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MODAL TRAFFIC IMPACTS OF WATERWAY USER CHARGES
Volume II: Distribution Systems Analysis

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16. Abstract

This report has considered waterway user charges, which have been proposed as a method of cost recovery of Federal expenditures. The report has examined possible modal carrier and traffic impacts due to user charges on the inland river system, and potential differential effects of various cost recovery options. It has found that inland waterway ton-miles may be reduced by as much as ten percent by the recovery of 100 percent of annual Federal operating, maintenance, and rehabilitation expenditures on rivers through a segment-specific toll. Adjustments to the change in transportation prices by economic agents such as shippers, carriers, and producers should act to lower these traffic impacts over the long term. The report is divided into three volumes.

This volume describes the detailed analyses performed to determine the potential impacts of inland waterway cost recovery on waterway traffic and markets. Each chapter describes the distribution system for a particular commodity/industry group and estimates the impact of cost recovery tolls on barge traffic by evaluating potential changes in transportation mode, routing, materials' source, and production technologies.

Volume I describes the methods used in the analyses, summarizes the findings of the distribution system studies, and explores issues related to the type of expenditure and payback level in navigation cost recovery. Volume III is a set of data appendices that summarize segment toll versus fuel tax impacts on barge rates by commodity and river.

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PREFACE

The U.S. Department of Transportation initiated an analysis of the impacts of Federal navigation cost recovery during May 1975. This study is one of a series conducted to examine the modal traffic and carrier impacts of imposing waterway user charges on the U.S. shallow- and deep-draft navigation system. The information provided by these studies will be used by Government and industry to help shape future transportation policies and aid in public resource allocation decisions across programs.

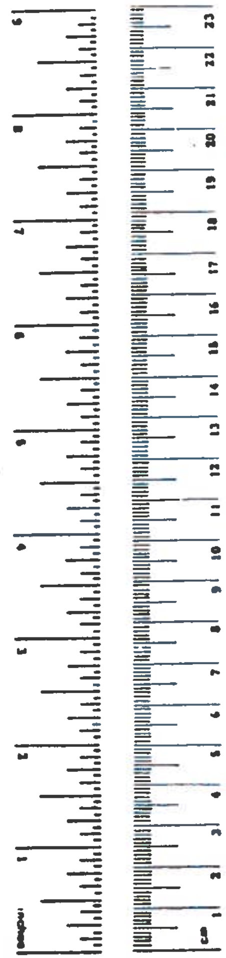
Work to date has focused on the evaluation of various cost recovery options, such as fuel taxes, segment tolls, lockage and license fees, and determining their relative impact on both waterborne commodity movements and alternative distribution systems. Ongoing analysis is evaluating alternative deep-draft navigation user charge options and investigating their impacts on both foreign and domestic traffic, including both coastal and Great Lakes trades.

The report was prepared by the National Transportation Research Division of the U.S. Department of Transportation, Transportation Systems Center in Cambridge MA. The study was sponsored by Dr. Philip E. Franklin, Chief, Special Projects Division (TPI-34) in the Office of the Secretary, Washington DC. Cooperation of the U.S. Coast Guard and the U.S. Army Corps of Engineers is acknowledged and appreciated.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

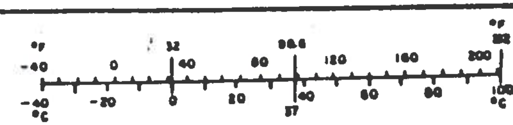


TABLE OF CONTENTS

Section		Page
1.	INTRODUCTION	1
2.	COAL TRAFFIC IMPACTS	3
2.1	Introduction	3
2.2	Energy Market Considerations	3
2.2.1	Western Coal	4
2.2.2	Air Quality Standards	4
2.2.3	Low-Sulfur Eastern Coal	6
2.2.4	Utility Facilities Planning	6
2.2.5	Energy Consumption Forecasts	7
2.3	Energy Transportation Considerations	7
2.4	Upper Mississippi River Utilities	10
2.4.1	Background	10
2.4.2	Coal Price Analysis	11
2.4.3	Coal Traffic Impacts	22
2.5	Illinois River Utilities	33
2.5.1	Background	33
2.5.2	Coal Price Analysis	35
2.5.3	Coal Traffic Impacts	44
2.6	Tennessee River Utilities	49
2.6.1	Background	49
2.6.2	Coal Price Analysis	51
2.6.3	Coal Traffic Impacts	60
2.7	Ohio River Utilities	65
2.7.1	Background	65
2.7.2	Coal Price Analysis	66
2.7.3	Coal Traffic Impacts	73
2.8	Monongahela, Allegheny, and Kanawha Rivers	76
2.8.1	Background	76
2.8.2	Coal Price Analysis	77
2.8.3	Coal Traffic Impacts	77

TABLE OF CONTENTS (CONTINUED)

Section		Page
2.9	Demand for Fossil Fuels by Utilities	80
2.9.1	Background	80
2.9.2	Model Specification	82
2.9.3	Estimation	85
3.	GRAIN TRAFFIC IMPACTS	106
3.1	The Grain Market	106
3.2	User Charge Impacts - An Overview	111
3.3	Traffic Impacts	119
3.3.1	Illinois River Traffic	119
3.3.2	Upper Mississippi River	134
3.3.3	Other Traffic	147
3.3.4	Farm Impacts	148
3.4	Trucking Costs	157
3.5	Estimating the Barge Procurement Area	160
3.5.1	When Bid Prices at Two Points are Known	160
3.5.2	When Bid Price Information is Limited	161
4.	FERTILIZER TRAFFIC IMPACTS	171
4.1	Introduction	171
4.2	Phosphates	173
4.3	Nitrogenous Products	177
4.4	Potash	180
4.5	Transport and Traffic Diversion of Phosphate Rock, Triple Superphosphate, Anhydrous Ammonia, Urea, and Diammonium Phosphate	181
4.6	Final Demand	186
4.7	Summary	190
5.	PETROLEUM TRAFFIC IMPACTS	191
5.1	Background	191
5.2	Future Market Conditions: Petroleum	196
5.3	Future Market Conditions: Transportation	198
5.3.1	Pipelines	198
5.3.2	Barge	198
5.3.3	Railroads	199
5.3.4	Outline of User Charge Analysis	200
5.3.5	Crude Oil Flow Impacts	200
5.3.6	Residual Fuel Oil Traffic Impacts	208
5.3.7	Distillate Fuel Oil Traffic Impacts	216
5.3.8	Gasoline Traffic Impacts	223
5.3.9	Jet Fuel/Kerosene Impacts	226

TABLE OF CONTENTS (CONTINUED)

Section		Page
6.	IRON AND STEEL TRAFFIC IMPACTS	247
6.1	Iron Ore	248
6.2	Coal	250
6.3	Fluxes	252
6.4	Manganese	253
6.5	Scrap	255
6.6	Supplemental Energy	255
6.7	Production Cost Impacts and Traffic Diversion	256
6.7.1	Pittsburgh	261
6.7.2	Ohio River Production Area	267
6.7.3	Illinois - Indiana	270
6.7.4	Alabama	272
6.7.5	Houston	275
6.8	Finished Products	279
6.9	Summary	285
7.	SAND AND GRAVEL TRAFFIC IMPACTS	287
7.1	Introduction	287
7.2	The Missouri River	294
7.3	The Arkansas River	296
7.4	The Upper Mississippi	297
7.5	The Illinois River	299
7.6	The Ohio River and Its Tributaries	300
7.7	The Tennessee and Cumberland Rivers	305
7.8	Gulf Intracoastal Waterway	307
7.9	The Columbia and Willamette Rivers	308
7.10	Other Rivers Where Sand and Gravel Traffic Will Be Significantly Impacted by User Charges	309
7.11	Related Products	310
7.12	Summary	310
8.	CHEMICAL TRAFFIC IMPACTS	313
8.1	Petrochemical	313
8.2	Benzene and Toluene (Commodity Code 2817)	314
8.2.1	Alcohols (Commodity Code 2813)	317
8.2.2	Other Commodities	320
8.2.3	Conclusions	320
8.3	Sulfur and Sulfuric Acid	321
8.3.1	Background	321
8.3.2	The Structure of the Sulfur Industry	324

TABLE OF CONTENTS (CONTINUED)

Section		Page
8.3.3	Product Characteristics and Shipping Considerations	325
8.3.4	The Importance of Water Transport	326
8.3.5	The Effect of a User Charge	327
8.3.6	Summary	332
9.	OTHER WATERBORNE TRAFFIC	334
9.1	Salt	334
9.2	Miscellaneous	337
10.	REFERENCES	339

LIST OF ILLUSTRATIONS

Figure		Page
1.	ILLINOIS RIVER PROCUREMENT AREA FOR CORN	128
2.	SHIFTS IN PROCUREMENT AREA DUE TO USER CHARGES	129
3.	APPROXIMATE RAIL RATE AREAS FOR 50 CAR SHIPMENTS TO GULF	138
4.	TRUCK-BARGE PROCUREMENT AREA U.S. 50, 75, AND 118 CAR RATES	140
5.	BARGE PROCUREMENT AREA -- 50 CAR RAIL-BARGE (BARGE RATE = CONTRACT LEVEL)	141
6.	TRUCKING COSTS TO COUNTRY ELEVATORS	159
7.	GRAIN PRICE BIDS AT TWO POINTS	160
8.	GRAIN TRANSSHIPMENT COMPETITION BETWEEN TWO POINTS	161
9.	DIFFERENTIAL BETWEEN GULF AND ILLINOIS RIVER BIDS FOR CORN	168
10.	DIFFERENTIAL BETWEEN GULF AND ILLINOIS RIVER BIDS FOR SOYBEANS	169
11.	GRAIN PROCUREMENT AREAS - CUMULATIVE PERCENTAGE OF GRAIN RECEIVED FROM DIFFERENT DISTANCES	170

LIST OF ILLUSTRATIONS (CONTINUED)

Figure — Page

12. PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICTS 230

13. INPUT OUTPUT RELATIONSHIPS IN THE IRON AND STEEL INDUSTRY 257

LIST OF TABLES

Table — Page

1. 1975 COAL DELIVERED PRICE IN CENTS PER MILLION BTU: UPPER MISSISSIPPI UTILITIES 13

2. DELIVERED PRICE (ILLINOIS COAL) IMPACTS OF POLLUTION CONTROL SYSTEMS: UPPER MISSISSIPPI UTILITIES (CENTS PER M. BTU) 16

3. COAL BY SULFUR CONTENT (%) BY WEIGHT: 1975 17

4. NAVIGATION COST RECOVERY IMPACTS ON DELIVERED COAL PRICES (1975 - ¢/M.BTU) 19

5. FUEL TAX AND CLEAN AIR IMPACTS ON DELIVERED COAL PRICES (1975: ¢/M. BTU) 20

6. RAIL/BARGE VERSUS ALL-RAIL COSTS TO UPPER MISSISSIPPI UTILITIES (1975-¢/M. BTU 21

7. 1975 WESTERN AND EASTERN COAL TONS AND TON-MILES: UPPER MISSISSIPPI RIVER (ESTIMATED) 24

8. EFFECTS OF STRICT AIR QUALITY REQUIREMENTS ON WATERBORNE COAL TRAFFIC TO UPPER MISSISSIPPI UTILITIES (ESTIMATED): 70% WESTERN COAL USE; 1975 DEMAND LEVELS 26

9. PRICE ELASTICITIES FOR WESTERN COAL COST SHARES: 1975 COAL USE - UPPER MISSISSIPPI UTILITIES 29

10. 1975 DELIVERED PRICE FOR COAL TO ILLINOIS RIVER UTILITIES (CENTS PER MILLION BTU) 36

11. ILLINOIS COAL DELIVERED PRICE IMPACTS OF POLLUTION CONTROL SYSTEMS (CENTS PER M.BTU) 38

LIST OF TABLES (CONTINUED)

Table		Page
12.	UTILITY COAL SULFUR CONTENT BY WEIGHT AS BURNED: 1975	39
13.	WATERWAY USER CHARGE IMPACTS ON DELIVERED COAL PRICES (1975 - ¢/M.BTU)	41
14.	ALL-RAIL VERSUS RAIL/BARGE DELIVERED COAL PRICES TO ILLINOIS WATERWAY UTILITIES (1975 - ¢/M.BTU)	43
15.	RAIL VERSUS BARGE COSTS (¢/M.BTU - 1975): FINAL DELIVERY TO PLANT VIA HAVANA, IL	45
16.	1975 DELIVERED PRICES FOR COAL IN CENTS PER MILLION BTU: TENNESSEE RIVER UTILITIES	53
17.	ESTIMATED DELIVERED PRICE OF HIGH-SULFUR COAL INCLUDING POLLUTION CONTROL COSTS: TENNESSEE RIVER UTILITIES (¢/M.BTU - 1975 PRICES)	55
18.	DELIVERED PRICE OF EASTERN LOW-SULFUR COAL VERSUS WESTERN COAL AND POLLUTION CONTROL: (¢/M.BTU - 1975	56
19.	DELIVERED PRICE IMPACTS OF WATERWAY USER CHARGES (¢/M.BTU - 1975)	58
20.	ALL-RAIL DELIVERED PRICES VERSUS EXISTING AND RAIL/ BARGE COSTS AFTER USER CHARGES (¢/M.BTU - 1975)	59
21.	1975 DELIVERED PRICE OF COAL FROM EASTERN AND WESTERN SOURCES: OHIO RIVER UTILITIES (¢/M.BTU)	67
22.	1975 DELIVERED COAL PRICES ASSUMING POLLUTION CONTROL REQUIREMENTS: OHIO RIVER UTILITIES (c/M.BTU)	68
23.	SULFUR CONTENT BY WEIGHT AT OHIO RIVER UTILITIES: 1975	70
24.	NAVIGATION COST RECOVERY IMPACTS ON EXISTING DELIVERED COAL PRICES: OHIO RIVER UTILITIES (¢/M.BTU)	71
25.	USER CHARGE IMPACTS ON DELIVERED PRICE OF WESTERN COAL TO OHIO RIVER UTILITIES (1975 - ¢M.BTU)	72

LIST OF TABLES (CONTINUED)

Table		Page
26.	USER CHARGE IMPACTS ON LOW-SULFUR WEST VIRGINIA COAL: OHIO RIVER UTILITIES (1975 - ¢/M.BTU).........	74
27.	1975 DELIVERED PRICE IMPACTS DUE TO WATERWAY USER CHARGES (¢/M.BTU).................................	78
28.	SYMBOL DEFINITIONS AND MODEL EQUATIONS...............	87
29.	WESTERN COAL COST SHARE EQUATIONS; UPPER MISSISSIPPI RIVER UTILITIES: SINGLE CONSTANT AND UTILITY DUMMIES..	88
30.	WESTERN COAL COST SHARE EQUATION: ¢ PER MILLION BTU (INSTEAD OF $/TON) AND LOGIT FORMULATION.............	89
31.	PRICE ELASTICITY CALCULATIONS: 1975 COAL COST SHARE VALUES FOR UPPER MISSISSIPPI UTILITIES...............	90
32.	MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): UPPER MISSISSIPPI RIVER.....................	91
33.	BN UNIT TRAIN COAL TARIFF DATA, 1975 (RATE IN DOLLARS PER TON)......................................	92
34.	STEAM COAL PURCHASES BY UPPER MISSISSIPPI UTILITIES BY ORIGIN: 1972 AND 1975..........................	94
35.	MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): ILLINOIS RIVER.............................	95
36.	UNIT TRAIN ICG BITUMINOUS COAL TARIFF DATA, 1975.....	96
37.	STEAM COAL PURCHASES BY ILLINOIS RIVER UTILITIES BY ORIGIN: 1973 AND 1975..........................	97
38.	MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): TENNESSEE RIVER............................	98
39.	UNIT TRAIN SOUTHERN RAIL COAL TARIFF (1975) (RATES IN $ PER TON).....................................	99
40.	STEAM COAL PURCHASES BY TENNESSEE RIVER UTILITIES BY ORIGIN STATE: 1973 AND 1975......................	100
41.	MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): OHIO RIVER.................................	101

