the case". Rather, the assumption of a constant mode split leads to forecasts of "what **could** be the case if relative transportation costs do not change". Given barge's declining share in many of the state-to-state movements of industrial chemicals, it is likely that the actual traffic levels will be somewhat lower than what we have projected.

Exhibits 23-27 graphically shows the amount of industrial chemicals forecasted to destinate in each state in the Study Area.

Exhibit 23



Industrial Chemicals Destinating in IL
(Millions of Short Tons)
25
20
15
10
5
0
Actual
Forecast
1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
Barge Tons
Barge Plus Rail

Exhibit 24

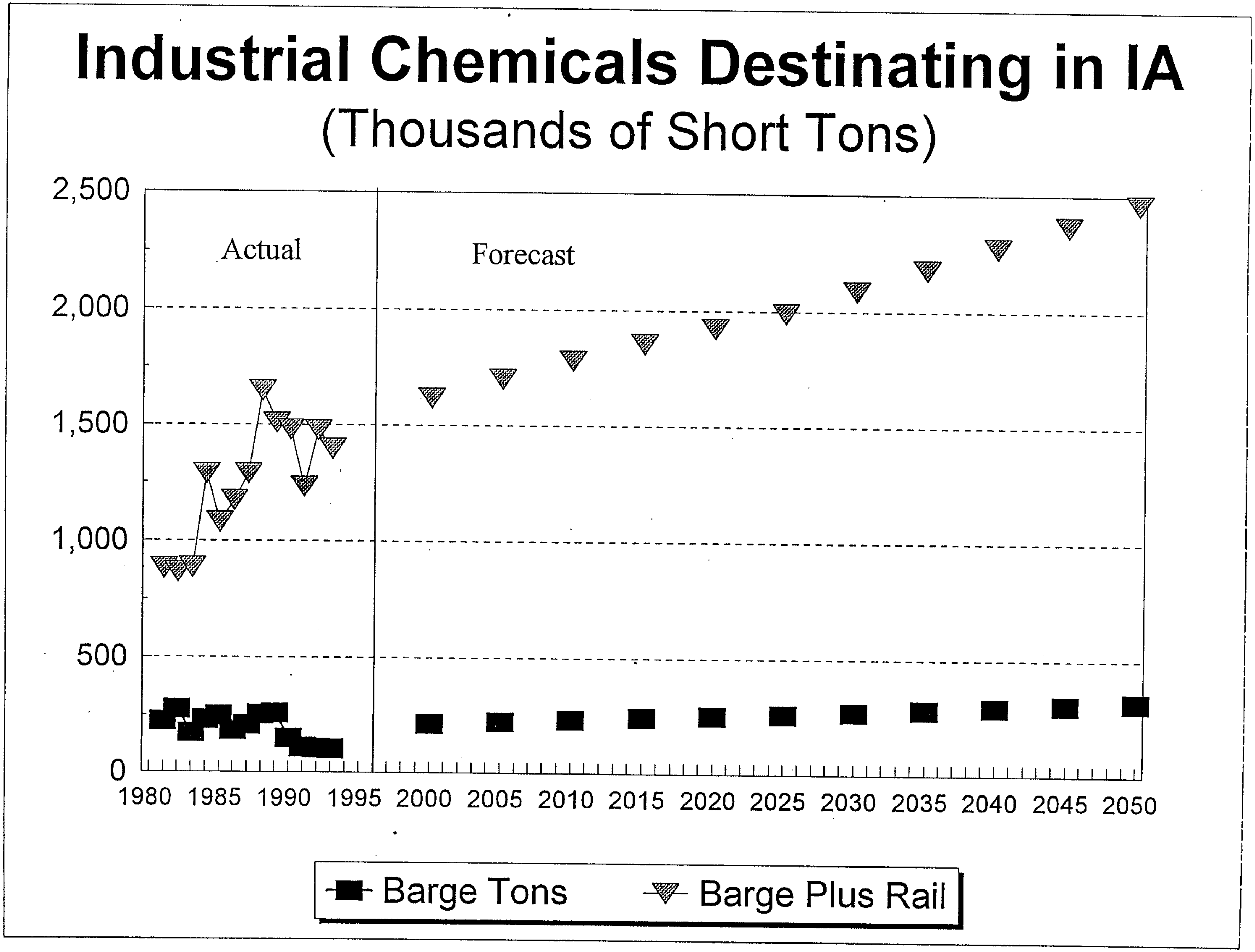

Industrial Chemicals Destinating in IA
(Thousands of Short Tons)
2,500
2,000
1,500
1,000
500
0
Actual
Forecast
1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
Barge Tons
Barge Plus Rail

