# NESP Economic Evaluation

# Waterway Traffic Forecast for Non-Grain Commodities

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**Submitted by:**

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# NESP ECONOMIC EVALUATION
# WATERWAY TRAFFIC FORECASTS FOR NON-GRAIN COMMODITIES


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# Organization of Report

The report is organized into three main sections. Section 1 is a Summary Report of the entire report. Section 2 provides the unconstrained waterway forecasts broken down individually by commodity. Section 3 is an analysis of Container on Barge traffic on the Mississippi Waterway system.

## List of Abbreviations

| Abbreviation | Description |
|---|---|
| 5-ST | 5 State Population (Illinois, Iowa, Minnesota, Missouri, Wisconsin) |
| Ag. Chem. | Agricultural Chemicals |
| AISI | American Iron and Steel Institute |
| BOF | Basic Oxygen Furnace |
| BTU | British Thermal Unit |
| CAGR | Cumulative Annual Growth Rate |
| CN | Canadian National (Railroad) |
| COB | Container on Barge |
| Consmp | Consumption |
| Const. Mat. | Construction Materials |
| DDG | Distilled Dried Grain |
| DWT | Dead Weight Tonnage |
| EAF | Electric Arc Furnace |
| EIA | Energy Information Administration |
| Fert. | Fertilizer |
| FEU | Forty-Foot Equivalent Unit |
| GDP | Gross Domestic Product |
| GMO | Genetically Modified Organism |
| HP | Horse Power |
| IISI | International Iron and Steel Institute |
| IWW | Illinois Waterway; from confluence with the Mississippi River at Grafton, IL (river mile 0.0) to T.J. O'Brien Lock in Chicago, IL (river mile 327.0), including the Calumet-Sag Channel, Chicago Sanitary and Ship Canal, and the Chicago River South Branch; WCUS/WCSC waterway code 7700 |
| IL Cap. | Illinois (Refinery) Capacity |
| Ind. Chem. | Industrial Chemicals |
| Ind. Prod. | Industrial Production |
| IPG | Identity Preserved Grain |
| K | Potassium |
| LBG | The Louis Berger Group Inc. |
| N | Nitrogen |
| NAFTA | North Atlantic Free Trade Agreement |
| NESP | Navigation and Ecosystem Sustainability Program |
| P | Phosphorous |
| Ref. Cap. | Refinery Capacity |
| TEU | Twenty-Foot Equivalent Unit |
| UM | Upper Mississippi; Mississippi River from Minneapolis, MN (river mile 857.6) to Mouth of Ohio River (river mile 0.0); WCUS/WCSC waterway code 6700 |
| UM+IL | Upper Mississippi and Illinois Waterway |
| US Cap. | United States (Refinery) Capacity |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| WCSC | Waterborne Commerce Statistics Center |
| WCUS | Waterborne Commerce of United States |

Note: The standard state name abbreviations are also used.

# SECTION 1: SUMMARY REPORT

## *1.1 Introduction*

The objective of the analysis, prepared by the Louis Berger Group (LBG) and included in this report, is to provide the investigation of the production and transportation of each of the major non-grain commodity groups transported via the Upper Mississippi Navigation System. The results of this investigation are to contribute to the Navigation and Ecosystem Sustainability Program (NESP), which, in turn, is part of the overall feasibility of the System expansion, especially for the capacity of navigation locks.

The general area of investigation is the Upper Mississippi River Basin. The study area comprises the Upper Mississippi River Navigation System, inclusive of the Illinois Waterway. For the purpose of investigating potential waterway improvements to expand navigation capacity on the system, the study area is defined as the entire Illinois Waterway from its confluence with the Mississippi River at Grafton, Illinois (river mile 0.0) to T.J O'Brien Lock in Chicago, Illinois (river mile 327) to include the Chicago Ship Canal and the segment of the Mississippi River from its confluence with the Ohio River (river mile 0.0) to Upper St. Anthony Falls Lock in Minneapolis-St. Paul, Minnesota (river mile 854.0).

The Consultant is tasked with projecting traffic by commodity group, inclusive of the following seven commodity classifications adapted by the Waterborne Commerce Statistic Center (WCSC):

1. Petroleum and Petroleum Products
2. Industrial Chemicals
3. Agricultural Chemicals
4. Iron & Steel, Metallic Ores, Products, Scrap
5. Coal/Coker/Lignite
6. Construction Materials
7. Miscellaneous

Each one of these commodity groups can be further disaggregated into a number of specific commodities. In general, however, the focus is on forecasting at the commodity group level. Within each commodity group, the attention is given to recent trends in some specific sub-commodities and the commodity group forecasts adjusted to reflect such trends. There are cases, such as Ethanol, when this commodity is analyzed separately from the commodity group.

Additionally, the Consultant addressed the potential and conditions necessary for the introduction of Container-on-Barge operations on the Mississippi Waterway System and, specifically, on the Upper Mississippi/Illinois reaches.

The presented forecasts are prepared at an unconstrained level, meaning that the analysis does not include the impact of possible capacity shortages for waterway and barge industries, associated congestions as well as changes in competing inter-modal transportation. Therefore, these forecasts represent an initial step to be further expanded with the introduction of other factors, which may affect actual waterway utilization.

Accordingly these forecasts can be defined as "Base Case" scenario. The commodity forecasts are made for the years 2005 – 2055 in 5-year increments for the first 30 years and in 10-year increments thereafter. As is typical with forecasts of such a long horizon, the short and mid-term forecasts, in the range of 20 years or longer if national or regional outlooks are available, will be based on regression models that define the relationship between waterway traffic and relevant variables. These models will be developed by the consultant. The long-term forecast is done through the application of long term growth rates on the short and mid-term forecasts. To illustrate the statistical validities of these forecasts the confidence limits are defined based on the uncertainty of the parameters used in forecast development.

## *1.2 Data Sources*

### Traffic Information

*Waterborne Commerce of the United States (WCUS) Database*

Main data source for annual traffic information is the Waterborne Commerce of the United States (WCUS) files made available by the Waterborne Commerce Statistics Center (WCSC). The WCUS is a series of publications which provide statistics on foreign and domestic waterborne commerce moved on US waterways. Data are published in four geographical areas:

- WCUS, Part 1 Atlantic Coast
- WCUS, Part 2 Gulf Coast, Mississippi River System, Puerto Rico, and Virgin Islands
- WCUS, Part 3 Great Lakes
- WCUS, Part 4 Pacific Coast, Alaska

For the study purposes, data files containing the Mississippi River System information (WCUS, Part 2) for the years 1997-2004 were aggregated on a single database to facilitate historic comparisons[1]. Data from years prior to 1997 were not used as they were 10 years older and therefore less reliable in terms of predicting traffic in the future. Data for 2005 was available but not used because of the impact of Hurricane Katrina and its aftereffects. The historic series analyzed includes tonnage for the years 1997-2004 for the following selected waterways:

[1] Data files are provided on a yearly basis for download from the Navigation Data Center (NDC) web site: http://www.iwr.usace.army.mil/NDC/data/datawcus.htm. In some cases, there exists minor differences between published flows and totals derived from the downloaded data but they are not significant.

- Mississippi River, Minneapolis, MN (river mile 857.6) to Mouth of Ohio River (river mile 0.0) - Waterway code 6700; segment called in this report "Upper Mississippi River" or UMR.

- Illinois Waterway, IL - Waterway code 7700, from confluence with the Mississippi River at Grafton, IL (river mile 0.0) to T.J. O'Brien Lock in Chicago, IL (river mile 327.0), including the Calumet-Sag Channel, Chicago Sanitary and Ship Canal, and the Chicago River South Branch.

The WCUS files classify tonnage by a 4-digit code, a field labeled "Publication Commodity Group" or "WCSC commodity code", as it is commonly referred. For the purposes of reporting and forecasting traffic, the Terms of Reference (TOR) mandated aggregating these groups into the seven broader categories shown in **Table 1** . In some cases where disaggregated analysis was required, the lowest level of detail was provided by the WCSC commodity code.

**Table 1: WSCS Commodity Codes Aggregated by Commodity Category**

| Category | WCSC Code | Commodity | WCSC Code | Commodity |
|---|---|---|---|---|
| 1. Petroleum and Petroleum Products | 2100 | Crude Petroleum | 2410 | Petro. Jelly & Waxes |
| | 2211 | Gasoline | 2429 | Naphtha & Solvents |
| | 2221 | Kerosene | 2430 | Asphalt, Tar & Pitch |
| | 2330 | Distillate Fuel Oil | 2540 | Petroleum Coke |
| | 2340 | Residual Fuel Oil | 2640 | Liquid Natural Gas |
| | 2350 | Lube Oil & Greases | 2990 | Petro. Products NEC |
| 2. Industrial Chemicals | 3211 | Acyclic Hydrocarbons | 3281 | Radioactive Material |
| | 3212 | Benzene & Toluene | 3282 | Pigments & Paints |
| | 3219 | Other Hydrocarbons | 3283 | Coloring Mat. NEC |
| | 3220 | Alcohols | 3284 | Medicines |
| | 3230 | Carboxylic Acids | 3285 | Perfumes & Cleansers |
| | 3240 | Nitrogen Func. Comp. | 3286 | Plastics |
| | 3250 | Organo-Inorganic Comp. | 3291 | Pesticides |
| | 3260 | Organic Comp. NEC | 3292 | Starches, Gluten, Glue |
| | 3271 | Sulphur (Liquid) | 3293 | Explosives |
| | 3272 | Sulphuric Acid | 3297 | Chemical Additives |
| | 3273 | Ammonia | 3298 | Wood & Resin Chem. |
| | 3274 | Sodium Hydroxide | 3299 | Chem. Products NEC |
| | 3275 | Inorg. Elem., Oxides, & Halogen S | | |
| | 3276 | Metallic Salts | | |
| | 3279 | Inorganic Chem. NEC | | |
| 3. Agricultural Chemicals | 3110 | Nitrogenous Fert. | 3130 | Potassic Fert. |
| | 3120 | Phosphatic Fert. | 3190 | Fert. & Mixes NEC |
| 4. Iron & Steel, Metallic Ores, Products, Scrap | 4410 | Iron Ore | 5312 | Pig Iron |
| | 4420 | Iron & Steel Scrap | 5315 | Ferro Alloys |

| Category | WCSC Code | Commodity | WCSC Code | Commodity |
|---|---|---|---|---|
| | 4515 | Marine Shells | 5320 | I&S Primary Forms |
| | 4630 | Copper Ore | 5330 | I&S Plates & Sheets |
| | 4650 | Aluminum Ore | 5360 | I&S Bars & Shapes |
| | 4670 | Manganese Ore | 5370 | I&S Pipe & Tube |
| | 4680 | Non-Ferrous Scrap | 5390 | Primary I&S NEC |
| | 4690 | Non-Ferrous Ores NEC | 5421 | Copper |
| | 4860 | Slag | 5422 | Aluminum |
| | | | 5429 | Smelted Prod. NEC |
| | | | 5480 | Fab. Metal Products |
| 5. Construction Materials | 4310 | Building Stone | 4331 | Sand & Gravel |
| | 4322 | Limestone | 4333 | Dredged Material |
| | 4323 | Gypsum | 4338 | Soil & Fill Dirt |
| | 4327 | Phosphate Rock | 5220 | Cement & Concrete |
| 6. Miscellaneous | 4110 | Rubber & Gums | 6822 | Dairy Products |
| | 4150 | Fuel Wood | 6835 | Fish, Prepared |
| | 4161 | Wood Chips | 6838 | Tallow, Animal Oils |
| | 4170 | Wood in the Rough | 6839 | Animals & Prod. NEC |
| | 4189 | Lumber | 6861 | Sugar |
| | 4190 | Forest Products NEC | 6865 | Molasses |
| | 4225 | Pulp & Waste Paper | 6885 | Alcoholic Beverages |
| | 4335 | Waterway Improv. Mat | 6887 | Groceries |
| | 4782 | Clay & Refrac. Mat. | 6888 | Water & Ice |
| | 4900 | Non-Metal. Min. NEC | 6889 | Food Products NEC |
| | 5110 | Newsprint | 6893 | Cotton |
| | 5120 | Paper & Paperboard | 6899 | Farm Products NEC |
| | 5190 | Paper Products NEC | 7110 | Machinery (Not Elec) |
| | 5210 | Lime | 7120 | Electrical Machinery |
| | 5240 | Glass & Glass Prod. | 7210 | Vehicles & Parts |
| | 5290 | Misc. Mineral Prod. | 7230 | Ships & Boats |
| | 5540 | Primary Wood Prod. | 7400 | Manufac. Wood Prod. |
| | 6134 | Fish (Not Shellfish) | 7500 | Textile Products |
| | 6653 | Vegetable Oils | 7600 | Rubber & Plastic Pr. |
| | 6654 | Vegetables & Prod. | 7800 | Empty Containers |
| | 6746 | Wheat Flour | 7900 | Manufac. Prod. NEC |
| | 6747 | Grain Mill Products | 8900 | Waste and Scrap NEC |
| | 6781 | Hay & Fodder | | |
| 7. Coal, coke | 1100 | Coal Lignite | 1200 | Coal Coke |

## Data Sources Used on Traffic Forecasts

Data on demographic, economic and industry variables affecting traffic flows for each commodity group were compiled from industry interviews and different public and private sources. Some of these sources also provided long-term forecasts that were used

for forecasting the base case of the future traffic flows. Variables affecting traffic and main data sources by commodity are detailed in **Table 2** shown below.

**Table 2: Summary of Main Data Sources for Variables Affecting Traffic Flows**

| Commodity Category | Variable | Data Source – Historic Data | Data Source – Forecasts |
|---|---|---|---|
| Petroleum and Petroleum Products | IL/US Refinery Capacity | Energy Information Administration | Energy Information Administration, International Outlook 2006. |
| | IL Population | U.S. Census Bureau, Population Division, Table CO-EST2001-12-00 - Time Series of Inter-censal State Population Estimates: April 1, 1990 to April 1, 2000. | U.S. Census Bureau, Population Division, Interim State Population Projections, 2005, Projections from 2004 to 2030. |
| Industrial Chemicals | US Industrial Production | U.S. Federal Reserve, Federal Reserve Statistical Release, Industrial Production and Capacity Utilization. | Derived by LBG from Bureau of Labor Statistics forecasted data. |
| | IL Industrial Production | IL Department of Commerce and Economic Activity. | Derived by LBG from IL Department of Commerce and Economic Activity with Global Insight forecasted data. |
| | US Ethanol Production | Renewable Fuels Association, Ethanol Industry Outlook, 2006. | Energy Information Administration, Annual Energy Outlook 2007 with Projections to 2030. |
| Agricultural Chemicals | US Total/Nitrogen Fertilizer Use | United States Department of Agriculture, Economic Research Service (ERS) Dataset, U.S. fertilizer Use & price, September 2006. | Derived by LBG from United States Department of Agriculture historic data |
| | 5 State Population | U.S. Census Bureau, Population Division, Table CO-EST2001-12-00 - Time Series of Intercensal State Population Estimates: April 1, 1990 to April 1, 2000. | U.S. Census Bureau, Population Division, Interim State Population Projections, 2005, Projections from 2004 to 2030. |
| Iron & Steel, Metallic Ores, Products, Scrap | US Steel Production | American Iron and Steel Institute, US Crude Steel Production 1997-2004. | International Iron and Steel Institute (IISI) "NAFTA Steel Production Projections 2005-2015". |
| | Share of Electric Furnaces in US Steel Industry | American Iron and Steel Institute, Electric Furnace Share of United States Steel Production 1996-2005. | Derived by LBG from American Iron and Steel Institute and Expert Interviews. |
| Construction Materials | State/US GDP | US Congressional Budget Office. | Derived by LBG from US Congressional Budget Office forecasts |

| Commodity Category | Variable | Data Source – Historic Data | Data Source – Forecasts |
|---|---|---|---|
| Coal & Coke | Coal Production, US Western Region | Energy Information Administration, Coal Industry Annual reports 1997-2004. | Energy Information Administration, Report #DOE/EIA-0383(2007) |
| | Coal Production, US Interior Western Region | Energy Information Administration, Coal Industry Annual reports 1997-2004. | Energy Information Administration, Report #DOE/EIA-0383(2007) |
| | State/US Populations | U.S. Census Bureau, Population Division, Table CO-EST2001-12-00 - Time Series of Intercensal State Population Estimates: April 1, 1990 to April 1, 2000. | U.S. Census Bureau, Population Division, Interim State Population Projections, 2005, Projections from 2004 to 2030. |
| | US Coal Imports | Energy Information Administration, Coal Industry Annual reports 1997-2004. | Energy Information Administration, Report #DOE/EIA-0383(2007) |
| | US Coal Consumption | Energy Information Administration, Coal Industry Annual reports 1997-2004. | Energy Information Administration, Report #DOE/EIA-0383(2007) |
| | Illinois Coal+Coke Consumption | Energy Information Administration, Coal Industry Annual reports 1997-2004. | Derived by LBG from the US coal consumption forecasted by the Energy Information Administration in Report #DOE/EIA-0383(2007) |

## *1.3 Methodology*

The main methodological approach is to develop baseline conditions for the integration of waterway activities into national and regional economies, future economic outlooks, existing origin-destinations, and forecast growth using qualitative and quantitative assessments.

A similar study by the USACE, published in 2004 as a part of the Upper Mississippi Development Plan, included a forecast for the same commodity groups for the period 2000 – 2050. A related response by the National Research Council in 2005 addressed some of the perceived shortfalls of the USACE study, mainly related to grain. These documents, along with other recently completed or on-going analyses conducted for NESP, such as the grain and oilseed forecast scenarios, provided initial references for this study.

The existing forecasts are, however, based on year 2000 data while the forecasts presented here are based on year 2004 data and, therefore, reflect recent shifts in the structure of waterway traffic, which appear to be significant. In recent years, some decline in long haul commodities, such as grain and coal, has been monitored. At the same time some changes during this last 5-year period are due to increases in oil prices and other related transport costs, consolidation of industries production sites; and an emphasis on Ethanol development etc. contributed to increase in local traffic. The

forecast presented here also provides for uniformity with the other elements of NESP economic planning.

As is indicated above, the data for the variables defining waterway traffic are primarily obtained from secondary sources inclusive of global, national and regional forecasts published by government agencies, consultations with research organizations and interviews with industries involved in each commodity. Each commodity is differently influenced by macro and micro variables. For example, in the case of steel, the study area includes most of the United States' national production capacity, which, however, influenced by expansion in the use of electric furnaces. In the case of petroleum and industrial chemicals, the focus on light products in Southern refineries shifted heavy petroleum and petroleum-related products to local plants because of the expense of the long haul from the Lower Mississippi. The construction materials are mostly locally generated.

Once the variables for each commodity are identified, their relative influence on waterway traffic is assessed using regression analysis. The input for forecasts is based on a combination of regression/trend analysis modified by information obtained from the above sources. Estimates of annual growth rates are presented for various commodity groups or in some cases, such as Ethanol, for the individual commodity.

Container-on-Barge (COB) traffic is the only one which is defined by its mode of transport not by commodity group. The traffic of containers in the waterway system under consideration is, unlike Western Europe, limited at present. Currently, however, there are some factors which can make container-on-barge more applicable. First, there is an increase of commodities on waterways, which may be subject to switching to containers, such as iron and steel, dry chemicals, some agricultural produce and so on. Second, is the potential to distribute containers from foreign destinations to Distribution Centers along the Upper Mississippi waterway system. This potential includes so-called "non fashionable goods", which are not time sensitive but cost dependent. Development on COB will, however, require a new system of barge operation and significant investments in lifting equipment for ports handling COB.

The analysis presented in this report is based on review of available COB investigations, contacts with port officials where COB has been attempted or is currently planned and most importantly interviews with knowledgeable individuals among barge lines involved in COB operations. Analytical evaluation of both, direct costs as well as frequency of service and transit time, are taken into consideration.

A summary of forecasts is presented for each commodity group follows. Each of commodity groupings is analyzed individually but, in general, contains the following sections:

a) Brief national background for the industry leading to;
b) Description of the Upper Mississippi Waterway statistics of traffic for last 8 years;

c) Directions of traffic (into, out, in and within the reaches);
d) Trends in traffic formation, based on available publications and interviews with experts and industry representatives;
e) Identification of critical parameters defining future traffic;
f) Design of regression equations; and
h) Forecasts accompanied by their confidence levels.

## 1.4 Petroleum and Petroleum Products

In 2004 there were 146 petroleum refineries operating in the United States using either domestic or imported crude oil. Petroleum based products contributed 40.2% of the energy used in the US. US petroleum demand currently is 19.7 million barrels a day and is projected to increase 1.5% annually, reaching 27.7 million barrels per day by 2025 (EIA).

The majority of refineries are located in the Southern and South-Western part of the US. Illinois and Minnesota and the only states with refineries in the Upper Mississippi and Illinois Waterway region; Illinois has the largest share. Petroleum refineries convert crude oil to different products, such as gasoline and diesel fuel, finished non-fuel products, petrochemical feed stock, etc.

Overall, the patterns of petroleum movements are likely to remain stable as refineries continue to ship refined products from high production regions in the South and the Great Lakes area to the Upper Mississippi and Illinois Waterway region. The structure of these movements is, however, changing with an increase of light products, which are shipped mostly by pipelines, at the expense of heavy products moved by waterways. Accordingly, it is expected that locally generated traffic will increase more than inflow from the Lower Mississippi waterway.

Most of the states in this region, except Illinois are net consumers of petroleum products. Illinois is both a producer and a consumer of petroleum products because of the highly industrial Gary-Chicago-Milwaukee economic zone. No new refineries or changes to existing refineries are planned in the region. The productivity of existing refineries is expected to increase in a limited fashion.

Petroleum and petroleum products make up about 9% of the total tonnage[2] in the system with 7.1% share of the total tonnage on the Upper Mississippi (6 million ton) and 13.4% share of the total cargo on the Illinois Waterway (9 million ton). The dominant flow for petroleum on the Upper Mississippi (UM) in 2004 is upstream from the lower Mississippi. This includes the movement of products from the refineries in the southern US and imports. The Illinois Waterway (IL) has both upstream and downstream flow due to the presence of the refineries in the state.

[2] Total tonnage includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.

The analysis of petroleum products movements by sub-categories shows that the types of cargo moving on both waterways are remarkably similar. It is evident that, although the waterway is not used to transport crude oil, it is used to ship the refined products. Asphalt, Petroleum Coke, Fuel Oils and Gasoline constitute 84%, 87% and 85% of the total petroleum tonnage on the UM, IL and combined waterways, respectively. Lube Oil & Greases constitute another 8% of the total petroleum tonnage in the UM and IL waterway systems.

Since petroleum commodity constituents are, to a large extent, an output of the refineries in the region, it is appropriate to consider the operating capacity of the refineries as an indicator of petroleum commodity-related activity, jointly with overall US petroleum production. In addition, the population of Illinois was used as an indicator of the consumption of petroleum commodity constituents in the region. Only Illinois statistics were used in the regression models as it carries the maximum share of petroleum waterway traffic.

The regression analysis shows that waterway traffic will increase with an increase in regional population as the consumption of petroleum products is expected to increase with more people. Waterway traffic also increases with an increase in Illinois' refining capacity. The traffic, however, decreases with an increase in the non-Illinois refinery capacity. This is primarily due to the gradual change in refinery production, increases in light fuels at the expense of transporting the crude oil, heavy petroleum products, asphalt and so on. The light fuels are distributed mostly by pipeline or rail. Additionally in the last 10 years, some petroleum products have begun to be supplied to the Upper Mississippi region by Canadian pipelines.

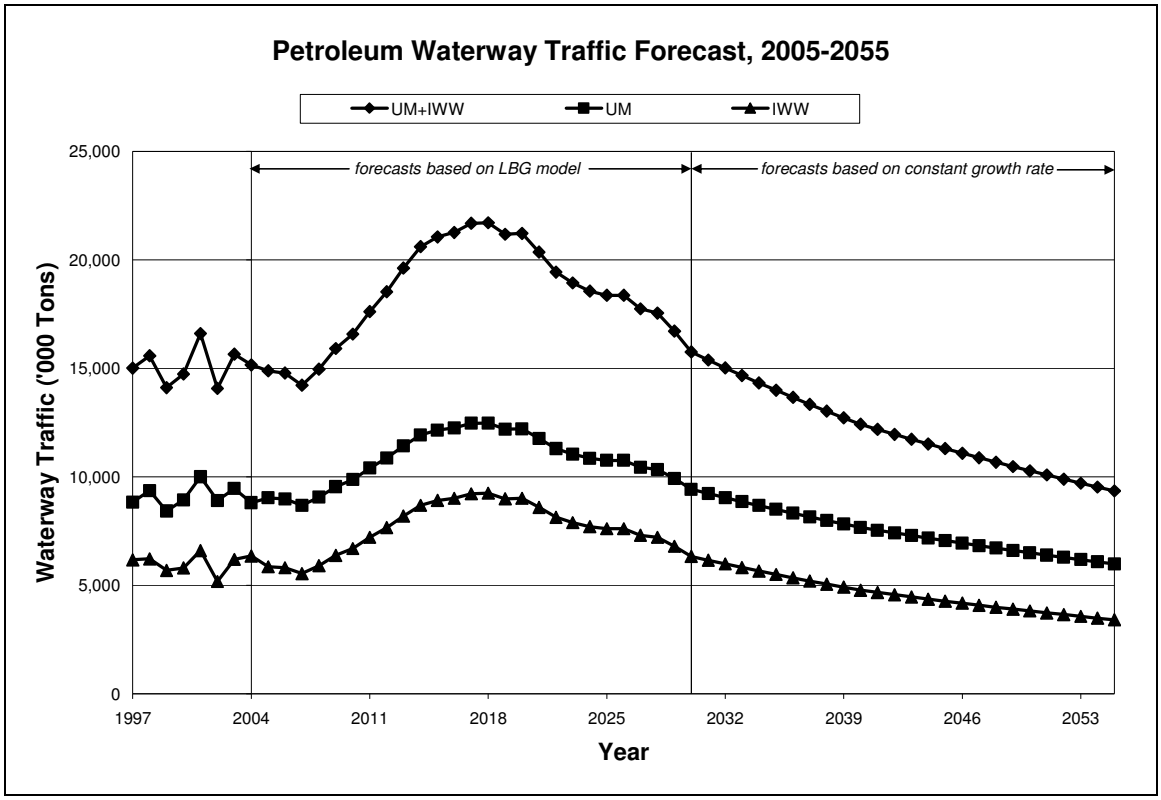
The minor impact of an increase in non-Illinois refineries on the Upper Mississippi and Illinois Waterway traffic is captured by the change in population. This variable works as an adjustment factor to the positive impact of population and Illinois refinery capacity.

The population forecasts are available through 2030 from U.S. Census Bureau, Population Division, Interim State Population Projections, (2005). The US refinery capacity forecasts are available through 2030 from Energy Information Administration Report #DOE/EIA-0383(2007).

It has been observed that there is currently only limited idle refinery capacity in Illinois and no new refinery is being planned. It is expected that only a nominal increase in the refinery output from the Illinois refineries will take place, which is assumed to reach a maximum value of 1100 million barrels per day in 2020 (the recorded historic maximum level). This level of capacity then remains constant until 2030.

As shown below in **Figure 1,** the forecasts indicate a decrease in waterway tonnage from 2005 to 2007 and then an increase until 2018, at which point it starts decreasing again. This decrease in waterway traffic is because of a higher negative impact of the above stated decrease in non-Illinois refinery inflow and input from Canada. A reduction in the

Illinois population growth rate from 2015 onwards also contributes to the reduction in waterway traffic in the later years.




(Source: LBG Analysis)

**Figure 1: Unconstrained Petroleum Waterway Forecasts**

## *1.5 Industrial Chemicals*

Industrial chemicals are mainly intermediate products that facilitate the manufacture of final consumer products and various industrial raw materials. The major types of industrial chemicals that move in the system are Alcohols with Ethanol as the major type of alcohol; Sodium Hydroxide, also commonly known as caustic soda; Benzene; Ammonia, for mainly use as chemical fertilizer to replenish soils and provide nutrients to agricultural crops.

Most of the industrial chemicals are produced on the Lower Mississippi and in South West Texas at local refineries and petrochemical plants. In recent years, however, there has been an increase in the production of industrial chemicals in Illinois at local refineries and petrochemical plants.

The waterborne industrial chemicals traffic consisted of about 4.5% of the total traffic[3] in the Upper Mississippi Waterway System. Most of the traffic is moved to industrial plants in Illinois. The volume of waterborne industrial chemicals has declined slightly since 1997 from 8.3 to 7.6 million tons in 2004. While the inbound movements have the largest share for the Illinois (73%), the trough movements have the largest share for the Upper Mississippi (68%). This is a reflection of higher industrial activity in Illinois; Illinois generates 81% of tonnage destined for the five regional states.

Based on the industry trends, it is expect that the change in Ethanol tonnage would be different than other industrial chemicals. This trend, coupled with the fact that Ethanol is the single largest constituent of industrial chemicals makes it appropriate to forecast Ethanol separately. Two models were thus developed, one for Ethanol and the other for the remaining industrial chemicals.

*Industrial Chemicals without Alcohols.*

Since industrial chemicals are an input and output of the industries in the region, it is appropriate to consider Industrial Production as an indicator of industrial chemicals waterway traffic. GDP for the US and Illinois was used as an indicator of the economic activity. The impact of other regional states was, however, found statistically insignificant during the regression analysis.

The analysis shows that Upper Mississippi and Illinois Waterway traffic increases with increases in industrial production in Illinois. An increase in industrial production will require more input of industrial chemicals which will also produce more output of industrial chemicals, and result in an increase in the waterway traffic. The regression also shows that waterway traffic decreases with an increase in US industrial production.

This negative impact of US industrial production is mostly explained by, similarly as it is mentioned for petroleum and petroleum production, a restructuring of the petrochemical industry. Most of interregional traffic is induced by the exchange of ingredients between different plants as well as consumption by end users. The current trend, however, is to expand processing at the existing plants to produce a fuller range of products. Therefore, shipments of industrial chemicals are becoming more localized. Also, US industrial production includes industrial production in Illinois. A negative sign discounts the double (positive) impact of Illinois industrial production in the regression equation.

The one of the variables, industrial production index projection, was available from the Bureau of Labor Statistics. This value, however, does not appear to be reasonable as it corresponds to an annual growth rate of 4.1% from 2006-2014, which is much higher than the annual growth rates for the previous 10 and 20 years and, accordingly, required adjustment based on historical trends.

[3] Total traffic includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.

The second variable, Illinois industrial production index, was prepared by Global Insight, which also required some reduction after 2010, considering historical trends in Illinois' industrial production and the fact that no radical changes are expected in Illinois' industrial activity in the future.

The forecasts for industrial chemicals without Ethanol, indicates that the waterway tonnage remains stable until 2010 and then shows a moderately increasing trend.

*Ethanol*

Ethanol waterway traffic is expected to be related to ethanol production in the Mid-Western and Great Plains (corn-belt). It is determined that there is a linear relationship between barge traffic of ethanol and the US ethanol production. Ethanol would need to be shipped from the production sector to the consumption sector. The production sector is mostly comprised of the Midwestern states. The consumption sector is the entire US (and international trade) and the Upper Mississippi and Illinois Waterway are the primary water transport options.

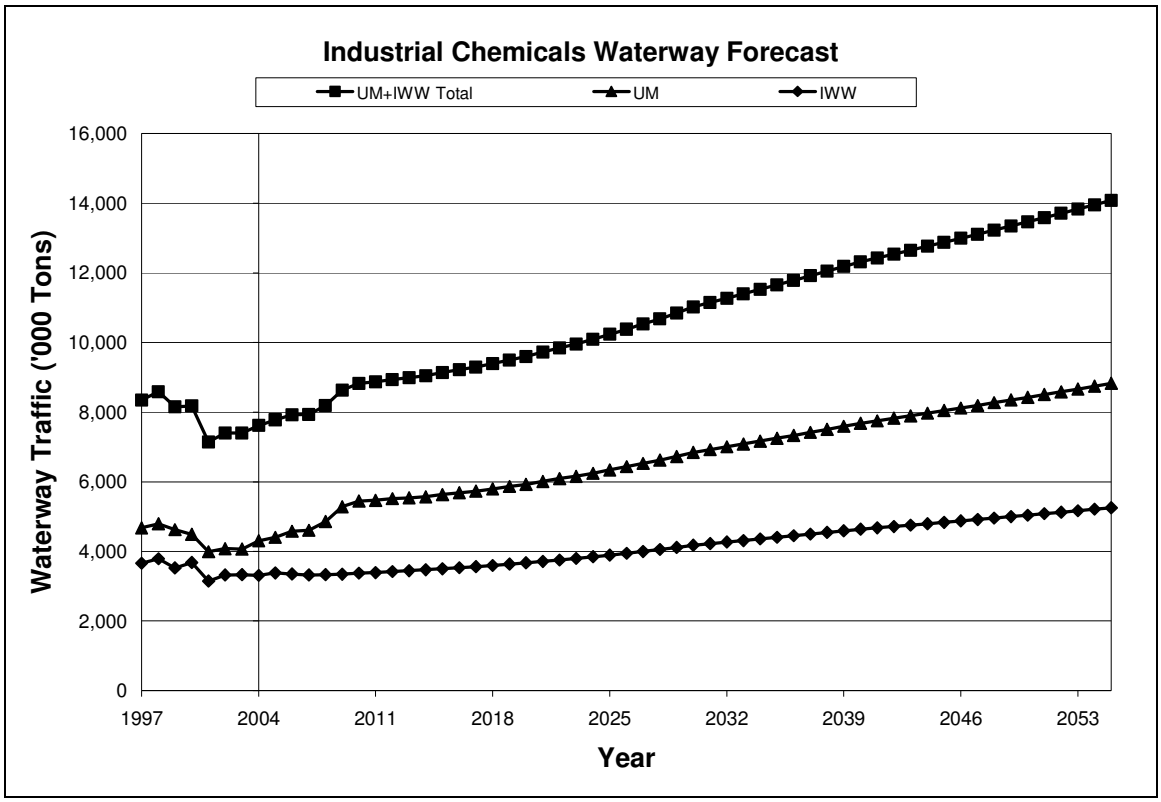
The regression equation also includes 5-state (Illinois, Iowa, Minnesota, Missouri and Wisconsin) regional population as a proxy for the ethanol consumption in the region. This factor reduces barge traffic. Ethanol production is related to ethanol consumption and the population variable dampens the positive impact of ethanol production on the waterway's traffic. Also waterway transportation is primarily used for long distances, while shorter distances are served by trucks. Local ethanol consumption using non-waterway modes reduces the amount of ethanol production going through the waterways.

Review of proposed Ethanol plants indicates that overall locations of these plants remain similar to the existing network. Accordingly allocation of traffic between the waterway and other transportation modes expected to follow current split.

The model for ethanol waterway traffic was based on existing US Fuel Ethanol production, which was obtained from the Energy Information Administration, United States Department of Energy, (2007), with a forecast of ethanol production growth rates for years 2006-2030.

The ethanol production according to this forecast indicates a rapid increase in ethanol until 2009 and then the growth stabilizes to approximately 1% per year. The resulting traffic forecasts for the Upper Mississippi and Illinois Waterway traffic also show a similar trend. The ethanol forecasts also show a rapid increase for the Upper Mississippi from 2005-2010, while the tonnage on Illinois Waterway remains stable throughout the forecast period. The primary reason for this is the ethanol production locations in the region. There are only a few ethanol production locations along the Illinois Waterway. On the other hand, there are many locations (both current and planned) in the Upper Mississippi.

Forecasted traffic for all traffic of industrial chemicals traffic is shown in **Figure 2**.




(Source: LBG Analysis)

**Figure 2: Unconstrained Forecasts for Industrial Chemicals**

## *1.6 Agricultural Chemicals*

Agricultural chemicals consist mainly of production of three basic nutrients – nitrogen (N), phosphorous (P) and potassium (K). These three nutrients (NPK) contribute to agricultural production in several specific ways. Nitrogen, for example, makes plants green and is most responsible for increasing yields; phosphate helps plants use water efficiently and promotes root growth; and potassium facilitates photosynthesis and makes plants hardy to withstand stress of drought and other diseases.

With the adoption of precision nutrient application technologies such as intensive soil analysis in different areas of the farm, computer assisted yield monitoring systems, and the use of variable rate-applicators have assisted farms to increase input-output ratios per unit of nutrient.

Fertilizer price trends for the crops produced also determine the levels of use. Fertilizer prices have grown at a much faster pace since 1990. The nitrogenous fertilizer prices registered the highest rate of increase (5.2% a year) mainly due to increase in the price of natural gas, the main source of raw material used in production. If all other factors remain constant, this development will lead to a decline in the demand for fertilizer.

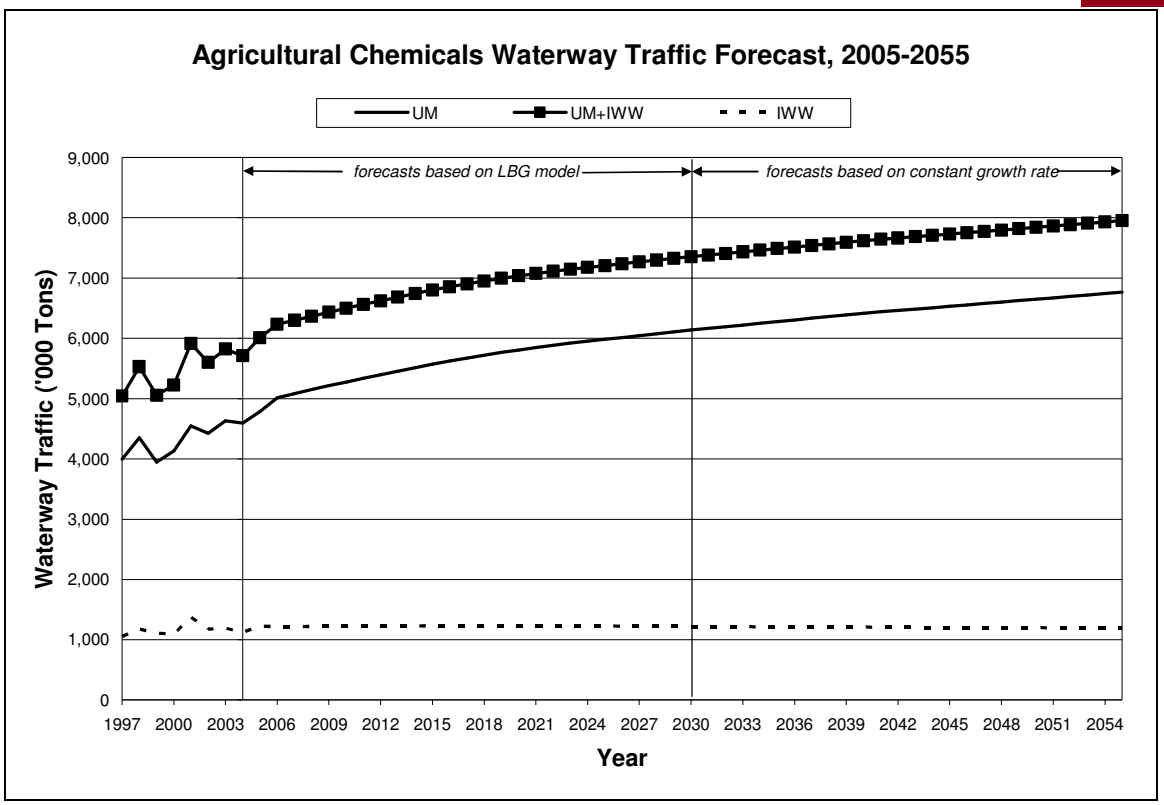
Agricultural chemicals, consisting primarily of fertilizer traffic are about 5.5 million tons with more than 75% concentrated on the Upper Mississippi river. The trend analysis indicates wide variations but, in general, positive growth rates on both waterways. Average annual growth rates of 2% for the upper Mississippi river, compared to 1% growth on the Illinois River. However, there has been a continuous decline of the growth rates for this commodity group.

The inbound movements have the largest share for both Illinois Waterway (79%) and Upper Mississippi (53%). This indicates that the region is a net consumer of fertilizers. Nitrogen-based fertilizers have about 45%-50% share of the waterway traffic. It would thus be important to consider the future trends and developments relating to nitrogen fertilizer during the forecasting process. It is also noted that the nutrient share has not changed substantially over the 7-10 year period preceding 2004, which shows that there has been no radical change in agricultural practices during this period.

The forecasting methodology included analysis of the barge traffic with variables including US fertilizer use (Nitrogen, Phosphate, Potash, and Total), the US Nitrogen fertilizer use, and Five State populations from 1997-2004. The Upper Mississippi and Illinois Waterway are predominantly affected by the US fertilizer use and 5 State populations. US fertilizer use signifies fertilizer demand/supply in the country, while the regional population signifies the local consumption. The Nitrogen fertilizer use variable provides a dampening effect to the increase in waterway traffic because of the positive correlation with the other two variables mentioned above.

The US fertilizer use forecasts were not available from any government agency. It was thus decided to explore the historical trends in fertilizer use. Both, the Nitrogen and total US fertilizer use, followed a logarithmic trend from 1960-2005. It was assumed that this trend will continue during the forecast period through 2030. 5-State population was obtained from the U.S. Census Bureau, Population Division, released on the Internet on April 21, 2005.

The forecasts presented in **Figure 3** show a stabilizing waterway forecast with a gradual increase in the waterway tonnage during the 2005-2030 period. This is a reflection of planned agricultural land use, which, with a relatively small increase (4%) to 2010, will remain stable for the remaining period of time.




(Source: LBG Analysis)

**Figure 3: Unconstrained Forecasts for Agricultural Chemicals**

## *1.7 Iron and Steel, Metallic Ores, Products, Scrap*

The major components of the industry include steel mills, iron and steel foundries, and the suppliers of ferrous scrap and iron ore. The major components of the steel production are Raw Materials and Primary Products and Finished Goods. Iron ore and recycled iron and steel scrap provide bulk of the raw-materials for the industry. The collection of scrap material from dispersed supply sources by brokers, collectors, and dealers and transporting them to steel mills and foundries is one of the most transportation cost intensive parts of the industry. The Steel manufacturing process involves the steel mills producing relatively simple steel shapes and then sending them to the adjoining finishing mills to roll or hammer into finished products such as bar, sheet, and structural shapes. Similarly, the foundries pour molten iron or steel into molds to produce castings with the approximate shape of the final products.

The highest geographic concentration of steel mills is in the Great Lakes, including Indiana, Illinois, Ohio, Pennsylvania, Michigan, and New York. Approximately 80% of US steelmaking capacity is in these states. To produce steel, facilities use one of two processes, which utilize different raw materials and technologies. Integrated steel mills use a blast furnace to produce iron from iron ore, coke, and fluxing agents. A basic oxygen furnace (BOF) is then used to convert the molten iron, along with up to 30% steel

scrap, into refined steel. Mini-mills use an electric arc furnace (EAF) to melt steel scrap and limited amounts of other iron-bearing materials to produce new steel. Mini-mills are largely scrap-based producers, which have traditionally accounted for 100 percent of the furnace "charge" or material loaded into an EAF.

EAF slab casting has radically changed the production of steel in the US because of the numerous advantages that are offered by this technology. The steel sheet and plate mills are no longer tied to the geography of ore and coal sources; and the scale of production and size of the market are not considerations for entry into steel production anymore.

China, Japan, and the U.S. produce more than 40 percent of the world steel supply. However between 1983 and 2001 the Chinese share increased from 6 to 18 percent, while the US share declined from 15 to 12 percent, currently 144 million tons. Foreign trade in the iron and steel sector encompasses iron and steel finished products as well as the necessary raw-materials. Because of the specialized nature of iron and steel finished products and seasonal price variations in different countries, foreign trade consists of exports as well as imports.

While the domestic producers emphasize the need for safeguards against subsidized imported steel flooding the market, the steel user-industries point to the importance of maintaining low prices for steel to avoid increases in the price of consumer goods. Foreign trade activities in iron and steel, in general, are favorable for inland waterborne movements, especially, when handled at Gulf Coast ports linked to the waterway network. Steel imports that are projected to increase are mostly raw materials such as iron ore and iron and steel scrap, etc., or "barge-friendly" commodities.

From the study of the recent trends in the steel industry, it was observed that growth in US steel production is the result of new, more efficient steel mini-mills that use less labor, use steel scrap, produce better quality steel, and are more environmentally friendly than the traditional integrated steel mills. As the mini-mills start commanding a larger share of US steel production, steel scrap will increase in order to supply the inputs for the mini-mills.

This commodity group represents 6.9% of the total cargo[4] on the Upper Mississippi and Illinois Waterway system with Illinois accounting for a 59% (8.5 million tons) and the Upper Mississippi for 42% (6.5 million tons) share. Through movements have the largest share for both waterways, which shows that the waterways are carriers for steel produced and consumed outside the region. It is also important to note that local demand for steel in Illinois is expected to be met from local steel mills using either truck or rail, which would be more efficient for shorter distances than barges. Illinois has a larger inbound share than Upper Mississippi, which is due to the raw materials being shipped to the new electric arc furnace steel mini-mills, which have been established across Illinois.

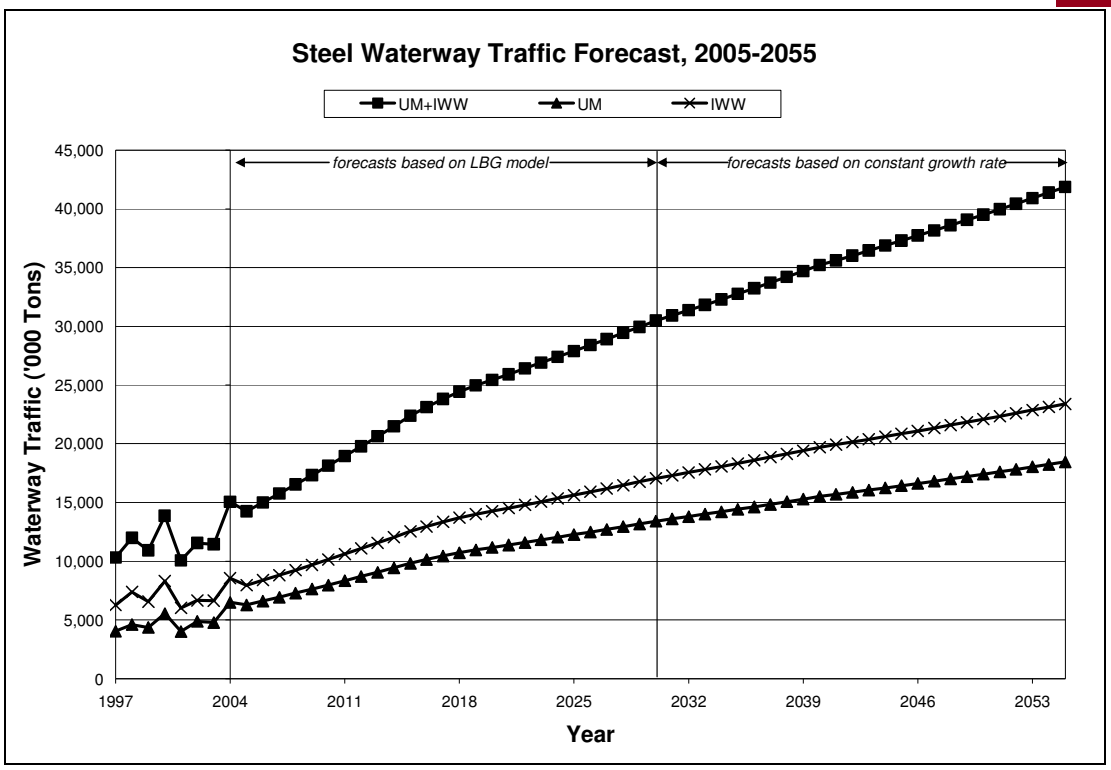
[4] Total cargo includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.

The analysis shows that the waterway traffic would increase with an increase in the US steel production and the Electric Furnace Share. An increase in steel production would result in higher tonnage that would need to be transported from the production to the consumption regions, increasing the waterway traffic. The electric furnace share increase would mean a greater number of mini-mills that produce a cheaper product. Since, there are fewer location constraints for mini-mills than traditional integrated steel mills. Therefore, new steel mills may come up in non traditional-steel-producing regions in the Upper Mississippi and Illinois Waterway catchment area.

The forecast of the steel waterway tonnage using regression equation requires forecast of the values of US Steel Production and Electric Furnace Share in US Steel Production. The first was obtained based on American Iron and Steel Institute (IISI) and by the International Iron and Steel Institute information as a share of NAFTA steel production. In turn The IISI forecasted the NAFTA annual growth rate of 1.9% until 2010. It was further assumed that the NAFTA annual growth rate would remain at 1.9% till 2015 and then reduce to 1% by 2020 and would remain at that level until 2030.

Historical data for electric furnace share shows a linear trend. It was thus assumed that the electric furnace share would follow the same trend. It is, however, important to consider the maximum possible share of electric furnace in US Steel production since all kinds and qualities of steel cannot be produced by this technology. Based on the information from different sources and the expert interviews the maximum electric furnace share was assumed to be 60% reached in 2020 and stabilizing after that period.

The forecast, as shown below in **Figure 4**, indicates continued growth with, however, reduced rates over a period of time, partly due to saturation of mini-mills production.




(Source: LBG Analysis)

**Figure 4: Unconstrained Forecasts for Steel Waterway Traffic**

## *1.8 Coal, Lignite and Coke*

Coal, inclusive of steam coal, lignite and coke, demand is mainly driven by the electric power and industrial sector, which respectively accounted for 87% and 12% of coal consumption in 2005. As the demand for electricity grew over the last few decades, the demand for coal also increased, resulting in a rise in coal production in the US.

In 2005, total domestic production reached 1.33 billion tons with the Appalachian region (mainly Kentucky, Virginia, and West Virginia) contributing 35%, the Interior Region (Illinois, Michigan) 13%, and the Western Region (Colorado, Wyoming) contributing 52%. The only significant coal production in the Upper Mississippi and Illinois Waterway region (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) was in Illinois with its access to the Interior region mines.

Coal demand to a large extent is satisfied by Wyoming and other Western coal producing states. With the dominance of Western coal in the Midwest markets, railroads increased their share as the main mode of transportation. Rail was used to transport at least 92% of the coal in Iowa, Minnesota, Missouri, and Wisconsin. The modal share of railroads in Illinois reached 78% in 2003 and 81% in 2004, with the rest split among river, conveyor/ pipeline, and trucks, reflecting the options available to transport local production. The water transportation share fluctuates between 1 and 6% depending on the state.

Coal commodity group represents about 16% of the total cargo[5] on the Upper Mississippi and Illinois Waterway system with Upper Mississippi accounting for 89% in comparison with the Illinois Waterway. This wide difference is explained by the large amount of western coal delivered by rail to transshipment terminals downstream of St. Louis and moved then by waterways to the South and North on barges. During the period 1997-2004, both waterways experienced declining trends for coal and coke traffic.

Specifically for the Upper Mississippi, traffic decline during 2003 was documented in the Energy Information Administration annual report. The weather played a part in some of the transportation bottlenecks, as the lack of rain led to low water levels in the river transportation system. Another reason has been increase in coal imports to the Gulf Coast.

On the Illinois Waterway long-term decline dates to the 1990 Clean Air Act, which sharply reduced the allowable limits for sulfur dioxide from fossil-fueled electric generating plants. Eight Illinois power plants switched to lower sulfur Western coal between 1991 and 2005. However, traffic increases in the Illinois Waterway for the years 2003-2004 reflect increased coal mine activity in the southern part of the state, the trend is expected to continue. Clean coal technologies are expected to progressively reduce air pollution from burning coal, which, in turn, accelerates production in the interior.

Through movements have the largest share for the Illinois Waterway, while outbound movements have the largest share for the Upper Mississippi. The Illinois region is a net importer of coal from the Ohio and Mississippi Rivers. The Upper Mississippi, on the other hand, is a net exporter and distributor of Western coal from St. Louis terminals to the South and North of the waterway.

It was important, therefore to consider separately coal movement north of St Louis and south of St Louis to indicate substantial differences in traffic density in these two waterway segments. These segments are, then, defined as: Upper Mississippi North, from Minneapolis, MN (river mile 857.6) to Mouth of Missouri River and (river mile 195.0); and Upper Mississippi South, from Mouth of Missouri River (river mile 195.0) to Mouth of Ohio River (river mile 0.0).

While coal and lignite are grouped together in the Waterborne Commerce database, coke is listed as a separate item. Lignite is the lowest ranked of coal, often referred to as brown coal. Coke is a product derived from burning bituminous coal, and is used as a fuel and as a reducing agent in smelting iron ore. Coke's share of total traffic[6] is important for the Illinois Waterway and has varied significantly, while for the Upper Mississippi it has been somewhat constant around 6%.

Coal cargo category has presented the most variability due the traditionally small share of barge movements in comparison with other modes and to exogenous factors

[5] Total cargo includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.
[6] Total traffic includes both grain and non-grain commodities.

(environmental regulations, energy generation and distribution deregulation, influx of imports, etc.). Accordingly, the methodology for forecasting these commodities relies on national trends of variables impacting the commodity waterway movement, refined to reflect regional/local conditions, and adjusted further with the input from expert opinions. The main independent variables, whose trends and relationships with the dependent variable (coal waterway movement) were explored in the forecasting models included:

- Regional Coal Production (Interior and Western Regions)
- US Coal Consumption
- US Coal Imports
- Illinois Electricity Generation
- Illinois Population

On the Illinois Waterway separate models were created for coal coke and total coal (includes coal coke and coal lignite) traffic. The analysis shows that the traffic on the Illinois Waterway is predominantly affected by local factors. The coke traffic indicates a high correlation with electricity generation. The total coal traffic on the Illinois Waterway has been very volatile, especially during 2001-2003, when traffic moved from a decreasing trend to an increasing trend.

The primary factors affecting barge coal traffic are interior and western coal production (coal supply) and Illinois population (which is a proxy for coal demand). Illinois coal barge traffic is positively correlated with Interior region coal production and Illinois population. Western region coal production negatively affects barge traffic. The primary mode of transportation for coal moving from the Western region towards the east is rail, which therefore diminishes waterway utilization.

For the Upper Mississippi North barge traffic increases with increases in the Interior and Western region coal production as main sources of local consumptions. An increase in overall US coal consumption, however, results in a negative impact on the Upper Mississippi North waterway traffic. US coal consumption dampens the impact of the Interior and Western region coal production on the waterway traffic because it is correlated with national production, imports and exports. Additionally, part of an increase in coal consumption would be also satisfied by more inflow, which would be transported by rail to the Upper Mississippi North region.

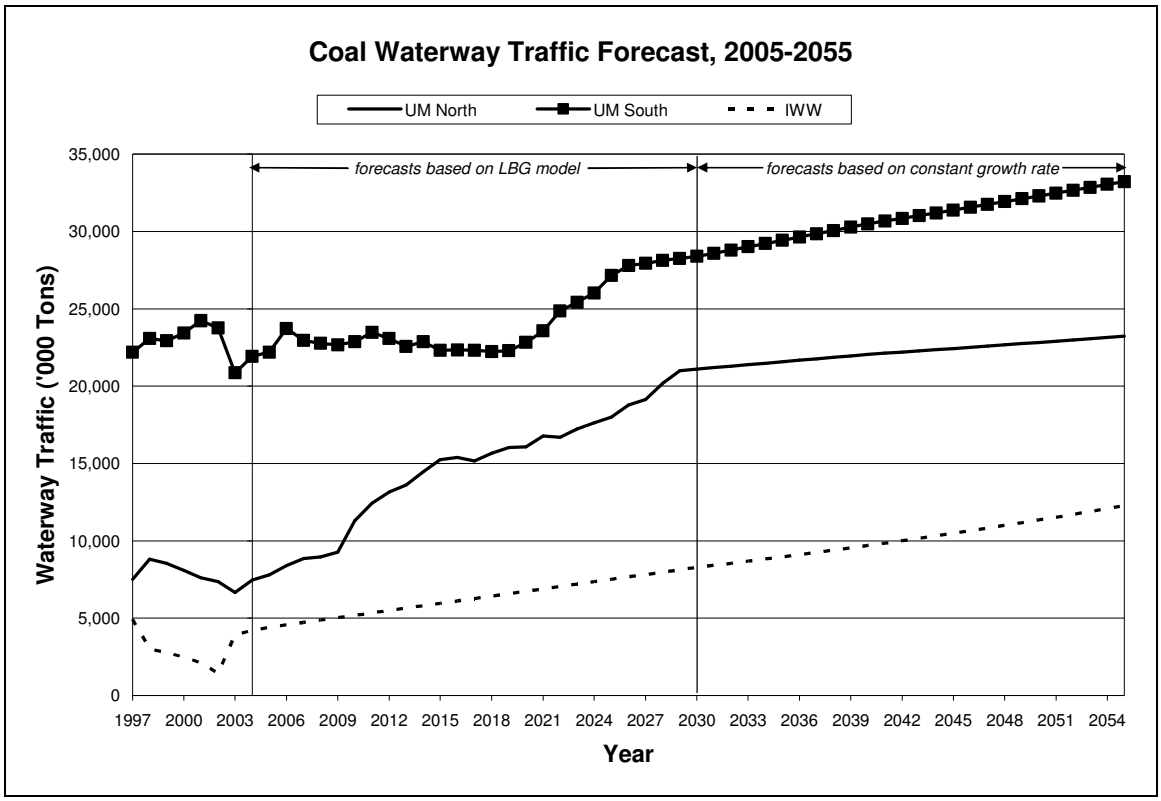
The Upper Mississippi South traffic would also increase with an increase in the Western region coal production. The increase in the Western region production would result in higher tonnage moving from the transshipment terminals below St. Louis, downstream to the Mississippi, thereby increasing the tonnage in southern part of this waterway (and towards the Ohio River).

This traffic density is, however, negatively impacted by coal imports. The main consumers of barge delivered coal from the Upper Mississippi and partly the Illinois waterways are power plants in the Gulf of Mexico, specifically Florida power plants. Utilization of this coal has been significantly reduced as a result of environmental

restrictions and delivery of low sulfur coal by import from Colombia. This reduction may be partly reduced by the introduction of clean coal technologies but still imports will continue to have negative impact on coal delivery by barges.

Extensive historical data and projections have been obtained from the Energy Information Administration, Report #DOE/EIA-0383(2007) released in February 2007. Illinois population was obtained from the U.S. Census Bureau, Population Division. Forecasts for the Illinois electricity generated by coal were not available from any government agency, but the forecasts for US electricity generated by coal were available from the Energy Information Administration. It was found that US and Illinois electricity generated by coal is highly correlated. The forecasted US electricity using coal was thus used to forecast the corresponding Illinois values.

The forecasts show a constant increase in the Upper Mississippi North waterway tonnage from 2005 onwards; the growth rates reduce, however, for the period 2015-2020. The Upper Mississippi South waterway traffic also shows a drop during this period (see **Figure 5**). This is due to the sudden surge in US imports as forecasted by the Energy Information Administration for this period. The rise in Illinois Waterway traffic between 2009 and 2015 and the subsequent drop from 2018-2025 is due to changes in growth rates of Western region coal production during these years as also forecasted by the Energy Information Administration.




(Source: LBG Analysis)

**Figure 5: Unconstrained Waterway Traffic Forecast for Coal**

## 1.9 Construction Materials

The construction materials industry can be broadly divided into three sub-categories: sand and gravel; cement and concrete; and limestone.

The sand and gravel sector, with widely accessible resources and handling large quantities of material, uses an extensive transportation network. US sand and gravel output reached a level of 1.24 billion tons in 2004. The volume of waterborne tonnage transported in the UMR area (4.9 million tons) represents 36% of the total sand and gravel moved on US waterways.

Approximately, 30% of the construction materials tonnage in the Upper Mississippi areas comprised of cement and concrete movements. Although, cement and concrete are grouped together as one commodity group, their transportation characteristics and other factors affecting long-term trends are quite different. Concrete mixture is generally uneconomical to transport more than 200 miles and therefore barges are rarely used. In contrast, cement is transported covering longer distances and substantial quantities are imported. In 2004, the US domestic production of Portland and masonry cement amounted to 95 million metric tons and it was supplemented by 23 million tons of imports.

In total, the construction materials group is the third largest commodity group in the system next to grains and coal. This commodity group represented, in 2004, about 12.8%, growing from 10.2% in 1997, of the total cargo on the Upper Mississippi and Illinois Waterway systems, Upper Mississippi accounting for 75% share. Annual growth rates of 7% for the Illinois Waterway and about 2% for Upper Mississippi are observed based on 1997 and 2004 tonnage data as point estimates.

The Upper Mississippi is a net exporter of construction materials with about 3 and 1.1 million tons going to the Lower Mississippi and Gulf Intracoastal Waterway, while 98% of the Illinois Waterway construction materials traffic comes from either the IL or the UM.

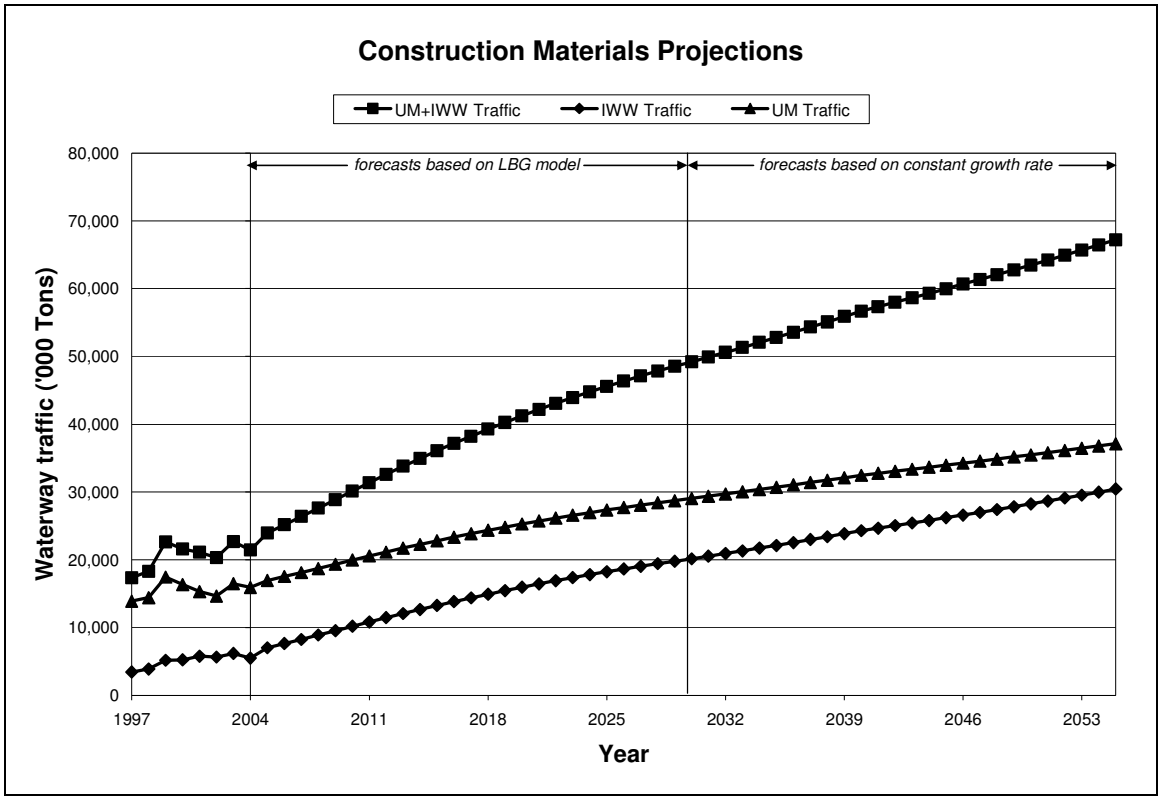
The demand for construction materials is derived mainly from the demand for construction for infrastructure including, among others, buildings, highways and bridges. The construction activity in any region depends on its economy and its growth trends. The leading component to forecast the construction materials waterway tonnage, can be, therefore, an economic indicator variable. Gross Domestic Product (GDP) is the most widely accepted economic indicator.

GDP for the states in the Upper Mississippi and Illinois Waterway region was considered in developing forecast models. These states included: Illinois, Iowa, Minnesota, Missouri and Wisconsin. GDP for these states was summed up to indicate the economic activity of

the entire region. It was, however, deemed important to use Illinois' GDP separately in the modeling exercise because Illinois has the maximum GDP share of 42% and nearly 100% of the traffic both originates and terminates on the Illinois Waterway, which indicates that the traffic in this waterway would be impacted mostly by Illinois' economy.

The regression equations include negative sign for the 4-State GDP indicating that the waterway traffic would reduce with an increase in the GDP for non-Illinois states in the region. This variable works as an adjustment to the impact of Illinois' GDP. The GDPs of all the states in the region are inter-related due to their relationships, especially for trade. Historically, these two variables have shown a similar trend (increasing or decreasing) and there are no radical changes in the economies of any of these states to project otherwise for the future.

The forecasts show a constant increase in the waterway tonnage from 2006 onwards (see **Figure 6**. The growth rates reduce over time.




(Source: LBG Analysis)

**Figure 6: Unconstrained Waterway Forecast for Construction Materials**

## *1.10 Summary of Forecasts*

This section summarizes the unconstrained Upper Mississippi and Illinois Waterway non-grain commodity forecasts for the period 2005-2055.

Unconstrained waterway forecast models were developed based on regression analysis conducted using the waterway data from 1997-2004. The objective was to obtain the forecasted waterway traffic separately for the Upper Mississippi and Illinois Waterways. The models developed by The Louis Berger Group, Inc. were used to forecast the traffic from 2005-2030. For subsequent years, a constant waterway traffic growth rate was used, which was based on the growth rates in the preceding years.

The graphs on the following page show these forecasts for the following commodities: Agricultural Chemicals, Industrial Chemicals (includes Ethanol), Coal[7] (includes Coke), Steel, Petroleum, Construction Materials and Miscellaneous[8].

**Table 3: Upper Mississippi Unconstrained Forecast Summary, 2005-2005**

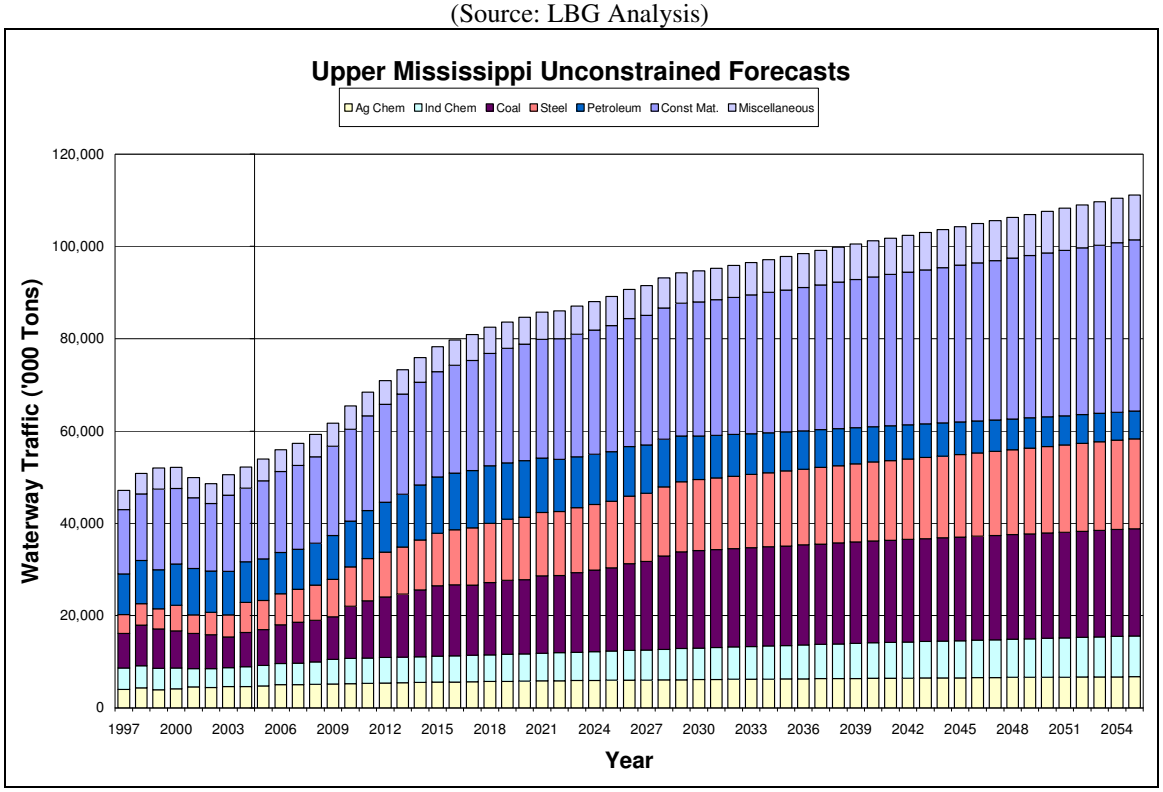
| Year | Agricult. Chemicals | Industrial Chemicals | Coal | Steel | Petroleum | Const. Materials | Misc. | Total |
|---|---|---|---|---|---|---|---|---|
| **Waterway Tonnage ('000 Tons)** | | | | | | | | |
| 2000 | 4,133 | 4,492 | 8,081 | 5,552 | 8,937 | 16,360 | 5,072 | 52,627 |
| 2005 | 4,786 | 4,402 | 7,802 | 6,287 | 9,028 | 16,946 | 4,661 | 53,911 |
| 2010 | 5,276 | 5,447 | 11,305 | 8,544 | 9,875 | 19,948 | 5,016 | 65,411 |
| 2015 | 5,570 | 5,632 | 15,253 | 11,402 | 12,153 | 22,815 | 5,398 | 78,223 |
| 2020 | 5,807 | 5,923 | 16,072 | 13,543 | 12,207 | 25,279 | 5,809 | 84,640 |
| 2025 | 5,984 | 6,344 | 18,012 | 14,426 | 10,756 | 27,345 | 6,251 | 89,118 |
| 2030 | 6,139 | 6,842 | 21,118 | 15,370 | 9,422 | 29,044 | 6,727 | 94,662 |
| 2035 | 6,276 | 7,249 | 21,581 | 16,224 | 8,497 | 30,705 | 7,239 | 97,772 |
| 2040 | 6,417 | 7,681 | 22,055 | 17,126 | 7,663 | 32,461 | 7,790 | 101,193 |
| 2045 | 6,532 | 8,044 | 22,441 | 17,884 | 7,056 | 33,940 | 8,383 | 104,281 |
| 2050 | 6,649 | 8,425 | 22,835 | 18,676 | 6,498 | 35,486 | 9,021 | 107,589 |
| 2055 | 6,769 | 8,824 | 23,235 | 19,502 | 5,983 | 37,102 | 9,708 | 111,123 |
| **Percent of Total Non-Grain Traffic** | | | | | | | | |
| 2000 | 8% | 9% | 15% | 11% | 17% | 31% | 10% | 100% |
| 2005 | 9% | 8% | 14% | 12% | 17% | 31% | 9% | 100% |
| 2010 | 8% | 8% | 17% | 13% | 15% | 30% | 8% | 100% |
| 2015 | 7% | 7% | 19% | 14% | 15% | 29% | 7% | 100% |
| 2020 | 7% | 7% | 19% | 16% | 14% | 29% | 7% | 100% |
| 2025 | 7% | 7% | 20% | 16% | 12% | 30% | 7% | 100% |
| 2030 | 6% | 7% | 22% | 16% | 10% | 30% | 7% | 100% |
| 2035 | 6% | 7% | 22% | 16% | 9% | 31% | 7% | 100% |
| 2040 | 6% | 7% | 22% | 17% | 7% | 32% | 8% | 100% |

[7] For Coal, only the Upper Mississippi (North) traffic was added in these charts. The coal forecast was done separately for Upper Mississippi (North) and Upper Mississippi (South), not for the entire Upper Mississippi.

[8] Miscellaneous waterway traffic is calculated by applying the 1997-2004 average miscellaneous share of total waterway traffic on each of the two waterways. The share used was 7.2% for Illinois Waterway and 8.8% for the Upper Mississippi. For the forecast years, the miscellaneous waterway traffic has been assumed to grow at the same rate as its cumulative annual growth rate from 1997-2004

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2045 | 6% | 8% | 21% | 17% | 7% | 32% | 8% | 100% |
| 2050 | 6% | 8% | 21% | 17% | 6% | 33% | 8% | 100% |
| 2055 | 6% | 8% | 21% | 18% | 5% | 33% | 9% | 100% |

(Source: LBG Analysis)




(Source: LBG Analysis)

**Figure 7: Upper Mississippi Unconstrained Forecasts, 2005-2055**

**Table 4: Illinois Waterway Unconstrained Forecast Summary, 2005-2005**

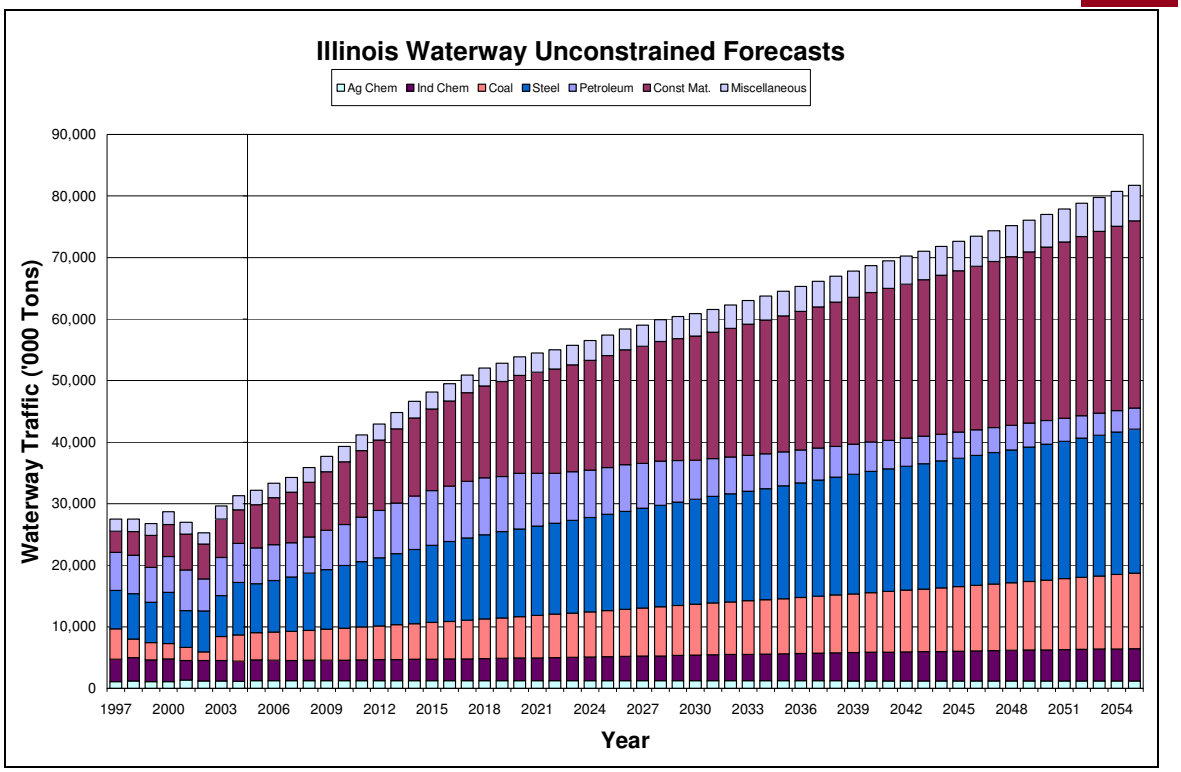
| Year | Agricult. Chemicals | Industrial Chemicals | Coal | Steel | Petroleum | Const. Materials | Misc. | Total |
|---|---|---|---|---|---|---|---|---|
| **Waterway Tonnage ('000 Tons)** | | | | | | | | |
| 2000 | 1,092 | 3,683 | 2,495 | 8,314 | 5,802 | 5,233 | 2,098 | 28,717 |
| 2005 | 1,224 | 3,378 | 4,417 | 7,965 | 5,856 | 7,029 | 2,295 | 32,164 |
| 2010 | 1,223 | 3,372 | 5,192 | 10,151 | 6,698 | 10,190 | 2,516 | 39,341 |
| 2015 | 1,230 | 3,501 | 5,966 | 12,547 | 8,905 | 13,261 | 2,759 | 48,168 |
| 2020 | 1,231 | 3,671 | 6,741 | 14,266 | 9,009 | 15,950 | 3,024 | 53,892 |
| 2025 | 1,225 | 3,893 | 7,515 | 15,624 | 7,612 | 18,240 | 3,316 | 57,425 |
| 2030 | 1,219 | 4,180 | 8,290 | 17,063 | 6,329 | 20,148 | 3,635 | 60,863 |
| 2035 | 1,214 | 4,403 | 8,968 | 18,331 | 5,498 | 22,127 | 3,985 | 64,526 |
| 2040 | 1,209 | 4,638 | 9,701 | 19,695 | 4,776 | 24,300 | 4,369 | 68,688 |
| 2045 | 1,204 | 4,835 | 10,495 | 20,859 | 4,269 | 26,195 | 4,790 | 72,647 |
| 2050 | 1,199 | 5,040 | 11,353 | 22,093 | 3,815 | 28,238 | 5,252 | 76,991 |
| 2055 | 1,194 | 5,255 | 12,282 | 23,400 | 3,410 | 30,440 | 5,757 | 81,807 |
| **Percent of Total Non-Grain Traffic** | | | | | | | | |
| 2000 | 4% | 13% | 9% | 29% | 20% | 18% | 7% | 100% |
| 2005 | 4% | 10% | 14% | 25% | 18% | 22% | 7% | 100% |
| 2010 | 3% | 8% | 13% | 26% | 17% | 26% | 6% | 100% |
| 2015 | 3% | 7% | 12% | 26% | 18% | 27% | 6% | 100% |
| 2020 | 2% | 7% | 12% | 26% | 16% | 29% | 6% | 100% |
| 2025 | 2% | 7% | 13% | 27% | 13% | 31% | 6% | 100% |
| 2030 | 2% | 7% | 13% | 28% | 10% | 33% | 6% | 100% |
| 2035 | 2% | 7% | 14% | 28% | 8% | 34% | 6% | 100% |
| 2040 | 2% | 7% | 14% | 28% | 7% | 35% | 6% | 100% |
| 2045 | 2% | 7% | 14% | 29% | 6% | 36% | 7% | 100% |
| 2050 | 2% | 7% | 15% | 29% | 5% | 37% | 7% | 100% |
| 2055 | 1% | 6% | 15% | 29% | 4% | 37% | 7% | 100% |

(Source: LBG Analysis)

**Table 5: Cumulative Annual Growth Rates, 1997-2055**
**(Unconstrained Forecasts)**

| From Year | To Year | Upper Mississippi | Illinois Waterway |
|---|---|---|---|
| 1997 | 2004 | 1.48% | 1.86% |
| 2005 | 2010 | 4.16% | 4.28% |
| 2010 | 2015 | 3.81% | 4.28% |
| 2015 | 2030 | 1.26% | 1.55% |
| 2030 | 2040 | 0.61% | 1.17% |
| 2040 | 2055 | 0.55% | 1.12% |
| **2005** | **2030** | **2.35%** | **2.64%** |
| **2005** | **2055** | **1.46%** | **1.88%** |

(Source: LBG Analysis)




(Source: LBG Analysis)

**Figure 8: Illinois Waterway Unconstrained Forecasts, 2005-2055**

The forecasts show that the overall waterway traffic growth rate would be higher in the Illinois Waterway (1.88%[9]) compared to the Upper Mississippi (1.46%[10]). Table 5 shows the cumulative annual growth rates for the two waterways for different intervals during the forecast period.

The maximum growth on the Upper Mississippi and Illinois Waterway is seen in Steel with 2.29% and Construction materials with 2.97% cumulative annual growth rates (2005-2055) respectively. This is followed by Coal for Upper Mississippi with growth rates of 2.21% and Steel for Illinois Waterway with a growth rate of 2.28%. This owes to the industrial progress expected in the states adjacent to the two waterways.

The minimum long-term growth on both the waterways is in the Petroleum commodity, which is primarily due to the fact that the refinery capacity in the region is not expected to increase and the petroleum products from refineries in other regions are focused on light products, mainly transported by pipeline. By 2018, petroleum traffic is expected to increase due to expansion of the Interior Range and then decline.