LIST OF TABLES (CONTINUED)

Table		Page
42.	STEAM COAL PURCHASES BY MAJOR U.S. UTILITIES IN 1975: OHIO RIVER	103
43.	MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): MONONGAHELA, ALLEGHENY AND KANAWA RIVERS	104
44.	STEAM COAL PURCHASES BY MAJOR U.S. UTILITIES IN 1975: MONONGAHELA, ALLEGHENY AND KANAWHA RIVERS	105
45.	ALTERNATIVE MARKETS FOR INLAND ELEVATORS	108
46.	AVERAGE PRICE DIFFERENTIALS ON CORN -- GULF VS. ILLINOIS RIVER BARGE TERMINAL (¢ bu)	109
47.	FARM SALE STRATEGY BEFORE AND AFTER IMPLEMENTATION OF A USER CHARGE	117
48.	GENERAL RAIL RATE INCREASES	118
49.	ILLINOIS RIVER BARGE SHIPMENT PATTERNS (1000 SHORT TONS)	120
50.	USER CHARGE FROM SELECTED ILLINOIS POINTS TO NEW ORLEANS (¢)	121
51.	CURRENT MULTI-CAR RATES FOR EXPORT FROM ILLINOIS POINTS	123
52.	PER BUSHEL ESTIMATED CONTRACT BARGE RATES - EARLY 1976	125
53.	GULF-BOUND EXPORT RAIL RATES FROM ILLINOIS	126
54.	GRAIN PROCUREMENT PATTERN FOR ILLINOIS RIVER BARGE TERMINALS	131
55.	THE UPPER MISSISSIPPI RIVER BARGE SHIPMENT PATTERN - 1974 (1000 SHORT TONS)	135
56.	USER CHARGES FOR UPPER MISSISSIPPI GRAIN SHIPMENTS TO NEW ORLEANS (100% OM&R)	137
57.	ESTIMATED PROCUREMENT PATTERNS OF UPPER MISSISSIPPI RIVER BARGE TERMINALS	143

LIST OF TABLES (CONTINUED)

Table		Page
58.	UNIT COSTS OF PRODUCING SELECTED GRAINS IN 1974 - U.S. AVERAGE PER BUSHEL	151
59.	POTENTIAL INCOME LEAKAGES FROM GRAIN SHIPPING REGIONS	154
60.	1974 CORN BIDS - CENTS/BUSHEL	162
61.	1975 CORN BIDS - CENTS/BUSHEL	163
62.	1976 CORN BIDS - CENTS/BUSHEL	164
63.	1974 SOYBEAN BIDS - CENTS/BUSHEL	165
64.	1975 SOYBEAN BIDS - CENTS/BUSHEL	166
65.	1976 SOYBEAN BIDS - CENTS/BUSHEL	167
66.	USES OF PHOSPHATE ROCK	174
67.	WET-PROCESS PHOSPHORIC ACID DISPOSITION IN FERTILIZER USE	176
68.	FERTILIZER MATERIALS: AVERAGE PRICE PER TON PAID BY FARMERS, BY STATES, APRIL 15, 1976	188
69.	PRICES PAID BY FARMERS PER TON FOR SELECTED COMMERCIAL FERTILIZERS, UNITED STATES	189
70.	COMPARATIVE MODAL TONS AND TON-MILES: CRUDE OIL AND PETROLEUM PRODUCTS (1973)	192
71.	REPRESENTATIVE CRUDE AND PETROLEUM PRODUCT SHIPMENT COSTS BY PIPELINE	194
72.	REPRESENTATIVE RAIL AND BARGE PETROLEUM SHIPMENT COSTS	195
73.	U.S. PIPELINE TRAFFIC TO 1990 (BILLIONS OF TON-MILES)	197
74.	1972 AND 1974 WATERBORNE CRUDE PETROLEUM TRAFFIC BY SECTOR	201
75.	BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF CRUDE PETROLEUM (1975$)	203

LIST OF TABLES (CONTINUED)

Table		Page
76.	MODAL SHIPMENT COSTS FOR CRUDE PETROLEUM: SELECTED ORIGIN/DESTINATIONS	205
77.	1972 WATERBORNE CRUDE PETROLEUM TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	206
78.	1972 AND 1974 WATERBORNE RESIDUAL FUEL OIL TRAFFIC BY SECTOR (000's OF TONS)	209
79.	BARGE SHIPMENT COSTS: RESIDUAL FUEL OIL (1975)	211
80.	MODAL SHIPMENT COSTS FOR RESIDUAL FUEL OIL: SELECTED ORIGIN/DESTINATIONS	214
81.	1972 WATERBORNE RESIDUAL FUEL OIL IMPACTS DUE TO USER CHARGES BY SECTOR	215
82.	1972 AND 1974 WATERBORNE DISTILLATE FUEL OIL TRAFFIC BY SECTOR (000's OF TONS)	217
83.	BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF DISTILLATE FUEL OIL (1975$)	219
84.	MODAL SHIPMENT COSTS FOR DISTILLATE FUEL OIL: SELECTED ORIGIN/DESTINATIONS	220
85.	1972 WATERBORNE DISTILLATE FUEL OIL TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	222
86.	1972 AND 1974 WATERBORNE GASOLINE TRAFFIC BY SECTOR (000's OF TONS)	224
87.	BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF GASOLINE	225
88.	1972 WATERBORNE GASOLINE TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	227
89.	1972 AND 1974 WATERBORNE JET/FUEL KEROSENE TRAFFIC BY SECTOR (000's OF TONS)	228
90.	1972 WATERBORNE JET FUEL/KEROSENE TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	229
91.	CRUDE OIL PIPELINE BETWEEN PADDS - 1973	231
92.	PETROLEUM PRODUCT PIPELINES BETWEEN PADDS -1973	232

LIST OF TABLES (CONTINUED)

Table		Page
58.	UNIT COSTS OF PRODUCING SELECTED GRAINS IN 1974 - U.S. AVERAGE PER BUSHEL	151
59.	POTENTIAL INCOME LEAKAGES FROM GRAIN SHIPPING REGIONS	154
60.	1974 CORN BIDS - CENTS/BUSHEL	162
61.	1975 CORN BIDS - CENTS/BUSHEL	163
62.	1976 CORN BIDS - CENTS/BUSHEL	164
63.	1974 SOYBEAN BIDS - CENTS/BUSHEL	165
64.	1975 SOYBEAN BIDS - CENTS/BUSHEL	166
65.	1976 SOYBEAN BIDS - CENTS/BUSHEL	167
66.	USES OF PHOSPHATE ROCK	174
67.	WET-PROCESS PHOSPHORIC ACID DISPOSITION IN FERTILIZER USE	176
68.	FERTILIZER MATERIALS: AVERAGE PRICE PER TON PAID BY FARMERS, BY STATES, APRIL 15, 1976	188
69.	PRICES PAID BY FARMERS PER TON FOR SELECTED COMMERCIAL FERTILIZERS, UNITED STATES	189
70.	COMPARATIVE MODAL TONS AND TON-MILES: CRUDE OIL AND PETROLEUM PRODUCTS (1973)	192
71.	REPRESENTATIVE CRUDE AND PETROLEUM PRODUCT SHIPMENT COSTS BY PIPELINE	194
72.	REPRESENTATIVE RAIL AND BARGE PETROLEUM SHIPMENT COSTS	195
73.	U.S. PIPELINE TRAFFIC TO 1990 (BILLIONS OF TON-MILES)	197
74.	1972 AND 1974 WATERBORNE CRUDE PETROLEUM TRAFFIC BY SECTOR	201
75.	BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF CRUDE PETROLEUM (1975$)	203

LIST OF TABLES (CONTINUED)

Table		Page
76.	MODAL SHIPMENT COSTS FOR CRUDE PETROLEUM: SELECTED ORIGIN/DESTINATIONS	205
77.	1972 WATERBORNE CRUDE PETROLEUM TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	206
78.	1972 AND 1974 WATERBORNE RESIDUAL FUEL OIL TRAFFIC BY SECTOR (000's OF TONS)	209
79.	BARGE SHIPMENT COSTS: RESIDUAL FUEL OIL (1975)	211
80.	MODAL SHIPMENT COSTS FOR RESIDUAL FUEL OIL: SELECTED ORIGIN/DESTINATIONS	214
81.	1972 WATERBORNE RESIDUAL FUEL OIL IMPACTS DUE TO USER CHARGES BY SECTOR	215
82.	1972 AND 1974 WATERBORNE DISTILLATE FUEL OIL TRAFFIC BY SECTOR (000's OF TONS)	217
83.	BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF DISTILLATE FUEL OIL (1975$)	219
84.	MODAL SHIPMENT COSTS FOR DISTILLATE FUEL OIL: SELECTED ORIGIN/DESTINATIONS	220
85.	1972 WATERBORNE DISTILLATE FUEL OIL TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	222
86.	1972 AND 1974 WATERBORNE GASOLINE TRAFFIC BY SECTOR (000's OF TONS)	224
87.	BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF GASOLINE	225
88.	1972 WATERBORNE GASOLINE TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	227
89.	1972 AND 1974 WATERBORNE JET/FUEL KEROSENE TRAFFIC BY SECTOR (000's OF TONS)	228
90.	1972 WATERBORNE JET FUEL/KEROSENE TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS	229
91.	CRUDE OIL PIPELINE BETWEEN PADDS - 1973	231
92.	PETROLEUM PRODUCT PIPELINES BETWEEN PADDS -1973	232

LIST OF TABLES (CONTINUED)

Table		Page
93.	1972 CRUDE PETROLEUM FLOWS ORIGINATING IN BEA 138 (NEW ORLEANS/BATON ROUGE)	233
94.	1972 CRUDE PETROLEUM FLOWS ORIGINATING IN BEA 140 (PORT ARTHUR TX)	234
95.	MAJOR U.S. UTILITIES RECEIVING PETROLEUM PRODUCTS VIA WATER (1974)	235
96.	RAIL RATES - RESIDUAL FUEL OIL - DONLEY STUDY	239
97.	RAIL RATES - RESIDUAL FUEL OIL - PACE COMPANY (1974).	240
98.	1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 138 (NEW ORLEANS/BATON ROUGE, LA)	241
99.	1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 140 (PORT ARTHUR, TX)	242
100.	1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 139 (LAKE CHARLES, LA)	243
101.	1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 141 (HOUSTON, TX)	244
102.	1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 52 (ASHLAND, KY)	245
103.	1972 RAIL FLOWS OF DISTILLATE FUEL OIL: SELECTED BEA MOVEMENTS (1972 ICC RAIL WAYBILL DATA)	246
104.	SALIENT MANGANESE STATISTICS IN THE UNITED STATES (SHORT TONS)	254
105.	INPUTS PER TON OF RAW STEEL PRODUCTION BY PROCESS - 1975 NATIONAL AVERAGES	259
106.	INPUTS PER TON OUTPUT OF PIG IRON	260
107.	STEEL PRODUCTION COST IMPACTS FROM WATERWAY USER CHARGES (100% OM&R, BASIC OXYGEN PROCESS)	262
108.	STEEL PRODUCTION COST IMPACTS FROM WATERWAY USER CHARGES (100% OM&R, BOP PROCESS)	269
109.	STEEL PRODUCTION COST INCREASES IN ILLINOIS-INDIANA PRODUCTION AREA (100% OM&R BOP PROCESS)	271

LIST OF TABLES (CONTINUED)

Table		Page
110.	STEEL PRODUCTION COST IMPACTS FROM WATERWAY USER CHARGES (100% OM&R, BASIC OXYGEN PROCESS)	276
111.	BARGE SHIPMENTS RELATIVE TO ESTIMATED TOTAL SHIPMENTS BY REGION — AVERAGE 1973 AND 1974	281
112.	MARKET SHARES BY DESTINATION FOR BARGE TRAFFIC FROM MAJOR PRODUCING AREAS 1974	282
113.	FINAL USES OF SAND AND GRAVEL	288
114.	METHOD OF TRANSPORTATION TO SITE OF USE	289
115.	THE OHIO RIVER AND ITS TRIBUTARIES	301
116.	DISTRIBUTION OF DOMESTIC SULFUR CONSUMPTION IN 1966	323
117.	DESTINATIONS OF RANGE SHIPMENT OF LIQUID SULFUR ON THE MISSISSIPPI RIVER SYSTEM	328
118.	MAJOR INTERNAL BARGE SHIPMENTS OF SULFURIC ACID, 1972 AND 1973	329
119.	MISSISSIPPI RIVER SYSTEM TON-MILES, 1972	335

EXECUTIVE SUMMARY

Volume II determines modal traffic and carrier impacts under user charge imposition by major commodity distribution systems; coal, grains, fertilizer, petroleum, iron and steel, sand and gravel, chemicals, and other traffic. User charge impacts are based on the potential recovery of 100 percent of Federal (Army Corps of Engineers and Coast Guard) operations, maintenance, and repair (OM&R) expenditures on the inland and coastwise waterway system. Two major recovery methods are considered; a uniform system-wide fuel tax to recover all expenditures and a segment toll that collects back expenditures on a river sector from traffic utilizing that part of the system. Toll calculations were based on a five-year (1971-1975) average of system expenditures (see Section 2, Volume I for details).

To consistently analyze waterborne traffic changes due to user charges across commodity distribution systems, the Waterways Traffic Impact Model (described in Volume I, Section 3) is used. The model combines data on the inland waterway network, 1972 system commodity flows, estimated barge rates, and proposed user charge options (segment and fuel tax) to calculate effects on shipment costs and, ultimately, traffic and carrier impacts due to user charges. The results were analyzed in the context of distribution systems and their constraints to determine actual modal or market shifts from user charges relative to future transportation and market changes from other factors.

The following sections summarize the findings by major commodity groups:

Coal Traffic

Cost recovery of Federal inland navigation expenditures will not seriously impact existing waterways coal traffic or hinder its future growth. In general, the cost for a water-served utility to shift to delivery of coal by rail is found to exceed by far the additional costs user charges imposed on water transportation. Further, an examination of energy markets and future demand reveals that shifts to low-sulfur fuels by utilities could increase waterway ton-miles and revenue due to longer length of river haul and increased tonnages. In almost all cases, user charges did not affect the relative price advantages of low-sulfur fuels over stack scrubber retrofit or of barge transportation over rail for final delivery to plant. If strict air quality standards are legislated, coal market adjustments that result will easily overwhelm impacts of user charges.

Detailed examination of river segments yielded some potential market diversion (i.e., shifts to alternative coal sources) by utilities due to user charges but little evidence of modal diversion from the relative increase in barge costs. In the highly competitive coal markets serving Upper Mississippi utilities, user charges would further increase the relative price advantage of western over eastern coal (due to a longer length of haul for eastern flows). Although final delivery remains via water, use of low-sulfur western coal could increase from 3 to 11 percent (at the expense of eastern coal) due to user charge imposition. The final market diversion depends on the severity of future air quality standards. Upper Mississippi coal ton-miles and carrier revenues would fall slightly due to shorter lengths of haul.

Illinois River's western and eastern coal traffic would be equally impacted by user charges since they both enter the river at Havana IL. Relative delivered price structures by mode are unchanged. All-rail operations for final delivery to Chicago area utilities is unlikely because of yard congestion and the high costs of converting to rail delivery.

Tennessee River utilities are also heavily committed to final plant delivery by water. User charges did not change the relative rail-barge rate structure to favor rail because substantial investment in new unloading facilities would also be required. If strict air quality standards were legislated, low-sulfur coal traffic from Knoxville, TN on the Tennessee River would increase, and overall ton-miles and revenue to carriers by water would rise.