Exhibit 25

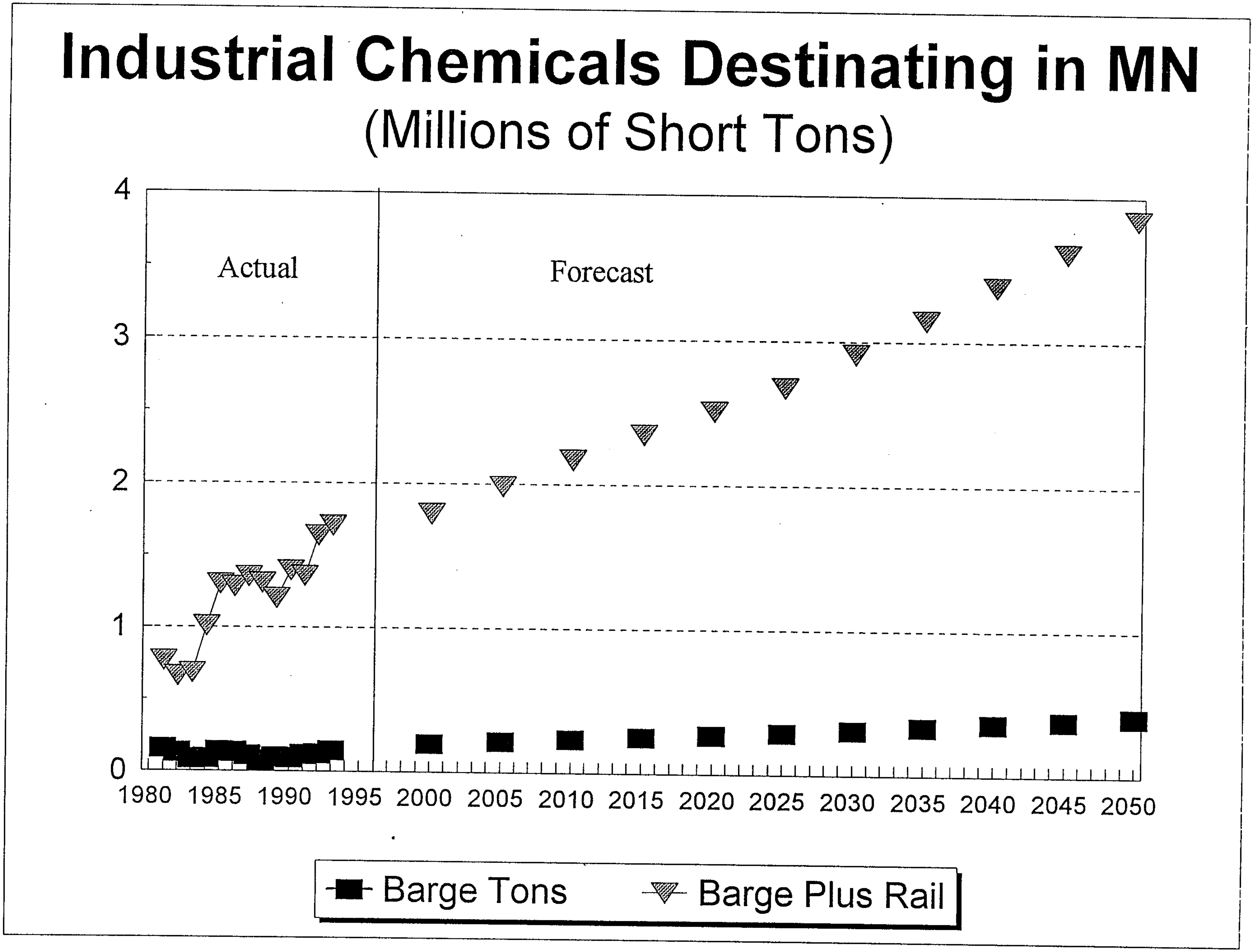