The growth in waterway traffic for agricultural chemicals (fertilizers) and industrial chemicals is expected to remain at existing level, with a slight increase in the Upper

[9] Cumulative Annual Growth Rate from 2005-2055
[10] Cumulative Annual Growth Rate from 2005-2055

Mississippi. This is mainly due to the fact that changes in agricultural practices and industrial development is very gradual.

Coal, Steel, and Construction Materials unconstrained waterway traffic is expected to grow more than 2% per annum, while agricultural chemicals, industrial chemicals and petroleum unconstrained waterway traffic is expected to grow at less than 1% per annum from 2005 to 2055.

## 1.11 Container on Barge

This report summarizes a review aimed at developing a 50-year outlook for container on barge (COB) traffic on the Upper Mississippi and Illinois Waterways. Presently, there is no COB system on the Upper Mississippi River and only irregular COB on the Illinois River. A regular, though limited, COB has been operating on the Lower Mississippi, between Memphis, TN, Baton Rouge, LA and New Orleans for about 3 years. However, the service between Baton Rouge and New Orleans has been curtailed recently. In addition, there were many past attempts to established COB on the Mississippi River System, but all were short-lived.

*Operational Systems*

The analysis indicates that while the present, limited system may survive and perhaps moderately grow, the emergence of a more significant COB requires radical changes in the system's operating concept, technology and a substantial increase in the overall traffic in the corridors it operates. Accordingly, the two main forecasting scenarios are defined as "No Change" and "Radical Change".

No Change scenario is based on General COB System, or standard open hopper "Jumbo" barges, general tows, and general terminals with minimal improvements. Radical Change scenario would use a Specialized COB System with utilization of deck barges (or self-propelled vessel) with lashing structure, dedicated tows and specialized terminals with container lifting equipment.

The principle difference between general and specialized COB inland terminals is in the dock, especially in the equipment used for barge handling. A specialized dock should be the length of a barge (at least), allowing dock-based equipment access to the entire barge without moving the barge. There is little difference between common and specialized terminals in terms of their yard and gate arrangement.

The main competition for COB on the Waterway is the intermodal rail, especially the rail provided by the CN (Canada) railroad, using the IC line along the Mississippi River. The rail line is parallel to the Waterway, with connections to all the major cities along it, with a continuation to Montreal in Canada. It covers the same area as the Waterway COB. The rail service has two advantages relative to COB: (a) Its route to Up-Waterway points

is shorter by about 1/3 than the meandering Waterway route; and (b) Its speed is much greater.

Although Barge transport is inherently slower than rail, this disadvantage is not as critical in the case of specialized COB since it is geared toward serving international trade and a liner shipping system based on weekly frequency and scheduled departures. If the COB is scheduled to arrive on-time to meet the ship, the actual speed is of lesser importance. In fact, the relationship between the deep-sea ship and the barge becomes similar to that of mother – feeder, a common arrangement in liner shipping.

Scheduled services can only be established with specialized COB whereby the boat remains permanently attached to the tow and the tow follows a fixed route. Transit times in general COB are much less reliable since container barges have to wait for general tows, which are not always available. Likewise, general tows serve other en route ports and cargoes.

*COB Advantages*

Discussions with COB operators indicated that costs of services by COB and rail are about equal. At the same time, COB offers some advantages.

- The most significant advantage is COB's ability to provide relatively high capacity. COB employs standard barges that can be leased from the general market in response to a seasonal demand. The rail service is based on assignment of a fixed number of cars for the daily train and, therefore, is geared to providing a fixed daily capacity with only small fluctuations.

- Another advantage of COB stems from potential savings in handling costs at deep-sea terminals. Since barge handling is done through the dock, the transfer between deep-sea ship and barge does not require gate crossing, drayage, etc. Double stack railcars are not designed to handle containers filled to their maximum weight. This is not the case with barges. Also, rail services that may cross urban areas sometimes do not accept hazardous cargoes.

- An interesting option, mainly for specialized COB systems, is using direct ship-to-barge transfer at the deep-sea port. In the most effective direct transfer system, the barge is staged alongside an ocean-going ship and the ship-to-shore gantry crane moves boxes between the two. This transfer, also called midstream, is common in handling steel, cotton, and project cargoes.

- There is a possibility, especially if a mother / feeder system is developed on the Waterway, that the inland terminal performs part of the activities presently performed at the deep-sea terminal, such as storage of boxes, Customs clearing, stuffing / destuffing, warehousing, box cleaning, and repair. The terminal also could serve as an inland depot for shipping lines. These services were in fact provided by the barge terminal in Baton Rouge.

It seems that the present COB system on the Waterways is complementary to the rail system; it fills a few gaps whereby the rail is either ineffective or, perhaps, finds it unprofitable to compete. Hence, the present COB competes with rail on a narrow segment of the market, which includes the seasonal, lowest value, and stock oriented cargoes. Broadening the market segment for which COB could compete with rail mandates transforming the present general COB system into a specialized one.

*Transportation Routes*

Present and future COBs are geared toward serving international trades, mainly imports and exports handled by the Gulf Coast deep-sea ports, specifically by port New Orleans. Presently, New Orleans involvement with (the largest trade) Asian trade is limited. Most of the Asia / US trade is routed through US West Coast ports. Only about 30% of the trade is handled by the so-called All Water services which are routed through the Panama Canal mostly, however, calling US East Coast. Due to a surge in demand, the Canal locks have been operating at or close to full capacity. Hence, no significant increase in All Water services could be expected in the near future. A major expansion of the Canal is planned for 2015. The inauguration of the expanded Canal could trigger a surge of All Water services, some of which are likely to call directly at New Orleans.

Relatively low value cargo, manufactured in China and other Asian countries, is shipped to the US year round to be accumulated at Distribution Centers (DC), from which it is send to stores. Recently, there is a trend to locate DCs in the Midwest, nearby main road and rail intersections such as Memphis, St. Louis, and Chicago. Existing general COB is rarely used for imported merchandise, mainly because they have an inadequate level of service required by this cargo. As noted above, a specialized COB would have reliable schedules that could be coordinated with those of deep-sea services, providing a level of service similar to that of rail, but with larger capacity and lower cost. The availability of a specialized COB could also provide incentives to locate DCs nearby the inland terminals, similar to the arrangement in East Coast ports.

On the export site two recent additions are Identity Preserved Grain (IPG) and Distilled Dried Grain (DDG), some of which already are shipped in containers. DDG is the dry leftover from Ethanol production from corn used locally for feeding and, as its volume rises, is likely to be exported. A large portion of "exports" from the Midwest is empty boxes since the Asia / US trade has large directional imbalance. This creates an accumulation of empty boxes that should be shipped back to Asia. This cargo is especially suited for COB, since empty boxes tend to move in large quantities. Likewise, this "cargo" is the most time-insensitive cargo.

*Potential Scenarios for COB Development*

The growing demand for Waterway traffic may induce transformation of the present general COB into specialized COB. The specialized COB will develop close relationships with deep-sea lines and terminals to coordinate schedules and, especially,

establish direct ship-to-barge transfer, resulting in considerable reduction in overall barging costs and increase its market share relative to the parallel rail service.

In longer term, existing intermodal routes through the West Coast are expected to become even more congested. The capacity expansion of Mexican and Canadian routes appears to be cost prohibitive. The result is a surge in Asian trade and shipping services to the Gulf Coast and New Orleans, especially after expansion of the Panama Canal. These developments may further strengthen introduction of specialized COB. General COB may continue to increase but in a slow pace. Moreover, the possibility that the existing COB will further decline or even entirely disappear should be considered.

To illustrate the possible extent of COB services a hypothetical case was assessed. It is estimated that, for the Upper Mississippi Waterway System, by 2015 COB may reach 11,000 TEU at St. Louis and 19,000 TEU at Chicago for specialized services. These estimates diminish to 3,000 TEU and 6,000 TEU, respectively for general services. By 2055, the volume for both types of COB services may increase three fold.

*European Experience*

The European COB system currently handles about 2.3 million TEU with COB accounts for 40% of Rotterdam's traffic vs. only 10% for rail. The differences between most extensive European COB services in comparison with the Mississippi Waterways can be explained by the following:

- The combined traffic handled by the two major Rhine ports, Rotterdam and Amsterdam, is projected to reach, in 2006, close to 10 million TEU vs. 300,000 TEU for New Orleans;

- The rail system along the Rhine is nationalized and maintains high operating costs; the rail route is congested since it mainly used for passengers; and there is no arrangement to allow double-stack cars and mile-long trains; and

- Following many years of development and large investments, the Rhine's COB is based on a large fleet of fast self-propelled ships calling at high-tech inland terminals; all services are scheduled with typical frequency of several departures per day.

Accordingly, it can be concluded that the European system is different in kind than expected on the Mississippi system even following the introduction of specialized types of services.

# SECTION 2: COMMODITY FORECASTS

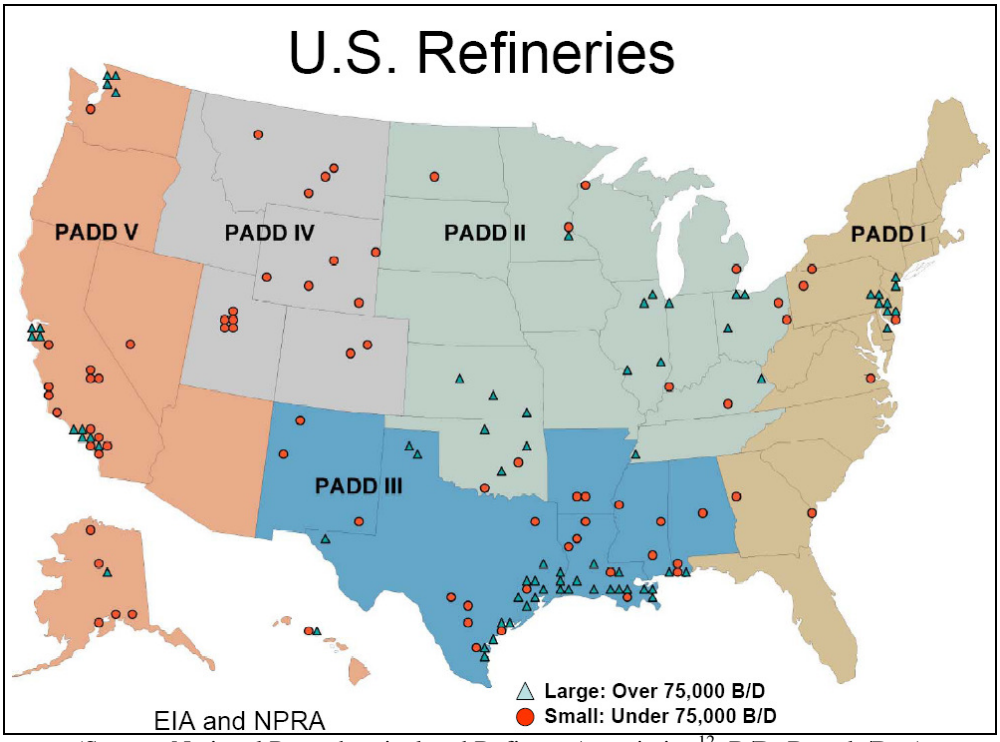
## *2.1 Petroleum and Petroleum Products*

This section discusses the current conditions and unconstrained forecasts for the movement of Petroleum on the Upper Mississippi and Illinois Waterway systems.

### 2.1.1 U.S. Petroleum Industry Overview

The performance of the US petroleum and the petroleum products industry is vitally important to economic growth and the national security interests. These are products of petroleum refineries that convert crude oil to different products that are used by industries and individuals across the country.

*Petroleum Refineries* – In 2004 there were 146 petroleum refineries operating[11] in the United States using either domestic or imported crude oil. **Figure 9** shows the location of the refineries in the United States in 2004.



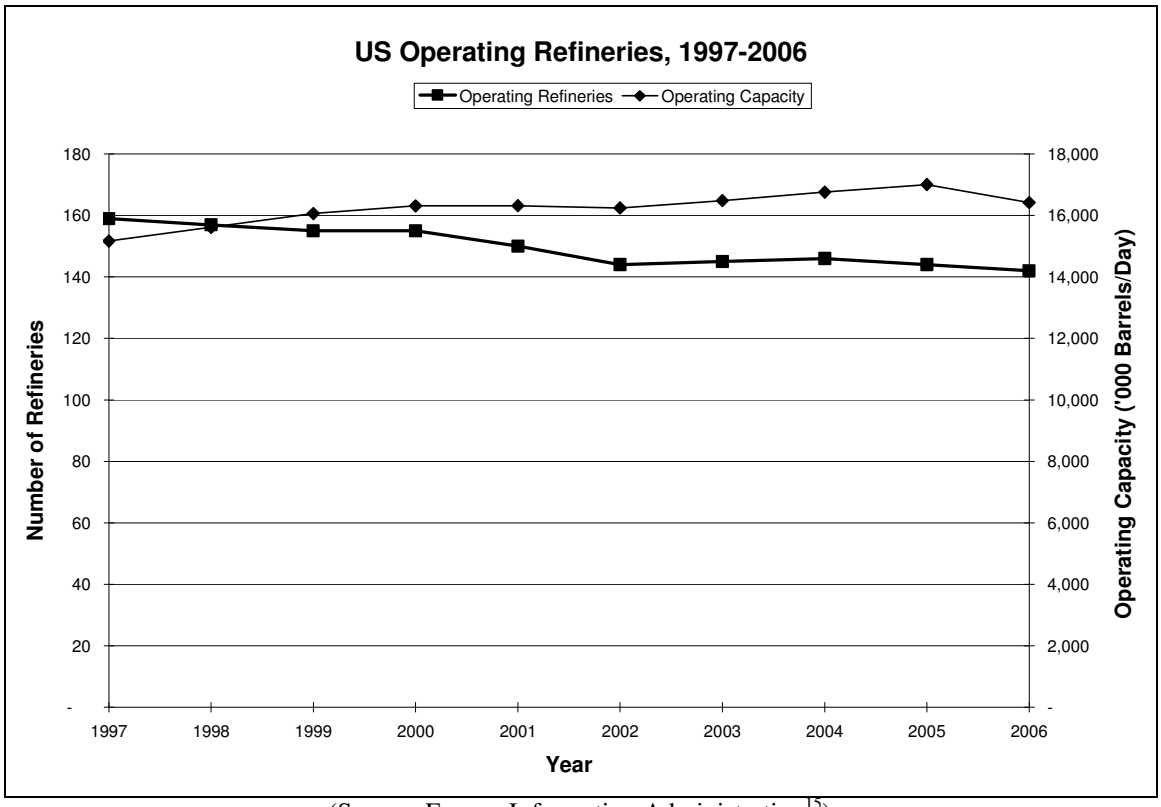

(Source: National Petrochemical and Refiners Association[12]; B/D: Barrels/Day)

**Figure 9: US Refinery Locations[13], 2004**

[11] Operable Refinery: Installed Refinery; Operating Refinery: Current working Refinery.
[12] Available from http://www.npra.org/news/testimony/pdf/7-15-04Attachment-3.pdf accessed on February 13, 2007.

A majority of the refineries are located in the Southern and South-Western part of the US. Only Illinois and Minnesota have refineries in the Upper Mississippi and Illinois Waterway region, with Illinois having the larger share. The refineries in Illinois are larger in terms of operating capacity compared to the ones in Minnesota. In addition, they are located across Illinois, while the Minnesota refineries are concentrated near the Minneapolis-St Paul twin cities region.

The number of refineries in the United States has been decreasing since 1997 as shown in **Figure 10**, but the total operating capacity[14] of US refineries has increased during the same period suggesting an increase in the capacity per refinery.




(Source: Energy Information Administration[15])

**Figure 10: US Operating Refineries and their Capacities, 1997-2006**

*Petroleum Product types* – Petroleum products fall into three major categories (listed in **Table 6**):

- Fuels such as motor gasoline and distillate fuel oils (diesel fuel) –These categories are mainly used to fuel automobiles, trucks, boats and other equipment;

[13] PADD are Petroleum Administration for Defense Districts defined by the EIA. More detail is available from http://tonto.eia.doe.gov/oog/info/twip/padddef.html accessed on February 13, 2007.
[14] Operable Capacity: Installed Capacity; Operating Capacity: Current working Capacity. An Operating Refinery may have a different value of operable capacity and operating capacity.
[15] Updated Nov 2006, Available from http://tonto.eia.doe.gov/dnav/pet/xls/pet_pnp_cap1_dcu_nus_a.xls accessed on March 23, 2007.

- Finished non-fuel products, such as solvents used in paints, greases used in automobile engines, and asphalt used to pave roads fall into this category; and
- Petrochemical feed-stocks - Petroleum feed-stocks are used to make plastics, synthetic rubber and fibers. Industry data indicate that the chemical industry uses nearly 1.5 million barrels per day of natural gas liquids and liquefied refinery gases as petrochemical feed – stock and as plant fuel[16].

**Table 6: US Petroleum (Refinery Output) Constituents Shares (2005)**

| Product | Quantity (Million Barrels) | Share (%) |
|---|---|---|
| Gasoline | 3,331 | 20% |
| Kerosene | 25 | 3% |
| Distillate Fuel Oil | 1,500 | 0% |
| Residual Fuel Oil | 333 | 1% |
| Lube Oil & Greases | 50 | 3% |
| Asphalt and Road Oil | 198 | 4% |
| Petroleum Coke | 187 | 44% |
| Others | 1,915 | 25% |
| **Total** | **7,539** | **100%** |

(Source: Energy Information Administration, Petroleum Products Annual Data, 2005)

*Variables Affecting Demand* – In 2004, petroleum products contributed 40.2 percent of the energy used in the US, compared to 23% share for natural gas and 22% for coal. The US petroleum demand which remained at 19.7 million barrels a day in 2004 is projected to increase 1.5% annually reaching 27.9 million barrels per day by 2025[17].

*Consumption by sectors* – The transportation sector is the biggest consumer of petroleum accounting for a share of 67%, industrial sector 23% and residential/ commercial sectors and electric utilities consuming 8%.

*Price levels, economic growth, and weather conditions* are the main variables affecting demand. Price increases lead to energy conservation as well as to shifts to substitutes. Increased economic activities associated with economic growth leads to an increase in demand for energy which is a factor of production. Extreme weather conditions that require air-conditioning and heating also influence the demand for petroleum.

*Environmental concerns* have brought about several changes in gasoline composition and use. The EPA regulations that new cars manufactured must use unleaded gas and catalytic converters in automobiles are among them.

Overall, the patterns of petroleum movements are likely to remain stable as refineries continue to ship refined products from the high producing regions in the South and the Great Lakes area to the Upper Mississippi and Illinois Waterway regions. The structure

[16] E.I.A., Energy Information Sheets, Petroleum Products, Updated in September 2005. www.eia.doe.gov.
[17] Available from www.eia.doe.gov/neic/infosheets/petroleumproducts.htm accessed on February 14, 2007.

of these movements is, however, changing with an increase in the movement of light products, mostly by pipelines. The heavy products continued to be moved by the waterways. It is thus expected that locally generated petroleum traffic will increase more than the inflow from the Lower Mississippi waterway.

Most of the states in this region, except Illinois are net consumers of petroleum products from the refineries. Illinois is both a producer and a consumer of petroleum products because of the highly industrial Gary-Chicago-Milwaukee economic zone. Since no new refineries or changes to existing refineries are planned in the region, the productivity of existing refineries is expected to experience an increase but it will be very limited. The petroleum products consumed would depend on the economic growth, which would impact the refinery output (tracked by the operating capacity).

The commodity flow survey conducted by the Bureau of Transportation Statistics was the source for Petroleum transportation. This survey is conducted every 5 years with the most recent in 2002. The next survey will be in 2007 and the data will be available in 2008. **Table 7** shows the transportation model shares for Petroleum (Fuel Oils, Gasoline and Aviation Fuel).

**Table 7: United States Petroleum Movement Transportation Modes**

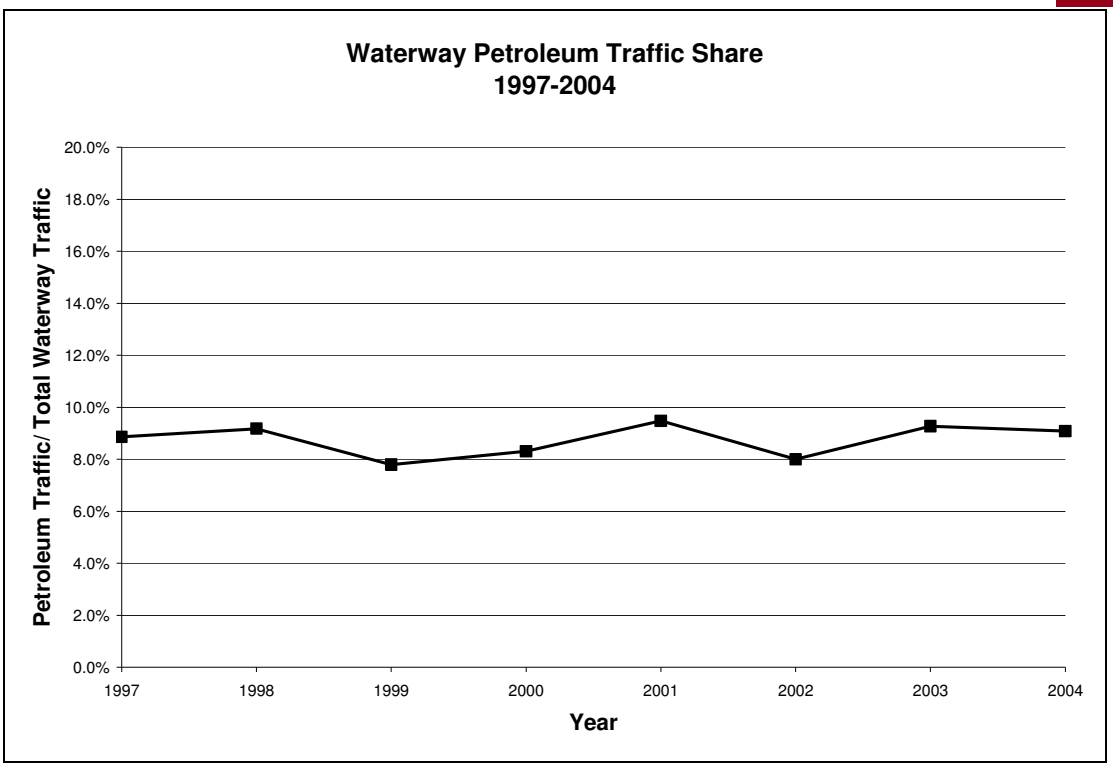
| Mode of transportation | Petroleum | |
|---|---|---|
| | Tons | Share |
| **All modes** | **1,612,576** | **100%** |
| Truck | 879,815 | 55% |
| Rail | 13,001 | 1% |
| Water | 148,981 | 9% |
| Pipeline[18] | 548,821 | 34% |
| **Other and unknown modes** | 11,148 | **1%** |

(Source: Commodity Flow Survey, 2002, Bureau of Transportation Statistics[19])

## 2.1.2 Petroleum Waterway Movements Overview

Petroleum has many constituents that are used across the Upper Mississippi and Illinois Waterway regions. Petroleum and petroleum products make up about 9% of the total tonnage[20] in the system (see **Figure 11**) with a 7.1% share of the total tonnage on the Upper Mississippi and 13.4% share of the total cargo on the Illinois Waterway.

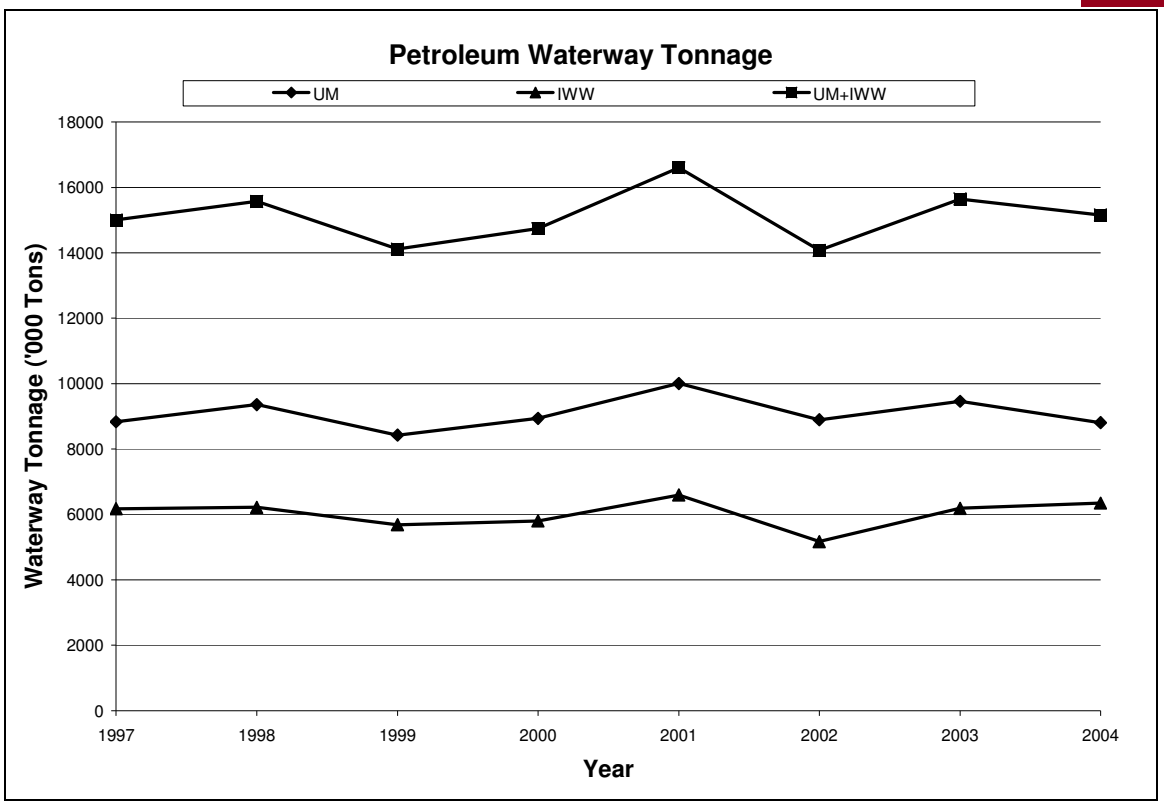
[18] Estimates for Pipeline exclude shipments of Crude Petroleum.
[19] Available from http://www.bts.gov/publications/commodity_flow_survey/2002/united_states/ accessed on April 2, 2007.
[20] Total tonnage includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.




(Source: Waterborne Commerce of United States)

**Figure 11: Waterway Petroleum Tonnage Share, 1997-2004**

**Figure 12** shows the Petroleum waterway tonnage for the Upper Mississippi and Illinois waterways from 1997-2004. The waterway tonnage has remained constant with a standard deviation of 6% around the mean for these years. The year-by-year trend is similar to the petroleum traffic share of the total waterway traffic in the Upper Mississippi and Illinois Waterway region as shown in **Figure 11.** In 2001, the greatest petroleum waterway tonnage and the tonnage were below the mean for 1999 and 2002.



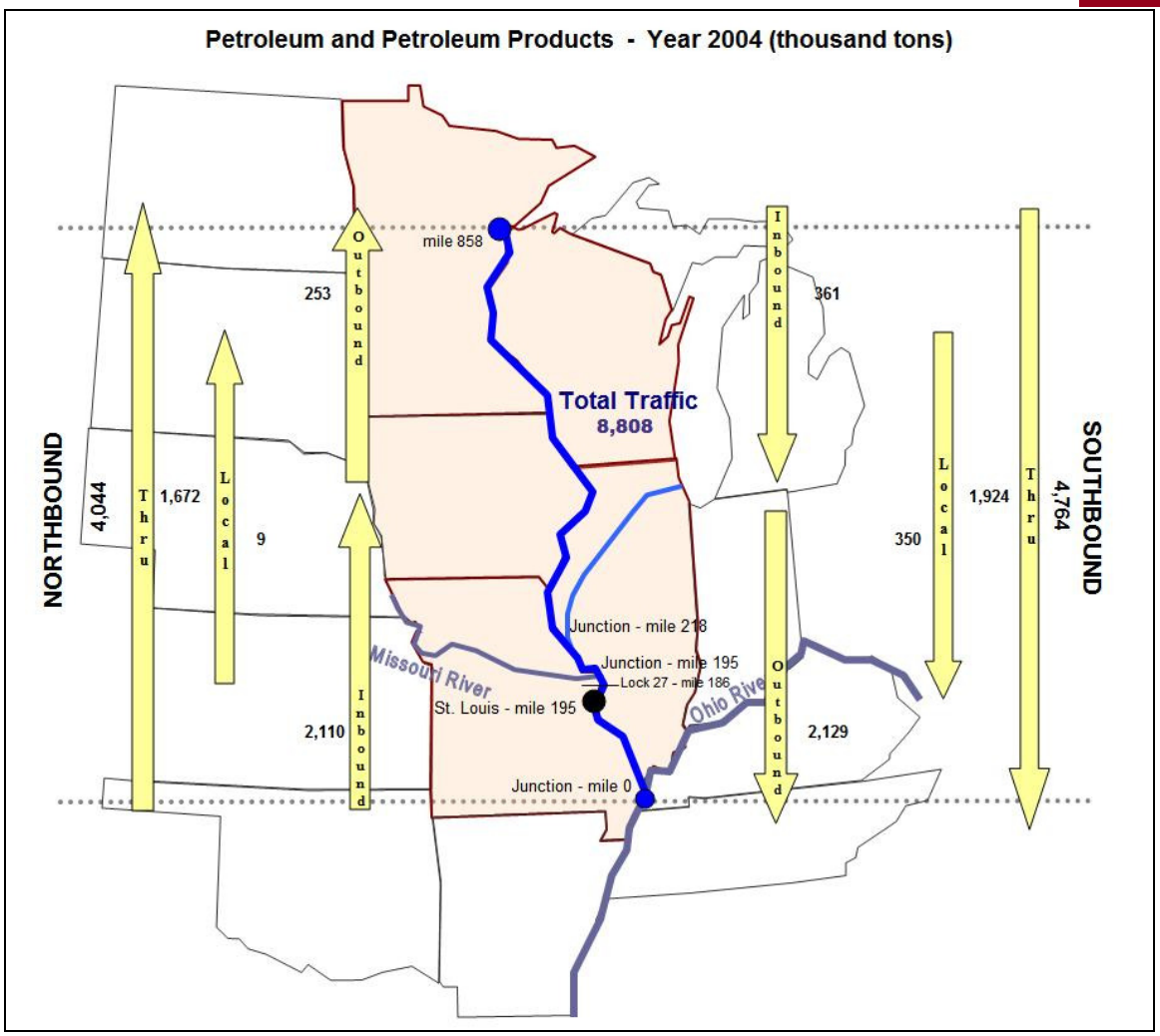

(Source: Waterborne Commerce of United States)

**Figure 12: Petroleum Waterway Tonnage 1997-2004**

**Table 8: Inbound, Outbound, Local and Through Petroleum Waterway Movements ('000 Tons)**

| Year | Illinois Waterway | | | | Upper Mississippi | | | |
|---|---|---|---|---|---|---|---|---|
| | Inbound | Outbound | Local | Through | Inbound | Outbound | Local | Through |
| 1997 | 2,178 | 2,570 | 983 | 444 | 2,487 | 3,517 | 545 | 2,281 |
| 1998 | 2,292 | 2,527 | 936 | 462 | 2,072 | 3,733 | 577 | 2,976 |
| 1999 | 1,809 | 2,834 | 738 | 308 | 1,943 | 3,051 | 559 | 2,873 |
| 2000 | 1,918 | 2,813 | 773 | 298 | 2,417 | 2,725 | 657 | 3,138 |
| 2001 | 3,326 | 2,667 | 554 | 51 | 2,937 | 2,467 | 490 | 4,110 |
| 2002 | 2,627 | 1,875 | 580 | 92 | 2,831 | 2,464 | 435 | 3,167 |
| 2003 | 2,235 | 3,190 | 635 | 127 | 3,066 | 2,340 | 452 | 3,603 |
| 2004 | 1,963 | 3,464 | 702 | 220 | 2,471 | 2,382 | 359 | 3,596 |

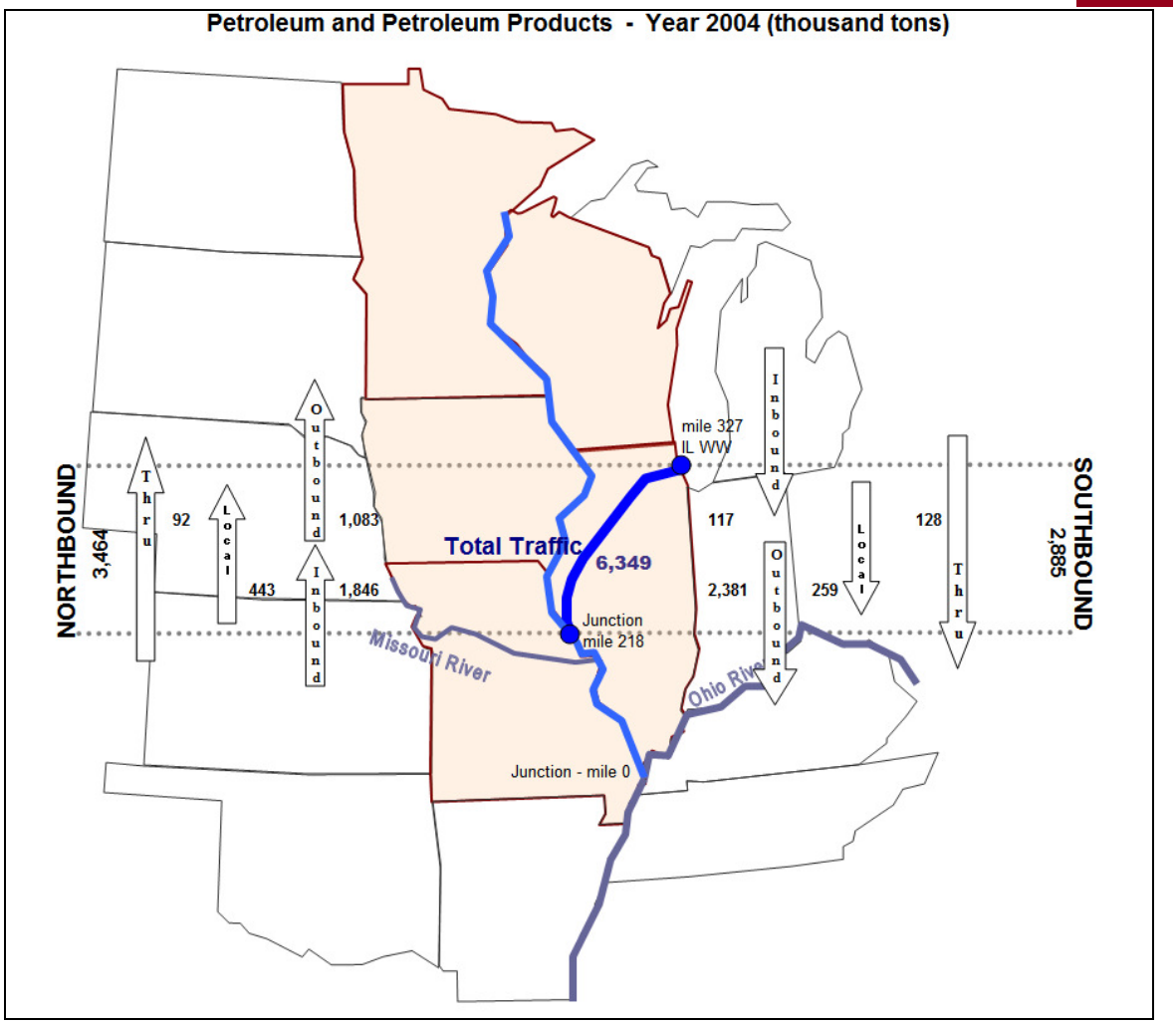
(Source: Waterborne Commerce of United States)




(Source: Waterborne Commerce of United States)

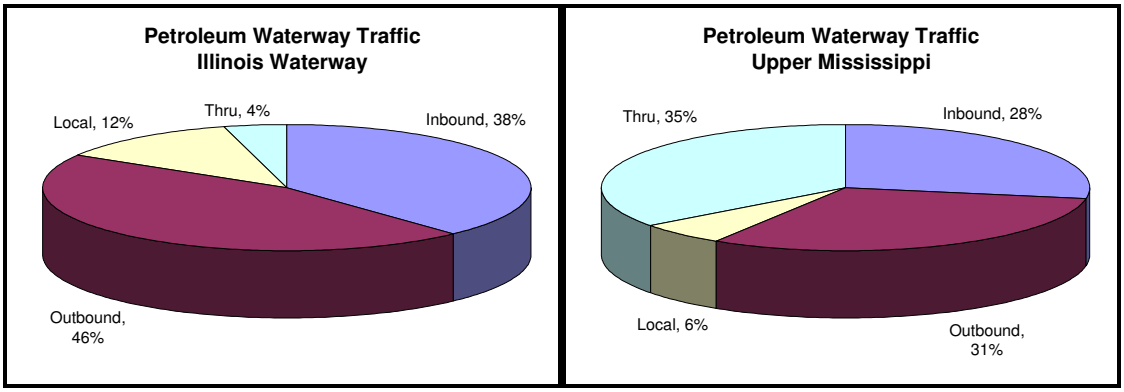
**Figure 13: Upper Mississippi Inbound, Outbound, Local, and Through Waterway Movements 2004**

**Table 8** shows the inbound, outbound, local and through traffic on the Upper Mississippi and Illinois Waterway. **Figure 13** and **Figure 14** illustrate these movements for the year 2004. While the outbound movements have the largest share for Illinois, the through movements have the largest share for the Upper Mississippi (**Figure 15**). Illinois has a larger local movement share than Upper Mississippi, which shows that petroleum products from Illinois refineries serve destinations within the state.




(Source: Waterborne Commerce of United States)

**Figure 14: Illinois Waterway Inbound, Outbound, Local and Through Waterway Movements 2004**




(Note: 1997-2004 Average; Source: Waterborne Commerce of United States)

**Figure 15: Inbound, Outbound, Local, and Through Petroleum Waterway Shares**

## Main Origin/Destination

The dominant flow for Petroleum on the Upper Mississippi in 2004 is upstream from the Lower Mississippi as shown in **Table 10**. This includes the movement of products from the refineries in the southern United States and imports. Illinois Waterway has both upstream and downstream flow due to the presence of the refineries in the state (**Table 9** and **Table 10**). About 10% of the Petroleum flow from the Upper Mississippi and Illinois Waterway goes to the Ohio River. Petroleum in the region would be impacted by Illinois' refineries and the traffic coming from the Lower Mississippi and Gulf Intracoastal Waterway would be impacted by the refineries outside the region.

**Table 9: Main Destinations of Petroleum Shipped FROM Upper Mississippi and Illinois Waterway**

| FROM Upper Mississippi | | FROM Illinois Waterway | |
|---|---|---|---|
| TO Waterway | Share | TO Waterway | Share |
| UPPER MISS | 31% | UPPER MISS | 2% |
| LOWER MISS | 27% | LOWER MISS | 40% |
| GIWW WEST | 26% | GIWW WEST | 26% |
| OHIO | 10% | OHIO | 10% |
| TENNESSEE | 6% | ILLINOIS | 21% |
| | | OTHERS | 2% |
| **Total** | **100%** | **Total** | **100%** |

(GIWW: Gulf Intracoastal Waterway)
(Source: Tennessee Valley Authority, 2004)

**Table 10: Main Origins of Petroleum Shipped TO Upper Mississippi and Illinois Waterway**

| TO Upper Mississippi | | TO Illinois Waterway | |
|---|---|---|---|
| FROM Waterway | Share | FROM Waterway | Share |
| LOWER MISS | 70% | LOWER MISS | 52% |
| GIWW WEST | 14% | GIWW WEST | 23% |
| UPPER MISS | 5% | ILLINOIS | 22% |
| OHIO | 4% | OHIO | 2% |
| ATCHAFALAYA | 3% | OTHERS | 2% |
| MRGO | 2% | | |
| ILLINOIS | 1% | | |
| OTHERS | 1% | | |
| **Total** | **100%** | **Total** | **100%** |

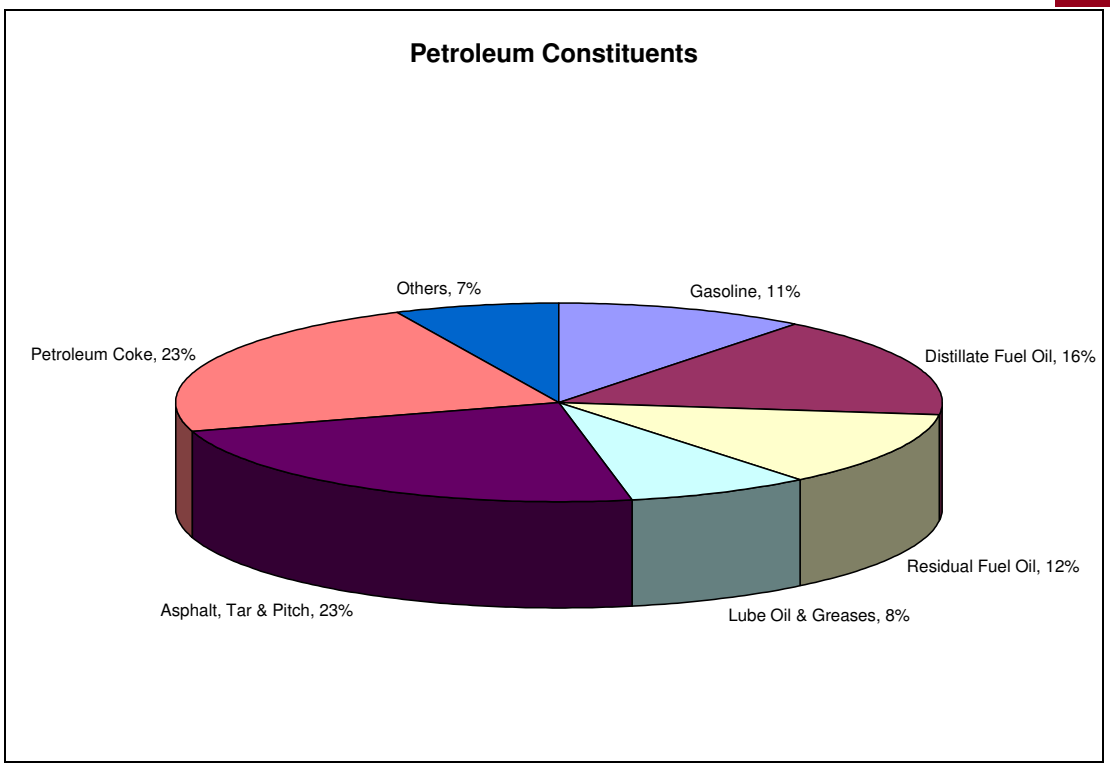
(GIWW: Gulf Intracoastal Waterway; MRGO: Mississippi River Gulf Outlet)
(Source: Tennessee Valley Authority, 2004)

**Table 11: Petroleum Constituents Waterway Tonnage Shares**

| Chemical Name | Share of Each Chemical | | |
|---|---|---|---|
| | UM | IL | UM+IL |
| Crude Petroleum | 0% | 0% | 0% |
| Gasoline | 13% | 7% | 11% |
| Kerosene | 0% | 1% | 0% |
| Distillate Fuel Oil | 17% | 16% | 16% |
| Residual Fuel Oil | 11% | 14% | 12% |
| Lube Oil & Greases | 10% | 5% | 8% |
| Petro. Jelly & Waxes | 0% | 0% | 0% |
| Naphtha & Solvents | 4% | 5% | 4% |
| Asphalt, Tar & Pitch | 26% | 19% | 23% |
| Petroleum Coke | 17% | 31% | 23% |
| Liquid Natural Gas | 0% | 0% | 0% |
| Petro. Products NEC | 2% | 3% | 2% |
| **Total Waterway Tonnage** | **9,090** | **6,024** | **15,114** |

(Waterway Tonnage in Million Tons, 1997-2004 Average)
(Source: Waterborne Commerce of United States)

Petroleum commodity comprises of many constituents that are listed in **Table 11** along with their waterway tonnage shares (see **Figure 16** for an illustration). Crude petroleum movements were not significant with less than 1% of the total petroleum tonnage on both waterways. The analysis of petroleum products movements by sub-categories shows that the types of cargo moving on both waterways are remarkably similar. It is evident that although the waterway is not used to transport crude oil, it is used to ship the products of the refineries. Asphalt, Petroleum Coke, Fuel Oils and Gasoline constitute 84%, 87% and 85% of the total petroleum tonnage on the UM, IL and combined waterways respectively. Lube Oil and Greases constitute another 8% of the total petroleum tonnage in the UM and IL waterway systems (see **Figure 16**).




(Source: Waterborne Commerce of United States)

**Figure 16: Petroleum Constituents Share on the UM and IWW Waterway System**

**Table 12** and **Table 13** show the Petroleum Waterway Tonnage origins and destinations in the five regional states from 1994-2004. Illinois appears to be a clear leader in shipping petroleum over the waterway systems with 93% of the tonnage originating in the five states (IA, IL, MN, MO, and WI). It commands 75% of the petroleum tonnage with destinations in the five states. Missouri has a 21% share. The primary reason for a high petroleum tonnage share of Illinois is the presence of refineries in the state.

**Figure 9** shows that Illinois has 5 large and 1 small refineries as compared to 1 large and 2 small refineries in Minnesota. In addition, petroleum produced in Minnesota is mostly used within the state.

Based on the above observations, the forecast methodology would concentrate on the demand/supply of petroleum in Illinois and the US.

**Table 12: Petroleum Waterway Tonnage for each Destination State ('000 Tons)**

| DEST | 1994 | 1995 | 1996 | 1997 | 1998 | 2000 | 2001 | 2002 | 2003 | 2004 | Wt Average | Share |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA | 314,595 | 358,657 | 265,273 | 248,606 | 216,861 | 210,660 | 17,419 | 62,281 | 127,122 | 100,811 | 192,229 | 3% |
| IL | 6,224,858 | 4,549,435 | 4,992,086 | 5,391,702 | 4,845,491 | 4,344,760 | 5,618,202 | 5,204,624 | 5,474,717 | 5,064,144 | 5,171,002 | 75% |
| MN | 34,968 | | 16,684 | 81,483 | | | | | 21,337 | | 38,618 | 1% |
| MO | 1,113,536 | 1,133,853 | 1,279,570 | 1,532,954 | 1,511,946 | 1,296,279 | 1,954,394 | 1,566,644 | 1,621,559 | 1,485,990 | 1,449,673 | 21% |
| WI | 68,422 | 78,790 | 118,999 | 81,402 | 167,904 | 117,950 | 60,715 | | | 56,632 | 93,852 | 1% |
| Grand Total | 7,756,379 | 6,120,735 | 6,672,612 | 7,336,147 | 6,742,202 | 5,969,649 | 7,650,730 | 6,833,549 | 7,244,735 | 6,707,577 | 6,903,432 | |

(Source: Waterborne Commerce Statistics Center)

**Table 13: Petroleum Waterway Tonnage for each Origin State ('000 Tons)**

| ORIGIN | 1994 | 1995 | 1996 | 1997 | 1998 | 2000 | 2001 | 2002 | 2003 | 2004 | Wt Average | Share |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| IL | 6,358,538 | 5,414,202 | 5,716,772 | 7,440,687 | 7,485,503 | 6,560,900 | 6,241,932 | 5,284,975 | 6,393,953 | 6,826,381 | 6,372,384 | 93% |
| MN | 351,251 | 674,644 | 593,855 | 543,460 | 735,140 | 519,283 | 185,610 | 155,515 | 169,043 | 243,009 | 417,081 | 6% |
| MO | 78,547 | 27,474 | 5,441 | 52,131 | 56,337 | 34,202 | | | | | 42,355 | 1% |
| WI | 66,708 | 36,836 | 8,387 | 69 | | | | | | | 28,000 | 0% |
| Grand Total | 6,855,044 | 6,153,156 | 6,324,455 | 8,036,347 | 8,276,980 | 7,114,385 | 6,427,542 | 5,440,490 | 6,562,996 | 7,069,390 | 6,826,079 | |

(Source: Waterborne Commerce Statistics Center)

**Table 14: Regression Variables 1997-2004**

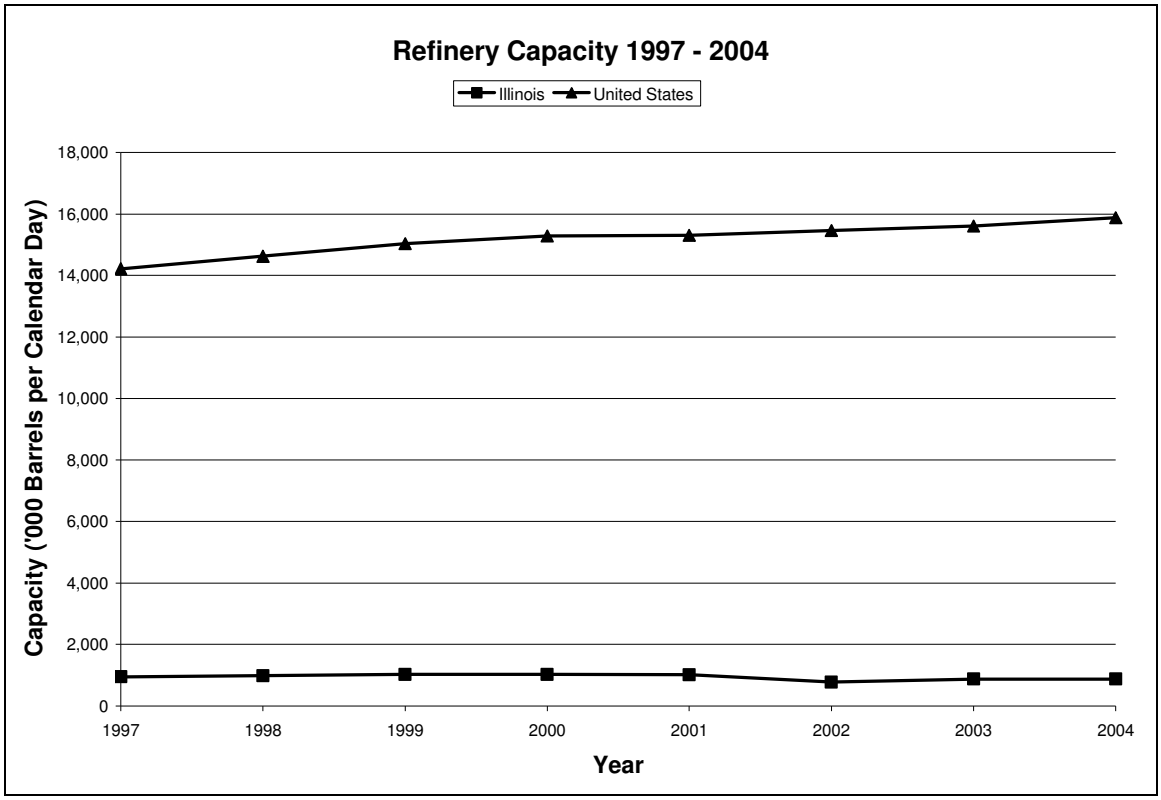
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| Upper Mississippi Waterway Tonnage ('000 Tons) | 8,830 | 9,358 | 8,426 | 8,937 | 10,004 | 8,897 | 9,461 | 8,808 |
| Illinois Waterway Tonnage ('000 Tons) | 6,175 | 6,217 | 5,689 | 5,802 | 6,598 | 5,174 | 6,187 | 6,349 |
| UM + IWW Waterway Tonnage ('000 Tons) | 15,005 | 15,575 | 14,115 | 14,739 | 16,602 | 14,071 | 15,648 | 15,157 |
| Refinery Operating Capacity (IL) (Barrels/Day) | 947,715 | 987,265 | 1,026,815 | 1,029,515 | 1,017,885 | 779,800 | 878,300 | 878,100 |
| Illinois Population ('000 Persons) | 12,186 | 12,272 | 12,359 | 12,441 | 12,525 | 12,595 | 12,650 | 12,714 |
| Refinery Operating Capacity (Non-IL) ('000 Barrels/Day) | 14,220 | 14,627 | 15,035 | 15,285 | 15,302 | 15,467 | 15,606 | 15,881 |
| IL Refinery Operating Capacity Share (IL Cap./US Cap.) | 6% | 6% | 6% | 6% | 6% | 5% | 5% | 5% |

(Source: Refinery Operating Capacity: Energy Information Administration, US Department of Energy; IL Population: US Census Bureau)

### 2.1.3 Forecasting Methodology

Since petroleum commodity constituents are an output of the refineries in the region, it would be appropriate to consider the operating capacity of the refineries as an indicator of petroleum commodity related activity. **Table 14** shows the operating capacity of the refineries in the state of Illinois and the US from 1997 – 2004 (see **Figure 17** for an illustration).

In addition to the above variables, Illinois' population was used as an indicator of the consumption of petroleum commodity constituents in the region. Only Illinois statistics are used in the regression models as it carries the maximum share of petroleum waterway traffic[21].




(Source: Energy Information Administration, 2006)

**Figure 17: Refinery Operating Capacity for United States and Illinois, 1997-2004**

[21] We tried several other models with the population of other states (MO, IA, MN, WI), but did not see any significant model improvement. In many cases, the variables were statistically insignificant.

The regression equations are given below:

| | | | | |
|---|---|---|---|---|
| **UM+IWW Barge Traffic =** | **-201969** | **+ 12.91 (IL Ref Cap)** | **- 7.804 (Non-IL Ref Cap)** | **+ 25.94 (IL Population)** |
| (Std Error) | (46120) | (2.86) | (1.792) | (5.66) |
| *t-statistic* | | *+4.52* | *-4.35* | *+4.59* |
| $R^2$ | 0.86 | | | |

| | | | | |
|---|---|---|---|---|
| **IWW Barge Traffic =** | **-99067** | **+ 6.88 (IL Ref Cap)** | **- 3.80 (Non-IL Ref Cap)** | **+ 12.54 (IL Population)** |
| (Std Error) | (29793) | (1.85) | (1.16) | (3.65) |
| *t-statistic* | | *+3.73* | *-3.28* | *+3.43* |
| $R^2$ | 0.79 | | | |

*Barge Traffic is in '000 Tons*
*Non-IL Refinery Operating Capacity is in '000 Barrels per Calendar Day*
*IL Refinery Operating Capacity is in '000 Barrels per Calendar Day*
*Illinois Population is in '000 Persons*

The Upper Mississippi Barge traffic can be calculated as follows:

**UM Barge traffic = (UM+IWW Barge traffic) – (IWW Barge traffic)**

The regression result shows that the unconstrained waterway traffic would increase with increases in Illinois' population, which is intuitive as the consumption of petroleum products is expected to increase with the number of people. The waterway traffic also increases with an increase in Illinois refinery capacity. The petroleum waterway traffic primarily consists of the output from refineries (**see Table 11**); therefore, an increase in the refinery output in Illinois would result in higher waterway traffic. The waterway traffic, however, decreases with an increase in the non-Illinois refinery capacity. This is due to the following reasons:

- A majority of the non-Illinois refineries are located in the Southern and South-Western United States and an increase in the output mainly impacts that region or the region where there are no refineries.

- A gradual change in refinery production has been taking place due to increases in light fuel production at the expense of transporting the crude oil and heavy products, such as residual fuel, asphalt, petroleum coke, and so on. These light fuels are distributed mostly by pipeline or rail. Additionally in the last 10 years, some of the petroleum products have begun to be supplied to the Upper Mississippi region by Canadian pipelines.

- The minor impact of an increase in non-Illinois refineries on the Upper Mississippi and Illinois Waterway traffic is captured by a change in Illinois' population. This variable works as an adjustment factor to the positive impact of Illinois' population and Illinois' refinery capacity.

The complete forecasting procedure is outlined below.

- Step 1: Forecast the UM+IWW waterway petroleum barge traffic using the regression equation given above (This would require forecasted values for Illinois population, Illinois refinery operating capacity, and non-Illinois refinery operating capacity).

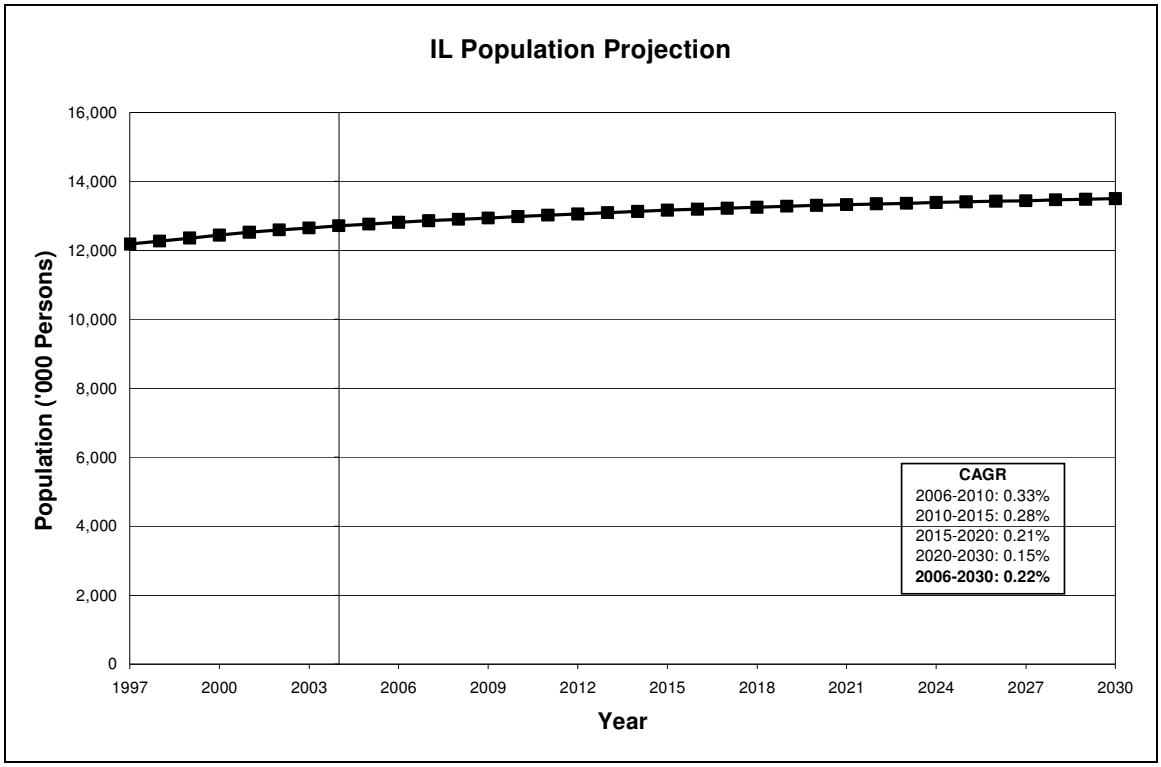
- Step 2: Forecast the IWW waterway petroleum barge traffic using the regression equation given above (This would require forecasted values for Illinois population, Illinois refinery operating capacity, and non-Illinois refinery operating capacity).

- Step 3: Calculate the UM waterway petroleum barge traffic by subtracting the value obtained in Step 2 from the value obtained in Step 1.

### 2.1.4 Petroleum Forecast

This section presents LBG scenarios for the unconstrained forecast of Petroleum movement on the Upper Mississippi and Illinois waterways. The following assumptions apply to these forecasts:

- Illinois refineries operating capacity is assumed to reach a maximum of 1100 million barrels per day in 2020 and then remain constant until 2030.

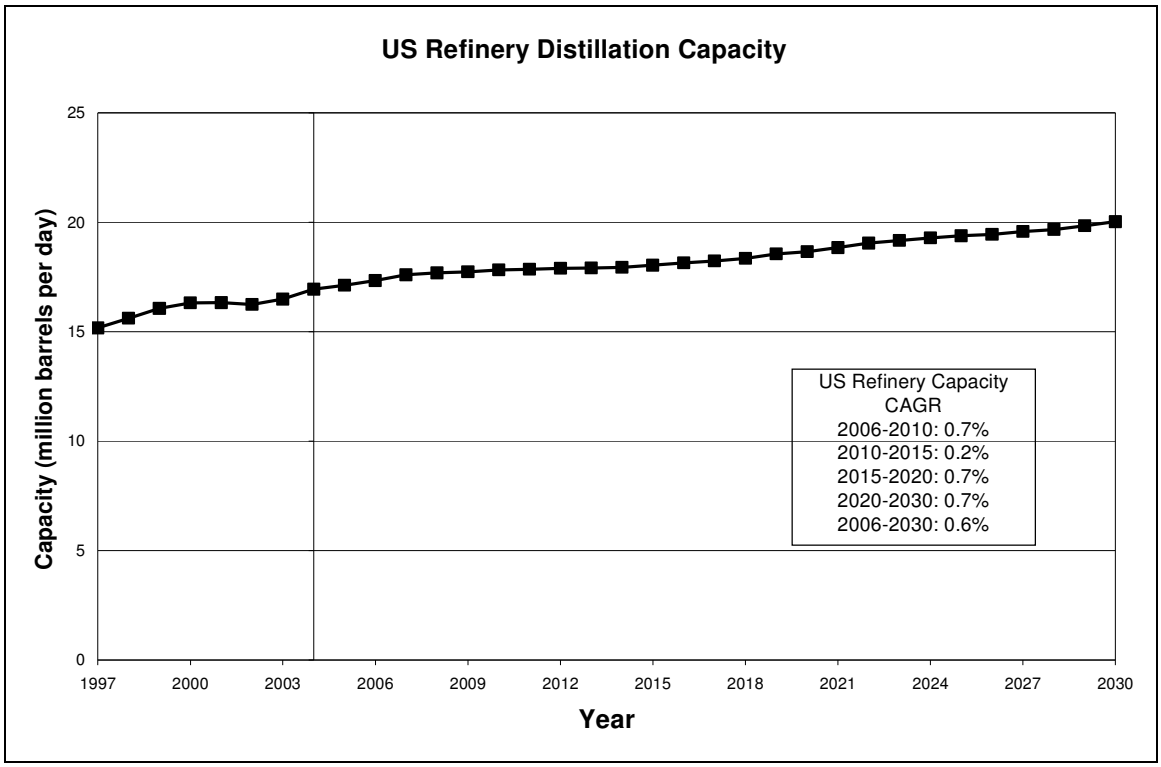



(Source: U.S. Census Bureau, Population Division, Interim State Population Projections, 2005)

**Figure 18: Illinois Population Projections**

To forecast the petroleum waterway tonnage using the regression equation developed in the previous section we need to forecast the values of Illinois and Non-Illinois refinery operating capacity and the Illinois Population.

The Illinois Population forecasts are available through 2030 from US Census Bureau, Population Division, Interim State Population Projections, (2005), and are presented in **Figure 18**. The US refinery capacity forecasts are available through 2030 from Energy Information Administration Report #DOE/EIA-0383(2007). **Figure 19** shows the historic and forecasted US refinery capacity.




(Source: Energy Information Administration, Report #DOE/EIA-0383(2007))

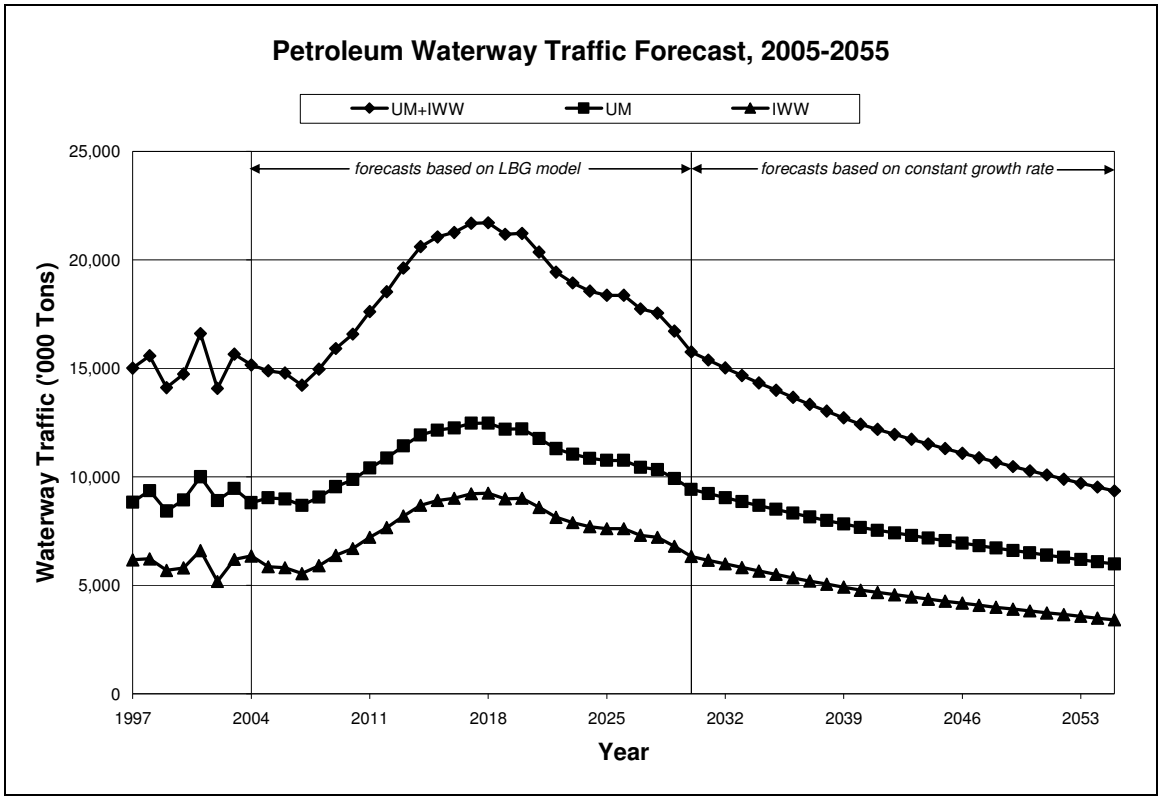
**Figure 19: Historic and Forecasted US Refinery Operating Capacity**

The next step is to determine the Illinois and Non-Illinois refinery operating capacity. The share for Illinois refinery operating capacity of US refinery operating capacity has remained constant at 6% from 1997-2004 (see **Table 14**). It has been observed, however, that currently, there is no idle refinery capacity and no new refinery is planned in Illinois. It was thus assumed that the refinery operating capacity will not increase in a similar manner as the US refinery capacity. We expect only a nominal increase in the refinery output from the Illinois refineries that is assumed to reach a maximum value of 1100 million barrels per day in 2020 (this is the recorded maximum capacity). This level of capacity then remains constant until 2030.

The Petroleum unconstrained waterway traffic forecast model developed in the previous section was used to forecast the total upper Mississippi and Illinois Waterway combined

traffic for Petroleum. The results are tabulated in **Table 15** and presented in **Figure 20**. The cumulative annual growth rates are given in **Table 16.**

The forecasts show a decrease in the waterway tonnage from 2005 to 2007 and then an increase until 2018. The Illinois refinery operating capacity growth rate should be more than 0.6%-0.7%[22] than the non-Illinois refineries operating capacity growth rate for the waterway traffic to increase. A reduction in the Illinois population growth rate from 2015 onwards also contributes to the reduction in waterway traffic in the later years.




(Source: LBG Analysis)

**Figure 20: Unconstrained Waterway Traffic Forecast for Petroleum (2006-2055)**

[22] This is just for reference; the actual value would depend on the refinery capacities and Illinois population in the previous years and the Illinois population growth rate.

**Table 15: Petroleum Unconstrained Waterway Forecasts: LBG Base Case Scenario Results**

| Year | Illinois Population | IL Refinery capacity | Non-IL Refinery Capacity | US Refinery Capacity | UM+IWW Tonnage | UM Tonnage | IWW Tonnage |
|---|---|---|---|---|---|---|---|
| | '000 Persons | '000 Barrels per Calendar Day | | | 000 Tons | 000 Tons | 000 Tons |
| 1997 | 12,186 | 948 | 14,220 | 15,168 | 15,005 | 8,830 | 6,175 |
| 1998 | 12,272 | 987 | 14,627 | 15,615 | 15,575 | 9,358 | 6,217 |
| 1999 | 12,359 | 1,027 | 15,035 | 16,061 | 14,115 | 8,426 | 5,689 |
| 2000 | 12,441 | 1,030 | 15,285 | 16,315 | 14,739 | 8,937 | 5,802 |
| 2001 | 12,525 | 1,018 | 15,302 | 16,320 | 16,602 | 10,004 | 6,598 |
| 2002 | 12,595 | 780 | 15,467 | 16,246 | 14,071 | 8,897 | 5,174 |
| 2003 | 12,650 | 878 | 15,606 | 16,484 | 15,648 | 9,461 | 6,187 |
| 2004 | 12,714 | 878 | 15,881 | 16,759 | 15,157 | 8,808 | 6,349 |
| 2005 | 12,763 | 896 | 16,110 | 17,006 | 14,884 | 9,028 | 5,856 |
| 2006 | 12,811 | 910 | 16,304 | 17,214 | 14,786 | 8,974 | 5,812 |
| 2010 | 12,981 | 964 | 16,733 | 17,697 | 16,573 | 9,875 | 6,698 |
| 2015 | 13,163 | 1,032 | 16,873 | 17,905 | 21,058 | 12,153 | 8,905 |
| 2020 | 13,303 | 1,100 | 17,431 | 18,531 | 21,216 | 12,207 | 9,009 |
| 2025 | 13,407 | 1,100 | 18,143 | 19,243 | 18,368 | 10,756 | 7,612 |
| 2030 | 13,500 | 1,100 | 18,787 | 19,887 | 15,751 | 9,422 | 6,329 |
| 2035 | | | | | 13,987 | 8,497 | 5,498 |
| 2040 | | | | | 12,420 | 7,663 | 4,776 |
| 2045 | | | | | 11,297 | 7,056 | 4,269 |
| 2050 | | | | | 10,275 | 6,498 | 3,815 |
| 2055 | | | | | 9,345 | 5,983 | 3,410 |

(Note: Analysis uses actual 2005 Refinery Capacity from EIA, 2005 Waterway Traffic is calculated)
(Source: LBG Analysis)

**Table 16: Cumulative Annual Growth Rates. 2000-2055**

| From Year | To Year | UM+IWW | UM | IWW |
|---|---|---|---|---|
| 1997 | 2004 | 0.1% | 0.0% | 0.4% |
| 2005 | 2010 | 2.2% | 1.8% | 2.7% |
| 2010 | 2015 | 4.9% | 4.2% | 5.9% |
| 2015 | 2020 | 0.1% | 0.1% | 0.2% |
| 2020 | 2030 | -2.9% | -2.6% | -3.5% |
| 2030 | 2040 | -2.3% | -2.0% | -2.8% |
| 2040 | 2055 | -1.9% | -1.6% | -2.2% |
| **2005** | **2030** | **0.2%** | **0.2%** | **0.3%** |
| **2005** | **2055** | **-0.9%** | **-0.8%** | **-1.1%** |

(Source: LBG Analysis)

## 2.2 Industrial Chemicals

This section discusses the current situation and unconstrained forecasts for the movement of Industrial Chemicals on the Upper Mississippi and Illinois Waterway systems.

### 2.2.1 U.S. Industrial Chemicals Industry Overview

Industrial chemicals are mainly intermediate products that facilitate the manufacture of final consumer products and various industrial raw materials. More than 50% of the industrial chemicals tonnage on the Upper Mississippi river moves up to Illinois Waterway, to meet the supply needs of manufacturing industries in the Illinois area. The major types of industrial chemicals that move in the system are as follows.

*Alcohols* – Ethanol produced using corn as a feedstock is the major type of alcohol that moved in the system. It is responsible for more than 30% of the total tonnage under this category accounting for about 2.5 million tons. The ethanol industry is analyzed as a separate section in this report.

*Sodium Hydroxide* – Also commonly known as caustic soda is used in the pulp and paper industries, textiles, drinking water, and in detergent production. Twenty percent of the industrial chemicals in the Upper Mississippi River/Illinois Waterway systems or 1.6 million tons is caustic soda. The major manufacturers are Dow Chemicals Company located in Freeport, Texas and Plaquemine, Louisiana that produced about 3.7 million tons in 2004, Oxychem, PPG and Olin. Caustic soda is most often handled in solution form dissolved in water, since handling in that form is easier and less expensive.

*Benzene and Toluene* – Benzene is a chemical compound solvent used in the production of drugs, plastics, synthetic rubber, and dyes. Benzene is a derivative from the petrochemical industry and small amounts are produced from coal as well. The US Department of Health and Human Services (HHS) classifies benzene as a carcinogen, as exposure to high levels of benzene in the air can cause leukemia.

*Ammonia* – Ammonia is mainly used as chemical fertilizer to replenish soils and provide nutrients to agricultural crops. The raw material used is mainly natural gas and liquefied petroleum gas.

Several features characteristic to the industrial chemicals industry are:

- Most of the products are hazardous cargo that move in solvent form and require special attention in handling and transportation;
- They will continue to be a vital ingredient, used as an intermediate product in numerous industrial processes; and
- Most of the production is based on the Lower Mississippi and South West Texas, where petroleum refining and natural gas supplies are abundant.

Industrial chemicals are a vital component supporting many industries in the Upper Mississippi River/Illinois Waterway area and the current supply pattern of moving supplies from the south to consumption areas in the Mid West is likely to continue. More regulatory control and security measure are likely to emerge in transportation of these materials to avert terrorist threats of using these products as a weapon to attack or sabotage. The demand for these products will depend on rates of economic growth, industry expansion associated with the general increase in population, and other technological developments.

The industrial chemicals transportation mode shares were not available from any source. The commodity flow survey conducted by the Bureau of Transportation Statistics, however, provided the mode shares for basic chemicals and is presented in **Table 17**. This survey is conducted every 5 years with the most recent in 2002. The next survey will be in 2007 and the data will be available in 2008.

**Table 17: United States Basic Chemicals Movement Transportation Modes**

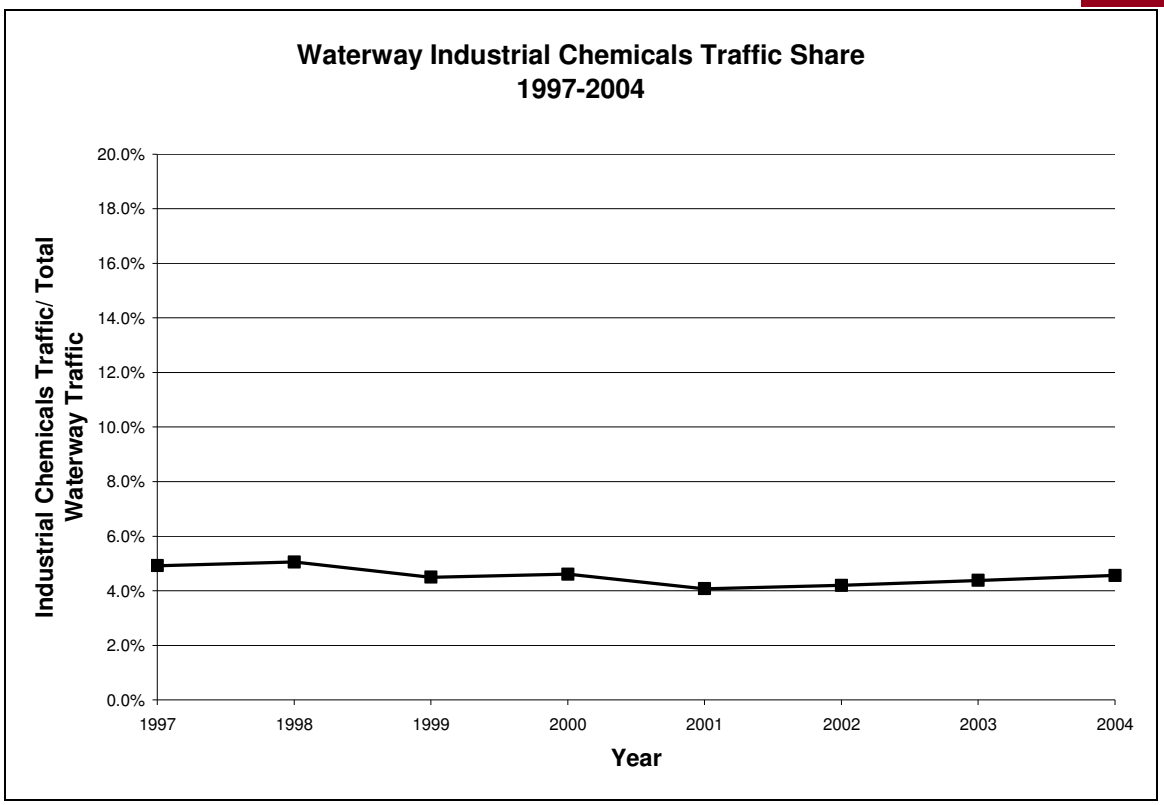
| Mode of transportation | Mode Share | |
|---|---|---|
| | Tons | Ton-Miles |
| **All modes** | **100%** | **100%** |
| Truck | 40% | 27% |
| Rail | 21% | 49% |
| Water | 13% | 13% |
| Pipeline (4) | 23% | |
| Other and unknown modes | 1% | |

(Source: Commodity Flow Survey, 2002, Bureau of Transportation Statistics[23])

## 2.2.2 Industrial Chemicals Waterway Movements Overview

Industrial chemicals comprise many of the chemicals that are used across the Upper Mississippi and Illinois Waterway regions. The waterborne industrial chemicals traffic consisted of about 4.5% of the total cargo[24] that moved in the system (**Figure 21**), with 7.7% of total cargo on the Illinois Waterway, compared to 3.4% on the Upper Mississippi.

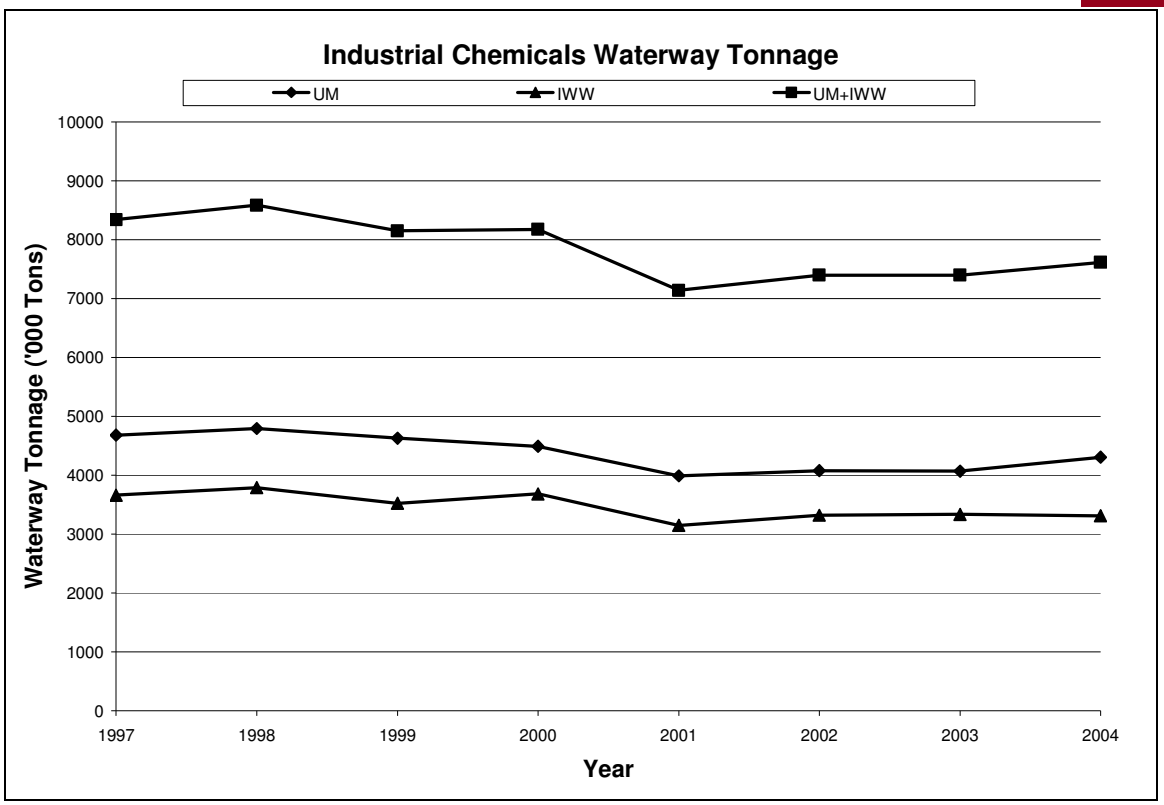
[23] Available from http://www.bts.gov/publications/commodity_flow_survey/2002/united_states/ accessed on April 2, 2007.
[24] Total cargo includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.