Utilities located along the Ohio River are also tied to barge delivery of coal. Coal flows tend to average less than 150 miles making them shorter than moves on other major rivers. Due to heavy commitments to waterborne delivery facilities, conversion to rail is expensive and unlikely. Estimated user charges reduce the all-rail versus barge rate differential by less than 10 percent. Potential coal market shifts are possible if cost-minimizing strategies remain a dominant decision mode. At present, the major factor is whether sufficient eastern low-sulfur coal is available to utilities on the Ohio to meet air quality standards. Longer lengths of haul of western low-sulfur coal to these utilities is possible but existing coal flow patterns and modes will probably remain unchanged even under user charges.

Although segment tolls are relatively high in comparison to other rivers, coal traffic on the Monongehela, Allegheny, and Kanawha Rivers should not be adversely affected by user charges. Average barge haulage of coal is between 10 and 25 miles on the rivers. Overall impacts of user charges on final delivered price are minimal and less than 5 percent of barge rates. As before, user charges are substantially less than rail conversion costs, making diversion not cost effective for utilities.

Finally, feedback effects from increased electricity prices due to user charge pass-through may act to reduce total fuel demand by utilities. Previous calculations indicated that, on average, 100-percent OM&R user charges would increase electricity prices to residential consumers by less than 0.5 percent. Using current long-run price elasticity measures for electricity demand, net reduction in demand would be slightly greater than 0.5 percent (-0.06 percent). Reduction in overall coal demand by the utility would be negligible. Factors such as decreasing Btu content of low-sulfur coal will result in higher tonnage shipments of coal to utilities that more than offset any feedback effects of a fall in electricity consumption due to user charges.

Grain Traffic

The study analyzes the impact of waterway user charges on the Upper Mississippi and Illinois River grain traffic, which, in 1972, accounted for almost 30 billion system ton-miles. Perhaps the most important factor in determining the traffic impacts of the user charge is the response to an eased competitive situation from other parties in the grain distribution system -- exporters, railroads, processors, feeders, etc. For example, if, as many industry analysts argue will happen, railroads respond to barge rate increases with comparable grain rate increases on competing traffic, the traffic diversion potential will be significantly reduced.

If other prices remain fixed -- i.e., if best alternative marketing channels remain at pre-user charge levels - potential diversion would be substantial. Under a segment toll for the recovery of 100% of OM&R, we estimate potential diversion of up to 10 percent on the Illinois River (slightly higher at the lower-volume upstream areas), and a ceiling of about that level on the Upper Mississippi. (The competitive picture in the area is currently in a state of flux which makes precise estimates difficult.) Ten-percent diversion of Upper Mississippi River and Illinois River grain traffic would account for about 3-billion ton-miles of barge commerce.

The grain traffic from these areas is heavily oriented toward export, and thus much of the flow is on the low-cost Lower Mississippi River. Because of this, user charges under the fuel tax option are considerably higher than under the segment toll approach. Potential diversion is, therefore, from 50 to 100 percent higher under that option--especially on the Illinois River.

If probabilities must be placed on the likelihood of these alternative scenarios, educated opinion would suggest that diversion will not be as large as the potentials suggested by the analysis. Although responses which are fully offsetting to user charges are unlikely, much of their impact will be mitigated in the short run by capacity considerations throughout the grain distribution system, and in the long run, by rail export responses and natural traffic growth.

To the extent that user charge impacts are not manifested in waterway traffic losses, the impact on farm grain prices will be extended to more producers. A brief analysis of farm impacts in this study suggests that while farm price declines of the magnitude of 1 to 3 cents per bushel (the average user charge in these areas) would reduce farm incomes (and, in the longer term, agricultural land values), these impacts are quite small when compared with the other market forces (particularly the world grain situation) which will determine the future welfare of the American farmer.

Because of the limitations on information at the time of this writing, the analysis does not extend to the less important Missouri and Ohio River shipping areas. Preliminary indications are that a segment toll (5 to 8 dollars per ton above Kansas City) would make the Missouri River totally non-economic as a grain outlet, and suggest that a fuel tax ($1.10 to $1.30 for the same area) would effect a similar result. The Ohio River would probably suffer only small traffic losses under a segment toll (0.6¢ per bushel at Evansville and 1¢ at Cincinnati), but would face user charges to export points three to four times that magnitude under a fuel tax.

The analysis also does not focus on the wheat economy. Because of the greater role of the Great Lakes in wheat exports, and the competition for spring wheat from the Dakotas among different coastal areas (Pacific, Gulf, and Great Lakes), it is preferable to treat this grain in the deep draft user charge context.

Fertilizer

User charge impacts would be negligible on the consumer of fertilizers due to the high value of the commodity and the already existing fluctuations in price common to the industry. Although the level of user charge is insignificant relative to the total price of fertilizer, it is fairly substantial as a percentage of transport costs. As a result there will be some modal diversion and shifting in the location of production facilities.

Quantification of the potential tonnage diversion is not possible at this time. The fertilizer industry is highly concentrated and company policy is an important factor in market area dominance and distribution strategy. The situation does not readily lend itself to a tight-knit statistical analysis, or are the data which would be required available.

The conclusions are thus conservative. Phosphate rock is the most highly divertable of the fertilizers moving on the river system due to the high cost of transport per ton of nutrient. The result would be expansion of existing facilities for DAP in the Delta area and Central Florida (secondary impacts would mean increased barge shipments of DAP). Anhydrous ammonia is the most important fertilizer moving by barge, and in the short run, it will continue to be due to the substantial investment in facilities to handle this commodity and the associated long-term contracts. In the long-run, pipeline will gain some of this tonnage. There will be an attempt to shift to rail for delivery of triple superphosphate, urea, and DAP to certain areas. Capacity constraints will inhibit a free decision of modal choice. The volume of fertilizer shipments coupled with the seasonal nature of demand means that all modes are necessary in an efficient fertilizer distribution system. Barge may lose a small share of its traffic but it will continue as an essential mode moving a large volume of fertilizer annually.

Petroleum Traffic

The combination of increased competition from pipelines and user charge impacts on relative modal costs will affect both existing and future levels of water petroleum traffic. In general, shipment costs via pipeline are significantly less expensive than either barge or rail delivery to inland consumers. However, pipeline capacity constraints, limited destinations and large shipment size requirements have traditionally allowed substantial delivery via water. In recent years, inland waterborne petroleum traffic has fallen rapidly in all groups except residual oil (no pipeline competition).

Predictions of future energy market conditions do not favor continuation of the current distribution pattern or modal shares of existing petroleum traffic. Although large amounts of petroleum products move from Gulf coast origins to northern consumption points such as St. Louis or Chicago, the major movement of petroleum on waterways is inter-facility transfers along the Gulf coast. Declining domestic oil production will impact both sets of flows. Intra-Gulf transfers of oil and product shipments to traditional Mid-continent markets will decline. Imports of foreign crude and Alaskan oil will travel directly via pipeline to northern refineries, replacing embargoed Canadian oil. Increased imports of foreign oil products is also possible. Unloaded at Gulf deep-water ports, these flows would tend to move directly to consumption centers via pipeline. Reduced domestic pipeline traffic will imply substantial competition for remaining oil flows. Relatively lower pipeline transportation costs will favor diversion from peak-load barge delivery to underutilized pipelines.

Under the above scenarios, user charges can only result in a worsening of the competitive position of barge in obtaining petroleum traffic. Imposition of fuel taxes to collect 100% of Federal OM&R expenditures would increase barge rates for petroleum products from 10 to 15 percent. Segment toll impacts are somewhat less, resulting in only 6-to-10 percent increases for major flows. Given that pipeline rates are already one-half to two-thirds of barge rates, cost advantages of pipelines will be strengthened. Since impacts and potential modal diversion vary among petroleum product classes, each is examined individually.

Impacts of user charges on crude oil traffic via waterways appear minimal. Barge serves as a short-haul collection and distribution system for crude oil in the Gulf region with operations to and from non-pipeline served facilities a major component of the traffic. Although some increase in pipeline competition for intra-Gulf crude transfers is possible, the non-substitute nature of crude oil barge traffic with respect to pipeline makes diversion unlikely. Declining domestic oil production will impact barge crude oil traffic much more severely.

Residual fuel oil flows on the inland river system face no competition from pipelines and almost none from railroads. Residual oils are highly viscous and generally non-pipeable. User charges have little impact on delivered prices for residual fuel and would result in no diversion of traffic from water. However, direct importation of foreign residual oil due to declining domestic supplies could affect present distribution patterns. Due to high fuel costs, inter-fuel substitution away from residual to coal or nuclear may also affect waterborne traffic.

Distillate fuel oil, gasoline and jet fuel/kerosene flows on inland waterways are closely competitive with pipeline traffic and may be the most heavily impacted by user charges. As long as product pipelines to the midwest remain near practical capacity, barge deliveries from the Gulf will remain substantial. However, reduced domestic product production could result in pipelines gaining traditional barge shipments due to favorable cost conditions. In general, five to seven percent of long-haul water movements of petroleum products (to major distribution centers) could divert to pipeline in the future due to transportation market conditions. User charges would act in a complementary fashion to increase the pipeline cost advantage over barge. Partial diversion may also occur. Petroleum products could be piped to St. Louis, Chicago, or along the Ohio River with final delivery by barge. The savings in transportation costs would be substantial if pipeline capacity were available. Reduction in barge ton-miles on the river system due to such an operation is estimated to be less than two percent if a maximum of six percent of petroleum products traffic is partially diverted to pipeline.

Iron and Steel Traffic

User charges for the recovery of 100 percent of Federal expenditures for operations and maintenance of the inland waterway system would have small impacts on the cost of producing steel in the areas bordering the river system. Even under a set of assumptions concerning input sources and steel making technologies which bias the results upward, the cost impacts are estimated to range from only 4 to 6 cents per ton in the Northern Illinois-Indiana production area which does not rely on the river system for iron ore, coal, or limestone, to between 40 and 50 cents for U.S. Steel's Alabama facility which receives its iron ore up the Warrior River from Mobile and Armco Steel's Houston plant which consumes barge-delivered coal from West Virginia. These cost increases represent from .0001 to .0017 of the composite price of finished steel in 1975.

For a variety of reasons, institutional as well as economic, little likelihood is seen of diversion of the important metallurgical coal traffic in the Pittsburgh and Ohio River producing areas. The study does identify three significant raw material flows which are potentially susceptible to diversion. The first involves barge flows of imported manganese, ferromanganese, and fluorspar from Lower Mississippi ports to Chicago, the Ohio River and Pittsburgh, and iron ore to the latter areas. These flows, which are imported at the Lower Mississippi River ports, account for as much as 1.5 million tons into the Ohio and Monongahela Rivers, and another half million tons into the Chicago area and represent approximately 3 billion ton-miles (out of a system total of nearly 170 billion in 1972). Although industry sources minimize the likelihood of this traffic leaving the waterway, the fact that some imported ores currently move into the Pittsburgh areas by rail from the Atlantic suggests the possibility of such a diversion - particularly for destinations farthest to the East.

The second potential major diversion involves a quarter to a half million tons of metallurgical coal from Ceredo, West Virginia to Houston (for Armco Steel). If coal supplies from its captive mines in West Virginia become tight, this shipper might be expected to enter the open market for Oklahoma metallurgical coal whether or not user charges are enacted, although such a policy would clearly add to the incentive for such a switch. Due to the relative scarcity of low volatile grade coal in this region, we would not expect the entire barge flow to be displaced under any foreseeable circumstances.

Finally, it appears that the all-rail rate on iron ore from Mobile to U.S. Steel's facility in the Birmingham area is currently competitive with the barge-rail rate between those same points. Full recovery of Federal OM&R on the Warrior River would add about 30 cents to the cost of the barge-rail alternative, which, in recent years, has handled all of that firm's three to four million ton consumption of imported iron ore. In spite of the additional raw materials cost in the vicinity of 1 million dollars, diversion of this flow, which accounts for over 30 percent of Warrior River ton-miles, is not expected.

Multi-plant production strategies and the nature of the steel distribution system will act to prevent most of the iron and steel products currently moving on the river from diverting to other modes. In the very worst case, a 1900 mile haul under a system-wide fuel tax on a low-priced product, the user charge amounts to less than one percent of product value, and impacts in the range of one tenth to three tenths of a percent are much more common. The bulk of the impact of user charges on the iron and steel industry will be manifested in localized price effects (in water-served markets) and losses in net revenue to the producers on those shipments. The balance of impact between market price and producer's revenue will be specific to each producer, product and market.

Because most of its traffic (especially long-haul) in both raw materials and finished products is on main stem rivers with lower-than-average segment tolls, the iron and steel industry would be impacted much more adversely by a uniform fuel tax than by a segment toll as long as the relatively expensive rivers remain in the calculation base. For most moves - with the prominent exception of the Warrior River traffic, which is indifferent between the toll schemes - the uniform fuel tax is fifty to over one hundred percent higher than the segment toll. The long-haul ore, coal, and product flows discussed above are impacted hardest by this differential.

Sand and Gravel

Impacts on waterborne sand and gravel traffic vary widely among river segments depending on the degree of competition from alternative local supply sources (this includes substitutable material, such as limestone, as well as inland sand and gravel quarries). Most water shipments of sand and gravel originate at river dredging operations - the low-value of this commodity and abundance of supply generally makes barge transportation of land-quarried material economically unfeasible. Sand and gravel transported by barge is thus very sensitive to changes in modal costs; user charges in several regions are high enough to drive a good portion of sand and gravel traffic off the waterways.

Based on information derived from firms specializing in the dredging of the waterways, the following reductions in sand and gravel tonnage on each river have been predicted: Arkansas and Kanawha Rivers, 10-15% loss in tonnage; Ohio, Columbia, 25-30% diversion; Missouri, Illinois, Allegheny, Monongahela, Cumberland, Tennessee, Gulf Intracoastal Waterway, and Alabama-Coosa Rivers, 50% loss in tonnage; and 100% of the sand and gravel traffic would probably be diverted from the Kentucky, the Kaskaskia, and the Apalachicola, Chattahoochee, and Flint Rivers. Corresponding reductions in total ton-miles for each river are minimal for the major rivers, that is, one percent or less for the Mississippi, Ohio, Illinois, and Missouri Rivers (the Arkansas, Columbia, and Monongahela also fall in this range). Ton-mile losses on the Kanawha and Tennessee are estimated to be 2% while diversion on the Cumberland, Allegheny, and Willamette will result in a ton-mile loss between 10% and 25%. At present, Kentucky and Kaskaskia River traffic consists only of sand and gravel traffic - a segment toll will drive all of the barge shipments off these rivers.

The substantial impacts on sand and gravel traffic must be considered in light of the fact that these companies aid the Corps of Engineers in maintaining navigation channels. If these firms were put out of business, the COE would have to increase substantially dredging expenditures on certain rivers to replace the former operations of privately-owned firms, resulting in even higher user charges. Either exemption for certain navigation-related sand and gravel operations or lower user charges should definitely be considered for this industry.

Chemicals Traffic

For basic petrochemicals (benzene and toluene, alcohols, etc.), existing distribution patterns would not be altered under proposed user charges. Substantial intra-Gulf transfer activity and some longer haul up-river movements would tend to be more affected by a fuel tax than segment tolls. For sulfur and sulfuric acid, market forces and technology changes in the future may have a more substantial impact on waterborne flows than user charges. Clearly, existing Frasch sulfur flows would be put at a greater disadvantage under user charges if alternative sulfur production either moved by other modes or occurred closer to demand locations. Midwestern sulfur markets served by barge from the Gulf will probably be most affected by user charges.

Other Waterborne Traffic

Salt to Midwest consumers via barge from the Gulf has been fairly insulated from other market or mode competition in the past. The potential user charges for these movements do not dramatically alter existing relative prices in favor of a change in current patterns. Some competition from western salt mines via rail is possible but unlikely if rail rates also increase. Fuel taxes would more seriously affect market competition in salt than segment toll but even 15 to 20 percent barge rate increases may not alter market or mode choice by consumers, according to industry sources.

1. INTRODUCTION

Volume II contains the detailed technical analysis of user charge impacts on major commodity distribution systems that utilize inland waterways as a mode of transportation. The overall analysis was carried out in the context of the markets and transportation networks that both define and constrain inter-regional commodity movements. The broader distribution system approach allows a more precise accounting of modal traffic as well as carrier impacts. Full consideration of shipper transportation options as well as alternative supply sources or demand outlets for a commodity extends the range and reliability of the final results.