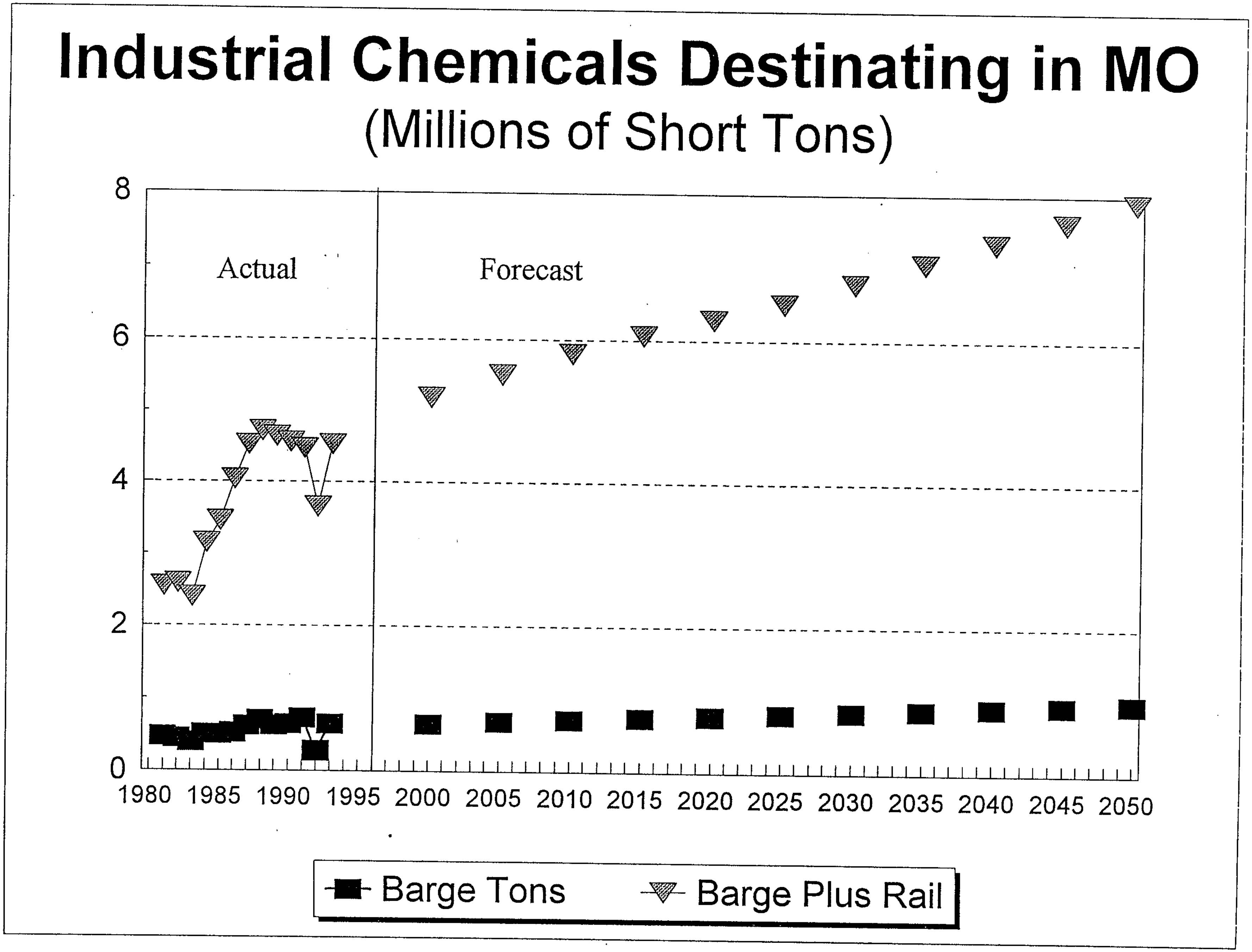
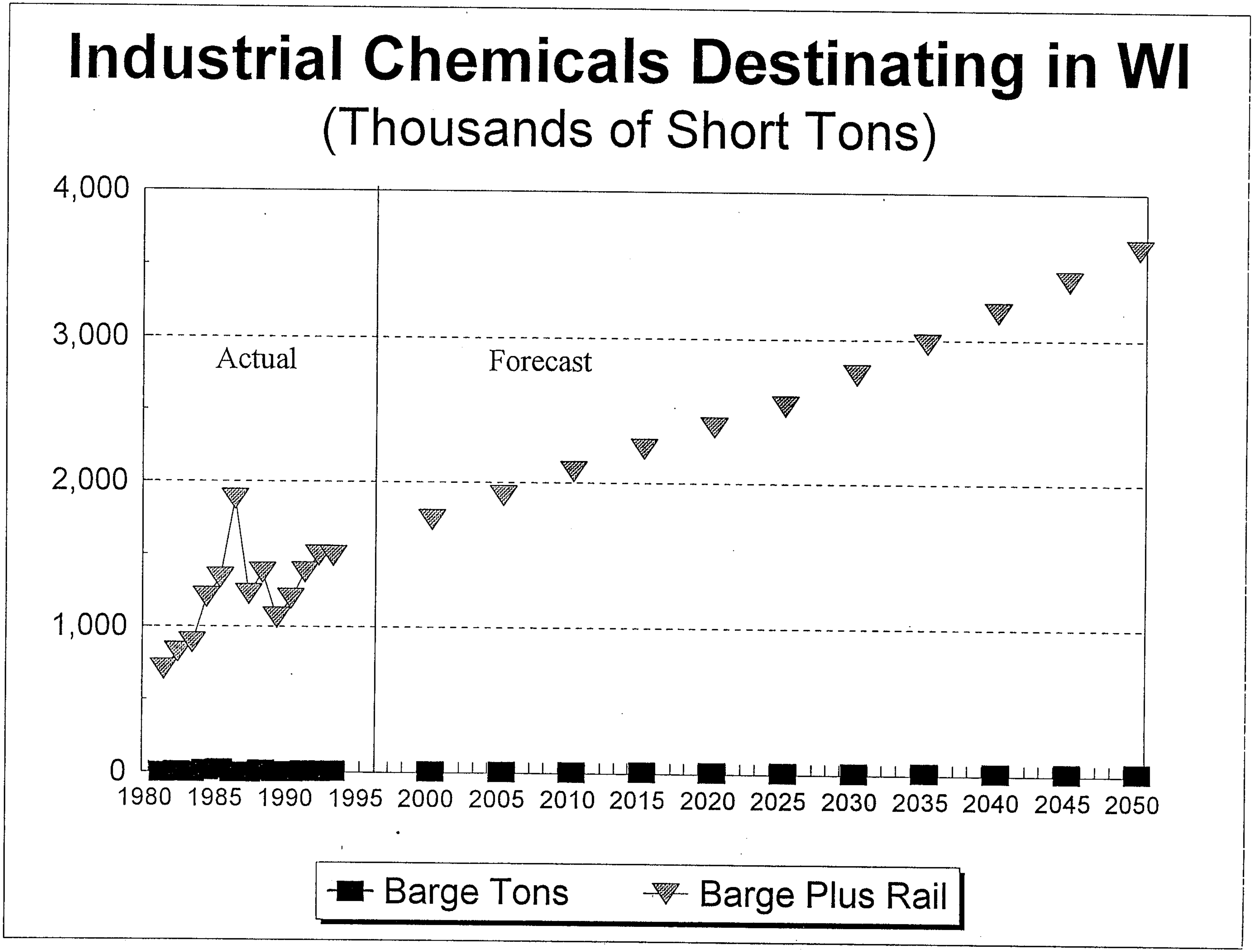