(Source: Waterborne Commerce of United States)

**Figure 21: Industrial Chemicals Waterway Traffic Share 1997-2004**

The year-to-year changes in traffic patterns between the two waterways indicate close similarities with a steep drop in tonnage in 2001. **Figure 22** shows the industrial chemicals waterway tonnage for the Upper Mississippi and Illinois waterways. **Table 19** shows the shares of the constituents of these chemicals on the two waterway systems (see **Figure 26** for an illustration).



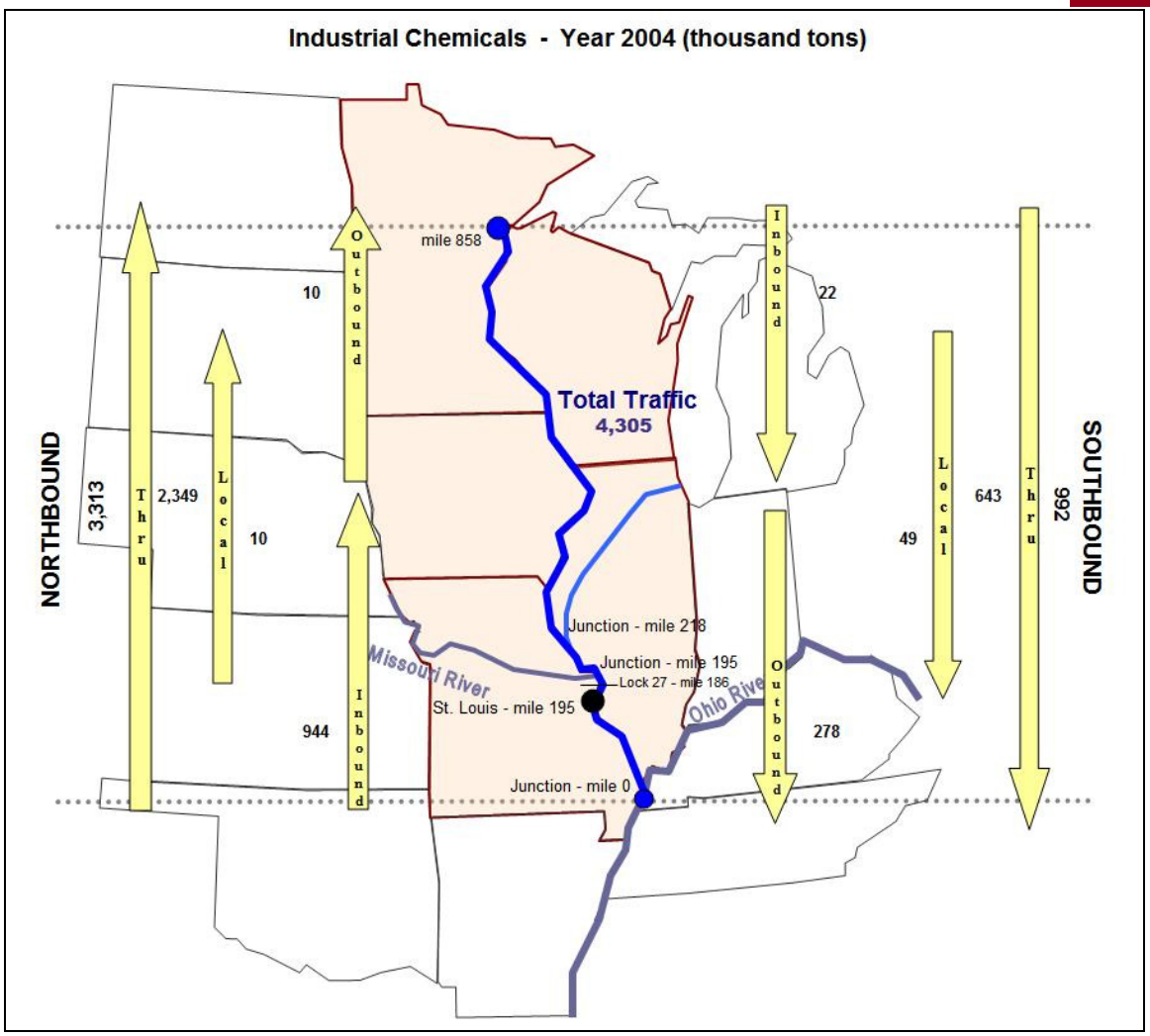

(Source: Waterborne Commerce of United States)

**Figure 22: Industrial Chemicals Waterway Tonnage 1997-2004**

**Table 18: Inbound, Outbound, Local and Through Industrial Chemicals Waterway Movements ('000 Tons)**

| Year | Illinois Waterway | | | | Upper Mississippi | | | |
|---|---|---|---|---|---|---|---|---|
| | Inbound | Outbound | Local | Through | Inbound | Outbound | Local | Through |
| 1997 | 2,522 | 524 | 292 | 324 | 1,046 | 342 | 125 | 3,166 |
| 1998 | 2,750 | 488 | 253 | 298 | 1,086 | 263 | 103 | 3,343 |
| 1999 | 2,627 | 426 | 289 | 183 | 1,148 | 387 | 93 | 2,999 |
| 2000 | 2,751 | 428 | 363 | 141 | 981 | 379 | 77 | 3,055 |
| 2001 | 2,327 | 443 | 295 | 85 | 952 | 301 | 73 | 2,664 |
| 2002 | 2,421 | 494 | 363 | 43 | 913 | 254 | 72 | 2,838 |
| 2003 | 2,337 | 650 | 332 | 15 | 900 | 263 | 78 | 2,825 |
| 2004 | 2,416 | 665 | 211 | 19 | 966 | 288 | 59 | 2,992 |

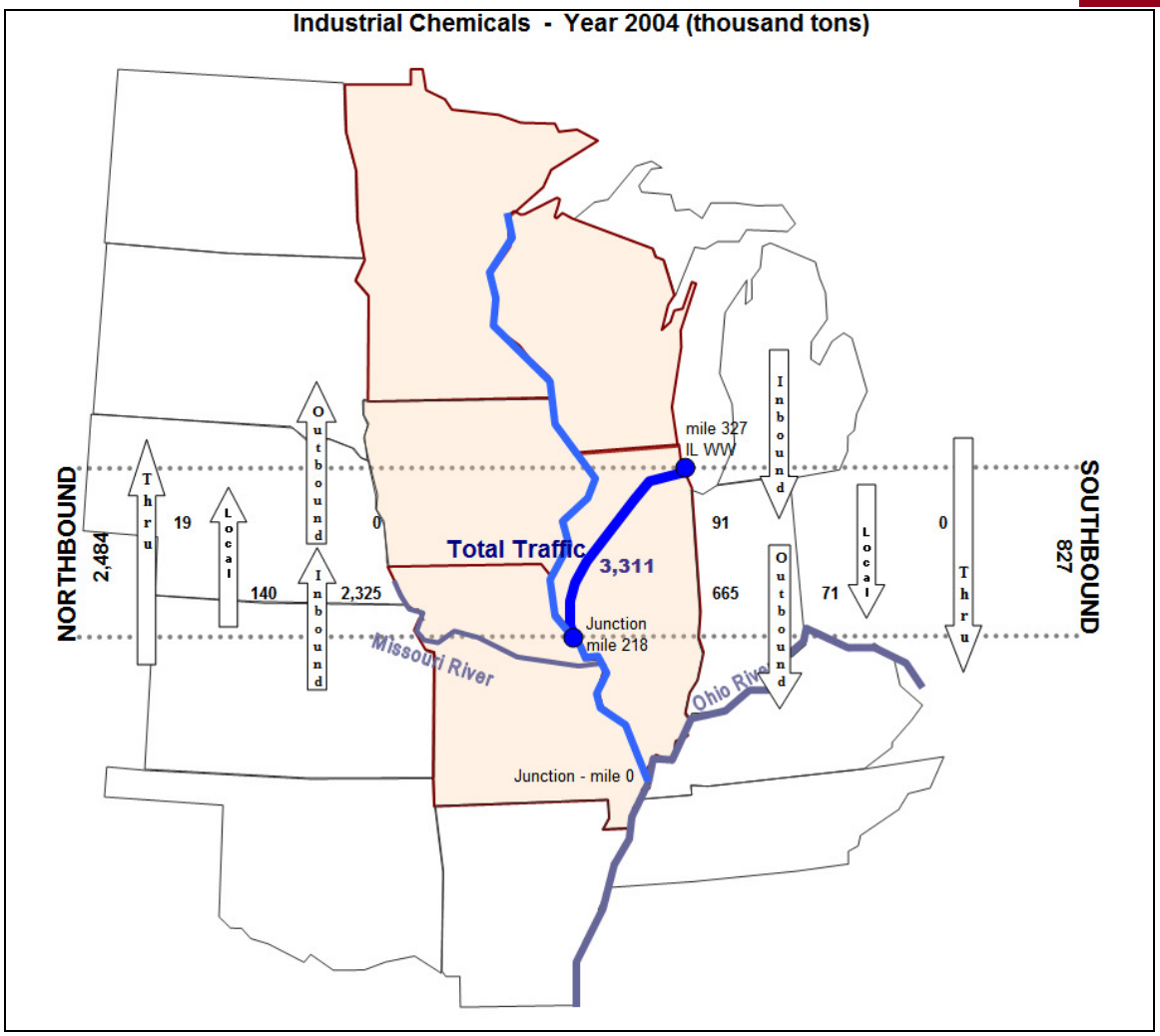
(Source: Waterborne Commerce of United States)




(Source: Waterborne Commerce of United States)

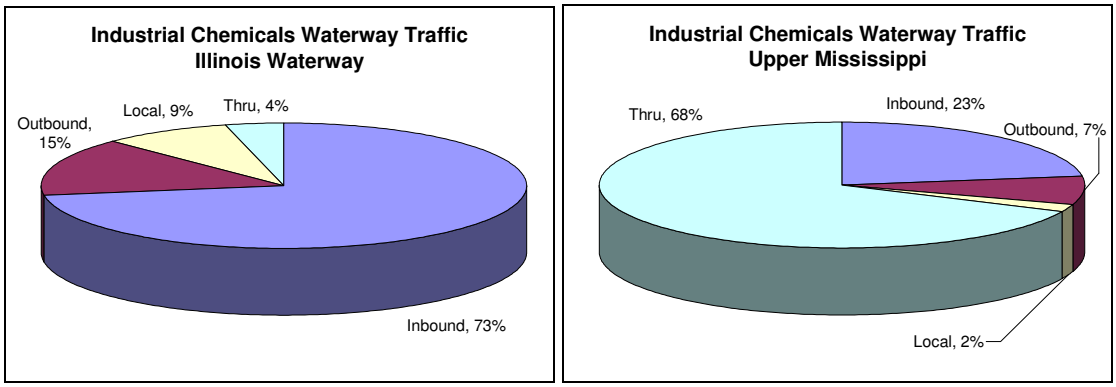
**Figure 23: Upper Mississippi Inbound, Outbound, Local and Through Waterway Movements 2004**

**Table 18** shows the inbound, outbound, local and through traffic on the Upper Mississippi and Illinois Waterway. **Figure 23** and **Figure 24** illustrate these movements for the year 2004. While the *inbound* movements have the largest share for Illinois Waterway (73%), the *through* movements have the largest share for the Upper Mississippi (68%), illustrated in **Figure 25.** This is a strong indication of the fact that the state of Illinois has more industrial activity than the other states in the region. It would thus be appropriate to observe the industrial trends in the US (68% of Upper Mississippi traffic is passing *through* with origin and destinations outside the region) and specifically for Illinois.



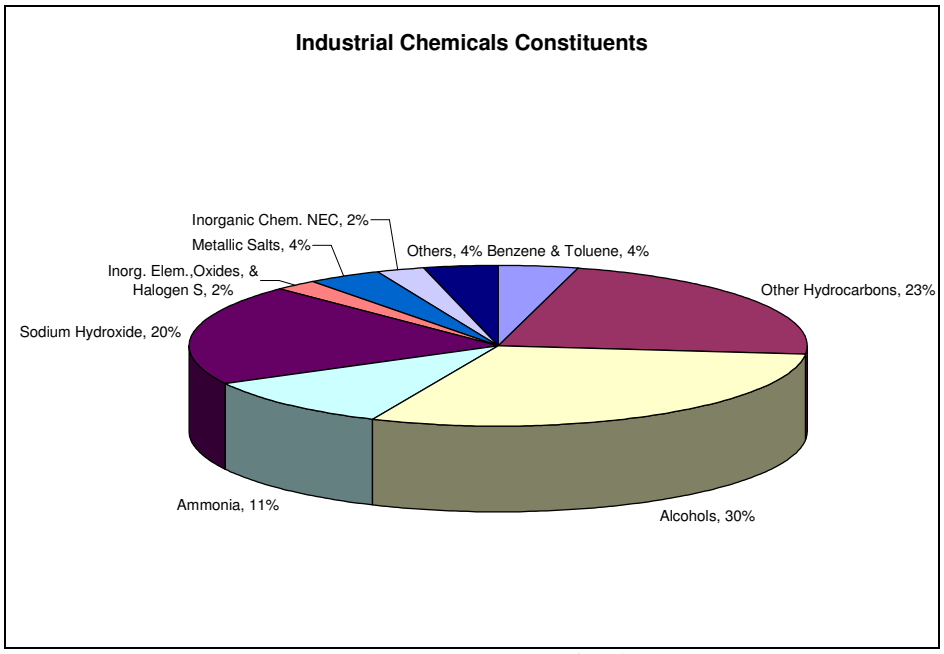

(Source: Waterborne Commerce of United States)

**Figure 24: Illinois Waterway Inbound, Outbound, Local and Through Waterway Movements 2004**




(Note: 1997-2004 Average; Source: Waterborne Commerce of United States)

**Figure 25: Inbound, Outbound, Local, and Through Industrial Chemicals Waterway Shares**




(Source: Waterborne Commerce of United States)

**Figure 26: Industrial Chemicals Constituents Share (1997-2004 Average)**

**Table 19: Industrial chemicals waterway tonnage shares**

| Chemical Name | Share of Each Chemical | | |
|---|---|---|---|
| | UM | IL | UM+IL |
| Acyclic Hydrocarbons | 1% | 1% | 1% |
| Benzene & Toluene | 5% | 3% | 4% |
| Other Hydrocarbons | 20% | 25% | 23% |
| Alcohols | 25% | 34% | 30% |
| Carboxylic Acids | 0% | 0% | 0% |
| Nitrogen Func. Comp. | 0% | 0% | 0% |
| Organic Comp. NEC | 1% | 2% | 1% |
| Sulphuric Acid | 1% | 0% | 0% |
| Ammonia | 12% | 9% | 11% |
| Sodium Hydroxide | 26% | 15% | 20% |
| Inorg. Elem., Oxides, & Halogen S | 2% | 2% | 2% |
| Metallic Salts | 4% | 4% | 4% |
| Inorganic Chem. NEC | 2% | 2% | 2% |
| Plastics | 0% | 0% | 0% |
| Pesticides | 0% | 0% | 0% |
| Starches, Gluten, Glue | 0% | 0% | 0% |
| Chemical Additives | 0% | 0% | 0% |
| Chem. Products NEC | 1% | 1% | 1% |
| **Total Waterway Tonnage** | **35,696** | **38,496** | **74,192** |

(Waterway Tonnage in Million Tons, 1997-2004 Average)
(Source: Waterborne Commerce of United States)

It is evident that Alcohols, Ammonia, and Sodium Hydroxide constitute 63%, 58%, and 61% of the total industrial chemicals tonnage on the UM, IWW and combined waterways, respectively. Benzene and Metallic salts constitute another 8-9% of the total industrial chemicals tonnage in the UM and IWW waterway systems.

**Table 21** and **Table 22** show the Industrial Chemicals Waterway Tonnage origins and destinations in different states from 1994-2004. Illinois appears to be a clear leader in shipping industrial chemicals over the waterway systems with 95% of the tonnage originating in the five states (IA, IL, MN, MO, and WI). It commands 81% of the industrial chemicals tonnage destined for the five states. Missouri has an 11% share.

A high share tonnage for Illinois is mainly due to high industrial activity in the state and greater accessibility to the waterway compared to the other states in the Upper Mississippi and Illinois Waterway region. The following observations are made in this regard:

- The state of Illinois (including non-urban regions) has greater accessibility to both the waterways as the Upper Mississippi flows towards the west of the state and the Illinois Waterway passes through the center of the state.

- The Illinois Waterway is easily accessible from the highly industrial Chicago region.

- Illinois has much higher industrial activity than the other states. **Table 20** shows that Illinois has a very high share of GDP and manufacturing establishments among the other states in the region.

**Table 20: Economic Indicators (1997-2005 Average)**

| State | GDP Share (Total) | GDP Share (Manufacturing) | Manufacturing Establishments |
|---|---|---|---|
| **Illinois** | **50%** | **46%** | **47%** |
| Iowa | 10% | 14% | 11% |
| Minnesota | 20% | 19% | 23% |
| Missouri | 19% | 21% | 20% |
| Total[25] | 100% | 100% | 100% |

(Source: US Census Bureau)

Based on the above observations, it was found appropriate to use Illinois statistics as an indicator for the industrial chemicals waterway shipments and, thus, the forecast methodology would concentrate on industrial data for Illinois and the US.

[25] The total may not exactly add to 100% due to rounding of individual state shares to the nearest integer.

**Table 21: Industrial Chemicals Waterway Tonnage for each Destination State ('000 Tons)**

| DEST | 1994 | 1995 | 1996 | 1997 | 1998 | 2000 | 2001 | 2002 | 2003 | 2004 | Total | Share |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA | 59,278 | 90,550 | 98,850 | 112,246 | 120,363 | 123,155 | 106,383 | 116,190 | 91,421 | 124,677 | 1,009,636 | 3% |
| IL | 2,836,719 | 2,721,081 | 3,046,241 | 3,106,473 | 3,227,937 | 3,274,546 | 2,833,148 | 3,017,496 | 2,829,368 | 2,965,313 | 28,389,898 | 81% |
| MN | 197,162 | 153,004 | 135,696 | 156,036 | 149,693 | 201,191 | 130,819 | 132,795 | 127,558 | 105,156 | 1,386,182 | 4% |
| MO | 535,733 | 534,936 | 508,655 | 516,002 | 513,866 | 445,001 | 414,840 | 305,463 | 273,152 | 318,439 | 3,997,064 | 11% |
| WI | 22,997 | 22,700 | 36,972 | 39,326 | 29,738 | 21,125 | 19,420 | 23,903 | 11,865 | 22,136 | 230,909 | 1% |
| Grand Total | 3,651,889 | 3,522,271 | 3,826,414 | 3,930,083 | 4,041,597 | 4,065,018 | 3,504,610 | 3,595,847 | 3,333,364 | 3,535,721 | 35,013,689 | |

(Source: Waterborne Commerce Statistics Center)

**Table 22: Industrial Chemicals Waterway Tonnage for each Origin State ('000 Tons)**

| ORIGIN | 1994 | 1995 | 1996 | 1997 | 1998 | 2000 | 2001 | 2002 | 2003 | 2004 | Total | Share |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA | 92,589 | 67,924 | 36,784 | 32,510 | 39,104 | | | 24,493 | 33,712 | | 273,721 | 3% |
| IL | 1,476,409 | 1,299,601 | 1,207,906 | 1,282,020 | 1,107,452 | 1,175,975 | 848,325 | 1,062,772 | 886,117 | 772,322 | 10,242,522 | 95% |
| MN | | 20 | 223 | 82 | 199 | | | | | 26,796 | 32,597 | 0% |
| MO | 41,699 | 44,817 | 35,741 | | 8,912 | | 20,149 | | 7,971 | | 129,739 | 1% |
| WI | 4,887 | 202 | 55 | 767 | 254 | 117,673 | 35,861 | | | | 159,824 | 1% |
| Grand Total | 1,615,584 | 1,412,564 | 1,280,709 | 1,315,379 | 1,155,921 | 1,293,648 | 904,335 | 1,087,265 | 927,800 | 799,118 | 10,838,403 | |

(Source: Waterborne Commerce Statistics Center)

**Table 23: Regression Variables 1997-2004**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| Upper Mississippi ('000 Tons) | 3,638 | 3,729 | 3,545 | 3,510 | 2,958 | 3,000 | 2,934 | 3,043 |
| Illinois Waterway ('000 Tons) | 2,486 | 2,609 | 2,289 | 2,480 | 2,013 | 2,084 | 2,060 | 2,129 |
| Both Waterways ('000 Tons) | 6,124 | 6,338 | 5,834 | 5,990 | 4,971 | 5,084 | 4,994 | 5,172 |
| Industrial Production (IL) | 100.0 | 106.2 | 110.4 | 114.5 | 107.9 | 107.5 | 107.1 | 111.0 |
| Industrial Production (US) | 100.0 | 105.9 | 110.6 | 115.4 | 111.5 | 110.9 | 111.2 | 114.0 |
| US GDP (Million $) | 8,237,994 | 8,679,657 | 9,201,138 | 9,749,103 | 10,058,168 | 10,398,402 | 10,896,356 | 11,655,335 |
| IL GDP (Million $) | 403,982 | 423,855 | 443,751 | 464,194 | 476,461 | 487,129 | 509,161 | 533,735 |

(Source: Industrial Production: Federal Reserve; US GDP: US Congressional Budget Office; IL GDP: Illinois Department of Commerce; Water Traffic: WCUS)

### 2.2.3 Forecasting Methodology

Based on the industry trends, we expect that the change in Ethanol tonnage would be different than other industrial chemicals. This trend coupled with the fact that Ethanol is the single largest constituent of industrial chemicals we found it appropriate to forecast Ethanol separately. Two models were thus developed, one for Ethanol and the other for the remaining industrial chemicals together. The alcohols reported by the Waterborne Commerce of the US as a constituent of Industrial chemicals on the waterway system is primarily composed of Ethanol. Ethanol is used interchangeably with alcohol in this section.

**Industrial Chemicals without Alcohols**

Since industrial chemicals are an input and output of the industries in the region, it would be appropriate to consider the Industrial Production as an indicator of industrial chemicals waterway traffic. **Figure 27** shows the modeling concept for industrial chemicals.

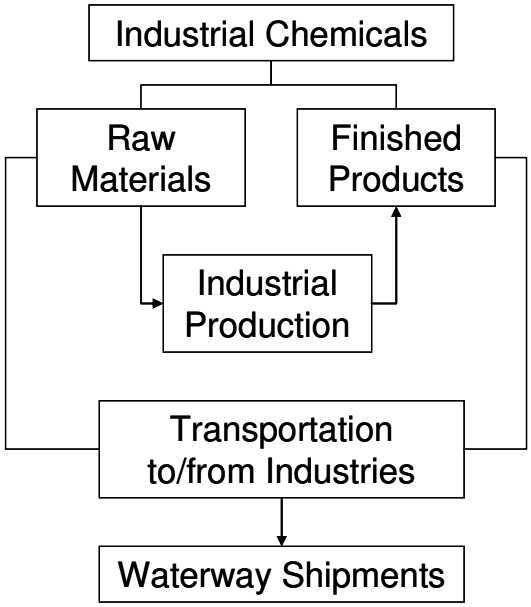



**Figure 27: Conceptual Model for Industrial Chemicals**

Industrial Production measures physical output of the nation's (or a state's) factories, mines, and utilities. The data is converted to an index equal to 100 in 1997 (earlier year used was 1992). Therefore, an Industrial Production index of 107.5 in 2002 indicates that overall production is 7.5% greater than it was in 1997. **Table 23** (and **Figure 28**) shows this index from 1997 – 2004 for US and Illinois.

(Source: IL: Illinois Department Commerce and Economic Activity[26]; US: Federal Reserve[27])

**Figure 28: Industrial Production for United States and Illinois, 1997-2004**

US and Illinois GDP were used as an indicator of the economic activity in the nation and the state. The impacts of other regional states were, however, found statistically insignificant during the regression analysis. Only Illinois statistics are used in the regression as it carries the maximum share of industrial chemicals waterway traffic. The resulting regression equations are given below:

| | | | |
|---|---|---|---|
| **UM+IWW Barge Traffic =** | **8353 –** | **276.2 (Ind. Prod US) +** | **276.34 (Ind. Prod IL)** |
| (Std Error) | (1659) | (35.6) | (41.1) |
| *t-statistic* | | *-7.75* | *6.73* |
| $R^2$ | 0.93 | | |

| | | | |
|---|---|---|---|
| **UM Barge Traffic =** | **4780 –** | **165.6 (Ind. Prod US) +** | **164.7 (Ind. Prod IL)** |
| (Std Error) | (808) | (17.4) | (20.0) |
| *t-statistic* | | *-9.54* | *8.23* |
| $R^2$ | 0.95 | | |

[26] Available from http://www2.illinoisbiz.biz/bus/research/econ/indicators/showIndicator.asp?Indicator=7 accessed on March 23, 2007.
[27] Available from http://www.federalreserve.gov/releases/G17/Current/table11.txt accessed on March 23, 2007.

*Barge Traffic is in '000 Tons*
*US Industrial Production Index is based on 1997=100*
*Illinois Industrial Production Index is based on 1997=100*

The regression equation shows that the Upper Mississippi and Illinois Waterway traffic increases with increases in industrial production in Illinois. This is intuitive because an increased industrial production would require more input industrial chemicals and would also produce more output industrial chemicals, which would result in an increase in the waterway traffic. The regression also shows that the waterway traffic reduces with an increase in US industrial production. The following key observations are made in this regard:

- The negative impact of US industrial production is primarily due to restructuring of the petrochemical industry. Most of the inter-regional traffic is induced by the exchange of ingredients between different plants as well as by end user consumption. The current trend, however, is to expand the processing capabilities at existing plants to produce a broader range of products. The industrial chemicals shipments have thus become more localized.

- US industrial production includes industrial production in Illinois. A negative sign discounts the double (positive) impact of Illinois industrial production in the regression equation.

- An increase in industrial production in non-Illinois states would not increase the industrial chemicals requirement/output for industries in the upper Mississippi and Illinois Waterway region.

The next step was to calculate the Illinois Waterway forecasted waterway traffic by subtracting the Upper Mississippi forecasted values from the combined waterways' forecasted values.

The complete forecasting procedure is outlined below.

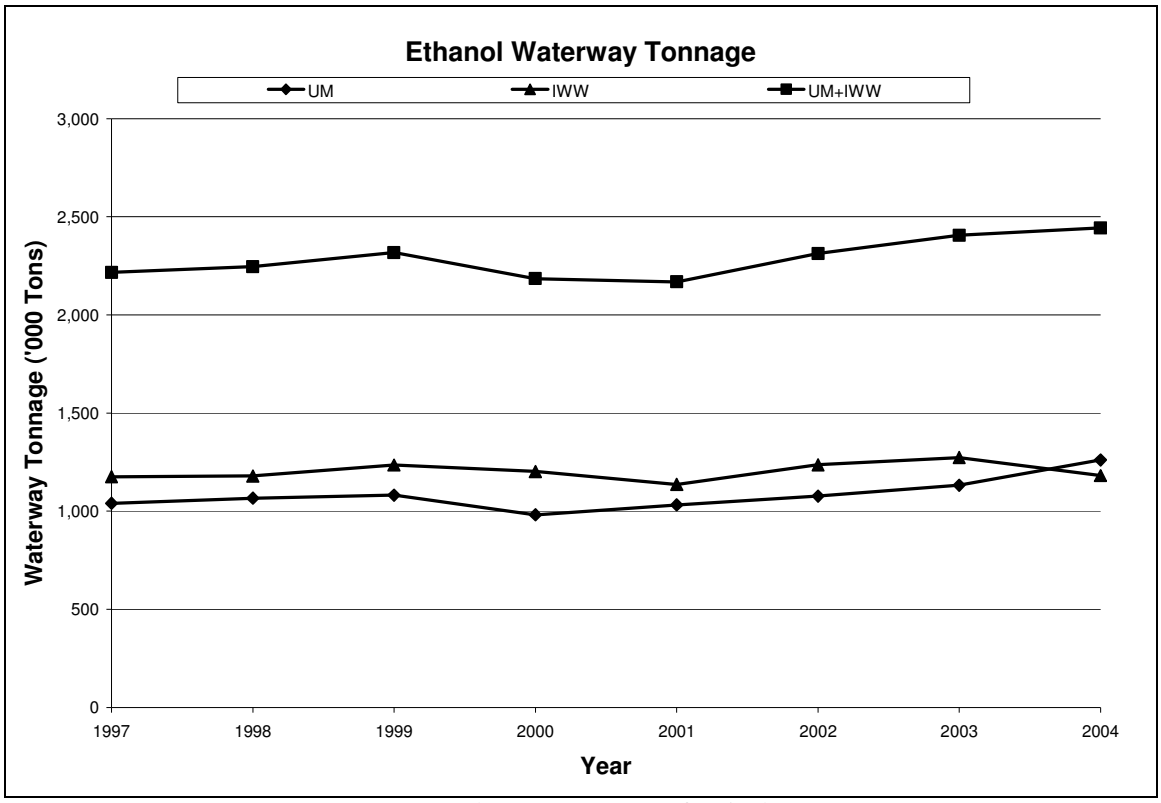
- Step 1: Forecast the UM + IWW waterway combined industrial chemicals (without alcohols) barge traffic using the regression equation given above. (This would need forecasted values for US and Illinois industrial production).

- Step 2: Forecast the UM waterway industrial chemicals (without alcohols) barge traffic using the regression equation given above. (This would need forecasted values for US and Illinois industrial production).

- Step 3: Determine the IWW waterway industrial chemicals barge traffic by subtracting the value obtained in Step 2 from the value obtained in Step 1.

### Ethanol

Ethanol constitutes 30% of the Upper Mississippi and Illinois Waterway Industrial Chemicals tonnage and is the largest single constituent of this commodity. **Figure 29** shows the Ethanol waterway tonnage for the Upper Mississippi and Illinois waterways.




(Source: Waterborne Commerce of United States)

**Figure 29: Ethanol Waterway Tonnage 1997-2004**

Ethanol waterway traffic is expected to be related to the Ethanol production in the mid-western and Great Plains states (corn-belt). **Table 24** shows the Ethanol traffic and production. The next step is to develop regression relationships between the barge traffic and ethanol production.

**Table 24: Ethanol Waterway Tonnage and Production**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| UM ('000 Tons) | 1041 | 1066 | 1082 | 982 | 1032 | 1077 | 1132 | 1262 |
| IWW ('000 Tons) | 1176 | 1180 | 1236 | 1203 | 1137 | 1237 | 1274 | 1182 |
| UM+IWW ('000 Tons) | 2217 | 2246 | 2318 | 2185 | 2169 | 2314 | 2406 | 2444 |
| 5 State Population ('000) | 30,588 | 30,808 | 31,045 | 31,224 | 31,416 | 31,609 | 31,801 | 31,994 |
| Ethanol (Million Gallons) | 1,300 | 1,400 | 1,470 | 1,630 | 1,770 | 2,310 | 2,810 | 3,410 |

(Source: Ethanol Industry Outlook, 2006 Renewable Fuels Association; Waterway Traffic: Waterborne Commerce of United States)

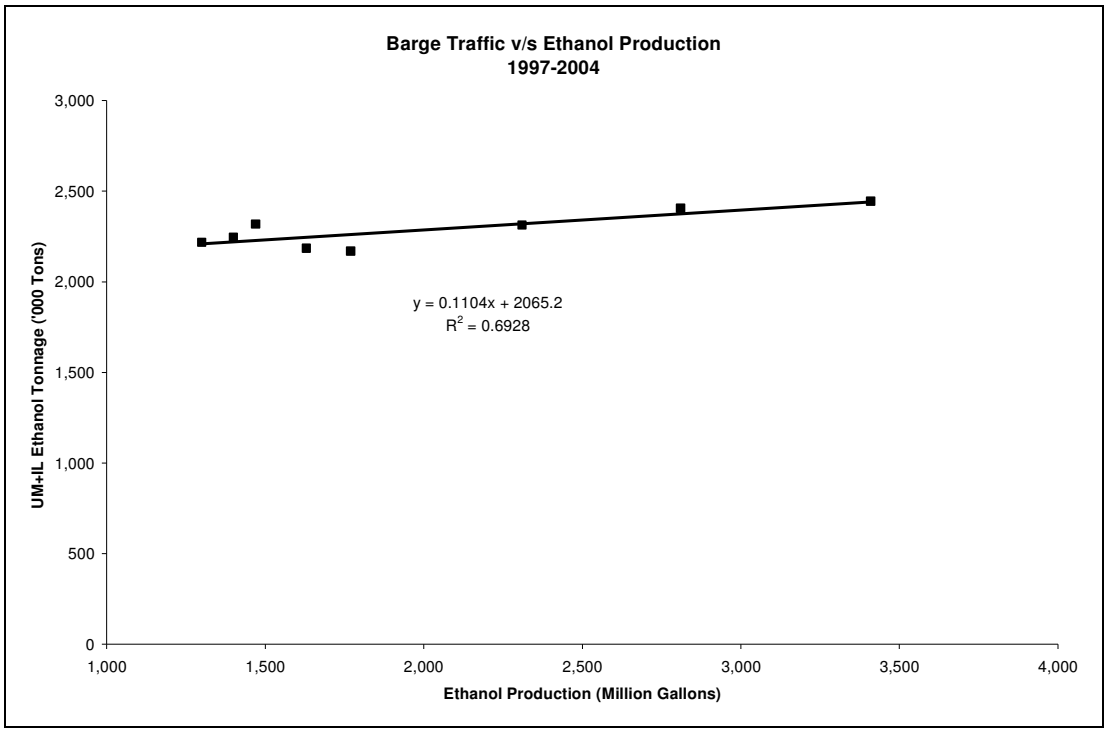



**Figure 30: Linear Relationship between Ethanol Barge Traffic and Production**

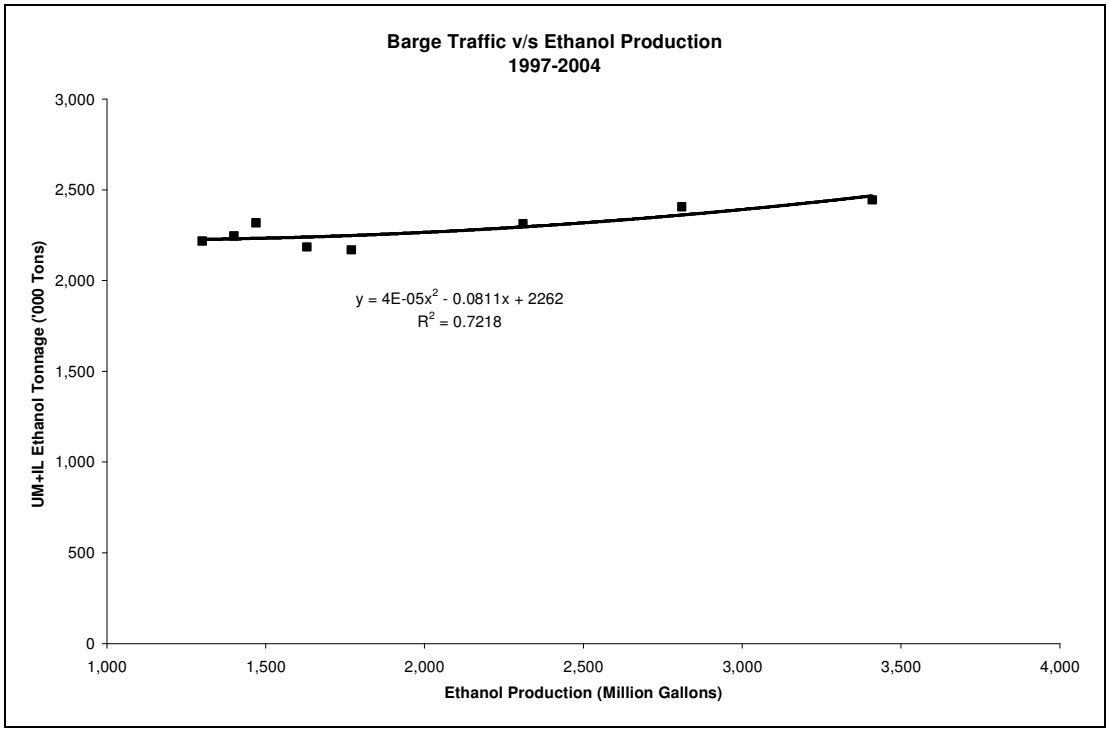



**Figure 31: Quadratic Relationship between Ethanol Barge Traffic and Production**

**Figure 30** and **Figure 31** show the linear and quadratic relationships between Ethanol barge traffic and the US Ethanol production fitted to the 1997-2004 data. Since, both the relationships result in similar $R^2$ values it was found reasonable to use the linear relationship because of its simplicity. Therefore, the following equation would be used to determine Ethanol barge tonnage from US Ethanol production[28]:

| | | | |
|---|---|---|---|
| **UM+IWW Ethanol Barge Traffic =** | **6356 +** | **0.1949 (US Ethanol Production)** | **- 0.1425 (5-ST Population)** |
| (Std Error) | (3678) | (0.07812) | (0.1221) |
| *t-statistic* | | *2.50* | *-1.17* |
| $R^2$ | 0.69 | | |

| | | | |
|---|---|---|---|
| **UM Ethanol Barge Traffic =** | **5855 +** | **0.1911 (US Ethanol Production)** | **- 0.1646 (5-ST Population)** |
| (Std Error) | (2443) | (0.0519) | (0.0811) |
| *t-statistic* | | *3.68* | *-2.03* |
| $R^2$ | 0.85 | | |

*Barge Traffic is in '000 Tons*
*US Ethanol Production is in Million Gallons*
*5 ST (IL, IA, MN, MO, WI) Population is in '000 Persons*

The regression shows that the Barge traffic increases with an increase in the Ethanol production in the United States. This is intuitive because ethanol would need to be shipped from the production to the consumption sectors. The production sector is what has been traditionally called the "corn belt" comprised of the Midwestern states. The consumption sector is the entire US (and international trade) and the Upper Mississippi and Illinois Waterway are the primary water transport options. The 5-State population is a proxy for the ethanol consumption in the region. The negative sign for its coefficient has two possible reasons:

- Waterway transportation is primarily used for long distances, while shorter distances are transported primarily using trucks. Local ethanol consumption using non-waterway modes reduces the amount of ethanol production going through the waterways.

- Ethanol production and consumption are inter-related as the production would depend on consumption and vice versa. The US Ethanol Production already includes the impact of the 5-State region. The 5-State Population variable refines the impact of this region on the waterway forecast by providing a dampening affect.

The next step was to calculate the Illinois Waterway forecasted waterway traffic by subtracting the Upper Mississippi forecasted values from the combined waterways' forecasted values.

[28] We studied the location of existing and new Ethanol production facilities in the US as given in the Wilson Report. The facilities located closer to the Upper Mississippi River are expected to use the waterway system, while others would use other waterways or modes. We assume that there will be no structural shift in the percentage of Ethanol production facilities using the Waterways.

The complete forecasting procedure is outlined below.

- Step 1: Forecast the UM + IWW waterway combined ethanol barge traffic using the regression equation given above. (This would need forecasted values for US ethanol production).

- Step 2: Forecast the UM waterway ethanol barge traffic using the regression equation given above. (This would need forecasted values for US ethanol production and 5-state population).

- Step 3: Determine the IWW waterway ethanol barge traffic by subtracting the value obtained in Step 2 from the value obtained in Step 1.

### 2.2.4 Industrial Chemicals Forecast

This section presents LBG scenarios for the unconstrained forecast of industrial chemicals movement on the upper Mississippi and Illinois waterways.

- The US industrial production annual growth rate will be assumed to remain stable at 2.8%.

- The Illinois industrial production annual growth rate would remain stable from 2010 onwards at 3%. It follows the forecast obtained from Illinois Department of Commerce and Economic Activity until 2010.

**Industrial Chemicals without Ethanol**

To forecast the industrial chemicals unconstrained waterway tonnage using the regression equation developed in the previous section we need to forecast the values of Industrial Production index for US and Illinois.

The US industrial production index projections are not available from the Federal Reserve or the Illinois Department of Commerce. Projected value for 2014 was available from the Bureau of Labor Statistics and is given in **Table 25**. This value, however, does not appear to be reasonable as it corresponds to an annual growth rate of 4.1% from 2006-2014, which is much greater than the annual growth rates for the previous 10 and 20 years. Since, there is no reason to believe that the US economy and the industrial production would grow at a substantially higher rate (4.1% compared to 2.8%) we have used the annual growth rate for industrial production as 2.8%.

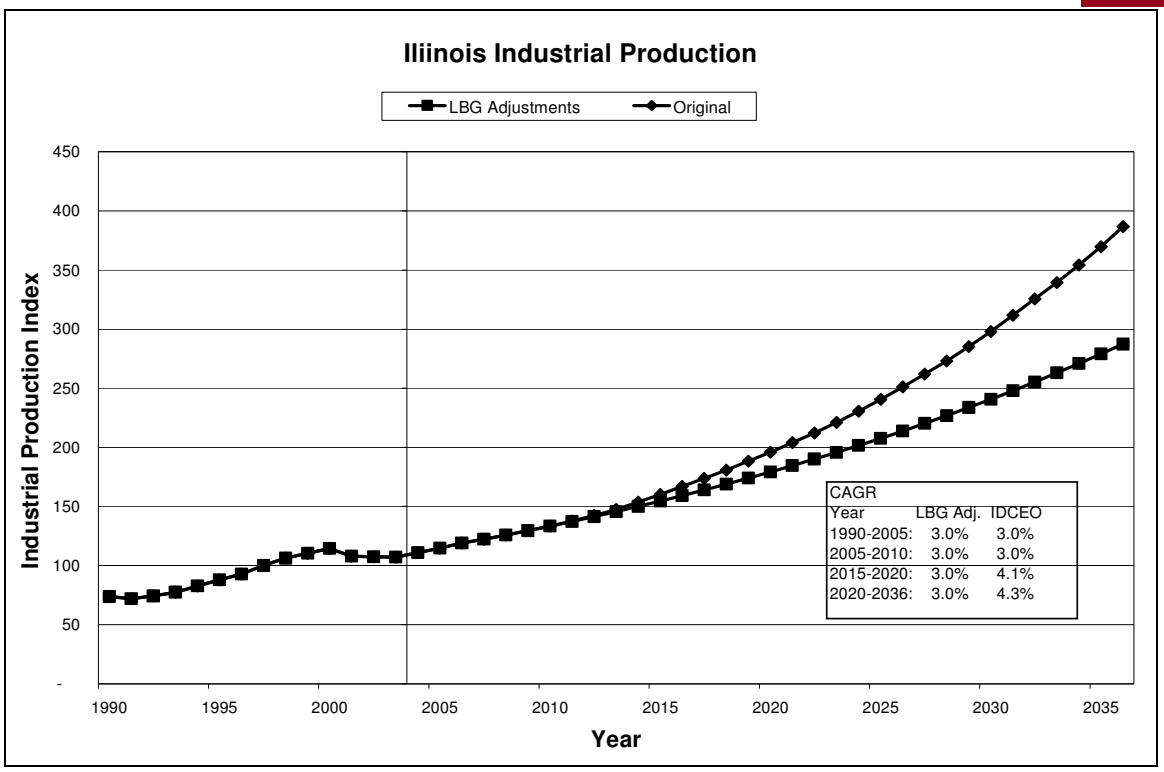
**Table 25: US Industrial Production Index 1984-2006[29]**
**(1997=100)**

| Year | Ind. Prod. | Change | Year | Ind. Prod. | Change |
|---|---|---|---|---|---|
| 1984 | 67.3 | 9.1% | 1996 | 93.1 | 4.3% |
| 1985 | 68.2 | 1.3% | 1997 | 100.0 | 7.4% |
| 1986 | 68.8 | 1.0% | 1998 | 105.9 | 5.9% |
| 1987 | 72.3 | 5.0% | 1999 | 110.6 | 4.4% |
| 1988 | 75.9 | 5.0% | 2000 | 115.4 | 4.4% |
| 1989 | 76.6 | 0.9% | 2001 | 111.5 | -3.4% |
| 1990 | 77.3 | 0.9% | 2002 | 110.9 | -0.6% |
| 1991 | 76.1 | -1.5% | 2003 | 111.2 | 0.3% |
| 1992 | 78.2 | 2.8% | 2004 | 114.0 | 2.5% |
| 1993 | 80.8 | 3.3% | 2005 | 117.6 | 3.2% |
| 1994 | 85.2 | 5.4% | 2006 | 122.3 | 4.0% |
| 1995 | 89.3 | 4.8% | | | |
| | | | | | |
| 1996-2006 | | 2.8% | | | |
| 1986-2006 | | 2.9% | | | |
| 2014 (BLS)[30] | 168.5 | 4.1% | | | |

(Source: US Federal Reserve, Bureau of Labor Statistics, 2005)

The Illinois industrial production index projections were available from the Illinois Department of Commerce and Economic Opportunity. The forecasts were prepared by Global Insight and are presented in **Figure 32**. The Cumulative Annual Growth Rates for the years 1990-2000 and 1990-2005 were 4.5% and 3.1%, respectively. The forecasted growth rates for 2006-2036 by Global Insight seem to be high considering these historical trends in Illinois industrial production and the fact that no radical changes are expected in Illinois industrial activity in the future. We have thus assumed that the Illinois industrial production annual growth rate would remain stable from 2010 onwards at 3%. **Figure 32** also shows the LBG adjusted Illinois industrial production.

[29] US Ind. Prod. Available from http://www.federalreserve.gov/releases/G17/Current/table11.txt accessed on January 25, 2007.
[30] Bureau of Labor Statistics Projection, 2005 available from http://www.bls.gov/emp/empmacagg99.pdf accessed on January 25, 2007.

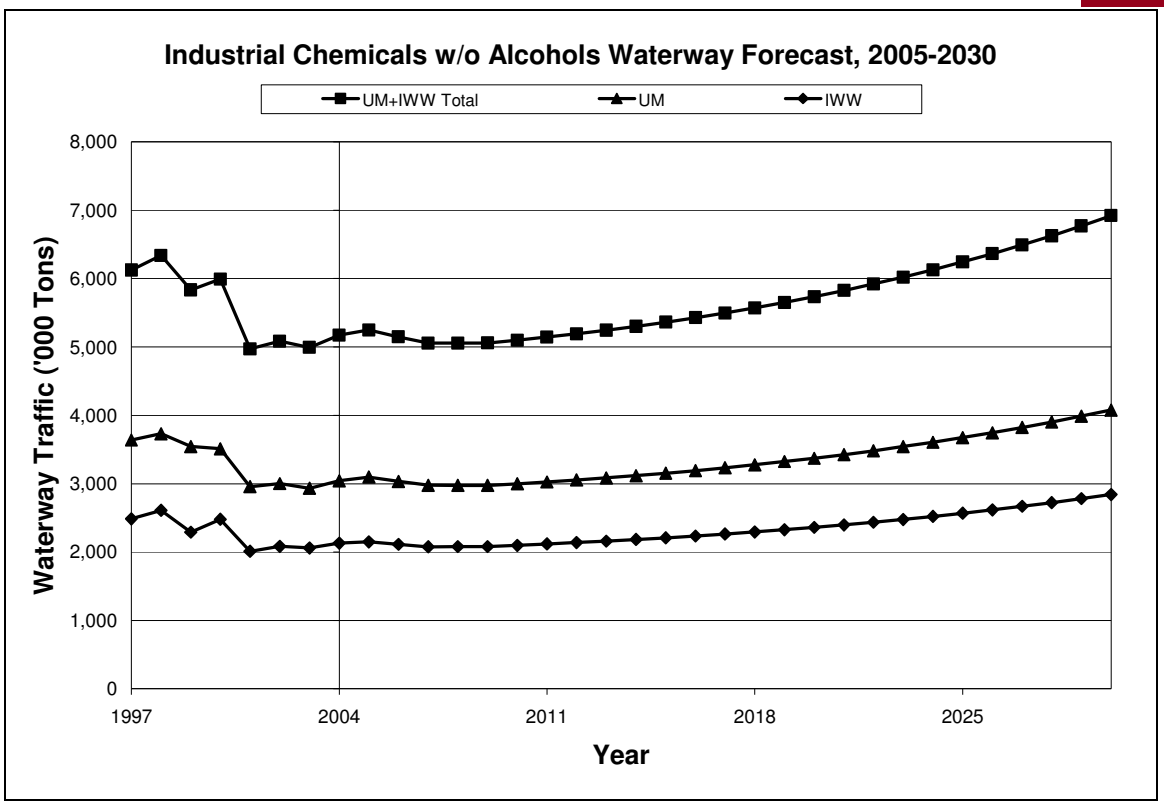



(Source: LBG Adjustments with forecast data from IL Department of Commerce and Economic Opportunity (IDCEO) Prepared by: Global Insight, 2006)

**Figure 32: Illinois Industrial Production Forecast 2006-2036**

The industrial chemicals waterway traffic forecast model developed in the previous section was used to forecast the total Upper Mississippi and Illinois Waterway combined traffic for all industrial chemicals without alcohols. The results are presented in **Figure 33**.

The forecasts show that the waterway tonnage remains stable until 2010 with then moderately increasing trend onwards.




(Source: LBG Analysis)

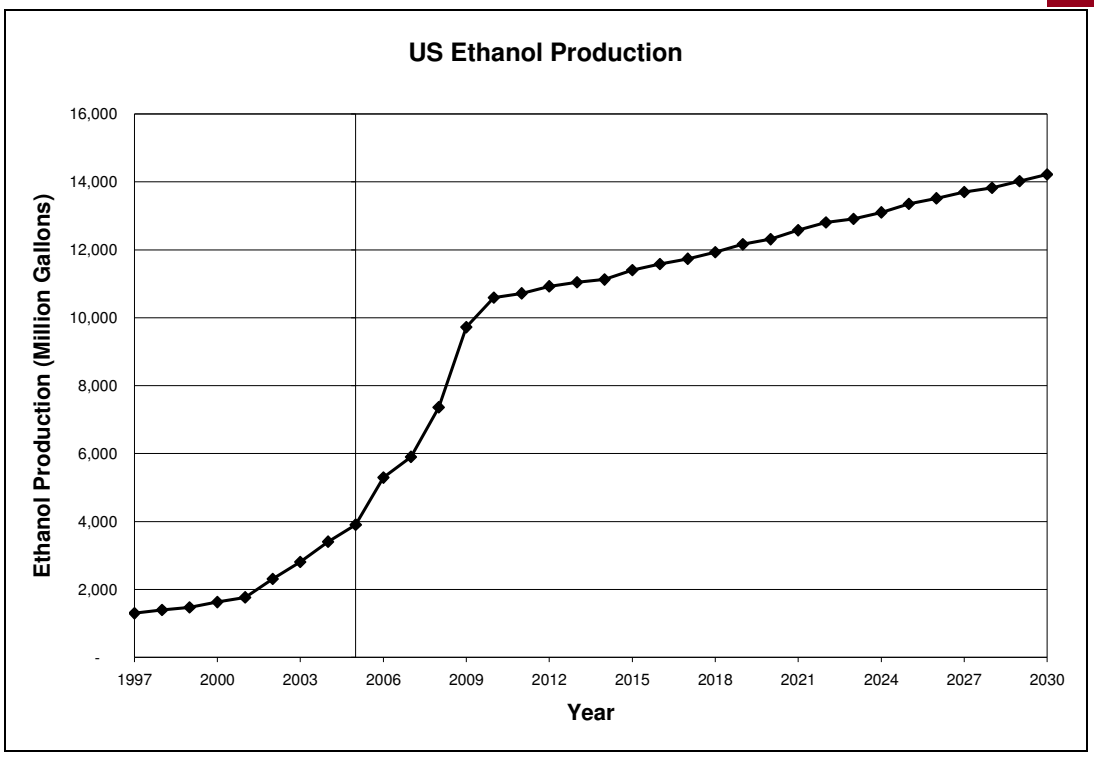
**Figure 33: Industrial Chemicals w/o Alcohols Unconstrained Waterway Traffic Forecast 2006-2036**

### Ethanol

Unconstrained waterway traffic for Ethanol is forecasted next based on the model developed in the previous section. The model was based on US Fuel Ethanol production, which was obtained from the Energy Information Administration, US Department of Energy (2007). The fuel Ethanol production forecasted growth rates for years 2006-2030 were also obtained from the same source. The Five State Population for years 2006-2030 was obtained from the Interim State Population Projections, 2005 prepared by the US Census Bureau.

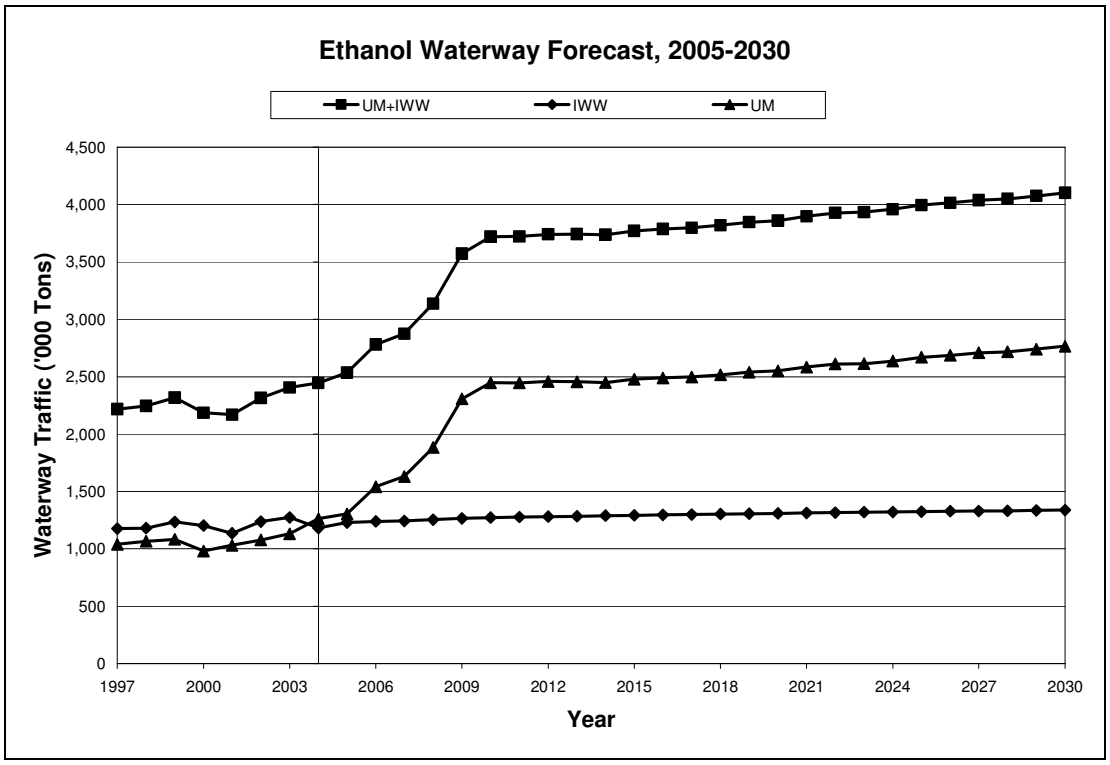
The Ethanol production in Million Gallons is presented in **Figure 34**. It shows a rapid increase in Ethanol production up to 2009 and then the growth stabilizes to approximately 1% per year. The resulting LBG model forecasts for the upper Mississippi and Illinois Waterway traffic also shows a similar trend and is illustrated in **Figure 35**. The ethanol waterway forecast numbers are given in **Table 26**.

**Figure 37** shows in addition to the total industrial chemicals traffic also the traffic on Upper Mississippi and Illinois Waterway separately. Both the waterways show an increase in industrial chemicals tonnage for the Upper Mississippi and Illinois Waterway. **Table 28** shows the annual growth rates for the waterway traffic from 1997-2055 and **Table 27** shows all the data used in the LBG base case forecast for industrial chemicals.




(Source: Energy Information Administration Annual Energy Outlook 2007 Forecast Tables)

**Figure 34: US Ethanol Production Forecast 2006-2030**




(Source: LBG Analysis)

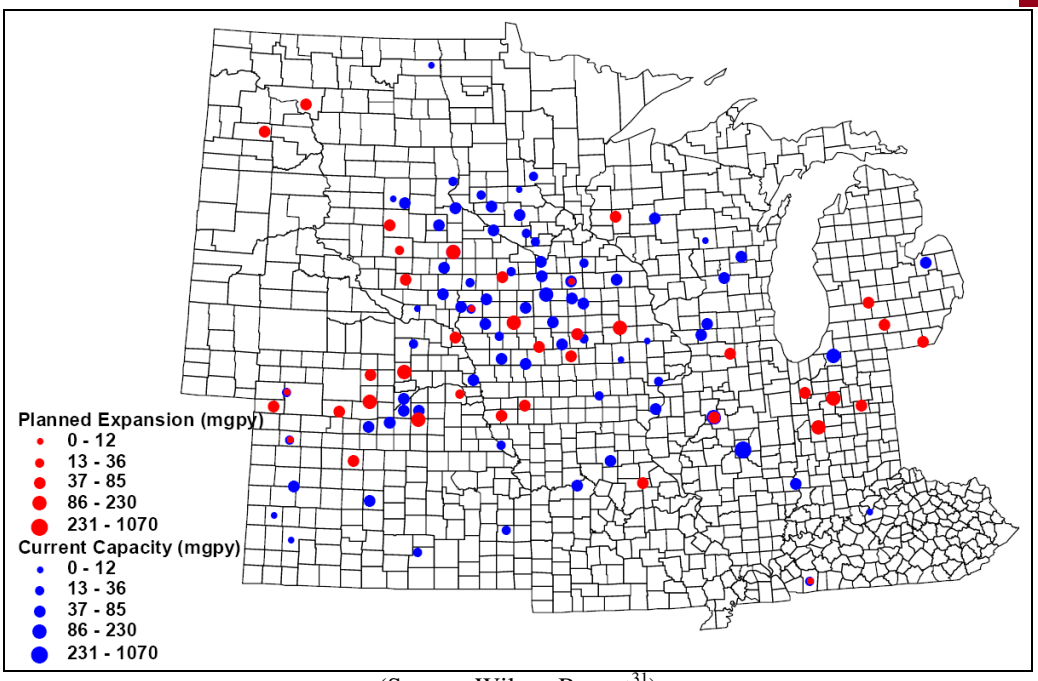
**Figure 35: Ethanol Unconstrained Waterway Traffic Forecast 2005-2055**

**Table 26: Ethanol Unconstrained Waterway Forecasts: LBG Base Case Scenario Results**

| Year | Ethanol Production (EIA) | 5 State Population | UM+IWW Total | UM Total | IWW Total |
|---|---|---|---|---|---|
| | Million Gallons | '000 Persons | 000 Tons | 000 Tons | 000 Tons |
| 1997 | 1,300 | 30,588 | 2,217 | 1,041 | 1,176 |
| 1998 | 1,400 | 30,808 | 2,246 | 1,066 | 1,180 |
| 1999 | 1,470 | 31,045 | 2,318 | 1,082 | 1,236 |
| 2000 | 1,630 | 31,224 | 2,185 | 982 | 1,203 |
| 2001 | 1,770 | 31,416 | 2,169 | 1,032 | 1,137 |
| 2002 | 2,310 | 31,609 | 2,314 | 1,077 | 1,237 |
| 2003 | 2,810 | 31,801 | 2,406 | 1,132 | 1,274 |
| 2004 | 3,410 | 31,994 | 2,444 | 1,262 | 1,182 |
| 2005 | 3,904 | 32,167 | 2,534 | 1,305 | 1,229 |
| 2006 | 5,294 | 32,340 | 2,780 | 1,542 | 1,238 |
| 2010 | 10,596 | 32,997 | 3,721 | 2,447 | 1,273 |
| 2015 | 11,402 | 33,744 | 3,771 | 2,478 | 1,293 |
| 2020 | 12,311 | 34,363 | 3,860 | 2,550 | 1,310 |
| 2025 | 13,352 | 34,846 | 3,994 | 2,670 | 1,325 |
| 2030 | 14,218 | 35,275 | 4,102 | 2,765 | 1,337 |
| 2035 | | | 4,190 | 2,849 | 1,341 |
| 2040 | | | 4,272 | 2,933 | 1,340 |
| 2045 | | | 4,332 | 2,999 | 1,334 |
| 2050 | | | 4,387 | 3,063 | 1,325 |
| 2055 | | | 4,434 | 3,125 | 1,311 |

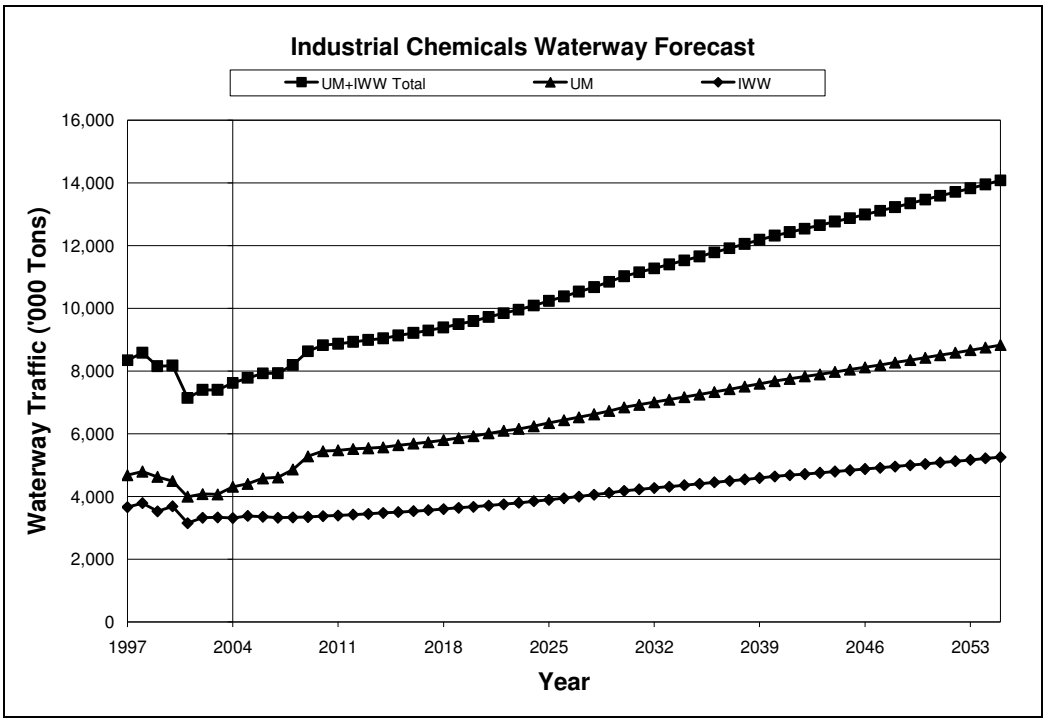
(Source: LBG Analysis)

The Ethanol unconstrained forecasts show a rapid increase for the Upper Mississippi from 2005-2010, while the tonnage on Illinois Waterway remains stable throughout the forecast period. The primary reason for this is the ethanol production locations in the region. **Figure 36** shows that there are only a few ethanol production locations along the Illinois Waterway. On the other hand, there are many locations (both current and planned) in the Upper Mississippi catchment area. Ethanol capacity expansion occurs in the vicinity of the existing plants (see **Figure 36**) leading to the no change in mode allocation for the forecast period.




(Source: Wilson Report[31])

**Figure 36: Current and Planned Expansion of Ethanol Capacity**




(Source: LBG Analysis)

**Figure 37: Industrial Chemicals Unconstrained Waterway Traffic Forecast 2006-2030**

[31] *Longer-Term Forecasting of Commodity Flows on the Mississippi River: Application to Grains and World Trade* by. William W Wilson et al. North Dakota State University Fargo, ND 58105, December 15, 2006.

**Table 27: Industrial Chemicals Unconstrained Waterway Forecasts: LBG Base Case Results**

| Year | Industrial Production (IL) | Industrial Production (US) | Ethanol Production (EIA) | 5 State Population | UM+IWW Total | UM Total | IWW Total |
|---|---|---|---|---|---|---|---|
| | Index | Index | Million Gallons | '000 Persons | 000 Tons | 000 Tons | 000 Tons |
| 1997 | 100 | 100 | 1,300 | 30,588 | 8,341 | 4,679 | 3,662 |
| 1998 | 106 | 106 | 1,400 | 30,808 | 8,584 | 4,795 | 3,789 |
| 1999 | 110 | 111 | 1,470 | 31,045 | 8,152 | 4,627 | 3,525 |
| 2000 | 115 | 115 | 1,630 | 31,224 | 8,175 | 4,492 | 3,683 |
| 2001 | 108 | 112 | 1,770 | 31,416 | 7,140 | 3,990 | 3,150 |
| 2002 | 107 | 111 | 2,310 | 31,609 | 7,398 | 4,077 | 3,321 |
| 2003 | 107 | 111 | 2,810 | 31,801 | 7,400 | 4,066 | 3,334 |
| 2004 | 111 | 114 | 3,410 | 31,994 | 7,616 | 4,305 | 3,311 |
| 2005 | 115 | 118 | 3,904 | 32,167 | 7,780 | 4,402 | 3,378 |
| 2006 | 119 | 122 | 5,294 | 32,340 | 7,926 | 4,576 | 3,350 |
| 2010 | 133 | 137 | 10,596 | 32,997 | 8,819 | 5,447 | 3,372 |
| 2015 | 155 | 157 | 11,402 | 33,744 | 9,133 | 5,632 | 3,501 |
| 2020 | 179 | 180 | 12,311 | 34,363 | 9,595 | 5,923 | 3,671 |
| 2025 | 208 | 207 | 13,352 | 34,846 | 10,237 | 6,344 | 3,893 |
| 2030 | 241 | 237 | 14,218 | 35,275 | 11,022 | 6,842 | 4,180 |
| 2035 | | | | | 11,652 | 7,249 | 4,403 |
| 2040 | | | | | 12,318 | 7,681 | 4,638 |
| 2045 | | | | | 12,878 | 8,044 | 4,835 |
| 2050 | | | | | 13,465 | 8,425 | 5,040 |
| 2055 | | | | | 14,077 | 8,824 | 5,255 |

(Source: LBG Analysis)

**Table 28: Cumulative Annual Growth Rates, 1997-2055**

| From Year | To Year | UM+IWW | UM | IWW |
|---|---|---|---|---|
| 1997 | 2004 | -1.3% | -1.2% | -1.4% |
| 2005 | 2010 | 2.5% | 4.4% | 0.0% |
| 2010 | 2015 | 0.7% | 0.7% | 0.8% |
| 2015 | 2020 | 1.0% | 1.0% | 1.0% |
| 2020 | 2030 | 1.4% | 1.5% | 1.3% |
| 2030 | 2040 | 1.1% | 1.2% | 1.0% |
| 2040 | 2055 | 0.9% | 0.9% | 0.8% |
| **2005** | **2030** | **1.4%** | **1.8%** | **0.9%** |
| **2005** | **2055** | **1.2%** | **1.4%** | **0.9%** |

(Source: LBG Analysis)

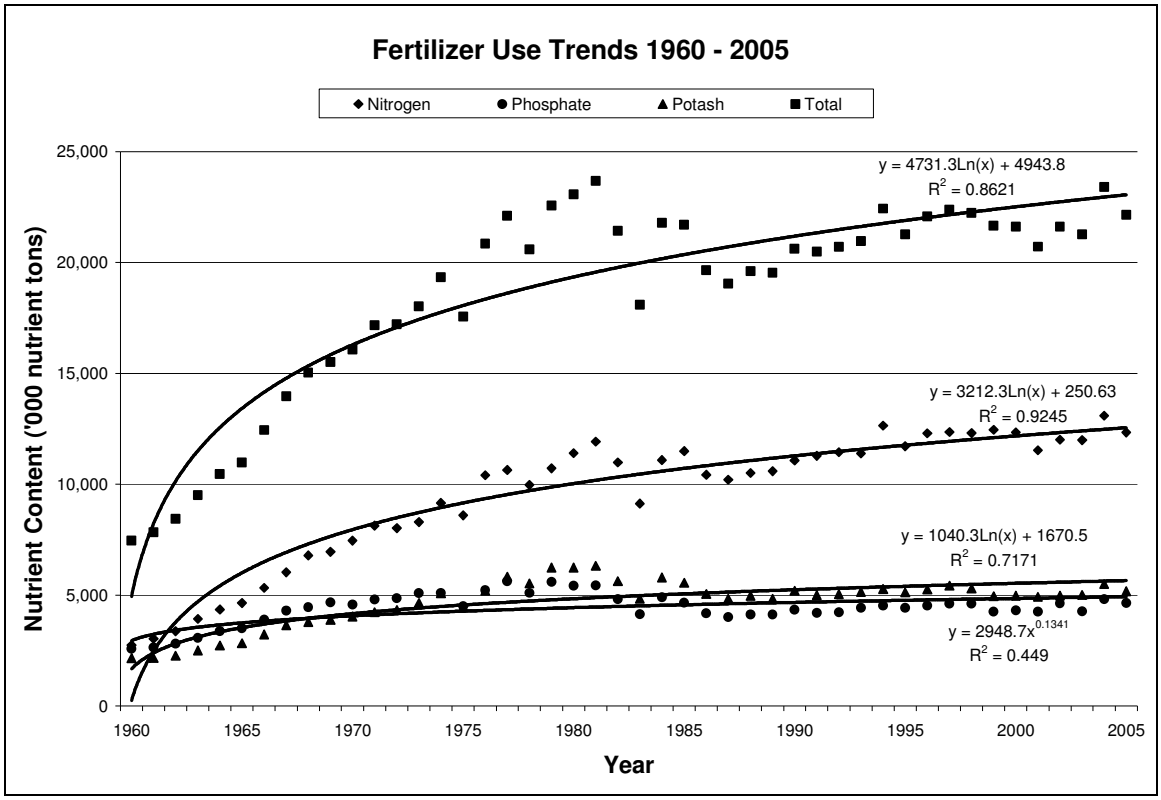
## 2.3 Agricultural Chemicals

This section discusses the current situation and unconstrained forecasts for the movement of agricultural chemicals on the Upper Mississippi and Illinois Waterway systems.

### 2.3.1 US Fertilizer Industry Overview

The discussion of the US fertilizer industry will be limited to the production of three basic nutrients – nitrogen (N), phosphorous (P), and potassium (K) because they constitute 70% of the total agricultural chemicals on the waterway system. The remaining 30% is comprised of small shares of various other nutrient and mixed fertilizers. These three nutrients (NPK) contribute to agricultural production in several specific ways. Nitrogen, for example, makes plants green and is usually most responsible for increasing yields; phosphate helps plants to use water efficiently and promotes root growth; and potassium facilitates photosynthesis, and makes plants hardy to withstand the stress of drought and other diseases.

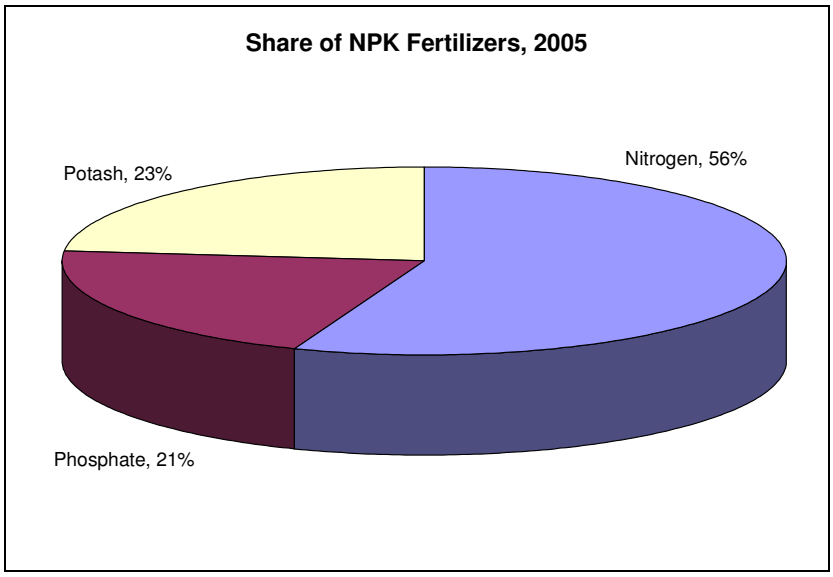
To further understand the trends of fertilizer use, the US fertilizer use data from 1960-2005 was obtained from the US Department of Agriculture (USDA). **Figure 38** shows the trends in the use of nitrogen, phosphate, and potash fertilizers in the US.




(Source: United States Department of Agriculture)

**Figure 38: US Fertilizer Use (1960-2005)**

Exploring the possible trends in use over a period it time, it was observed that the nitrogen fertilizers follow a logarithmic pattern with a goodness of fit value of 0.92. In the event of no radical changes in the agricultural practices, this trend could be used to forecast the US nitrogen fertilizer use in the future years. The potash fertilizers also show a high goodness of fit value (0.72) for a logarithmic series representing the data from 1960-2005. These two nutrients constitute the major share of fertilizer movement along the Upper Mississippi and Illinois Waterways. **Figure 39** illustrates the shares of the nutrients in the US for 2005.




(Source: United States Department of Agriculture)

**Figure 39: Types of Fertilizer Consumed (2005)**

The total amount of fertilizer used and the combinations of different types applied are determined by regional farm practices, soil conditions, crop rotations and many other technical considerations. Total fertilizer use by types of nutrients for different crops is shown in **Table 29**. With the adoption of precision nutrient application technologies such as intensive soil analysis in different areas of the farm, computer assisted yield monitoring systems, and the use of variable rate-applicators have assisted farms to increase input-output ratios per unit of nutrient.

**Table 29: Estimated U.S. Plant Nutrient Use by Selected Crops, 2005 ('000 Tons)**

| Crop | Nitrogen | Share | Phosphate | Share | Potash | Share | Total | Share |
|---|---|---|---|---|---|---|---|---|
| Corn | 4,959 | 40% | 1,758 | 38% | 1,823 | 35% | 13,499 | 39% |
| Cotton | 521 | 4% | 215 | 5% | 290 | 6% | 1,547 | 5% |
| Soybean | 151 | 1% | 448 | 10% | 860 | 17% | 1,610 | 5% |
| Wheat | 1,625 | 13% | 581 | 13% | 198 | 4% | 4,029 | 12% |
| Other | 5,080 | 41% | 1,636 | 35% | 2,002 | 38% | 13,798 | 40% |
| **Total** | **12,336** | **100%** | **4,638** | **100%** | **5,173** | **100%** | **34,483** | **100%** |

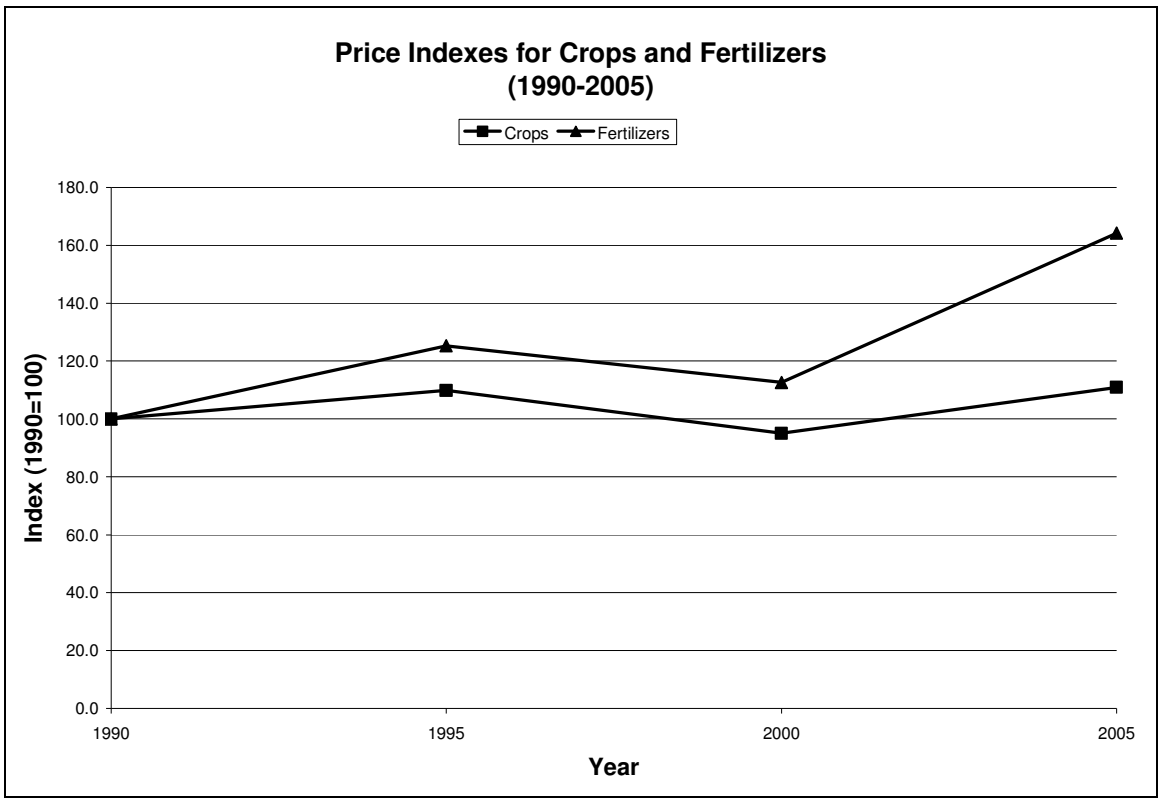
(Source: United States Department of Agriculture)

As profit maximizing farming enterprises will apply fertilizer only as long as it adds more to the total revenue than it adds to the total cost, price trends for the crops produced and the price of fertilizer determines the levels of input use. The time series price data, shown in **Table 30**, developed for agricultural product prices and fertilizer indicate that fertilizer prices grew at a much faster pace since 1990 (**Figure 40**). While farm product prices grew at about 0.7% a year, fertilizer input prices were increasing at 3.4%. Theoretically, if all other factors remained constant, this development would lead to a decline in demand for fertilizer.