For each major distribution system considered, the following general approach was used: First, major shippers and receivers on the inland waterways were identified, existing distribution patterns and systems characterized and present (all modes) commodity flows developed. Next, since user charges affect relative market prices, the correct "price" for analysis was selected. In the case of grains, river versus rail terminal bid prices for grain were used. For coal and petroleum, modal delivered price in cents per million Btu was chosen. Third, a user charge impact analysis was developed and relative changes in modal prices (due to user charges) used to calculate potential modal or market shifts. Finally, revenue and ton-mile impacts on waterborne traffic due to user charge imposition were calculated.

A detailed example may help clarify the procedure. The distribution system analysis for coal proceeded as follows: Water-served utilities burning coal were identified along with their current distribution facilities (rail/water/truck shares), current modal coal flows and relative delivered coal prices from each coal source. Next, to place user charge impacts in the correct context, a coal price analysis was performed for each utility. The effects of major market changes (EPA air quality regulation, strip mining controls) relative to modal changes (mode shift costs, user charges) on delivered price were calculated. A utility fuel demand model was constructed that estimated relative coal market shares in utility coal use as a function of delivered prices. For example, the typical utility may purchase coal from four or five sources, generally in different states. Effects of user charges on waterborne coal flows were determined by calculating source changes in utility coal demand using price elasticities from the models. Under user charges, waterborne coal prices from distant sources would increase relative to more proximate mines or to rail transportation. Assuming cost minimization by a utility, modal or market shifts could occur and diversion due to user charges can be measured. Finally, barge revenue and ton-mile changes due to user charges can be calculated using the waterway network model.

The following chapters present various analyses of user charge impacts on commodity distribution systems. The degree of sophistication in analyses depends on the amount of data and information available to the analyst. In some cases, especially coal and grains, substantial previous analysis and new data were available. Other cases, such as sand/gravel and fertilizer systems, have little public data available and are not especially easy to analyze. As a result, a uniformly accurate view of user charge impacts across commodity distribution systems is not possible at present.

2. COAL TRAFFIC IMPACTS

2.1 INTRODUCTION

Future conditions in energy supply and demand markets remain a major uncertainty in estimating coal traffic impacts due to waterway user charges. Changing fuel markets, environmental quality concerns, facilities planning and generating technology considerations have produced rapid change and a dynamic environment with a wide range of equally probable futures. Prediction of future market behavior based on past decision processes has produced unlikely results (i.e., historical energy-use growth despite real price increases over time). Existing utility and consumer behavioral rules have become rapidly dated and new decision processes are difficult to identify.

Prior to the analysis of coal transportation impacts due to the imposition of user charges, major market and transportation trends that will dominate the energy production and use environment during the next ten years will be discussed. These factors will provide the context within which waterway user charge impacts on coal markets and traffic can be assessed.

The initial discussion will be divided into two major areas; energy markets and energy transportation, with a number of factors examined under each topic.

2.2 ENERGY MARKET CONSIDERATIONS

Five major areas will be examined: growth of western coal consumption, clean-air act requirements, potentials for low-sulfur eastern coal, utility facility planning and future U.S. energy consumption:

2.2.1 Western Coal

Although western (Montana, Wyoming, and Utah) coal consumption has grown rapidly in the past five years, high transportation costs have restricted its major area market to west of the Mississippi River. A limited number of utilities (American Electric Power and Commonwealth Edison - Illinois) east of the Mississippi River use western coal to meet stringent air quality regulations. Due to the low volatility (heat value) of western coal, boiler conversion is necessary for some plants designed for other coals.*

The penetration of midwestern utility coal markets by low-sulfur western coal depends on federal and state regulatory actions on air quality and strip mining. Imposition of strict sulfur-dioxide (SO_2) emission standards by utilities could potentially extend western coal markets to utilities in Illinois, Indiana, and perhaps Ohio. In general, a utility will have to trade off the higher costs of western coal including boiler derating and new coal feeding equipment against retrofit scrubber costs necessary for use with high-sulfur eastern coal. Alternately, strip mining regulation could double the existing low price western coals (\$5 to \$7 per ton) by requiring extensive land rehabilitation following strip mining. These uncertainties make western coal use only a possibility on eastern portions of the major rivers (Ohio, Monongehela) affected by user charges, but a likely substitute for eastern coal along the Mississippi and Illinois Rivers.

2.2.2 Air Quality Standards

Substantial debate continues at the federal level on the type of air pollution control equipment to be required on coal-fired electric utilities. The Federal Energy Administration

Western coal boiler conversion costs average .50 to .55 mills per kilowatt hour of electric output. National Academy of Sciences Air Quality and Stationary Source Emission Control. Washington: U.S. Government Printing Office. 1975. Ch. 10. Hereafter referred to as NAS - Air Quality favors temporal emissions controls for reducing sulfur dioxide levels at power plants. Utilities would switch to low sulfur fuel or transfer a portion of the electric load to stations in less polluted areas in times of high concentrations of pollutants that exceed standards. Tall stacks are a major part of so-called Supplementary Control System (SCS) approaches. Increased stack height reduces emissions in the vicinity of power plants, but clearly makes the pollution another state or country's problem.

The Environmental Protection Agency (EPA) considers dispersion procedures incompatible with the Clean Air Act of 1971. They favor Flue Gas Desulfurization (FGD) processes that scrub effluents from stack gas emissions of high-sulfur eastern coal. Only lime and limestone scrubbers have been operated over extended periods of time (with limited success).

System costs and reliability are a major factor influencing the decision. FGD retrofit systems on existing utilities costs 4.0 mils per kilowatt hour (or 30 cents per million BTU added to the cost of using high-sulfur coal, averaging 70 to 90 cents per million BTU). They have not been operated for more than a few months on high-sulfur coal without problems. SCS systems cost only ten percent of the FGD retrofit, are reliable in operation but do not reduce emissions in the U.S. airshed (only near the utility).**

The adoption of strict air quality standards requiring the use of FGD systems or low-sulfur fuels would dramatically alter present coal distribution patterns (independent of waterway user charges). Initial shifts by eastern utilities to low-sulfur western coal sources to meet standards may be tempered in the long-run (five to ten years) by increased production and use of low-sulfur eastern coal or nuclear power.

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*NAS-Air Quality. 212.
**NAS-Air Quality. 202-203.

Final decision may be left to the courts as many cases against FGD-required retrofit at utilities are pending.

2.2.3 Low-Sulfur Eastern Coal

The use of eastern low-sulfur coal to meet air quality standards is a recent option generated in response to Clean Air Act debates. Unfortunately, low-sulfur eastern coal is generally metallurgical grade coal and steam coal production is almost non-existent. Increased production is hindered by the uncertainties in energy markets, air quality standards debate, continued strip mining, mine labor problems, and supply ownership by steel mills.

A recent study by Charles River Associates, The Supply Potential for Eastern Low-Sulfur Coal to 1990 (Reference [2]) details many of these and other problems and forecasts available supply under alternative mine-price scenarios. Eastern low-sulfur coal will probably raise utility fuel costs by greater than fifty percent. Low-sulfur coal is quite limited in comparison to eastern high-sulfur deposits.

Low-sulfur coal from eastern mines may solve the air quality problems of selected utilities but high costs due to inadequate production may make FGD or western coal attractive for many other plants. Existing coal traffic patterns would be substantially changed if eastern low-sulfur coal gained widespread use among eastern utilities.

2.2.4 Utility Facilities Planning

The continuing debate over the safety of nuclear power and resulting construction delays has increased utility reliance on traditional coal-fired facilities to meet new demands and to replace depreciated operations. Coupled with air quality decisions, the design specification of these plants will affect coal traffic patterns during the period of user charge imposition. For example, Upper Mississippi and Illinois River utilities are designing new boilers to directly accommodate western coal. Plants along the Ohio and Tennessee Rivers are also considering adopting western coal for new capacity increases. Unfortunately, direct information beyond 1980 on utility planning awaits resolution of the nuclear power/air quality debates.

2.2.5 Energy Consumption Forecasts

Future growth and change in coal traffic to utilities depends heavily on forecasts of electricity consumption. Present forecasts are consistent with maintenance of historical growth rates (two to five percent per year) nationwide. Growth in coal-generated electricity is projected to be highest west of the Mississippi, where coal is slated to replace existing gas and oil-fired units in the Southwest. Significantly, in those utility regions served by the Mississippi River system, electricity demand is projected to grow at rates above U.S. averages.* Any adverse effects on coal traffic due to user charges could be reduced by growth in waterborne coal traffic to meet the new electricity demands.

2.3 ENERGY TRANSPORTATION CONSIDERATIONS

The U.S. transportation system has historically adapted well to required alterations in coal traffic patterns due to changing coal market conditions. Water-served utilities shifting from eastern to western coal may still receive coal

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*ICF Incorporated, Electric Utility Coal Consumption and Generation Trends, 1976-1985. (FEA Final Report, August 1976). P.4.

via the river system but now preceded by a thousand mile rail haul from western fields. New rail-to-water transloading facilities are being built at many river points to facilitate eastern delivery of western coal to present water-served utilities. Cooperation between barge and rail carriers is at a high level on most major rivers. Unit-train rail costs for coal delivery have stabilized, allowing for longer term planning by utilities and reduced shifting among coal markets. Finally, growth in coal consumption has increased carrier revenues and allowed overdue facility and equipment investments.

Problems also exist as the result of energy market transition. The conversion to western coal by some eastern (Illinois) utilities has caused friction between eastern and western railroads. Interline activity between east and west (of the Mississippi River) carriers is necessary for final delivery of western coal. In many cases, the western coal substitutes for a longer coal haul by the eastern road from Southern Illinois fields. The result has been high transfer and delivery charges by eastern roads for western coal that raise the overall rail cents per ton-mile for coal brought east of the Mississippi by up to thirty percent over western territory rail rates.

In the eastern regions, higher rail transportation costs coupled with car shortages in the past have given eastern railroads image problems. Many utilities continue to favor final delivery by water (based partly on past unloading facility investment decisions and lower ton-mile rates by water for coal from distant markets). Major carriers, such as Southern, L&N, and CONRAIL have targeted coal traffic as a major growth area and are attempting to improve service and lower costs through cooperative efforts among carriers and with utilities.

Future energy transportation activity, especially of western coal will emphasize multi-mode delivery that avoids higher eastern rail rates and utility unloading facility constraints. Although user charges will influence these decisions, costs of shifting to all-rail delivery are substantial and generally exceed additional waterway fees. Traffic patterns will change if western coal further penetrates eastern utility markets with eastern railroads losing traffic to western coal barge and rail carriers. In general, transportation appears quite capable of responding to the energy transportation requirements of the future. A major uncertainty is coal slurry pipelines which may force otherwise profitable coal-carrying railroads into bankruptcy (and federal control).

The next sections describe in detail the coal traffic and modal impacts of user charges on inland waterways relative to other projected energy market and transportation changes in the next ten years.

2.4 UPPER MISSISSIPPI RIVER UTILITIES

2.4.1 Background

Water-served electric utilities, ranging from the Black Dog plant of Northern States Power in Minneapolis to the Muscatine plant of the Muscatine, Iowa Electric Company, produced over twenty-eight percent of the 1975 net kilowatt hour generation in Wisconsin, Minnesota, and Iowa. With the exception of two plants partially served by railroads, the utilities are dependent on the Mississippi River system for fuel delivery (see Table 32). Traditional (pre 1972) patterns of coal movement to the utilities included flows from Southern Illinois via East St. Louis and flows from Kentucky via Green River origins. Southern Illinois coal made up almost two-thirds of the aggregate burn-mix although some plants burned substantial amounts of Kentucky coal.

The development of western coal resources in Montana and Wyoming during the early 1970's introduced a new and cheaper source of coal to these utilities ($6.00 to $7.00 per ton for strip-mined western coal versus $13.00 to $18.00 per ton for Illinois and Kentucky deep mined coal). In 1972, total western coal use by these utilities was 435 thousand tons, increasing to 479, 2332, and 2750 thousand tons in 1973, 1974, and 1975 respectively. Western coal currently accounts for over forty percent of Upper Mississippi utility coal usage and continues to grow rapidly.* The low sulfur content of western coal (.75 to 1.00% by weight for western versus 3.0% for Illinois/Kentucky coal) is another necessary feature. Utilities, especially those located near urban areas, are using western coal to meet EPA Clean-Air Act standards without the costly flue gas desulfurization retrofit required to continue use of high-sulfur coal.

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*Constraints on optimal burn-mix in utility boilers probably limit western coal use to 70 through 85 percent of total coal consumption.

Although the basic coal source for the utilities is rapidly becoming western fields, fuel delivery remains via the Mississippi River. Burlington-Northern delivers western coal to transshipment facilities near Minneapolis, MN for final delivery by barge. The utilities tend to have substantial investments in water unloading facilities and generally do not have rail sidings and rotary dump equipment. Typical rail unit-train rates per ton for the rail portion of the delivery are found in Table 33. Burlington-Northern is considering construction of a larger transshipment facility in Montrose, IA which would reduce delivered coal costs to river-served plants in Iowa and Missouri. In terms of total mileage, the western rail/water delivery may easily be twice the distance of the water delivery originating in Illinois or Kentucky. Further, the average river haul for western coal may by one-third to one-half the average haul of eastern coal. User charges would clearly impact the already declining use of eastern coal more severely than western coal flows.

New construction, according to the utilities, will emphasize boilers that can burn up to 95 percent western coal, given the lower costs of usage. Dairyland Power Coop has petitioned for rail service to a new plant but environmental considerations may prevent other than river delivery.

2.4.2 Coal Price Analysis

Public regulation of utilities results in little direct control over electric rates or return on investment by companies. As a result, cost minimization especially in fuel purchases (34 percent of direct operating costs, U.S. average) tends to be a major industry objective. Upper Mississippi utilities coal purchases have experienced a switch to western sources as detailed in Table 34 for 1973 and 1975. Relatively lower costs (in cents per million BTU) of western versus eastern coal during the period was perhaps the primary reason.

Given that user charges enter the decision process of a utility via relative delivered prices for coal from competing markets, a broad understanding of price impacts (including user charges) during cost recovery implementation is necessary. Environmental considerations such as Clean Air Act requirements and strip mining controls may have the most dramatic impact on fuel prices. Strip-mining controls may, for example, restrict production of low-sulfur fuels and raise market prices. Requirements to reduce sulfur dioxide emissions from power plants could substantially increase the cost of using high sulfur coals due to scrubber retrofit investments.

Table 1 contains 1975 relative fuel costs for Upper Mississippi utilities of coal originating in Illinois, Montana and Wyoming.* In general, Montana coal is cheaper than existing Illinois or Kentucky coal sources.** Due to burn mix requirements shifting by smaller plants has been slow. Further, long-term coal contracts commit many utilities to continued purchases of relatively higher cost eastern coal.
Table 34 does indicate the quantity response to a relative price change in fuel sources over the 1973 to 1975 period. An initial conclusion is that cheaper western coal is making substantial inroads into traditional eastern coal markets.

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*Kentucky coal costs are not included because they are generally at least equal to or higher than Illinois costs.

**The Montpelier and Muscatine plants would probably have coal delivered via Montrose, IA which would reduce delivered costs of western coal. The Allan King plant, as of May 1976 is paying 75 to 78¢/M.Btu for Montana coal versus 80 to 82 ¢/M.Btu for Illinois coal (<u>Fuel Price Analysis</u>, August 1976).