Industrial Chemicals Destinating in MN
(Millions of Short Tons)
4
3
2
1
0
Actual
Forecast
1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
Barge Tons
Barge Plus Rail

Exhibit 26



Industrial Chemicals Destinating in MO
(Millions of Short Tons)
8
6
4
2
0
Actual
Forecast
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Barge Tons
Barge Plus Rail

Exhibit 27



Industrial Chemicals Destinating in WI
(Thousands of Short Tons)
4,000
3,000
2,000
1,000
0
Actual
Forecast
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Barge Tons
Barge Plus Rail

<u>Traffic Originating in the Study Area</u>

The procedure used to estimate traffic originating in each state in the Study Area is similar to the one previously described. Total tons originating in each state in the Study Area were forecasted and then allocated to state destinations and modes.

The forecasts of total tons originating in the state required two steps. First, the ratio of tonnage originating (barge plus rail) to state chemical industry GSP was projected based upon historical trend. The forecasted ratios were then multiplied by OBERs GSP projections for the industrial chemicals industry to estimate the tonnage originating in each Study Area state.

The allocation of the tonnage to state destinations was accomplished in a manner similar to that described above. Base year destination shares were computed from historical commodity flow data (rail plus barge) and then adjusted for relative changes in intermediate demand. Using the procedure described above, rough estimates of total intermediate demand were calculated for each destination state. These estimates were used to produce state level shares of intermediate demand for the base year and for the years in the forecast period. Changes in these shares of intermediate demand were used to adjust the destination shares, which then were applied to the tonnage originating in the state.

As in the case of traffic destinating in the Study Area, the state-to-state flows of total tonnage (barge plus rail) originating in the Study Area were allocated to the two modes using the average historical mode share for 1989-1992.

Exhibits 28-32 graphically shows the amount of industrial chemicals forecasted to originate in each state in the Study Area.

Exhibit 28

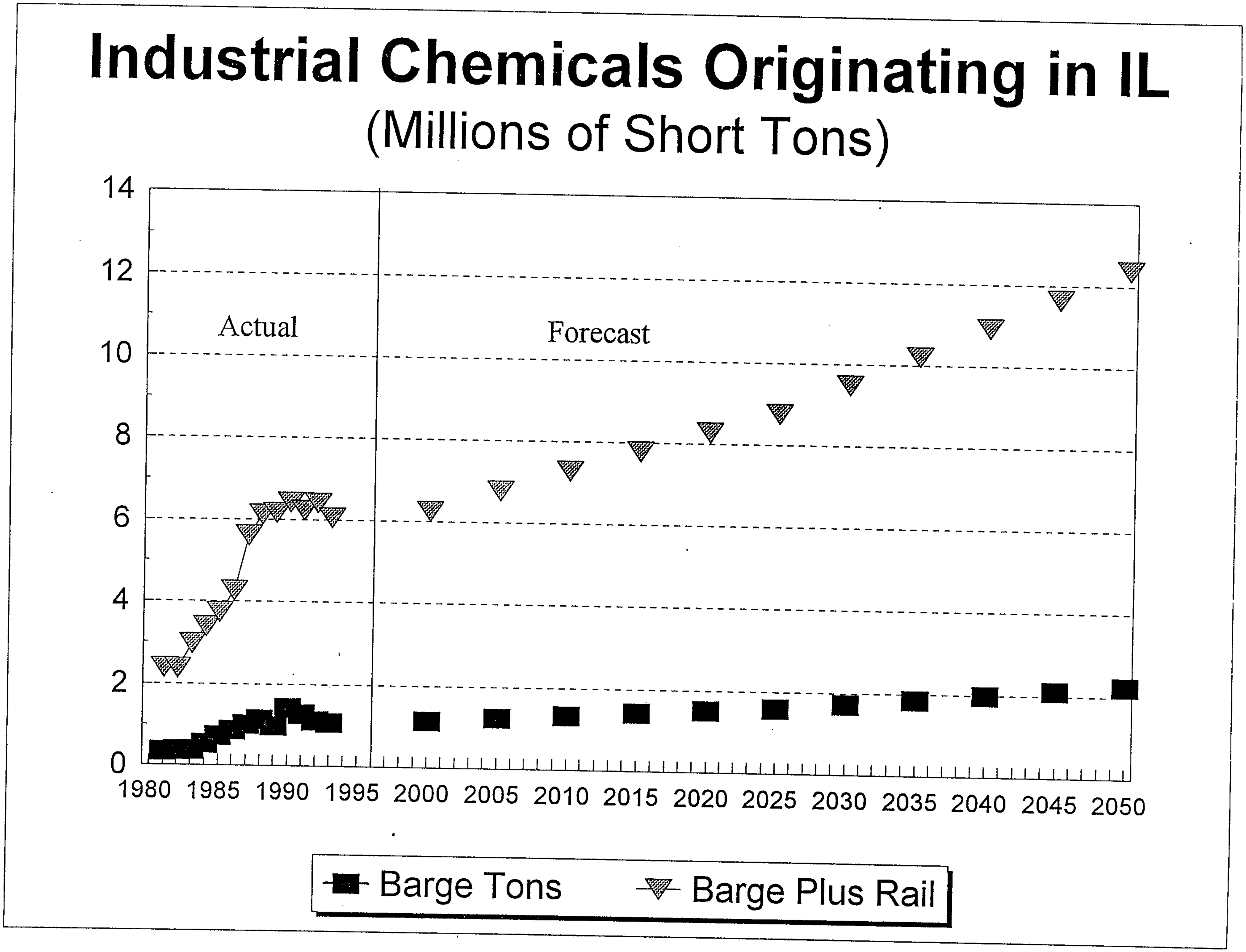

Industrial Chemicals Originating in IL
(Millions of Short Tons)
14
12
10
8
6
4
2
0
Actual
Forecast
1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
Barge Tons
Barge Plus Rail