**Table 30: Price Indexes for Crops and Fertilizers, 1990-2005**

| Year | All Crops | ALL Fertilizers | Nitrogen | Phosphate | Potash |
|---|---|---|---|---|---|
| | | | | | |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | N/A |
| 1995 | 109.9 | 125.3 | 140.2 | 112.4 | N/A |
| 2000 | 95.0 | 112.6 | 128.3 | 100.0 | N/A |
| 2005 | 110.9 | 164.2 | 214.1 | 132.0 | N/A |
| **CAGR** | **0.7%** | **3.4%** | **5.2%** | **1.9%** | **N/A** |

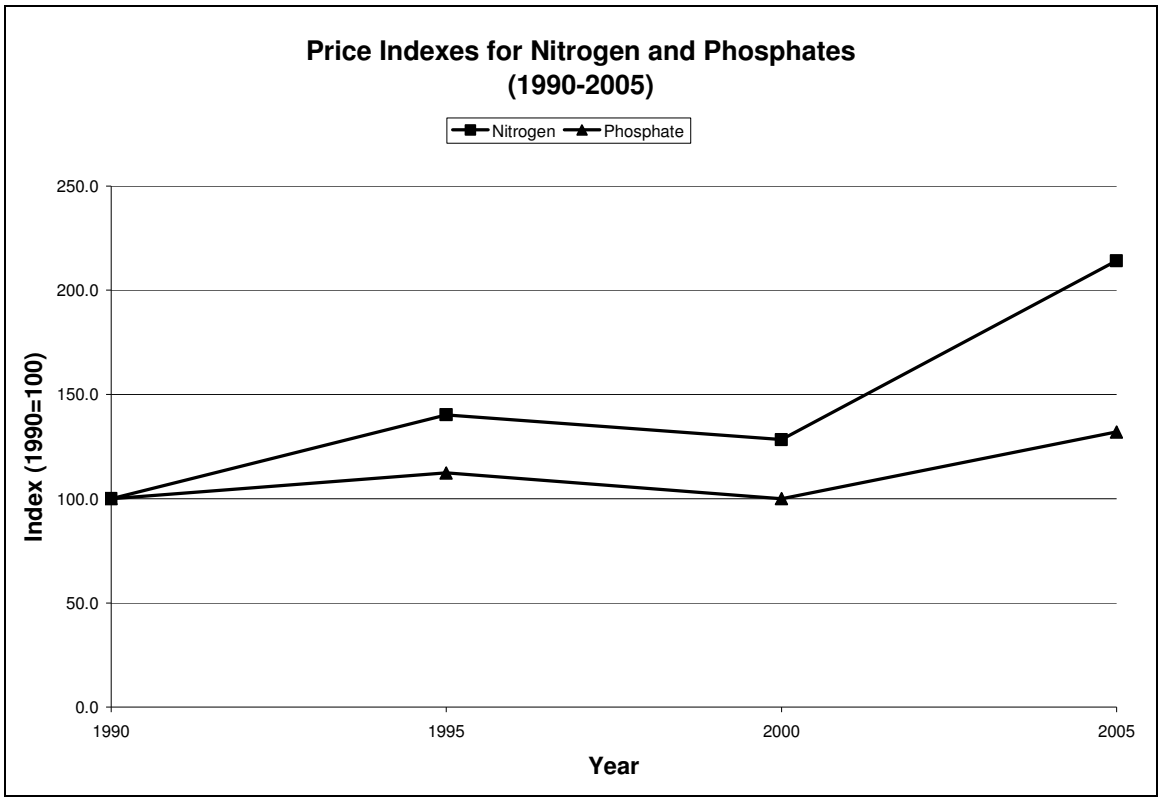
(Note: Potash data was not available from the United States Department of Agriculture)
(Source: United States Department of Agriculture and Bureau of Labor Statistics)




(Source: United States Department of Agriculture and Bureau of Labor Statistics)

**Figure 40: Price Index for Crops and Fertilizers (1990-2005)**

The nitrogenous fertilizer prices registered the highest rate of increase (5.2% a year) mainly due to increase in the price of natural gas, which is the main raw material used in production (**Figure 41**).




(Source: United States Department of Agriculture and Bureau of Labor Statistics)

**Figure 41: Price Index for Nitrogen and Phosphate Fertilizers (1990-2005)**

The contamination of water sources from water runoff containing chemical fertilizers has remained an important issue challenging the industry. New chemical combinations that are less harmful and recently developed advanced application methods have reduced the damaging effects to some extent. On the other hand, efficient use of fertilizer allows increased food production per unit land area limiting the expansion of cropland at the expense of forests, and other environmentally important habitats.

Fertilizer movement in the United States has been mainly dominated by truck and rail. **Table 31** shows the transportation modal shares for fertilizers.

**Table 31: United States Fertilizer Movement Transportation Modes**

| Mode of transportation | TONS Share | | Ton-miles Share | |
|---|---|---|---|---|
| | 2002 | 1997 | 2002 | 1997 |
| **All modes** | **100%** | **100%** | **100%** | **100%** |
| Truck | 57% | 52% | 50% | 23% |
| Rail | 36% | 36% | 40% | 55% |
| Water | 4% | 5% | 7% | 12% |
| Pipeline (4) | 1% | 1% | | |
| **Other and unknown modes** | **1%** | **5%** | | |

(Source: Commodity Flow Survey, 1997, 2002, Bureau of Transportation Statistics[32])

## 2.3.2 Agricultural Chemicals Waterway Traffic Movement Overview

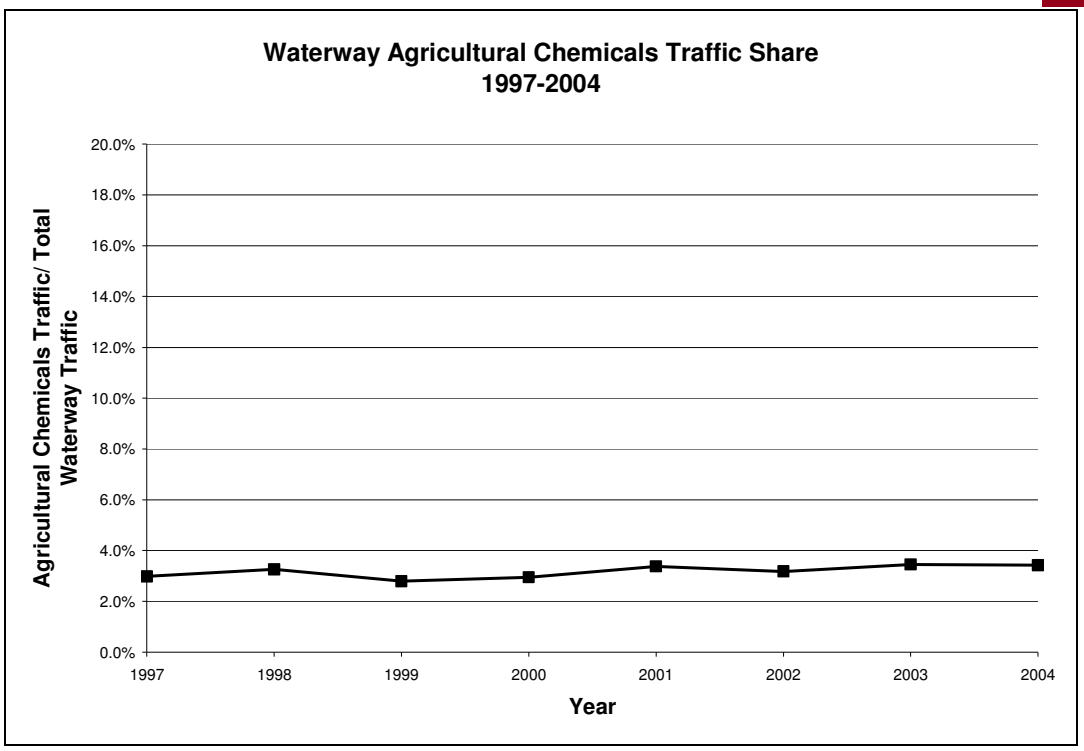
Agricultural chemicals, consisting mainly of fertilizers comprised of about 5.5 million tons[33] with more than 75% of it concentrated on the Upper Mississippi River (see **Table 32**). Agricultural chemicals are comprised of fertilizers that are primarily of three kinds based on the nutrient – Nitrogen, Phosphate and Potash[34]. It comprises of about 3% of the total waterway traffic[35] on the Upper Mississippi and Illinois Waterways (**Figure 42**).

**Table 32: Agricultural Chemicals Waterway Traffic 1997-2004**

| Year | UM Tonnage ('000 Tons) | Annual Change | IWW Tonnage ('000 Tons) | Annual Change | UM+IWW Tonnage ('000 Tons) | Annual Change |
|---|---|---|---|---|---|---|
| 1997 | 3,993 | | 1,051 | | 5,044 | |
| 1998 | 4,351 | 9.0% | 1,178 | 12.1% | 5,529 | 9.6% |
| 1999 | 3,947 | -9.3% | 1,110 | -5.8% | 5,057 | -8.5% |
| 2000 | 4,133 | 4.7% | 1,092 | -1.6% | 5,225 | 3.3% |
| 2001 | 4,544 | 9.9% | 1,372 | 25.6% | 5,916 | 13.2% |
| 2002 | 4,424 | -2.6% | 1,176 | -14.3% | 5,600 | -5.3% |
| 2003 | 4,634 | 4.7% | 1,190 | 1.2% | 5,824 | 4.0% |
| 2004 | 4,592 | -0.9% | 1,119 | -6.0% | 5,711 | -1.9% |
| **Average** | **4,327** | | **1,161** | | **5,488** | |

(Source: Waterway Commerce of United States)

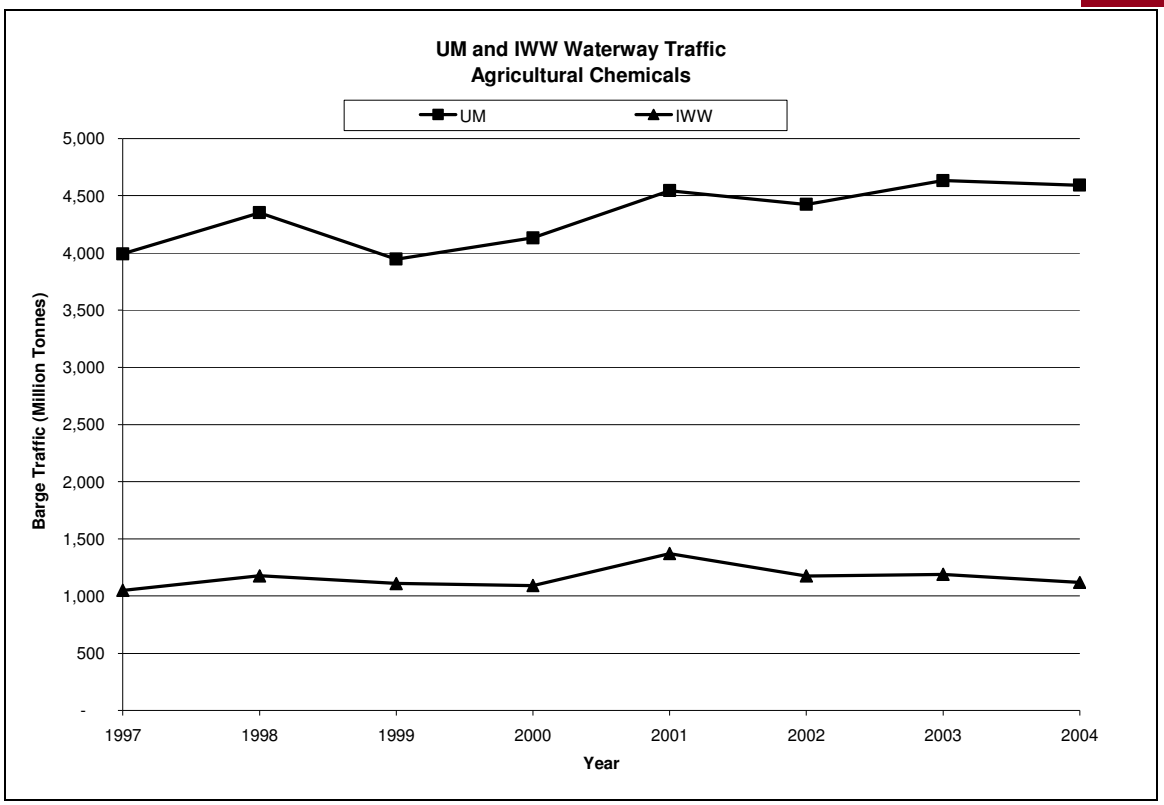
[32] Available from http://www.bts.gov/publications/commodity_flow_survey/2002/united_states/ and http://www.bts.gov/publications/commodity_flow_survey/1997/united_states/ accessed on April 2, 2007.
[33] Average value for 1994-2004 Agricultural Chemicals Tonnage.
[34] All the other fertilizers using the waterway were classified as 'mixes'.
[35] Total waterway traffic includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.




(Source: Waterborne Commerce of United States)

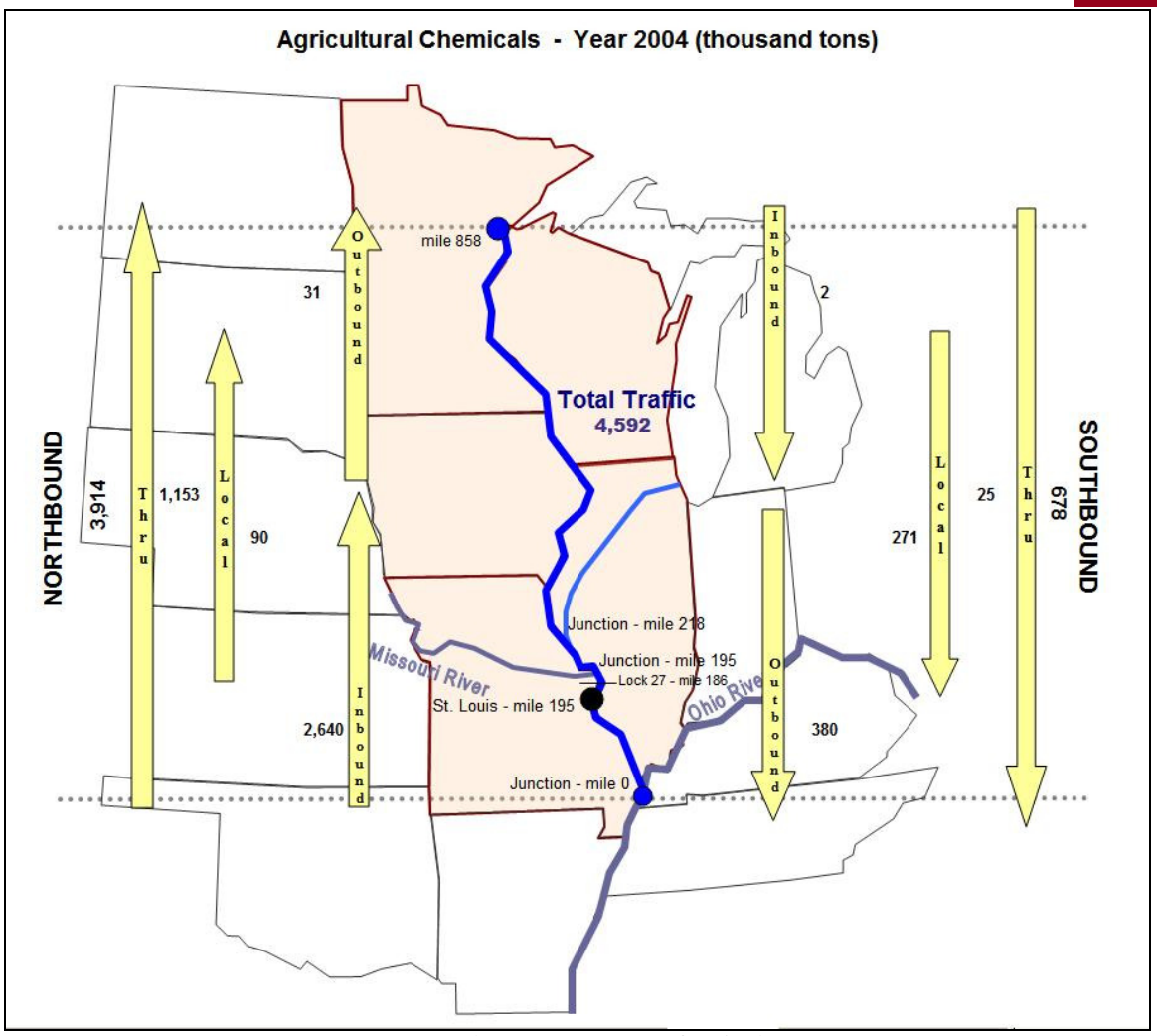
**Figure 42: Waterway Agricultural Chemicals Traffic Share, 1997-2004**

The trend analysis indicated positive growth rates on both waterways, with average annual growth rates of 2% for the Upper Mississippi River, compared to 1% growth on the Illinois Waterway. The analysis of time series data from 1997 to 2004 indicates that the tonnage increased gradually with movements below the mean during the period 1997 to 2000 and volumes above the mean 2002 to 2004. The smooth increase for both waterways and the movement of residuals together, except in 2004, without many random variations indicate the applications of progressively more fertilizer over time. The tonnage trends on the two waterways were positively correlated with a coefficient of 0.618. **Figure 43** shows the agricultural chemicals traffic on the waterway system from 1997-2004.




(Source: Waterway Commerce of United States)

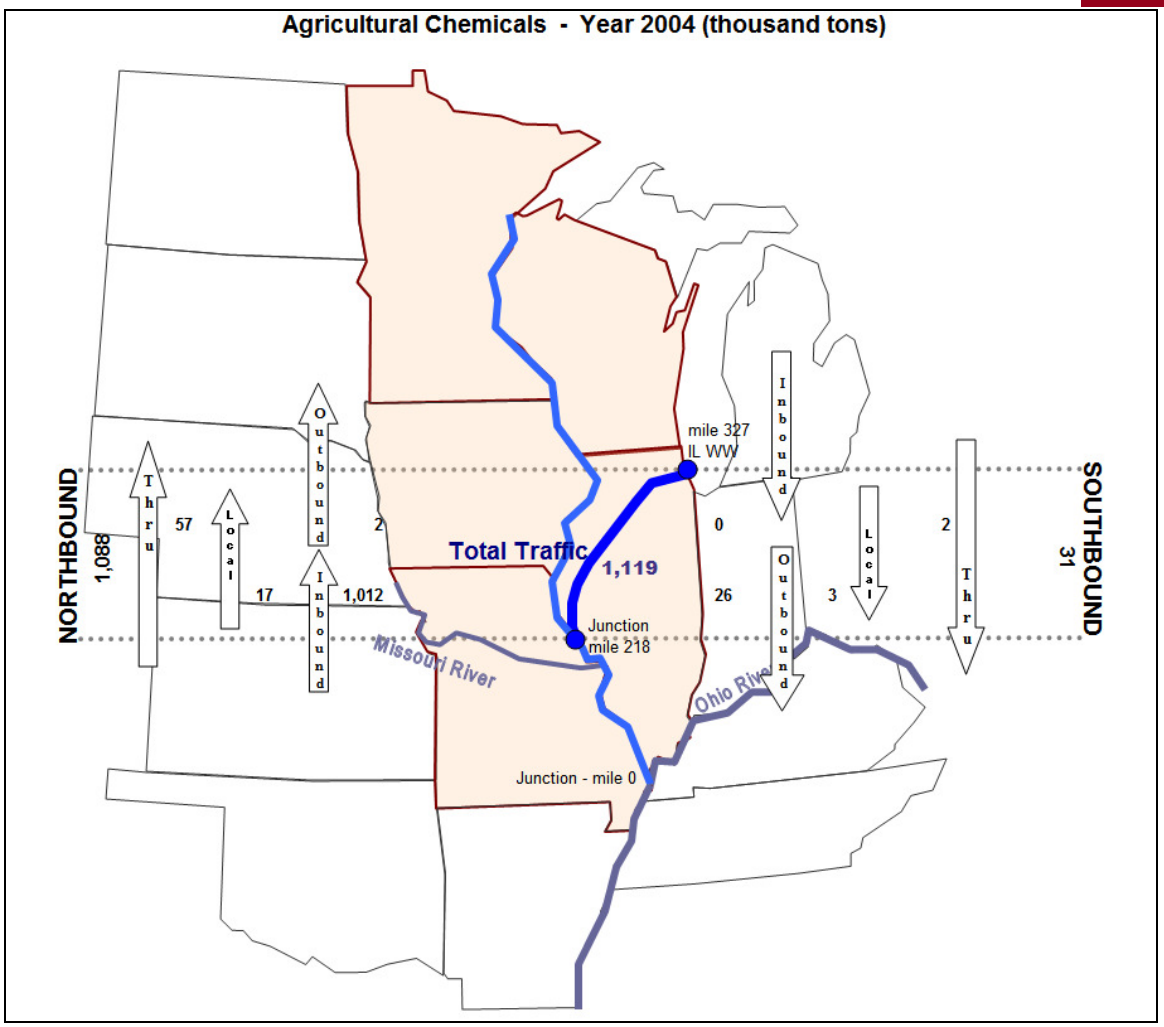
**Figure 43: Agricultural Chemicals UM and IWW Waterway Traffic**




(Source: Waterborne Commerce of United States)

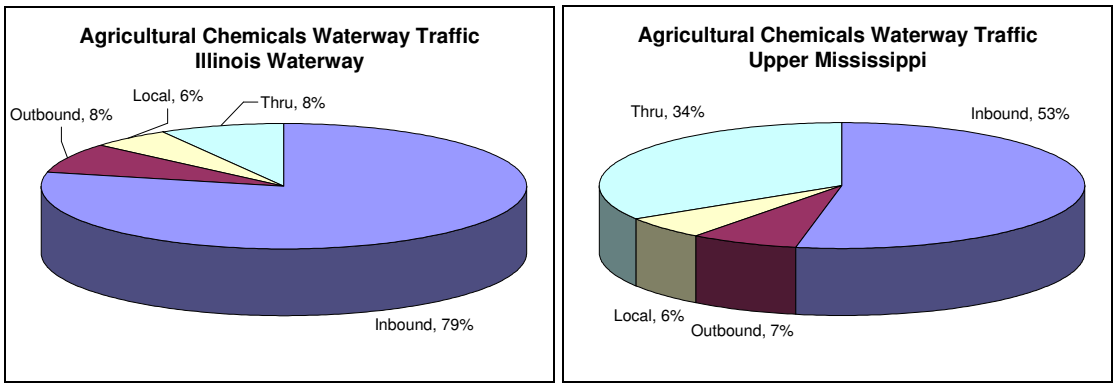
**Figure 44: Upper Mississippi Inbound, Outbound, Local and Through Waterway Movements 2004**

**Figure 44** and **Figure 45** show the inbound, outbound, local, and through traffic on the Upper Mississippi and Illinois Waterways for 2004. The *inbound* movements have the largest share for both Illinois Waterway (79%) and Upper Mississippi (53%), illustrated in **Figure 46.** 58% of the combined traffic on UM and IL is *inbound* and 28% is *through* traffic. This indicates that the region is a net consumer of fertilizers.




(Source: Waterborne Commerce of United States)

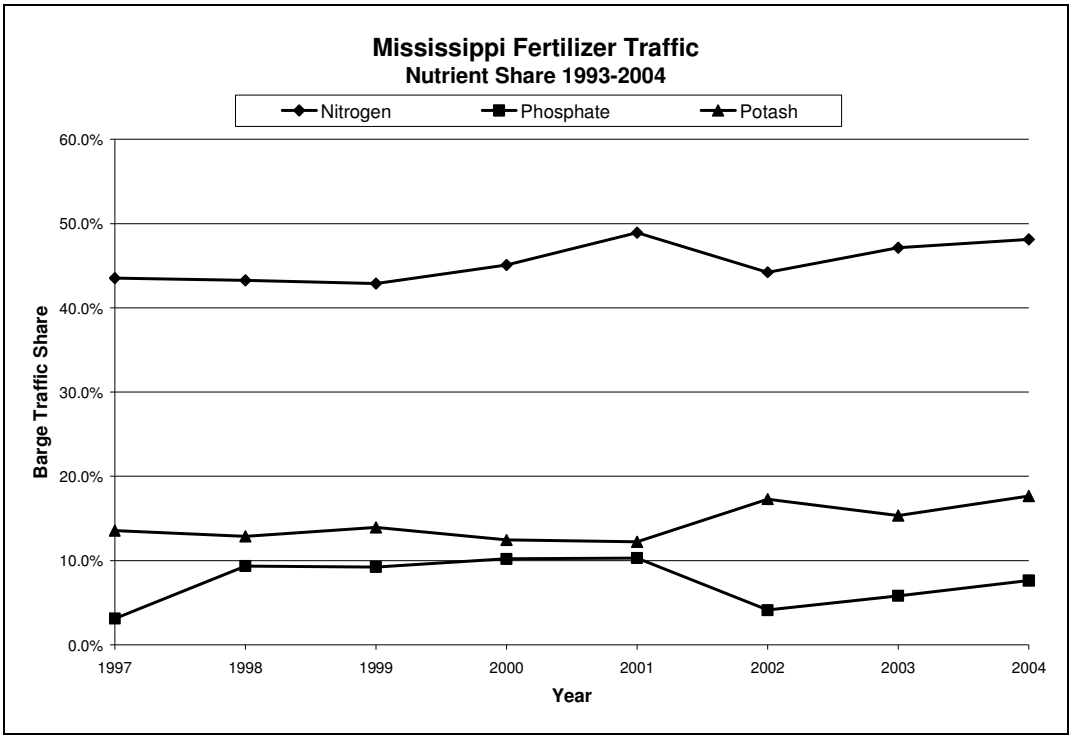
**Figure 45: Illinois Waterway Inbound, Outbound, Local and Through Waterway Movements 2004**




(Note: 1997-2004 Average; Source: Waterway Commerce of United States)

**Figure 46: Inbound, Outbound, Local, and Through Agricultural Chemicals Waterway Shares**

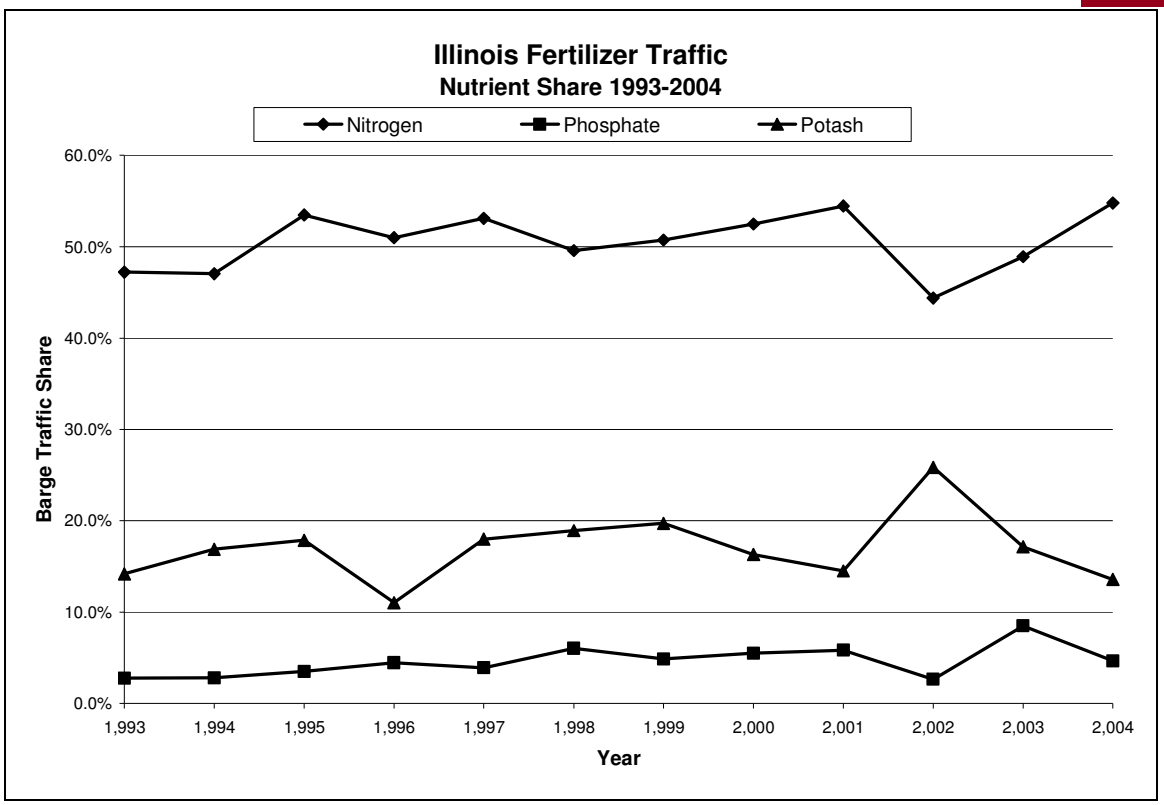
**Figure 47** and **Figure 48** illustrate the share of nutrients, which are the main components of fertilizers, transported through the Upper Mississippi and Illinois Waterway system.




(Source: Waterborne Commerce of United States)

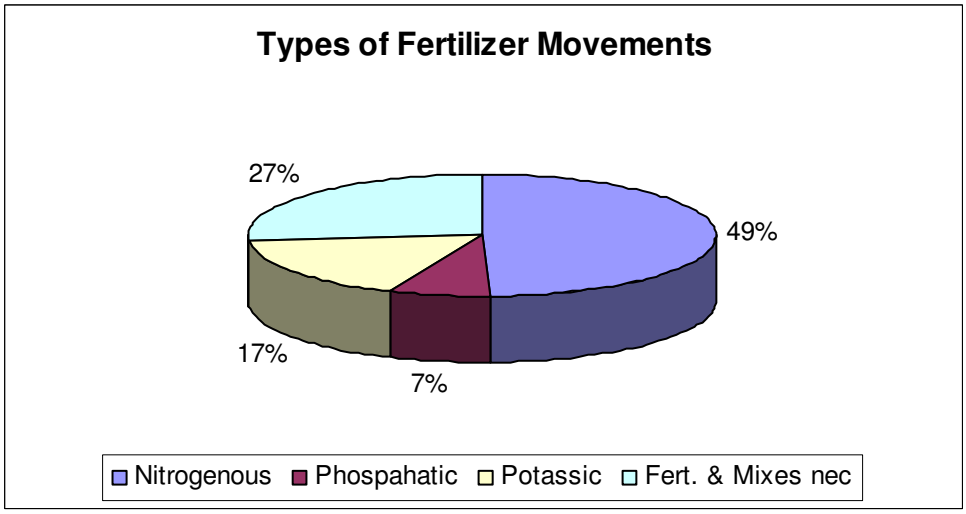
**Figure 47: Upper Mississippi River Fertilizer Traffic Nutrient Share (1997-2004)**

Nitrogen-based fertilizers make up about 45%-50% share of the waterway traffic. It would thus be important to consider the future trends and developments relating to nitrogen fertilizer during the forecasting process. It is also noted that the nutrient share has not changed substantially over a period of 7-10 years preceding 2004, which shows that there has been no radical change in agricultural practices during this time period. **Figure 47** and **Figure 48** show the share of each nutrient for both the Upper Mississippi and Illinois Waterways.




(Source: Waterborne Commerce of United States)

**Figure 48: Illinois River Fertilizer Traffic Nutrient Share (1993-2004)**




(Note: Data for Combined UM and IWW; Source: Waterborne Commerce of United States)

**Figure 49: Types of Fertilizer Movements**

### 2.3.3 Forecasting Methodology

It has been assumed that the agricultural chemicals barge traffic would be correlated to the fertilizer consumption. **Figure 50** shows the conceptual diagram for the model for Agricultural chemicals.

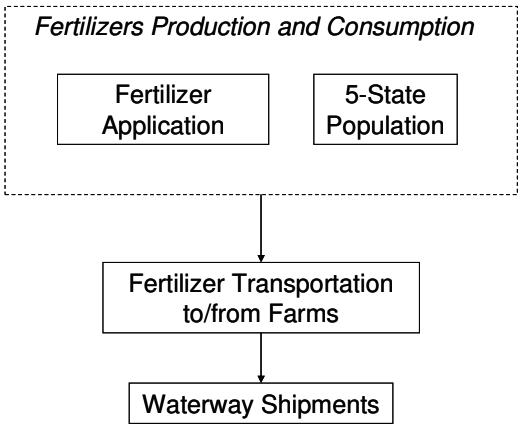



**Figure 50: Conceptual Description of the Model for Agricultural Chemicals**

The forecasting methodology considered the regression analysis of the total barge traffic with many variables including the US fertilizer use (Nitrogen, Phosphate, Potash and Total), US planted and harvested acreage, Illinois and Five State populations from 1997-2004. The final linear regression results are presented below for the Upper Mississippi and Illinois Waterways. All the variables used (except one) are statistically significant at 95% confidence level with acceptable values for goodness of fit. The regression variables are given in **Table 33.**

**Table 33: Regression Variables**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| US Total Fertilizer Use | 22,388 | 22,229 | 21,660 | 21,619 | 20,718 | 21,621 | 21,272 | 23,408 |
| US Nitrogen Fertilizer Use | 12,352 | 12,313 | 12,452 | 12,334 | 11,535 | 12,009 | 11,991 | 13,098 |
| 5-State Population | 30.588 | 30.808 | 31.045 | 31.224 | 31.416 | 31.609 | 31.801 | 31.994 |
| IWW Tonnage | 1,051 | 1,178 | 1,110 | 1,092 | 1,372 | 1,176 | 1,190 | 1,119 |
| UM Tonnage | 3,993 | 4,351 | 3,947 | 4,133 | 4,544 | 4,424 | 4,634 | 4,592 |
| UM+IWW Tonnage | 5,044 | 5,529 | 5,057 | 5,225 | 5,916 | 5,600 | 5,824 | 5,711 |

(Source: US Total/Nitrogen Fertilizer Use ('000 Tons): US Department of Agriculture; 5 State Population (Million Persons): US Census Bureau; Tonnage ('000 Tons): Waterborne Commerce of United States)

| | | | | |
|---|---|---|---|---|
| **UM Barge Traffic =** | **-9408** | **– 0.7503 (US Nitrogen Fert. Use)** | **+ 0.3552 (US Fert. Use)** | **+ 484.4 (5-State Population)** |
| (Std Error) | (3513) | (0.2939) | (0.1622) | (105.8) |
| *t-statistic* | | *-2.55* | *+2.19* | *+4.58* |
| $R^2$ | 0.86 | | | |

| | | | | |
|---|---|---|---|---|
| **UM+IWW Barge Traffic =** | **-8780** | **– 0.9927 (US Nitrogen Fert. Use)** | **+ 0.4013 (US Fert. Use)** | **+ 564.2 (5-State Population)** |
| (Std Error) | (4837) | (0.4047) | (0.2233) | (145.7) |
| *t-statistic* | | *-2.45* | *+1.80* | *+3.87* |
| $R^2$ | 0.83 | | | |

*Barge Traffic is in '000 Tons*
*US Nitrogen/Total Fertilizer Use is in '000 Tons*
*5-State (Illinois, Iowa, Minnesota, Missouri and Wisconsin) Population is in Million Persons*

The regression results show that the traffic on the Upper Mississippi and Illinois Waterway is predominantly affected by the US fertilizer use and 5-State population. US fertilizer use signifies fertilizer demand/supply in the country, while the Illinois population signifies the local consumption. Intuitively, the agricultural chemicals barge traffic is positively correlated with the US fertilizer use and 5-State Population. The Nitrogen fertilizer use variable provides a dampening effect to the increase in waterway traffic because of the positive correlation with the other two variables mentioned above.

The complete forecasting procedure is outlined below.

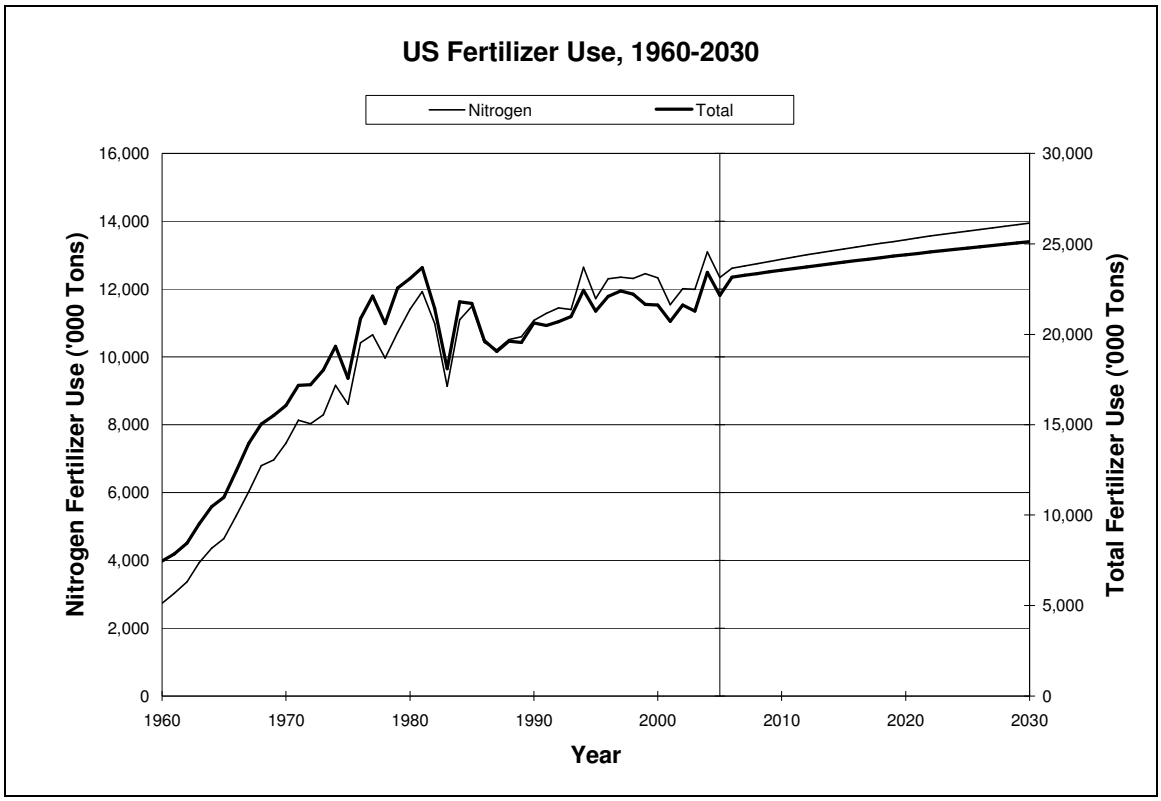
- Step 1: Forecast the Upper Mississippi + Illinois Waterway agricultural chemicals traffic using the regression equation given above. (This would need forecasted values for US fertilizer use, US Nitrogen fertilizer use and 5-State population).

- Step 2: Forecast the Upper Mississippi Waterway agricultural chemicals traffic using the regression equation given above. (This would need forecasted values for US fertilizer use, US Nitrogen fertilizer use, and 5-State population).

- Step 3: Calculate the Illinois Waterway agricultural chemicals forecast by subtracting the Upper Mississippi forecast obtained in Step 2 from the Upper Mississippi + Illinois Waterway forecast obtained in Step 1.

### 2.3.4 Agricultural Chemicals Forecast

This section presents LBG's unconstrained forecast of agricultural chemicals movement on the Upper Mississippi and Illinois Waterways.




(Source: LBG Trend Analysis with data from US Department of Agriculture)

**Figure 51: US Fertilizer Use Projections**

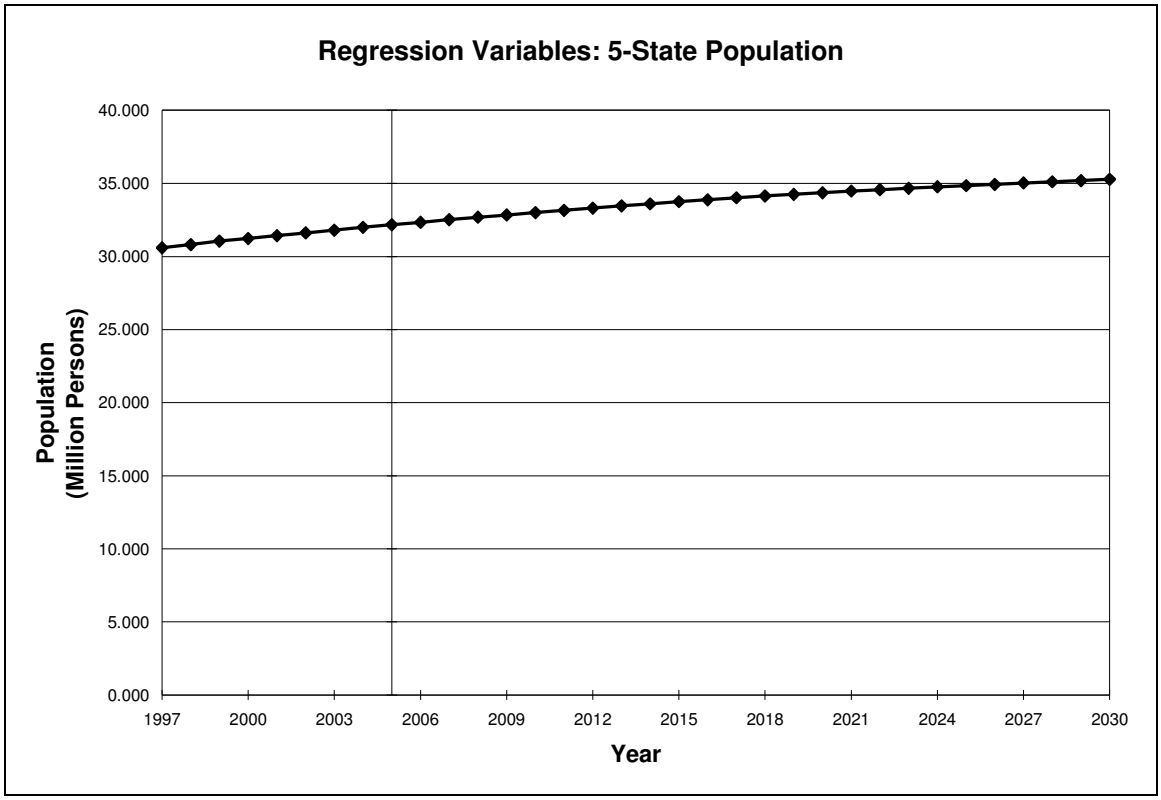
To forecast the agricultural chemicals waterway tonnage using the regression equation developed in the previous section we need to forecast the values of US total/Nitrogen fertilizer use and the 5-State Population.

The US Fertilizer Use forecasts were not available from any government agency. It was thus decided to explore the historical trends in fertilizer use[36]. Both, Nitrogen and total US fertilizer use followed a logarithmic trend from 1960-2005[37] (See **Figure 51**). Since any structural changes are not expected in the agricultural practices in the future, it was assumed that this trend will continue during the forecast period through 2030. The forecasted US Fertilizer Use is presented in **Figure 51.** (The data for each forecasted year

[36] We also explored using planted/harvested acreage in the model but it did not give satisfactory results. The fertilizer use is impacted by acreage and thus the fertilizer use values implicitly accommodate for changes in planted acreage.

[37] USDA, available from http://www.ers.usda.gov/Data/FertilizerUse/Tables/Table1.xls, accessed on March 27, 2007.

is shown in **Table 34**). Five-State population was obtained from the U.S. Census Bureau, Population Division, released on the Internet on April 21, 2005. The forecasts are presented in **Figure 52**.

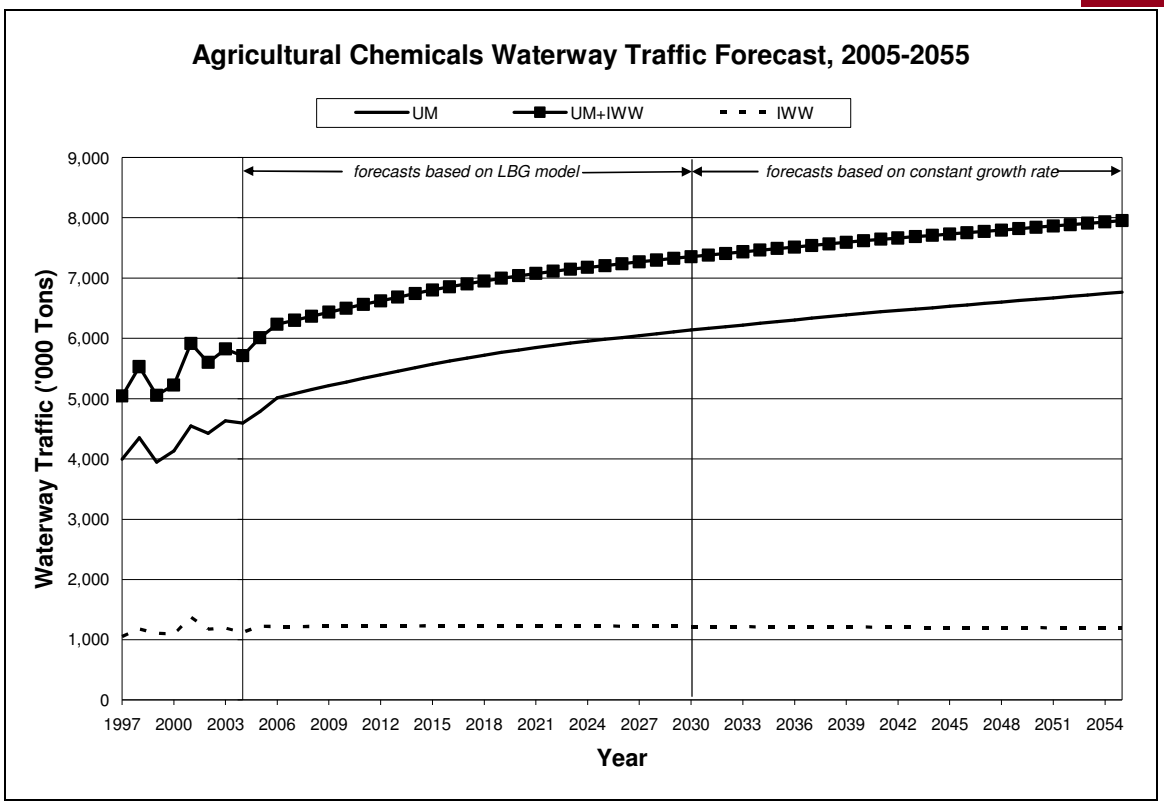



(Source: US Census Bureau)

**Figure 52: Historic and Forecasted 5-State Population**

The Agricultural chemicals unconstrained waterway traffic forecast model developed in the previous section was used to forecast the Upper Mississippi and Illinois Waterway traffic for Agricultural chemicals. The results are tabulated in **Table 34** and presented in **Figure 53**.

The forecasts show a stabilizing waterway forecast with a gradual increase in the waterway tonnage during the 2005-2030 period. This is primarily due to the stable nature of fertilizer use and no revolutionary change in agricultural practices expected in the future. This is a reflection of planned agricultural land use, which, with a relatively small increase (4%) to 2010, will remain stable for the remaining period of time.




(Source: LBG Analysis)

**Figure 53: Agricultural Chemicals Unconstrained Waterway Traffic Forecast 2005-2055**

**Table 34: Agricultural Chemicals Unconstrained Waterway Forecasts: LBG Base Case Results**

| Year | US Total Fertilizer Use | US Nitrogen Fertilizer Use | 5-State Population | IWW Tonnage | UM Tonnage | UM+IWW Tonnage |
|---|---|---|---|---|---|---|
| | '000 Tons | '000 Tons | Million Persons | 000 Tons | 000 Tons | 000 Tons |
| 1997 | 22,388 | 12,352 | 30.588 | 1,051 | 3,993 | 5,044 |
| 1998 | 22,229 | 12,313 | 30.808 | 1,178 | 4,351 | 5,529 |
| 1999 | 21,660 | 12,452 | 31.045 | 1,110 | 3,947 | 5,057 |
| 2000 | 21,619 | 12,334 | 31.224 | 1,092 | 4,133 | 5,225 |
| 2001 | 20,718 | 11,535 | 31.416 | 1,372 | 4,544 | 5,916 |
| 2002 | 21,621 | 12,009 | 31.609 | 1,176 | 4,424 | 5,600 |
| 2003 | 21,272 | 11,991 | 31.801 | 1,190 | 4,634 | 5,824 |
| 2004 | 23,408 | 13,098 | 31.994 | 1,119 | 4,592 | 5,711 |
| 2005 | 22,146 | 12,336 | 32.167 | 1,224 | 4,786 | 6,010 |
| 2006 | 23,160 | 12,618 | 32.340 | 1,216 | 5,017 | 6,233 |
| 2010 | 23,546 | 12,881 | 32.997 | 1,223 | 5,276 | 6,499 |
| 2015 | 23,989 | 13,181 | 33.744 | 1,230 | 5,570 | 6,800 |
| 2020 | 24,394 | 13,456 | 34.363 | 1,231 | 5,807 | 7,038 |
| 2025 | 24,766 | 13,709 | 34.846 | 1,225 | 5,984 | 7,209 |
| 2030 | 25,112 | 13,944 | 35.275 | 1,219 | 6,139 | 7,357 |
| 2035 | | | | 1,214 | 6,276 | 7,489 |
| 2040 | | | | 1,209 | 6,417 | 7,623 |
| 2045 | | | | 1,204 | 6,532 | 7,732 |
| 2050 | | | | 1,199 | 6,649 | 7,842 |
| 2055 | | | | 1,194 | 6,769 | 7,954 |

(Source: LBG Analysis)

**Table 35: Cumulative Annual Growth Rates, 1997-2055**

| From Year | To Year | IWW Tonnage | UM Tonnage | UM+IWW Tonnage |
|---|---|---|---|---|
| 1997 | 2004 | 0.9% | 2.0% | 1.8% |
| 2005 | 2010 | 0.0% | 2.0% | 1.6% |
| 2010 | 2015 | 0.1% | 1.1% | 0.9% |
| 2015 | 2020 | 0.0% | 0.8% | 0.7% |
| 2020 | 2030 | -0.1% | 0.6% | 0.4% |
| 2030 | 2040 | -0.1% | 0.4% | 0.4% |
| 2040 | 2055 | -0.1% | 0.4% | 0.3% |
| **2005** | **2030** | **0.0%** | **1.0%** | **0.8%** |
| **2005** | **2055** | **0.0%** | **0.7%** | **0.6%** |

(Source: LBG Analysis)

## 2.4 Iron, Steel, Metallic Ores, Products, & Scrap

This section discusses the current situation and unconstrained forecasts for the movement of steel on the Upper Mississippi and Illinois Waterway systems.

### 2.4.1 U.S. Steel Industry Overview

The iron and steel industry is a basic industry that is vital to the overall development of the US economy and for national security. The major components of the industry consist of steel mills, iron and steel foundries, and the suppliers of ferrous scrap and iron ore. Transportation costs are an important element in the manufacturing and distribution process as it has to support an extensive transportation network for the collection of raw materials and for the distribution of finished products to a wide variety of user-industries dispersed country-wide.

*Raw Materials* – Iron ore and recycled iron and steel scrap provide bulk of the raw-materials for the industry. The collection of scrap material from dispersed supply sources by brokers, collectors, and dealers and transporting them to steel mills and foundries is one of the transportation cost intensive part of the industry. Several technological developments in the type of shears and presses used and the development of a shredder or fragmentizer that has the capacity to reduce an automobile to fist-size pieces in less than a minute are among them. Another development is the mobile car crusher, which flattens cars prior to shipment to the scrap yard making it more economical to transport scrapped automobiles greater distances.

*Primary Products and Finished Goods* – Steel manufacturing process involves the steel mills to produce relatively simple steel shapes and then the adjoining finishing mills to roll or hammer into finished products such as bar, sheet, and structural shapes. Similarly, the foundries pour and molten iron or steel into molds to produce castings with the approximate shape of the final products.

*Type of Mills* –The highest geographic concentration of steel mills is in the Great Lakes region, including Indiana, Illinois, Ohio, Pennsylvania, Michigan, and New York. Approximately 80% of US steelmaking capacity is in these states[38]. To produce steel, facilities use one of two processes, which utilize different raw materials and technologies.

- Integrated steel mills: use a blast furnace to produce iron from iron ore, coke, and fluxing agents. A basic oxygen furnace (BOF) is then used to convert the molten iron, along with up to 30% steel scrap, into refined steel.

- Mini-mills: use an electric arc furnace (EAF) to melt steel scrap and limited amounts of other iron-bearing materials to produce new steel. Mini-mills are largely scrap-

[38] Environmental Protection Agency, *Iron and Steel Sector Strategies Performance Report*, Available from http://www.epa.gov/opispdwb/pdf/2006/ironandsteel.pdf accessed on February 12, 2007.

based producers, which has traditionally accounted for 100 percent of the furnace "charge" or material loaded into an EAF. In modern steel production, however, Mini-mills often mix ferrous scrap with "alternative irons," such as pig iron, directly reduced iron (DRI), and hot briquetted iron (HBI). These alternatives to ferrous scrap are derived by processing iron ore, and EAF steel mills that use these products mainly import them from beyond the continental US.

EAF slab casting has radically changed the production of steel in the US because of the numerous advantages that are offered by this technology. The steel sheet and plate mills are no longer tied to the geography of ore and coal sources; and the scale of production and size of the market are not considerations for entry into steel production anymore. It uses ferrous scrap material as input and has a considerably less environmental impact than the ore-based integrated steel mills. This process, however, cannot produce all kinds of steel products, especially for the automobile industry and the quality of steel produced is less than what is required by certain industries. **Table 36** shows the EAF steel producers in the United States in 2005.

**Table 36: Thin- and Intermediate-Slab EAF Steel Producers in the United States, 2005**

| Firm | Plant | State | Start Year | 2005 Capacity ('000 Tons) | Cumulative Capacity |
|---|---|---|---|---|---|
| Nucor | Crawfordsville | Indiana | 1989 | 2,000 | 2,000 |
| Nucor | Hickman | Arkansas | 1993 | 2,400 | 4,400 |
| Gallatin | Ghent | Kentucky | 1995 | 1,400 | 5,800 |
| Nucor | Berkeley | South Carolina | 1996 | 1,800 | 7,600 |
| NorthStar Bluescope | Delta | Ohio | 1996 | 1,500 | 9,100 |
| Steel Dynamics, Inc. | Butler | Indiana | 1996 | 2,800 | 11,900 |
| IPSCO | Montpelier | Iowa | 1997 | 1,250 | 13,150 |
| Nucor | Decatur (Trico) | Alabama | 1997 | 2,200 | 15,350 |
| IPSCO | Mobile | Alabama | 2001 | 1,250 | 16,600 |
| Nucor | Hertford | North Carolina | 2001 | 1,000 | 17,600 |

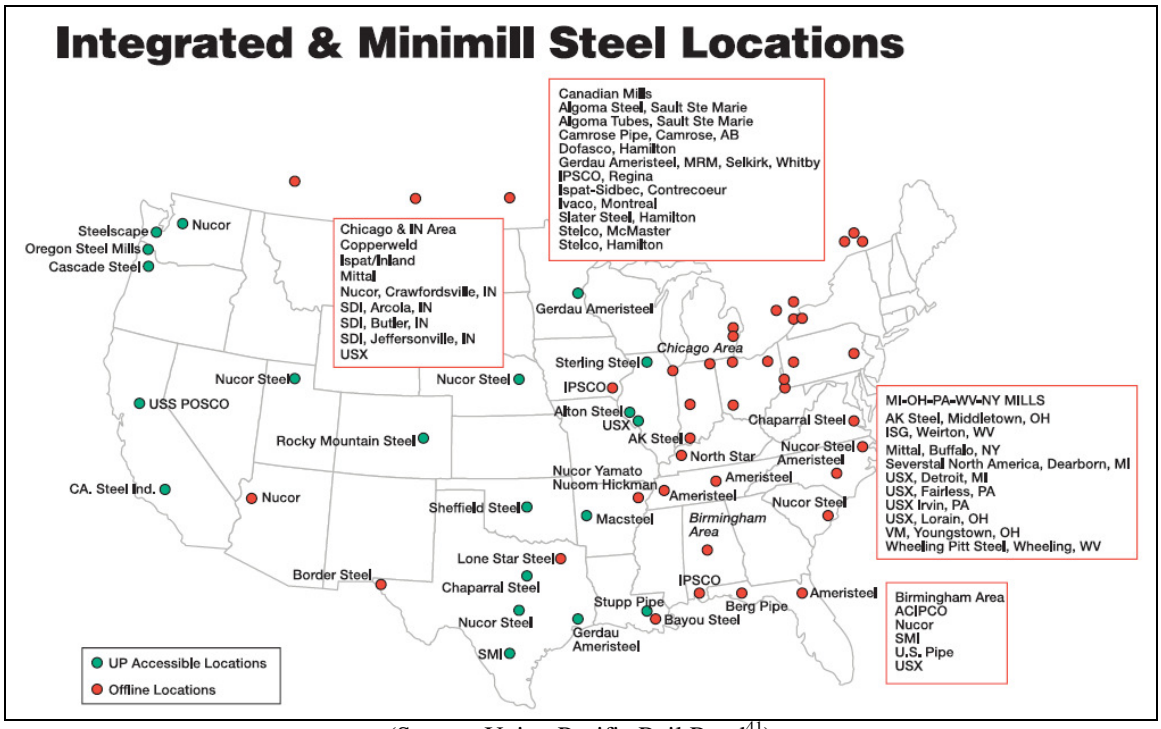
(Source: Company Reports and Steel Plant Database, 2005)

A similar shift from large integrated mills to mini-mills is observed in other countries, with integrated mill output declining to about 63 percent in China, 56 percent in Europe and 71 percent in Japan.

*World Supply and Demand* – China, Japan, and the US produced more than 40% of the world's steel supply. However between 1983 and 2001 the Chinese share increased from 6 to 18%, while the U.S. share declined from 15 to 12%. Iron and steel consumption trends, in general, are expected to increase in developing countries as their economies are transformed, and the future demand in developed countries to decline because of substitution possibilities and as major growth sectors will be in service industries that consume less iron and steel.

*Industry Re-structuring and Productivity* – According to 2003 estimates, the capacity of the US iron and steel industry is about 144 million metric tons with raw steel mills

located at 139 sites in different parts of the country[39]. **Figure 54** shows the location of steel mills across the United States in 2004. In recent years, the world supply of iron and steel far exceeded demand, resulting in a 30% downward spiral in prices reaching a twenty-year low in 2001. As a result, the high cost producers in the industry dropped out allowing the industry to restructure itself. The industry went through several consolidations extracting substantial concessions from the labor unions. Since 1990, the labor productivity of the US iron and steel industry has improved 5.7% per year compared to 3.9% growth in other manufacturing sectors of the economy. In terms of conservation, the industry has reduced 17% in energy consumption since 1990 per ton of steel shipped and has plans to further reduce this amount by anther 10% by 2010[40].




(Source: Union Pacific Rail Road[41])

**Figure 54: US Integrated and Mini-mill Steel Locations**

*Foreign Trade and Tariffs* – Foreign trade in the iron and steel sector encompasses iron and steel finished products as well as the necessary raw-materials. Because of the specialized nature of iron and steel finished products and seasonal price variations in different countries foreign trade consists of exports as well as imports. The issue to impose an import tariff on imported steel remains controversial among different interest groups. While the domestic producers emphasize the need for safeguards against

[39] *Mineral Commodity Profiles – Iron and Steel:* Michael D. Fenton, In Mineral Summaries. US Geological Survey. 2003.

[40] *The Transformation of the North American Steel Industry: Drivers, Prospects and Vulnerabilities,* Timothy J. Considine, Professor of Natural Resource Economics, The Pennsylvania State University, Available at the US Iron and Steel Institute website.

[41] Available from http://www.uprr.com/customers/ind-prod/metals/minimill.shtml accessed on Feb 12, 2007.

subsidized imported steel flooding the market, the steel user-industries point to the importance of maintaining low prices for steel to avoid increase in price of consumer goods. The effect of the most recent round of tariffs imposed in 2002 had only limited effect, because tax-exempt NAFTA partners increased their exports to the US.

Foreign trade activities in iron and steel, in general, are favorable for inland waterborne movements, especially, when handled at the Gulf Coast ports that are linked to the waterway network. A recent study commissioned to estimate the effects of an import tariff on ports and other related-service providers (stevedores and ship agents, trucking, rail and barge services, etc.) came up with several findings relevant to this report:[42]

- Overall, imports of steel products declined by 7% in the year after the safeguards[43].
- Imports of steel production inputs and US steel exports increased after the safeguards.
- The U.S. ports and related-service provider's revenue from steel imports declined by 53%.

The steel production input imports that are projected to increase are mostly raw materials such as iron ore and iron and steel scrap, etc., "barge-friendly" commodities. Therefore, the adverse effects of an import tariff on barge operators may be less than for the other sectors.

*Product Distribution* – The iron and steel sector manufactures the steel used in the production of thousands of manufactured products, ranging from toasters to automobiles to defense applications. Steel is also a key material in infrastructure such as office buildings and bridges. Construction, automotive, and industrial equipment account for more than 75% of total US steel consumption, with construction representing 22% of total steel shipments[44]. The distribution of finished products is also an important component of the total transportation system. In 1997 the delivered cost of steel products consumed is estimated at $77.6 billion for the industry, and the share of top five industries that consumed steel by value are as follows.[45]

- Motor vehicle parts manufacturing 17.8%
- Architectural and structural metals manufacturing 12.1%
- Steel products manufacturing from purchased steel 10.1%
- Agriculture, construction, and mining machinery manufacturing. 5.3%
- Forging and stamping 5.2%

C*ontainerization* – The imported steel products are mainly shipped as break-bulk or neo-bulk cargo of large coils of steel and bundled bars, etc. According to US Customs records, 88% to 91% of the imports were shipped as break-bulk cargo in the two-year

[42] *Steel: Monitoring Developments within the Industry.* US International Trade Commission. Steel Consuming Industries, Chapter 3, September 2003.
[43] In the report, the term "safeguards" is used instead of the term "tariff".
[44] Environmental Protection Agency, Iron and Steel Sector Strategies Performance Report, Available from http://www.epa.gov/opispdwb/pdf/2006/ironandsteel.pdf accessed on February 12, 2007.
[45] *Material Summary, 1997 Economic Census, Manufacturing.* U.S. Department of Commerce, Bureau of the Census.

period 2002/3 and the rest was shipped in containers. Between 85%-97% of the stainless steel bar and light shapes, rod, and wire, as well as flanges and fittings were shipped in containers. Approximately 27% to 32% of the slab was also shipped in containers[46]. So far containers of steel are only occasionally moved on the waterways.

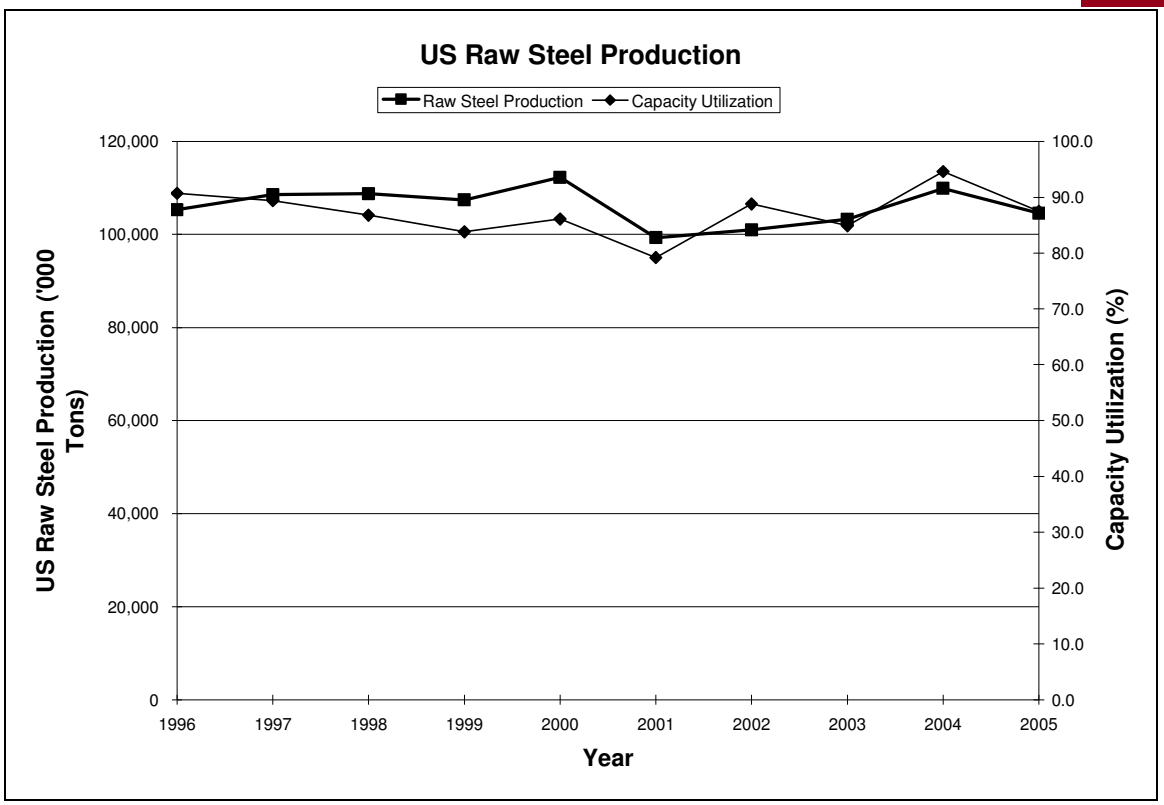
*Industry Sub-Sectors* – In order to analyze waterborne cargo movements the industry should be divided into five major sub-sectors. The iron and steel scrap, iron ore, and DRI (direct-reduced iron) are the three major raw-material sub-sectors of the industry, and iron and steel slag is a co-product of processing (see **Table 37**). In addition to these four sub-sectors, the primary products of iron and steel are the fifth sub-sector. The transportation demand characteristics as well as materials utilization patterns in terms of local supply, imports, and exports are quite distinct to each sub-sector. The monthly production of raw steel for 2005 and the rates of capacity utilization are shown in **Figure 55**. The total transportation demand of the industry will be the aggregate demand of all five sub-sectors.

**Table 37: Production, Exports, Imports and Total Consumption in Major Sub-Sectors of the U.S. Iron and Steel Industry, 2005**

| Item Description | Iron & Steel Scrap | | Iron Ore | | Directly Reduced Iron | | Iron & Steel Slag[47] | |
|---|---|---|---|---|---|---|---|---|
| | Quantity ('000 Tons) | Share (%) | Quantity ('000 Tons) | Share (%) | Quantity ('000 Tons) | Share (%) | Quantity ('000 Tons) | Share (%) |
| Local Supply | 54,300 | 78% | 36,800 | 72% | 1,740 | 40% | 20,000 | 95% |
| Imports | 3,590 | 5% | 5,450 | 11% | 2,510 | 58% | 1,000 | 5% |
| Exports | 12,000 | 17% | 8,800 | 17% | 60 | 1% | 100 | 1% |
| Total Consumption[48] | 57,890 | 83% | 42,250 | 83% | 4,250 | 99% | 21,000 | 100% |
| Total Availability[49] | 69,890 | 100% | 51,050 | 100% | 4,310 | 100% | 21,100 | 100% |

(Source: U.S. Geological Survey, Minerals Summaries Database, 2005)

[46] Ibid., page 3-8.
[47] Iron and Steel Slag Data is for 2004.
[48] Total Consumption = Local Supply + Imports.
[49] Total Availability = Total Consumption + Exports.




(Source: American Iron and Steel Institute, Annual Statistical Report, 2005)

**Figure 55: US Raw Steel Production and Capacity Utilization**

## 2.4.2 Steel Waterway Movements Overview

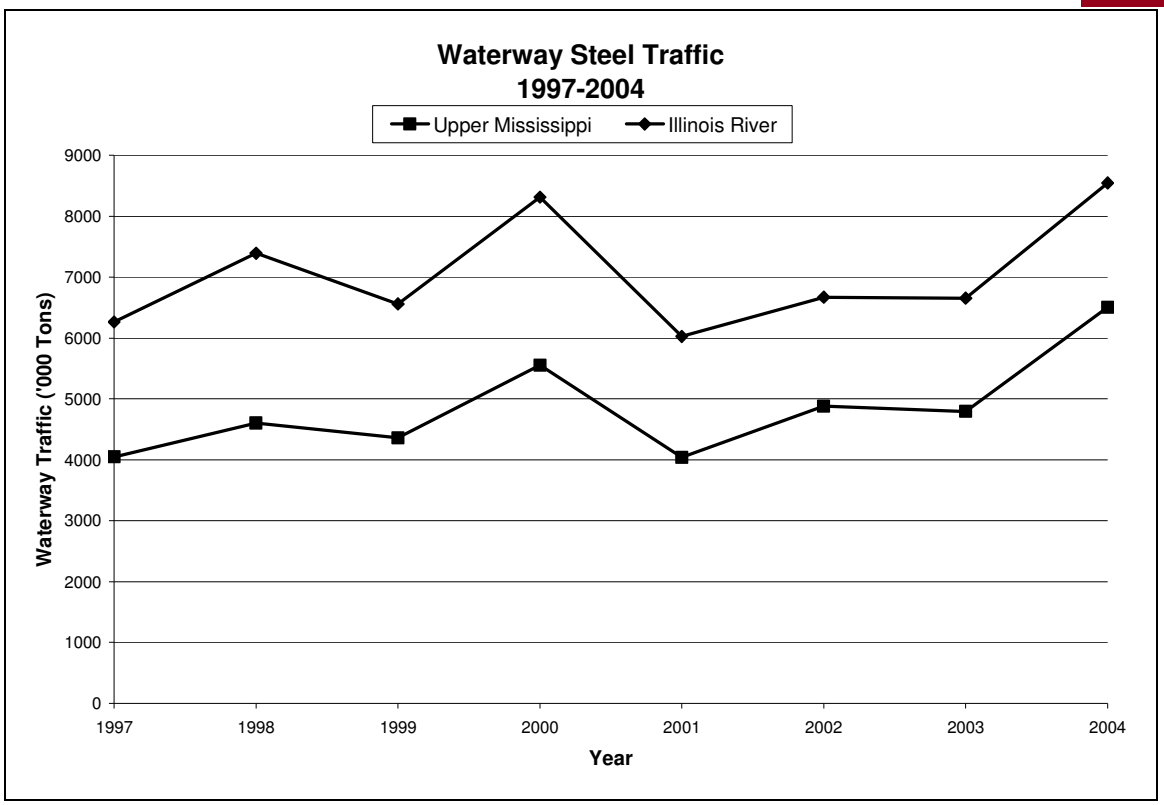
This commodity group represents 6.9% of total cargo[50] on the Upper Mississippi and Illinois Waterway system (**Figure 56**), with Illinois accounting for a 59% share (**Figure 58**). The share of steel traffic has remained relatively stable; however, it has shown an increasing trend since 2001 (its lowest share in last 10 years). The recent increase in steel's share suggests that the steel industry has witnessed a stronger change compared to the other industries using the waterways to transport their raw materials and products.

(Source: Waterborne Commerce of United States)

**Figure 56: Waterway Steel Traffic Share, 1997-2004**

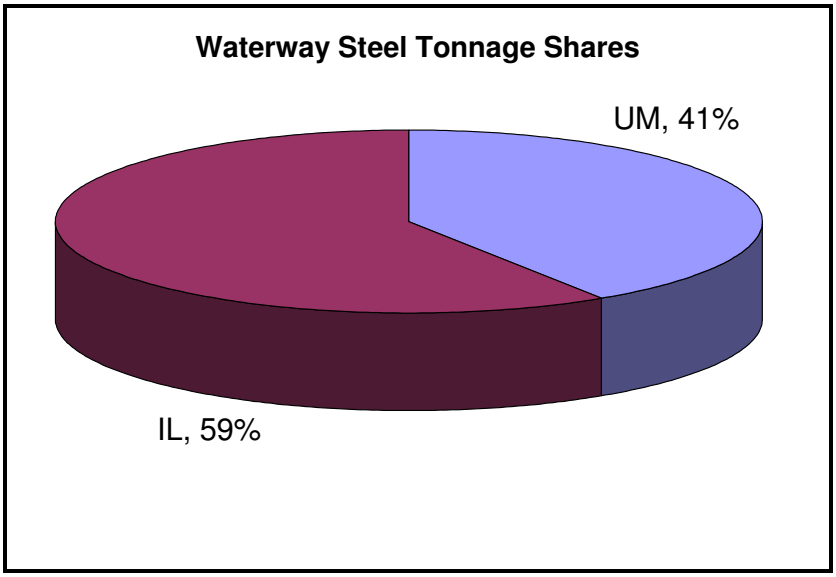
The year-to-year tonnage data indicates substantial variations ranging from 25% to 30% on both waterways more or less in a similar fashion (**Figure 56**). A correlation analysis of the iron and steel tonnage data for Upper Mississippi and Illinois Waterway illustrated a strong positive relationship with a correlation coefficient of 0.915, indicating that traffic patterns on both waterways are generally affected by similar conditions.

[50] Total cargo includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.




(Source: Waterborne Commerce of United States)

**Figure 57: Steel Waterway Tonnage 1997-2004**



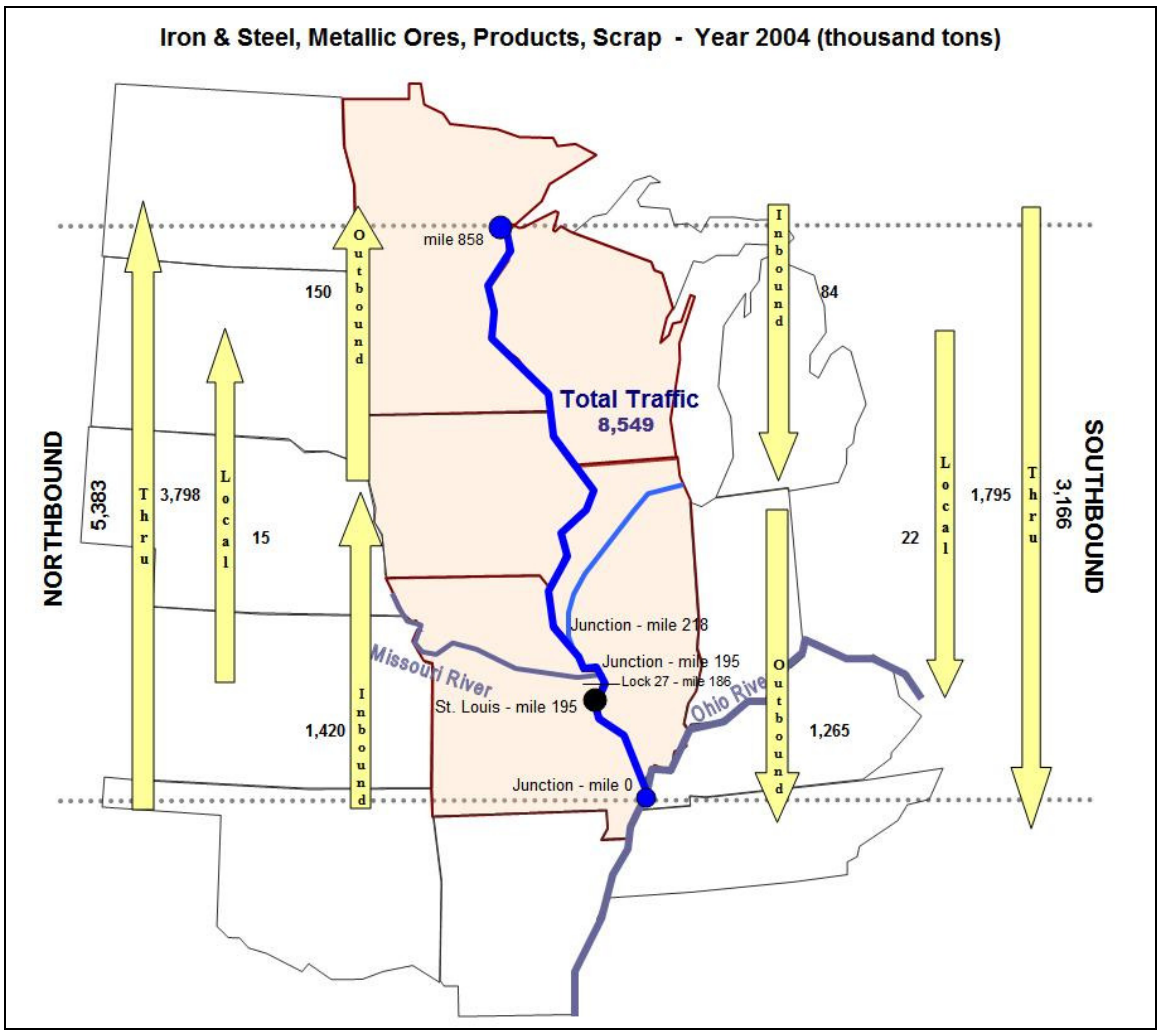

(Source: Waterborne Commerce of United States)

**Figure 58: Steel Commodity Waterway Tonnage Share, 1997-2004 Average**

**Table 38: Inbound, Outbound, Local and Through Steel Waterway Movements ('000 Tons)**

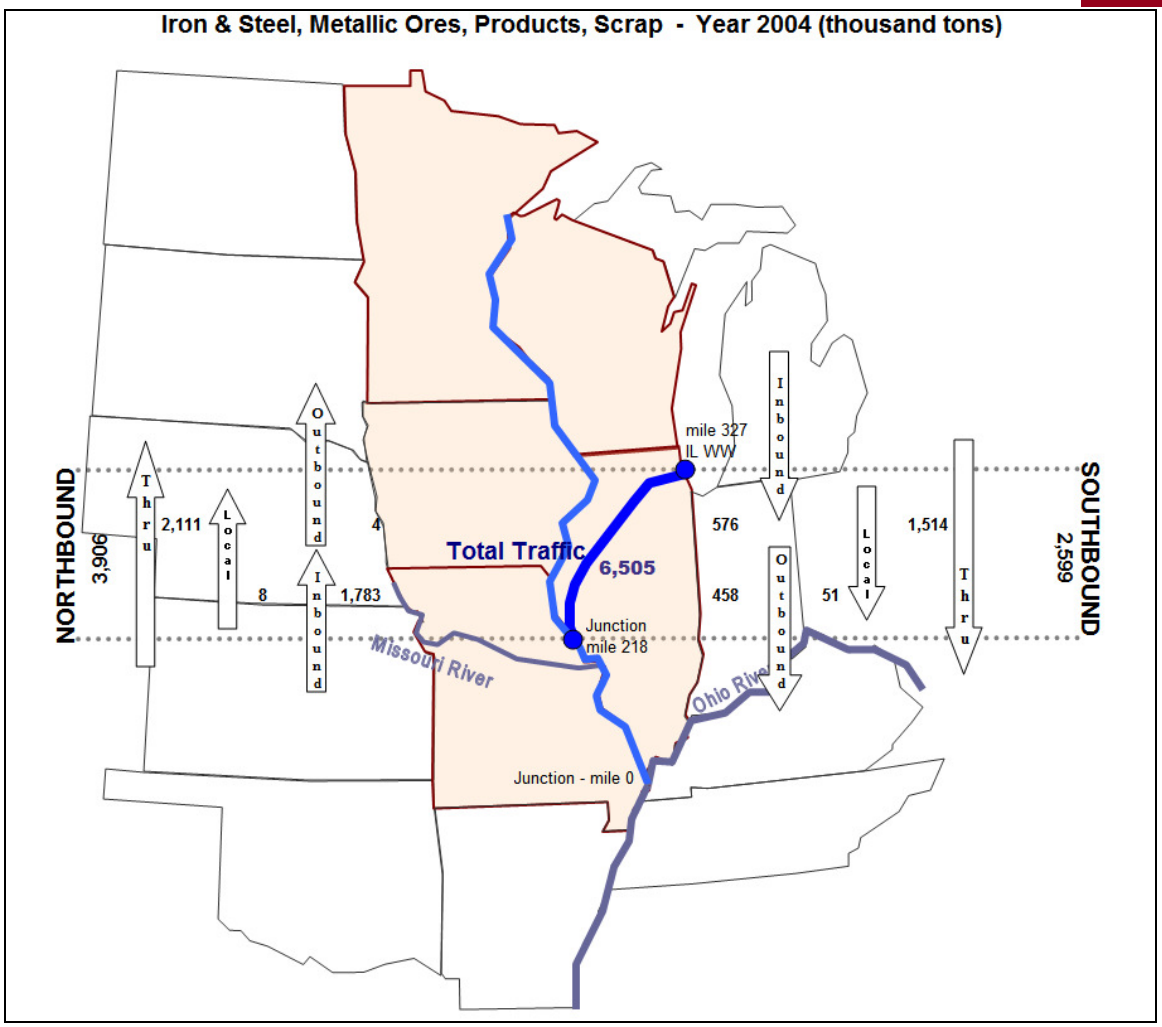
| Year | Illinois Waterway | | | | Upper Mississippi | | | |
|---|---|---|---|---|---|---|---|---|
| | Inbound | Outbound | Local | Through | Inbound | Outbound | Local | Through |
| 1997 | 1,056 | 247 | 86 | 2,660 | 1,529 | 1,060 | 40 | 3,637 |
| 1998 | 1,391 | 206 | 113 | 2,896 | 2,099 | 894 | 26 | 4,375 |
| 1999 | 1,161 | 284 | 83 | 2,835 | 1,734 | 718 | 14 | 4,095 |
| 2000 | 1,813 | 348 | 17 | 3,374 | 1,895 | 985 | 61 | 5,373 |
| 2001 | 1,506 | 404 | 37 | 2,091 | 1,161 | 974 | 63 | 3,827 |
| 2002 | 1,537 | 450 | 24 | 2,871 | 1,159 | 915 | 64 | 4,533 |
| 2003 | 1,309 | 546 | 20 | 2,919 | 951 | 1,281 | 13 | 4,410 |
| 2004 | 2,359 | 462 | 59 | 3,625 | 1,504 | 1,415 | 37 | 5,593 |

(Source: Waterborne Commerce of United States)




(Source: Waterborne Commerce of United States)

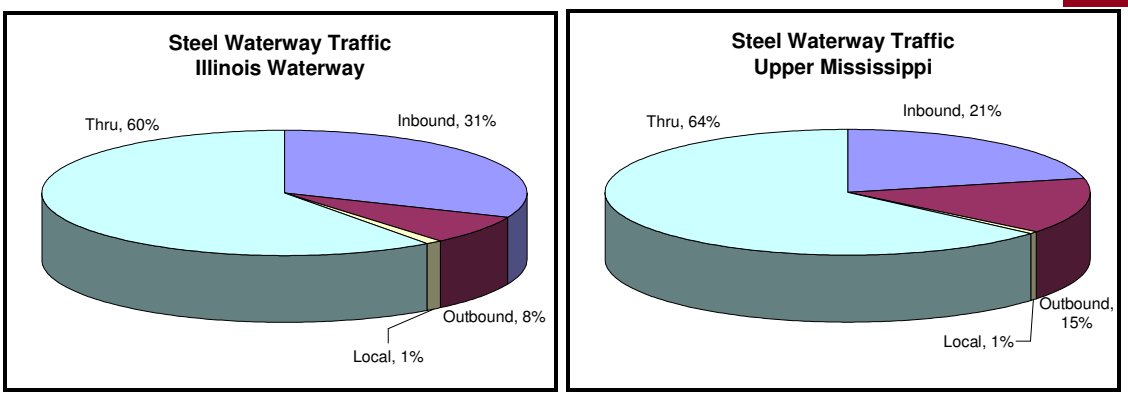
**Figure 59: Upper Mississippi Inbound, Outbound, Local and Through Waterway Movements 2004**




(Source: Waterborne Commerce of United States)

**Figure 60: Illinois Waterway Inbound, Outbound, Local and Through Waterway Movements 2004**

**Table 38** shows the inbound, outbound, local, and through traffic on the Upper Mississippi and Illinois Waterway from 1997-2004. **Figure 59** and **Figure 60** illustrate these movements for the year 2004. Through movements have the largest share for both the waterways (**Figure 61**), which shows that the waterway are carriers for steel produced and consumed *outside* the region. This shows that, in addition to the Illinois steel mills raw materials and products, waterway traffic is also transporting steel to/from the Great Lakes and northern regions from/to the southern US. It is also important to note that local demand for steel in Illinois is expected to be met from local steel mills using either truck or rail, which would be more efficient for shorter distances than barges. Illinois has a larger inbound movement share than Upper Mississippi, which is due to the raw materials being shipped to the new electric arc furnace steel mini-mills across Illinois.