TABLE 1

1975 COAL DELIVERED PRICE IN CENTS PER MILLION BTU: UPPER MISSISSIPPI UTILITIES*

Plant**	Illinois Coal	¢/M.BTU Montana Coal	Wyoming Coal
HGHBRDG	72.30	68.56	82.15
BLCKDG	72.70	69.71	82.15
ALLNKNG	70.40	73.89	82.86
ALMA	85.80	85.20	86.62
GENOA	90.50	82.10	88.83
LNSNG	80.50	78.91	89.34
STNMN	100.20	90.33	90.64
NLSNDWY	93.50	90.33	90.64
DBQE	85.70	80.94	91.29
MLKAPP	90.00	82.38	92.68
MNTPLR	90.30	93.40	93.60
MSCTNE	75.60	93.70	93.89

*Source: Federal Power Commission Form No. 423 Reports (unpublished data via FEA). Western coal prices constructed for some utilities.

**Plant name abbreviations are explained in Table 28.

Market-centered price impacts on relative fuel costs are most likely to be due to environmental restrictions. Control over strip mining was recently vetoed and, although the bill will certainly be reintroduced during the coming year, the actual cost impacts on western coal are difficult to estimate. Impacts ranging from fifty cents to five dollars per ton (three to thirty cents per million Btu, western coal) have been discussed. Obviously, such costs would price western coal out of many existing markets (given that flue gas desulfurization is not required). As we shall see, increasing western coal by thirty cents per million Btu is almost equivalent to the costs of complete clean-air retrofit for a utility, implying that the relative western vs. eastern delivered prices would remain the same if severe environmental (air and land) controls are imposed.

A second market-price consideration are the additional costs in boiler and coal feeding systems due to use of western versus eastern coal. The Environmental Protection Agency (EPA) has estimated the capital costs at between $2 and $40 per kilowatt generating capacity at a utility, or .5 mil (average) per kilowatt hour of operation; 6 cents per M.BTU western coal.* Again, if western coal conversion costs were an average of $20 per KW, western coal costs would be higher than existing eastern coal costs at utilities planning to convert. Conversations with Upper Mississippi and Illinois utilities indicate that capital costs due to western coal usage are minimal. The major effect is to run the conveyors-to-boilers at a faster rate to make up for the lower heat (BTU) content of western coal and maintain optimal burn temperatures.

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*Commission on Natural Resources, National Academy of Sciences, Air Quality and Stationary Source Emission Control, prepared for the U.S. Senate Committee on Public Works (March 1975). Hereafter, NAS-Air Quality.

We do not consider conversion costs further in this section, nor include estimated conversion costs in price analyses.

The most significant (potential) impact on coal prices are additional costs for pollution controls on utilities burning high-sulfur coal. As previously discussed, EPA would require FGD with high-sulfur coal while FEA would seek only SCS. The differences in annualized capital and operating costs are substantial. Full FGD retrofit on existing facilities would cost 4.0 mils/KWH while SCS ("tall stacks") average about ten percent of FGD costs. Table 2 details delivered price impacts on Illinois coal of either FGD or SCS requirements.

FGD adds approximately thirty to thirty-five cents per million BTU to the delivered price of eastern high-sulfur coal, whereas SCS adds two to three cents per M.BTU. The probability of FGD being required for urban power plants using high-sulfur coal is high. Already, state ambient air standards in the Upper Mississippi region have required that Northern States Power plants in Minneapolis reduce emissions. Table 3 contains existing average sulfur percent by weight for Upper Mississippi utilities in 1975.

Given that reduced emissions at these plants will require burning coal with a sulfur content of less than 1.0% by weight or FGD, western coal costs are quite attractive even if boiler conversion costs are six to ten cents per M.BTU.* Limitations due to burn-mix requirements (discussed in the next section) restrict total conversion by all Upper Mississippi utilities to western coal, so that some FGD retrofit may occur in this region.

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*As previously discussed, eastern sources of low-sulfur coal are concentrated in West Virginia and Eastern Kentucky, making transportation to these utilities very expensive and not competitive with western sources.

TABLE 2

DELIVERED PRICE (ILLINOIS COAL)
IMPACTS OF POLLUTION CONTROL
SYSTEMS: UPPER MISSISSIPPI
UTILITIES (CENTS PER M. BTU)*

Plant	1975 Illinois Coal Costs	Illinois Coal Costs + FGD	Illinois Coal Costs + SCS
HGHBRDG	72.30	101.00	75.10
BLCKDG	72.70	103.04	75.58
ALLNKNG	70.40	106.35	73.82
ALMA	85.80	114.51	88.53
GENOA	90.50	123.20	93.61
LNSNG	80.80	108.53	83.43
STNMN	100.20	129.05	102.94
NLSNDWY	93.50	129.32	96.90
DBQE	85.70	109.27	87.94
MLKAPP	90.00	120.73	92.92
MNTPLR	90.30	122.30	93.34
MSCTNE	70.60	101.12	78.02

*Source: NAS-Air Quality Chs. 11 and 12 and FPC Form No. 423 (unpublished).

TABLE 3

COAL BY SULFUR CONTENT (%)
BY WEIGHT: 1975*

Plant	%
HGHBRDG	1.12
BLCKDG	1.56
ALLNKNG	2.42
ALMA	2.58
GENOA	2.50
LNSNG	2.35
STNMN	3.19
NLSNDWY	4.55
DBQE	2.60
MLKAPP	2.48
MNTPLR	2.57
MSCTNE	3.01

*Source: 1975 FPC Form No. 423 (unpublished FEA data).

In the context of the above relative price effects that may be imposed on utility operations, the effects of user charge imposition can now be discussed. Table 4 presents the impacts on Illinois and Montana delivered coal prices due to the imposition of 100% OM&R cost recovery via a uniform fuel tax or segment toll. In each case, segment tolls are fifty percent higher than fuel taxes. Note that for the first five utilities (largest consumers of western coal; see Table 34), the relative fuel or segment tax impact goes against Illinois coal (given that western coal enters the river system at Minneapolis). For segment tolls impact may be as much as two-thirds of the costs of conversion to western coal.

In relation to previously discussed price impacts, user charges are generally smaller. At maximum, they are only ten percent of FGD costs, two-thirds of coal conversion costs and about equal to SCS costs.

If 100% OM&R cost recovery and FGD retrofit are implemented, western coal, even with some boiler conversion costs, is by far the cost-effective fuel source. Table 5 contains the fuel costs after a uniform fuel tax and FGD costs are added to existing coal prices. The last column is the extra cost imposed by user charges on utilities using Illinois coal (over using western coal).

As a final coal price analysis, all-rail versus rail/barge delivery costs are examined to determine if the all-rail mode is cheaper. As Table 32 indicates, almost all the Upper Mississippi utilities are entirely served by water. Few have provisions for unloading rail cars or have a rail siding. Table 6 compares all-rail delivered costs (including capital and operating costs of new rail unloading

TABLE 4

NAVIGATION COST RECOVERY IMPACTS ON DELIVERED COAL PRICES (1975 - ¢/M.BTU)

I. Illinois Coal

Plant	Existing Cost	Change Due To Fuel Tax	Change Due To Segment Toll
HGHBRDG	72.30	2.42	3.64
BLCKDG	72.70	2.47	3.70
ALLNKNG	70.40	2.39	3.59
ALMA	85.80	2.10	3.15
GENOA	90.50	1.83	2.75
LNSNG	80.80	1.76	2.64
STNMN	100.20	1.56	2.34
NLSNDWY	93.50	1.57	2.35
DBQE	85.70	1.46	2.20
MLKAPP	90.00	1.22	1.84
MNTPLR	90.30	1.06	1.59
NSCTNE	75.60	1.00	1.50

II. Montana Coal

Plant	Existing Cost	Change Due To Fuel Tax	Change Due To Segment Toll
HGHBRDG	68.56	.03	.04
BLCKDG	69.71	.03	.04
ALLNKNG	73.89	.06	.09
ALMA	86.14	.44	.66
GENOA	88.44	.77	1.16
LNSNG	78.91	.85	1.29
STNMN	90.33	1.11	1.66
NLSNDWY	90.33	1.11	1.66
DBQE	80.94	1.23	1.85
MLKAPP	82.38	1.53	2.30
MNTPLR	93.40	1.74	2.61
MSCTNE	93.70	1.81	2.72

TABLE 5

FUEL TAX AND CLEAN AIR
IMPACTS ON DELIVERED COAL PRICES
(1975: ¢/M. BTU)*

Plant	Illinois + FGD + Fuel Tax	Montana + Fuel Tax	Illinois Coal Fuel Tax Minus Montana Fuel Tax
HGHBRDG	101.82	68.59	2.40
BLCKDG	103.06	69.74	2.44
ALLNKNG	106.40	73.96	2.34
ALMA	114.86	86.57	1.75
GENOA	123.82	89.21	1.21
LNSNG	109.21	79.77	1.07
STNMN	129.93	91.43	.68
NLSNDWY	130.20	91.43	.68
DBQE	110.25	82.17	.48
MLKAPP	121.95	83.91	.01
MNYPLT	123.69	95.14	-.33
MSCTNE	102.56	95.51	-.44

*Source: Tables 2 and 4.

TABLE 6

RAIL/BARGE VERSUS ALL-RAIL COSTS TO UPPER MISSISSIPPI UTILITIES (1975-¢/M. BTU)

Plants	Existing Montana costs	Montana + Fuel Tax	All-rail + unload facility costs*	Illinois costs + Fuel Tax
HGHBRDG	68.56	68.59	71.70	74.72
BLCKDG	69.71	69.74	72.85	75.17
ALLNKNG	73.89	73.96	76.65	72.79
ALMA	86.14	86.57	88.53	87.90
GENOA	88.44	89.21	91.73	92.33
LNSNG	78.91	79.77	82.50	82.56
STNMN	90.33	91.43	94.88	101.76
NLSNDWY	90.33	91.43	94.88	95.07
DBQE	80.94	82.17	86.05	87.16
MLKAPP	82.38	83.91	88.89	91.22
MNTPLR	93.40	95.14	100.97	91.36
MSCTNE	93.70	95.51	101.62	76.60

*Assumed an all-rail cost of .762 cent per ton-mile from Decker MT via Northtown MN; either direct BN or interlining with the CNW (depending on which side of the river the utility was located on). Annualized capital costs for the rotary dump rail unloading facility ranged between $1.00 and $1.20 per ton of coal throughout.

facilities) to existing costs of moving Montana coal via rail/barge. It is assumed that railroads would construct sidings to the utilities and some adjustment was made in rates via rail to reflect the investment costs.

Overall, all-rail costs average about two cents per million BTU greater than existing rail/barge operations. Rail capital costs for siding construction are probably understated, so that the all-rail costs should be regarded as a minimum rather than an average delivered price. Little advantage in cost terms to all-rail delivery is apparent, so that the present rail/barge distribution pattern appears to be the dominant system for the future. The consideration by Burlington-Northern to construct a new transshipment facility at Montrose, IA is also relevant evidence.

In summary, user charge costs to Upper Mississippi utilities are small in comparison to other potential markets or regulation induced price changes. Although unionization of western mines may raise coal prices in the future, almost a doubling of western coal prices would be necessary to make Illinois/ Kentucky coal with FGD retrofit a cost competitive alternative (assuming eastern prices remain constant). In the past three years, eastern coal prices have risen more rapidly than western prices. The trend is due to increasing costs of deep mining relative to strip mining and will likely not abate unless strict controls over strip mining are legislated.

2.4.3 Coal Traffic Impacts

The previous section detailed relative changes in delivered coal prices to Upper Mississippi utilities due to a variety of market and legislative-induced impacts, including waterway user charges. As shown, navigation cost recovery (if passed on to waterway shippers) alters the relative delivered price of coal to further favor western over eastern markets. Similarly, FGD retrofit costs would also increase eastern coal prices relative to western sources but with perhaps one-hundred times the effect.

Such considerations must be kept in mind while evaluating potential traffic impacts on waterways due to user charges. If stricter air quality standards are legislated at the federal or state level, user charges may only accelerate the trend towards increased use of western coal at Upper Mississippi utilities. Further, western coal already enjoys a price advantage at major Upper Mississippi utilities, that has resulted in a rapid shift to western coal use by cost-minimizing fuel purchasing managers.

To judge the impact of user charges on utility coal traffic, a comparison to project utility fuel-use trends is necessary. Assuming strict air quality standards are legislated, utilities will have to choose between low-sulfur coal use or FGD retrofit with existing coal. Given that western coal will probably maintain its price advantage, an acceleration of the shift to Montana and Wyoming sources is likely. The following analyzes the impacts on waterborne coal traffic ton-miles and revenues of a burn-mix using 70 percent western coal at Upper Mississippi utilities. At present, western coal accounts for 38 percent of total utility coal use along the Upper Mississippi River and 33 percent of the waterborne coal traffic on the river.

Table 7 contains estimated* 1975 coal tonnage and ton-miles on the Upper Mississippi River for flows to utilities. Note that although waterborne western coal flows

*The year 1975 official Army CoE waterborne commodity statistics were not released at the time of the analysis.

TABLE 7

1975 WESTERN AND EASTERN COAL TONS AND TON-MILES: UPPER MISSISSIPPI RIVER (ESTIMATED)

		%
I. Tonnage (000's)*		
Eastern Coal	4213.4	
Western Coal	2068.8	(33)
Total	6283.2	
II. Ton-miles (millions)		
Eastern Coal	2,181.6	
Western Coal	140.9	(6)
Total	2,322.5	

*Tonnage figures calculated using the TSC waterways traffic impact model. These numbers should not agree with Table 30. since they represent waterborne flows only. Finally, the data represents coal flows only to those utilities listed in Table 32.

to utilities is 33 percent of total water delivered coal, it accounts for only six percent of barge ton-miles in 1975. If strict ambient air standards are developed, the price analysis in the previous section implies that a switch to low-sulfur western coal is cost effective relative to FGD retrofit for these utilities. Assuming that existing utility boilers could not burn more than 70 percent western coal to maintain heat requirements, Table 8 calculates potential tonnage, ton-mile, and revenue impacts on Upper Mississippi waterborne coal traffic. If western coal usage increased to an average of 70 percent (although some plants can and do use higher percentages), waterborne coal ton-miles would drop to 68 percent of estimated 1975 levels. Net revenue loss over 1975 estimated traffic revenues from coal via water would be 21 percent.* Given that legislated air quality standards may result in an evolution to a new distribution system involving a shorter waterborne movement to utilities, the results can be viewed as a functioning of the market under social pricing schemes that include pollution control costs. Whether the impact on barge operators is politically or socially acceptable is a separate consideration. However, waterway carriers would bear part of the burden for pollution abatement at Upper Mississippi utilities.

With these results as a guide and a standard, the impacts of user charges on Upper Mississippi waterborne coal traffic can be examined. One method of evaluating impacts of relative market price changes on utility fuel consumption from spatially separate coal sources is the estimation of fuel-share factor

*Based on an estimated $14 million in barge revenues from Upper Mississippi coal traffic, as calculated by the waterway traffic impact model.

TABLE 8

EFFECTS OF STRICT AIR QUALITY REQUIREMENTS ON WATERBORNE COAL TRAFFIC TO UPPER MISSISSIPPI UTILITIES (ESTIMATED): 70% WESTERN COAL USE; 1975 DEMAND LEVELS

I. Tonnage (000's)		%
Eastern Coal	1885.0	
Western Coal	4398.2	(70)
Total	6283.2	

II. Ton-Miles (millions)		%
Eastern Coal	1,028.9	
Western Coal	541.5	(34)
Total	1,570.41	

III. Revenue Impacts (1975 $) on Traffic

Loss on Eastern Coal = $6.1 million
Gain from Western Traffic = 3.3 million

FGD-net loss in revenue = $2.8 million

demand equations. Chapter 2.8 presents the detailed derivation of the cost-minimizing model of fuel purchases by utilities in the context of an energy sub-model from a production structure of generalized (and separable) functional form. The equations are estimated using Federal Power Commission Form No. 423 coal use data for Upper Mississippi utilities. Essentially, fuel cost shares of different coal markets at a utility are modelled from a translog price possibility frontier. The share in a utility energy budget of a certain fuel (western vs. eastern coal) is a log-linear function of factor (energy source) prices. At present, Btu and sulfur content of various coal sources are not considered in the analysis although they are relevant to the utility fuel purchasing agent.