Exhibit 29

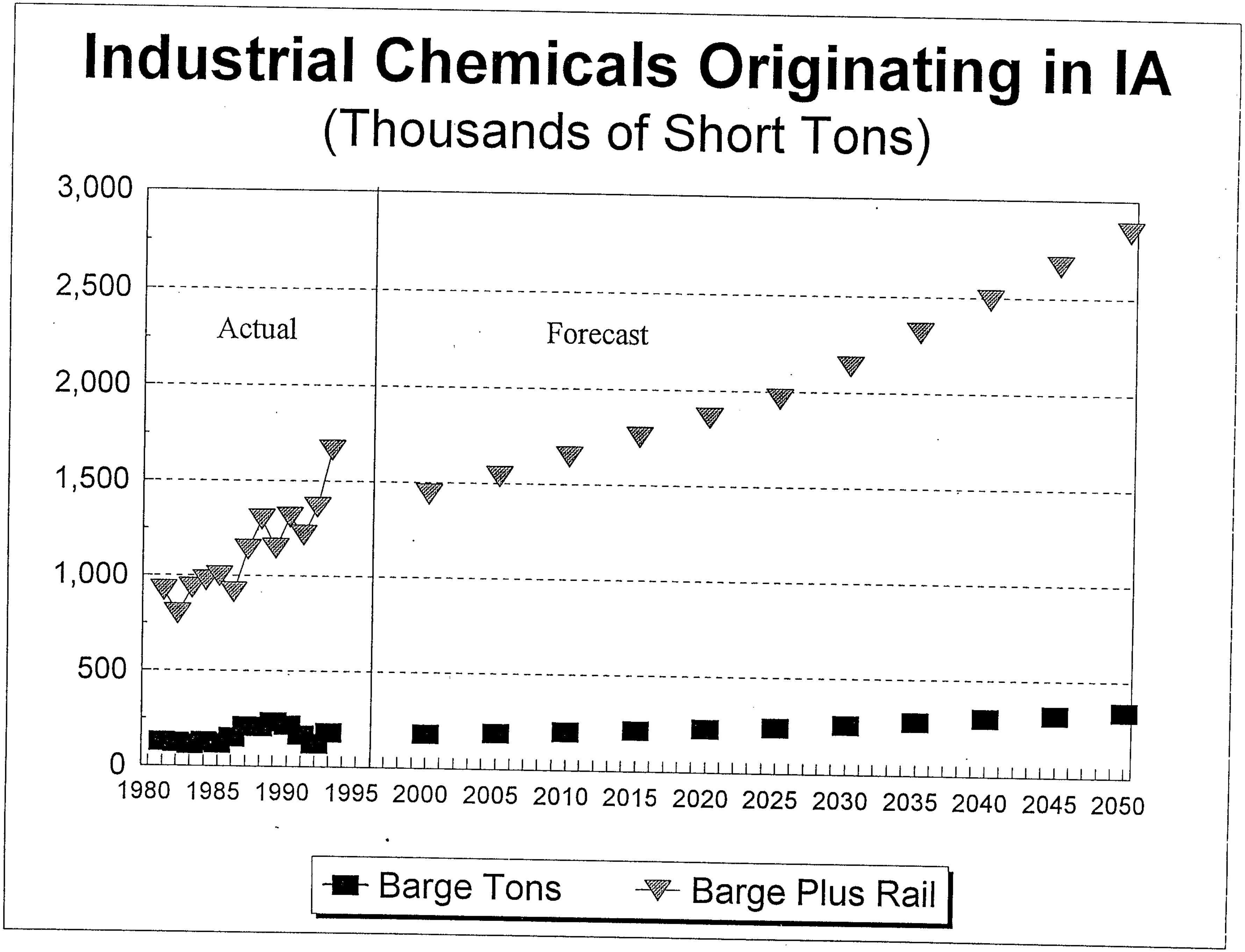
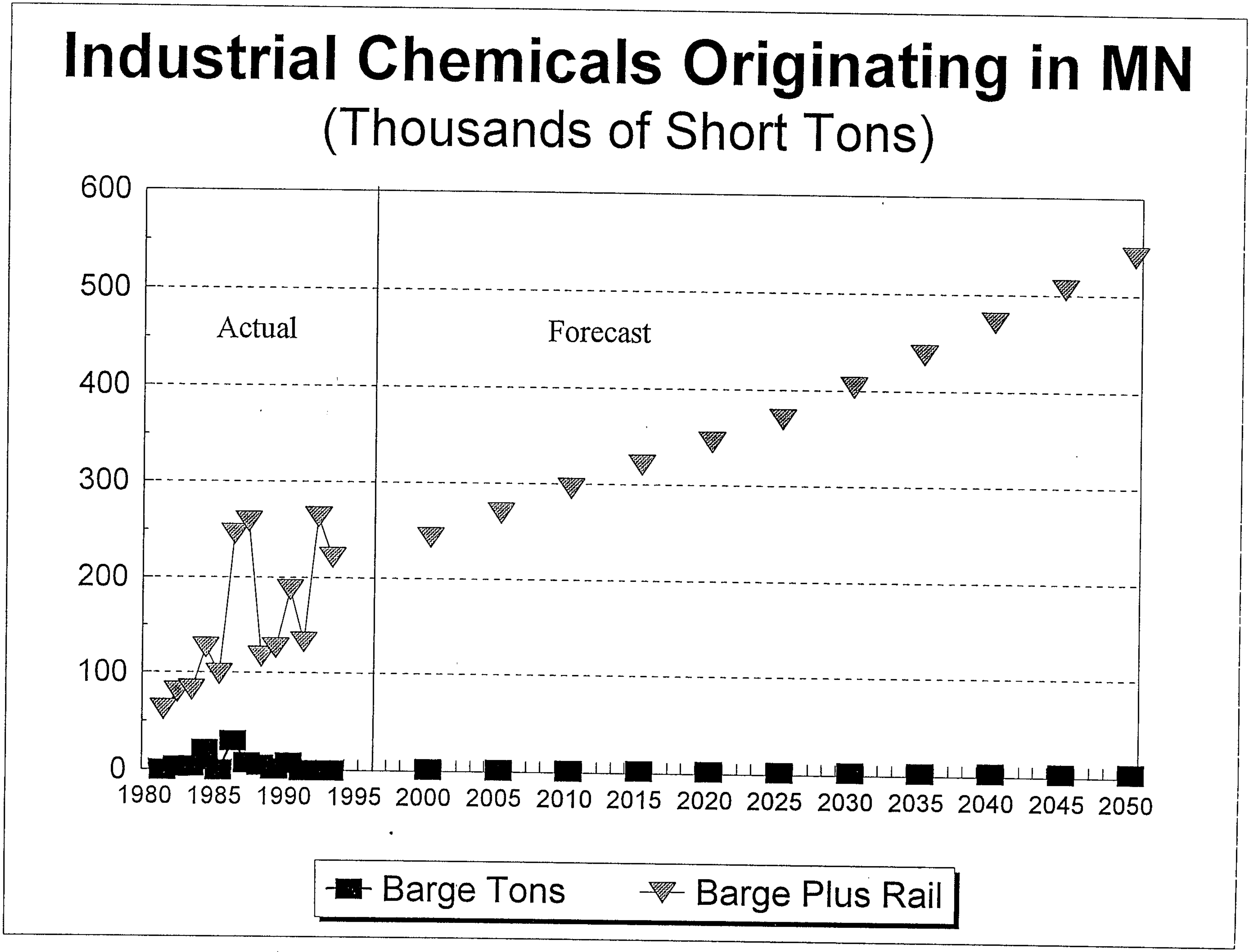