(Note: 1997-2004 Average; Source: Waterborne Commerce of United States)

**Figure 61: Inbound, Outbound, Local, and Through Steel Waterway Shares**

## Main Origin/Destinations

The dominant flow for steel to/from the Upper Mississippi and Illinois Waterway in 2004 is with the lower Mississippi as shown in **Table 39** and **Table 40**. This includes the movement of raw materials to the steel mills in the region and the finished good from the mills in the region. About 15% of the steel flow from both waterways originates/terminates in the Ohio River. A high share of steel tonnage moving to the Lower Mississippi and other waterways coupled with fact that about 60% of the total waterway movements are *through* traffic shows that the steel waterway movement is impacted by the entire US and not just the region.

**Table 39: Main Destinations of Steel Shipped FROM Upper Mississippi and Illinois Waterway**

| FROM Upper Mississippi | | FROM Illinois Waterway | |
|---|---|---|---|
| TO Waterway | Share | TO Waterway | Share |
| LOWER MISS | 64% | LOWER MISS | 63% |
| GIWW WEST | 9% | OHIO | 14% |
| OHIO | 8% | ILLINOIS | 11% |
| GIWW EAST | 7% | UPPER MISS | 7% |
| UPPER MISS | 4% | TENNESSEE | 2% |
| ARKANSAS | 3% | GIWW WEST | 2% |
| OTHERS | 5% | OTHERS | 2% |
| **Total** | | **Total** | |

(GIWW: Gulf Intracoastal Waterway)
(Source: Tennessee Valley Authority, 2004)

**Table 40: Main Origins of Steel Shipped TO Upper Mississippi and Illinois Waterway**

| TO Upper Mississippi | | TO Illinois Waterway | |
|---|---|---|---|
| FROM Waterway | Share | FROM Waterway | Share |
| LOWER MISS | 66% | LOWER MISS | 82% |
| OHIO | 15% | ILLINOIS | 4% |
| ILLINOIS | 8% | OHIO | 4% |
| TENNESSEE | 4% | TENNESSEE | 3% |
| UPPER MISS | 4% | GIWW WEST | 2% |
| GIWW WEST | 2% | CUMBERLAND | 2% |
| OTHERS | 2% | OTHERS | 3% |
| **Total** | | **Total** | |

(GIWW: Gulf Intracoastal Waterway)
(Source: Tennessee Valley Authority, 2004)

The volumes of waterborne cargo generated by each sub-sector of the iron and steel industry from 1997-2004 indicate that a higher quantity of iron and scrap steel is moving in the Upper Mississippi and Illinois Waterway system than iron ore (**Table 41**). It is evident that the waterway has a high share of raw materials used in the steel mini-mills that have been increasing in the region, particularly Illinois. The lower part of **Table 41** shows the steel industry finished products that are carried by the waterway. The share of these products combined for the entire waterway is about 42%. The waterway is thus used by both the inputs and outputs of steel production.

**Table 41: Steel Commodity Constituents Waterway Tonnage Shares (1997-2004 Average)**

| | Constituent | UM | IWW | UM+IWW |
|---|---|---|---|---|
| Raw Materials | Iron Ore | 4% | 3% | 3% |
| | Iron & Steel Scrap | 19% | 20% | 19% |
| | Slag | 6% | 6% | 6% |
| | Pig Iron | 18% | 21% | 19% |
| | Ferro Alloys | 4% | 4% | 4% |
| Finished Goods | I&S Primary Forms | 5% | 5% | 5% |
| | I&S Plates & Sheets | 20% | 19% | 20% |
| | I&S Bars & Shapes | 6% | 6% | 6% |
| | Primary I&S NEC | 7% | 9% | 8% |
| | Fab. Metal Products | 3% | 3% | 3% |
| Others | | 8% | 4% | 6% |

(Source: Waterborne Commerce of United States)

A large share of the Upper Mississippi and Illinois Waterway tonnage originates and terminates in Illinois (77%)[51], which is because of the high presence of steel mills in the state as compared to Iowa, Wisconsin, Minnesota and Missouri. Of the waterway tonnage 20% originates in Wisconsin, while about 6% destines in the same state. Of the steel

[51] Source: Waterborne Commerce Statistics Center, New Orleans

waterway tonnage, 12% terminates in Missouri and about 2% terminates in both Minnesota and Iowa.

### 2.4.3 Forecasting Methodology

The conceptual diagram for the steel industry is shown in **Figure 62**. The end industries are listed in the box on the left. These are the industries that use the steel produced and imported by the US. The main factors that are of importance for these industries are listed in the middle box in **Figure 62**[52]. These are the factors that would impact the end user industries for steel and thus it would be appropriate for us to determine the parameters affecting these factors. The amount of steel production describes the demand and supply while the method of production governs the cost, type, and quality of steel. Steel commodity waterway traffic is thus dependent on the steel being produced in the region and the country. US steel production was considered an independent variable because it describes the changes in steel demand and supply in the region. **Table 42** shows the US steel production from 1997 – 2004.

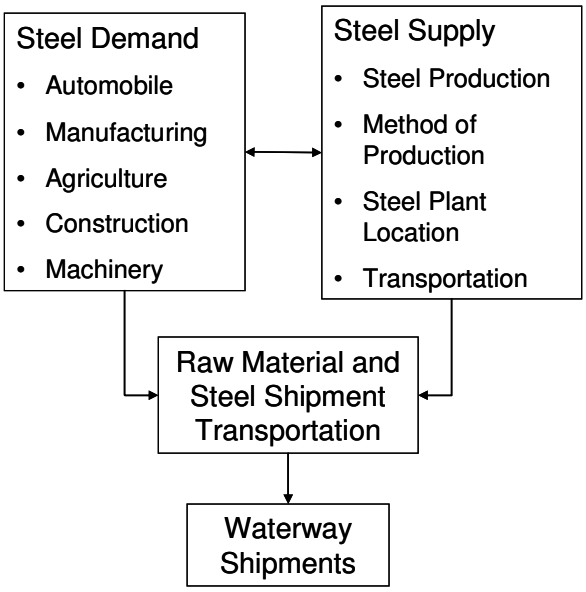



**Figure 62: Steel Industry Conceptual Diagram**

US steel production is a function of consumption, imports, and exports. Since, these four variables are interdependent because of factors like domestic and international steel price and demand, US production also implicitly reflects the variation in these variables.

From the study of the recent trends in the steel industry, it was observed that growth in US steel production is the result of new, more efficient steel mini-mills that use less labor, steel scrap, produce higher quality steel, and are more environmentally friendly than the traditional integrated steel mills. As the mini-mills start commanding a larger

[52] Price is an important component for both the Steel Demand and Supply and is not shown in the figure

share of U.S. steel production, steel scrap barge movements will increase in order to supply the inputs for the mini-mills.

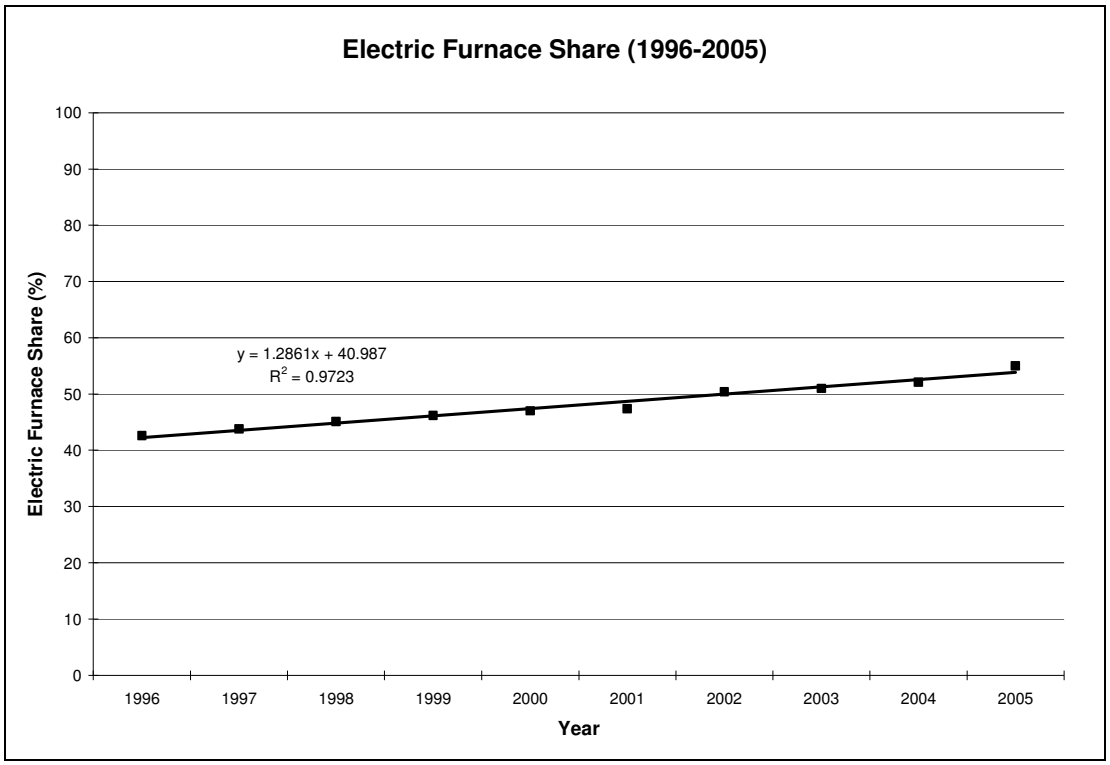
It was thus considered important to consider the share of electric furnaces in the US steel industry as an independent variable. The electric furnace share data was obtained from the American Iron and Steel Institute for 1996-2005 and is tabulated in **Table 42** (See **Figure 63**).

The linear regression results are presented below for the Upper Mississippi and UM and IL Waterways combined. The traffic for Illinois Waterway is calculated by subtracting the Upper Mississippi traffic from the combined traffic for both waterways. All the variables used are statistically significant at 95% confidence level with very high values for goodness of fit.

**Table 42: Regression Variables 1997-2004**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| US Crude Steel Production | 8,059 | 8,108 | 8,013 | 8,393 | 7,476 | 7,634 | 7,612 | 8,210 |
| Electric Furnace | 44% | 45% | 46% | 47% | 47% | 50% | 51% | 52% |
| UM Total Steel Tonnage | 4,049 | 4,606 | 4,363 | 5,552 | 4,038 | 4,882 | 4,794 | 6,505 |
| IWW Total Steel Tonnage | 6,266 | 7,394 | 6,561 | 8,314 | 6,025 | 6,671 | 6,655 | 8,549 |
| UM+IWW Total Tonnage | 10,315 | 12,000 | 10,924 | 13,866 | 10,063 | 11,553 | 11,449 | 15,054 |

(Source: US Steel Production, Electric Furnace Share: American Iron and Steel Institute, Annual Statistical Report 2005; Waterway Traffic: Waterborne Commerce of United States)




(Source: American Iron and Steel Institute, Annual Statistical Report, 2005)

**Figure 63: Electric Furnace Share of United States Steel Production, 1996-2005**

The resulting regression equations are given below.

| | | | |
|---|---|---|---|
| **UM+IWW Barge Traffic =** | **-45427** | **+ 4.62 (US Steel Production)** | **+ 431.73 (Electric Furnace Share)** |
| (Std Error) | (6249) | (0.59) | (64.04) |
| *t-statistic* | | *+7.89* | *+6.74* |
| $R^2$ | 0.94 | | |

*Barge Traffic is in '000 Tons*
*US Steel Production is in Million Metric Tons*
*Electric Furnace Share is in %*

| | | | |
|---|---|---|---|
| **UM Barge Traffic =** | **-22244** | **+ 1.94 (US Steel Production)** | **+ 243.65 (Electric Furnace Share)** |
| (Std Error) | (2214) | (0.21) | (22.69) |
| *t-statistic* | | *+9.37* | *+10.74* |
| $R^2$ | 0.97 | | |

*Barge Traffic is in '000 Tons*
*US Steel Production is in Million Metric Tons*
*Electric Furnace Share is in %*

The regression results show that waterway traffic will increase with an increase in the US steel production and the electric furnace share. An increase in steel production would result in higher tonnage that needing transportation from the production site to consumption regions increasing waterway traffic. An increase in the electric furnace share translates into a greater number of mini-mills producing a cheaper product. Since, there are fewer location constraints for mini-mills than for traditional integrated steel mills, new steel mills may come up in non traditional-steel-producing regions in the Upper Mississippi and Illinois Waterway catchment area.

The next step was to subtract the forecasted waterway traffic for Upper Mississippi from the forecasted combined waterway traffic.

The complete forecasting procedure is outlined below.

Step 1: Forecast the Upper Mississippi Waterway steel traffic using the regression equation given above. (This will need forecasted values for US Steel Production and Electric Furnace Share).

Step 2: Forecast the Upper Mississippi and Illinois Waterway Combined Steel traffic using the regression equation given above. (This will need the forecasted values for US Steel Production and Electric Furnace Share).

Step 3: Calculate the Illinois Waterway Steel Traffic by subtracting the value obtained in Step 1 from Step 2.

### 2.4.4 Steel Forecast

This section presents LBG's scenarios for the unconstrained steel movement forecast on the Upper Mississippi and Illinois Waterways.

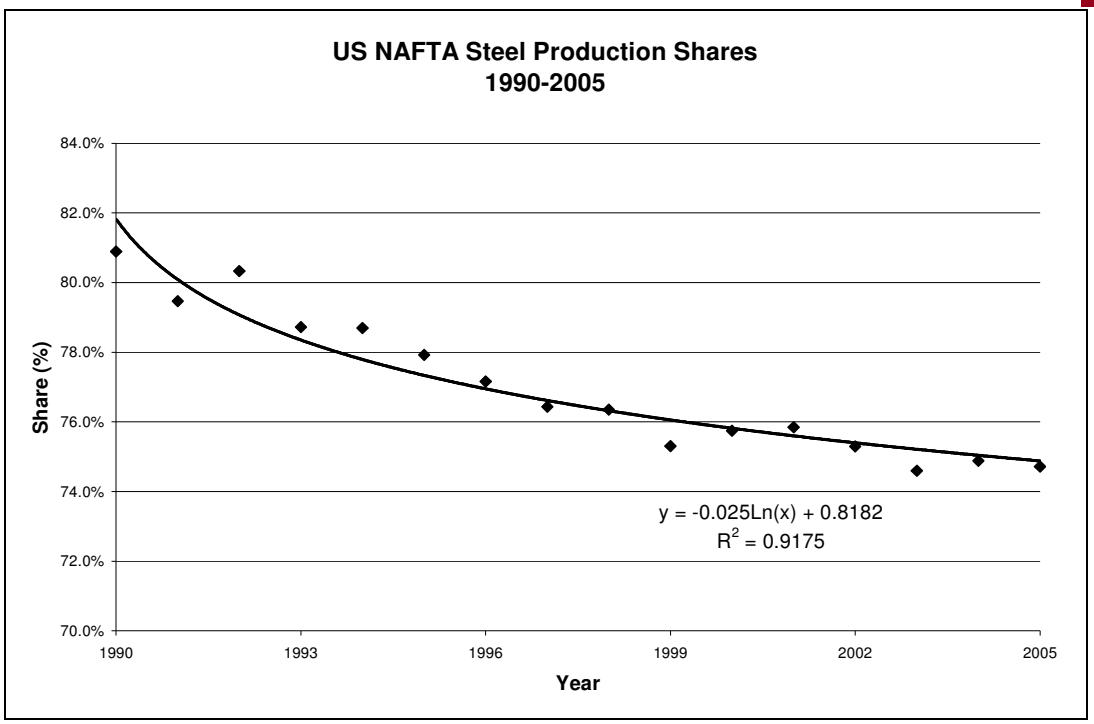
- The US NAFTA steel production shares will follow the historical trend from 1990-2005 for the forecast years through 2030.

- The Electric furnace share of total US steel production will reach 65% in 2020 and then remain constant.

To forecast steel waterway tonnage using the regression equation developed in this section, we need to forecast the values of US steel production and electric furnace share in US steel production.

According to the American Iron and Steel Institute's Director of Statistics, Mr. Robert MacDonald[53], the US steel production projection can be obtained from the NAFTA steel production projections using the growth rates forecasted by the International Iron and Steel Institute (IISI)[54]. To calculate US Steel production from NAFTA steel production, the trends in US share of NAFTA were analyzed from 1990-2005. The illustration in **Figure 64** shows that the share has been decreasing in a logarithmic fashion. It was thus assumed that this share would decrease following the same trend reaching a value of 73% in 2030. The US steel production forecasted values were obtained by multiplying the NAFTA steel forecast with the forecasted values of US share of NAFTA steel production.

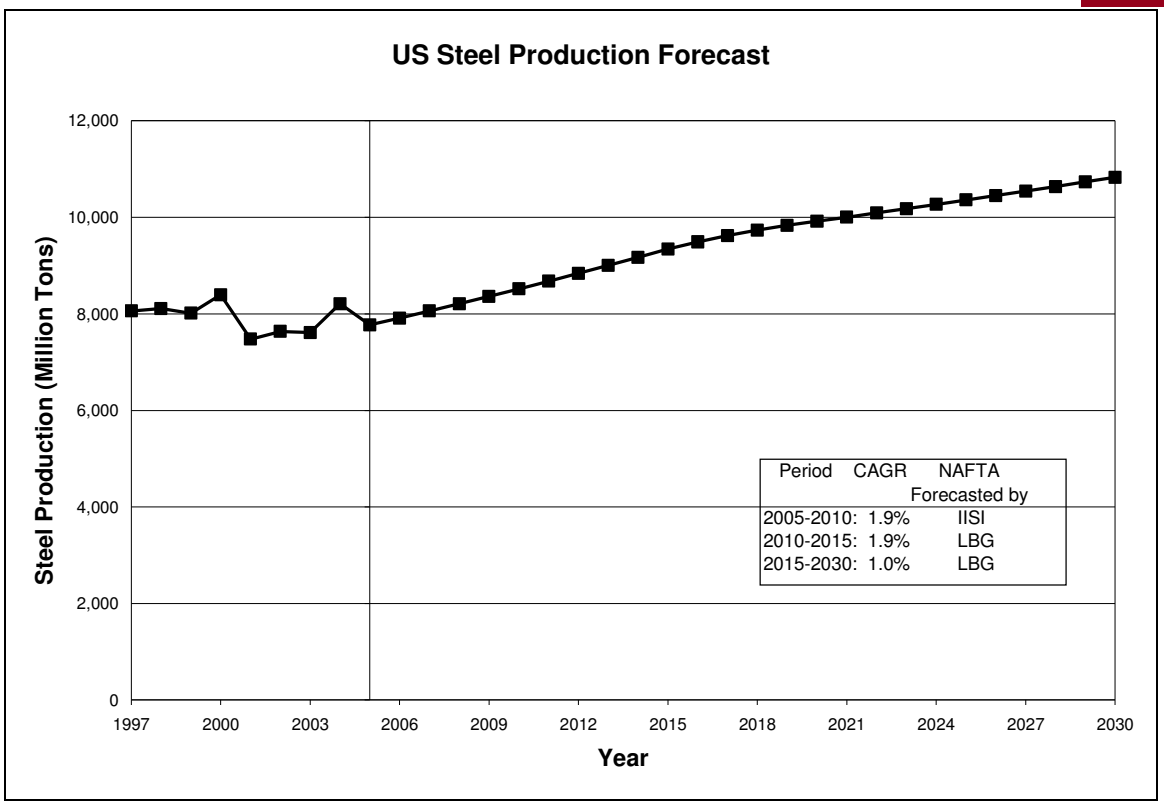
[53] Phone Interview, Mr. Robert MacDonald, Director of Statistics at the American Iron and Steel Institute. (January 30, 2007).
[54] *Short range Outlook and Medium Term Forecast*, October 2, 2006. Available from http://www.worldsteel.org/pictures/newsfiles/061002%20Short%20Range%20Outlook.pdf accessed on March 5, 2007.




(Source: International Iron and Steel Institute, 2006)

**Figure 64: US NAFTA Steel Production Shares, 1990-2005**

The IISI forecasted the NAFTA annual growth rate of 1.9% until 2010. It was further assumed that the NAFTA annual growth rate would continue till 2015 and then reduce to 1% by 2020 and would remain at that level until 2030. The forecasted US steel production is presented in **Figure 65**. (The data is shown in **Table 43**).

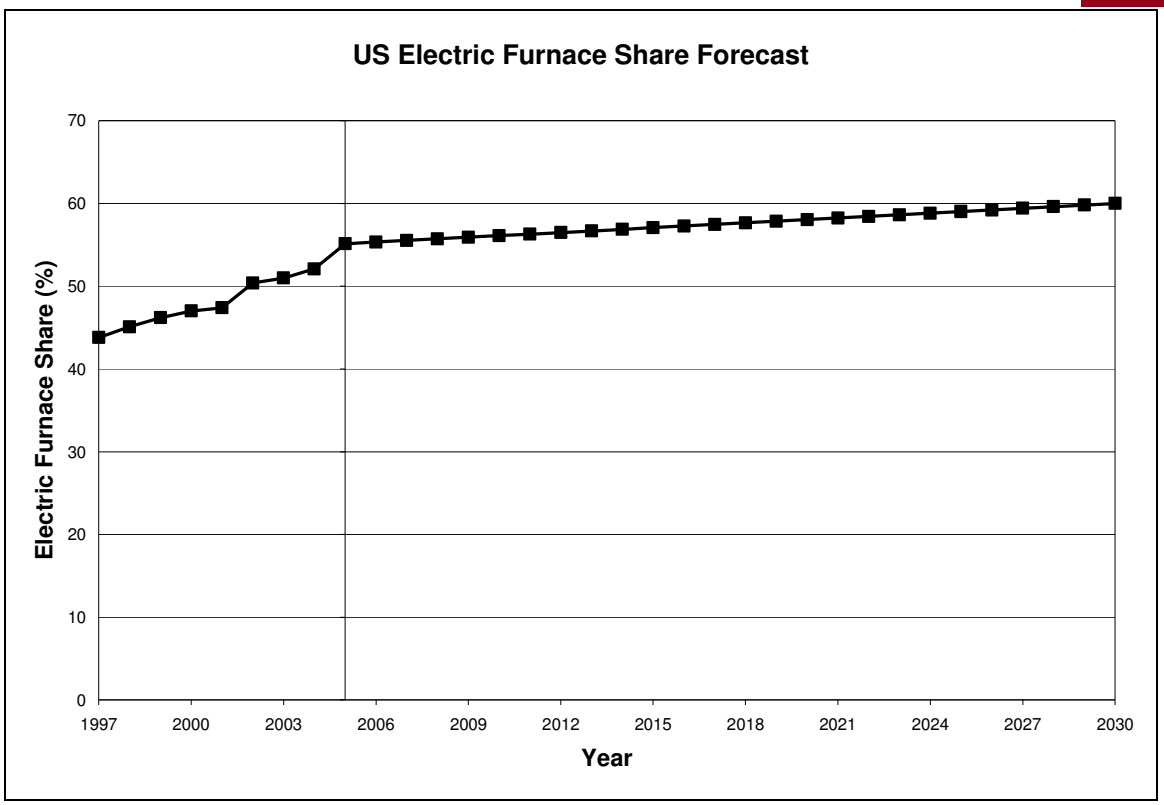



(Source: International Iron and Steel Institute (IISI) NAFTA Steel Production Projections)

**Figure 65: US Steel Production Forecasts, 2006-2030**

Historical data for electric furnace share (shown in **Figure 66**) shows a linear trend with a very high goodness of fit value (0.97). It was thus assumed that the electric furnace share would follow the same trend. It was, however, important to consider the maximum possible share of electric furnaces in US Steel production since all kinds and qualities of steel cannot be produced by this technology. One expert suggested that the growth of electric furnace mini-mills would come to equilibrium mainly because of the rising price of scrap.[55] Another expert agreed with the understanding that the electric furnace share would reach a maximum level and then stabilize.[56] Based on the knowledge from different sources and the expert interviews the maximum electric furnace share was assumed to be 60% reached in 2020. The forecasts are presented in **Figure 66**.

[55] *Iron and Steel Engineer*, November 1997, Page 52.
[56] Phone Interview with Mr. Tom Graham, (February 1, 2007).

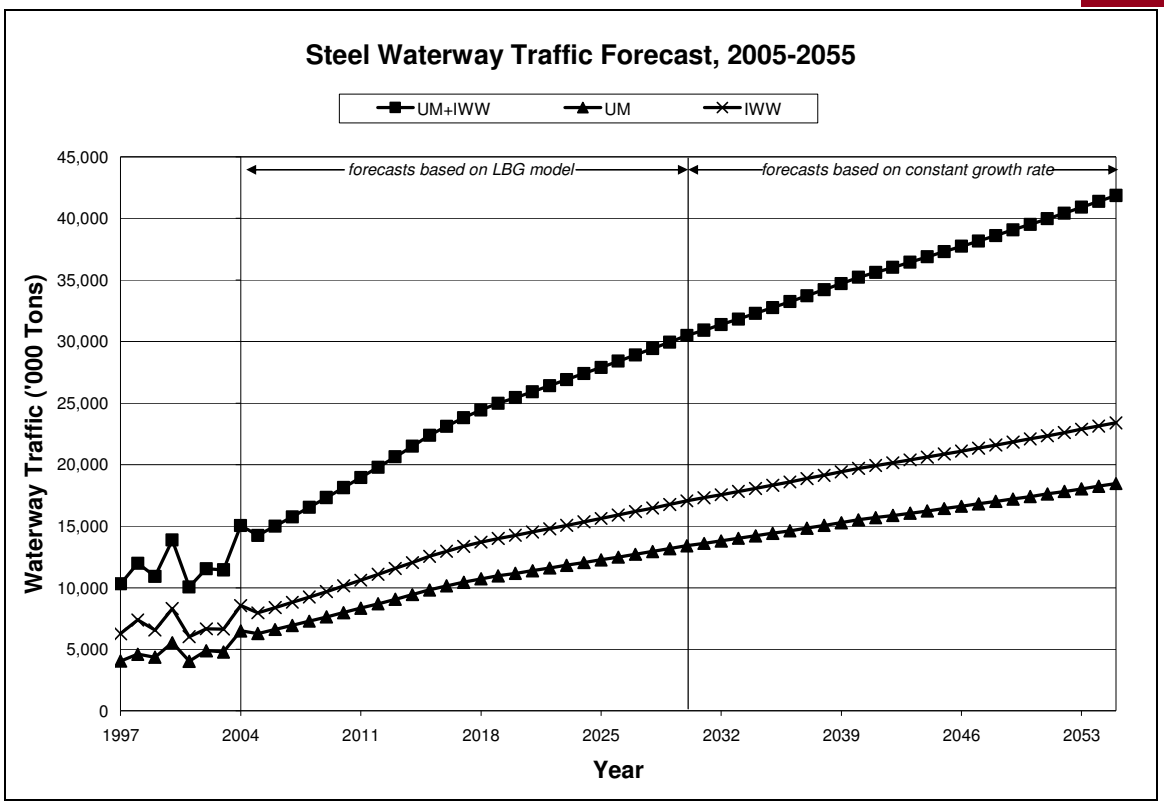



(Source: LBG Analysis with data from American Iron and Steel Institute and Expert Interviews)

**Figure 66: US Electric Furnace Share Forecast, 2006-2030**

The unconstrained steel waterway traffic forecast model developed in the previous section was used to forecast the total Upper Mississippi and Illinois Waterways combined traffic for steel through 2030. It is difficult to reasonably predict the changes in distant future for any industry, therefore, constant growth rates were used to forecast the waterway traffic beyond 2030. It was assumed that the waterway traffic for the period 2030-2040 would grow at 80% of the growth rate from 2020-2030. For 2040-2055, waterway traffic was assumed to grow at 80% of the growth rate from 2030-2040. The forecast results are tabulated in **Table 44** and presented in **Figure 67**.

The forecasts show a constant increase in the waterway tonnage from 2007 onwards. The growth rates reduce over time (See **Table 44**).




(Source: LBG Analysis)

**Figure 67: Steel Unconstrained Waterway Traffic Forecast 2006-2055**

**Table 43: Steel Unconstrained Waterway Forecasts: LBG Base Case Scenario Results**

| Year | US Steel Production | Electric Furnace Share | UM+IWW Tonnage | UM Tonnage | IWW Tonnage |
|---|---|---|---|---|---|
| | Million Tons | % | 000 Tons | 000 Tons | 000 Tons |
| 1997 | 8,059 | 44 | 10,315 | 4,049 | 6,266 |
| 1998 | 8,108 | 45 | 12,000 | 4,606 | 7,394 |
| 1999 | 8,013 | 46 | 10,924 | 4,363 | 6,561 |
| 2000 | 8,393 | 47 | 13,866 | 5,552 | 8,314 |
| 2001 | 7,476 | 47 | 10,063 | 4,038 | 6,025 |
| 2002 | 7,634 | 50 | 11,553 | 4,882 | 6,671 |
| 2003 | 7,612 | 51 | 11,449 | 4,794 | 6,655 |
| 2004 | 8,210 | 52 | 15,054 | 6,505 | 8,549 |
| 2005 | 7,768 | 55 | 14,252 | 6,287 | 7,965 |
| 2006 | 7,912 | 55 | 14,999 | 6,614 | 8,386 |
| 2010 | 8,517 | 56 | 18,131 | 7,980 | 10,151 |
| 2015 | 9,344 | 57 | 22,371 | 9,824 | 12,547 |
| 2020 | 9,918 | 58 | 25,444 | 11,178 | 14,266 |
| 2025 | 10,357 | 59 | 27,892 | 12,268 | 15,624 |
| 2030 | 10,827 | 60 | 30,480 | 13,418 | 17,063 |
| 2035 | | | 32,756 | 14,425 | 18,331 |
| 2040 | | | 35,202 | 15,507 | 19,695 |
| 2045 | | | 37,293 | 16,433 | 20,859 |
| 2050 | | | 39,507 | 17,414 | 22,093 |
| 2055 | | | 41,854 | 18,454 | 23,400 |

(Source: LBG Analysis)

**Table 44: Cumulative Annual Growth Rates. 2000-2055**

| From Year | To Year | UM+IWW | UM | IWW |
|---|---|---|---|---|
| 1997 | 2004 | 5.5% | 7.0% | 4.5% |
| 2005 | 2010 | 4.9% | 4.9% | 5.0% |
| 2010 | 2015 | 4.3% | 4.2% | 4.3% |
| 2015 | 2020 | 2.6% | 2.6% | 2.6% |
| 2020 | 2030 | 1.8% | 1.8% | 1.8% |
| 2030 | 2040 | 1.5% | 1.5% | 1.4% |
| 2040 | 2055 | 1.2% | 1.2% | 1.2% |
| **2005** | **2030** | **3.1%** | **3.1%** | **3.1%** |
| **2005** | **2055** | **2.2%** | **2.2%** | **2.2%** |

(Source: LBG Analysis)

## 2.5 Coal, Coke, Lignite

This section discusses the current situation and unconstrained forecasts for the movement of coal on the Upper Mississippi and Illinois Waterway systems.

### 2.5.1 U.S. Coal Industry Overview

Coal[57] demand in the US is mainly driven by the electric power and industrial sector, which, respectively, accounted for 87% and 12% of coal consumption in 2005. As the demand for electricity grew over the last few decades, the demand for coal also increased, resulting in a rise in coal production in the US. There were years in which coal production declined from the prior year but annual increases in coal production since 1950 outnumber decreases by almost two to one, and, as a result, coal production has more than doubled, averaging an annual growth rate of 2.4% from 1950 to 2005.

**Table 45: Coal Industry Production, Consumption, and Trade, 2005 (Million Short Tons[58])**

| Production/Consumption/ Trade | Quantity | Share (%) |
|---|---|---|
| Production by Region | | |
| Appalachian Region | 396 | 35% |
| Interior | 149 | 13% |
| Western | 587 | 52% |
| Total U.S. Production | 1,132 | 100% |
| Consumption by Sector | | |
| Electric Power | 1,039 | 87% |
| Industrial Plants | 145 | 12% |
| Residential & Commercial | 10 | 1% |
| Total Consumption | 1,194 | 100% |
| Foreign Trade | | |
| Imports | 31 | 38% |
| Exports | 50 | 62% |
| Total Foreign Trade | 81 | 100% |

(Source: Energy Information Administration, U.S. Coal Supply and Demand, 2005)

The most recent statistics for the US Coal Industry in terms of production, consumption, and foreign trade are included in **Table 45**. In 2005, total domestic production reached 1.33 billion tons with the Appalachian region (mainly Kentucky, Virginia, and West

[57] The Navigation Data Center, Waterborne Commerce Statistics Center, groups coal and coke commodities in two categories: "Coal Lignite" and "Coal Coke". "Coal Lignite" includes: "Coal, Whether or not Pulverized, but Not Agglomerated"; "Briquettes, Ovoid and Similar Solid Fuels from Coal"; "Lignite, Whether or not Pulverized (Excluding Jet)"; and "Peat (Including Peat Litter), Agglomerated or Not". "Coal Lignite" is described as "Coke, Semi-Coke of Coal, of Lignite or of Peat".

[58] Short Ton is a unit of mass equal to 2,000 lb (907.18474 kg). It differs from the metric ton (or tonne) equal to 1,000 kilograms (2,204.623 pounds) or the long ton equal to 2,240 pounds (1016.0469088 kg).

Virginia) contributing 35%, the Interior Region (Illinois, Michigan) 13%, and the Western Region (Colorado, Wyoming) contributing 52%. Some degree of regional specialization is observable in regional markets, such as low-sulfur coal from Wyoming, metallurgical coal from the Appalachian region, and high-sulfur coal from the Illinois Basin.

In terms of national consumption, out of the 1.19 billion tons available for use in the US, more than one billion tons or 87% was utilized for electric power generation and 13% for other industrial uses. In terms of foreign trade, in 2005, total US coal exports exceeded imports by about 19 million tons. Major export destinations were Canada with 8.98 million tons, Brazil 1.94 million tons, and several West European countries importing more than one million tons.

**Coal Industry in the Upper Mississippi and Illinois Waterway Region**

Coal production and consumption in the Upper Mississippi and Illinois Waterway region (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) for 2005 is summarized in **Table 46**. Only Illinois has significant coal production, though, in historical terms, Illinois' current production is limited. The 32 million tons produced in 2005 is a little more than half of its peak reached in the early 1990's, around 60 million tons. Coal demand is mostly satisfied by Wyoming and other Western coal producing states.

As with the national trend, most of the coal used in the region is for electric power generation. In fact, coal accounts for over 70% of all electric power generation in the East North Central Division[59], making it the largest coal consuming region in the U.S., using 23% of US coal supplies. Looking at 2005 state by state statistics, electric power generation consumes from 87% to 94% of the coal supplied at the state level (see **Table 46**). With electric demand growing constantly, coal consumption by the electric power industry has increased steadily in recent decades (see **Figure 68**).

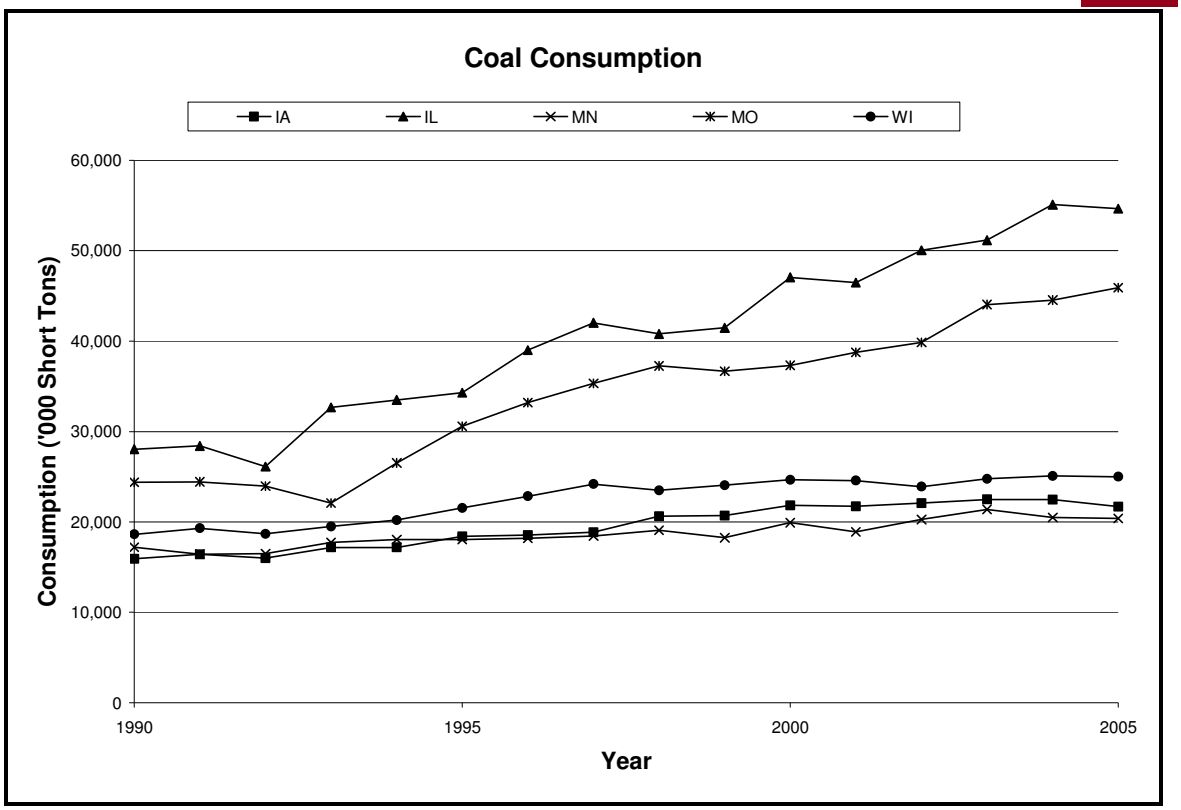
As mentioned above, the increased demand in the study region has mostly been supplied by western coal. The increased size and productivity of western surface mines has diminished the relative importance of regional coal production. Coal production in the Western region increased by more than 800% from 1973 to 2003 (50.5 to 492.6 million short tons). Appalachian and interior region coal production, however, remained stable during the same period with the former reducing from 381.6 million short tons in 1973 to 376.8 million short tons in 2003 and the latter decreasing from 156.4 million short tons in 1973 to 146.3 million short tons in 2003. With the dominance of Western coal in the Midwest markets, railroads increased their share as the primary mode of transportation.

[59] As defined by the U.S. Census Bureau, it includes Wisconsin, Illinois, Indiana, Michigan and Ohio.

**Table 46: Coal Production and Consumption in the UM and IL Waterway Region, 2005 ('000 Short Tons)**

| State Production/Consumption | Quantity | Share |
|---|---|---|
| **ILLINOIS** | | |
| Production by Mine Type | | |
| Underground | 26,343 | 82% |
| Surface | 5,671 | 18% |
| Total Production | 32,014 | 100% |
| Consumption by Sector | | |
| Electric Power | 53,822 | 94% |
| Industrial Plants | 3,502 | 6% |
| Residential & Commercial | 146 | 0% |
| Total Consumption | 57,470 | 100% |
| **IOWA** | | |
| Consumption by Sector | | |
| Electric Power | 21,072 | 87% |
| Industrial Plants | 2,930 | 12% |
| Residential & Commercial | 274 | 1% |
| Total Consumption | 24,276 | 100% |
| **MINNESOTA** | | |
| Consumption by Sector | | |
| Electric Power | 20,008 | 94% |
| Industrial Plants | 1,300 | 6% |
| Residential & Commercial | 72 | 0% |
| Total Consumption | 21,380 | 100% |
| **MISSOURI** | | |
| Production by Mine Type | | |
| Surface | 598 | |
| Consumption by Sector | | |
| Electric Power | 45,765 | 97% |
| Industrial Plants | 1,052 | 2% |
| Residential & Commercial | 215 | 0% |
| Total Consumption | 47,032 | 100% |
| **WISCONSIN** | | |
| Consumption by Sector | | |
| Electric Power | 24,615 | 92% |
| Industrial Plants | 1,695 | 6% |
| Residential & Commercial | 417 | 2% |
| Total Consumption | 26,727 | 100% |

(Source: Energy Information Administration, 2005)




(Source: Energy Information Administration, 2005)

**Figure 68: Coal Consumption by Electric Power Industry in the Study Region, 1990-2005**

**Table 47**[60] details the method of transportation used to distribute coal in 2003 and 2004 for each of the states in the region. Rail was used to transport at least 92% of the coal in Iowa, Minnesota, Missouri, and Wisconsin. The modal share of railroads in Illinois reached 78% in 2003 and 81% in 2004, with the rest split among river, conveyor/ pipeline, and trucks, reflecting the options available to transport local production.

[60] The Coal tonnage values in this table for river transportation do not match with the values used in the next section because this table shows the coal that terminates in each state from any waterway. The next chapter uses the coal tonnage values for each waterway and not each state.

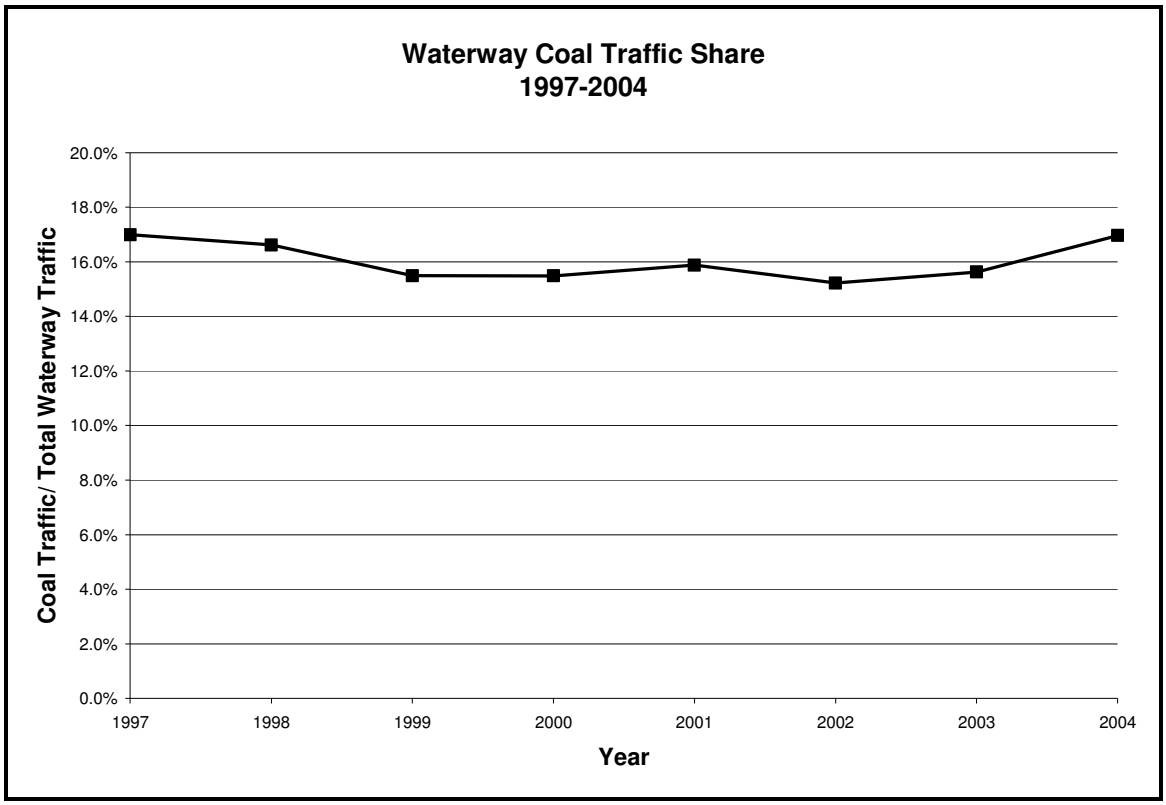
**Table 47: Domestic Distribution of U.S. Coal by Destination State and Method of Transportation, 2003-2004 (Thousand Short Tons)**

| Destination/Mode | 2003 | | 2004 | |
|---|---|---|---|---|
| | Volume | Share | Volume | Share |
| **ILLINOIS** | **60,546** | | **58,082** | |
| Great Lakes | 0 | 0% | 7 | 0% |
| Railroad | 47,350 | 78% | 47,293 | 81% |
| River | 3,068 | 5% | 1,010 | 2% |
| Tramway, Conveyor, and Slurry Pipeline | 4,762 | 8% | 4,984 | 9% |
| Truck | 5,365 | 9% | 4,788 | 8% |
| **IOWA** | **22,199** | | **21,753** | |
| Railroad | 20,418 | 92% | 20,991 | 96% |
| River | 1,306 | 6% | 697 | 3% |
| Truck | 474 | 2% | 66 | 0% |
| **MINNESOTA** | **22,126** | | **21,283** | |
| Great Lakes | 1,307 | 6% | 963 | 5% |
| Railroad | 20,570 | 93% | 20,203 | 95% |
| River | 132 | 1% | 118 | 1% |
| Truck | 117 | 1% | 0 | 0% |
| **MISSOURI** | **44,812** | | **49,266** | |
| Railroad | 42,906 | 96% | 47,505 | 96% |
| River | 972 | 2% | 644 | 1% |
| Truck | 935 | 2% | 1,118 | 2% |
| **WISCONSIN** | **26,382** | | **27,248** | |
| Great Lakes | 1,483 | 6% | 1,640 | 6% |
| Railroad | 23,989 | 91% | 24,457 | 90% |
| River | 893 | 3% | 1,138 | 4% |
| Truck | 17 | 0% | 13 | 0% |

(Source: Energy Information Administration, State Energy Profiles, 2005)

## 2.5.2 Coal Waterway Movements Overview

This commodity group represents about 16% of total cargo[61] on the Upper Mississippi and Illinois Waterway system (**Figure 69**), with Upper Mississippi accounting for 89% of the share (**Figure 70**). This difference in Upper Mississippi and Illinois Waterway shares is explained by the large amount of western coal delivered by rail to the transshipment terminals downstream of St. Louis and then moved on waterways in every direction. The share of coal traffic has shown slight variation from 1997-2004 within the 15%-17% band. This stable trend in coal's waterway share suggests that the coal industry has not witnessed any radical changes compared to the other industries that use the waterway for transporting their raw materials and products.



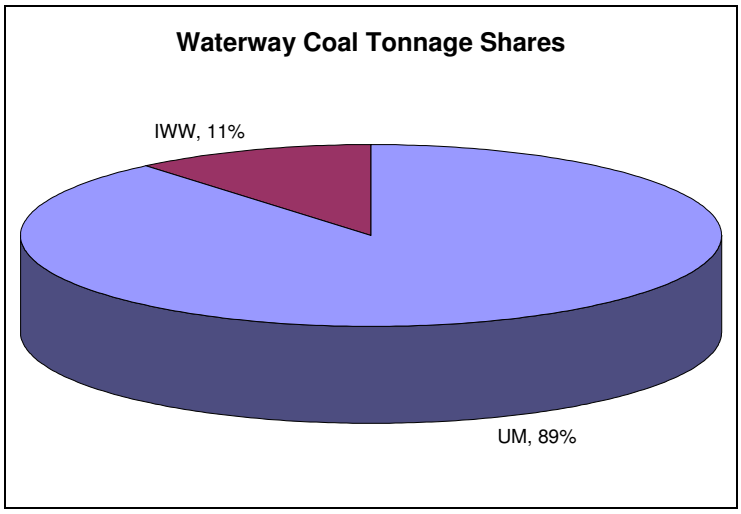

(Source: Waterborne Commerce of United States)

**Figure 69: Waterway Coal Traffic Share, 1997-2004**

**Figure 71** shows the coal traffic tonnage on the Upper Mississippi and Illinois Waterway system. During the period 1997-2004, both waterways experienced declining trends for coal and coke traffic, with Upper Mississippi tonnage declining annually by 129,000 tons and the tonnage on Illinois Waterway decreasing by 60,000 ton per year. These trends, however, translate into annual growth rates of -0.7% and -1.9% for Upper Mississippi

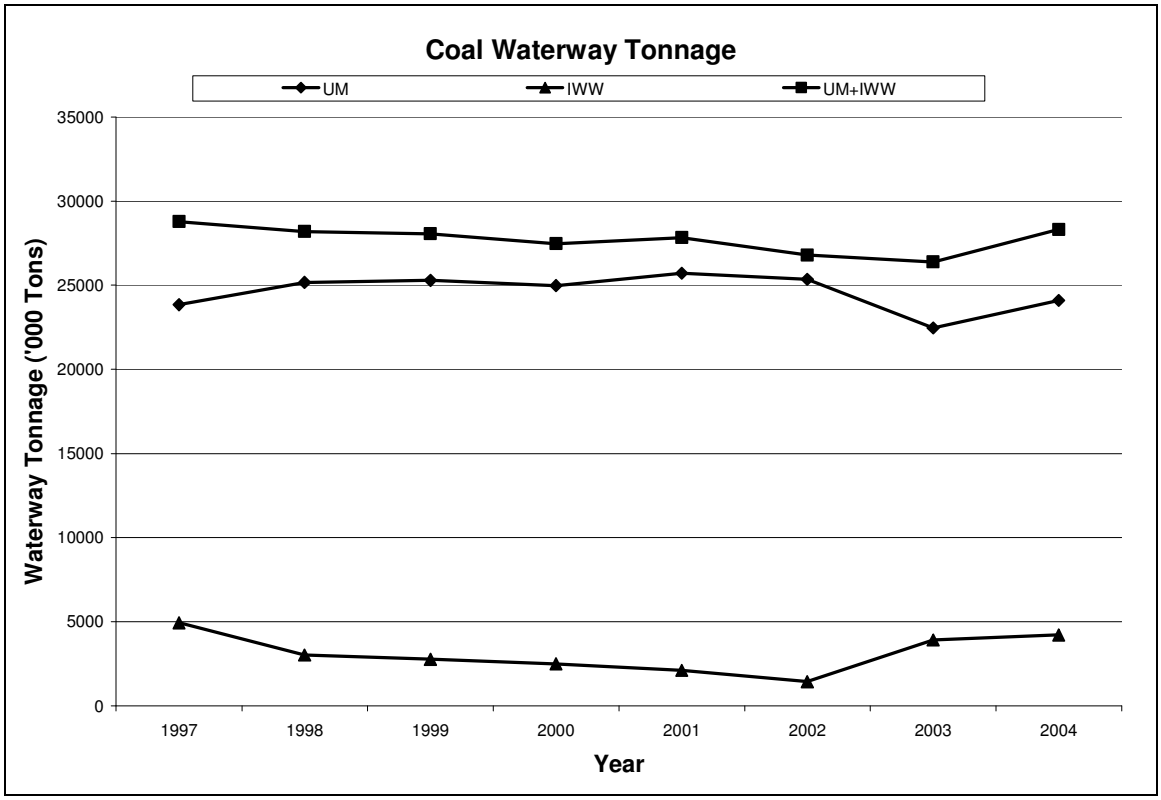
[61] Total cargo includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.

and Illinois Waterway respectively because of a larger cargo base on the Upper Mississippi.




(Source: Waterborne Commerce of United States)

**Figure 70: Coal Commodity Waterway Tonnage Share, 1997-2004 Average**




(Source: Waterborne Commerce of United States)

**Figure 71: Coal Waterway Tonnage 1997-2004**

Marked decreasing traffic during specific years reflects industry-wide developments. For example, the year 2002 was peculiar with declining production of coal, while the consumption increased. The lack of demand for coal deliveries led to some large companies idling mines for periods of time ranging from a few weeks to several months. As a result, coal production decreased in 2002 by 3% to a level of 1,094 million short tons. The drop of 33.4 million short tons in US coal production in 2002 was primarily a consequence of lower demand by all coal consuming sectors due to a weak economy and milder than normal weather for many parts of the country during most of the year.[62]

Specifically for the Upper Mississippi, a traffic decline during 2003 was documented in the Energy Information Administration annual report. Weather played a part in some of the transportation bottlenecks, as the lack of rain led to low water levels in the river transportation system, in particular on the Mississippi River in January and again in August, which resulted in delayed coal barge shipments. The increase in coal imports in the Gulf Coast added to this impact.

On the Illinois Waterway, the long-term decline dates back to the 1990 Clean Air Act, which sharply reduced the allowable limits for sulfur dioxide from fossil-fueled electric generating plants. Eight Illinois power plants switched to lower sulfur Western coal between 1991 and 2005, resulting in an annual loss of 10.7 million tons of Illinois coal sales. In addition, Illinois coal sales to other states dropped 20.5 million tons due to changes in air regulations and, to a lesser extent, price competition.[63] However, traffic increased in the Illinois Waterway for the years 2003-2004 reflecting increased coal mine activity in the southern part of the state; a trend which is expected to continue.

The coal production activity in Illinois is expected to increase in the future due to the reasons listed below. We also heard similar sentiments in our expert interviews conducted in the region strengthening the expectation of increases in Illinois coal output.

- To combat the high-sulfur content in Illinois basin coal in order to comply with the emission norms, power plants are retrofitting fuel gas desulphurization (FGD) or scrubbers.[64] This would eliminate the need for these plants to obtain low-sulfur coal from non-Illinois regions.
- The high reserve base of coal in the Illinois basin is the domestic substitute for the depleting reserves in the other regions of the US.[65]
- The price of Illinois coal is lower than similar coal from the Appalachian region and the energy output of Illinois coal is higher than the coal from the Western region.[66]
- Governmental support and initiative in making Illinois coal more competitive.[67]

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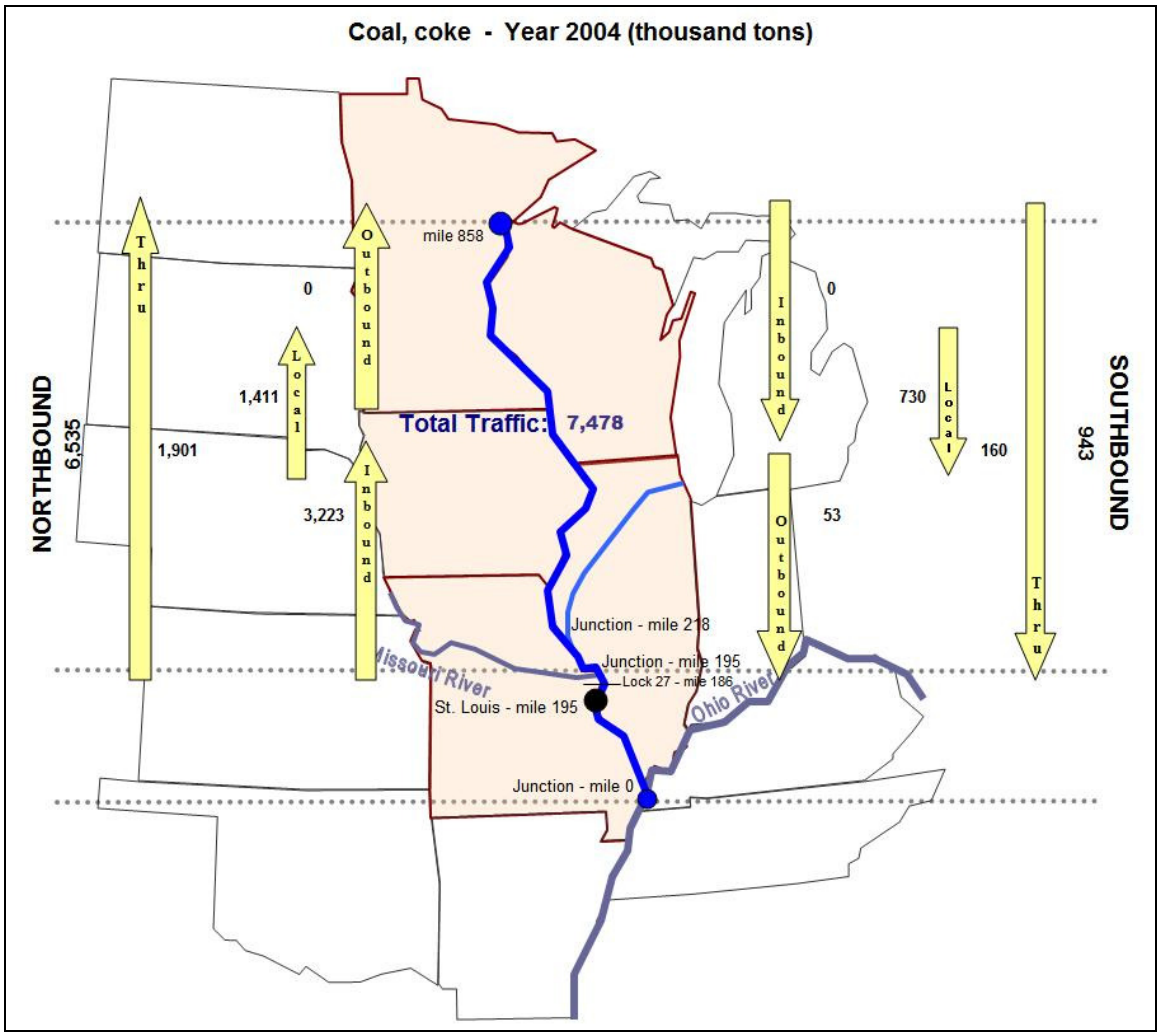
[62] Energy Information Administration, Annual Coal Report 2002-2003.
[63] The Illinois Coal Industry, Report of the Office of Coal Development, June 2006.
[64] Coal Market Watch, February 2005, http://www.evainc.com/EVAPR-PDF/February_Market_Watch.pdf accessed on March 30, 2007.
[65] For Coal reserves information: Energy Information Administration, Annual Report, Table 15, Available from http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html accessed on March 30, 2007.
[66] Coal Outlook, March 5, 2007, Available from, http://www.platts.com/Coal/Newsletters%20&%20Reports/Coal%20Outlook/See%20A%20Sample/index.pdf?o=v accessed on March 30, 2007.

**Table 48: Inbound, Outbound, Local and Through Coal Waterway Movements ('000 Tons)**

| Year | Illinois Waterway | | | | Upper Mississippi | | | |
|---|---|---|---|---|---|---|---|---|
| | Inbound | Outbound | Local | Through | Inbound | Outbound | Local | Through |
| 1997 | 3,214 | 183 | 5 | 1,540 | 3,434 | 13,574 | 3,821 | 3,019 |
| 1998 | 1,311 | 155 | 6 | 1,557 | 4,149 | 13,252 | 4,917 | 2,852 |
| 1999 | 1,274 | 59 | 1 | 1,434 | 3,346 | 13,352 | 6,110 | 2,481 |
| 2000 | 781 | 163 | - | 1,551 | 2,871 | 14,151 | 5,845 | 2,115 |
| 2001 | 733 | 76 | - | 1,302 | 3,178 | 15,306 | 5,216 | 2,020 |
| 2002 | 453 | 122 | - | 860 | 3,242 | 16,460 | 4,402 | 1,253 |
| 2003 | 461 | 154 | 2,505 | 800 | 2,892 | 14,354 | 3,978 | 1,243 |
| 2004 | 500 | 150 | 2,142 | 1,423 | 2,398 | 15,669 | 4,192 | 1,836 |

(Source: Waterborne Commerce of United States)

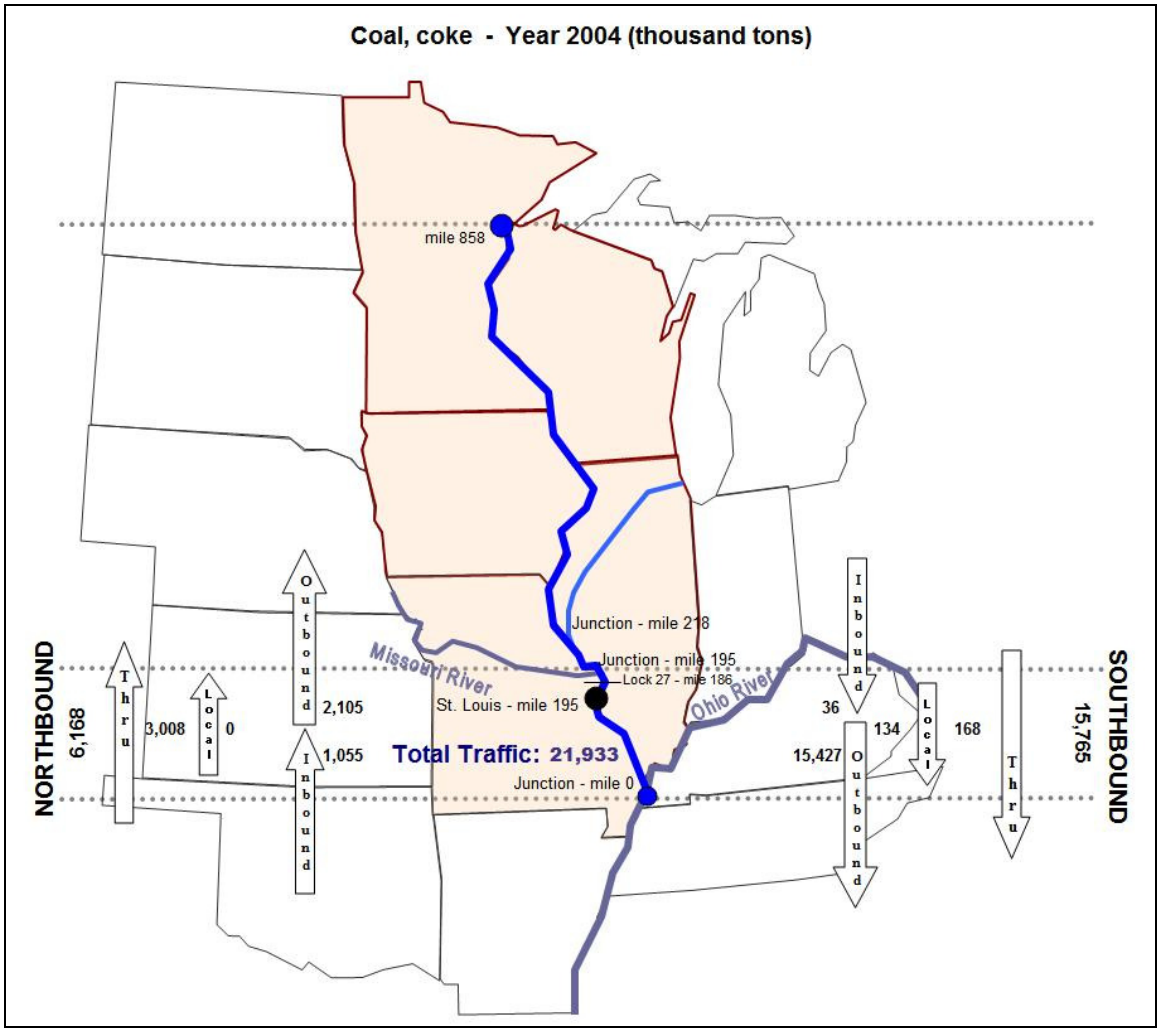



[67] References (accessed on March 30, 2007): http://www.ethanol-gec.org/08222006.htm and http://www.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=3&RecNum=4340.

(Source: Waterborne Commerce of United States)

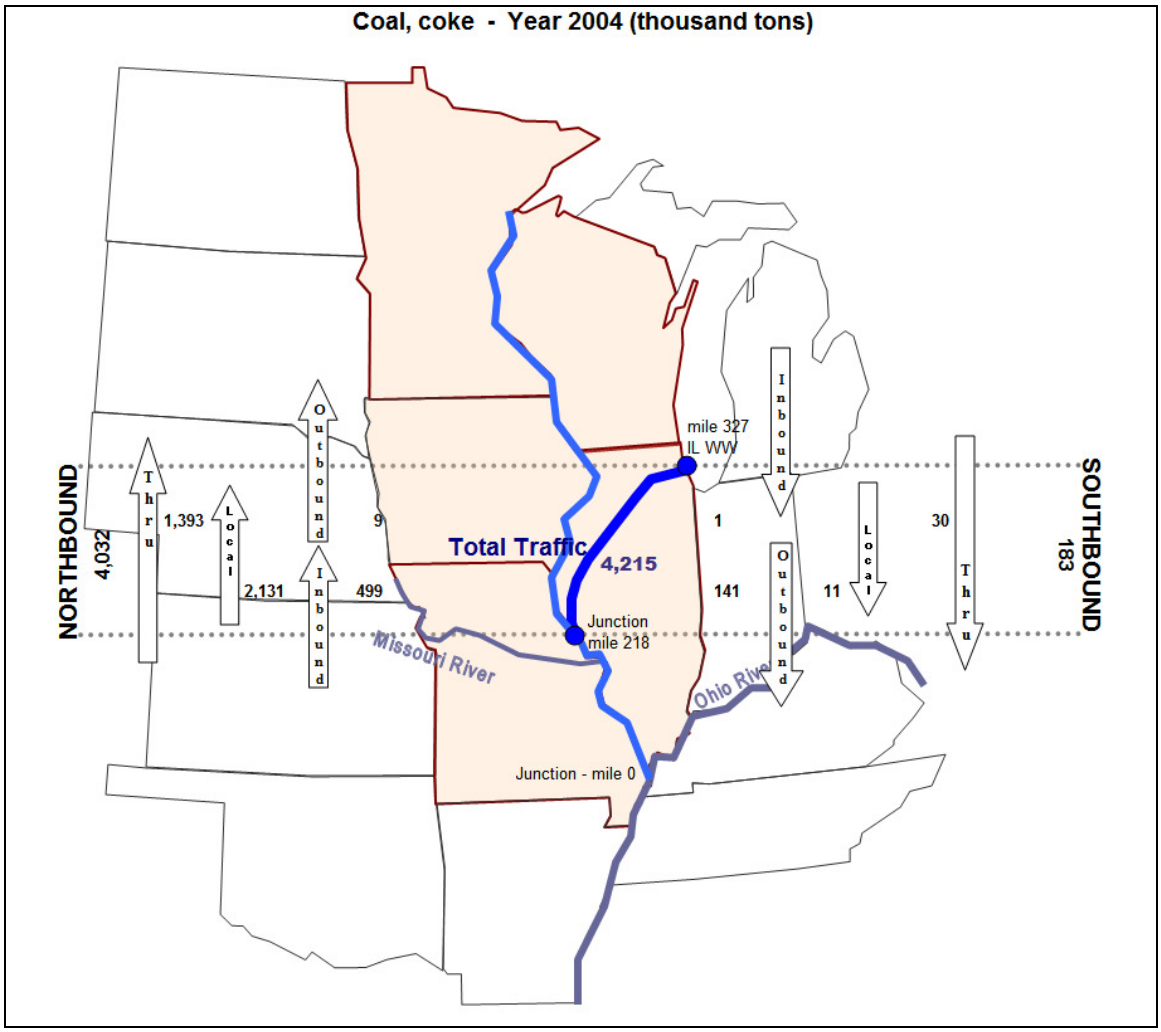
**Figure 72: Upper Mississippi (North) Inbound, Outbound, Local and Through Movements 2004**

The Upper Mississippi can be characterized as one of the gateways of Western Coal. **Table 48** shows the inbound, outbound, local, and through traffic on the Upper Mississippi and Illinois Waterway. **Figure 72** through **Figure 74** illustrate these movements for the year 2004. **Figure 75** shows that the *through* movements have the largest share for the Illinois Waterway, while *outbound* movements have the largest share for the Upper Mississippi. Illinois region is a net importer of coal with about 500,000 tons from the Ohio and Upper Mississippi Rivers. A high share of *through* movements for the Illinois Waterway suggests the movement of coal from the Great Lakes region to the West and South of US. The Upper Mississippi, on the other hand, is a net exporter of coal with about 16 Million Tons *outbound* traffic (including 11 Million (55%) to the Lower Mississippi River).



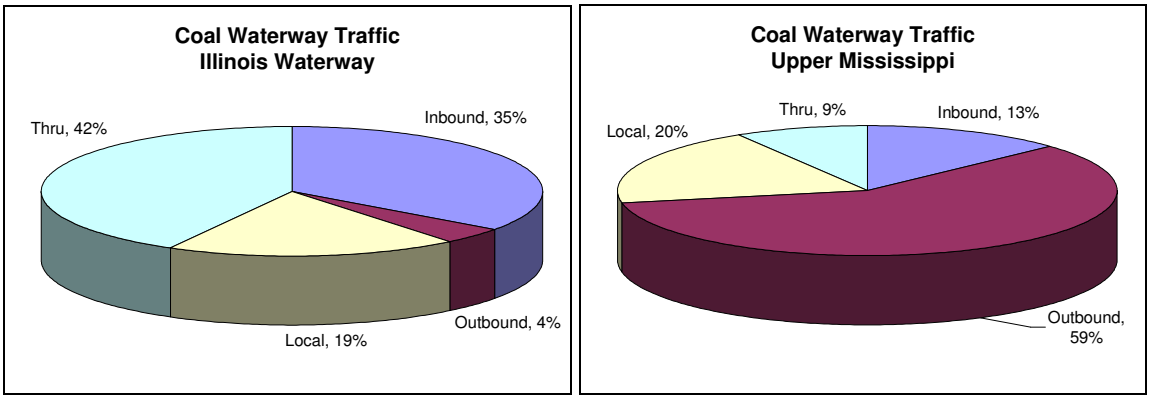

(Source: Waterborne Commerce of United States)

**Figure 73: Upper Mississippi (South) Inbound, Outbound, Local and Through Movements 2004**




(Source: Waterborne Commerce of United States)

**Figure 74: Illinois Waterway Inbound, Outbound, Local and Through Movements 2004**




(Note: 1997-2004 Average; Source: Waterway Commerce of United States)

**Figure 75: Inbound, Outbound, Local, and Through Coal Waterway Shares**

**Table 49: Main Destinations of Coal Shipped FROM Upper Mississippi and Illinois Waterway**

| FROM Upper Mississippi | | FROM Illinois Waterway | |
|---|---|---|---|
| TO Waterway | Share | TO Waterway | Share |
| LOWER MISS | 55% | ILLINOIS | 100% |
| UPPER MISS | 21% | UPPER MISS | 0% |
| OHIO | 19% | OHIO | 0% |
| OTHERS | 6% | | |
| **Total** | **100%** | **Total** | **100%** |

(GIWW: Gulf Intracoastal Waterway)
(Source: Tennessee Valley Authority, 2004)

**Table 50: Main Origins of Coal Shipped TO Upper Mississippi and Illinois Waterway**

| TO Upper Mississippi | | TO Illinois Waterway | |
|---|---|---|---|
| FROM Waterway | Share | FROM Waterway | Share |
| UPPER MISS | 65% | ILLINOIS | 80% |
| OHIO | 30% | OHIO | 12% |
| OTHERS | 5% | UPPER MISS | 6% |
| | | OTHERS | 1% |
| **Total** | **100%** | **Total** | **100%** |

(GIWW: Gulf Intracoastal Waterway)
(Source: Tennessee Valley Authority, 2004)

## Key Sub-commodities

While coal and lignite are grouped together in the Waterborne Commerce database, coke is listed as a separate item. Lignite is the lowest rank of coal, often referred to as brown coal. Coke is a product derived from burning bituminous coal, and is used as a fuel and as a reducing agent in smelting iron ore.

**Table 51: Disaggregated Traffic by Sub-commodities ('000 short tons)**

| Year | Illinois Waterway | | | Upper Mississippi | | | UM + IWW | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coke | Coal | Total | Coke | Coal | Total | Coke | Coal | Total |
| 1997 | 650 | 4,292 | 4,942 | 1,272 | 22,576 | 23,848 | 1,922 | 26,868 | 28,790 |
| 1998 | 810 | 2,219 | 3,029 | 1,585 | 23,585 | 25,170 | 2,395 | 25,804 | 28,199 |
| 1999 | 469 | 2,299 | 2,768 | 1,087 | 24,202 | 25,289 | 1,556 | 26,501 | 28,057 |
| 2000 | 761 | 1,734 | 2,495 | 1,461 | 23,521 | 24,982 | 2,222 | 25,255 | 27,477 |
| 2001 | 579 | 1,532 | 2,111 | 1,285 | 24,435 | 25,720 | 1,864 | 25,967 | 27,831 |
| 2002 | 966 | 469 | 1,435 | 1,719 | 23,638 | 25,357 | 2,685 | 24,107 | 26,792 |
| 2003 | 979 | 2,941 | 3,920 | 1,756 | 20,711 | 22,467 | 2,735 | 23,652 | 26,387 |
| 2004 | 1,444 | 2,771 | 4,215 | 1,806 | 22,289 | 24,095 | 3,250 | 25,060 | 28,310 |

(Source: Waterborne Commerce of United States)

Coke's share of total traffic is important for the Illinois Waterway and has varied significantly, while for the Upper Mississippi it has been somewhat constant at around 6.1%. **Table 51** shows the tonnages for coke and coal (including lignite). **Figure 76** illustrates the coal lignite share from 1997-2004. All forecasts done in this chapter included both coal and coke given in **Table 51**.

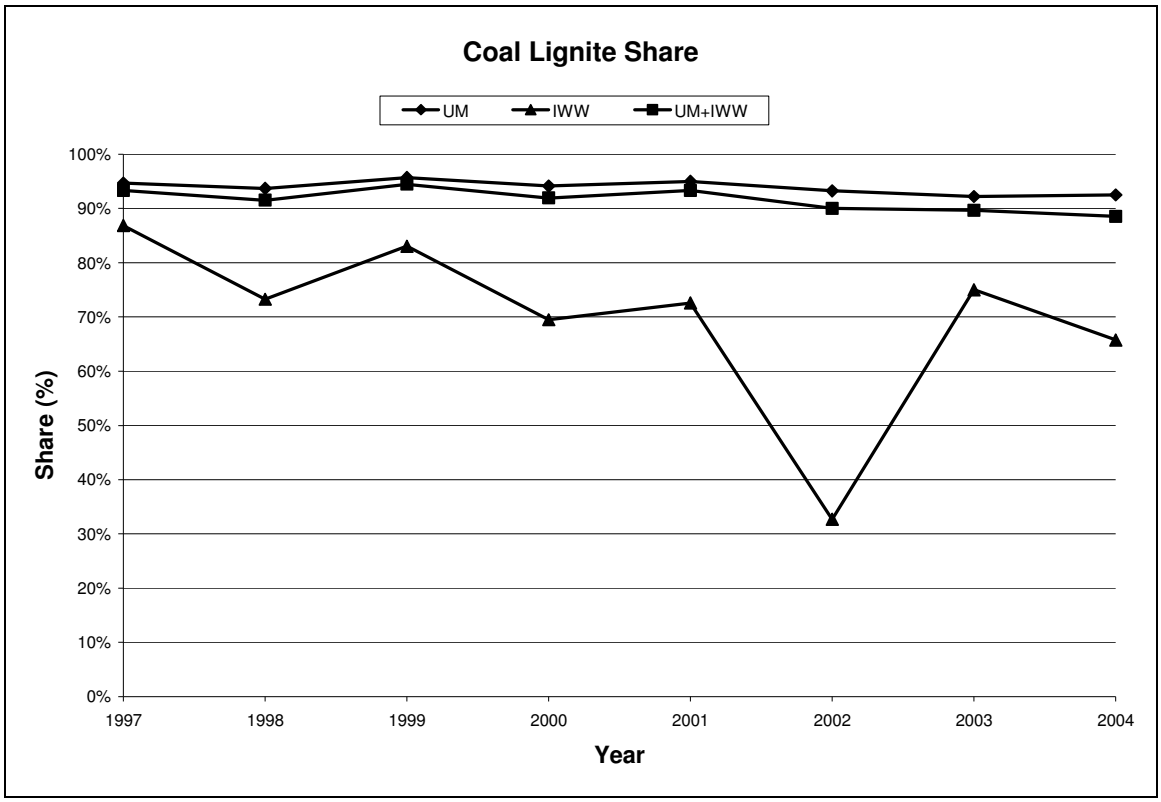



**Figure 76: Coal Lignite Waterway Tonnage Share, 1997-2004**

### 2.5.3 Forecasting Methodology

The demand for coal is derived mainly from the demand to generate electric power in a region. As illustrated in **Figure 77**, either the power supplies can be outsourced, in which case the grid must be able to carry the extra loads. The second choice is to use substitute sources such as natural gas or nuclear power. Natural gas remained a very competitive alternative until recent price escalations.

Another important variable affecting the demand for coal will be the government's policies regarding air pollution standards and emissions from burning coal. Clean coal technologies are expected to progressively reduce air pollution from burning coal, and the long-term prospects are good for coal to remain one of the major sources of energy.