Optimization procedures yield a set of energy input functions in terms of cost shares of the aggregate energy budget of a utility, or:

$$SE_i = B_i + \Sigma_j B_{ij} \log P_{E_i} \qquad i,j = 1,..,n$$

where

S_{E_i} is the percent share of total cost of the i^{th} coal source (western versus eastern).

B_i, B_{ij} are coefficients to be estimated.

P_{E_i} are the relative energy delivered prices for each coal source.

n is the number of alternative coal sources purchased by a utility.

In order to assure that the shares S_{Ei} add to one, certain cross-equation coefficient constraints are necessary in the estimation process. The Zellmer "system-efficient" estimation technique is used in conjunction with a covariance approach to account for cross-utility variations. Both western and eastern coal demand for Upper Mississippi utilities for 1972 to 1975 were pooled to form a cross-section of time series for each coal source. Delivered fuel price data was derived from various transportation and utility sources.

Chapter 2.8 calculates relative price elasticities from the Allen-Uzawa partial elasticities of substitutions associated with the translog specification. Elasticities will differ by year and by utility. Table 9 contains measures of price responsiveness evaluated at 1975 western and eastern coal cost share values for utilities burning western coal along the Upper Mississippi. For example, a one percent increase in western coal price at the Highbridge Plant of Northern States Power would produce an estimated decline in the western coal cost share of the energy budget of -1.26 percent. An increase in eastern coal prices would increase the cost share of western coal by 1.27 percent for each one percent increase.

The user charge evaluation procedure is quite straightforward. The previous section estimated the relative impact on delivered coal prices at Upper Mississippi utilities of segment and fuel cost recovery taxes. Using the calculated price elasticities, the relative impact on western or eastern coal demand can be computed. Since most coal is water delivered, user charges affect the delivered price of both western and eastern coal. The effects are differential as shown in the previous section with eastern coal being relatively more

TABLE 9

PRICE ELASTICITIES FOR WESTERN COAL COST SHARES: 1975 COAL USE - UPPER MISSISSIPPI UTILITIES

	Elasticity with respect to:	
Plant	Western Coal Price	Eastern Coal Price
HGHBRDG	-1.26	1.27
BLKDG	-1.82	1.84
ALLNKNG	-3.96	4.00
ALMA	-3.72	3.77
GENOA	-4.09	4.14
LSNSNG	-4.37	4.42
STNMN	-*	-
NLSNDWY	-*	-
DBQE	-7.06	7.15
MLKAPP	-5.85	5.92
MNTPLR	-*	-
MSCTNE	-*	-

*Western coal currently not in use at these facilities; plant coal use excluded from the estimation.

impacted. Once changes in relative (east versus west) coal demand in known, changes in waterborne ton-miles and revenue can be calculated. The latter two data points are especially interesting since western coal moves about one-third the river distance of eastern coal. Even though total tonnage on the waterway may remain constant, ton-miles and revenue will fall. Assuming other factors constant, proportionate changes in delivered prices (dollars per ton) for each coal source were multiplied times relative price elasticities. For the western coal cost share equation, the results produce an estimate of the increase in western coal costs in the utility energy budget due to user charges. Some attempt was made to constrain certain utilities to fixed percentages of western coal use to optimize burn-mix. As previously mentioned, relative delivered prices of western coal increase less than delivered prices of eastern coal under cost recovery resulting in increased western coal usage (based on past Upper Mississippi utilities experience). The following impacts assume coal use at the utilities remain fixed at 1975 levels so that only relative east/west coal cost shares change. Simulation with an increased coal use assumption is possible but not complete due to time limits.

A 100% OM&R segment toll on the Upper Mississippi (introduced immediately) would the demand for water-delivered western coal to 2.65 million tons from 2.10 million tons per year, or an increase of 9% in the western coal share of the utility energy budget. The increase in western coal usage is at the expense of eastern coal, given that we have constrained total coal use to be fixed at 1975 levels. Ton-miles associated with western coal movement would increase to 162.8 million, or 16 percent. Since the traffic would now originate in Minneapolis and experience a much shorter river haul to utilities, overall system (Upper Mississippi) ton-miles would fall by a larger amount; 365.3 million per year. The net result is that overall system ton-miles will fall by 16 percent, assuming total waterborne coal tonnage remains constant.

Revenue impacts on water carriers may also be estimated. Existing (1975) revenues in towing charges to carriers op- erating in the Upper Mississippi western coal traffic market are $1.4 million per year. The nine percent increase in western traffic (at the expense of eastern coal) would result in an increase in carrier revenues to $1.6 million per year, a net gain of 14 percent. However, water carriers presently engaged in moving eastern coal to Upper Mississippi utilities would lose an estimated $1.8 million in revenues, or a fall of total (western plus eastern coal) revenue of 14 percent. The revenue impacts assume a 100% pass through of tolls to waterway shippers.*

The above results should be considered as a "worst-case" impact on coal traffic to Upper Mississippi utilities due to user charges. Secondary traffic impacts are not considered. Given that fuel taxes would increase relative delivered prices by a lesser amount than a segment tolls, traffic impacts would be approximately ten percent lower than calculated above. It should be remembered that current market condi- tions and potential government regulations may result in these shifts occurring anyway over the next few years. Pre- dicted user charge impacts require that all other factors be constant for valid interpretation.

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*Interpretation of this increase should include the consideration that such shifts are already occurring and that user charges complements these impacts, rather than acting against them.

In summary, segment user charges on the Upper Mississippi would complement and perhaps accelerate the effects of changing relative delivered coal prices on coal market shifts by utilities. The existing relative price advantage enjoyed by western coal has already caused significant increases in western coal usage by Upper Mississippi utilities in the past three years (see Table 34). If strict federal ambient air standards are legislated, the trend to western low-sulfur will further accelerate, due to the high costs of pollution control equipment for eastern coal. Abstracting from these events, user charges could increase the use of western coal by about nine percent (at the expense of eastern coal; if relative mine prices remained the same and FGD is not required). The traffic impacts include a fall in total Upper Mississippi coal ton-miles of nine percent and a two to five percent decrease in net carrier revenues from coal traffic, depending on price elasticities and market response. In constrast, a predicted shift to seventy percent western coal would induce revenue losses of almost twenty percent (of 1975 levels) on carriers of eastern coal. In all, the predicted traffic and revenue impacts due to user charges will probably occur in the context of current market conditions given that user charges on complement existing relative prices.

2.5 ILLINOIS RIVER UTILITIES

2.5.1 Background

Electric utilities located on the Illinois River supplied nineteen percent of the net kilowatt hour generation by all Illinois utilities in 1975. Commonwealth Edison plants near Chicago are the major destination of waterborne coal traffic. In 1975, seventy-three percent of the river coal tonnage -- (ninety-seven percent western coal) moved to these plants (see Table 35).

The primary river origination for these movements is Havana, IL (river mile 118) where Burlington-Northern and other railroads transfer coal to river barges for movement to final destination. Other coal flows originate near St. Louis on the Mississippi (Illinois side) as well as on the Ohio and Tennessee Rivers. These flows are to the Meredosia and Hennepin plants and comprise less than five percent of 1975 Illinois river coal tonnage. Havana serves both western and eastern coal, with western tonnage predominating (see Table 37. As Table 35 indicates, all plants (except Wallace) are dependent on the Illinois for final delivery of coal. Patterns of coal flows to the utilities have not changed substantially during the past five years, except that western has replaced Illinois coal through Havana.

As previously discussed, the switch by Upper Mississippi utilities to western coal was in part due to a market price advantage enjoyed by Montana versus Illinois coal sources. Strict air quality standards and inadequate pollution control technologies forced Commonwealth Edison to switch to western coal in the early 1970's. Even though high-sulfur Illinois coal is twenty cents per million Btu cheaper than low-sulfur western coal, the costs of removing the sulfur from Illinois coal exceed the existing market price differential. Western coal is also one-half the cost of residual fuel oil or gas on a per million Btu cost basis. Commonwealth Edison is by far the largest consumer of western coal in Illinois, using a burn-mix of sixty percent western coal in their boilers.

At present, Commonwealth Edison burns high-sulfur Illinois coal on one boiler at the Will County plant equipped with an experimental FGD limestone scrubber. Full conversion back to Illinois coal is only a distant possibility in that operating problems (due to high-sulfur content of the coal) have arisen. The Wallace plant of Central Illinois Light in E. Peoria, IL is the only other water-located utility with air quality restrictions. They currently use a burn-mix of sixty percent low-sulfur western coal to reduce SO_2 emissions to acceptable levels.

Substantial in-state rail traffic of coal to non-water served utilities exists but rates per ton-mile are high relative to rail/water delivery (see Table 36). Of the major utilities located on the Illinois waterway, only the Wallace (100% rail, 1975) and the Fisk plant have rail unloading facilities. The Fisk unloader is an old singlecar dumper used only when the Illinois River is frozen and then for less than one percent of yearly coal tonnage flows. Conversion of existing water-served utilities to rail delivery would involve substantial investments at each plant, perhaps with an aggregate cost of seventy-five to one hundred million for Commonwealth Edison plants alone.

The impact of waterway user charges on western and eastern coal flows to Illinois River utilities would be identical since both enter the river system at Havana. Unlike the Upper Mississippi River case, no inter-coal source substitution is expected to result from user charges. Potential impacts include mode changes (all rail instead of rail/barge) or changes in river origin for transshipment of western coal

(E. St. Louis instead of Havana). These and other possibilities are examined in detail below.

2.5.2 Coal Price Analysis

Any price analysis of coal flows to Illinois River utilities must be centered on the relative coal market impacts of air pollution control costs. The high capital costs and unreliability of early stack gas scrubber systems lead major (urban) Illinois utilities to switch to low-sulfur western coal instead of removing sulfur from Illinois coal. However, current market prices for western and eastern coal in Illinois do not reflect the social costs of air quality inherent in the use of Illinois coal. Table 10 contains the relative 1975 coal costs in cents per million BTU at Illinois River utilities for coal originating in Illinois and Montana. At existing market prices, western coal averages twenty-five to thirty cents per million BTU more expensive than Illinois coal. Clearly, Illinois coal prices do not reflect the air pollution control costs required for its use as a utility fuel. Since 1973, use of Illinois coal at water-served utilities has fallen by one million tons while "expensive" western coal consumption is up one and one-half million tons (reference: Table 37). The price differentials in existing coal markets do not reflect the true costs to a utility of consuming Illinois coal.

As in the case of Upper Mississippi utilities, strict strip mining controls via legislation could increase the cost of using western coal by up to thirty cents per million Btu. If workable scrubber equipment is developed as well, Illinois coal may become competitive once again due to shorter lengths of haul and higher heat values than western coal.

TABLE 10

1975 DELIVERED PRICE FOR COAL TO ILLINOIS RIVER UTILITIES* (CENTS PER MILLION BTU)

Plant**	Illinois Coal	Montana Coal
MRDSA	91.20	96.98
WLLCE	71.50	97.89
HNNPN	86.80	97.16
WLLCNTY	69.80	96.39
CRWFRD	70.00	96.96
FISK	70.00	97.04

*Source: FPC Form No. 423 Reports (unpublished data from FPC).

**Plant name abbreviations are explained in Table 35.

In order to calculate the true costs to utilities of using illinois coal, retrofit capital costs of SCS and FGD emissions control systems were added to the 1975 delivered price of eastern coal. Table 11 presents the results.

The most striking discrepancy is that although the Crawford and Fisk plants of Commonwealth Edison are presently one hundred percent western coal, the cost of Illinois coal after FGD costs are included is less expensive than existing western coal prices. The explanation is straightforward. No reliable scrubber technology exists to effectively remove the large quantities of sulfur from Illinois coal. In calculating scrubber costs for retrofit, a low average of 4 mils per kilowatt hour of generation was used to determine annualized capital plus operating costs. True costs of FGD retrofit for these plants may be much higher. However, this is irrelevant since available scrubber technology does not permit the use of high-sulfur coal if clean-air standards are to be maintained.

As before, SCS systems add one to two cents per million BTU while FGD accounts for twenty to thirty cent per million BTU price increases for Illinois coal use. Table 12 indicates that fairly strict emission controls are enforced on the four utilities located in urban areas.*

As was stated above, ninety-five percent of all Illinois River coal traffic enters the system at Havana. Thus, movements of western and eastern coal to utilities along the river face approximately the same user charges.** In effect

*The Wallace Plant is located in E. Peoria IL.

**Since all prices are reduced to cents per million Btu, variations in the heat value of coal could result in the same toll having different delivered price impacts.

TABLE 11

ILLINOIS COAL DELIVERED PRICE IMPACTS OF POLLUTION CONTROL SYSTEMS (CENTS PER M.BTU)*

Plant	Existing Illinois Cost	Illinois & SCS	Illinois & FGD
MRDSA	91.20	93.61	115.33
WLLCE	71.50	72.54	81.91
HNNPN	86.80	87.53	94.06
WLLCNTY	69.80	74.18	113.61
CRWFRD	70.00	72.00	90.01
FISK	70.00	71.59	85.86

*Source: NAS - Air Quality Chs. 11 and 12 and unpublished FPC Form No. 423 data.

TABLE 12

UTILITY COAL SULFUR CONTENT BY WEIGHT AS BURNED: 1975*

Plant	% by Weight
MRDSA	2.86
WLLCE	1.35
HNNPN	2.95
WLLCNTY	.65
CRWFRD	.41
FISK	.41

*Source: FPC Form No. 423 data (unpublished).

navigation cost recovery will not alter relative coal prices as in the Upper Mississippi River utilities situation. Table 13 contains the impacts on Illinois and Montana coal delivered via Havana as well as Montana coal delivered to barges at E. St. Louis. The alternative rail/barge move via E. St. Louis will be discussed later. Except for some discrepancies due to varying heat value (Btu) of delivered coal, the segment and fuel tax impacts on coal via Havana are identical. The expectation is that user charges will not alter relative eastern versus western coal demand or existing traffic patterns for Illinois River utilities.

Relative to FGD scrubber retrofit costs, user charges will only minimally impact utility delivered coal prices. On average, prices paid for coal delivered via the Illinois waterway will increase less than one percent. The final question to be examined in the price analysis section is whether all-rail moves to presently water-served Illinois utilities would be more cost effective than rail/barge if user charges were imposed.

Both the Wallace plant of Central Illinois Light and the Waukegan plant of Commonwealth Edison (near Chicago) receive eastern and western coal via unit trains (using specially designed rapid unloading facilities). The Waukegan plant receives Montana and Wyoming coal at 82.4 cents and 65.4 cents (per million Btu), respectively. Waukegan evidently receives a very favorable rail rate from Wyoming for a volume move of over 1.5 million tons per year. Calculations indicate that in cents per ton-mile the Wyoming-Waukegan rate is about two-thirds of any other volume western coal rate with a destination in Illinois. For this analysis, rail rates were

TABLE 13

WATERWAY USER CHARGE IMPACTS ON DELIVERED COAL PRICES (1975 - ¢/M.BTU)

Plant	Existing Coal	Change Due to Fuel Tax	Change due to Segment Toll
I. Illinois Coal via Havana			
MRDSA	91.20	.20	.20
WLLCE	71.50	.18	.19
HNNPN	86.80	.39	.41
WLLCNTY	69.80	.73	.76
CRWFRD	70.00	.83	.86
FISK	70.00	.84	.88
II. Montana Coal via Havana			
MRDSA	96.98	.19	.20
WLLCE	102.99	.18	.19
HNNPN	97.16	.38	.40
WLLCNTY	96.39	.72	.75
CRWFRD	96.96	.82	.85
FISK	97.04	.83	.86
III. Montana Coal via E. St. Louis			
MRDSA	92.41	.44	.53
WLLCE	100.94	.82	.92
HNNPN	94.38	1.02	1.13
WLLCNTY	92.98	1.36	1.48
CRWFRD	93.43	1.46	1.58
FISK	93.49	1.47	1.60

chosen that more directly related to average Montana/Wyoming to Illinois movements during 1975.* Since existing river facilities would have to build rotary dumpers for unit coal trains, an additional $1.20 per ton of coal consumed in 1975 was included to reflect capital and operating expenses of the transloaders. Table 14 compares all-rail delivered costs of Montana coal for both Havana and E. St. Louis River transfer points. Rail costs for all-rail delivery do not include costs of sidings to plants (most of which have no facilities for unit trains) or loop tracks required for rapid unloading. These all-rail rates should be considered as minimum alternative mode costs. The all-rail rates from Havana are based on "eastern" rail rates (i.e., rates on western coal involving interline operations between western and eastern carriers). These rates tend to be one to three cents per ton-mile higher than "western" rates which generally end at the Mississippi River (thus involving no interline operations for final delivery). The analysis in Table 14 employs both rail rates to determine whether all-rail options are cost-effective under lowest to highest rail rates currently in force (1975). The evidence indicates that rail/barge operations even with a 100% OM&R fuel tax on the water portion of the delivery are less expensive than the estimated (and minimum) all-rail rate. In order for all-rail flows of western coal to be competitive with rail/barge in major Illinois utility markets, rates of at least 0.2 cent per ton-mile lower than present (west of the Mississippi) rail rates would be required. Further discussion of this point occurs in the next section.