Industrial Chemicals Originating in IA
(Thousands of Short Tons)
3,000
2,500
2,000
1,500
1,000
500
0
Actual
Forecast
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Barge Tons
Barge Plus Rail

Exhibit 30



Industrial Chemicals Originating in MN
(Thousands of Short Tons)
600
500
400
300
200
100
0
1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
Actual
Forecast
Barge Tons
Barge Plus Rail

Exhibit 31

Industrial Chemicals Originating in MO
(Millions of Short Tons)

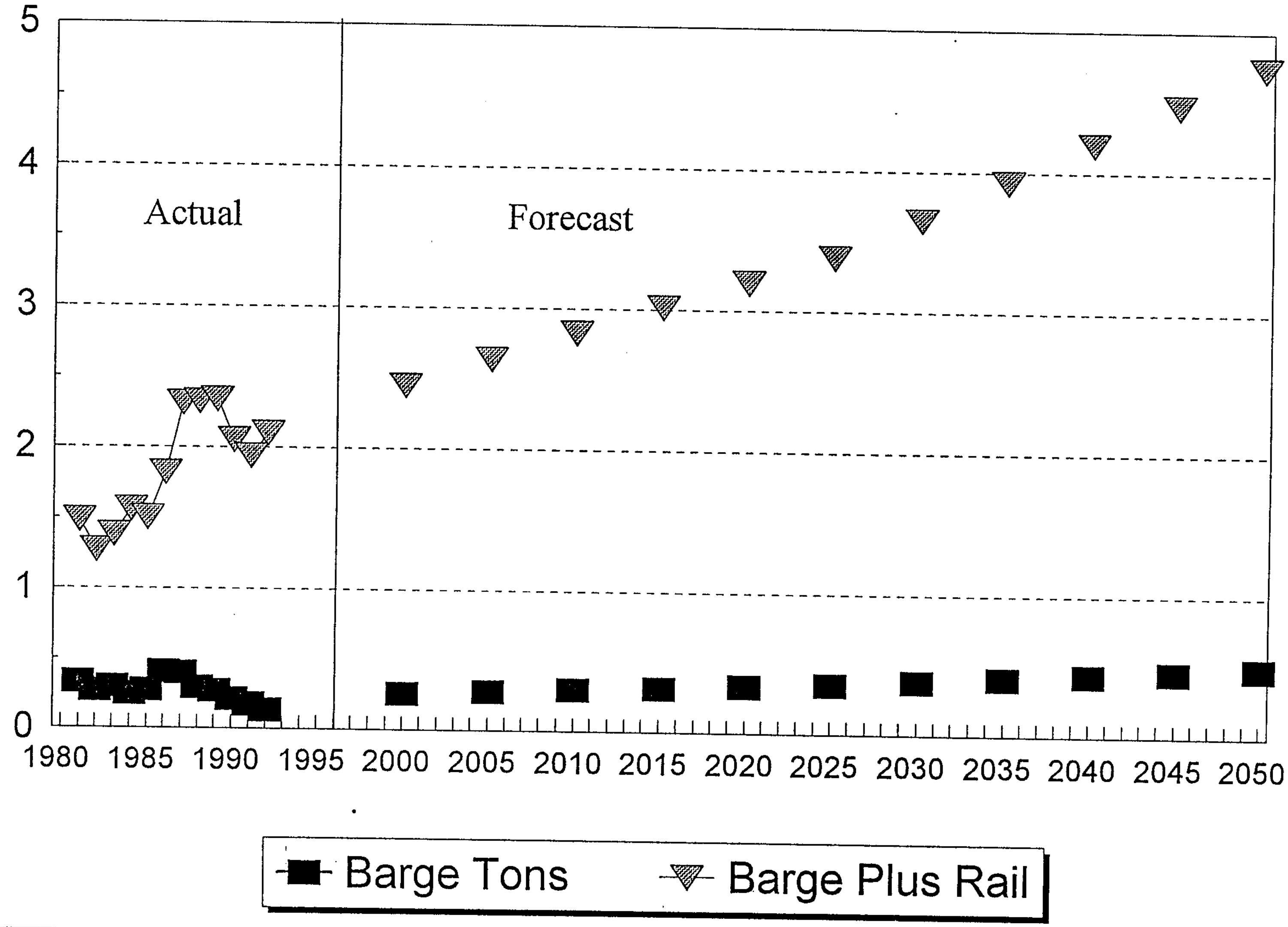
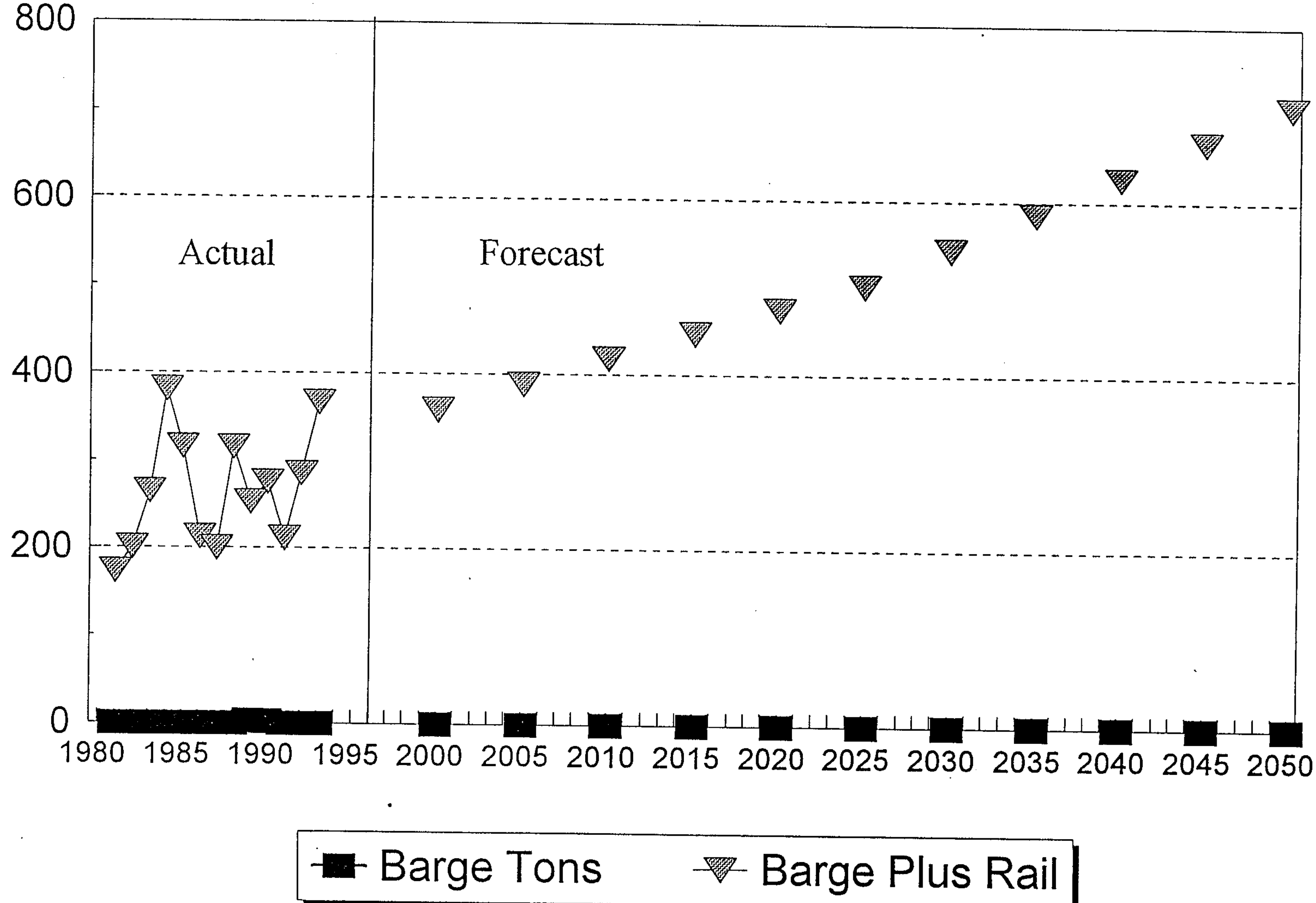


Exhibit 32

Industrial Chemicals Originating in WI

(Thousands of Short Tons)



Traffic Forecasts by River Segment

Exhibits 33-35 tabulate the forecasts for the three main river segments of the Upper Mississippi River basin: the Illinois River, the Upper Mississippi River between the Twin Cities and the mouth of the Missouri River, and the Upper Mississippi River between the mouth of the Missouri River and the mouth of the Ohio River. The state-to-state barge traffic forecasts were first converted into flows between one of these three river segments and state origins/destinations outside of the Study Area. State origins/destinations within the Study Area were assigned to one of the three river segments and, for the given segment, the associated traffic was designated as either "inbound", "outbound", or "intra" depending upon the corresponding destination/origin. For a given flow, the most likely route was then appraised and used to develop through traffic estimates for the other two river segments. As an example, a barge flow originating in Minnesota and destinating in Louisiana would have resulted in an outbound estimate for the Twin Cities to St. Louis segment and a through traffic estimate for the Upper Mississippi River segment below St. Louis. All of barge flows were then aggregated by river segment and type of flow (outbound, inbound, intra, and through) to produce the tabulations shown in exhibits 22-35. Three forecasts are presented: a low scenario, a medium scenario, and a high scenario. The high and low series are based upon the historical variance (1981-1993) associated with each corresponding river segment and type of movement (inbound, outbound, intra, through).