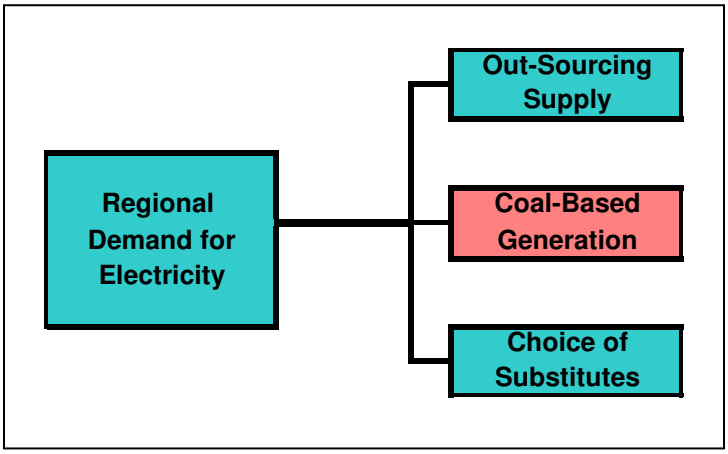
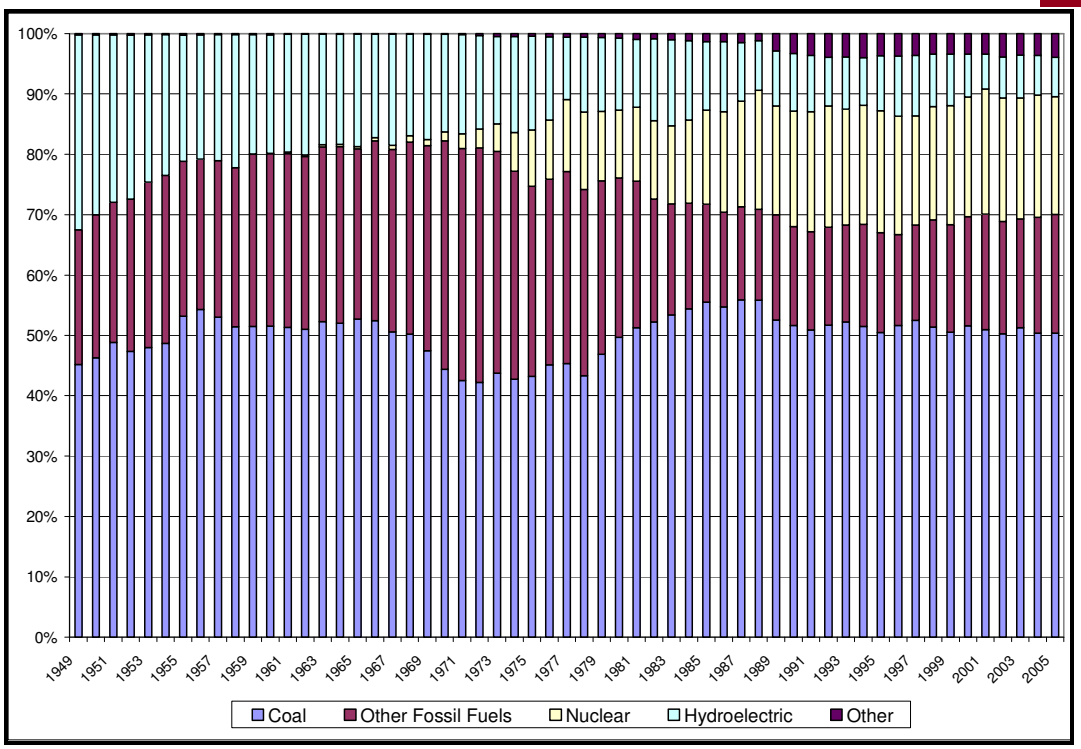



**Figure 77: Coal Industry Conceptual Diagram**

Historically coal has been a consistent source of energy for electricity generation. In terms of energy generated (BTU), coal has the highest share among the sources of energy used for electricity generation averaging 50% of all sources used (see **Figure 78**).

This cargo category has presented the most variability due to the traditionally small share of barge movements (1%-6%, see **Table 47**) compared to other modes and exogenous factors (environmental regulations, energy generation, and distribution deregulation, influx of imports, etc.). The methodology for forecasting these commodities thus relies on national trends, which are refined to reflect regional/local conditions by exploring regional or state consumption and production trends, and then further adjusted with input from expert opinions.




(Source: Energy Information Administration, 2005)

**Figure 78: Energy Consumption for Electricity Generation by Source, 1949-2005**

Typically, coal/coke traffic forecasts have been developed for the following flows:

- Utility/Industrial steam coal (used for generation of electricity and as a fuel in industrial manufacturing operations)
- Metallurgic coal (used to produce coke to fuel steel plants)

From the barge traffic flow databases, the current share of each commodity was disaggregated and specific forecasting models were developed. As each waterway has a characteristic flows, different models were developed and tested for the Illinois River and the Upper Mississippi.

Forecasting models were prepared for each waterway. Main independent variables are:

- Regional Coal Production (Interior and Western Regions)
- US Coal Consumption
- US Coal Imports
- Illinois Electricity Generation
- Illinois Population

It was important to consider coal movements north of St Louis and south of St Louis. This is because of the eastbound movement of coal from Wyoming that comes by rail to the transshipment terminals below St. Louis and then moves on the Ohio River, Upper

Mississippi, or Lower Mississippi. To study the differences in the two sections of the Upper Mississippi, south and north of St. Louis, the two sections were treated separately.

The linear regression results are presented below for the Upper Mississippi and Illinois Waterways. All the variables used are statistically significant at 95% confidence level with acceptable values for goodness of fit. The regression variables are given in **Table 52**.

**Table 52: Regression Variables 1997-2004**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| Interior Production | 171 | 168 | 163 | 144 | 147 | 147 | 146 | 146 |
| Western Production | 451 | 489 | 512 | 511 | 548 | 550 | 549 | 575 |
| US consumption | 1,030 | 1,037 | 1,039 | 1,084 | 1,060 | 1,066 | 1,095 | 1,107 |
| US Imports | 7 | 9 | 9 | 13 | 20 | 17 | 25 | 27 |
| IL Population | 12,186 | 12,272 | 12,359 | 12,419 | 12,477 | 12,535 | 12,593 | 12,650 |
| IL Electricity Generation | 78 | 75 | 75 | 82 | 80 | 87 | 88 | 94 |
| IWW Coal Tonnage | 4,942 | 3,029 | 2,768 | 2,495 | 2,111 | 1,435 | 3,920 | 4,215 |
| UM North Coal Tonnage | 7,500 | 8,817 | 8,553 | 8,081 | 7,609 | 7,379 | 6,665 | 7,478 |
| UM South Coal Tonnage | 22,192 | 23,098 | 22,930 | 23,431 | 24,234 | 23,779 | 20,871 | 21,933 |

(Source: Coal Production/Imports/Consumption (Million Short Tons) and IL Electricity Generation ('000 KWHrs): Energy Information Administration; IL Population ('000 Persons): US Census Bureau Waterway Traffic ('000 Tons): Waterway Commerce of United States)

### *Illinois Barge Traffic*

Illinois coal traffic was divided into coal coke and coal lignite traffic. Separate models were created for coal coke and total coal (includes coal coke and coal lignite) traffic on the Illinois Waterway. The regression results are given below.

| **IWW COKE Barge Traffic =** | **-7055** | **+ 0.0971 (Illinois Coal+Coke Consumption)** | **+ 18.827 (Interior Coal+Coke Production)** |
|---|---|---|---|
| Standard Error | (2254) | (0.0213) | (8.237) |
| *t-statistic* | *-3.13* | *+4.56* | *+2.29* |
| R-squared | 0.85 | | |

| **IWW Total COAL Barge Traffic =** | **487496** | **+ 105.83 (Interior Prod)** | **- 39940 ln(Western Prod)** | **+ 24208 (Illinois Population)** |
|---|---|---|---|---|
| Standard Error | (209641) | (51.96) | (14489) | (7966) |
| *t-statistic* | *+2.33* | *+2.04* | *-2.76* | *+3.04* |
| R-squared | 0.75 | | | |

*Barge Traffic is in '000 Tons*
*Interior/Western Coal Production is in Million Short Tons*
*Illinois Coal Consumption is in Million Short Tons*
*Illinois Population is in Million Persons*

The regression results show that the traffic on the Illinois Waterway is predominantly affected by local factors. The coke traffic shows a very high correlation with both coal consumption and production in the region and results in goodness of fit value of 0.85.

Total coal traffic on the Illinois Waterway has been very volatile, especially during 2001-2003, when it changed from a decreasing trend to an increasing trend. The primary factors affecting coal traffic are Interior and Western coal production (coal supply) and Illinois population (which is a proxy for coal demand). Intuitively, Illinois coal barge traffic is positively correlated with Interior region coal production and Illinois Population. The negative sign for the Western region coal production is due to the following:

- The primary mode of transportation for Coal moving from the Western region towards the East is rail. Therefore, the Illinois Waterway traffic is not positively impacted by an increase in Western coal production.

- Western region coal production mainly affects the region in the vicinity of the coal production locations. Since, Western region coal production is highly correlated with Interior region coal production (0.82[68]) and Illinois population (0.97[69]), this variable provides a dampening affect to the positive impact of the other two variables on the Illinois Waterway traffic forecast.

***Upper Mississippi Barge Traffic***

Upper Mississippi coal traffic was not divided into coal coke and coal lignite traffic as coal coke was only 6% of the total coal traffic. Separate models were, however, created for the Upper Mississippi North and South sections. The regression results are given below.

| **UM North Traffic =** | **-399569** | **+ 140.3 (Interior Prod.)** | **- 19.58 (US Coal Consumption)** | **+ 20237 ln(Western Prod)** |
|---|---|---|---|---|
| Standard Error | (53676) | (18.95) | (4.5) | (2611) |
| *t-statistic* | *-7.44* | *+7.41* | *-4.35* | *+7.75* |
| R-squared | 0.97 | | | |

*Barge Traffic is in '000 Tons*
*Interior/Western Coal Production is in Million Short Tons*
*US Coal Consumption is in Million Short Tons*

The regression results show that the Upper Mississippi North traffic would increase with an increase in Interior and Western region coal production. This is intuitive as an increase in coal production would result is higher tonnage moving on the Upper Mississippi North. An increase in US coal consumption, however, results in a negative impact on the UM North waterway traffic. US coal consumption has the following roles in the regression model:

- It serves as a proxy for the coal consumption in the region served by the Upper Mississippi North region.
- It dampens the impact of the Interior and Western region coal production on the waterway traffic because it is correlated with production, imports and exports.

[68] Coefficient of Correlation between Western region production and Interior region coal production.
[69] Coefficient of Correlation between Western region production and Illinois population.

- An increase in coal consumption would be satisfied by more inflow which would be transported by rail to the Upper Mississippi North region.

| | | | | |
|---|---|---|---|---|
| **UM South Traffic =** | **-730300** | **- 260 (US Coal Imports)** | **+ 355 (US Coal Consumption by Ind)** | **+ 36577 ln(Western Prod)** |
| Standard Error | (260331) | (79.25) | (197.45) | (12493) |
| *t-statistic* | *-2.81* | *-3.28* | *+1.80* | *+2.93* |
| R-squared | 0.74 | | | |

*Barge Traffic is in '000 Tons*
*Western Coal Production is in Million Short Tons*
*US Coal Imports is in Million Short Tons*
*US Consumption by Industrial Sector is in Million Short Tons*

The regression results show that the Upper Mississippi traffic would increase with an increase in the Western region coal production and decrease with US coal imports. This is intuitive as the increase in the Western region production would result in higher tonnage moving from the transshipment terminals below St. Louis into the Upper Mississippi, thereby increasing the tonnage in southern part of this waterway (and towards the Ohio River).

The main consumers of Waterway delivered coal from the Upper Mississippi and partly the Illinois waterways are power plants in the Gulf of Mexico, specifically the Florida power plants. Utilization of this coal has been significantly reduced as a result of environmental restrictions and delivery of low sulfur coal from Colombia. For example, the volume of coal transiting Inner Harbor Navigation Canal in Louisiana has been decreased by close to 6 million tons in last decade.[70] This reduction may be partly off-set the current introductions of clean coal technologies. However, due to increasing energy demand coal imports will continue to have a negative impact on coal delivery by the Waterways.

It is important to note here that US coal imports, exports, production, and consumption are highly correlated as they are inter-dependent. The positive and negative signs for the US consumption variables in the regression equations are mathematical adjustments to the values forecasted by other variables. The signs for US consumption do not hold any meaning independently and are a part of the Import-Production-Consumption mechanism.

The complete forecasting procedure is outlined below.

- Step 1: Forecast the Illinois Waterway Coal traffic using the regression equation given above. (This will need the forecasted values for Illinois consumption and Interior production).

[70] Lock Investigation Study for Inner Harbor Navigation Canal, University of New Orleans, 2005.

- Step 2: Forecast the Upper Mississippi (North) Waterway Coal traffic using the regression equation given above. (This will need the forecasted values for US Coal Consumption and Western and Interior Region Coal production).

- Step 3: Forecast the Upper Mississippi (South) Waterway Coal traffic using the regression equation given above. (This will need the forecasted values for US Coal Imports, Consumption by Industrial Sector and Western Region Coal production).

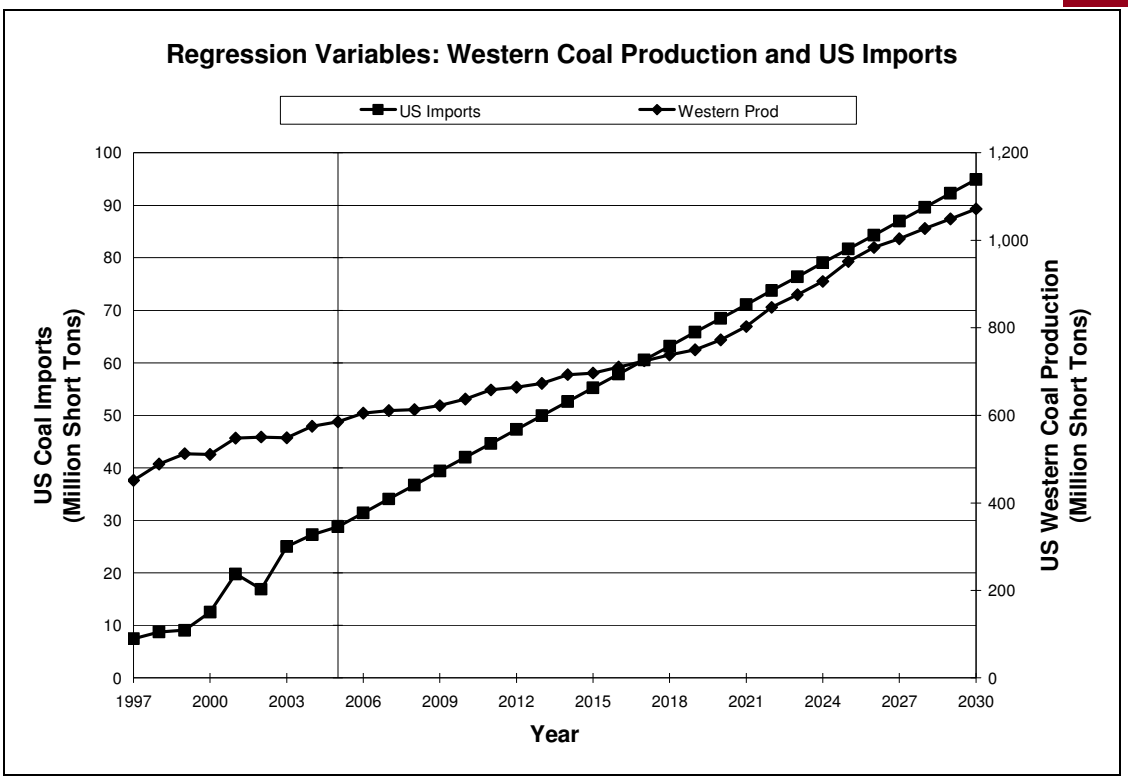
### 2.5.4 Coal Forecast

This section presents LBG's unconstrained Coal movement forecast on the Upper Mississippi and Illinois Waterways.

To forecast the coal[71] waterway tonnage using the regression equations developed in the previous section we need to forecast the values of US Interior and Western region coal production, US coal imports, US coal consumption, Illinois population, and Illinois electricity generated by coal.

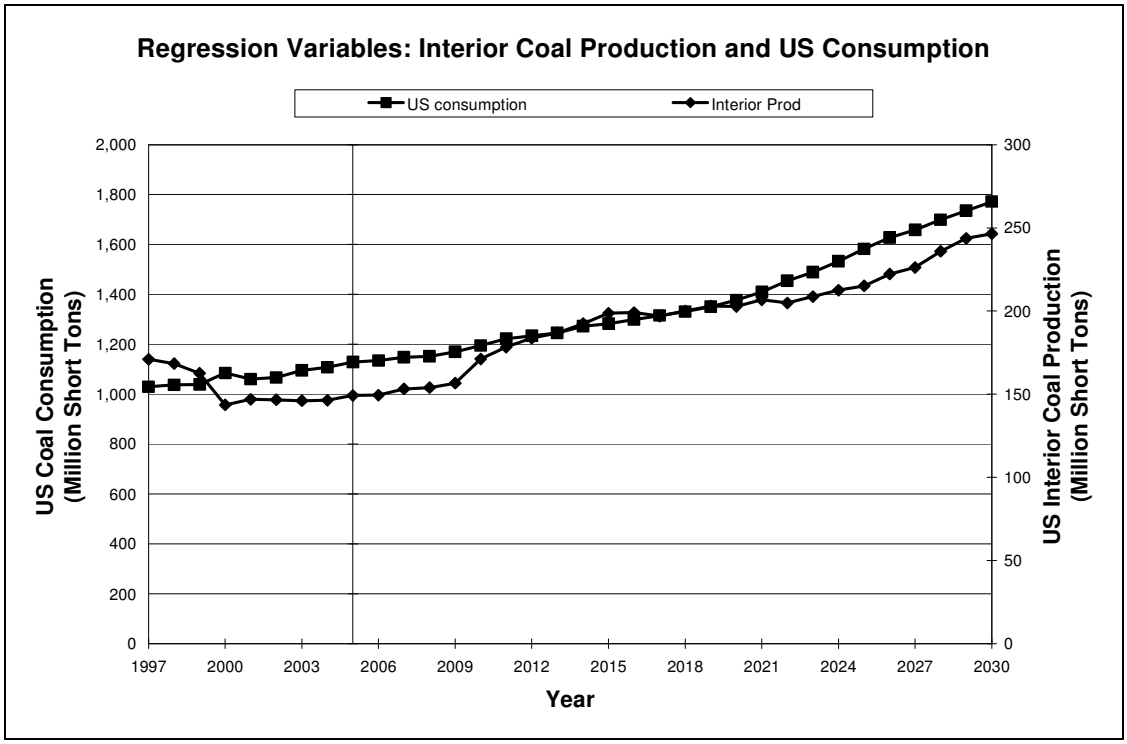
Extensive historical and forecasted data for coal and their forecasts were obtained from the Energy Information Administration, United States Department of Energy. The US Western region coal production and US coal imports from 1997-2030 are presented in **Figure 79**. Due to variations in the US coal imports forecast in the intermediary years, we used the EIA forecast for 2005 and 2030 and assumed a linear interpolation for the intermediary years. **Figure 80** presents the US Interior region coal production and US coal consumption. The forecasts have been obtained from the Energy Information Administration, Report #DOE/EIA-0383(2007) released in February 2007. (All data for these figures is shown in **Table 53**).

[71] Unless otherwise noted, coal includes coal coke and coal lignite.




(Source: Energy Information Administration, Report #: DOE/EIA-0383(2007), February 2007)

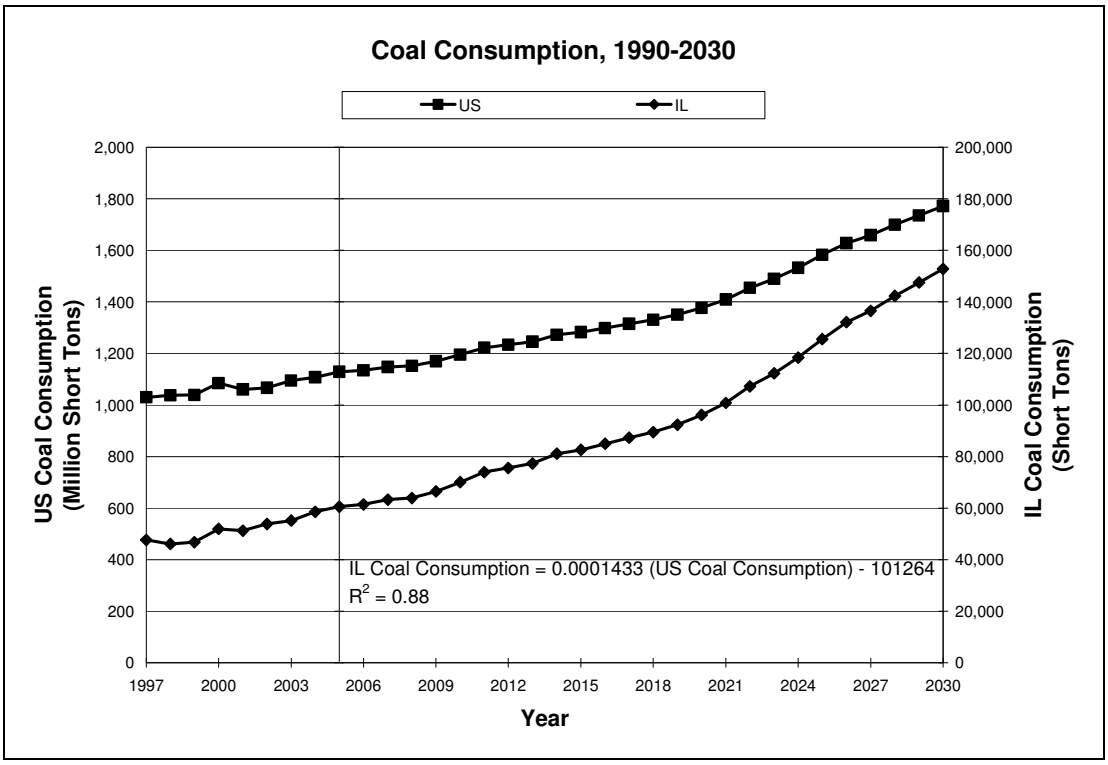
**Figure 79: Western Region Coal Production and US Coal Imports Forecasts, 2006-2030**




(Source: Energy Information Administration, Report #: DOE/EIA-0383(2007), February 2007)

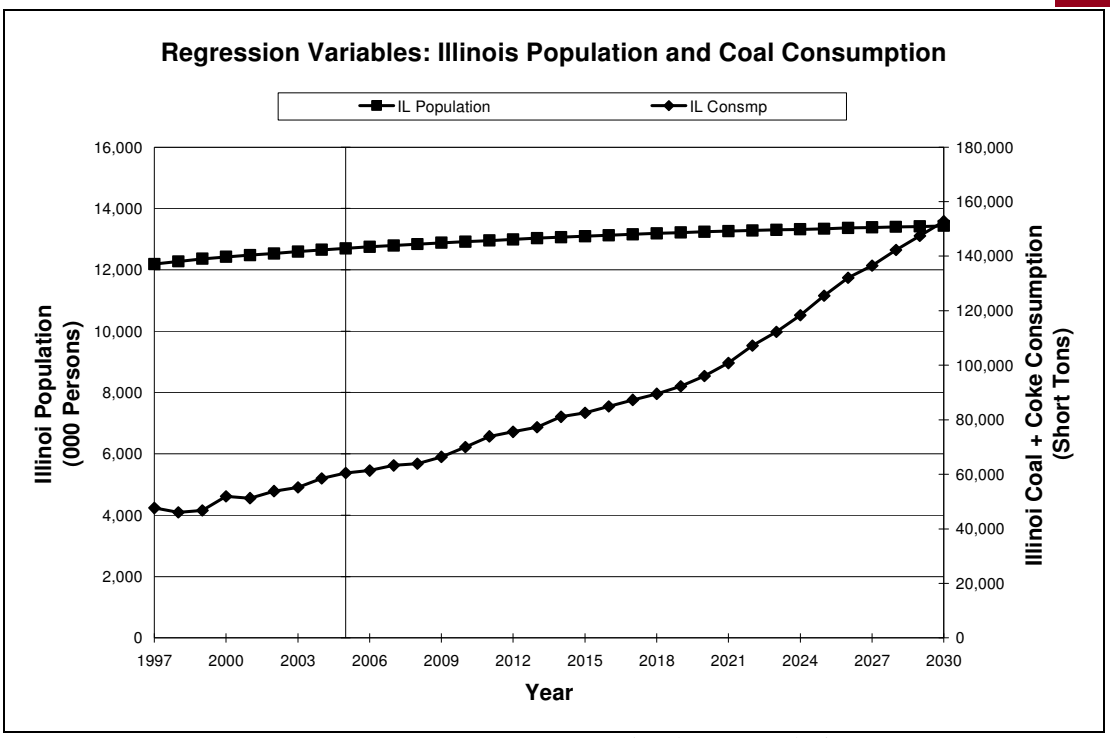
**Figure 80: US Coal Consumption and Interior Region Coal Production Forecast 2006-2030**

**Figure 82** presents Illinois population and Illinois coal consumption from 1997-2030. Illinois population was obtained from the US Census Bureau, Population Division, released on the Internet on April 21, 2005. Forecasts for the Illinois coal consumption were not available from any government agency, but the forecasts for the US coal consumption were available from the Energy Information Administration, Report #DOE/EIA-0383(2007) released in February 2007. It was found that the US and Illinois coal consumption is highly correlated with an $R^2$ value of 0.88. The forecasted US coal consumption values were thus used to forecast the corresponding Illinois values as shown in **Figure 81**.




(Source: Energy Information Administration, Report #: DOE/EIA-0383(2007), February 2007)

**Figure 81: US and Illinois Coal Consumption, 2006-2030**

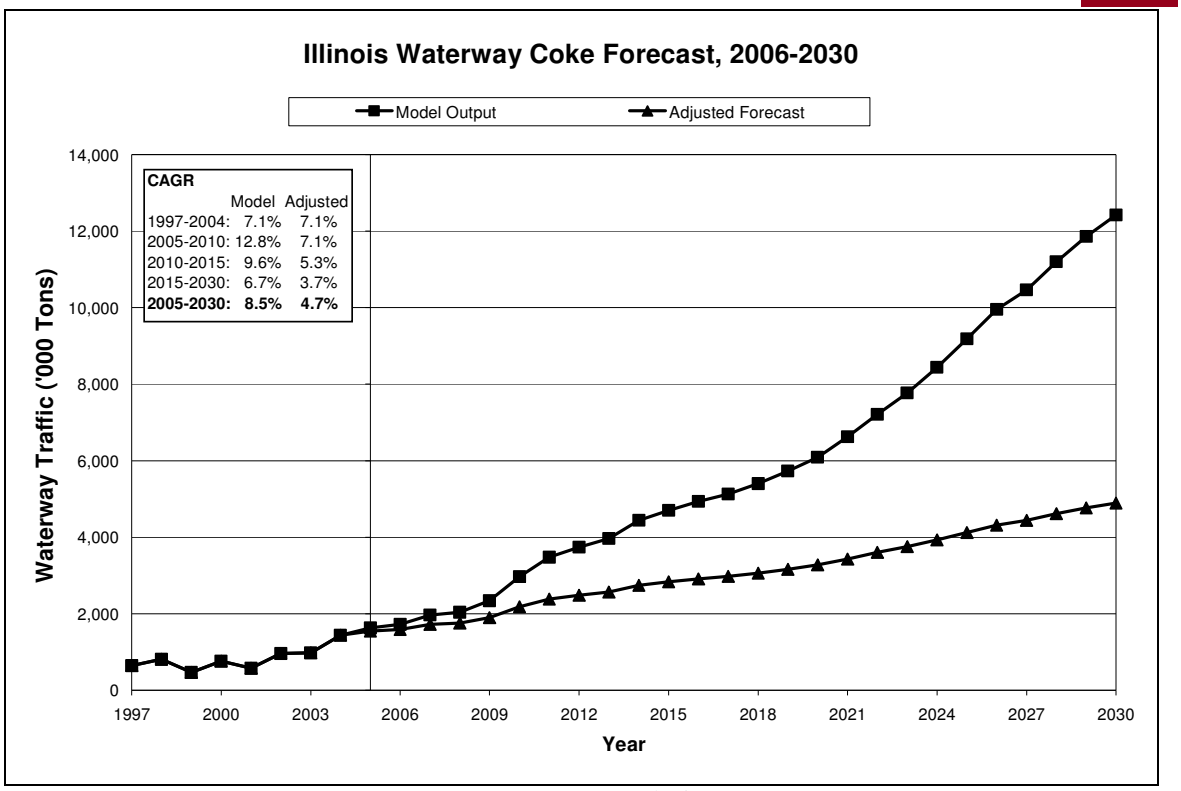



(Source: U.S. Census Bureau, 2005 and LBG Analysis)

**Figure 82: Illinois Population and Coal Consumption Forecast 2006-2030**

The coal unconstrained waterway traffic forecast model developed in the previous section was used to forecast the coal traffic on the Upper Mississippi North, Upper Mississippi South and Illinois Waterway from 2005-2030. The Illinois Waterway traffic forecast for coke obtained from the model was, however, adjusted because the forecasted growth rates were very high compared to historic levels and there was no reason to believe that a substantial increase in coke waterway traffic would occur. The cumulative annual growth rate from 1997-2004 was 7.1% and it was assumed that this would be the maximum cumulative growth rate for any five year period during the forecast period. The maximum cumulative growth rate (12.8% for 2005-2010) was adjusted to 7.1% and the other growth rates were adjusted accordingly. **Figure 83** shows the model and adjusted Illinois Waterway coke forecasts.

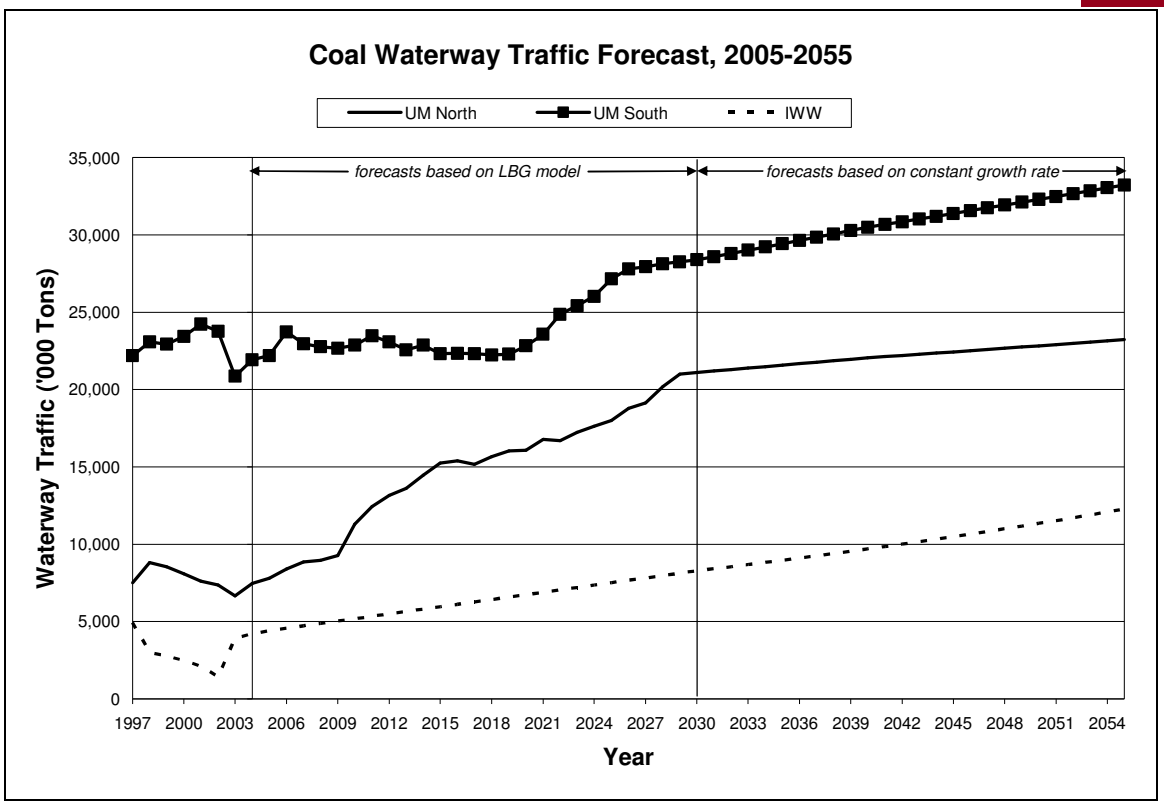
The initiated increase in utilization of the Interior region expected to substantially increase coal traffic in the Illinois and partially on the Mississippi waterways. It is assumed that this increase will develop gradually in the 2005 – 2020 period.




(Source: LBG Analysis)

**Figure 83: Illinois Waterway Unconstrained Coke Traffic Forecast 2005-2030**

The period from 2030 to 2055 is the distant future and it is difficult to reasonably predict the changes in any industry. It was thus assumed that the Illinois Waterway traffic for the period 2030-2040 would grow at 80% of the growth rate from 2025-2030. Based on the observation that the Upper Mississippi traffic in both the north and south sections, which started stabilizing around 2030, it assumed that the UM North traffic for the period 2030-2040 would grow at 80% of the growth rate from 2029-2030 and the UM South traffic for the period 2030-2040 would grow at 80% of the growth rate from 2029-2030. For 2040-2055 the waterway traffic was assumed to grow at 80% of the growth rate from 2030-2040 for all waterways. The model output for Illinois Waterway resulted in a very high growth rate from 2006 to 2015 and a subsequent drop from 2018 to 2027. We found this characteristic in Illinois Waterway traffic unreasonable and used the model values for 2005 and 2030 with a linear interpolation for the intermediary years. The results are tabulated in **Table 54** and presented in **Figure 84**.




(Source: LBG Analysis)

**Figure 84: Coal Unconstrained Waterway Traffic Forecast 2005-2055**

The forecasts show a constant increase in the waterway tonnage from 2005 onwards. The growth rates reduce over time (See **Table 54**), except during the period 2020-2030. The increase in Illinois Waterway traffic between 2005 and 2030 is anticipated due to extensive production in the Interior region during this time as forecasted by the Energy Information Administration (See **Figure 79**).

**Table 53: Coal Unconstrained Waterway Forecasts: LBG Base Case Scenario Results**

| Year | Interior Region Coal Prod | Western Region Coal Prod | US Coal Consmp | US Coal Imports | Illinois Population | Illinois Coal Consmp | UM North Tonnage | UM South Tonnage | IWW Coke Tonnage | IWW Lignite Tonnage | IWW Tonnage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Million Tons | Million Tons | Million Tons | Million Tons | 000 Persons | Million Tons | 000 Tons | 000 Tons | 000 Tons | 000 Tons | 000 Tons |
| 1997 | 171 | 451 | 1,030 | 7 | 12,186 | 47,638 | 7,500 | 22,192 | 650 | 4,292 | 4,942 |
| 1998 | 168 | 489 | 1,037 | 9 | 12,272 | 46,067 | 8,817 | 23,098 | 810 | 2,219 | 3,029 |
| 1999 | 163 | 512 | 1,039 | 9 | 12,359 | 46,719 | 8,553 | 22,930 | 469 | 2,299 | 2,768 |
| 2000 | 144 | 511 | 1,084 | 13 | 12,419 | 51,865 | 8,081 | 23,431 | 761 | 1,734 | 2,495 |
| 2001 | 147 | 548 | 1,060 | 20 | 12,477 | 51,236 | 7,609 | 24,234 | 579 | 1,532 | 2,111 |
| 2002 | 147 | 550 | 1,066 | 17 | 12,535 | 53,835 | 7,379 | 23,779 | 966 | 469 | 1,435 |
| 2003 | 146 | 549 | 1,095 | 25 | 12,593 | 55,135 | 6,665 | 20,871 | 979 | 2,941 | 3,920 |
| 2004 | 146 | 575 | 1,107 | 27 | 12,650 | 58,523 | 7,478 | 21,933 | 1,444 | 2,771 | 4,215 |
| 2005 | 149 | 585 | 1,128 | 29 | 12,699 | 60,486 | 7,802 | 22,202 | 1,546 | 2,871 | 4,417 |
| 2006 | 149 | 605 | 1,135 | 31 | 12,747 | 61,405 | 8,400 | 23,734 | 1,596 | 2,976 | 4,572 |
| 2010 | 171 | 637 | 1,195 | 42 | 12,917 | 70,016 | 11,305 | 22,869 | 2,182 | 3,010 | 5,192 |
| 2015 | 199 | 697 | 1,282 | 55 | 13,097 | 82,574 | 15,253 | 22,316 | 2,833 | 3,133 | 5,966 |
| 2020 | 203 | 772 | 1,377 | 68 | 13,237 | 96,078 | 16,072 | 22,836 | 3,275 | 3,466 | 6,741 |
| 2025 | 215 | 951 | 1,582 | 82 | 13,341 | 125,510 | 18,012 | 27,157 | 4,128 | 3,387 | 7,515 |
| 2030 | 247 | 1,072 | 1,772 | 95 | 13,433 | 152,735 | 21,118 | 28,397 | 4,891 | 3,399 | 8,290 |
| 2035 | | | | | | | 21,581 | 28,956 | 5,291 | 3,677 | 8,968 |
| 2040 | | | | | | | 22,055 | 29,525 | 5,723 | 3,978 | 9,701 |
| 2045 | | | | | | | 22,441 | 29,990 | 6,192 | 4,303 | 10,495 |
| 2050 | | | | | | | 22,835 | 30,461 | 6,698 | 4,655 | 11,353 |
| 2055 | | | | | | | 23,235 | 30,940 | 7,246 | 5,036 | 12,282 |

(Source: LBG Analysis)

**Table 54: Cumulative Annual Growth Rates, 1997-2055**

| From Year | To Year | UM North | UM South | IWW |
|---|---|---|---|---|
| 1997 | 2004 | 0.0% | -0.2% | -2.2% |
| 2005 | 2010 | 7.7% | 0.6% | 3.3% |
| 2010 | 2015 | 6.2% | -0.5% | 2.8% |
| 2015 | 2020 | 1.1% | 0.5% | 2.5% |
| 2020 | 2030 | 2.8% | 2.2% | 2.1% |
| 2030 | 2040 | 0.4% | 0.4% | 1.6% |
| 2040 | 2055 | 0.3% | 0.3% | 1.3% |
| **2005** | **2030** | **4.1%** | **1.0%** | **2.6%** |
| **2005** | **2055** | **2.2%** | **0.7%** | **2.1%** |

(Source: LBG Analysis)

## 2.6 Construction Materials

This section discusses the current conditions and unconstrained forecasts for the movement of Construction Materials on the Upper Mississippi and Illinois Waterway systems.

### 2.6.1 U.S. Construction Materials Industry Overview

The construction materials industry can be broadly divided into three sub-categories: sand and gravel; cement and concrete; and limestone. The following sub-sections describe these constituents of the construction materials industry in the US.

**The Sand and Gravel Industry**

The sand and gravel sub-sector has widely accessible resources and the ability to handle large quantities of material demands on an extensive transportation network. Sand and gravel output in the US increased each year from 1991 for 13 years and reached an output level of 1.24 billion tons in 2004.[72] A total of 10,164 active sand and gravel pits managed by 3,892 companies or government agencies were in operation in 2004.

*Major Variables Affecting Demand* - Two important variables that influenced this growth are the boom in the building construction led by housing starts and large-scale public spending programs sponsored by the federal government such as the ISTEA program and other highway improvements. The top 4 sectors using 94% of the sand and gravel consumption are closely related to these two developments (**Table 55**).

**Table 55: Major Uses of Sand and Gravel**

| Sand and Gravel Major Use | Percent of Production |
|---|---|
| Concrete Aggregates | 44% |
| Road base, coverings, and road stabilization | 22% |
| Construction fill | 15% |
| Asphalt concrete aggregates or other bituminous mixtures | 13% |
| Concrete products such as bricks, blocks and pipes | 2% |
| Plaster and gunite sand | 2% |
| Snow and ice control, Railroad ballast and other uses | 2% |

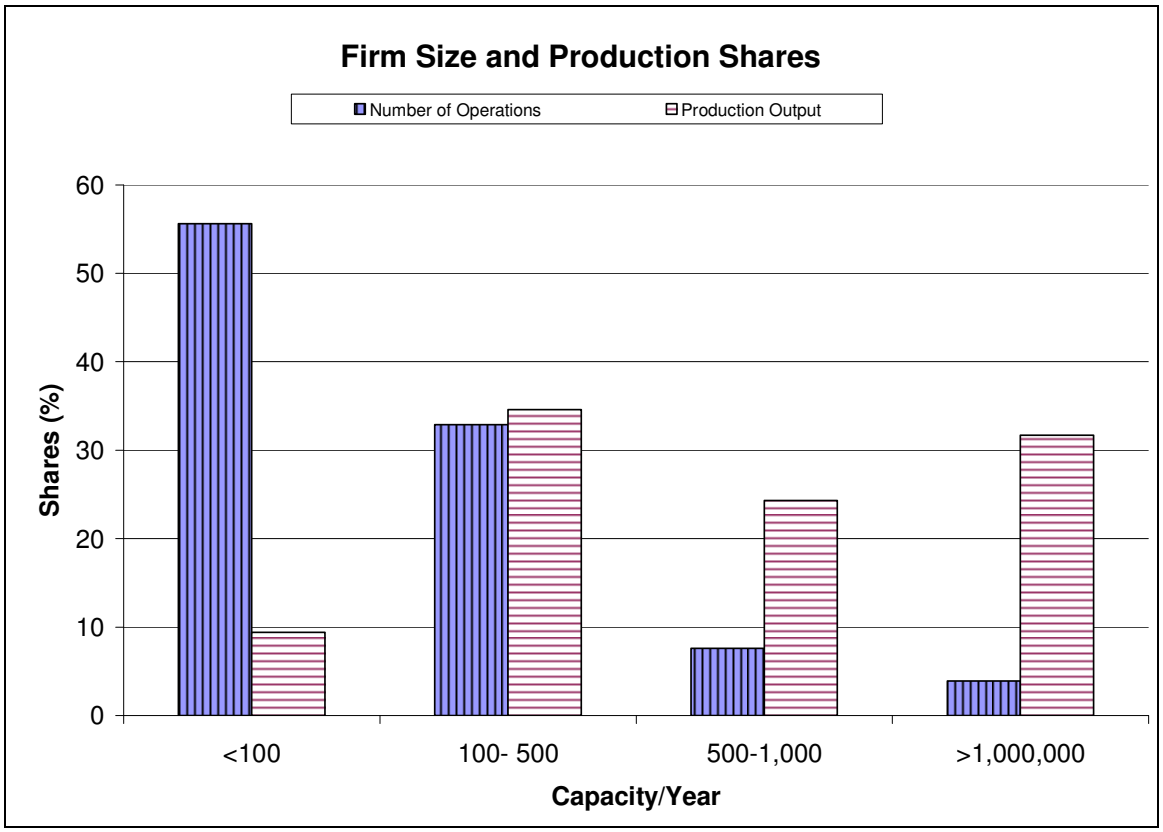
(Source: US Geological Survey, 2004[73])

*Industry Structure* – As the sand and gravel industry is operated by a large number of businesses that are often idle, closed, or abandoned, the collection of detailed industry information on production, distribution, and foreign trade remains problematic. For example, sand and gravel consumption may be estimated based on production data and

[72] *Sand and Gravel, Construction.* Wallace P. Bolen, U.S. Geological Survey, Minerals Information, 2004.
[73] *Minerals Yearbook-2004*, U.S. Geological Survey, p.64.2

regional demand for sand and gravel may use the amount of cement and concrete sold in the area as a proxy to derive sand and gravel estimates. Fifty-three percent of the 2004 production is categorized under the "use–unspecified" category because of difficulties in data collection and as information is not available.[74]

The structure of the US sand and gravel industry, in terms of size of operations, is illustrated in **Figure 85**. At the lower end are small-scale operations which constitute of 55.6% of the operations, but controlling only 9.4% of the total output, In contrast, operations with more than one million tons of annual capacity consist of 3.9% of the operations, but are responsible for 31.7% of the total output.




(Note: Total Number of Operations: 6,270; Total Production: 1.24 Billion Tons)

**Figure 85: Firm Size and Production Shares**[75]

*Production and Foreign Trade* - Because of the low unit prices, sand and gravel industry largely depends on domestic supplies. Total exports and imports added together account for less than 1.5% of the domestic production (Table 56). The major importers from the US are Canada (48%), Taiwan (15%) and Mexico (14%). The U.S. imports are mainly from Canada (82.1%) and Mexico (11.5%).

[74] *Minerals Yearbook-2004,* U.S. Geological Survey, p.64.3.
[75] *Minerals Yearbook 2005*, U.S. Geological Survey; Data extracted from Table 8A: Construction Sand and Gravel Production in the United States in 2004, by Region and Size of Operation.

**Table 56: Production and Trade Data for US Sand and Gravel Industry, 2001-2005**

| Item | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total Production (Million Metric Tons) | 1130 | 1130 | 1160 | 1240 | 1270 |
| Total Value of Production (Million Dollars) | 5670 | 5750 | 5990 | 6600 | 7460 |
| Value of Exports ('000 Dollars) | 19,100 | 23,400 | 24,900 | 32,100 | 28,200 |
| Value of Imports ('000 Dollars) | 40,800 | 53,900 | 57,700 | 56,900 | 86,800 |

(Source: US Geological Survey, 2005[76])

The data on sand and gravel mining operations in the five states emphasize the large number of operations in the area (**Table 57**) While Wisconsin, Minnesota, Illinois, and Iowa had the largest number of operations in that order, portable plants seem to be the most common type of operation. Sand and gravel industry operations continue to be increasingly regulated by zoning laws in densely populated urban areas forcing them to abandon operations in extreme cases. As a result, sand and gravel shortages in large urban areas are likely in the future.

The transportation modes used for moving sand and gravel from mines to consuming points in the UMR/IWW area are shown in **Table 58**. The volume of waterborne tonnage transported (4.9 million tons) represents 36% of the total sand and gravel moved on US waterways. However, the 2.1% share of water is rather low, compared to 7.3% moved by water in the area immediately to the south (East South Central Division consisting MS, AL, TN, and KY).

**Table 57: Number of Sand and Gravel Operation Units in 5-States**

| State | Stationary | Portable | Stationary & Portable | No Plant | Dredging Operation | Total Operations |
|---|---|---|---|---|---|---|
| Illinois | 57 | 29 | 8 | 6 | 41 | 141 |
| Iowa | 39 | 57 | 5 | 2 | 35 | 138 |
| Minnesota | 107 | 144 | 15 | 23 | 6 | 295 |
| Missouri | 35 | 9 | 5 | 1 | 31 | 81 |
| Wisconsin | 90 | 170 | 17 | 27 | 2 | 306 |
| **Total** | **328** | **409** | **50** | **59** | **115** | **961** |

(Source: US Geological Survey, 2005[77])

*Long-term Trends* - Sand and gravel is the main raw material driving the construction industry which will continue to grow with population growth, increased housing demand and continued demand for infrastructure expansion. While the growth may move with economic cycles, the long-term trends will remain positive.

[76] US Geological Survey, *Minerals Yearbook 2004* Table 1: Salient U.S. Construction Sand and Gravel Statistics, and *Yearbook 2005*.
[77] US Geological Survey, *Minerals Yearbook 2004*, Data Extracted from Table 11:Number of Construction Sand and Gravel Operations and Processing Plants in the United States in 2004, by State.

**Table 58: Mode of Transport for Sand and Gravel Operation Units in 6-States (MN, WI, IL, IN, MI, OH)**

| Mode of Transport | Tonnage (1,000 metric tons) | Share (%) | Share (only for data with mode specified) (%) |
|---|---|---|---|
| Truck | 77,200 | 33.5% | 82.5% |
| Rail | 406 | 0.2% | 0.4% |
| Water | 4,930 | 2.1% | 5.3% |
| Other | 141 | 0.1% | 0.2% |
| Not Transported | 10,900 | 4.7% | 11.6% |
| Total Mode Specified | 93,577 | | **100.0%** |
| Mode Not Specified | 137,000 | 59.4% | |
| **Total** | **230,577** | **100.0%** | |

(Source: US Geological Survey, 2004[78])

### The Cement and Concrete Industries

Approximately, 30% of construction materials tonnage in the UMR/IWW area is comprised of cement and concrete movements. Although, cement and concrete are grouped together into one commodity group, their transportation characteristics and other factors affecting long-term trends are quite different.

*Industry Characteristics:* Concrete - Concrete mixtures, on the average, consist of 11% cement (in volumetric terms), 26% sand and fine aggregates, 41% crushed stones or coarse aggregates with 22% of water and air. It is generally uneconomical to transport concrete mixtures for more than 200 miles.

*Cement* - In contrast, cement is transported covering longer distances and substantial quantities are imported. The main ingredients used to make Portland cement are pulverized clinker and gypsum. Clinker, an intermediate product in the cement industry, is produced by combining limestone, clay and shale in kilns reaching up to 3,700$^0$F. Because of this fact, cement is an energy intensive industry and production costs will be sharply affected by energy prices.

In 2004, US domestic production of Portland and masonry cement amounted to 95 million metric tons and it was supplemented by 23 million tons of imports (**Table 59**). The domestic production of clinker during the period was 85 million metric tons with an additional 2 million metric tons in imports. US cement imports are mainly from Canada (21%), Thailand (17%), China (11%), Venezuela (7%), and all other countries combined for 44%. The major cement importing ports are shown in **Table 60**, and the Lower Mississippi River (New Orleans) and Detroit, Michigan are the leading ports.

[78] US Geological Survey, *Minerals Yearbook-2004*, Data Extracted from Table 9: Construction Sand and Gravel Sold or Used by Producers in the United States in 2004 by Geographic Division and Method of Transportation.

*Recycling* - Currently, there is a limited market for recycled cement concrete in the area. Illinois and Minnesota recycled more than 250,000 metric tons of cement concrete in 2004. In Minnesota, recycled concrete prices are about 4% higher than the US average (**Table 61**).

**Table 59: Domestic Production and Foreign Trade Data: U.S. Cement Industry, 2003**

| Item | Quantity ('000 Tons) |
|---|---|
| Production Portland Cement & Masonry Cement | 92,843 |
| Production: Clinker | 81,822 |
| Shipments to final Customers, including exports | 112,927 |
| Imports: Cement | 21,015 |
| Imports: Clinker | 1,808 |
| Exports: Cement & Clinker | 837 |
| **Total Consumption** | **114,100** |

(Source: US Geological Survey, Minerals Commodity Summary, 2005)

**Table 60: Hydraulic Cement and Clinker Imports, 2004**

| Ports/Customs District | Quantity ('000 Tons) |
|---|---|
| Chicago, IL | 36 |
| Cleveland, OH | 699 |
| Detroit, MI | 1,448 |
| Duluth, MN | 172 |
| Milwaukee, WI | 278 |
| Mobile, AL | 529 |
| New Orleans, LA | 2,551 |
| Houston/Galveston, TX | 155 |

(Source: US Geological Survey, Minerals Yearbook 2004)

**Table 61: Recycled Cement Concrete Sold, 2004**

| State | Quantity | US Share | Avg. Price per ton ($) |
|---|---|---|---|
| Illinois | 286 | 7.0% | 5.37 |
| Iowa | 24 | 0.6% | 5.75 |
| Wisconsin | 121 | 3.0% | 4.69 |
| Minnesota | 571 | 14.0% | 6.11 |
| US Total | 4,080 | 100.0% | 5.88 |

(Source: US Geological Survey, Minerals Yearbook 2004)

*Long-term Trends for Cement and Concrete* - A number of environmental issues, particularly the carbon dioxide emissions and high energy costs, remain major concerns and challenges to the industry. In response to these problems, fuel-efficient kiln designs

and other environmentally friendly technologies are constantly tested and adopted by the industry.

Although a large number of substitute materials such as aluminum, asphalt, clay bricks, and rammed earth are used in the building industry, no real substitute for cement and concrete is available. The industry is bound to grow with increasing population and the demand for additional infrastructure and housing, etc.

### The Limestone Industry

Under construction materials group, 1.85 million tons of limestone moved on the UMR while the movements on the IWW were negligible with only 93,000 tons. Ninety-six percent of the tonnage that moved on the UMR was outbound, with 1.067 million down-bound and 0.7 million tons up-bound. Almost all cargo movements remained within the system indicating limestone markets are mainly local.

The total limestone and dolomite[79] production in the US exceeded 1 billion tons in 2004, and the total value of production was estimated to be $5.7 billion. Limestone was produced by 666 companies in the US, with 1,808 quarry operations in 45 states. The leading limestone producing states, in descending order of tonnage in 2004 were Texas, Florida, Ohio, Pennsylvania, and Missouri, together producing 418 Million tons or 41% of the industry output.

**Table 62: Crushed Limestone and Dolomite Used by Producers in Selected States in 2004**

| State | Limestone ('000 Tons) | Dolomite ('000 Tons) | Total ('000 Tons) |
|---|---|---|---|
| Illinois | 56,300 | 20,200 | 76,500 |
| Iowa | 34,800 | W | 34,800 |
| Minnesota | 4,300 | W | 4,300 |
| Missouri | 64,200 | 3,060 | 67,260 |
| Wisconsin | 32,500 | 1,100 | 33,600 |
| Five State Total | 192,100 | 24,360 | 216,460 |
| U.S. Total | 1,020,000 | 95500 | 1,115,500 |
| Five-State Total as a Share of US Production | 18.8% | 25.5% | 19.4% |

(Source: US Geological Survey, 2004[80])

The total quantities of limestone and dolomite used by the five-state area are shown in **Table 62**. In Iowa and Minnesota, the dolomite production was limited and, therefore,

[79] Dolomite, also called Magnesium Limestone, is a type of limestone, the carbonate fraction of which is dominated by the mineral dolomite, calcium magnesium carbonate $CaMg(CO_3)_2$. It is used in Cement manufacture and also in place of calcite limestone as a flux (impurity remover) for the smelting of iron and steel. (Primary source: Encyclopedia Britannica)

[80] US Geological Survey, *Minerals Yearbook-2004*, Data Extracted from Table 8: Crushed Limestone and Dolomite Sold or Used by Producers in the United States in 2004, by State.

information is withheld to prevent disclosure of company information. The total use of limestone and dolomite by the five states constitutes less than 20% of US production.

Limited information available on modes of transport for crushed stone[81] is presented in **Table 63**. Out of the total industry output of 1.59 billion tons no information is available to allocate 902 million tons to any mode. For 688 million tons the modes of transport information is available. Out of this amount, almost 80% of the output was hauled from the quarry to sales units by trucks, 5.9% by rail, and 4.1% by water.

**Table 63: Modes of Transport for Crushed Stone Group, US Average 2004**

| Mode/Industry | Tonnage (Million Tons) | Modal Share (%) |
|---|---|---|
| Industry Total | 1,590 | --- |
| Unknown Total | 902 | --- |
| Known total | 688 | 100.0% |
| Truck | 548 | 79.7% |
| Rail | 41 | 5.9% |
| Water | 28 | 4.1% |
| Used on-site | 22 | 3.2% |

(Source: US Geological Survey, Minerals Yearbook 2004)

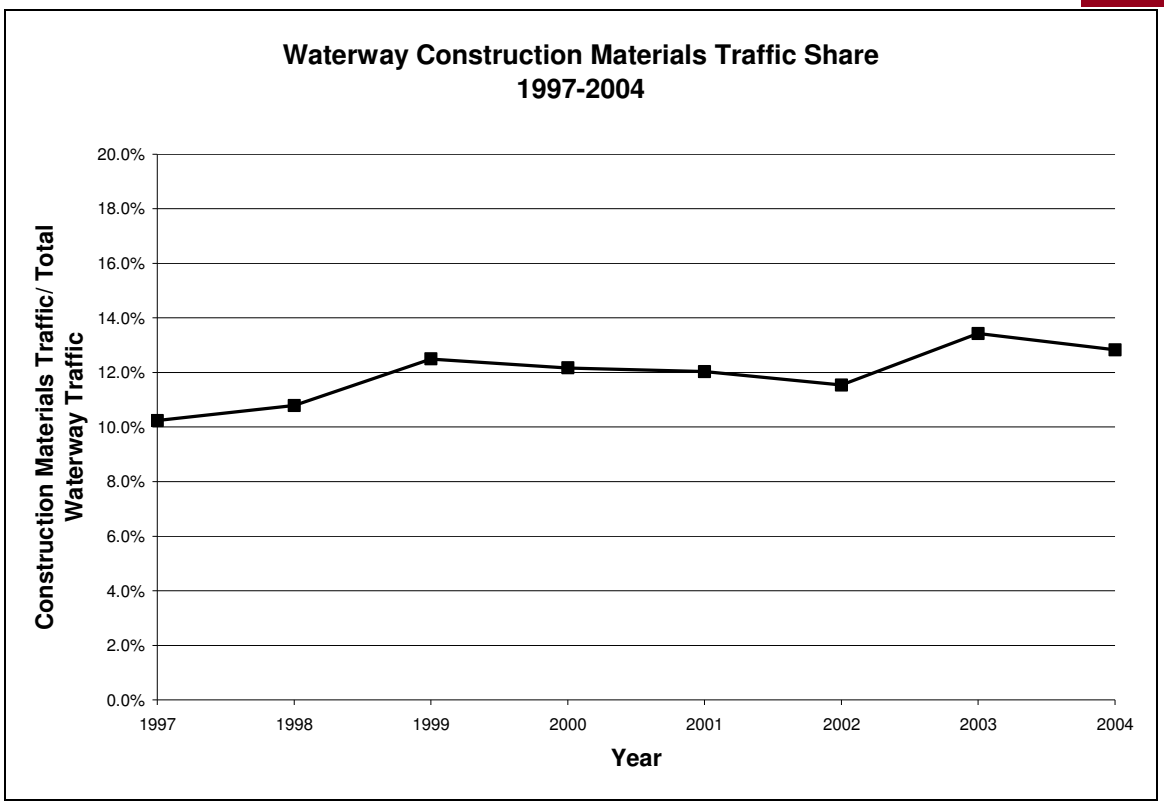
## 2.6.2 Construction Materials Waterway Movements Overview

Construction materials group is the third largest commodity group in the system next to grains and coal. This commodity group represents about 12% of the total cargo[82] on the Upper Mississippi and Illinois Waterway system (**Figure 86**), with Upper Mississippi accounting for 75% share (**Figure 87**). The share of Construction Materials traffic has grown from 10.2% in 1997 to 12.8% in 2004. It has shown an increasing trend from 1997-2004 except in 2001 and 2002, which can be attributed to the 2001 recession in the US.

Total construction materials tonnage averaged 20.7 million tons during the period 1997-2004 and 75% of the total (15.5 million tons) moved on the Upper Mississippi (**Figure 87**). Annual growth rates of 7% for the Illinois Waterway and about 2% for Upper Mississippi are observed based on 1997 and 2004 tonnage data as point estimates.

[81] Crushed stone is any type of natural rock that, in order to be mined has to be first blasted from its natural state in the ground, and then processed (crushed and screened). The most common types of stone processed into crushed stone include limestone and dolomite, granite, and trap rock. Smaller amounts of marble, slate, sandstone, quartzite, and volcanic cinder are also used. Available from the Mineral Information Institute, http://www.mii.org/Minerals/photocrushedstone.html accessed on March 4, 2007.

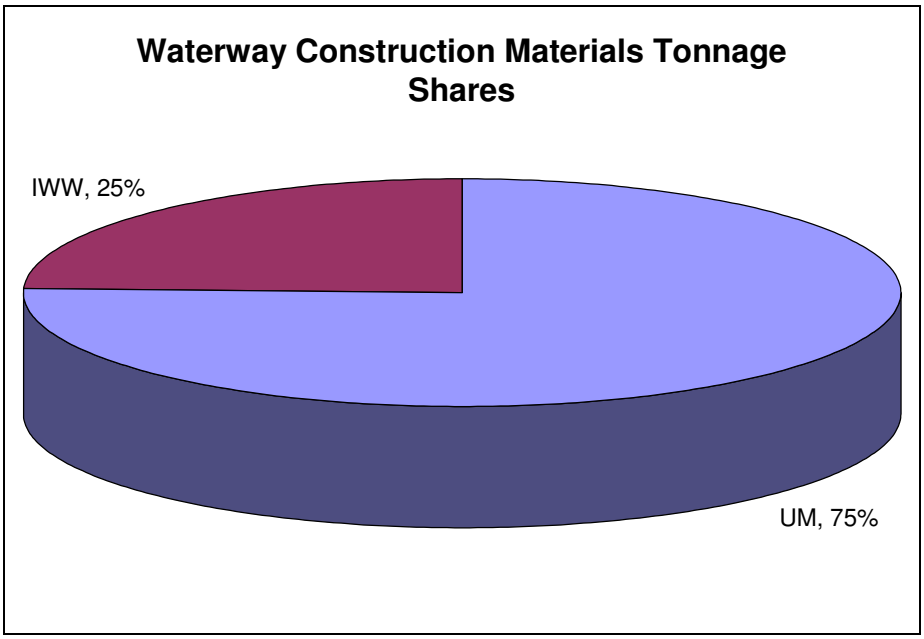
[82] Total cargo includes both grain and non-grain commodities. Shares calculated from 1997-2004 average tonnage data for each commodity.




(Source: Waterborne Commerce of United States)

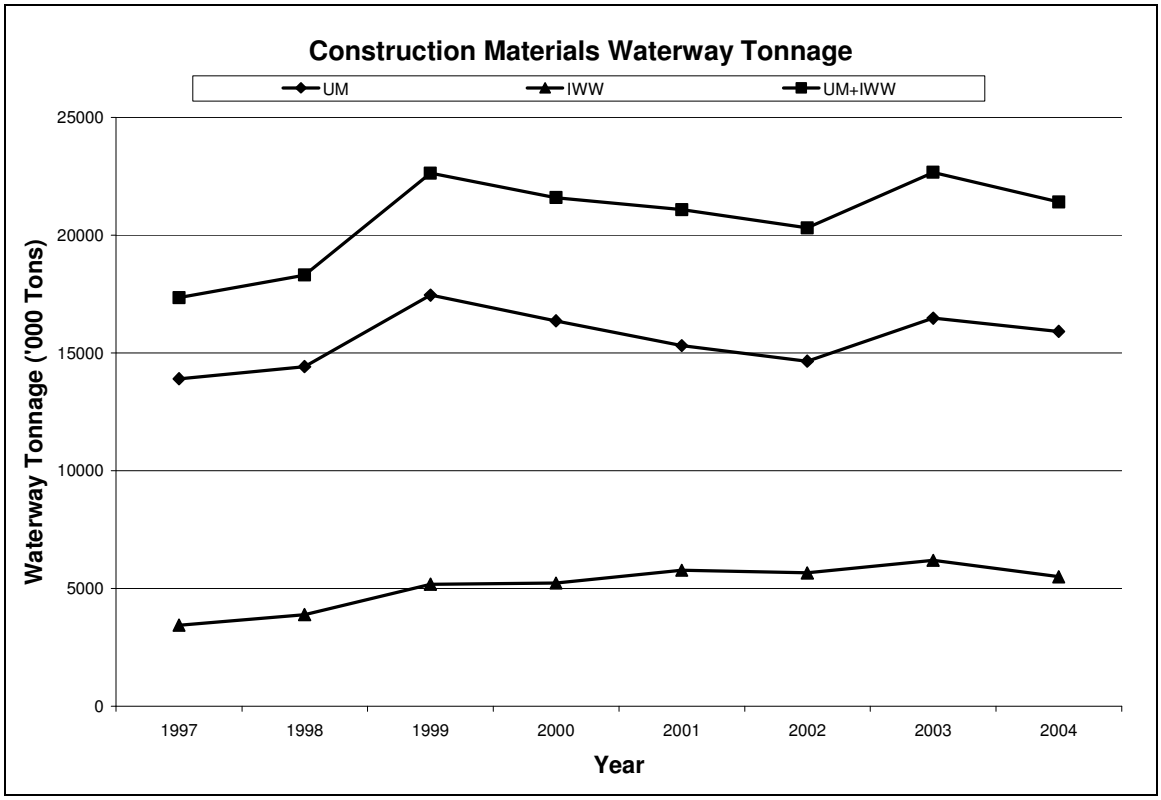
**Figure 86: Waterway Construction Materials Traffic Share, 1997-2004**

**Figure 88** shows the construction materials traffic tonnage on the Upper Mississippi and Illinois Waterway system. During the period 1997-2004, the Illinois Waterway experienced increasing trends for construction materials (except 2003-2004), while the Upper Mississippi experienced mixed trends with an increase from 1997-1999 then decrease until 2002 and then a further increase.




(Source: Waterborne Commerce of United States)

**Figure 87: Construction Materials Commodity Waterway Tonnage Share, 1997-2004 Average**



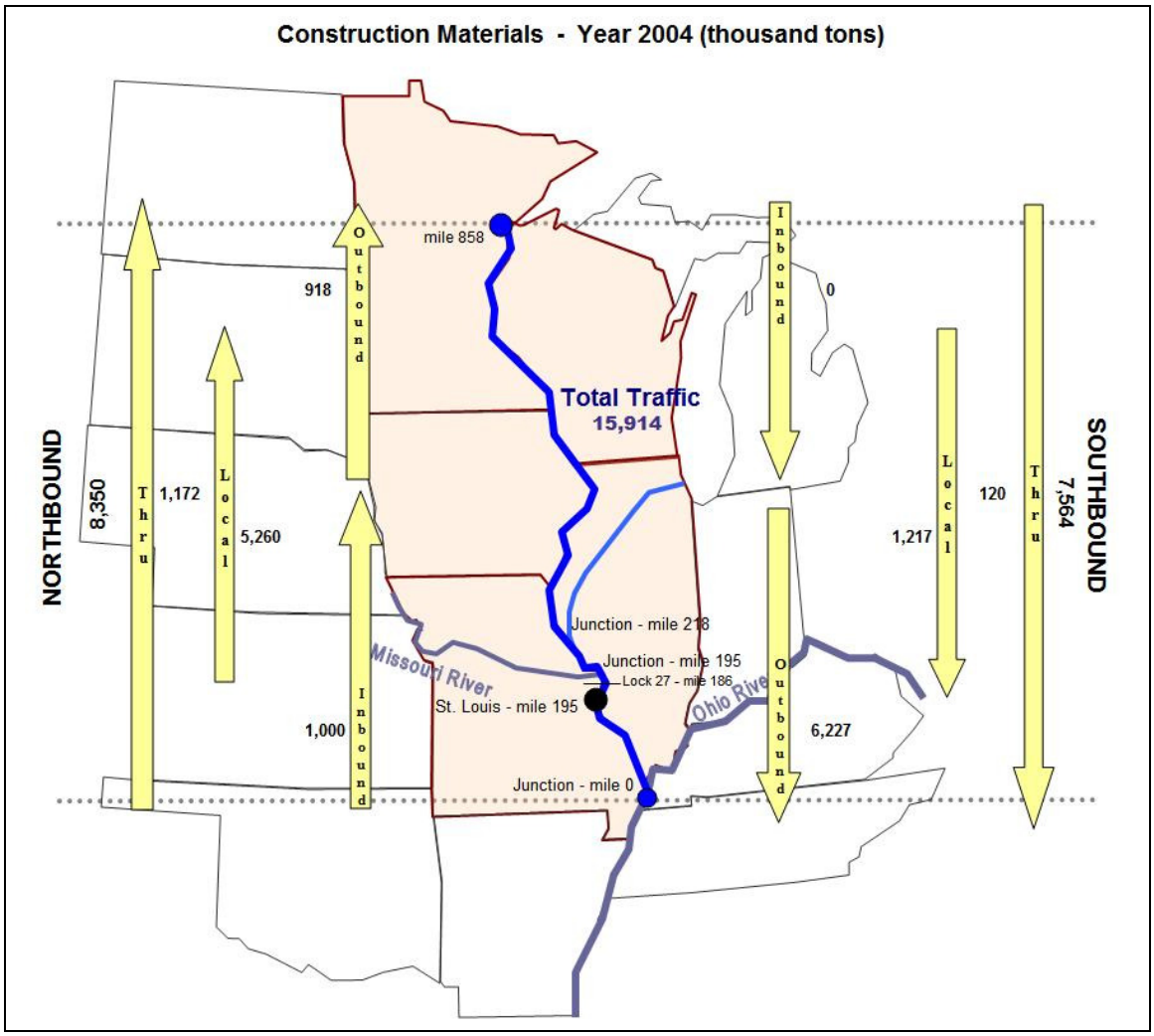

(Source: Waterborne Commerce of United States)

**Figure 88: Construction Materials Waterway Tonnage 1997-2004**

**Table 64: Inbound, Outbound, Local and Through Construction Materials Waterway Movements ('000 Tons)**

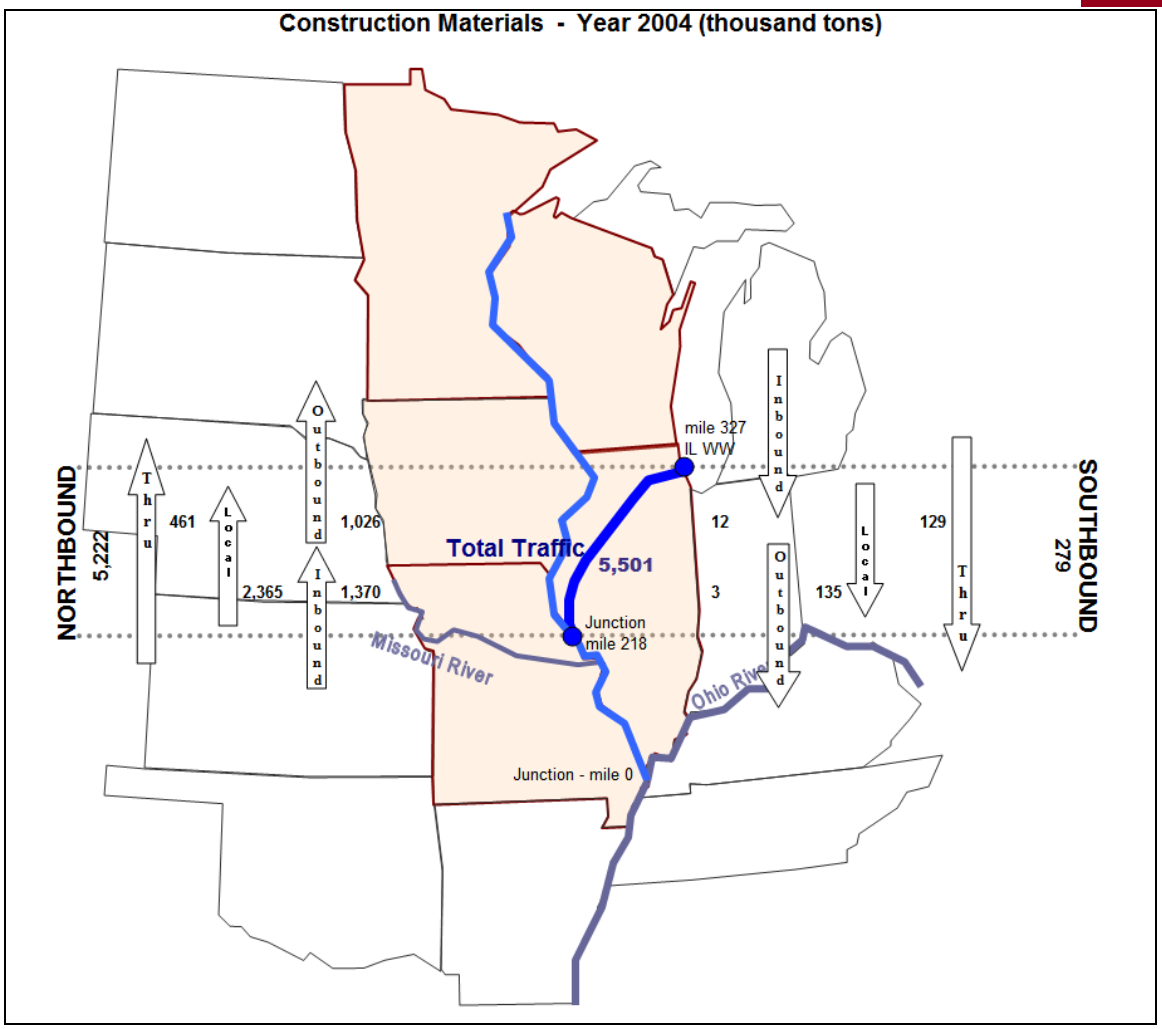
| Year | Illinois Waterway | | | | Upper Mississippi | | | |
|---|---|---|---|---|---|---|---|---|
| | Inbound | Outbound | Local | Through | Inbound | Outbound | Local | Through |
| 1997 | 1,223 | 436 | 1,661 | 119 | 565 | 7,420 | 5,308 | 611 |
| 1998 | 1,070 | 548 | 2,091 | 179 | 794 | 7,420 | 5,419 | 783 |
| 1999 | 1,464 | 754 | 2,641 | 317 | 1,337 | 8,947 | 5,911 | 1,264 |
| 2000 | 1,481 | 919 | 2,415 | 418 | 1,326 | 7,822 | 5,873 | 1,339 |
| 2001 | 1,487 | 1,088 | 2,813 | 384 | 1,019 | 7,220 | 5,814 | 1,259 |
| 2002 | 1,391 | 994 | 2,867 | 410 | 1,134 | 6,464 | 5,914 | 1,138 |
| 2003 | 1,540 | 1,050 | 3,134 | 474 | 907 | 8,089 | 6,431 | 1,044 |
| 2004 | 1,382 | 1,029 | 2,500 | 590 | 1,000 | 7,145 | 6,477 | 1,292 |

(Source: Waterborne Commerce of United States)




(Source: Waterborne Commerce of United States)

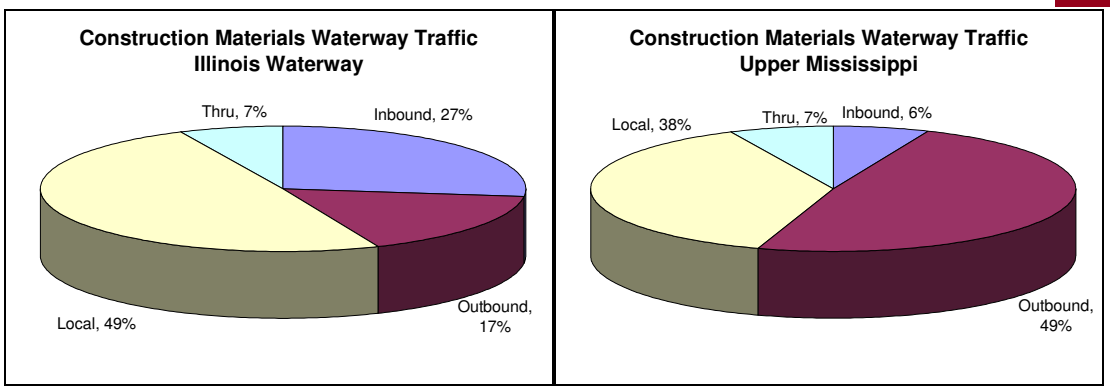
**Figure 89: Upper Mississippi Inbound, Outbound, Local and Through Waterway Movements 2004**




(Source: Waterborne Commerce of United States)

**Figure 90: Illinois Waterway Inbound, Outbound, Local and Through Waterway Movements 2004**

**Table 64** shows the inbound, outbound, local, and through traffic on the Upper Mississippi and Illinois Waterway. **Figure 89** and **Figure 90** illustrate these movements for the year 2004. **Figure 91** shows that the *local* movements have the largest share for the Illinois Waterway, while *outbound* movements have the largest share for the Upper Mississippi followed closely by local movements. The *local* and *outbound* trips constitute 41% each of the total combined waterway construction materials traffic. Almost all of the construction material on the Upper Mississippi *comes* from the Upper Mississippi (see **Table 65**), while the construction material on the Illinois Waterway *goes* to the Illinois Waterway. This indicates that the Upper Mississippi is a net exporter of construction materials with about 3 and 1.1 Million tons, respectively going to the Lower Mississippi and Gulf Intracoastal Waterway (see **Table 65**). Ninety-eight percent of the Illinois Waterway construction materials traffic comes from either the IL or the UM.




(Note: 1997-2004 Average; Source: Waterborne Commerce of United States)

**Figure 91: Inbound, Outbound, Local, and Through Construction Materials Waterway Shares**

**Table 65: Main Destinations of Construction Materials Shipped FROM Upper Mississippi and Illinois Waterway**

| FROM Upper Mississippi | | FROM Illinois Waterway | |
|---|---|---|---|
| TO Waterway | Share | TO Waterway | Share |
| UPPER MISS | 47% | ILLINOIS | 100% |
| LOWER MISS | 26% | OHIO | 0% |
| GIWW WEST | 10% | | |
| RED | 7% | | |
| OHIO | 4% | | |
| ILLINOIS | 3% | | |
| OTHERS | 4% | | |
| **Total** | **100%** | **Total** | **100%** |

(GIWW: Gulf Intracoastal Waterway)
(Source: Tennessee Valley Authority, 2004)

**Table 66: Main Origins of Construction Materials Shipped TO Upper Mississippi and Illinois Waterway**

| TO Upper Mississippi | | TO Illinois Waterway | |
|---|---|---|---|
| FROM Waterway | Share | FROM Waterway | Share |
| UPPER MISS | 94% | ILLINOIS | 90% |
| MISSOURI | 3% | UPPER MISS | 8% |
| LOWER MISS | 2% | LOWER MISS | 1% |
| OTHERS | 1% | ARKANSAS | 1% |
| | | OTHERS | 1% |
| **Total** | **100%** | **Total** | **100%** |

(Source: Tennessee Valley Authority, 2004)

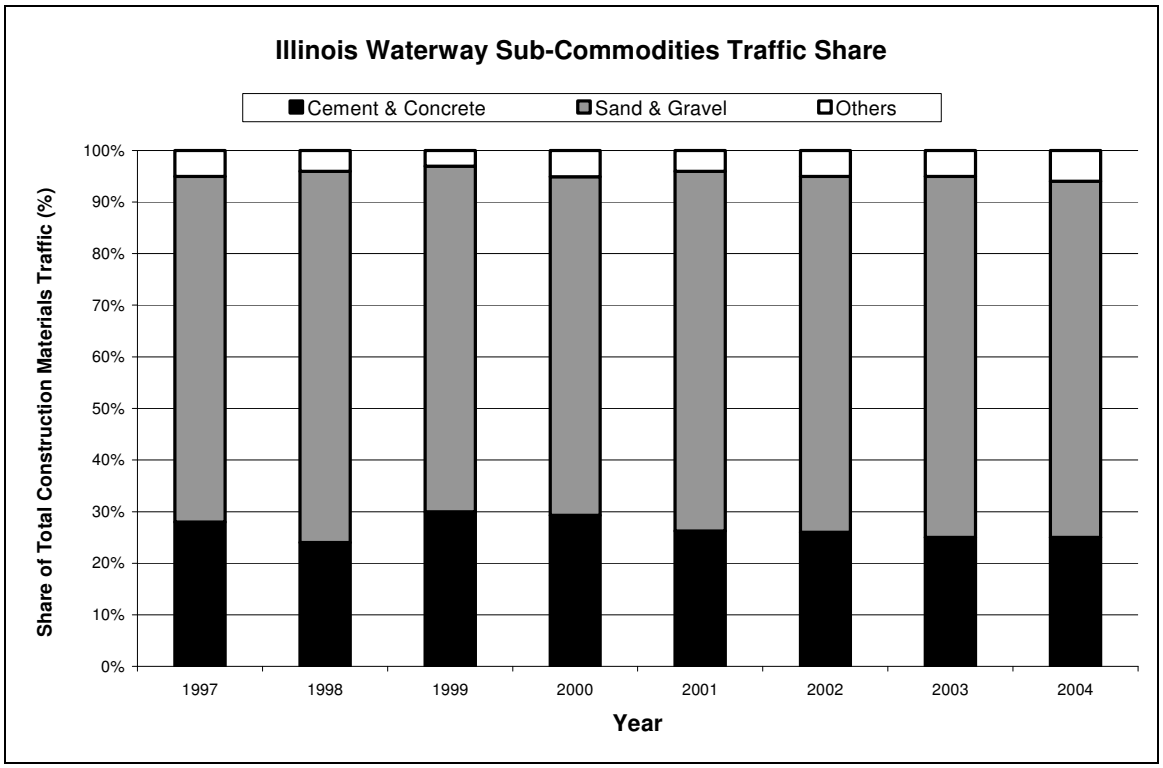
## Key Sub-commodities

**Table 67**, **Table 68,** and **Table 69** show the sub-commodity tonnages and shares for the Illinois Waterway, Upper Mississippi, and Combined Waterway, respectively (See **Figure 92**, **Figure 93,** and **Figure 94**).