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*The rail rates used to calculate all-rail alternatives are closer to the cents per ton-mile for delivery to Peoria (Wallace Plant). See Table 33, Chapter 2.

TABLE 14

ALL-RAIL VERSUS RAIL/BARGE DELIVERED COAL PRICES TO ILLINOIS WATERWAY UTILITIES (1975 - ¢/M.BTU)

I. Havana Transfer

Plant	Rail/Barge & Fuel Tax	All-Rail & Unloader Costs†
MRDSA	97.17	99.80
WLLCE	103.17	98.87*
HNNPN	97.54	100.91
WLLCNTY	97.11	102.50
CRWFRD	97.78	103.84
FISK	97.87	104.03

II. E. St. Louis Transfer

Plant	Rail/Barge & Fuel Tax	All-Rail & Unloader Costs†
MRDSA	92.86	94.77††
WLLCE	101.76	94.68*
HNNPN	95.40	98.89
WLLCNTY	94.34	99.15
CRWFRD	94.89	100.11
FISK	94.95	100.23

*New rail rotary dumper costs not included since plant is all-rail at present.

† "Eastern" rail rate.

††Based on "western" rail rate (see text).

Finally, all-rail costs of moving Illinois coal to Meredosia or Hennepin plants via ICG unit train rates (based on an annual volume of 500,000 tons) are slightly lower (before user charges and unloading facility costs) than existing barge rates. Table 15 compares rail versus barge costs from Havana to each plant. Although all-rail rates are lower than barge for the competing final move to plant, existing rail/barge operations remain cost effective when full shipment costs are considered. Direct rail rates (instead of via Havana) to these utilities may be slightly less expensive but their low volume of coal use does not make them eligible for annual tonnage discounts (see Table 36).

In summary, relative eastern versus western delivered coal prices to Illinois River utilities would not be adversely affected by a user charge. The analysis did indicate, however, that user charges may alter the distribution system for Illinois River coal delivery. Uncertainty surrounding FGD scrubber performance and strict clean-air requirements implied increasing western at the expense of eastern coal use at utilities. All-rail and alternative water transfer points for western coal delivery were examined. Finally, all-rail delivery to utilities still consuming Illinois coal was analyzed.

2.5.3 Coal Traffic Impacts

The absence of user charge-induced market impacts on the demand for coal eliminates the requirement for a utility factor demand study (as in the case of Upper Mississippi utilities). This sector examines various modal and intermodal changes that may result from user charges.

TABLE 15

**RAIL VERSUS BARGE COSTS
(¢/M.BTU - 1975):
FINAL DELIVERY TO PLANT
VIA HAVANA, IL**

I. Existing Rates

Plant	Barge	Rail*
MRDSA	3.46	2.43
HNNPN	5.20	4.85

II. Existing Rates Plus User Charges and Unloading Costs

Plant	Barge	Rail**
MRDSA	3.66	8.65
HNNPN	5.60	11.07

*Assuming a ¢/Ton-mile rail rate of .993 (1975).

**Includes 6.22 cents per million BTU for capital and operating costs of rail rotary dump facilities: $1.20/ton converted to ¢/M.BTU.

Since user charges will increase the costs of rail/barge operations, all-rail delivery options are a potential option for reducing such costs. Table 14 concluded that for major coal flows to Illinois River utilities, rail/barge operations remained the least-cost delivery system even after user charges. It was further suggested that direct rail rates would have to fall below existing minimum rates for high volume movements to compete with rail/barge flows.

The potential for a decrease in all-rail high volume rates to the Chicago area from western coal fields is low. Existing rail rates average between .9 and 1.1 cents per ton-mile, far above the theoretical minimum rates would have to fall below to be competitive with rail/barge. The western railroads engaged in the present rail/barge movement generally prefer the existing situation. Operating one hundred-ten car unit trains within the heavily congested Chicago yard area increases operating costs per ton-mile and requires increased rates to maintain profitability. By using water transfer facilities in less congested areas (such as Havana), increased equipment utilization due to lower mine-to-transfer cycle times lowers overall operating costs. Finally, eastern railroads are not especially eager to handle interline western coal traffic. The western coal replaces Illinois coal flows formerly handled by the eastern roads, usually over longer distances at higher rates. Rail rates on western coal slated for delivery east of the Mississippi River tend to be substantially higher on a ton-mile basis than those in western regions (see Table 33).

In conclusion, substantial biases against all-rail utility coal flows to the Chicago area exist that reinforce the findings that direct rail service for western coal is not cost-competitive with existing rail/barge operations. Unless improvements in Chicago rail yard operations occur and eastern carriers become more cooperative on interline western coal traffic, the current coal delivery system via the Illinois River appears optimal. For Chicago area utilities, no diversion to direct rail due to user charges is predicted. At maximum, user charges account for ten percent of existing all-rail versus rail/barge rate differentials. Finally, these results appear true regardless of whether eastern or western coal is used by Chicago area utilities in the future.

Diversion of Illinois coal moving via the Illinois River to the Meredosia and Hennepin plants to direct rail service appears improbable, based on the evidence in Table 15. When rail unloading facility capital and operating expenditures are added to the projected rail rate between Havana and these utilities, direct rail becomes twice the cost of existing rail/barge flows of Illinois coal.

The price analysis section also examined an alternative delivery system involving transfer to water at E. St. Louis rather than Havana for western coal. Table 13 indicated that Montana coal delivered via E. St. Louis averaged four cents per million Btu cheaper than via Havana. The major reason is less expensive rail rates (.785 versus 1.102 cents per ton-mile for delivery to E. St. Louis instead of Havana) due to direct Burlington-Northern service. The addition of user charges reduces the cost advantage on flows to Chicago area utilities to two cents per million BTU. Given that utilities tend to be cost minimizers, the higher cost direct rail flow of western coal to Havana requires explanation. First, movement of western coal via E. St. Louis would imply an increase in throughput of five and one-half million tons per year, or an additional 550 unit trains per year to E. St. Louis (more than one per day). The BN coal transfer facility in E. St. Louis is located in a populated area and protests are already strong about the existing level of operations. The facility is fast reaching design capacity and expansion plans are in doubt due to environmental constraints.* Finally, all coal moving to the Illinois River utilities would have to pass through Alton Locks and Dam 26. This facility is presently quite congested with delays of up to twenty-four hours during harvest months. An additional five and one-half million tons of coal would further increase lockage waiting time for all traffic (including the coal). In general, although apparently cheaper in terms of direct costs for final delivery, the use of E. St. Louis as a coal transfer point for western flows to Illinois River utilities may result in substantial indirect costs (delay, environmental, etc.) that reduce the attractiveness of the option.

In summary, western and eastern coal flows to Illinois River utilities via Havana should be unaffected by the imposition of user charges. Ton-miles and revenues from coal traffic on the Illinois River will grow with utility consumption of coal. Direct rail and alternative transfer facilities options were generally found to be substantially more expensive than present operations. Waterway user charges reduced the differential between existing rail/barge and more expensive options by at maximum ten percent.

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*For these reasons, BN is proposing a coal transfer facility at Montrose, IA to serve Upper Mississippi utilities.

2.6 TENNESSEE RIVER UTILITIES

2.6.1 Background

The Tennessee Valley Authority (TVA) currently operates four major plants on the Tennessee River (see Table 38). In 1975, the stations generated twenty-six percent of the electric power output of Tennessee and Alabama.* Only the Widows Creek station receives a majority (82 percent) of its coal via rail (L&N). Johnsonville has a rotary dumper facility but received only two percent of its coal via rail in 1975. The Colbert station is 100% water-served, with the L&N Railroad delivering the coal to Florence, AL for transloading to barges for a two mile trip to the plant. Watts Bar receives eighty-five percent by water with the remainder via truck.

Of all the utilities studied, TVA is most active in the coal spot (short-term) market in an effort to minimize fuel costs. Whereas utilities will generally sign long-term (10 year) coal purchase contracts, TVA contracts may be only one to three years. The impact on coal flow patterns is significant. Examination of Table 40 reveals substantial changes in coal sources over the last three years. Even within a state such as Kentucky, mine originations vary greatly from year to year. Given that the plants are tied to substantial water delivery, final moves to plant have not changed recently. Major river originations have remained somewhat constant, although mine-to-utility analysis is greatly hindered. For example, the Johnsonville plant purchased fifty percent (1.7 million tons) of its total coal supply in 1975 from Ohio mines in a non-recurring contract. The contract was not renewed in 1976, although a bid from other Ohio mines is under consideration.

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*Two of the plants, Colbert and Widows Creek are located on that portion of the Tennessee River in Alabama.

Like other U.S. utilities, TVA is attempting to reduce sulfur-dioxide (SO_2) emissions from generating stations. The Tennessee River plants were designed to burn high-sulfur (up to four percent) coal. Experimentation with various low-sulfur coals is underway (which explains many of the coal supply pattern changes in recent years). For example, Watts Bar is currently burning 2.5 percent coal from Southern Illinois, a barge movement of almost 775 miles. The TVA experience with electro-precipitators and FGD scrubbers has been similar to other utilities, with substantial problems due to overloaded removal capacity from high-sulfur coals.

Both the Widows Creek and Colbert Plants are equipped with lime scrubbers operating in the unsaturated mode.* The Colbert station bench lime scrubber is the model for eventual system-wide operations. The flue gas flow is for about a one-MW electrical capacity. The coal averages three percent sulfur. The operation has been intermittant and did not simulate load following.** Commercial operation is underway at Widows Creek Station. Results are guarded at present with TVA currently exploring both low-sulfur coal and scrubbers with equal interest.

Eventually, TVA will either have to convert the low-sulfur coal or retrofit boilers with FGD scrubbers. Although not currently pressed to reduce emissions to the level of Chicago area utilities, TVA plans to reduce the overall sulfur content of its coal in the future. The impact could reverse the flow of coal on the Tennessee River, in a manner similar to the Upper Mississippi experience. Low-sulfur coal sources are

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*The unsaturated mode is the most commercially advanced scrubber at present.

**NAS - Air Quality P. 205.

located in Eastern Kentucky and Virginia countries near the head of the Tennessee River. Low-sulfur coal would be put on the river near Knoxville, TN for barge shipment to TVA plants. Substantial uncertainty surrounds low-sulfur coal availability from eastern sources. First, lack of a clear national energy policy and clean-air requirements does not encourage new mine openings or increased production. Second, much of the low-sulfur coal is classified as metallurgical grade coal for eastern steel mills. Total reclassification of coal would be necessary. The next section explores these and other questions in detail.

2.6.2 Coal Price Analysis

TVA is currently evaluating various scrubber technologies and alternative fuel sources in order to comply with increasingly stringent air quality regulations. Unlike Commonwealth Edison of Illinois, TVA has experienced boiler problems in using low-sulfur (eastern) coal due to among other factors low volatility content. TVA has not tested low-sulfur western (Wyoming) coal since it has a heat value ten to twenty percent lower than eastern coal. TVA is quite uncertain about the types of coal or emissions control technologies they will employ in the future. The options will vary with plant and the coal flow pattern two years hence may be significantly different from present. This section examines the most likely occurrences and evaluates the impact of waterway user charges on the coal traffic patterns to Tennessee River utilities.

The use of low-sulfur western coal is a potential (but perhaps unlikely according to TVA) solution to reducing emissions at Tennessee River utilities. The low volatility of Wyoming coal would require some capital costs for boiler conversion.* An alternate western low-sulfur source is Utah coal. The heat content of Utah coal is 24.2 million BTU/ton versus 18.1 million Btu/ton for Wyoming coal, making boiler conversion unnecessary. However, transportation costs of Utah coal are higher due to a five hundred mile longer rail haul. Table 16 contains relative 1975 fuel costs of existing versus western sources of coal for Tennessee River utilities. The Wyoming coal is transferred by Burlington-Northern to barges at E. St. Louis for final delivery to plant. The Utah coal moves by unit train to Metropoles IL for transfer to barge and final delivery.** Unlike Upper Mississippi utilities, western coal is not price competitive under current market conditions and emissions standards. Substantial transportation costs (over fifty percent of total cost on upper river moves) price the coal out of the competitive range.

As in the case of other utilities, retrofit of FGD scrubber or SCS emission control systems is quite expensive, averaging over thirty cents per million Btu for FGD and five cents per million Btu for SCS.*** At present, all Tennessee River utilities are burning high-sulfur coal (see Table 38). Table 17 estimates the delivered price of high-sulfur.

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*Boiler conversion costs average 0.55 mile/kwh (annualized) versus 4.0 miles/kwh (annualized) for capital and operating costs of an FGD retrofit scrubber system. NAS - Air Quality. Ch. 11.

**American Electric Power plants in Illinois and Indiana are currently burning substantial quantities of Utah coal. A long term contract exists for up to 5 million tons/year by 1980.

***Many inherent emission control/coal sulfur content tradeoffs are not considered at present. For example, utilities may use 2.5% sulfur coal with a lower cost scrubber or 3.5-4.0% sulfur coal with a higher cost system. Scrubbers work well with coal having sulfur content below 2.0% making the use of less than one percent sulfur coal unnecessary for some plants.

TABLE 16

1975 DELIVERED PRICES FOR COAL IN CENTS PER MILLION BTU: TENNESSEE RIVER UTILITIES*

Plant**	Existing Weighted Average Plant Price	Wyoming Coal***	Utah Coal
JNVLL	91.04	95.20	107.07
CLBRT	83.20	98.14	109.98
WDWCRK	80.30	100.60	112.36
WATTBAR	68.40	102.30	114.10

*Existing ¢/M.Btu costs are from FPC Form No. 423 data (unpublished) for 1975. Wyoming and Utal coal costs to Tennessee River destinations are constructed costs based on rail/barge delivery (least expensive at present).

**Plant name abbreviations are found in Table 38.

***Includes boiler conversion costs.

(existing) coal at these utilities under both FGD and SCS emission control systems. Comparison of Tables 16 and 17 indicates that western coal may become competitive with existing high-sulfur coal if stringent air quality standards require FGD retrofit at these plants. TVA forecasts that the emissions standards will become more strict in the near future. However, TVA is seeking low-sulfur coal in eastern fields either to burn directly with no controls or with scrubbers.*

As mentioned previously, availability of supply of eastern low-sulfur coal is the major constraint to widespread use by utilities to reduce emissions. Much of the low-sulfur eastern coal is produced for metallurgical purposes and is priced at two or even three times high-sulfur eastern coal. New supplies of low-sulfur eastern coal for steam coal use are limited and expensive. A recent report by Charles River Associates entitled, The Supply Potential for Eastern Low-Sulfur Coal to 1990 (January, 1976, prepared for EPA), details these and other problems associated with increasing low-sulfur eastern coal supplies. TVA is currently obtaining limited supplies of low-sulfur coal from Eastern Kentucky and Virginia coal regions. At present, none is consumed by Tennessee River utilities.