Exhibit 33
Upper Mississippi River Traffic Projections for Industrial Chemicals: Medium Forecast
(Short Tons)

Year	Illinois Waterway				Twin Cities to St. Louis				St. Louis to Cairo			
	Outbound	Inbound	Intra	Through	Outboun	Inbound	Intra	Through	Outboun	Inbound	Intra	Through
Avg 91-93	709,936	2,827,709	450,870	1,212	105,858	269,779	74,436	0	156,627	511,096	29,233	3,259,741
2000	680,163	3,051,571	435,541	0	117,133	318,675	64,090	0	220,532	605,280	40,660	3,394,639
2005	736,911	3,302,545	474,642	0	124,519	343,336	67,496	0	235,991	639,887	43,485	3,668,217
2010	790,367	3,551,097	512,455	0	132,416	367,236	71,128	0	251,452	671,489	46,208	3,937,054
2015	842,392	3,789,873	549,099	0	140,441	389,608	74,745	0	266,575	699,738	48,775	4,196,049
2020	892,733	4,017,064	584,302	0	148,494	410,275	78,287	0	281,309	724,541	51,180	4,443,383
2025	943,075	4,244,255	619,504	0	156,547	430,942	81,830	0	296,043	749,344	53,585	4,690,718
2030	1,018,654	4,582,871	671,483	0	170,142	459,917	87,629	0	318,833	780,971	57,016	5,060,105
2035	1,094,232	4,921,487	723,463	0	183,737	488,892	93,428	0	341,624	812,597	60,446	5,429,492
2040	1,169,811	5,260,103	775,442	0	197,332	517,866	99,227	0	364,414	844,224	63,877	5,798,879
2045	1,245,389	5,598,719	827,422	0	210,927	546,841	105,026	0	387,205	875,850	67,307	6,168,266
2050	1,320,968	5,937,335	879,401	0	224,522	575,816	110,825	0	409,995	907,477	70,737	6,537,653

Exhbit 34
Upper Mississippi River Traffic Projections for Industrial Chemicals: Low Forecast
(Short Tons)

	Illinois Waterway				Twin Cities to St. Louis				St. Louis to Cairo			
Year	Outbound	Inbound	Intra	Through	Outbound	Inbound	Intra	Through	Outbound	Inbound	Intra	Through
Avg 91-93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	209,783	2,490,980	184,907	0	35,584	245,195	27,809	0	89,389	323,747	7,531	2,736,787
2005	227,286	2,695,849	201,507	0	37,828	264,170	29,287	0	95,655	342,257	8,055	2,957,348
2010	243,774	2,898,741	217,561	0	40,227	282,559	30,863	0	101,923	359,160	8,559	3,174,087
2015	259,820	3,093,652	233,118	0	42,665	299,772	32,432	0	108,052	374,269	9,035	3,382,891
2020	275,347	3,279,106	248,063	0	45,111	315,674	33,970	0	114,024	387,536	9,480	3,582,294
2025	290,874	3,464,561	263,008	0	47,558	331,575	35,507	0	119,997	400,802	9,926	3,781,697
2030	314,184	3,740,971	285,075	0	51,688	353,869	38,023	0	129,234	417,718	10,561	4,079,500
2035	337,495	4,017,382	307,143	0	55,818	376,163	40,539	0	138,472	434,634	11,197	4,377,303
2040	360,806	4,293,792	329,211	0	59,948	398,457	43,056	0	147,710	451,550	11,832	4,675,106
2045	384,117	4,570,202	351,278	0	64,078	420,750	45,572	0	156,948	468,466	12,467	4,972,909
2050	407,427	4,846,613	373,346	0	68,208	443,044	48,088	0	166,185	485,383	13,103	5,270,712

Exhbit 35
Upper Mississippi River Traffic Projections for Industrial Chemicals: High Forecast
(Short Tons)

Year	Illinois Waterway				Twin Cities to St. Louis				St. Louis to Cairo			
	Outbound	Inbound	Intra	Through	Outbound	Inbound	Intra	Through	Outbound	Inbound	Intra	Through
Avg 91-93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	1,150,543	3,612,161	686,175	0	198,682	392,155	100,371	0	351,674	886,814	73,788	4,052,491
2005	1,246,535	3,909,242	747,777	0	211,210	422,503	105,706	0	376,327	937,517	78,914	4,379,086
2010	1,336,960	4,203,454	807,349	0	224,604	451,913	111,393	0	400,982	983,818	83,857	4,700,021
2015	1,424,964	4,486,094	865,081	0	238,217	479,444	117,057	0	425,098	1,025,207	88,516	5,009,207
2020	1,510,120	4,755,021	920,540	0	251,876	504,876	122,605	0	448,594	1,061,547	92,880	5,304,473
2025	1,595,277	5,023,948	976,000	0	265,535	530,309	128,153	0	472,089	1,097,886	97,245	5,599,738
2030	1,723,123	5,424,770	1,057,891	0	288,595	565,965	137,235	0	508,432	1,144,223	103,470	6,040,710
2035	1,850,969	5,825,592	1,139,782	0	311,655	601,620	146,317	0	544,776	1,190,560	109,696	6,481,681
2040	1,978,816	6,226,414	1,221,674	0	334,715	637,276	155,399	0	581,119	1,236,897	115,921	6,922,652
2045	2,106,662	6,627,236	1,303,565	0	357,776	672,932	164,481	0	617,462	1,283,234	122,147	7,363,623
2050	2,234,508	7,028,057	1,385,456	0	380,836	708,588	173,563	0	653,805	1,329,572	128,372	7,804,594