**Table 67: Illinois Waterway Traffic by Sub-commodities ('000 short tons)**

| Year | Cement & Concrete | | Sand & Gravel | | Other | | Grand Total |
|---|---|---|---|---|---|---|---|
| | Tons | Share | Tons | Share | Tons | Share | |
| 1997 | 954 | 28% | 2,310 | 67% | 175 | 5% | 3,439 |
| 1998 | 939 | 24% | 2,812 | 72% | 137 | 4% | 3,888 |
| 1999 | 1,541 | 30% | 3,490 | 67% | 145 | 3% | 5,176 |
| 2000 | 1,536 | 29% | 3,417 | 65% | 280 | 5% | 5,233 |
| 2001 | 1,516 | 26% | 4,001 | 69% | 255 | 4% | 5,772 |
| 2002 | 1,453 | 26% | 3,909 | 69% | 300 | 5% | 5,662 |
| 2003 | 1,527 | 25% | 4,359 | 70% | 312 | 5% | 6,198 |
| 2004 | 1,359 | 25% | 3,809 | 69% | 333 | 6% | 5,501 |

(Note: Other includes Limestone, Gypsum, Phosphate Rock, Soil and Fill Dirt)
(Source: Waterborne Commerce of United States)




(Source: Waterborne Commerce of United States)

**Figure 92: Illinois Waterway Sub-Commodities Traffic Share, 1997-2004**

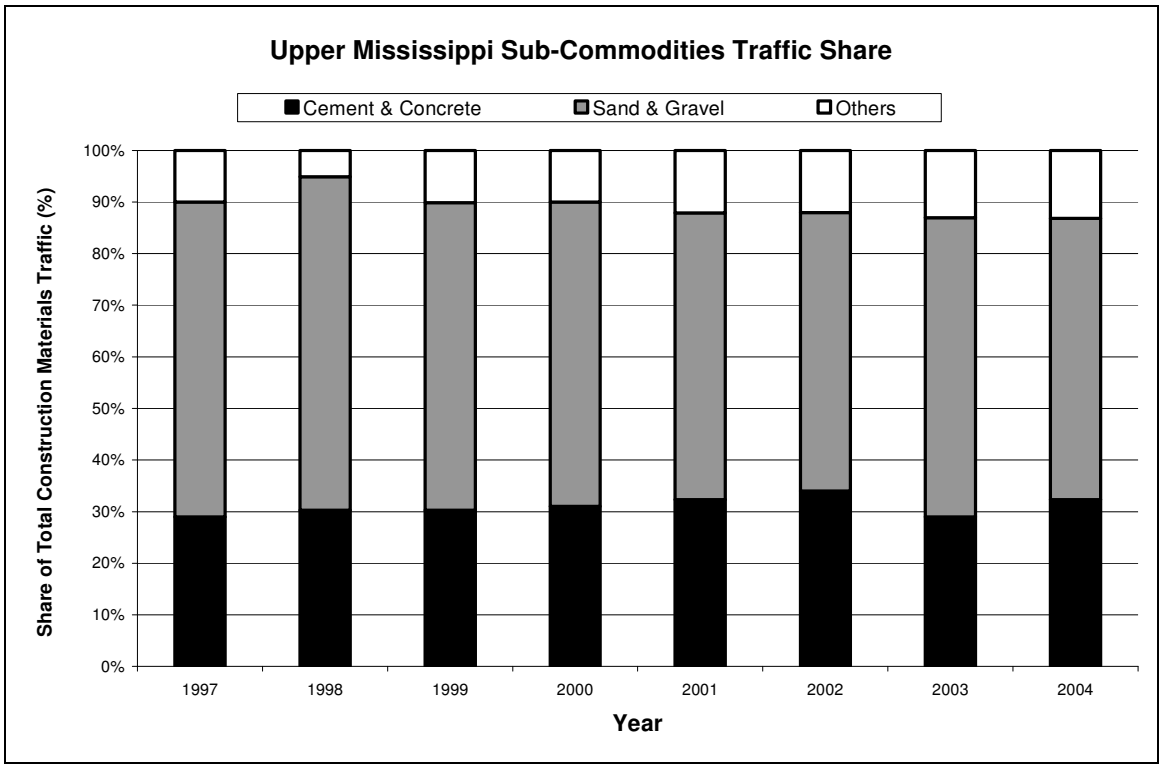
The primary sub-commodities of construction materials are cement and concrete and sand and gravel. These constitute more than 90% of the total Upper Mississippi and

Illinois Waterway construction materials tonnage. The remaining 10% is comprised of Limestone, Gypsum, Phosphate Rock, Soil, and Fill Dirt. The relative share of cement and concrete tonnage has remained stable from 1997-2004, while the other two sub-commodities have changed by about 3%.

**Table 68: Upper Mississippi Traffic by Sub-commodities ('000 short tons)**

| Year | Cement & Concrete | | Sand & Gravel | | Other | | Grand Total |
|---|---|---|---|---|---|---|---|
| | Tons | Share | Tons | Share | Tons | Share | |
| 1997 | 4,049 | 29% | 8,522 | 61% | 1,333 | 10% | 13,904 |
| 1998 | 4,377 | 30% | 9,254 | 64% | 785 | 5% | 14,416 |
| 1999 | 5,295 | 30% | 10,381 | 59% | 1,783 | 10% | 17,459 |
| 2000 | 5,102 | 31% | 9,689 | 59% | 1,569 | 10% | 16,360 |
| 2001 | 4,941 | 32% | 8,496 | 55% | 1,875 | 12% | 15,312 |
| 2002 | 4,961 | 34% | 7,941 | 54% | 1,748 | 12% | 14,650 |
| 2003 | 4,767 | 29% | 9,538 | 58% | 2,166 | 13% | 16,471 |
| 2004 | 5,126 | 32% | 8,645 | 54% | 2,143 | 13% | 15,914 |

(Note: Other includes Limestone, Gypsum, Phosphate Rock, Soil and Fill Dirt)
(Source: Waterborne Commerce of United States)



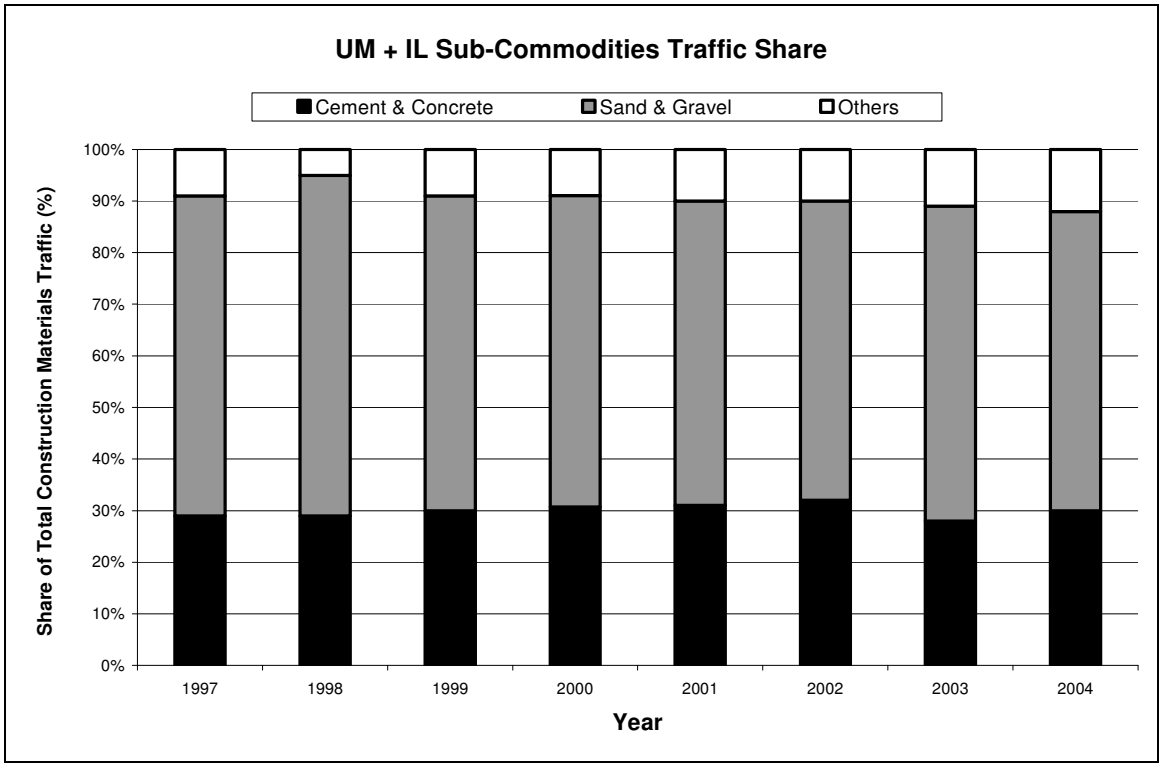

(Source: Waterborne Commerce of United States)

**Figure 93: Upper Mississippi Sub-Commodities Traffic Share, 1997-2004**

**Table 69: UM+IL Combined Traffic by Sub-commodities ('000 short tons)**

| Year | Cement & Concrete | | Sand & Gravel | | Other | | Grand Total |
|---|---|---|---|---|---|---|---|
| | Tons | Share | Tons | Share | Tons | Share | |
| 1997 | 5,003 | 29% | 10,832 | 62% | 1,508 | 9% | 17,343 |
| 1998 | 5,316 | 29% | 12,066 | 66% | 922 | 5% | 18,304 |
| 1999 | 6,836 | 30% | 13,871 | 61% | 1,928 | 9% | 22,635 |
| 2000 | 6,638 | 31% | 13,106 | 61% | 1,849 | 9% | 21,593 |
| 2001 | 6,457 | 31% | 12,497 | 59% | 2,130 | 10% | 21,084 |
| 2002 | 6,414 | 32% | 11,850 | 58% | 2,048 | 10% | 20,312 |
| 2003 | 6,294 | 28% | 13,897 | 61% | 2,478 | 11% | 22,669 |
| 2004 | 6,485 | 30% | 12,454 | 58% | 2,476 | 12% | 21,415 |

(Note: Other includes Limestone, Gypsum, Phosphate Rock, Soil and Fill Dirt)
(Source: Waterborne Commerce of United States)




(Source: Waterborne Commerce of United States)

**Figure 94: UM + IL Sub-Commodities Traffic Share, 1997-2004**

### 2.6.3 Forecasting Methodology

The demand for Construction Materials is derived mainly from the demand for construction for infrastructure including, among others, buildings, highways and bridges. The construction activity in any region depends on its economy and its growth trends. To forecast the construction materials waterway tonnage we need to use an economic indicator variable. Gross Domestic Product (GDP) is the most widely accepted economic indicator. GDP is computed for each state and also for the US. **Figure 95** illustrates the relationships of the construction materials industry in the US.

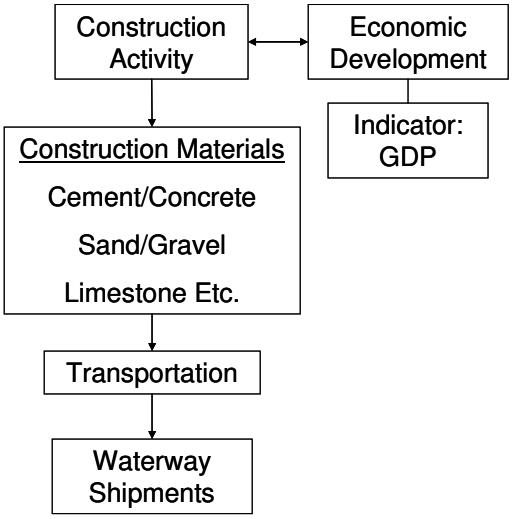



**Figure 95: Construction Materials Industry Conceptual Diagram**

GDP for the states in the Upper Mississippi and Illinois Waterway region was considered in developing forecast models. These states included: Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The GDP for all these states was summed up to indicate the economic activity of the entire region. It was, however, deemed important to use Illinois GDP separately in the modeling exercise based on the following observations:

- Illinois has the maximum share of the five-state GDP, 42%.
- Illinois has the maximum access to both waterways. Illinois Waterway lies entirely within the state and the Upper Mississippi is the western boundary of the state.
- Nearly 100% of the traffic on the Illinois Waterway originates and terminates on the same waterway, which indicates that the traffic in this waterway would be impacted mostly by Illinois' economy.

Based on the above observations three GDP variables were used in the models: Illinois GDP, and 4-State GDP (Iowa, Minnesota, Missouri, and Wisconsin).
**Table** 70 shows the data for these variables used in model development.

**Table 70: Regression Variables 1997-2004**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| IL GDP | 403,982 | 423,855 | 443,751 | 464,194 | 476,461 | 487,129 | 509,161 | 533,735 |
| 4-ST GDP | 547,613 | 573,510 | 596,979 | 627,724 | 646,449 | 672,865 | 703,624 | 748,416 |
| UM+IWW Traffic | 17,343 | 18,304 | 22,635 | 21,593 | 21,084 | 20,312 | 22,669 | 21,415 |
| IWW Traffic | 3,439 | 3,888 | 5,176 | 5,233 | 5,772 | 5,662 | 6,198 | 5,501 |
| UM Traffic | 13,904 | 14,416 | 17,459 | 16,360 | 15,312 | 14,650 | 16,471 | 15,914 |

(Source: GDP: LBG Analysis based on US GDP forecasts from Congressional Budget Office; Waterway Traffic: Waterway Commerce of United States)

The regression results are presented below.

| **IWW CONST. MATERIALS Barge Traffic =** | **-10219** | **+ 0.1353 (IL GDP)** | **- 0.07496 (4-State GDP)** |
|---|---|---|---|
| Standard Error | (2414) | (0.0354) | (0.02268) |
| *t-statistic* | *-4.23* | *+3.82* | *-3.31* |
| R-squared = 0.91 | | | |

*Barge Traffic is in '000 Tons*
*4-State (IA, MO, MN, and WI) GDP is in Million Dollars*
*Illinois GDP is in Million Dollars*

| **UM+IWW CONST. MATERIALS Barge Traffic =** | **-11525** | **+ 0.352 (IL GDP)** | **- 0.207(4-State GDP)** |
|---|---|---|---|
| Standard Error | (7238) | (0.106) | (0.068) |
| *t-statistic* | *-1.59* | *+3.32* | *-3.04* |
| R-squared = 0.81 | | | |

*Barge Traffic is in '000 Tons*
*4-State (IA, MO, MN, and WI) GDP is in Million Dollars*
*Illinois GDP is in Million Dollars*

The Upper Mississippi traffic is obtained by subtracting the Illinois traffic from the UM+IL traffic obtained by using the models presented above.

The regression results show that traffic on both waterways would increase with an increase in Illinois' GDP. This is intuitive as the economic development in the state would directly impact the construction materials traffic on the waterways as both waterways serve Illinois. The negative sign for the 4-State GDP indicates that the waterway traffic would reduce with an increase in the GDP for non-Illinois states in the region. This variable works as an adjustment to the impact of Illinois' GDP. The GDPs of all the states in the region are inter-related due to their relationships, especially for trade. Historically, these two variables have shown a similar trend (increasing or decreasing) and there are no radical changes projected in the economies of any of these states.

The complete forecasting procedure is outlined below.

- Step 1: Forecast the Illinois Waterway Construction Materials traffic using the regression equation given above. (This would need forecasted values for Illinois and 4-State GDP).

- Step 2: Forecast the Upper Mississippi and Illinois Waterway Combined Construction Materials traffic using the regression equation given above. (This would also need forecasted values for Illinois and 4-State GDP).

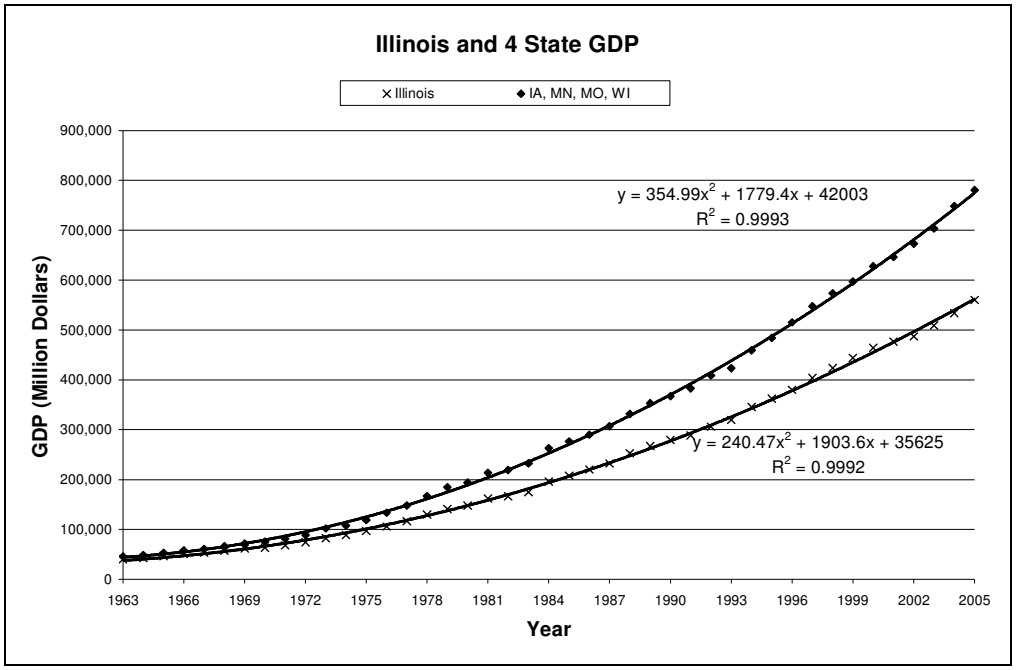
- Step 3: Calculate the Upper Mississippi Construction Materials Traffic by subtracting the value obtained in Step 1 from Step 2.

### 2.6.4 Construction Materials Forecast

This section presents LBG scenarios for the Construction Materials unconstrained movement forecast on the upper Mississippi and Illinois waterways.

- The Illinois and 5-State (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) GDP will follow the historical trend from 1963-2005 for the forecast years through 2030.

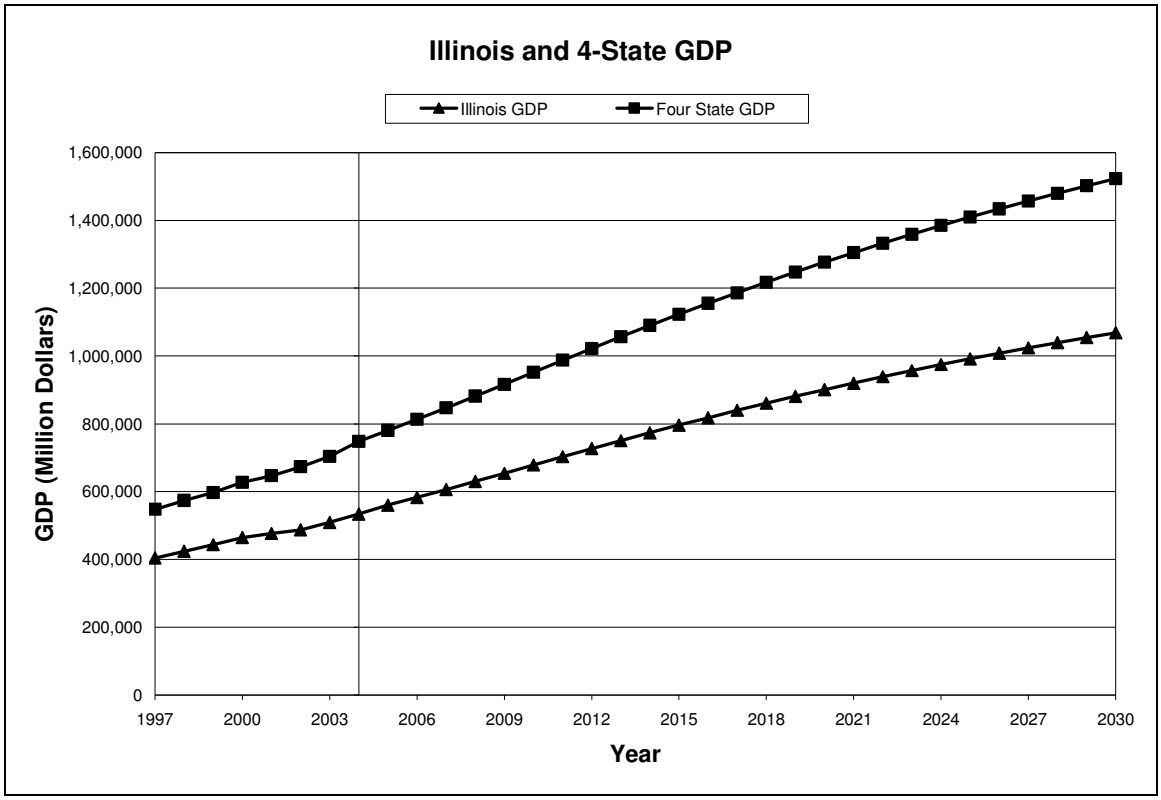
To forecast the Construction Materials unconstrained waterway tonnage using the regression equation developed in the previous section we need to forecast the values of Illinois and 4-State GDP.




(Source: Bureau of Economic Analysis, US Department of Commerce, 2006)

**Figure 96: Illinois and 4-State GDP, 1963-2005**

The state GDP forecasts were not available from any government agency. The trends for Illinois and 4-State (Iowa, Minnesota, Missouri, and Wisconsin) were observed over the past 40 years using the data available from the US Department of Commerce, Bureau of Economic Analysis. It was found that these followed a near-perfect quadratic trend from 1963-2005 with a very high goodness of fit value of 0.999 (see **Figure 96**). It was thus assumed that these trends would continue through 2010. From 2011 onwards the GDP growth rate was assumed to be 95% of the previous year's growth rate. The corresponding forecasts are shown in **Figure 97**.



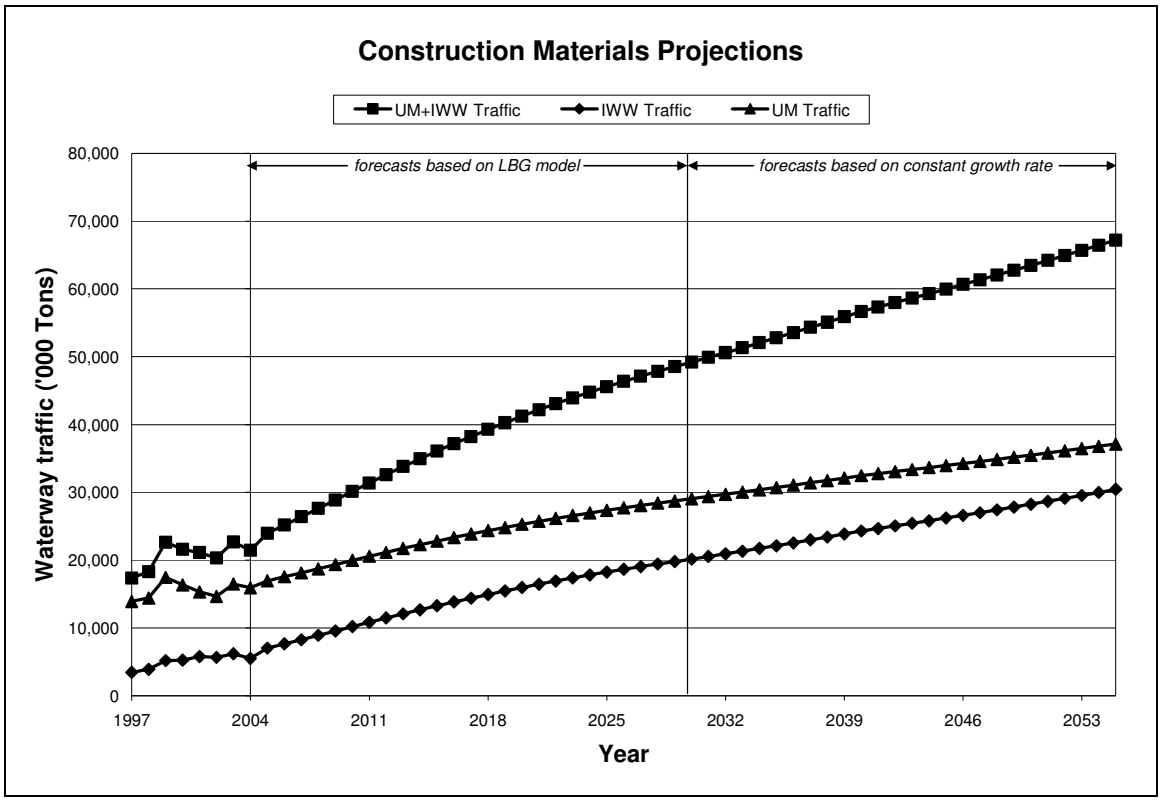

(Source: LBG Analysis)

**Figure 97: Illinois and 4-State GDP Forecast 2006-2030**

The Construction Materials waterway traffic forecast model developed in the previous section was used to forecast the total Upper Mississippi and Illinois Waterway combined traffic for construction materials through 2030. Since, the 2030 to 2055 period is in the distant future and it is difficult to reasonably predict the changes in any industry. It was thus assumed that the waterway traffic for the period 2030-2040 would grow at 80% of the growth rate from 2020-2030. For 2040-2055 the waterway traffic was assumed to grow at 80% of the growth rate from 2030-2040. The results are tabulated in **Table 71** and presented in **Figure 98**.

The forecasts show a constant increase in the waterway tonnage from 2006 onwards. The growth rates decrease over time (See **Table 72**). It would be important to analyze the

waterway capacity constraints for this forecast as the combined waterway traffic increases rapidly over the forecast period.




(Source: LBG Analysis)

**Figure 98: Construction Materials Unconstrained Waterway Traffic Forecast 2005-2055**

**Table 71: Construction Materials Unconstrained Waterway Forecasts: LBG Base Case Results**

| Year | IL GDP | 4-State GDP (IA,MN,MO,WI) | UM+IWW Tonnage | IWW Tonnage | UM Tonnage |
|---|---|---|---|---|---|
| | Million Dollars | Million Dollars | 000 Tons | 000 Tons | 000 Tons |
| 1997 | 403,982 | 547,613 | 17,343 | 3,439 | 13,904 |
| 1998 | 423,855 | 573,510 | 18,304 | 3,888 | 14,416 |
| 1999 | 443,751 | 596,979 | 22,635 | 5,176 | 17,459 |
| 2000 | 464,194 | 627,724 | 21,593 | 5,233 | 16,360 |
| 2001 | 476,461 | 646,449 | 21,084 | 5,772 | 15,312 |
| 2002 | 487,129 | 672,865 | 20,312 | 5,662 | 14,650 |
| 2003 | 509,161 | 703,624 | 22,669 | 6,198 | 16,471 |
| 2004 | 533,735 | 748,416 | 21,415 | 5,501 | 15,914 |
| 2005 | 560,032 | 780,491 | 23,975 | 7,029 | 16,946 |
| 2006 | 582,772 | 813,390 | 25,166 | 7,639 | 17,527 |
| 2010 | 678,524 | 952,139 | 30,138 | 10,190 | 19,948 |
| 2015 | 795,854 | 1,122,904 | 36,076 | 13,261 | 22,815 |
| 2020 | 900,793 | 1,276,393 | 41,229 | 15,950 | 25,279 |
| 2025 | 991,664 | 1,409,820 | 45,585 | 18,240 | 27,345 |
| 2030 | 1,068,396 | 1,522,826 | 49,192 | 20,148 | 29,044 |
| 2035 | | | 52,800 | 22,127 | 30,705 |
| 2040 | | | 56,671 | 24,300 | 32,461 |
| 2045 | | | 59,977 | 26,195 | 33,940 |
| 2050 | | | 63,476 | 28,238 | 35,486 |
| 2055 | | | 67,178 | 30,440 | 37,102 |

(Source: LBG Analysis)

**Table 72: Cumulative Annual Growth Rates, 1997-2055**

| From Year | To Year | UM+IWW | IWW | UM |
|---|---|---|---|---|
| 1997 | 2000 | 7.6% | 15.0% | 5.6% |
| 1997 | 2004 | 3.1% | 6.9% | 1.9% |
| 2005 | 2010 | 4.7% | 7.7% | 3.3% |
| 2010 | 2015 | 3.7% | 5.4% | 2.7% |
| 2015 | 2020 | 2.7% | 3.8% | 2.1% |
| 2020 | 2030 | 1.8% | 2.4% | 1.4% |
| 2030 | 2040 | 1.4% | 1.9% | 1.1% |
| 2040 | 2050 | 1.1% | 1.5% | 0.9% |
| 2005 | 2030 | 2.9% | 4.3% | 2.2% |
| 2005 | 2055 | 2.1% | 3.0% | 1.6% |

(Source: LBG Analysis)

# SECTION 3: CONTAINER ON BARGES

## *3.1 General*

### 3.1.1 Objective

This section summarizes a review aimed at developing a 50-year outlook for container on barge (COB) traffic on the Upper Mississippi and Illinois Waterways. Presently, there is no COB system on the Upper Mississippi River and only an irregular COB on the Illinois River. A regular, though limited COB has been operating on the Lower Mississippi, between Memphis, TN, Baton Rouge, LA and New Orleans for about 3 years. However, the service between Baton Rouge and New Orleans has been curtailed recently. In addition, there have been many attempts to established COB on the Mississippi River System, but all were short-lived.

Operationally, the COB on the Upper Mississippi and Illinois are extensions of the COB on the lower and more heavily-trafficked segment of the Mississippi River. Hence, the analysis of the prospects of COB on these rivers is part of a broader analysis of the viability and prospects of COB on the Mississippi River and its main tributaries (referred to hereafter as Waterway). COB on the Waterway, as evidenced by the above description, is still in its initial exploratory stage. The analysis in the following sections indicates that while the present, limited system may survive and perhaps moderately grow, the emergence of a more significant COB requires radical changes in the system's operating concept, technology, and a substantial increase in the overall traffic in the corridors it operates.

Accordingly, the two main forecasting scenarios are defined as No Change and Radical Change. The specific objective of this study is to indicate the possible extent of COB development on the Waterway and for its Upper Mississippi and Illinois segments according to the two defined scenarios above.

There is also a possibility that the present No Change COB system will fail and quit operations, as was the case with many previous systems.

### 3.1.2 Methodology and Organization of the Report

A long-term forecasting methodology based on the extension of past trends is not applicable here. Accordingly, the study methodology includes, first, a general review of COB systems followed by a definition of the Waterway COB systems in the No Change and Radical Change scenarios, including assumptions regarding: (a) Types of boxes and trades served by the systems, their vessels, ports and overall operational concepts; (b) Comparative analysis of the performance and competitiveness of existing Waterway COB relative to the intermodal rail services along the same corridor; (c) Review of trends in international trade and shipping services along with an assessment of the competition

from intermodal rail services based on ports outside the Gulf Coast; and (d) Summary definition of scenarios along with a set of factors that determine the respective long-term forecasts.

The main sources of information for this study are industry interviews with the present operators of COB, other barge lines, freight forwarders, shipping lines using COB, and ports presently and potentially involved with COB. In addition, a comprehensive review of COB-related literature was conducted, including a USACE report *Improving and Expanding Inland Waterways Containerization: a Report to Congress*, May 2006. Three other notable reports are: (1) A. Hochstein *Comparative Review of Domestic Water Tran*sportation, 2005; (2) *Container-on-Barge Pre-Feasibility Study,* Port of Pittsburgh, 2003; and (3) *Container Transport by Inland Waterways*, MARAD / LSU National Ports & Waterways Institute, 1987. The latter, though undated, includes a comprehensive analysis and observations that are still applicable today, almost 20 years later.

## *3.2 Definition and Assumptions regarding the Mississippi Waterway COB System*

### 3.2.1 Alternative Operational Concepts

**The Components of the COB System**

COB, like any other maritime transport system, consists of 4 basic components:

- ***Cargoes*** – The types of boxes and trades that the system handles;
- ***Vessels*** – The types of barges that the system employs;
- ***Ports*** – The types of inland ports that handle the system's barges and cargoes; and
- ***Routes and Services*** – The waterway segments and ports where services are offered and the types of these services.

**General vs. Specialized COB Systems**

There are 2 generic operational concepts along which COB can be developed:

- ***General COB System*** – Based on standard open hopper "Jumbo" barges, general tows and general terminals with minimal improvements; and
- ***Specialized COB System*** – Based on deck barges (or self-propelled vessel) with lashing structure, dedicated tows and specialized terminals with container lifting equipment.

In reality, there could obviously be a whole range of concepts based on various combinations of components from both systems. For example, a general COB that also employs specialized deck barges. However, in light of the long-term (50 years) focus of this study and the respective two main scenarios defined at the outset, the above somewhat simplistic categorization of concepts is considered adequate.

The general COB is similar to that presently in operations on the River; it also is the system assumed in the No Change Scenario. The specialized COB is similar to that presently in operation along the US Atlantic Coast and between Houston and New Orleans and, especially, in Europe on the Rhine River. The specialized COB is assumed in the Radical Change Scenario (with some adjustments as will be seen later).

The following sections include a description of the two COB concepts, including assumptions regarding the respective No Change and Radical Change forecasting scenarios.

### 3.2.2 Cargo

**General COB**

Presently, the Mississippi River COB is only involved with marine (international, ISO) containers. This also is the case with the present Colombia River's COB, the only large-scale river COB in the US, and this also is the main stay of the European Rhine River COB. Theoretically, COB can be expanded to include domestic containers. The same vessel and port system could serve both marine and domestic boxes, and both types of boxes could be handled by the same lifting equipment using the same spreader bars. In fact, COB's main competitor, intermodal rail, employs double-stack cars carrying a mixture of marine and domestic containers.

However, there are several technical and operational problems that hinder mixing international and domestic boxes in the same COB system. First, the overall dimensions of the two types of boxes are different. Marine boxes are typically either 20 or 40 ft. long by 8 ft. wide while most of the domestic boxes are 53 ft. long by 8.5 ft. wide. This difference mandates separate on-board stows of boxes, resulting in a significant reduction in barge capacity. Second, domestic containers cannot be stacked more than 2-high while present COB is based stacking boxes 3-high. In comparison, mixing international and domestic boxes is not a problem for intermodal rail since the new double-stack cars have wells of 53 x 8.5 ft. Even if older double-stack cars with 40-ft wells are used, the larger domestic boxes can ride over the smaller international boxes.

General COB also is not suitable for handling domestic trailers since the capacity of hopper barge would be very limited. In addition, lifting and staging trailers inside hopper barges is complicated and there is a need for fitting the barges with lashing equipment.

### Specialized COB

Specialized COB could handle both international and domestic boxes. The system envisioned for these services is based on deck barges and dedicated tows. These deck barges, unlike the standard hopper barges, could be designed to fit the dimensions of both international and domestic containers. However, due to stacking limitation, the capacity for domestic boxes will be limited. The main obstacle for handling a mixture of international and domestic box is the need for separate port facilities and the related double-calling (see more below).

Deck barges could also hold many more trailers than hopper barges. However, since trailers cannot be stacked, carrying capacity would be limited. Special multi-deck barges, similar to ocean-going barges deployed en-route to Puerto Rico, could provide enhanced capacity, but at a much higher construction cost. Another obstacle for handling trailers is port operations. Lifting and staging trailers is complicated. The more common system of handling trailers, using roll on / roll off system, requires special ramps which, due to the wide variations in water level, will be large and expensive, especially in the case of multi-deck barges.

### Domestic Freight in International Boxes

Theoretically, there is a possibility of developing a pure domestic COB, moving international or domestic boxes filled with domestic freights between Waterway ports. In fact, the Port of Pittsburgh was involved in such an attempt. The prospects of domestic COB, however, are deemed unlikely since: (a) Domestic freight usually is too time sensitive to withstand the slow transit time inherent in barging even in a specialized system; (b) Domestic freight usually is not generated / terminated on the Waterway and requires additional truck drayage which significantly adds to the cost; and (c) Volume of domestic traffic along the Waterway corridor is relatively small and not expected to grow significantly even in the long-term future.

Another option is to use repositioning of empty international boxes to carry domestic freight. This practice is common with the competing intermodal rail services, especially on the backhaul leg between the Midwest and West Coast ports. In the case of COB, such practice is operationally difficult. The barges usually are handled in the deep-sea international ports, in the Customs area, with special security arrangement and an elaborate gate system that would make handling of domestic freight very costly and time consuming.[83] This is not the case with intermodal rail where yards, except in special cases, are located outside the marine terminals and can serve both types of freight.

Therefore, in both No Change and Radical Change Scenarios, it can be assumed that present and future cargo composition for the Mississippi River COB would be based on marine containers with international freight.

[83] This problem can be overcome by developing specialized barge terminals outside the deep-sea terminals. This, however, would require additional inter-terminal drayage.

### 3.2.3 Vessel System

**General COB**

The present COB on the Waterway, which serves as the prototype for the General COB, is based on hopper barges and general tows. This also was the case with all past COBs. The overall dimensions of the Mississippi River Jumbo standard open hopper barges are:

- ***Box Barge*** – Outside 195 x 35 x 12 x 9/12 ft (length x width x depth x draft) and inside space of 188 x 28 x 14 ft (length x width x depth); and

- ***Rake Barge*** – Outside 195 x 35 x 12 x 9 ft (length x width x depth x draft) and inside space of 158 x 28 x 14 ft (length x width x depth).

Since the barge's hold is uncovered it allows rain and splash water in. To protect their bottom, the containers have to be mounted on wooden spacers. The common arrangement of containers in hopper barges, assuming all are 20-ft boxes, is 8-long and 3-wide, or 24 per layer. The maximum number of layers is 3 high and the respective total capacity is 72 TEU (24 x 3). A rake barge has about ¼ less capacity than a box barge. In special cases, up to 10 20-ft boxes can be added in the space remaining at the end of the stack, resulting in an overall capacity of 82 TEU for the box barge. Towing barges with containers stacked 3-high requires special boats with high pilot houses, which are not always available. Also, often there is not enough cargo to fill the entire barge capacity. Therefore, in reality, barges carry an average of about 50 TEU.

The DWT capacity of a standard hopper barge is about 1,500 ton. The average weight of a container is about10 ton/TEU. Hence, a barge carrying 72 TEU is only loaded with 720 tons, less than half of its DWT capacity. **Figure 99** on the following page presents a picture of a 15-barge general COB. Note that the third tier is only partially utilized to avoid obstruction of the line of sight.

**Figure 99: General COB Tow**

### Specialized COB

Deck barges for a specialized COB are not limited in their dimensions since they do not use common tows. Likewise, the push boat used for these tows could be specially designed, including using boats with a high pilot house. If a deck barge with the same dimensions of a standard hopper barge (195 x 35 ft) is selected, each layer could accommodate 36 TEU (9 x 4), with the total capacity when stacking 3 high of 108 TEU, which is still less than the DWT capacity of the barge.

The common deck barges on the Waterway are 250 x 72 x 15.5 x 12 ft (length x width x depth x draft) and have a carrying capacity of 4,800 DWT. The theoretical capacity of this barge is about 60 TEU per tier. Hence, at 3-high the capacity is 180 TEU. The height of the container stack on a deck barge is much higher than hopper barges, hence existing push boats, even with a high pilot house, will have difficulty with their line of site. Therefore, a specialized push boat will be required with an elevated pilot house similar to that used in Europe. Likewise, the barge will have to be fitted with special lashing equipment. A tug-barge combination based on two deck barges of the above dimensions could sail at an average (upriver & downriver) speed of 9 mph (8 knots), about twice that of common tows. As a result, specialized COB could offer a 3 day transit time on the 625-mile New Orleans to Memphis route compared to 7 days for general COB and 1 day for rail.

A more ambitious specialized COB could be based on self-propelled ships, similar to those used in Europe. Due to their superior hydrodynamic hull and maneuverability, these ships have a still water speed of 15 mph and therefore could probably sail at an average speed of 12 mph on the Waterway. Typically, this ship's dimensions are 360 x

36 x 12 ft (length x width x draft) and their container capacity is about 120 TEU. **Figure 100** presents a picture of a typical self-propelled Rhine River ship from Damen shipyard.

**Figure 100: Rhine River Container Ship**

presents a comparison of the fuel costs of a standard hopper barge in a general COB and a typical Rhine River ship. As seen in this figure, the higher speed and capacity of the ship offset the higher HP per TEU capacity resulting in similar overall fuel cost as measured by HP / TEU-Mile.

**Table 73: Comparison of Fuel Costs of a Standard Hopper Barge in General COB and typical Rhine River Ship**

| Parameter | Unit | 15-Barge Tow | Damen River Liner 1080 |
|---|---|---|---|
| Main Engine | HP | 3,000 | 1,000 |
| Number of Units | | 15 | 1 |
| | HP/Unit | 200 | 1,000 |
| Unit Capacity | TEU | 72 | 120 |
| | HP per TEU | 2.78 | 8.33 |
| Speed | MPH | 4 | 12 |
| Fuel Consumption | HP per TEU-Mile | 0.69 | 0.69 |

An in-depth assessment of inland waterways barges and ships is beyond the scope of this study. Cursory assessment suggests that although the capital cost of these ships is considerably higher than a tug and barge combination, their overall operating cost is similar and even lower if they can take advantage of their higher speed. The main

disadvantage of these ships is that unlike push boats and deck barges they are not available domestically. Hence, COB based on specialized ships requires large initial investments.

**Scheduled vs. Inducement Services**

Barge transport is inherently slower than rail, its chief competitor. This disadvantage is not as critical in the case of specialized COB since it is geared toward serving international trade and a liner shipping system based on weekly frequency and scheduled departures. If the COB is scheduled to arrive on time to meet the ship, the actual speed is of lesser importance. In fact, the relationship between the deep-sea ship and the barge becomes similar to that of mother – feeder, a common arrangement in liner shipping. For example, in the case of the New Orleans / Memphis service, a specialized COB could complete a roundtrip within a week, providing for a fixed day of the week schedule.

Scheduled services can only be established with specialized COB whereby the boat remains permanently attached to the tow and the tow follows a fixed route. Transit times in general COB are much less reliable since container barges have to wait for general tows, which are not always available. Likewise, general tows serve other en route ports and cargoes.

### 3.2.4 Inland Terminals

**General COB**

Handling containers at a river terminal require, at the minimum, a mooring structure to secure a single barge (200 ft) and a dock to support a shore-based crane. This crane should have the capacity to lift full 40-ft marine container (30 ton) reaching the entire width of a standard hopper (35 ft). The crane could either be a crawler crane (e.g., the 250-ton American Crane), a common machine in these terminals, or a heavy truck crane with outriggers. In the most basic operation, the loading / unloading can be performed directly to / from trucks staged on the dock. Due to water-stage variations, a floating dock is more suitable then a fixed one. The dock and crane are not dedicated to containers and can serve other cargoes as well, by using the same cranes with different attachments such as clam shell for bulk cargo, etc. **Figure 101** illustrates the barge loading at a general COB port in Memphis' Fullen Dock.

**Figure 101: Barge Loading at General COB Port (Memphis' Fullen Dock)**

The barge handling productivity in the basic port system described above is around 10 – 15 moves/hour. A fully-loaded 72-TEU hopper barge has about 40 boxes; assuming a 75 % / 25 % split between 20 and 40-ft boxes, the discharge could take 4 – 5 hours. If the same barge is also re-loaded, the entire unloading / loading process can be completed within 1 shift of 8 hours.

In addition to the dock, there is a need for a storage area for containers (container yard) and a toploader to load / unload trucks and move boxes around. The container yard should desirably be located close to the dock but not necessarily immediately adjacent to it. Toploaders do not require paved areas and can work on gravel.

There is also a need for a rudimentary gate, mainly for security purposes. There is no need however for a freight gate or Customs since the inland terminal only handle boxes, all of which are Customs cleared.

### Specialized COB

The main difference between general and specialized COB inland terminals is in the dock, especially in the equipment used for barge handling. A specialized dock should be the length of a barge (at least), allowing dock-based equipment access to the entire barge without moving the barge. There are several options for box handling equipment. If the specialized barge used is a deck barge similar in dimensions to a standard hopper, a

special reachstacker with negative lift can be used, eliminating the need for cranes. The advantage of a reachstacker over a crane is much better control (no dangling cables) and higher productivity. Another advantage is the ability to also use the reachstacker for yard handling of trucks when not serving barges. **Figure 102** illustrates the barge loading at a specialized COB port in Baton Rouge, using a specialized reachstacker.

**Figure 102: Specialized Reachstacker at Specialized COB Port in Baton Rouge, Louisiana**

The reachstacker cannot handle larger deck barges. One option for handling these barges is to use specially designed gantry cranes, similar to those used in Waterway terminals for handling steel. Another possibility is to use a "pass-pass" system based on 2 toploaders, one staged on the barge and the other on the dock. This system is common for coastal barges (e.g., Puerto Rico and Alaskan trades). Finally there is the European port system based on a single wide-gauge gantry crane that straddles over the entire terminal and serves both the dock and the container yard behind it.

There is not much difference between common and specialized terminals in terms of their yard and gate arrangement. There is a possibility, especially if a mother / feeder system is developed on the Waterway, that the inland terminal performs part of the activities presently performed at the deep-sea terminal, such as storage of boxes, Customs clearing, stuffing / destuffing, warehousing, box cleaning and repair. The terminal also could serve as an inland depot for shipping lines. These services were in fact provided by the barge terminal in Baton Rouge.

The investment in specialized terminals is considerably higher than in a general one. However, because of the higher handling productivity of barges, the overall handling cost may be similar and even lower. Higher handling productivity also would result in shorter barge stay at the terminal and the respective savings in barge cost.

**COB Systems' Cost and Performance**

The two major differences between general and specialized COBs are:

- A specialized system requires much higher investments in vessels and terminals and therefore requires much larger traffic volume to amortize these investments; and

- A specialized system has a much higher utilization of equipment and provides a much higher level of service in terms of transit time, frequency and, especially reliability.

Assuming sufficient volume is available, it appears that the specialized COB is more cost effective than the general one. The 1987 study by the National Ports and Waterways Institute mentioned at the outset of this report also reached similar conclusions. More important, perhaps, is that the higher level of service of the specialized COB would allow it to compete on a broader segment of the market and attract a larger volume of traffic.

**Development of Specialized COB and Specialized Intermodal Rail Development**

The example of transformation of specialized intermodal rail transportation of containers illustrates the importance of specialized COB. Initially, containers were handled by general, 50 and 60-ft flatcars with capacities of 2 TEU. These cars moved on general freight trains and through a lengthy process of classification in special "hump" yards, where trains were broken and rebuilt according to their destinations. The level of service of this rail system was poor and its market share reflected it. The breakthrough in intermodal rail was accomplished through comprehensive specialization. First, the size of cars was modified, beginning with the introduction of the 4-TEU, 89-ft flatcar and then with the 10-TEU, 300-ft articulated 5-platform well car double-stacked boxes. Second, unit-trains, or trains dedicated to containers by-passing classification yards were introduced, along with special intermodal yards to load / unload them. The result is that presently almost all the long haul transport of containers in the US is handled by rail.

### 3.2.5 Direct Transfer at Deep-Sea Ports

There is not much difference in the handling systems of general and specialized COB in deep-sea ports. The only difference, already mentioned above, is that some of the deep-sea activities can be shifted to the COB inland specialized terminal, where land and labor are considerably cheaper.

An interesting option, mainly for specialized COB systems, is using direct ship-to-barge transfers at the deep-sea port. In the most effective direct transfer system, the barge is staged alongside an ocean-going ship and the ship-to-shore gantry crane moves boxes between the two. This transfer, also called midstream, is common in handling steel,

cotton and project cargoes. It is also understood that it has been performed on several occasions for containers in New Orleans. The advantages of direct transfer relative to ship-to-rail transfer are: (a) Saving the cost of terminal handling to and from the stack; (b) Saving drayage and gate crossing; and (c) Saving of terminal space. Likewise, the direct transfer takes much less time than rail loading at an adjacent intermodal yard. The main disadvantage is that the direct transfer to/from barges is more operationally difficult and requires a special stowage plan of the deep-sea ship. The transfer is viable only in case the deep-sea ship has a large number of boxes destined to / from the same barge. It is also geared more towards specialized COB due to the need to match ship and barge timing, which requires a reliable barge service schedule.

## *3.3 Present COB and Rail Competition*

### 3.3.1 Osprey Experience

**Past and Present COB Services**

There is only one active COB on the Waterway, provided by Osprey Line. Osprey is owned by Kirby Corporation (2/3), a major barge line specializing in liquid bulk, and Cooper T. Smith (1/3), a major terminal operator. Osprey maintains only one weekly service between New Orleans and Memphis. The service is scheduled to leave Memphis on Wednesday, arriving the next Thursday in New Orleans, which means a transit time of about 7 – 8 days southbound and probably 1 – 2 days more northbound.

In addition, the line provides COB services on inducement to Chicago and Cincinnati. Another COB service, between Baton Rouge, New Orleans, and Houston was terminated earlier this year. It should be noted that for this service, the Port of Baton Rouge invested $3.6 million in providing a specialized terminal and equipment that are currently unutilized.

The line also is involved in COB along the Gulf of Mexico, provided by an ocean going barge, between Houston, Lake Charles, and New Orleans. Another service, between Tampa, New Orleans, and Houston, provided by an ocean-going ship was recently terminated.

According to media publications, Osprey handled a total of 22,970 TEU in 2003, 23,901 TEU in 2004 and 41,297 TEU in 2005. No statistics on its expected 2006 traffic volume are available. Likewise, the breakdown between the ocean-going and the Waterway services is not known. From discussions with the line and other sources it appears that the New Orleans / Memphis service involves 3 – 5 barges per week, which assuming an average of 50 TEU/barge, would amount to about 20,000 TEU/year (4 x 50 x 52 x 2). There is no data on the traffic volume between New Orleans and Chicago, but from discussions with the Osprey line, it appears that it is about half that of New Orleans / Memphis, or 5,000 TEU/year. The main cargo is steel. It is also understood that there is no meaningful movement of containers on other Waterway segments.

#### Barges, Ports and Operating Concept

Osprey owns about 30 barges, mostly standard hopper barges with a few single-skin tank barges converted to handling containers. The line does not have its own boats and tows but uses Kirby's tows. Kirby has 240 boats and 900 tank barges. The line usually calls on Napoleon Avenue terminal in New Orleans and Fullen Dock in Memphis. The Napoleon Avenue terminal is a modern deep-sea container terminal equipped with 4 gantry and 2 harbor mobile cranes. Osprey's barges are handled either by a gantry crane or, if unavailable, a mobile crane. Fullen Dock is a general terminal whereby barges are handled by a crawler crane.

As indicated by Osprey's type of vessels, tows, and port terminals, Osprey's operating concept is general COB.

#### Cargoes

Osprey only handles marine containers for deep-sea lines, mostly MSC, Hapag Lloyd and its subsidiary CP Ships, and Maersk, all of which call at New Orleans. Based on discussions with the industry, it appears that the main commodities shipped southbound are cotton, resins and chemicals; and northbound; lumber, structural steel and steel coil. A large number of the boxes handled by Osprey are empty (repositioning). It was also understood that there are wide fluctuations in the traffic volume due to seasonality.

Some other barge lines, among them Ingram and ACBL, have been involved in handling containers in recent years, but only on an irregular basis.

### 3.3.2 Competing Rail Service

#### Routes and Services

The main competition for COB on the Waterway is the intermodal rail, especially the rail provided by the CN railroad, using the IC line along the Mississippi River. **Figure 103** presents the CN route map, along with that of its alliance railroads, the KCS, TM, and TFM. In addition, CN has a rail barge between New Orleans and Coatzacoalcos in Mexico. As seen in the map, the rail line is parallel to the Waterway, with connections to all the major cities along it, with a continuation to Montreal in Canada. It covers the same area as the Waterway COB.

**Figure 103: CN Rail Route Map**

The rail service has two advantages relative to COB: (a) Its route to Up-Waterway points is shorter by about 1/3 than the meandering Waterway route; and (b) Its speed is much greater. The result is much shorter transit times. **Table 74** presents the comparative distances and transit times of a general COB, a specialized COB, and intermodal rail. As seen in this figure, the transit times for the New Orleans / Memphis route are less than a day (next morning) for the rail vs. 5 - 7 days for general, and 2 - 3 days for specialized COB.

**Table 74: River Distances and Transit Times for General COB, Specialized COB and Intermodal Rail**

| | Distance (Miles) | | | Transit Time (Days) | | |
|---|---|---|---|---|---|---|
| | Water | Rail | Water / Rail | General COB | Specialized COB | Rail |
| Baton Rouge | 135 | 89 | 1.52 | | | |
| Memphis | 625 | 394 | 1.59 | 5 - 7 | 2 - 3 | 1 |
| St. Louis | 1,034 | 699 | 1.48 | 7 - 9 | 3 - 4 | 2 |
| Chicago | 1,358 | 921 | 1.47 | 10 - 12 | 5 - 6 | 3 |
| St. Paul | 1,694 | 1,273 | 1.33 | 20 - 30 | 14 - 16 | 4 |

Presently, CN has a daily train between New Orleans, Memphis and Chicago, with a connection to Montreal. The train typically consists of 75 double-stack platform with a total capacity of 300 TEU. The train handles both international and domestic boxes. Most of the international boxes in the New Orleans area are handled at an intermodal yard adjacent to Napoleon Avenue, with the rest at the intermodal yard in the Harahan area along with domestic boxes. No data on overall traffic volume was provided by the CN, partially because the region is still recovering from Hurricane Katrina. Still, based on discussion with the CN and the Port of New Orleans, it is estimated that the traffic volume of international containers is about 150 TEU/day (90 boxes) each way or about a total of 100,000 TEU/year.

### General COB Costs

No information is available on either Osprey or CN rates, except for general statements as shown below. The only information publicly available is on barge towing rates ($/ton), which is monitored by the USDA for grain exports in standard hoppers. **Table 75** on the following page presents a sample of the rates charged for towing a loaded hopper barge between New Orleans and Waterway points. The rates, which are published in $/ton, are converted first into $/barge-load by multiplying them by 1,500 tons, which is typical barge capacity. The resulting towing rates of full barges were checked against industry estimates and found to be realistic. Finally, the barge rates are converted into equivalent container rates in $/FEU, since it is understood that most of the containers transported to Waterway points by rail or barge are 40-ft. As seen in this figure, the calculated cost between New Orleans and Memphis by general COB is $625/FEU. Between New Orleans and Chicago the cost is $1,075/FEU. It should be noted that these costs do not include general administration expenses (overhead). Handling containers, unlike bulk cargo, involves dealing with multiple cargo units and shippers and generating extensive documentation. No cost estimate is available for overhead expenses but, based on a National Ports and Waterways 1987 study it seems that it would range 20 – 40%, depending on traffic volumes.

**Table 75: General COB Towing Costs**

| From | To | Rates | | Linehual | Port Cost | Total | Time |
|---|---|---|---|---|---|---|---|
| | | $/Ton | $/Barge | $/FEU | $/FEU | $/FEU | Days |
| New Orleans | Memphis | 9 | 13,500 | 450 | 175 | 625 | 5 - 7 |
| New Orleans | St Louis | 12 | 18,000 | 600 | 175 | 775 | 7 - 9 |
| New Orleans | Chicago | 18 | 27,000 | 900 | 175 | 1,075 | 10 - 12 |
| New Orleans | St Paul | 28 | 42,000 | 1,400 | 175 | 1,575 | 20 - 30 |

Conversion from barge to box rate based on 30 40-ft boxes/barge

Source: USDA grain rate sampling and industry interviews October 2006

As noted above, there are no published rates available for either COB or rail. Nevertheless, during the interviews with Osprey, CN, shipping lines and the freight forwarder, it became evident that the rail rates are essentially similar to the barge costs as calculated above. The following section attempts to explain how COB, which has such inferior transit times, can charge similar rates to the rail, and still capture about 15% of the market.

### 3.3.3 Advantages of COB Relative to the Rail

#### Large Capacity for Large Shipments

From discussion with COB users it became evident that the main advantage of COB stems from its ability to provide relatively high capacity. COB employs standard barges that can be leased from the general market in response to seasonal demand. The rail service is based on assignment of a fixed number of cars for the daily train and, therefore, is geared to providing a fixed daily capacity with only small fluctuations. A case in point is the shipment of a full 15-barge tow from Memphis to New Orleans with 375 containers of cotton exports in August 2005. Sending such a large number of boxes by rail would require 5 full daily trains, which, in reality, would take much longer since the rail cannot dedicate the entire capacity to cotton. Another example is lumber imports that occasionally amount to a shipment of 100 boxes brought in by one deep-sea ship. Spreading the shipment over 5 – 10 days means that consignees will be charged for demurrage (for storage space) by the container terminal operator and detention (for keeping the boxes) by the line. Likewise, sending the entire shipment of boxes together in one tow of barges requires one set of papers while for rail each shipment requires separate documentation.

#### Direct Ship-to-Barge Transfer

A major advantage of COB stems from potential savings in handling cost at deep-sea terminals. Since barge handling is done through the dock, the transfer between deep-sea ship and barge does not require gate crossing, drayage, etc. Substantial savings are

generated especially in the case of direct transfer between deep-sea ship and barges using the same crane cycle. In comparison, the transfer between deep-sea ship and rail involves intermediate storage at the terminal yard and, later on, drayage to the intermodal yard. If this yard is not on-dock, there is a need to cross the terminal gate, drop the box at the storage stack of the intermodal terminal, etc.

**Inland Terminals Substitute Deep-Sea Terminals**

Another potential terminal-related savings may arise depending on whether or not the inland terminal provides cargo processing and other value-added services such as storage, stuffing/de-stuffing, inspection, and Custom clearance of boxes at a fraction of the cost charged by deep-sea terminals. Moreover, shipping lines usually agree to recognize dock receipts of inland terminal as a basis to issuing Bills of Ladings, allowing shippers to immediately process payments.

**Overweight and Hazardous Cargo**

Double stack railcars are not designed to handle containers filled to their maximum weight. For example, they cannot carry 4 24-ton 20-ft boxes. This is not the case with barges, where only part of the DWT capacity is utilized (see Section II.3.1). Also, rail services that may cross urban areas sometimes do not accept hazardous cargoes.

**Complementary, Niche-Based System**

Based on the above observations, it seems that the present COB system on the Waterway is complementary to the rail system; it fills a few gaps where the rail is either ineffective or, perhaps, finds it unprofitable to compete. Hence, the present COB competes with the rail on a narrow segment of the market, which includes the seasonal, lowest value, and stock oriented cargoes. Broadening the market segment for which COB could compete with the rail mandates transforming the present general COB system into a specialized one.

## *3.4 International Trades, Hinterland Regions, and COB Development*

### 3.4.1 International Trades

Present and future COBs are geared toward serving international trades, mainly imports and exports handled by the Gulf Coast deep-sea ports, referred to hereafter as the Gulf Coast gateway and of/from the Waterway hinterland. Presently, the Port of New Orleans is the only port that handles a significant number of containers to/from this hinterland. In the past, the Port of Houston was involved with containers generated on the Waterway and may be involved again in the future—but probably to a much lesser extent because it is located further away from the Waterway ports. For example, the rail distance between

Houston and Memphis is 616 mile vs. 394 miles for New Orleans. Likewise, Houston's water and rail connections are much inferior to New Orleans.

Generally, the Port of New Orleans is involved in 3 major international trades:

- South and Central America;
- North Europe and the Mediterranean; and
- Asia, mainly the Far East.

Presently, New Orleans' involvement with the Asian trade is limited, since there is no direct service from Asia calling at this port. This explains the relatively low volume of traffic handled by the Port of New Orleans, which is projected to reach about 300,000 TEU in 2006, or less than 0.7% of the projected US total traffic of about 45 million TEU.

The small volume that this port handles is either by non-containerized services, or by feeder services based either in Houston or Freeport, Bahamas. For example, it is understood that the cotton exports from Memphis were shipped first to Freeport, Bahamas and from there, through the Panama Canal to China, a very long and circuitous route. Trade with Asia, however, is the largest US trade source, accounting for more than 60% of its total trade and is by far larger than US trade with Latin America and Europe combined. It also the largest trade worldwide.

### 3.4.2 Hinterland Regions

For the purpose of this study, the relevant Waterway segments and the nearby hinterland can be roughly divided into 3 ranges according to their proximity to the gateway ports in the Gulf Coast:

- ***Close Range*** – The southernmost part of the Waterway, which mainly includes Memphis;
- ***Mid Range*** – The middle part, which mainly includes St Louis and Chicago; and
- ***Remote Range*** – The northernmost part, beyond St Louis, which mainly includes Minneapolis/St Paul.

**Figure 104** illustrates the various Waterway hinterland ranges. For convenience of analysis, the above ranges will also be referred to according to the major city in the range. For example, the Close Range will be referred to as Memphis.

**Figure 104: Waterway Hinterland Regions**

### 3.4.3 Trade Flows and Coastal Gateways

Theoretically, there are 9 trade flows based on the 3 international trades and the 3 Waterway ranges, all of which can be served by the Waterway COB and the intermodal rail parallel to the Waterway. All these trade flows use New Orleans as their gateway.

These trade flows can also be served through other gateway ports on the East and West Coasts of the US using the intermodal rail services. **Figure 105** illustrates some of the optional routings using East and West Coast gateways to Waterway ranges. As seen in this figure, because of its proximity, the Close Range traffic is "captive" to the Gulf Coast gateway. This is presently the case with the Europe and South/Central America trades with Memphis; almost all use the Port of New Orleans. Likewise, it is reasonable to assume that once a direct Asia service is calling New Orleans, most of Asia's trade with Memphis will be served through New Orleans either by COB or the rail.

**Figure 105: Optional Routings of Up River Ranges**

The situation with the Mid Range—especially with Chicago—is different because this range is further away from the Gulf Coast. **Table 76** on the following page presents a comparison of costs and transit times of 2 alternative routings for Asian imports, via New Orleans and via Tacoma, WA. As seen in this figure, the difference in the ocean freight between using a direct transpacific and the much-longer All Water service is about $800/FEU, while the cost difference in the inland segments is only $125/FEU. Hence, presently, the Tacoma route has a significant advantage over the New Orleans, both in cost and in time. This situation may radically change in the future in light of: (a) Congestion on the West Coast and especially their connecting rail services; and (b) Reduction in the All Water Rate following the expansion of the Panama Canal.

However, a shift of the Mid Range trade with Europe toward a route that includes New Orleans and the Waterway is unlikely. The East Coast ports are much closer to Europe than New Orleans while the land distances are similar. Future congestion concerns on the East Coast, similar to those on the West Coast ports, are not an issue on the near future as trade is allocated among many more ports along the East Coast and there is still room for expansion in the Mid- and South-Atlantic ports. Also, distribution centers on the East Coast are located close to the ports and drayage is more localized; logistics, then, have a regional and not a national scope, and the impact of incresing trade is more moderate.

**Table 76: Comparison of Rates/Transit Times for Alternative Routings of Asian Imports to Chicago**

***Intermodal West Coast***

| From | To | Mode | Cost | Time |
|---|---|---|---|---|
| | | | $/FEU | Days |
| Far East | PNW | Ocean | 1,800 | 12 |
| PNW | Chicago | Rail | 1,200 | 3 |
| Total | | | 3,000 | 15 |

***All Water Gulf Coast***

| | | | | |
|---|---|---|---|---|
| Far East | New Orleans | Ocean | 2,600 | 20 |
| New Orleans | Chicago | Barge | 1,075 | 11 |
| Total | | | 3,675 | 31 |

### 3.4.4 All Water Services to the Gulf Coast serving Chicago

Most of the Asia/US trade is currently routed through US West Coast ports. About 30% of the trade is handled by the so-called All Water services which are routed through the Panama Canal mostly calling the US East Coast. Only one is calling the Gulf Coast (Houston) and even this service has limited capacity, since it employs ships of about 3,000 TEU. In comparison, the common ship size in services calling at the West Coast is about 7,500 TEU (second generation of post-Panamax).

The main incentive for the introduction of an additional All Water service to the Gulf Coast, and for them to call New Orleans, would be the potential to serve the Mid Range, especially Chicago, which is much larger than Memphis. It seems, therefore, that the future of the Waterway COB (and rail) depends on the prospects of the New Orleans gateway to divert the Asian trade with Chicago from its current route through the West Coast ports.

### 3.4.5 New Orleans Services and Panama Canal Expansion

The All Water services are routed though the Panama Canal. Due to a recent surge in demand, the Canal locks have been operating at or close to full capacity. Hence, no significant increase in All Water services can be expected in the near future. Moreover, it is reasonable to assume that if the Canal allows for the addition of a few services, lines will prefer directing them to the East Coast where the demand is much greater. A major expansion of the Canal is planned for 2015. The expanded Canal will have the capability to handle ships of about 12,500 TEU (vs. 5,000 TEU presently) along with the capacity of doubling the trade flowing through it (TEU/year). The inauguration of the expanded Canal could trigger a surge in All Water services, some of which are likely to call directly at New Orleans.

Still, even if the Panama Canal expansion is delayed, Asian services may call directly at New Orleans following an alternative route through the Suez Canal. Moreover, these services could divert large volumes of Asian traffic to the East Coast ports, which may become congested much like the West Coast ports at the present.

### 3.4.6 Potential Imports and Near-River Distribution Centers

COB services, especially the general COB service, are much slower than the rail. Naturally, COB is geared toward the imports of cargoes which are of low value, usually lumber and construction materials intended to replenish stocks and therefore are time insensitive. For example, yard furniture, one of the largest imports from China, is a seasonal product and therefore, presumably, time sensitive. However, because it is also of relatively low value, cargo is manufactured and shipped to the US year-round to be accumulated at Distribution Centers (DC), from which it is shipped to stores in late spring. This product, which is also high volume, would fit well with COB transport system.

Most of the US DC's for consumers' goods are geared toward Asian imports. Hence, until now, most of them have been located near ocean ports and consumption centers such as Los Angeles, CA; Savannah, GA; Houston, TX; and others. Recently, there has been a trend to locate DC's in the Midwest, near the main road and rail intersections such as Memphis; St. Louis; and Chicago. In fact, Memphis already has one of the largest concentrations of DC's in the country, with several hundred millions of square feet of storage, some of them are located adjacent to the Waterway. Memphis also is the only Waterway port served by COB on a regular basis. However, Memphis' COB is rarely used for imported merchandise, primarily because the general COB level of service is inadequate for this cargo. As noted above, a specialized COB would have reliable schedules that could be coordinated with those of deep-sea services, providing a level of service similar to that of the rail, but with larger capacity and lower cost. The availability of a specialized COB could also provide incentive to locate DC's near the inland terminals, similar to the arrangement in East Coast ports.

### 3.4.7 Potential Exports

#### Specialty Grain

The traditional exports generated in the Waterway hinterland is agricultural commodities, mostly grain. The most common transport system of this voluminous and relatively low value cargo is bulk. The bulk transport and logistic system includes farm elevators, hopper railcars and unit-trains, upriver elevators, hopper barges, deep-sea elevators and dry-bulk ships. Recently, an alternative container transport system has been introduced for grain where boxes are stuffed with bulk grain at the farm elevator, from which they

are trucked to an intermodal yard and onward to a double-stack train to a deep-sea container terminal.

The introduction of the container transport system for grain has been propelled by two factors:

- The imbalance of US foreign trade creating a need to reposition empty boxes to foreign markets, mainly in Asia; and
- The specialization in grain production and the related requirement to segregate the specialized grain during the transportation process.

In the beginning, the specialization trend involved either the development of new varieties of grains, or development of grains with exact content specifications e.g., soybean with high protein or corn with high oil or lysine. A more recent specialization has emerged with the introduction of Genetically Modified Organism (GMO) grain, organic grain and "pure" grain, or grain which does not contain GMO. The latter is often defined as Identity Preserved Grain (IPG). The containerized transport system allows preservation of the specialty grain, which is particularly important for the non-GMO grain. When bulk containers are used, the inside of the boxes is covered with a liner that avoids contamination from a previous grain load. Sometimes the specialty grain is first put in smaller bags and only then into a container.

Segregation and preservation of specialty grains is impossible in bulk transport system. In fact, this system involves the commingling of grains from various sources, including blending to create grains of uniform average quality to suit an elaborate system of grading.

The container transport system generally is substantially more expensive than the bulk system. However, due to the growing demand for IPG, especially in Japan, these grains command a premium price of 400% over regular "commodity" type grain and can absorb the higher transport cost. Even more important is the cross subsidy provided by the need to reposition empty boxes that have no other cargo to carry on the way back to Asia. Indeed, industry interviews indicate that shipping lines charge between $700 – 1,200 per FEU for the entire trip from a Midwest intermodal yard to an Asian port. It should be noted that the same trip, but in the opposite direction, costs $3,000 per FEU. The containerized system has additional advantages over the bulk system including: (a) Allowing smaller shipments to smaller buyers; (b) Much shorter transit times; and (c) Direct contracting between farmers and foreign buyers. It should be noted that containerized shipping is not limited to specialty grains but also may include regular grain.[84]

The container shipping of grain has been on the rise in recent years. According to recent USDA reports, monthly grain shipments to Asia were up 44% in September 2006 from a

[84] A point in case is reported by the Marketing Services of Illinois State, for exporting a 1,000 tons/month by container of soybean #1 to Manila.

year earlier and 110% above the three-year average. During 2005, 5% of grain exports to Asia and 4% of all grain exports went in containers, up from 3% and 2%, respectively. The monthly average during the first 9 months of 2006 is about 15,000 TEU.

### Distilled Dried Grain (DDG)

The rapid growth of the corn-made ethanol industry has resulted in large supplies of a co-product, the Distilled Dried Grain (DDG). DDG is obtained after the removal of ethyl alcohol by distillation following the yeast fermentation of a grain or a grain mixture, by separating the resultant coarse grain faction of the whole stillage and drying it. The production of ethanol, a substitute for gasoline, has been on the rise in several Midwestern states along the Upper Mississippi Waterway. Presently, most of the DDG is used there locally as competitively priced feed ingredient for livestock and poultry diets. However, as its volume rises, the surplus is likely to be used in other states and, eventually, also for exports. The export volumes, at least initially, are not expected to warrant using a bulk handling system. Also, DDG tends to be sticky and not free flowing. Hence, despite the higher cost of transport, it is reasonable to expect the exports to be containerized.

Theoretically, both IPG and DDG may use COB, especially specialized COB that can be coordinated with deep-sea shipping services. A point in case is Minnesota, according to publications and interviews; it has been promoting the export of both IPG and DDG. A recent project, announced to facilitate the transport of these products in containers, is the development of an intermodal yard in Montevideo, 130 miles west of St. Paul. The plan is to use a new rail technology, the Rail Runner to move the boxes between Montevideo and St. Paul. Rail Runner is bi-modal system suitable for short distance, which saves on the need to lift boxes in order to transfer them from road chassis to railcars. From St. Paul the boxes will be moved by CN on regular intermodal trains either to Montreal or Vancouver, BC. If a regular COB service was available in St. Paul, some of these containers could be moving downriver.

### Repositioning of Empty Containers

In spite of the substantial increase in using containers for grain exports, a large portion of "exports" from the Midwest is empty boxes. As noted above, the Asia / US trade has high directional imbalance, currently, the imports / exports ratio is about 3:1. This creates an accumulation of empty boxes that should be shipped back to Asia.

Specialty grain, DDG, and empty boxes are all suited for COB, since all move in relatively large quantities and are time insensitive. However, as was the case with the COB in the Lower River, the COB faces competition from rail services either along the River or using alternative routes to the Pacific Northwest ports. In the case of grain and DDG, the rail has the additional advantage of being available at intermodal yard located close to the grain generation areas, some of which are located far away from the River.

### 3.4.8 COB on the Remote Range of the Upper Mississippi Waterway

**Route-Specific Obstacles**

Among the three Waterway ranges, the Remote Range, the segment beyond St. Louis, has several specific problems, including:

- ***Winter Freeze*** – The system is fully or partially closed for navigation during 4 - 5 months;
- ***Locks*** – The system has many locks, a few of them are plagued with seasonal congestion and breakdowns; and
- ***Limited Traffic Generation*** – The area has relatively small concentration of population and industries.

The following is a list of the problems and its expected impact on COB.

The unavailability of the Waterway services during winter months will adversely impact both users and providers of COB. The impact on potential users mainly relates to importers since, unlike agricultural commodities, imports of commodities are transported year-round. Hence, importers using COB will have to find an alternative transportation system for winter months, which may be both inconvenient and costly.

The problem facing providers of COB is even more difficult; especially in specialized COB, the system requires large fixed costs because investments in terminals and barges, and the requirement to maintain permanent staff, all of which may be at least partially idle for almost 1/3 of the time, except, perhaps for barges that could find employment elsewhere. In any event, the lack of year-round employment would results in a substantial increase in the capital cost.

The Upper Mississippi River currently has 27 lock sites. Most locks were put in place in the 1940s and are based on 600-foot chambers requiring time-consuming "double-lockage". In addition, the aging locks suffer from breakdowns.

The result is long transit times and especially wide variations in these times. This is evident in **Table 75.** As quoted by the industry, transit times between New Orleans and St. Paul, general tows, taking into account port times and fleeting times, range between 20 and 30 days (!). The transit time may shorten and reliability may improve if priority is granted to containers at the locks. This is relevant only for specialized COB that does not use general tows. However, specialized COB based on relatively expensive and fast vessels would incur high costs due to the frequent time-consuming locking even if granted priority locking. Lock rehabilitation and new constructions will mitigate this problem.

**Limited Imports and Change in Traffic Direction**

The Remote Range is less populated and industrialized than the Mid Range. Hence, imports of consumer goods or raw materials, the main stay of any river-based COB system, are relatively small. Another, more recent phenomenon is due to an increase in corn-based ethanol production there has been a reduction in corn exports. As a result, recent northbound traffic—mainly salt and fertilizers—and southbound traffic—mainly corn—have been almost in balance. Hence, at this time, there is no surplus of empty barges in New Orleans heading northbound that can be used for containers in a general COB.

Because of its specific problems, it seems reasonable to assume that no meaningful general or specialized COB is likely to develop in the Remote Range of the Upper Mississippi Waterway. A more likely development would be the use of road transport from this region to a downriver, unrestricted port, for example St. Louis, and from there using COB.

## *3.5 Future Developments of COB on the Upper Mississippi Waterway*

### 3.5.1 Forecasting Methodology

**External and Internal Competition**

The forecasting methodology, as defined at the outset of this report, involves the specification of two scenarios, No Change and Radical Change. The specification, in turn, should reflect the peculiar competitive setting of COB facing 2 levels of competition:

- ***Internal*** – From the intermodal rail service along the same corridor connecting the Gulf Coast gateway and the Close and Mid Waterway Ranges; and

- ***External*** – From the intermodal rail services using other gateways and corridors to reach the same Waterway ranges.

The main port in Gulf Coast gateway that has the connections to these Waterway Ranges is New Orleans, and the main competition is on handling Asian trade to/from the Mid River range, mostly Chicago and to a lesser extent St. Louis.

The forecasting process itself is based on assumptions reflecting likely developments in three main factors:

(a) New Orleans international traffic (TEU/year), especially as affected by the expansion of Panama Canal;

(b) The share of this traffic flowing to / from Close and Mid Waterway ranges;

(c) The share of COB in these ranges.

The following discussion provides specific assumptions underlying each scenario and the value assigned to the factors that quantify it, beginning with what is considered the most critical factor, New Orleans' international trade and related traffic.

### 3.5.2 Assumptions regarding Port of New Orleans' Traffic and COB Market Share

The international trade through the Gulf Coast ports mainly relates to the Port of New Orleans, and to a lesser extent Houston and, in the long term, Mobile and other ports. Gulf Ports handle 3 major international trades, with Europe, Latin America, and Asia. No major change is expected in the trades with Europe and Latin America and the respective shipping line services that handle these trades. The major change, if any, is expected to take place in the trade with Asia, especially with regards to the introduction of direct services. These changes are expected to be triggered by the expansion of Panama Canal in about 10 years, in 2015. Accordingly, for convenience, the forecasting horizon of 50 years is divided into 3 periods: the near future 2005–2014, and long future 2015–2050.

**Near Future: 2005 – 2014**

In the No Change Scenario, Gulf Coast trade and the respective Port of New Orleans traffic are expected to retain their market share and therefore follow the growth of the total US foreign trade. There is a wide consensus that the latter is expected to grow at an average annual rate of about 5% during this period.[85]

In the Radical Change Scenario, the growth rate of New Orleans traffic is assumed higher than that of the US, at the level of 6%. The higher growth rate reflects the assumption of additional direct and indirect Asian services calling the Gulf, most of which currently follow the Suez route. The introduction of additional Asian services would be driven by growing congestion on the West Coast ports, especially in their intermodal connections, resulting in considerable delays and cost escalations in the intermodal route to the Midwest.[86] The additional Asian services geared toward handling the Midwest cargoes will also result in higher share of the Mid Range traffic.

Another change in this scenario would be that, in response to the growing demand for Waterway traffic, the present general COB will be transformed into specialized COB. The specialized COB will develop close relationships with deep-sea lines and terminals to coordinate schedules and, especially, establish direct ship-to-barge transfer, resulting

[85] See, for example, Ocean Shipping Consultants' recent press release.
[86] See, for example, "Not in my back yard", *The Journal of Commerce*, November 13, 2006.

in considerable reductions in overall barging costs and increase its market share relative to the parallel rail service.

**Long Future: 2015 – 2025 and 2026 – 2050**

The recently-approved Panama Canal expansion project is expected to be completed in 2015. In the No Change Scenario this expansion is assumed to have a limited impact on the Port of New Orleans' traffic. The limited impact is attributed to high Panama tolls required to amortize the huge investments in the expansion project or, perhaps, due to the development of intermodal alternatives to the Canal and existing US West Coast ports. Accordingly, the Port of New Orleans will maintain its market share unchanged and, therefore, continue to grow at the same pace as overall US foreign trade. This prediction is reflected by assigning the value 1.0 to the Panama Canal impact multiplier.

In the Radical Change Scenario, higher tolls following the inauguration of the expanded Panama Canal are expected to only partially offset the savings in shipping costs stemming from the ability to employ larger and more economical ships. In parallel, existing intermodal routes through the West Coast are expected to become even more congested and the new Mexican and Canadian routes prove cost prohibitive due to the huge investments required. The result is a surge in Asian trade and shipping services to the Gulf Coast and New Orleans, expressed by assigning a value of 1.2 to the Panama Canal impact multiplier. The assessment and related values assigned to the multiplier are based on the study of the impact of the Panama Canal expansion.[87]

Accordingly, in the No Change Scenario, the Port of New Orleans is expected to retain its market share, with its growth rate following that of the overall US foreign trade. The latter, in turn, is expected to grow in this period at an average annual growth of about 4% during the first 10 years, slowing to 3% during the rest of the period. None of the forecasts of the US international containerized trade reviewed for this study extend beyond 2020. However, the long-term slow down in the growth rate assumed here is in line with the observed worldwide trend that as a national economy becomes more mature, the share of foreign trade in goods and commodities in its economic activity decline. After 2015, the two scenarios are assumed to continue developing in parallel.

One more possibility should be considered in the No Change Scenario, existing COB will further decline or even entirely disappear. The assumption, in this case, is that once the present COB terminates its remaining Waterway services no other COB operation will be developed. As discussed above, it appears that the present general COB on the Waterway has limited cost advantage over the competing rail service along the same corridor, while its level of service, reflected in transit times, frequency, and reliability are much inferior. It seems that the present COB keeps on simply because the CN is not willing to commit more capacity to its daily service – which may happen in the near future. Future improvements in the ship-to-rail transfer process, now under consideration, could offset

[87] "Study of the Panama Canal Impact on the Liner Container Shipping Industry and the Transshipment Activity in the Republic of Panama", The Louis Berger Group, 2003.

the limited cost advantage of barges over rail triggering a decision to quit COB operations.

The assumption about no new COB following termination of the present stems from the observation that the present system has been the most successful COB thus far, including almost 3 years of operations. Its success can be attributed to the fact that it was developed by a relative large and committed operator, taking advantage of its non-container operations, including low-cost tows, and with the generous support of established River ports. In light of a failure of the present general COB, it may be unlikely that a specialized COB, which requires large investments, will be introduced.

### 3.5.3 Example of COB Development

**Table 77** presents a summary of the assumptions underlying the High and Low Scenarios as discussed above. **Table 78** presents the assumptions related to the present Port of New Orleans traffic, the Waterway share and its division between rail and COB, which provide the starting point for the forecasting effort. **Table 79** presents the results of the No Change and Radical Change Scenarios.

As seen in **Table 77**, in 2015, following the expected inauguration of the Panama Canal, The Port of New Orleans traffic in the Radical Change is assumed to reach about 600,000 TEU, or twice the present traffic. In the No Change, the traffic will grow to about 450,000 TEU or 1.5 times the present. The Up River Share, the traffic originated / terminates from / to the Close and Mid River Ranges, is expected to increase from the existing 0.4 of the total New Orleans traffic, which is also the assumption in No Change Scenario, to 0.5 in the Radical Change Scenario. In parallel, COB share of the Up River traffic in the Radical Change is expected to increase from the present 0.17 to 0.25, reflecting the transformation of the system from general to specialized. Accordingly, the total COB traffic in the Radical Change Scenario is expected to reach about 75,000 TEU in 2015 vs. 30,000 TEU for the No Change Scenario and the present 20,000 TEU.

**Table 77: Assumptions Underlying COB Scenarios**

| | | | 2006 - 2015 | | | | 2015 - 2025 | | | 2025 - 2050 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | International Trade and Shippin Services | COB System | Port Traffic Growth | Up River Share | COB Share | Panama Canal Multiplier | Port Traffic Growth | Up River Share | COB Share | Port Traffic Growth | Up River Share | COB Share |
| No Change | No or Little Asian Services. Most Traffic Remains South/Central America and Europe | General | 5% | 0.40 | 0.17 | 1.00 | 4% | 0.40 | 0.17 | 3% | 0.40 | 0.17 |
| Radical Change | Suez Asian Direct Services, followed, after the 2015 Canal Expansion, by a surge of All Water Asian Services | Specialized; Direct Ship-to-Barge Transfer | 6% | 0.50 | 0.25 | 1.20 | 4% | 0.50 | 0.25 | 3% | 0.50 | 0.25 |

The breakdown of the COB traffic by River Ranges is expected to change in both scenarios following the assumed introduction of service to St. Louis, with St. Louis used as a representative point for the Upper Mississippi segment below the locks. As seen in this figure, in line with the assumptions regarding diversion of Chicago traffic in the Radical Change, this River section, which relates to the Illinois River, is assigned a higher share of the COB traffic. Altogether, the COB traffic in these two Mid River segments, the focus of this analysis, is expected to reach in 2015:

- ***Radical Change Scenario*** – St Louis 11,000 TEU and Chicago 19,000 TEU; and
- ***No Change Scenario*** – St Louis 3,000 TEU and Chicago 6,000 TEU.

**Table 78: Port of New Orleans' Present Traffic and It's Division between Rail and COB**

| | |
|---|---|
| Port of New OrleansTraffic | 300,000 |
| Up-River Traffic | 120,000 |
| Up-River Share | 0.40 |
| Rail Traffic | 100,000 |
| COB Traffic | 20,000 |
| COB Share of Up-River | 0.17 |

| ***COB Breakdown*** | |
|---|---|
| Total COB | 20,000 |
| Memphis Share | 0.75 |
| Memphis Traffic | 15,000 |
| St Louis Share | - |
| St Louis Traffic | - |
| Chicago Share | 0.25 |
| Chicago Traffic | 5,000 |

All figures in TEU

***Memphis stands for Lower River Reach; St Louis and Chicago for Mid River Reach

At the end of the forecasting horizon, in 2050, in the Radical Scenario the entire River traffic is forecasted to reach 235,000 TEU of which St. Louis' share will be 35,000 TEU and Chicago's about 60,000 TEU. In the No Change Scenario, the expected 2050 figures are close to 100,000, 10,000, and 20,000 TEU, respectively.

**Table 79: COB Forecast for the No Change and Radical Change Scenarios**

| | 2006 | 2015 | | 2025 | | 2050 | |
|---|---|---|---|---|---|---|---|
| | | No Change | Radical Change | No Change | Radical Change | No Change | Radical Change |
| Base-Year Multiplier | 1.00 | 1.55 | 2.03 | 2.30 | 3.00 | 4.81 | 6.28 |
| Port of New Orleans | 300,000 | 465,398 | 608,212 | 688,903 | 900,303 | 1,442,411 | 1,885,034 |
| Up River Share of New Orelans | 0.40 | 0.40 | 0.50 | 0.40 | 0.50 | 0.40 | 0.50 |
| Up River Traffic | 120,000 | 186,159 | 304,106 | 275,561 | 450,151 | 576,964 | 942,517 |
| COB Share of Up River | 0.17 | 0.17 | 0.25 | 0.17 | 0.25 | 0.17 | 0.25 |
| Total COB | 20,000 | 31,647 | 76,027 | 46,845 | 112,538 | 98,084 | 235,629 |
| COB Breakdown | | | | | | | |
| Total COB | 20,000 | 31,647 | 76,027 | 46,845 | 112,538 | 98,084 | 235,629 |
| Memphis Share | 0.75 | 0.70 | 0.60 | 0.70 | 0.60 | 0.70 | 0.60 |
| Memphis Traffic | 15,000 | 22,153 | 45,616 | 32,792 | 67,523 | 68,659 | 141,378 |
| St Louis Share | - | 0.10 | 0.15 | 0.10 | 0.15 | 0.10 | 0.15 |
| St Louis Traffic | - | 3,165 | 11,404 | 4,685 | 16,881 | 9,808 | 35,344 |
| Chicago Share | 0.25 | 0.20 | 0.25 | 0.20 | 0.25 | 0.20 | 0.25 |
| Chicago Traffic | 5,000 | 6,329 | 19,007 | 9,369 | 28,134 | 19,617 | 58,907 |

All figures in TEU

Multipliers are the cummulative growth rates indicated in Figure 11.

### 3.5.4 European Experience

The European COB system, especially on the Rhine, was noted in this report for its success. Currently, the system handles about 2.3 million TEU with COB accounting for 40% of Rotterdam's traffic vs. only 10% for rail. The traffic presently handled by the European COB is about 10 times greater than that forecasted for the Mississippi River in 2050 in the Radical Scenario.

The differences between the Rhine and Mississippi Rivers' COB performance can be explained by the following:

- ***Much Larger Overall Traffic*** – The combined traffic handled by the 2 major Rhine ports, Rotterdam and Amsterdam, is projected to reach in 2006 close to 10 million TEU vs. 300,000 TEU for New Orleans;

- ***High Cost Rail Services*** – The rail system along the Rhine is nationalized and hence, involves high operating costs; the rail route is congested since it mainly used for passengers; and there are no arrangement to allow double-stack cars and mile-long trains; and

- ***Highly Specialized COB System*** – Following many years of development and large investments, the Rhine's COB is based on a large fleet of fast self-propelled ships calling at high-tech inland terminals; all services are scheduled with typical frequency of several departures per day.

Accordingly, it can be concluded that the European system is different in kind than that expected on the Mississippi system even following the Radical Changes.

## Agricultural Chemicals

Figure 1 and Figure 2 show the unconstrained waterway forecasts for Agricultural Chemicals with high and low forecast bands.

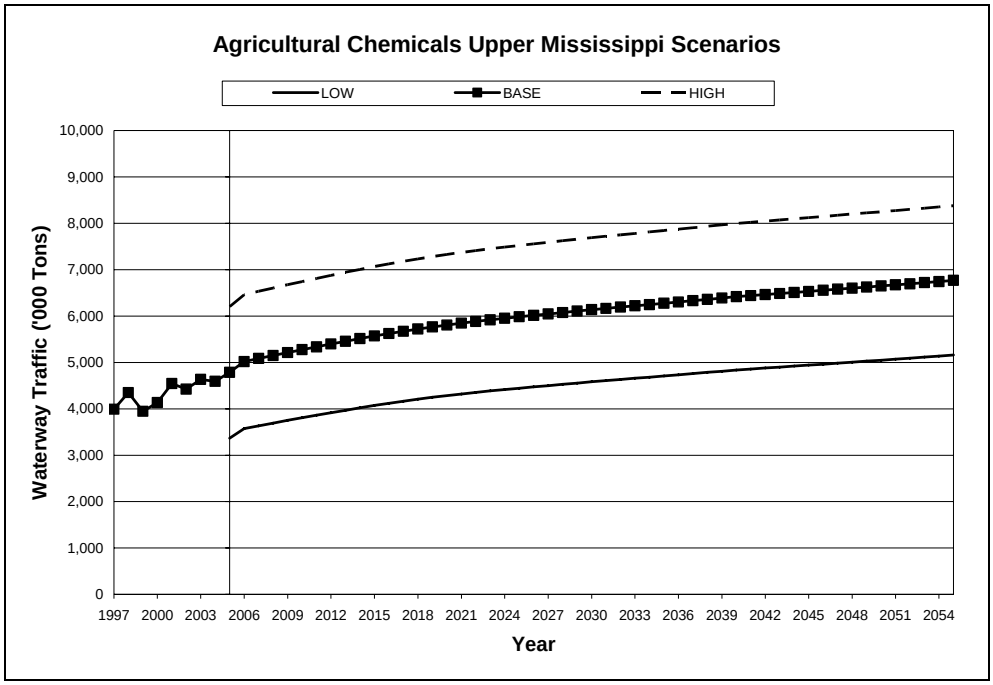



**Figure 1: Upper Mississippi Ag. Chem. Unconstrained Forecast with high and low forecast bands**

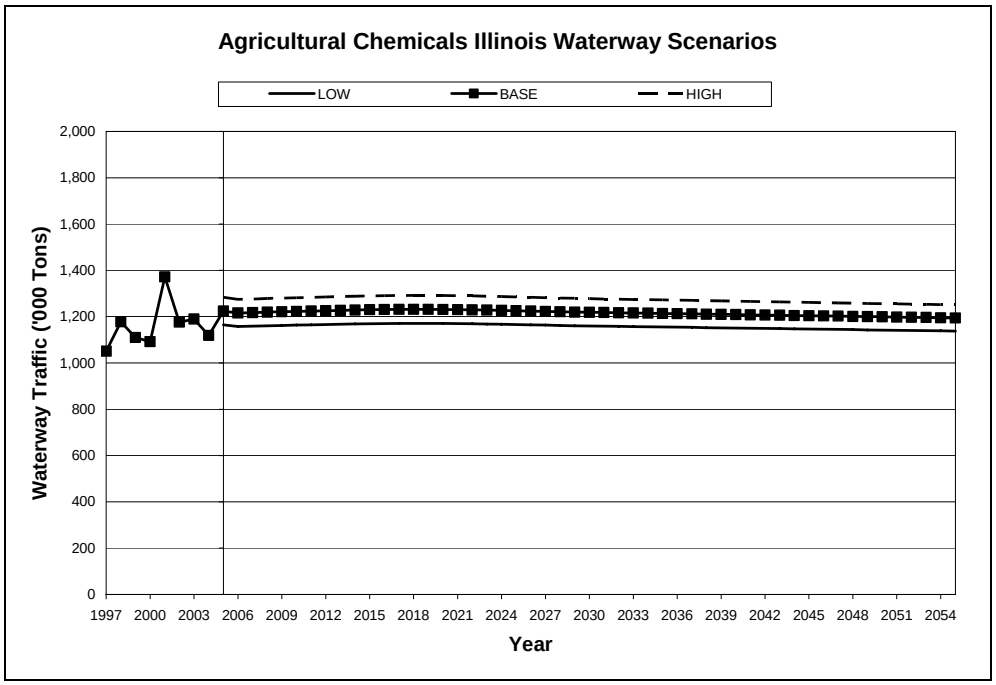



**Figure 2: Illinois Waterway Ag. Chem. Unconstrained Forecast with high and low forecast bands**

**Table 1: Agricultural Chemicals Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 3,993 | 3,993 | 3,993 | 1,051 | 1,051 | 1,051 |
| 1998 | 4,351 | 4,351 | 4,351 | 1,178 | 1,178 | 1,178 |
| 1999 | 3,947 | 3,947 | 3,947 | 1,110 | 1,110 | 1,110 |
| 2000 | 4,133 | 4,133 | 4,133 | 1,092 | 1,092 | 1,092 |
| 2001 | 4,544 | 4,544 | 4,544 | 1,372 | 1,372 | 1,372 |
| 2002 | 4,424 | 4,424 | 4,424 | 1,176 | 1,176 | 1,176 |
| 2003 | 4,634 | 4,634 | 4,634 | 1,190 | 1,190 | 1,190 |
| 2004 | 4,592 | 4,592 | 4,592 | 1,119 | 1,119 | 1,119 |
| 2005 | 3,366 | 4,786 | 6,205 | 1,165 | 1,224 | 1,284 |
| 2006 | 3,575 | 5,017 | 6,460 | 1,157 | 1,216 | 1,275 |
| 2007 | 3,635 | 5,084 | 6,533 | 1,159 | 1,218 | 1,277 |
| 2008 | 3,694 | 5,149 | 6,605 | 1,160 | 1,219 | 1,278 |
| 2009 | 3,751 | 5,214 | 6,676 | 1,162 | 1,221 | 1,280 |
| 2010 | 3,808 | 5,276 | 6,745 | 1,163 | 1,223 | 1,282 |
| 2011 | 3,863 | 5,338 | 6,812 | 1,165 | 1,224 | 1,284 |
| 2012 | 3,918 | 5,398 | 6,879 | 1,166 | 1,226 | 1,285 |
| 2013 | 3,971 | 5,457 | 6,944 | 1,167 | 1,227 | 1,287 |
| 2014 | 4,022 | 5,515 | 7,007 | 1,169 | 1,229 | 1,288 |
| 2015 | 4,072 | 5,570 | 7,068 | 1,170 | 1,230 | 1,290 |
| 2016 | 4,120 | 5,623 | 7,126 | 1,170 | 1,231 | 1,291 |
| 2017 | 4,165 | 5,673 | 7,181 | 1,171 | 1,231 | 1,291 |
| 2018 | 4,208 | 5,721 | 7,234 | 1,171 | 1,232 | 1,292 |
| 2019 | 4,248 | 5,766 | 7,283 | 1,171 | 1,231 | 1,292 |
| 2020 | 4,286 | 5,807 | 7,329 | 1,171 | 1,231 | 1,291 |
| 2021 | 4,321 | 5,847 | 7,372 | 1,170 | 1,230 | 1,291 |
| 2022 | 4,355 | 5,884 | 7,413 | 1,169 | 1,229 | 1,290 |
| 2023 | 4,386 | 5,919 | 7,452 | 1,168 | 1,228 | 1,288 |
| 2024 | 4,416 | 5,952 | 7,489 | 1,167 | 1,227 | 1,287 |
| 2025 | 4,445 | 5,984 | 7,523 | 1,166 | 1,225 | 1,285 |
| 2026 | 4,473 | 6,015 | 7,558 | 1,164 | 1,224 | 1,283 |
| 2027 | 4,501 | 6,046 | 7,592 | 1,163 | 1,223 | 1,282 |
| 2028 | 4,528 | 6,077 | 7,626 | 1,162 | 1,221 | 1,280 |
| 2029 | 4,556 | 6,108 | 7,659 | 1,161 | 1,220 | 1,279 |
| 2030 | 4,584 | 6,139 | 7,693 | 1,160 | 1,219 | 1,278 |
| 2035 | 4,709 | 6,276 | 7,844 | 1,155 | 1,214 | 1,272 |
| 2040 | 4,837 | 6,417 | 7,998 | 1,151 | 1,209 | 1,267 |
| 2045 | 4,943 | 6,532 | 8,123 | 1,147 | 1,204 | 1,262 |
| 2050 | 5,050 | 6,649 | 8,250 | 1,142 | 1,199 | 1,256 |
| 2055 | 5,160 | 6,769 | 8,380 | 1,138 | 1,194 | 1,251 |

(Source: LBG Analysis)

## Industrial Chemicals without Ethanol

Figure 3 and Figure 4 show the unconstrained waterway forecasts for Industrial Chemicals without Ethanol with high and low forecast bands.

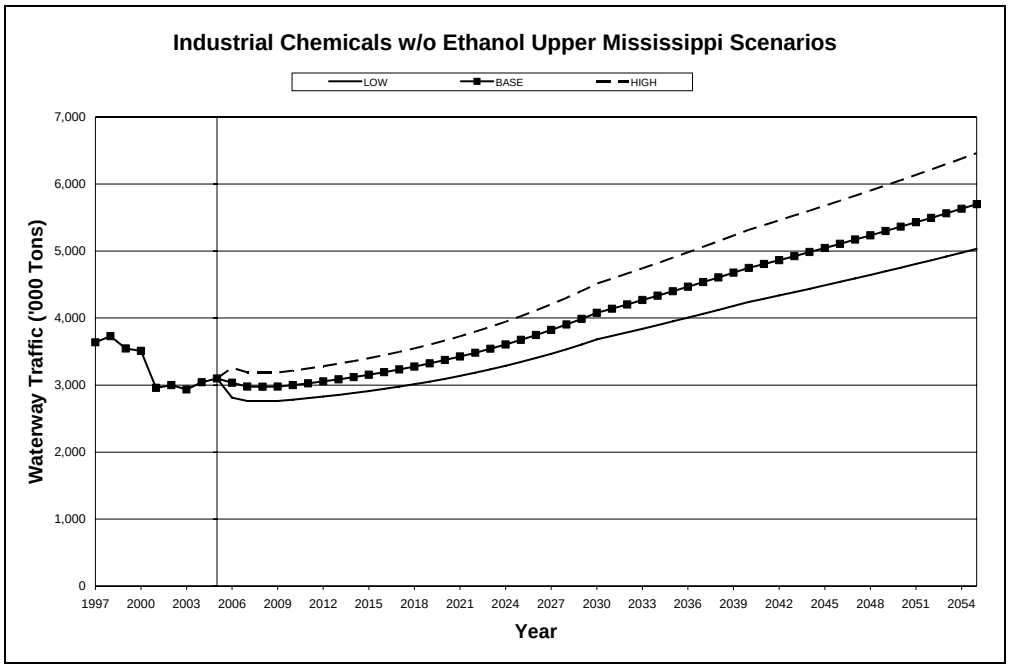



**Figure 3: Upper Mississippi Ind. Chem. Unconstrained Forecast with high and low forecast bands**

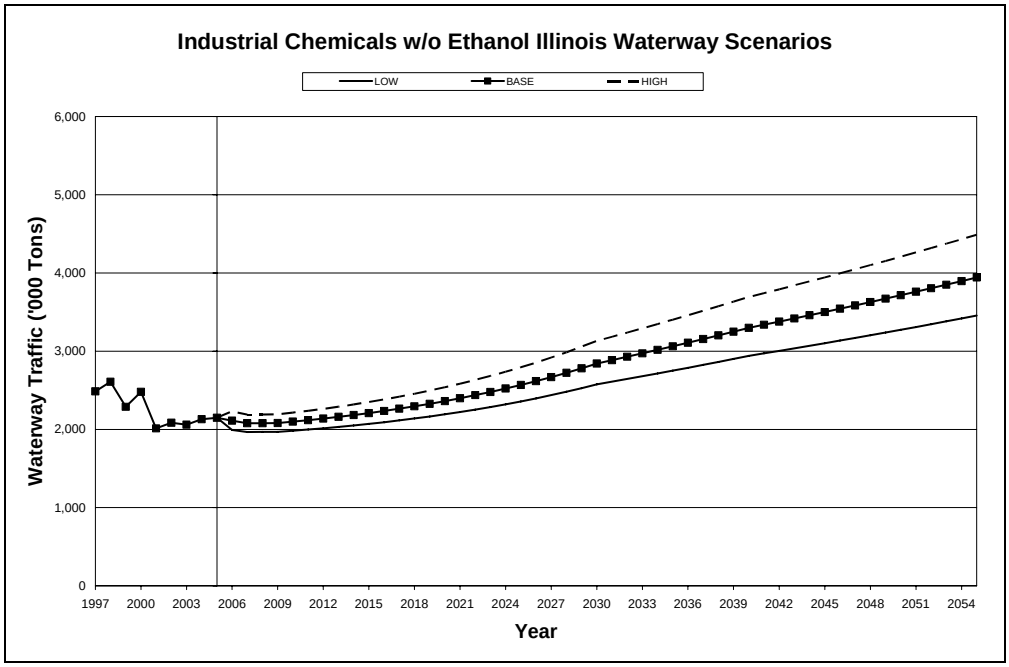



**Figure 4: Illinois Waterway Ind. Chem. Unconstrained Forecast with high and low forecast bands**

**Table 2: Industrial Chemicals w/o Ethanol Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 3,638 | 3,638 | 3,638 | 2,486 | 2,486 | 2,486 |
| 1998 | 3,729 | 3,729 | 3,729 | 2,609 | 2,609 | 2,609 |
| 1999 | 3,545 | 3,545 | 3,545 | 2,289 | 2,289 | 2,289 |
| 2000 | 3,510 | 3,510 | 3,510 | 2,480 | 2,480 | 2,480 |
| 2001 | 2,958 | 2,958 | 2,958 | 2,013 | 2,013 | 2,013 |
| 2002 | 3,000 | 3,000 | 3,000 | 2,084 | 2,084 | 2,084 |
| 2003 | 2,934 | 2,934 | 2,934 | 2,060 | 2,060 | 2,060 |
| 2004 | 3,043 | 3,043 | 3,043 | 2,129 | 2,129 | 2,129 |
| 2005 | 3,098 | 3,098 | 3,098 | 2,149 | 2,149 | 2,149 |
| 2006 | 2,811 | 3,034 | 3,257 | 1,993 | 2,111 | 2,230 |
| 2007 | 2,764 | 2,977 | 3,189 | 1,966 | 2,078 | 2,188 |
| 2008 | 2,763 | 2,976 | 3,187 | 1,967 | 2,079 | 2,190 |
| 2009 | 2,763 | 2,976 | 3,187 | 1,968 | 2,081 | 2,193 |
| 2010 | 2,783 | 3,000 | 3,216 | 1,982 | 2,098 | 2,214 |
| 2011 | 2,805 | 3,026 | 3,247 | 1,997 | 2,117 | 2,238 |
| 2012 | 2,828 | 3,055 | 3,282 | 2,014 | 2,138 | 2,263 |
| 2013 | 2,854 | 3,085 | 3,318 | 2,031 | 2,160 | 2,290 |
| 2014 | 2,881 | 3,118 | 3,358 | 2,050 | 2,183 | 2,319 |
| 2015 | 2,911 | 3,154 | 3,401 | 2,070 | 2,208 | 2,349 |
| 2016 | 2,943 | 3,192 | 3,447 | 2,091 | 2,235 | 2,383 |
| 2017 | 2,977 | 3,233 | 3,496 | 2,114 | 2,264 | 2,418 |
| 2018 | 3,013 | 3,276 | 3,548 | 2,139 | 2,294 | 2,455 |
| 2019 | 3,052 | 3,323 | 3,605 | 2,165 | 2,327 | 2,496 |
| 2020 | 3,094 | 3,373 | 3,664 | 2,192 | 2,361 | 2,538 |
| 2021 | 3,138 | 3,426 | 3,728 | 2,221 | 2,398 | 2,583 |
| 2022 | 3,185 | 3,483 | 3,796 | 2,253 | 2,437 | 2,631 |
| 2023 | 3,235 | 3,543 | 3,869 | 2,285 | 2,478 | 2,682 |
| 2024 | 3,288 | 3,607 | 3,945 | 2,320 | 2,522 | 2,736 |
| 2025 | 3,345 | 3,674 | 4,027 | 2,357 | 2,568 | 2,793 |
| 2026 | 3,405 | 3,746 | 4,113 | 2,397 | 2,617 | 2,854 |
| 2027 | 3,468 | 3,822 | 4,204 | 2,438 | 2,669 | 2,918 |
| 2028 | 3,535 | 3,903 | 4,301 | 2,482 | 2,724 | 2,985 |
| 2029 | 3,606 | 3,988 | 4,404 | 2,528 | 2,782 | 3,056 |
| 2030 | 3,681 | 4,078 | 4,512 | 2,576 | 2,842 | 3,131 |
| 2035 | 3,950 | 4,400 | 4,899 | 2,751 | 3,062 | 3,402 |
| 2040 | 4,240 | 4,748 | 5,317 | 2,940 | 3,298 | 3,693 |
| 2045 | 4,488 | 5,046 | 5,675 | 3,101 | 3,500 | 3,943 |
| 2050 | 4,752 | 5,363 | 6,057 | 3,273 | 3,715 | 4,207 |
| 2055 | 5,033 | 5,700 | 6,462 | 3,455 | 3,943 | 4,488 |

(Source: LBG Analysis)

## Ethanol

Figure 5 and Figure 6 show the unconstrained waterway forecasts for Ethanol with high and low forecast bands.

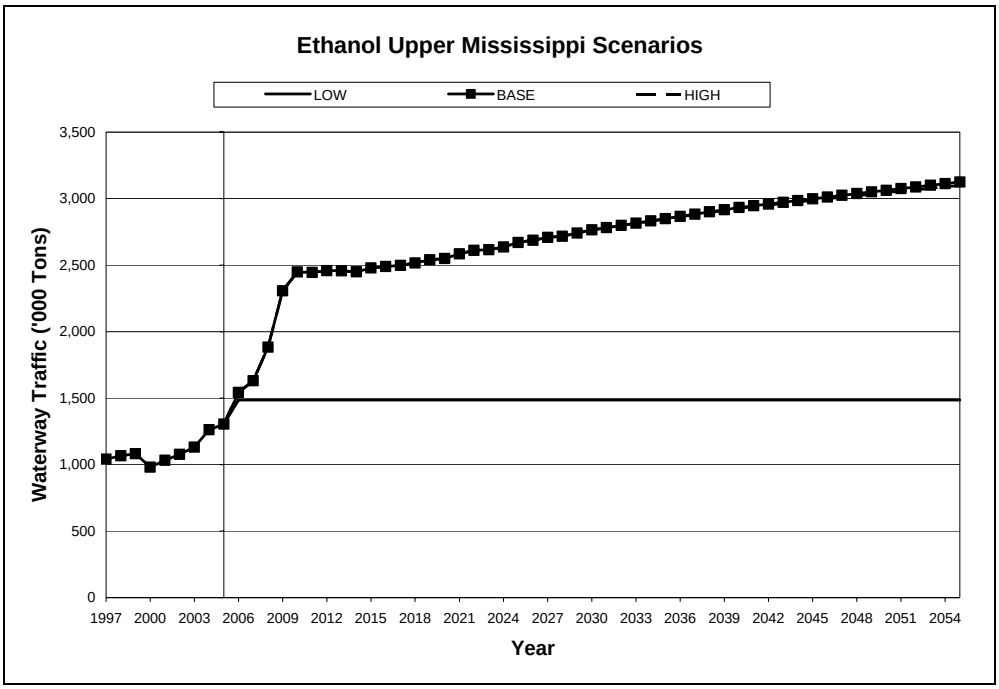



**Figure 5: Upper Mississippi Ethanol Unconstrained Forecast with high and low forecast bands**

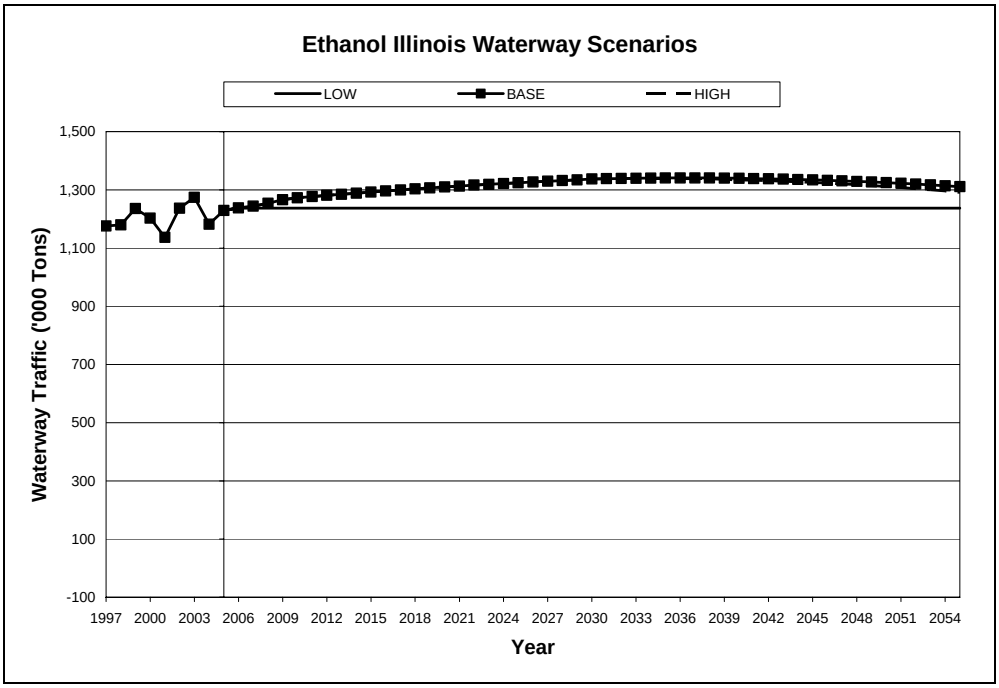



**Figure 6: Illinois Waterway Ethanol Unconstrained Forecast with high and low forecast bands**

**Table 3: Ethanol Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 1,041 | 1,041 | 1,041 | 1,176 | 1,176 | 1,176 |
| 1998 | 1,066 | 1,066 | 1,066 | 1,180 | 1,180 | 1,180 |
| 1999 | 1,082 | 1,082 | 1,082 | 1,236 | 1,236 | 1,236 |
| 2000 | 982 | 982 | 982 | 1,203 | 1,203 | 1,203 |
| 2001 | 1,032 | 1,032 | 1,032 | 1,137 | 1,137 | 1,137 |
| 2002 | 1,077 | 1,077 | 1,077 | 1,237 | 1,237 | 1,237 |
| 2003 | 1,132 | 1,132 | 1,132 | 1,274 | 1,274 | 1,274 |
| 2004 | 1,262 | 1,262 | 1,262 | 1,182 | 1,182 | 1,182 |
| 2005 | 1,305 | 1,305 | 1,305 | 1,229 | 1,229 | 1,229 |
| 2006 | 1,486 | 1,542 | 1,542 | 1,237 | 1,238 | 1,238 |
| 2007 | 1,486 | 1,631 | 1,631 | 1,237 | 1,244 | 1,244 |
| 2008 | 1,486 | 1,883 | 1,883 | 1,237 | 1,254 | 1,254 |
| 2009 | 1,486 | 2,306 | 2,306 | 1,237 | 1,266 | 1,266 |
| 2010 | 1,486 | 2,447 | 2,447 | 1,237 | 1,273 | 1,273 |
| 2011 | 1,486 | 2,445 | 2,445 | 1,237 | 1,277 | 1,277 |
| 2012 | 1,486 | 2,459 | 2,459 | 1,237 | 1,281 | 1,281 |
| 2013 | 1,486 | 2,457 | 2,457 | 1,237 | 1,285 | 1,285 |
| 2014 | 1,486 | 2,449 | 2,449 | 1,237 | 1,289 | 1,289 |
| 2015 | 1,486 | 2,478 | 2,478 | 1,237 | 1,293 | 1,293 |
| 2016 | 1,486 | 2,490 | 2,490 | 1,237 | 1,296 | 1,296 |
| 2017 | 1,486 | 2,498 | 2,498 | 1,237 | 1,300 | 1,300 |
| 2018 | 1,486 | 2,516 | 2,516 | 1,237 | 1,303 | 1,303 |
| 2019 | 1,486 | 2,540 | 2,540 | 1,237 | 1,307 | 1,307 |
| 2020 | 1,486 | 2,550 | 2,550 | 1,237 | 1,310 | 1,310 |
| 2021 | 1,486 | 2,583 | 2,583 | 1,237 | 1,313 | 1,313 |
| 2022 | 1,486 | 2,611 | 2,611 | 1,237 | 1,316 | 1,316 |
| 2023 | 1,486 | 2,615 | 2,615 | 1,237 | 1,319 | 1,319 |
| 2024 | 1,486 | 2,636 | 2,636 | 1,237 | 1,322 | 1,322 |
| 2025 | 1,486 | 2,670 | 2,670 | 1,237 | 1,325 | 1,325 |
| 2026 | 1,486 | 2,687 | 2,687 | 1,237 | 1,327 | 1,327 |
| 2027 | 1,486 | 2,708 | 2,708 | 1,237 | 1,330 | 1,330 |
| 2028 | 1,486 | 2,717 | 2,717 | 1,237 | 1,332 | 1,332 |
| 2029 | 1,486 | 2,741 | 2,741 | 1,237 | 1,335 | 1,335 |
| 2030 | 1,486 | 2,765 | 2,765 | 1,237 | 1,337 | 1,337 |
| 2035 | 1,486 | 2,849 | 2,847 | 1,237 | 1,341 | 1,339 |
| 2040 | 1,486 | 2,933 | 2,926 | 1,237 | 1,340 | 1,335 |
| 2045 | 1,486 | 2,999 | 2,987 | 1,237 | 1,334 | 1,326 |
| 2050 | 1,486 | 3,063 | 3,045 | 1,237 | 1,325 | 1,312 |
| 2055 | 1,486 | 3,125 | 3,099 | 1,237 | 1,311 | 1,292 |

(Source: LBG Analysis)

## Coal

Figure 7, Figure 8 and Figure 9 show the unconstrained waterway forecasts for Coal with high and low forecast bands.

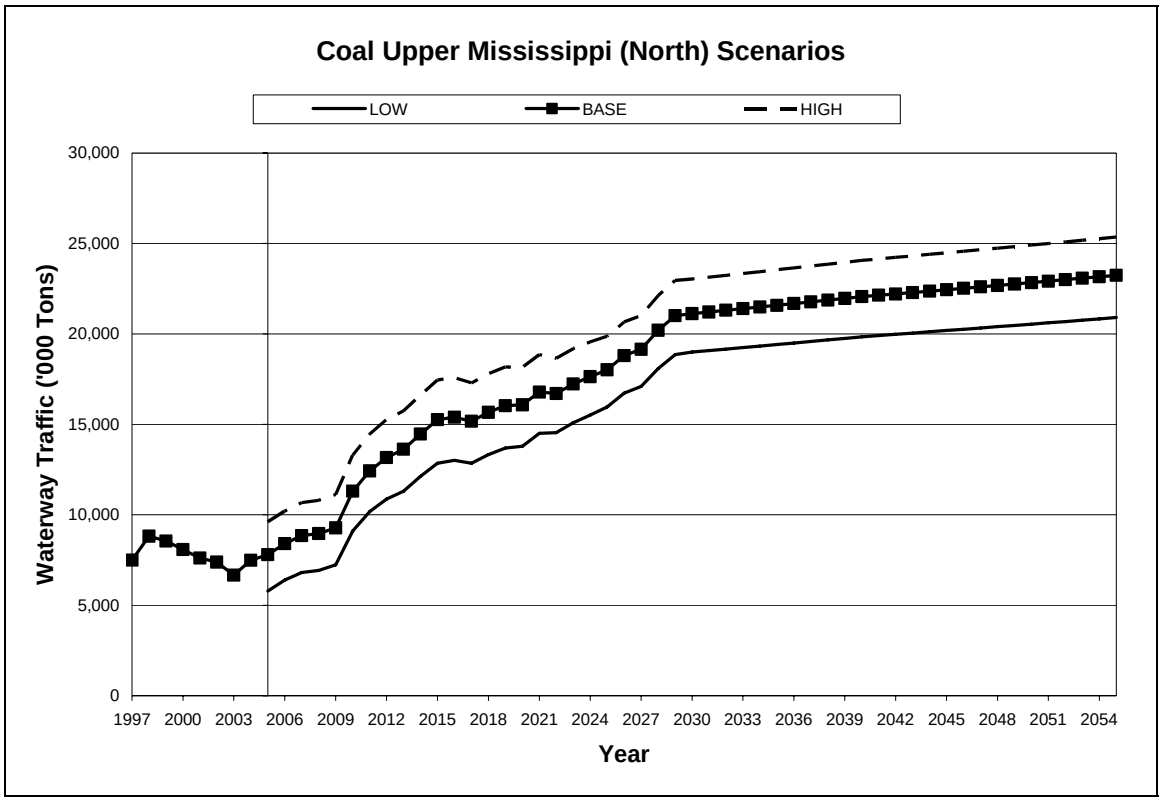



**Figure 7: Upper Mississippi (North) Coal Unconstrained Forecast with high and low forecast bands**

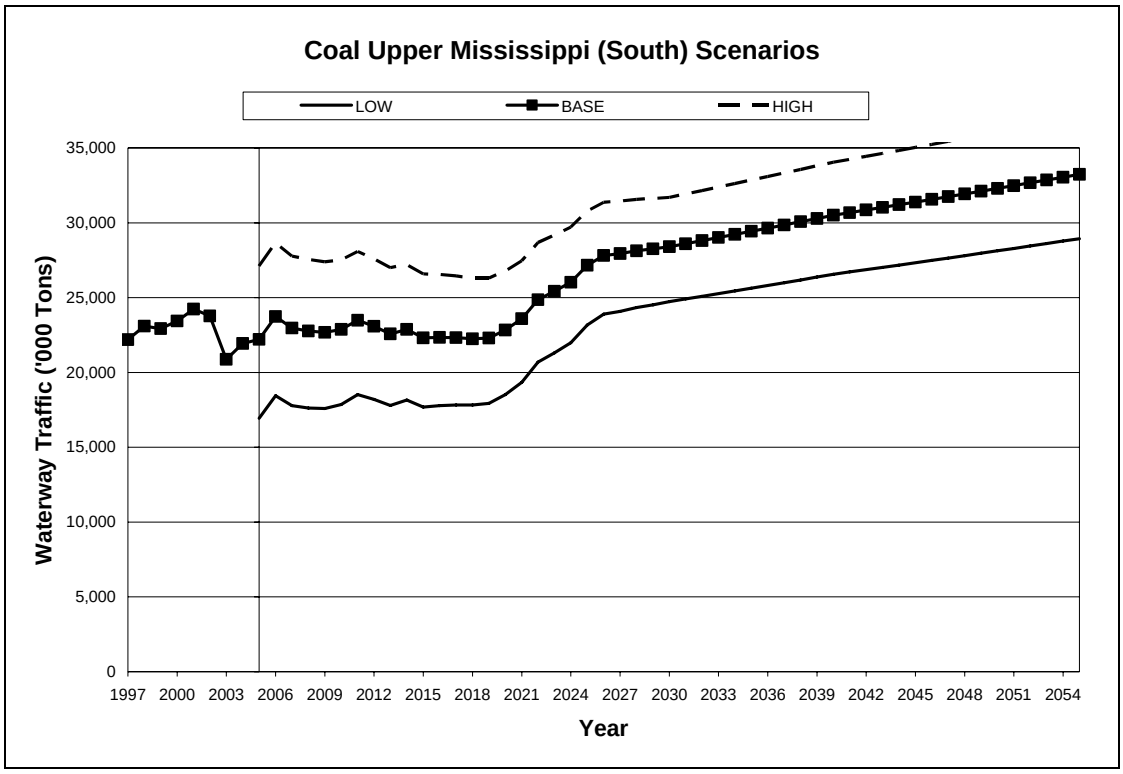



**Figure 8: Upper Mississippi (South) Coal Unconstrained Forecast with high and low forecast bands**

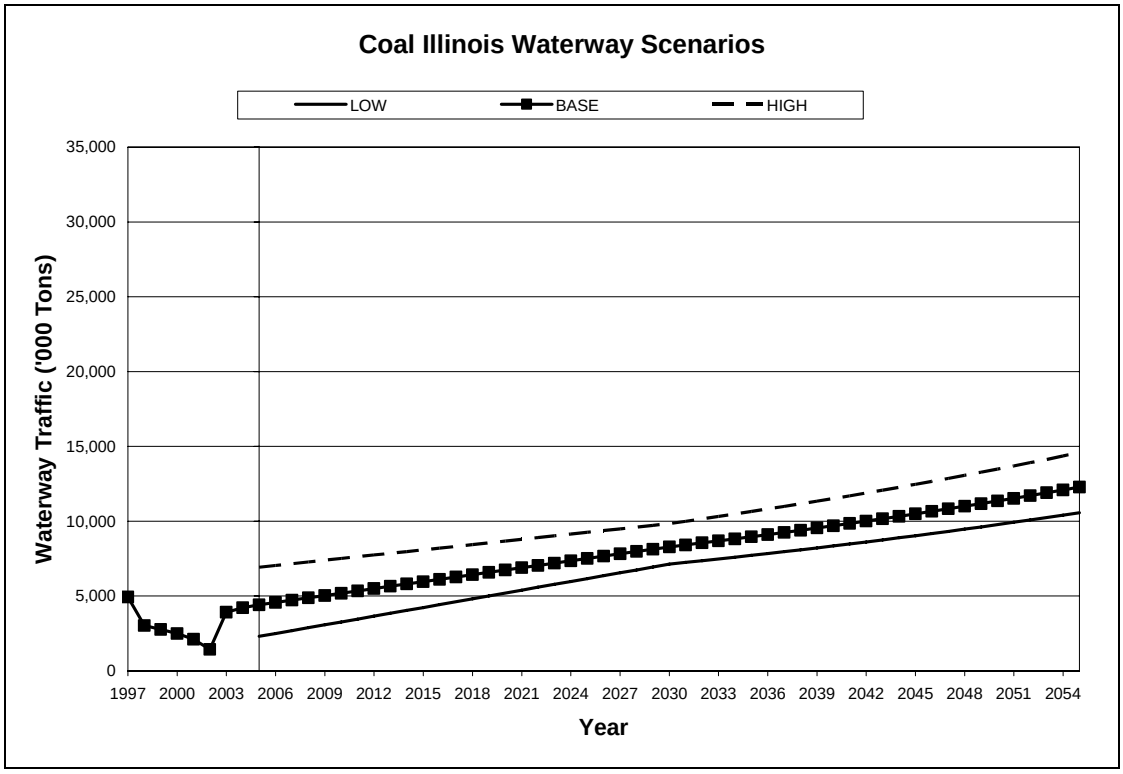



**Figure 9: Illinois Waterway Coal Unconstrained Forecast with high and low forecast bands**

**Table 4: Coal Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi (North) | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 7,500 | 7,500 | 7,500 | 4,942 | 4,942 | 4,942 |
| 1998 | 8,817 | 8,817 | 8,817 | 3,029 | 3,029 | 3,029 |
| 1999 | 8,553 | 8,553 | 8,553 | 2,768 | 2,768 | 2,768 |
| 2000 | 8,081 | 8,081 | 8,081 | 2,495 | 2,495 | 2,495 |
| 2001 | 7,609 | 7,609 | 7,609 | 2,111 | 2,111 | 2,111 |
| 2002 | 7,379 | 7,379 | 7,379 | 1,435 | 1,435 | 1,435 |
| 2003 | 6,665 | 6,665 | 6,665 | 3,920 | 3,920 | 3,920 |
| 2004 | 7,478 | 7,478 | 7,478 | 4,215 | 4,215 | 4,215 |
| 2005 | 5,785 | 7,802 | 9,615 | 2,308 | 4,417 | 6,928 |
| 2006 | 6,392 | 8,400 | 10,205 | 2,501 | 4,572 | 7,044 |
| 2007 | 6,816 | 8,850 | 10,680 | 2,694 | 4,727 | 7,161 |
| 2008 | 6,925 | 8,962 | 10,796 | 2,887 | 4,882 | 7,278 |
| 2009 | 7,240 | 9,280 | 11,117 | 3,080 | 5,037 | 7,394 |
| 2010 | 9,110 | 11,305 | 13,297 | 3,273 | 5,192 | 7,511 |
| 2011 | 10,187 | 12,428 | 14,466 | 3,466 | 5,346 | 7,628 |
| 2012 | 10,866 | 13,161 | 15,252 | 3,660 | 5,501 | 7,744 |
| 2013 | 11,308 | 13,624 | 15,737 | 3,853 | 5,656 | 7,861 |
| 2014 | 12,125 | 14,465 | 16,602 | 4,046 | 5,811 | 7,978 |
| 2015 | 12,844 | 15,253 | 17,458 | 4,239 | 5,966 | 8,094 |
| 2016 | 13,005 | 15,387 | 17,566 | 4,432 | 6,121 | 8,211 |
| 2017 | 12,846 | 15,167 | 17,284 | 4,625 | 6,276 | 8,328 |
| 2018 | 13,331 | 15,664 | 17,795 | 4,819 | 6,431 | 8,444 |
| 2019 | 13,694 | 16,031 | 18,165 | 5,012 | 6,586 | 8,561 |
| 2020 | 13,790 | 16,072 | 18,150 | 5,205 | 6,741 | 8,678 |
| 2021 | 14,508 | 16,782 | 18,853 | 5,398 | 6,896 | 8,794 |
| 2022 | 14,542 | 16,701 | 18,656 | 5,591 | 7,050 | 8,911 |
| 2023 | 15,089 | 17,234 | 19,175 | 5,784 | 7,205 | 9,028 |
| 2024 | 15,520 | 17,635 | 19,546 | 5,977 | 7,360 | 9,144 |
| 2025 | 15,958 | 18,012 | 19,863 | 6,171 | 7,515 | 9,261 |
| 2026 | 16,728 | 18,792 | 20,653 | 6,364 | 7,670 | 9,378 |
| 2027 | 17,090 | 19,149 | 21,005 | 6,557 | 7,825 | 9,495 |
| 2028 | 18,078 | 20,196 | 22,110 | 6,750 | 7,980 | 9,611 |
| 2029 | 18,849 | 21,004 | 22,955 | 6,943 | 8,135 | 9,728 |
| 2030 | 18,995 | 21,118 | 23,037 | 7,136 | 8,290 | 9,845 |
| 2035 | 19,412 | 21,581 | 23,543 | 7,720 | 8,968 | 10,650 |
| 2040 | 19,838 | 22,055 | 24,059 | 8,352 | 9,701 | 11,521 |
| 2045 | 20,185 | 22,441 | 24,481 | 9,035 | 10,495 | 12,463 |
| 2050 | 20,539 | 22,835 | 24,910 | 9,774 | 11,353 | 13,483 |
| 2055 | 20,899 | 23,235 | 25,347 | 10,573 | 12,282 | 14,586 |

(Source: LBG Analysis)

## Steel

Figure 10 and Figure 11 show the unconstrained waterway forecasts for Steel with high and low forecast bands.

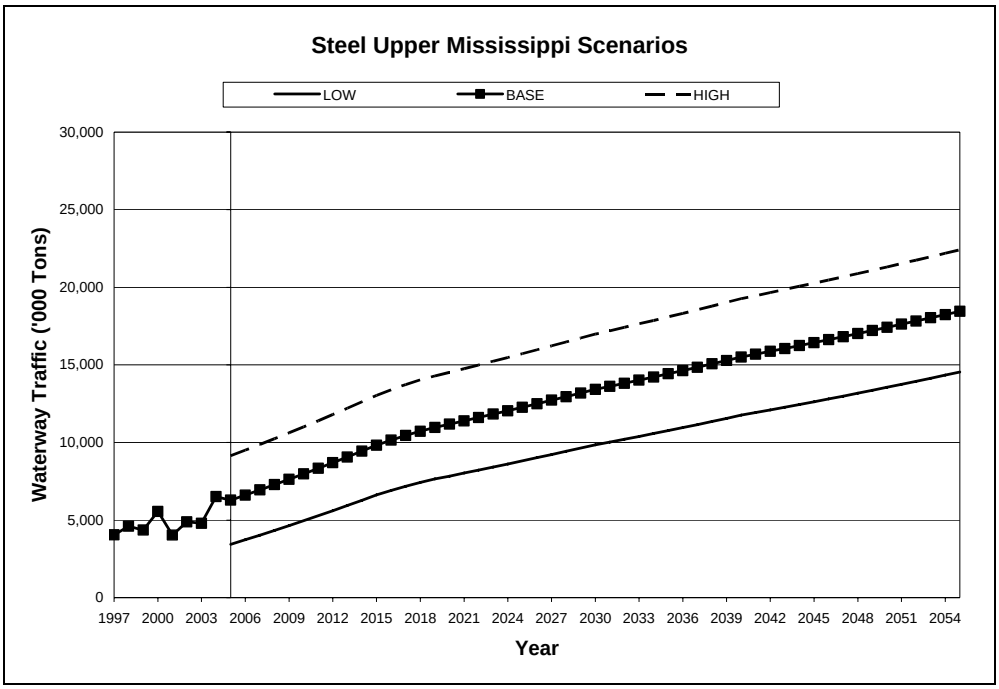



**Figure 10: Upper Mississippi Steel Unconstrained Forecast with high and low forecast bands**

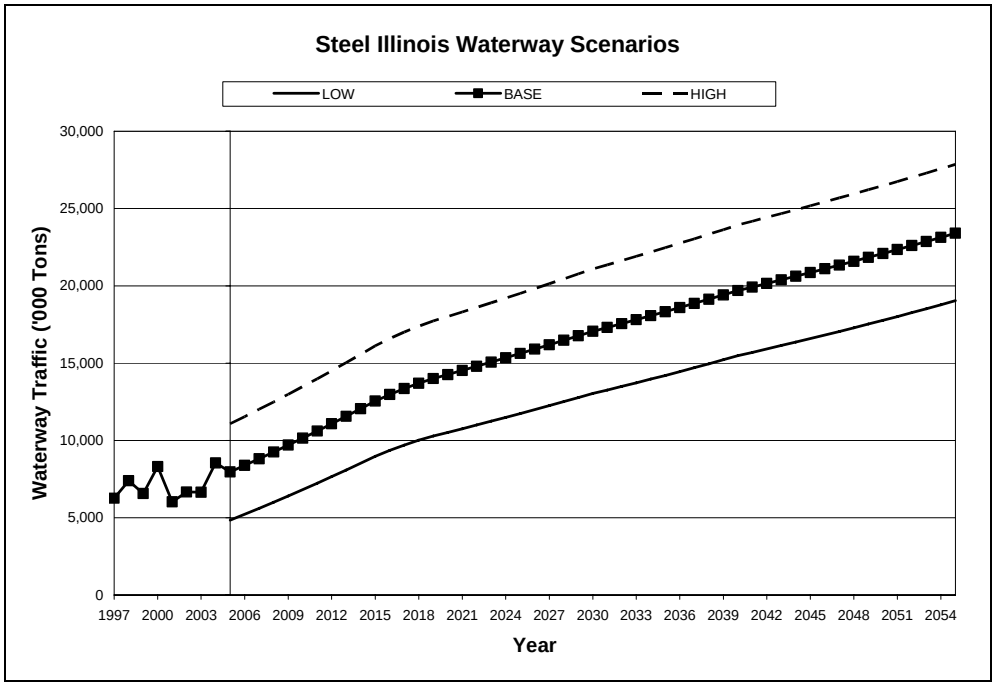



**Figure 11: Illinois Waterway Steel Unconstrained Forecast with high and low forecast bands**

**Table 5: Steel Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 4,049 | 4,049 | 4,049 | 6,266 | 6,266 | 6,266 |
| 1998 | 4,606 | 4,606 | 4,606 | 7,394 | 7,394 | 7,394 |
| 1999 | 4,363 | 4,363 | 4,363 | 6,561 | 6,561 | 6,561 |
| 2000 | 5,552 | 5,552 | 5,552 | 8,314 | 8,314 | 8,314 |
| 2001 | 4,038 | 4,038 | 4,038 | 6,025 | 6,025 | 6,025 |
| 2002 | 4,882 | 4,882 | 4,882 | 6,671 | 6,671 | 6,671 |
| 2003 | 4,794 | 4,794 | 4,794 | 6,655 | 6,655 | 6,655 |
| 2004 | 6,505 | 6,505 | 6,505 | 8,549 | 8,549 | 8,549 |
| 2005 | 3,434 | 6,287 | 9,140 | 4,850 | 7,965 | 11,080 |
| 2006 | 3,728 | 6,614 | 9,499 | 5,229 | 8,386 | 11,543 |
| 2007 | 4,027 | 6,946 | 9,865 | 5,615 | 8,815 | 12,015 |
| 2008 | 4,332 | 7,285 | 10,237 | 6,009 | 9,252 | 12,496 |
| 2009 | 4,642 | 7,629 | 10,616 | 6,410 | 9,698 | 12,986 |
| 2010 | 4,957 | 7,980 | 11,002 | 6,818 | 10,151 | 13,485 |
| 2011 | 5,278 | 8,336 | 11,394 | 7,234 | 10,613 | 13,993 |
| 2012 | 5,604 | 8,699 | 11,793 | 7,657 | 11,084 | 14,510 |
| 2013 | 5,936 | 9,067 | 12,199 | 8,088 | 11,563 | 15,037 |
| 2014 | 6,274 | 9,443 | 12,611 | 8,527 | 12,050 | 15,574 |
| 2015 | 6,617 | 9,824 | 13,031 | 8,974 | 12,547 | 16,120 |
| 2016 | 6,913 | 10,152 | 13,392 | 9,354 | 12,969 | 16,585 |
| 2017 | 7,183 | 10,453 | 13,722 | 9,701 | 13,355 | 17,008 |
| 2018 | 7,428 | 10,725 | 14,022 | 10,012 | 13,700 | 17,389 |
| 2019 | 7,646 | 10,967 | 14,288 | 10,286 | 14,005 | 17,723 |
| 2020 | 7,835 | 11,178 | 14,520 | 10,521 | 14,266 | 18,011 |
| 2021 | 8,027 | 11,391 | 14,754 | 10,760 | 14,531 | 18,303 |
| 2022 | 8,222 | 11,607 | 14,992 | 11,001 | 14,799 | 18,598 |
| 2023 | 8,418 | 11,825 | 15,232 | 11,246 | 15,071 | 18,896 |
| 2024 | 8,616 | 12,045 | 15,474 | 11,493 | 15,346 | 19,199 |
| 2025 | 8,817 | 12,268 | 15,720 | 11,743 | 15,624 | 19,505 |
| 2026 | 9,020 | 12,494 | 15,967 | 11,996 | 15,905 | 19,814 |
| 2027 | 9,225 | 12,721 | 16,218 | 12,253 | 16,190 | 20,127 |
| 2028 | 9,432 | 12,951 | 16,471 | 12,512 | 16,478 | 20,444 |
| 2029 | 9,640 | 13,183 | 16,726 | 12,773 | 16,769 | 20,764 |
| 2030 | 9,852 | 13,418 | 16,984 | 13,038 | 17,063 | 21,087 |
| 2035 | 10,763 | 14,425 | 18,088 | 14,209 | 18,331 | 22,462 |
| 2040 | 11,758 | 15,507 | 19,265 | 15,484 | 19,695 | 23,927 |
| 2045 | 12,622 | 16,433 | 20,262 | 16,589 | 20,859 | 25,169 |
| 2050 | 13,550 | 17,414 | 21,311 | 17,772 | 22,093 | 26,475 |
| 2055 | 14,545 | 18,454 | 22,414 | 19,039 | 23,400 | 27,849 |

(Source: LBG Analysis)

## Petroleum

Figure 12 and Figure 13 show the unconstrained waterway forecasts for Petroleum with high and low forecast bands.

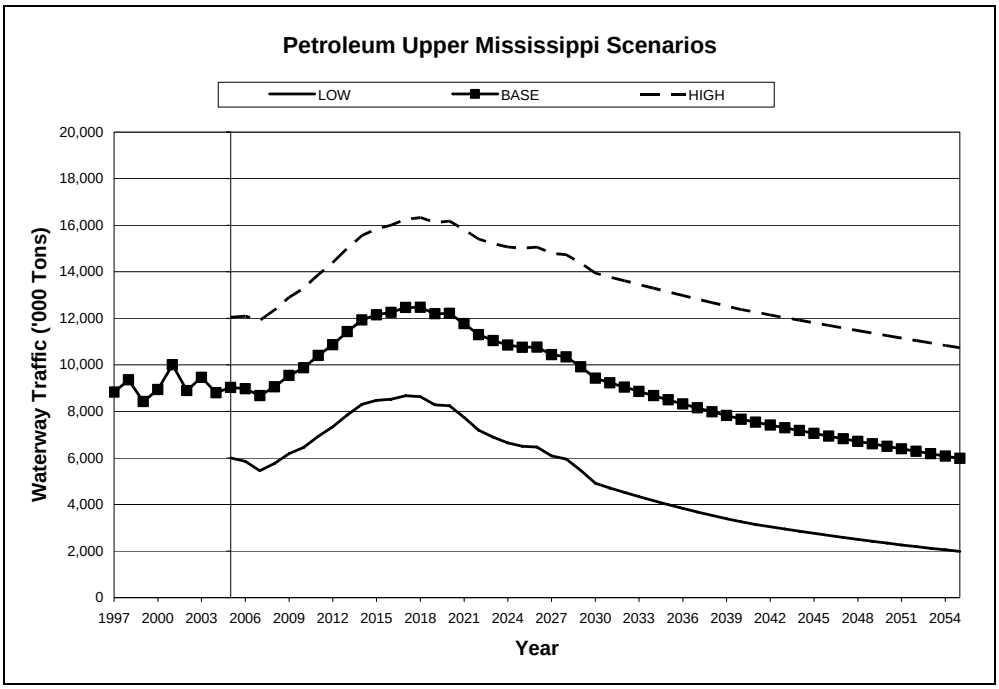



**Figure 12: Upper Mississippi Petroleum Unconstrained Forecast with high and low forecast bands**

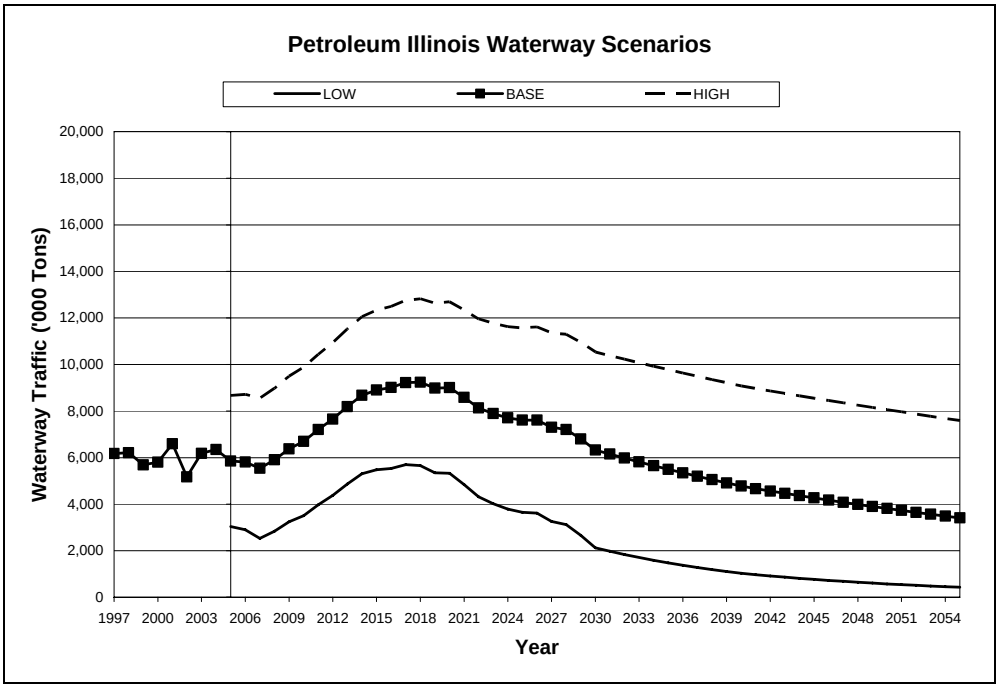



**Figure 13: Illinois Waterway Petroleum Unconstrained Forecast with high and low forecast bands**

**Table 6: Petroleum Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 8,830 | 8,830 | 8,830 | 6,175 | 6,175 | 6,175 |
| 1998 | 9,358 | 9,358 | 9,358 | 6,217 | 6,217 | 6,217 |
| 1999 | 8,426 | 8,426 | 8,426 | 5,689 | 5,689 | 5,689 |
| 2000 | 8,937 | 8,937 | 8,937 | 5,802 | 5,802 | 5,802 |
| 2001 | 10,004 | 10,004 | 10,004 | 6,598 | 6,598 | 6,598 |
| 2002 | 8,897 | 8,897 | 8,897 | 5,174 | 5,174 | 5,174 |
| 2003 | 9,461 | 9,461 | 9,461 | 6,187 | 6,187 | 6,187 |
| 2004 | 8,808 | 8,808 | 8,808 | 6,349 | 6,349 | 6,349 |
| 2005 | 6,007 | 9,028 | 12,048 | 3,041 | 5,856 | 8,671 |
| 2006 | 5,855 | 8,974 | 12,094 | 2,905 | 5,812 | 8,719 |
| 2007 | 5,454 | 8,681 | 11,907 | 2,533 | 5,540 | 8,548 |
| 2008 | 5,762 | 9,058 | 12,354 | 2,835 | 5,906 | 8,978 |
| 2009 | 6,186 | 9,543 | 12,900 | 3,247 | 6,375 | 9,502 |
| 2010 | 6,454 | 9,875 | 13,296 | 3,511 | 6,698 | 9,885 |
| 2011 | 6,932 | 10,404 | 13,877 | 3,975 | 7,209 | 10,444 |
| 2012 | 7,342 | 10,868 | 14,394 | 4,374 | 7,657 | 10,942 |
| 2013 | 7,852 | 11,424 | 14,998 | 4,868 | 8,195 | 11,522 |
| 2014 | 8,308 | 11,927 | 15,548 | 5,312 | 8,681 | 12,052 |
| 2015 | 8,476 | 12,153 | 15,831 | 5,483 | 8,905 | 12,329 |
| 2016 | 8,518 | 12,255 | 15,994 | 5,533 | 9,011 | 12,492 |
| 2017 | 8,677 | 12,464 | 16,255 | 5,696 | 9,221 | 12,748 |
| 2018 | 8,630 | 12,475 | 16,323 | 5,663 | 9,241 | 12,822 |
| 2019 | 8,281 | 12,194 | 16,110 | 5,344 | 8,985 | 12,630 |
| 2020 | 8,245 | 12,207 | 16,173 | 5,322 | 9,009 | 12,699 |
| 2021 | 7,740 | 11,771 | 15,806 | 4,839 | 8,591 | 12,346 |
| 2022 | 7,196 | 11,296 | 15,400 | 4,319 | 8,136 | 11,956 |
| 2023 | 6,890 | 11,045 | 15,205 | 4,025 | 7,894 | 11,767 |
| 2024 | 6,645 | 10,851 | 15,062 | 3,789 | 7,706 | 11,627 |
| 2025 | 6,505 | 10,756 | 15,011 | 3,653 | 7,612 | 11,575 |
| 2026 | 6,471 | 10,761 | 15,055 | 3,618 | 7,613 | 11,613 |
| 2027 | 6,096 | 10,441 | 14,790 | 3,259 | 7,306 | 11,358 |
| 2028 | 5,954 | 10,341 | 14,735 | 3,121 | 7,208 | 11,301 |
| 2029 | 5,468 | 9,915 | 14,368 | 2,656 | 6,800 | 10,949 |
| 2030 | 4,912 | 9,422 | 13,938 | 2,126 | 6,329 | 10,538 |
| 2035 | 3,997 | 8,497 | 13,135 | 1,478 | 5,498 | 9,781 |
| 2040 | 3,253 | 7,663 | 12,377 | 1,027 | 4,776 | 9,079 |
| 2045 | 2,760 | 7,056 | 11,804 | 769 | 4,269 | 8,555 |
| 2050 | 2,342 | 6,498 | 11,257 | 576 | 3,815 | 8,061 |
| 2055 | 1,988 | 5,983 | 10,735 | 432 | 3,410 | 7,595 |

(Source: LBG Analysis)

## Construction Materials

Figure 14 and Figure 15 show the unconstrained waterway forecasts for Construction Materials with high and low forecast bands.

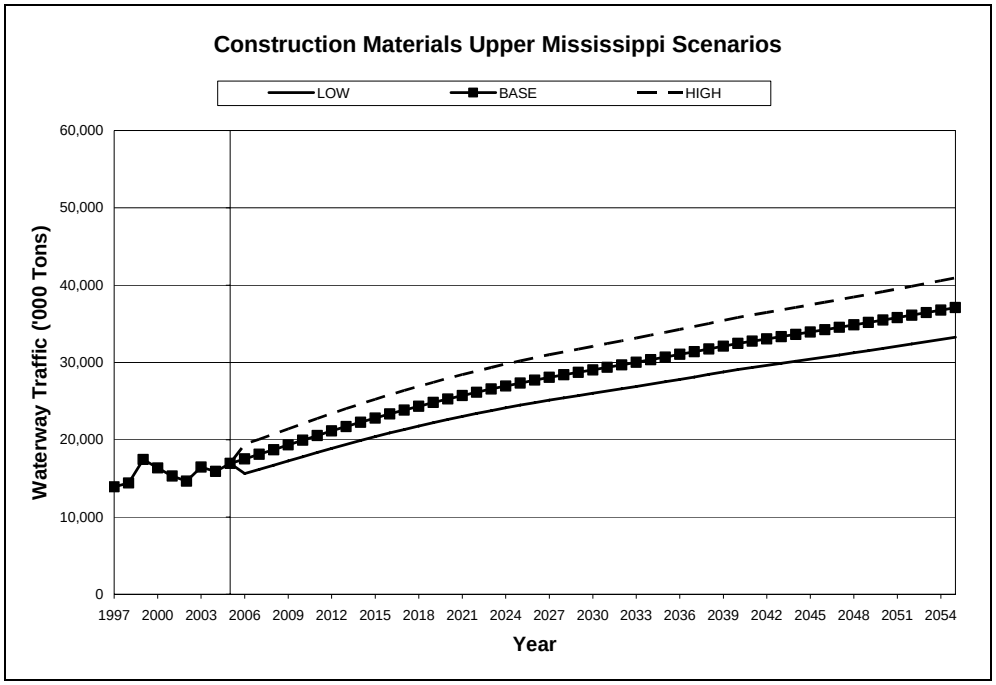



**Figure 14: Upper Mississippi Const. Mat. Unconstrained Forecast with high and flow forecast bands**

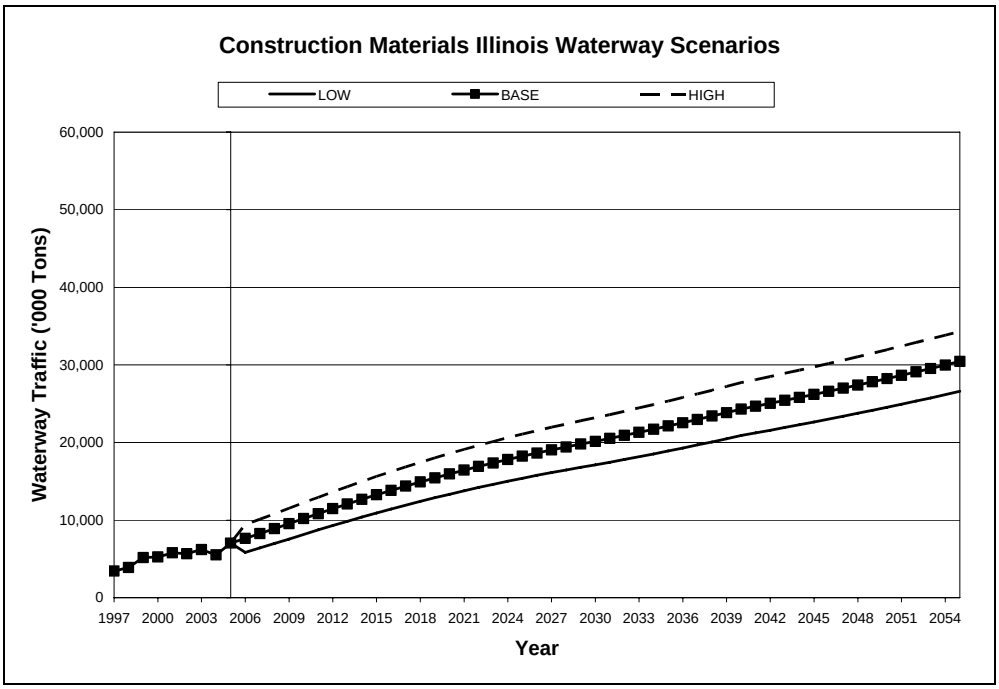



**Figure 15: Illinois Waterway Const. Mat. Unconstrained Forecast with high and flow forecast bands**

**Table 7: Construction Materials Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 13,904 | 13,904 | 13,904 | 3,439 | 3,439 | 3,439 |
| 1998 | 14,416 | 14,416 | 14,416 | 3,888 | 3,888 | 3,888 |
| 1999 | 17,459 | 17,459 | 17,459 | 5,176 | 5,176 | 5,176 |
| 2000 | 16,360 | 16,360 | 16,360 | 5,233 | 5,233 | 5,233 |
| 2001 | 15,312 | 15,312 | 15,312 | 5,772 | 5,772 | 5,772 |
| 2002 | 14,650 | 14,650 | 14,650 | 5,662 | 5,662 | 5,662 |
| 2003 | 16,471 | 16,471 | 16,471 | 6,198 | 6,198 | 6,198 |
| 2004 | 15,914 | 15,914 | 15,914 | 5,501 | 5,501 | 5,501 |
| 2005 | 16,946 | 16,946 | 16,946 | 7,029 | 7,029 | 7,029 |
| 2006 | 15,644 | 17,527 | 19,411 | 5,853 | 7,639 | 9,425 |
| 2007 | 16,176 | 18,118 | 20,061 | 6,412 | 8,260 | 10,108 |
| 2008 | 16,716 | 18,719 | 20,721 | 6,981 | 8,892 | 10,803 |
| 2009 | 17,265 | 19,329 | 21,392 | 7,560 | 9,536 | 11,511 |
| 2010 | 17,822 | 19,948 | 22,073 | 8,149 | 10,190 | 12,231 |
| 2011 | 18,367 | 20,552 | 22,738 | 8,727 | 10,832 | 12,938 |
| 2012 | 18,897 | 21,142 | 23,386 | 9,293 | 11,461 | 13,629 |
| 2013 | 19,413 | 21,715 | 24,017 | 9,846 | 12,076 | 14,305 |
| 2014 | 19,915 | 22,273 | 24,631 | 10,386 | 12,676 | 14,965 |
| 2015 | 20,403 | 22,815 | 25,227 | 10,913 | 13,261 | 15,609 |
| 2016 | 20,876 | 23,340 | 25,805 | 11,425 | 13,830 | 16,235 |
| 2017 | 21,334 | 23,849 | 26,365 | 11,924 | 14,384 | 16,844 |
| 2018 | 21,777 | 24,342 | 26,907 | 12,408 | 14,922 | 17,436 |
| 2019 | 22,206 | 24,819 | 27,431 | 12,878 | 15,444 | 18,010 |
| 2020 | 22,620 | 25,279 | 27,937 | 13,333 | 15,950 | 18,567 |
| 2021 | 23,020 | 25,723 | 28,426 | 13,774 | 16,440 | 19,106 |
| 2022 | 23,406 | 26,152 | 28,897 | 14,200 | 16,913 | 19,627 |
| 2023 | 23,777 | 26,564 | 29,351 | 14,612 | 17,371 | 20,130 |
| 2024 | 24,135 | 26,962 | 29,789 | 15,010 | 17,813 | 20,617 |
| 2025 | 24,480 | 27,345 | 30,210 | 15,394 | 18,240 | 21,086 |
| 2026 | 24,811 | 27,712 | 30,614 | 15,764 | 18,651 | 21,538 |
| 2027 | 25,129 | 28,066 | 31,003 | 16,121 | 19,047 | 21,974 |
| 2028 | 25,434 | 28,406 | 31,377 | 16,464 | 19,429 | 22,394 |
| 2029 | 25,728 | 28,731 | 31,735 | 16,794 | 19,796 | 22,797 |
| 2030 | 26,009 | 29,044 | 32,079 | 17,112 | 20,148 | 23,185 |
| 2035 | 27,505 | 30,705 | 33,905 | 18,912 | 22,127 | 25,344 |
| 2040 | 29,087 | 32,461 | 35,836 | 20,902 | 24,300 | 27,705 |
| 2045 | 30,419 | 33,940 | 37,461 | 22,648 | 26,195 | 29,754 |
| 2050 | 31,812 | 35,486 | 39,160 | 24,539 | 28,238 | 31,955 |
| 2055 | 33,269 | 37,102 | 40,935 | 26,588 | 30,440 | 34,319 |

(Source: LBG Analysis)

## All Commodities

Figure 16 and Figure 17 show the unconstrained waterway forecasts for all non-grain commodities with high and low forecast bands.

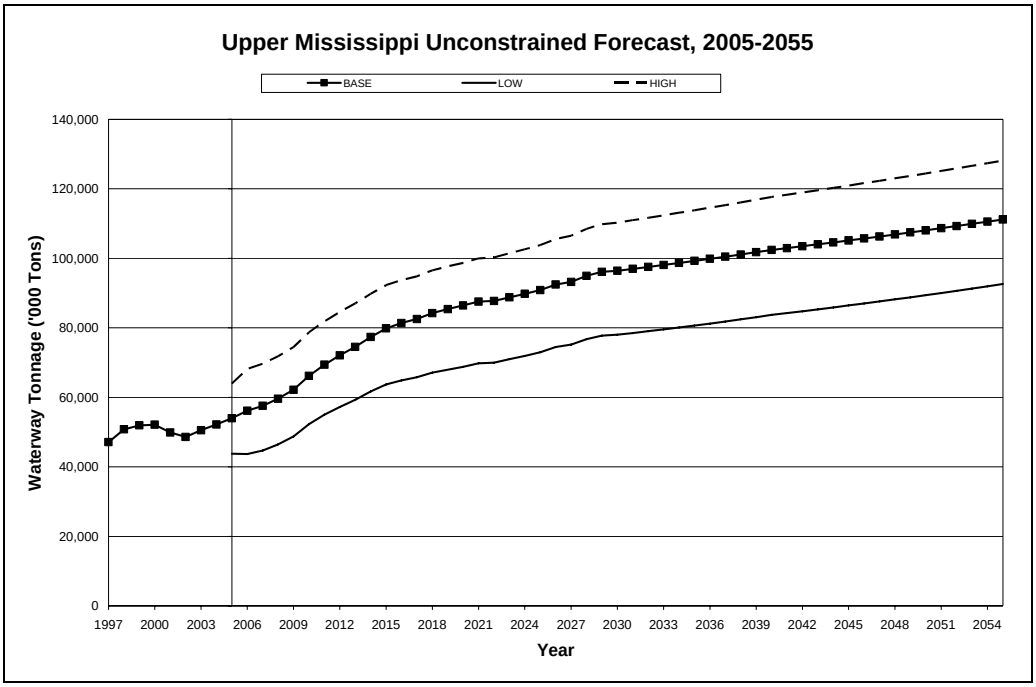



**Figure 16: Upper Mississippi Unconstrained Forecast with high and flow forecast bands**

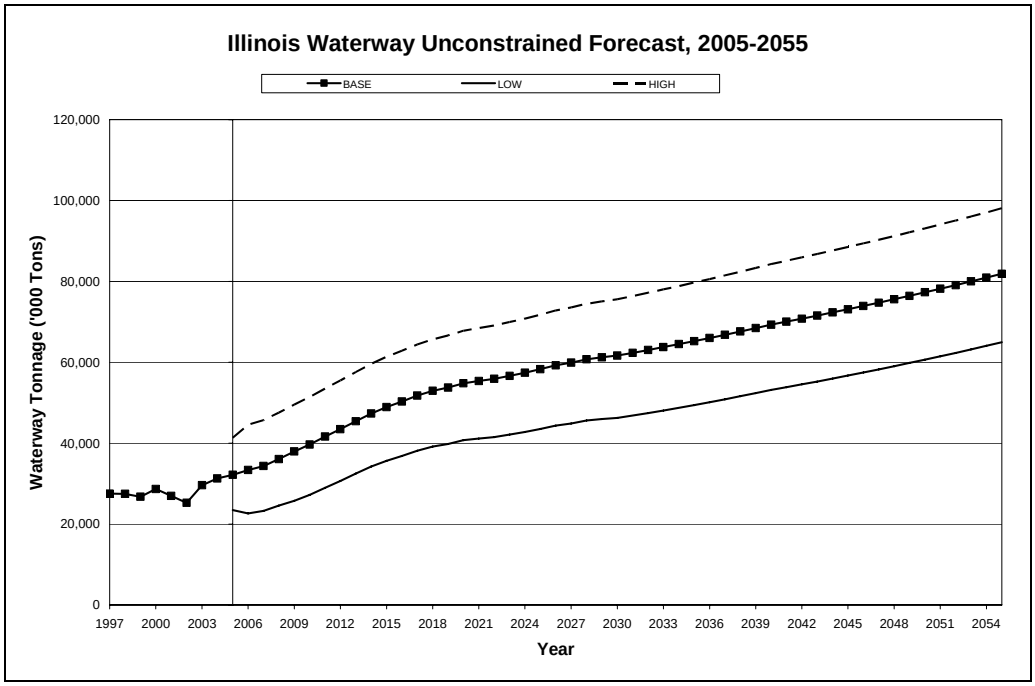



**Figure 17: Illinois Waterway Unconstrained Forecast with high and flow forecast bands**

**Table 8: All Commodities Unconstrained (base, low and high) Forecasts**

| Year | Upper Mississippi | | | Illinois Waterway | | |
|---|---|---|---|---|---|---|
| | Low | Base | High | Low | Base | High |
| 1997 | 47,100 | 47,100 | 47,100 | 27,516 | 27,516 | 27,516 |
| 1998 | 50,815 | 50,815 | 50,815 | 27,473 | 27,473 | 27,473 |
| 1999 | 51,946 | 51,946 | 51,946 | 26,755 | 26,755 | 26,755 |
| 2000 | 52,144 | 52,144 | 52,144 | 28,684 | 28,684 | 28,684 |
| 2001 | 49,887 | 49,887 | 49,887 | 26,970 | 26,970 | 26,970 |
| 2002 | 48,584 | 48,584 | 48,584 | 25,258 | 25,258 | 25,258 |
| 2003 | 50,538 | 50,538 | 50,538 | 29,616 | 29,616 | 29,616 |
| 2004 | 52,195 | 52,195 | 52,195 | 31,297 | 31,297 | 31,297 |
| 2005 | 43,794 | 54,002 | 63,988 | 23,459 | 32,186 | 41,346 |
| 2006 | 43,689 | 56,164 | 68,169 | 22,604 | 33,378 | 44,522 |
| 2007 | 44,732 | 57,580 | 69,710 | 23,278 | 34,355 | 45,676 |
| 2008 | 46,456 | 59,616 | 71,812 | 24,554 | 36,082 | 47,546 |
| 2009 | 48,736 | 62,202 | 74,455 | 25,785 | 37,945 | 49,546 |
| 2010 | 52,277 | 66,222 | 78,708 | 27,195 | 39,682 | 51,428 |
| 2011 | 55,014 | 69,396 | 81,889 | 28,971 | 41,616 | 53,493 |
| 2012 | 57,250 | 72,082 | 84,589 | 30,659 | 43,479 | 55,488 |
| 2013 | 59,310 | 74,553 | 87,026 | 32,462 | 45,432 | 57,567 |
| 2014 | 61,708 | 77,366 | 89,804 | 34,213 | 47,326 | 59,587 |
| 2015 | 63,714 | 79,852 | 92,308 | 35,626 | 48,932 | 61,328 |
| 2016 | 64,881 | 81,373 | 93,757 | 36,844 | 50,317 | 62,842 |
| 2017 | 65,779 | 82,552 | 94,829 | 38,138 | 51,757 | 64,396 |
| 2018 | 67,122 | 84,240 | 96,515 | 39,159 | 52,935 | 65,689 |
| 2019 | 67,965 | 85,401 | 97,691 | 39,813 | 53,755 | 66,629 |
| 2020 | 68,794 | 86,438 | 98,676 | 40,746 | 54,814 | 67,783 |
| 2021 | 69,804 | 87,552 | 99,984 | 41,149 | 55,387 | 68,469 |
| 2022 | 70,004 | 87,735 | 100,243 | 41,508 | 55,907 | 69,102 |
| 2023 | 70,988 | 88,800 | 101,479 | 42,127 | 56,646 | 69,940 |
| 2024 | 71,922 | 89,790 | 102,616 | 42,779 | 57,431 | 70,818 |
| 2025 | 72,981 | 90,863 | 103,795 | 43,519 | 58,308 | 71,779 |
| 2026 | 74,494 | 92,460 | 105,567 | 44,375 | 59,276 | 72,825 |
| 2027 | 75,182 | 93,234 | 106,516 | 44,870 | 59,903 | 73,546 |
| 2028 | 76,791 | 94,984 | 108,498 | 45,606 | 60,745 | 74,469 |
| 2029 | 77,794 | 96,122 | 109,861 | 45,968 | 61,245 | 75,065 |
| 2030 | 78,030 | 96,420 | 110,312 | 46,250 | 61,668 | 75,588 |
| 2035 | 80,669 | 99,269 | 113,848 | 49,417 | 65,238 | 79,708 |
| 2040 | 83,718 | 102,415 | 117,675 | 53,167 | 69,309 | 84,288 |
| 2045 | 86,445 | 105,151 | 120,957 | 56,724 | 73,122 | 88,515 |
| 2050 | 89,416 | 108,079 | 124,439 | 60,653 | 77,306 | 93,103 |
| 2055 | 92,626 | 111,201 | 128,126 | 64,962 | 81,876 | 98,071 |

(Source: LBG Analysis)