Table 18 estimates the delivered price of low-sulfur eastern versus western coal and FGD retrofit at Tennessee River utilities. The eastern low-sulfur coal is assumed to be transported by unit train from Eastern Kentucky and loaded onto

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*Eastern coal has a higher relative sulfur content than western low-sulfur coal and may require scrubbers if sulfur percent exceeds 2.

TABLE 17

ESTIMATED DELIVERED PRICE OF HIGH-SULFUR COAL INCLUDING POLLUTION CONTROL COSTS: TENNESSEE RIVER UTILITIES (¢/M.BTU - 1975 PRICES)*

Plant	Existing Plant Price	+ FGD	+ SCS
JNVLL	91.04	124.51	94.39
CLBRT	83.20	126.60	87.54
WDWCRK	80.30	117.01	83.94
WATTBAR	68.40	88.30	70.39

*Source: NAS - Air Quality. Chs. 11 and 12.

TABLE 18

DELIVERED PRICE OF EASTERN LOW-SULFUR COAL VERSUS WESTERN COAL AND POLLUTION CONTROL: (¢/M.BTU - 1975)

Plant	Existing Coal + FGD	Wyoming Coal	Utah Coal	Low-Sulfur Eastern Coal*
JNNVLL	124.51	95.20	107.07	87.57
CLBRT	126.60	98.14	109.98	85.92
WDWCRK	117.01	100.60	112.36	84.00
WATTBAR	88.30	102.30	114.10	82.18

*The John Sevier plant of TVA in Knoxville currently receives low-sulfur Eastern Kentucky coal via rail at a delivered price of $16.00/ton. Barge transport costs plus rail-to-barge transfer costs were added to computed delivered price at Tennessee River utilities. Source: Fuel Price Analysis (August 1976). Sulfur content of eastern coal is assumed to be less than 1% by weight.

barges at Knoxville, TN at the head of the Tennessee River for movement to the utilities. It is clear that, if supplies are available, eastern low-sulfur coal (less than 1% by weight) is the cost-effective market substitute for either western coal or FGD retrofit systems.

In the context of the above market and air quality considerations, the price impact of waterway user charges can now be evaluated. Table 19 estimates the effects of user charges on existing and predicted optional coal flows to Tennessee River utilities. In general, the impacts on delivered prices range from two to three percent. Relative advantages of various coal fields are unchanged, although Wyoming coal via E. St. Louis bears a higher average toll due to long river movements. Similarly, flows of low-sulfur Kentucky coal experience delivered price increases of three and one-half percent. Eastern coal is still cost-effective relative to western fields but the margin is reduced (especially for Johnsonville). Thus, comparison of eastern high-sulfur coal costs after FGD and user charge increments to similar eastern low-sulfur and western coal costs remains unchanged by segment tolls or fuel taxes. If supply is available, eastern low-sulfur is cheapest. Western coal may be used if eastern supplies are not forthcoming but probably only at Johnsonville and Colbert Plants.

As a final price analysis, all-rail versus rail/barge is analyzed to determine if all-rail costs are competitive with rail/barge after user charges are imposed. Table 20 compares a variety of all-rail/rail-barge options with mixed results. The all-rail western moves, for example, are computed using the most favorable long-haul western rates available, alternatively, low-sulfur Kentucky coal is moved by existing unit

TABLE 19

DELIVERED PRICE IMPACTS OF
WATERWAY USER CHARGES
(¢/M.BTU - 1975)

I. Existing Coal Flows

Plant	Existing Price	Change Due to Toll Segment	Change Due to Fuel Tax
JHNVLL	91.04	.93	1.33
CLBRT	83.20	.04*	.05
WDWCRK	80.30	.40	.36
WATTBAR	68.40	1.67	1.88

II. Utah Coal via Metropoles

Plant	Existing Price	Change Due to Toll Segment	Change Due to Fuel Tax
JHNVLL	107.07	.37	.36
CLBRT	109.98	.87	.84
WDWCRK	112.36	1.41	1.35
WATTBAR	114.10	1.86	1.78

III. Wyoming Coal via E. St. Louis

Plant	Existing Price	Change Due to Toll Segment	Change Due to Fuel Tax
JHNVLL	95.20	1.78	1.44
CLBRT	98.14	2.45	2.08
WDWCRK	100.60	3.17	2.76
WATTBAR	102.30	3.78	3.34

IV. Kentucky Low-Sulfur Coal
via Knoxville

Plant	Existing Price	Change Due to Toll Segment	Change Due to Fuel Tax
JHNVLL	87.57	3.09	2.94
CLBRT	85.92	2.56	2.44
WDWRK	84.00	2.00	1.90
WATTBAR	82.18	1.53	1.45

*Colbert plant coal moves only 2 to 3 miles on the river from Florence AL (95% of tons).

TABLE 20

ALL-RAIL DELIVERED PRICES VERSUS
EXISTING AND RAIL/BARGE COSTS AFTER USER CHARGES
(¢/M.BTU - 1975)

I. All-Rail*

Plant	Existing All-Rail**	Utah Coal***	Wyoming Coal†	Kentucky All-Rail††
JHNVLL	118.40	104.10	94.5	111.52
CLBRT	124.00	113.90	107.46	105.30
WDWCRK	77.50	114.98	108.40	94.33
WATTBAR	-	127.64	118.78	92.13

II. Rail/Barge After User Charges

Plant	Existing Cost & Segment Toll	Utah Coal & Segment	Wyoming & Segment	Kentucky & Segment
JHNVLL	91.97	107.44	96.98	90.66
CLBRT	83.24	110.85	100.59	88.48
WDWCRK	80.70	113.77	103.77	86.00
WATTBAR	70.07	115.96	106.08	83.71

*Includes the capital costs per million Btu of constructing rotary railcar dumper facilities at Colbert and Watts Bar.

**Constructed rates for JHNVLL and CLBRT; actual for WDWCRK.

***L&N interline with D&RGW at Metropoles 0.81¢/ton-mile.

†Minimum all-rail cost using .785¢/ton-mile western rate.

††Kentucky rate uses average 1.0¢/ton-mile unit train rate in Alabama/Tennessee area.

train rates in the Southern District (see Table 39). In some cases, all-rail movements may be competitive with rail/barge operations. In general, however, existing barge final delivery costs even after user charges are still lower than either all-rail or other barge/rail options. Widow Creek plant is an exception, given that they have a high volume (3.5 million tons per year) rail operation in place. The constructed rail rates contain unloading (rotary dumper) costs at facilities not presently taking rail coal.

In summary, the price analysis reveals no significant differential impacts on coal markets presently or predicted to serve Tennessee River utilities. User charge impacts represent a two to three percent increase in delivered price, or ten percent of full FGD retrofit costs (in ¢/M.Btu terms). Finally, the imposition of user charges does not appear to alter relative transportation costs in favor of all-rail delivery options to the utilities.

2.6.3 Coal Traffic Impacts

The question of future coal traffic patterns on the Tennessee River with or without user charges is complex and difficult to answer. Recent TVA burn-mix experimentation and coal purchases on non-recurring contracts make the coal demand data difficult to interpret and almost impossible to use in predicting market impacts due to user charge - induced price changes. Delineation of coal market areas is also difficult, unlike the western/S. Illinois competition found earlier.

This section will examine the effects of stricter air quality standards on Tennessee River utility coal purchase patterns and explore the feasibility of loss of river traffic to rail as the result of waterway user charges. By default, the analysis will be less rigorous and more intuitive than previous studies.

The relative success of FGD scrubber technology in the next few years will determine the future patterns of coal flows on the Tennessee River. In the extreme case where low-sulfur coal must be used, flows would reverse on the river. Originations at Knoxville, TN would become common in order to move Eastern Kentucky low-sulfur coal to the utilities. The only plant where low-sulfur western coal appears competitive is the Johnsonville plant (100 miles down the Tennessee from the Ohio). If burn-mix volatility is an issue, Utah low-sulfur, high Btu coal may be a distant option at Johnsonville and (less likely) Colbert.

Less stringent clean-air requirements and some success in scrubber operations would lead to fewer Knoxville coal originations and perhaps no chance for western coal inroads. The most likely scenario appears to be increased use of lower sulfur coal from Eastern Kentucky fields for use with (or without) scrubbers. Continued experimentation with alternative eastern coal sources is also likely to occur. Use of western coal on the Tennessee River is unlikely at present but future changes may alter this conclusion.

In summary, longer coal hauls from Knoxville, TN river origins will likely increase barge revenues and ton-miles on the Tennessee River during the next five years. Major existing traffic patterns may not change but Ohio and Green River coal origins for Tennessee River utility coal will probably cease as increased low-sulfur coal use is required.

An analysis of potential changes in modal traffic patterns to Tennessee River utilities due to user charges is best performed at the individual plant level. Existing traffic patterns are heavily dependent on available unloading facilities, institutional constraints, and centralized coal purchases by TVA.

The Johnsonville plant (100 miles from the Ohio River) received ninety-eight percent of its coal by water in 1975. The plant has a rotary coal dumper for rail service, but generally uses the facility only for "experimental" coal flows for burn-mix testing. The constructed all-rail rate to Johnsonville in Table 20 reflects a less than optimal utilization of the rail unloading facility. In general, even after user charges are incorporated, barge service remains cheaper. All-rail versus rail/barged low-sulfur eastern coal indicates a substantial savings in long-haul river operations (twenty cents per million Btu). If western coal were used at the facility and the very low "western" rail rate maintained for delivery, all-rail may be somewhat less expensive than barge (94.50 versus 96.98 ¢/M.Btu). However, the use of western coal is questionable as is the maintenance of a rail rate of .785 ¢/ton-mile east of the Mississippi River. If "eastern" rail rates were charged for the move (say, 1.0¢/ton-mile) the all-rail western coal delivered price would rise to around 105 ¢/M.Btu, well above the rail/barge cost from E. St. Louis. In summary, the Johnsonville plant will likely maintain substantial barge traffic even after user charges, air quality controls, etc. are imposed. Rail/barge rates remain favorably lower than a variety of all-rail options examined in Table 20.

The TVA Colbert plant currently receives all its coal by water from Kentucky and Tennessee mines. The plant is located on the southern side of the river in Alabama, 245 miles from the Ohio River. Interline rail operations across the river are expensive. The L&N Railroad unloads the coal at Florence, AL for a three-mile barge haul to the utility. User charges alter the delivered price of coal at Colbert by .04 cents per million Btu, or five one-hundreths of one percent. About fifeteen percent of the coal moving into Colbert travels two to three hundred miles on the river. User charges would increase the delivered cost of the coal 1.0 to 1.5 cents per million BTU, or on average two percent. Considering the cost per million BTU for installing a rotary railcar dumper is at least five cents per million Btu, even if rail rates equal barge rates, a move to rail is not cost-effective. No modal diversion at Colbert is anticipated as the result of user charges.

The Widows Creek plant, located 400 miles down the Tennessee River from the Ohio received only 18 percent of its coal via water in 1975. The delivered price of the barge coal was 75.9 cents per million BTU versus 77.5 cents for rail coal. The waterborne coal moves only ten miles on the Tennessee with a segment toll of .9¢ per ton or .04¢ per million BTU. No diversion to rail is anticipated from user charges, although TVA may eliminate the water move for other reasons.

The Watts Bar utility is 530 miles from the Ohio and receives about 85 percent of its coal via water, mostly from intra-Tennessee River origins. A user charge on a typical flow from river mile 100 would increase the barge rate from about $2.25 per ton to $2.65 per ton, or an increase of 18 percent. Delivered price would increase by 1.7¢ per million Btu or less than two percent. Since Watts Bar is located near coal fields and truck competition with barge exists, some diversion may occur. Watts Bar does not have rail unloading facilities and receives fifeteen percent of its coal via truck. In 1976, a major (250,000 ton) coal flow was initiated between Southern Illinois and Watts Bar, a river distance of 775 miles. A user charge of 65¢ per ton would increase the barge rate eight percent. However, the flow occurred for burn-mix requirements at the plant. TVA officials indicated that the coal was necessary to optimize plant operation and would not be diverted by a waterway user charge. Watts Bar does have significantly longer river flows than other plants. Competition from short-haul truck may influence coal purchase decisions after user charges are imposed. If correct types of coal were available locally, TVA may alter its purchase patterns. It is difficult to quantify diversion, but ten percent (50,000 tons in 1975) is a minimum estimate. TVA is converting Watts Bar to peak-load use only so that coal demand will fall in the future. User charges may speed up retirement of the plant if correct coal supplies cannot be found locally.

In summary, total coal diversion estimates due to user charges are minimal (50,000 tons out of 5.96 million tons of traffic in 1974) for Tennessee River utilities. Market and air quality factors will probably result in increased ton-miles and revenue due to longer hausl of eastern low-sulfur coal along the river. As before, user charge impacts are small in comparison to coal market price changes.

2.7 OHIO RIVER UTILITIES

2.7.1 Background

Ohio River utilities generated twenty-nine percent of the electricity production in Illinois, Indiana, Ohio, Kentucky, and Pennsylvania during 1975. With exceptions noted in Table 41, the plants received about sixty-four percent of their coal by water. Typical coal originations include the Green River (8 million tons), Kanawha River (5 million tons) and the Monongehela (7.5 million tons) for sixty-eight percent of water delivered coal to Ohio utilities in 1975. The remainder originated on the Ohio River or from western coal fields via E. St. Louis or Metropoles, IL (see Table 42). Kentucky and Ohio coal provides over sixty percent of all coal burned at Ohio River utilities.

Initial use of western coal has begun along the Ohio River as far east as the Ohio Electric Co. Gavin plant (900 miles from E. St. Louis). The utility is an exception among Ohio River plants, employing twenty-five percent western (Utah and Wyoming) coal in its burn-mix. The Gavin plant accounts for seventy percent of western coal use among river-served utilities along the Ohio. As in the Tennessee River utilities, western coal has not supplanted traditional eastern sources.

Two factors distinguish the Ohio River from previous rivers studied for traffic impacts due to user charges. First, the average length of haul for barge-delivered coal is shorter, less than one hundred miles for most major movements. Second, the Ohio River is not expensive to maintain and the user charge segment toll is only sixty percent of the uniform ton-mile toll (fuel tax). These factors combine to reduce the overall traffic impacts due to user charges if a segment toll is adopted. If Ohio River traffic is forced to pay a surcharge to help support expensive and little-used rivers (such as the Kentucky) via a uniform fuel tax, changes in traffic patterns or mode could result. Utilities presently receiving coal via both rail and water (Cardinal and Joppa plants; see Table 41) are most likely candidates for modal shift. In general, even under a fuel tax, average delivered price increases by less than two cents per million BTU, substantially less than the six cents per million BTU required to install a railcar rotary dump facility at a utility.

2.7.2 Coal Price Analysis

Ohio River utilities purchase coal from highly competitive coal markets in states from Pennsylvania to Illinois. As in the case of Tennessee River utilities, although basic river traffic patterns for coal delivery remain fixed, mine origins of the coal and the pre-river movement characteristics may vary substantially from year to year. Depiction of alternative eastern sources and delivered prices for coal at particular Ohio River utilities would be dated as it was being prepared.

Table 21 estimates 1975 relative fuel costs for Ohio River utilities of coal from existing, Wyoming and Utah origins. Western coal is not generally competitive under existing air quality regulation (generally more lax in the Ohio Valley than in other river basins previously examined). The substantial variation in existing coal prices among Ohio River utilties may be due purchases of higher-cost coals to maintain burn-mix or plants forced to renew coal contracts after recent coal price escalations.

Strict air-quality standards for the Ohio Valley could significantly alter the competitiveness of low-sulfur western coal in the region. Table 22 compares relative coal costs after retrofit Flue Gas Desulfurization (FGD) costs are added

TABLE 21

1975 DELIVERED PRICE OF COAL FROM EASTERN AND WESTERN SOURCES: OHIO RIVER UTILITIES (¢/M.BTU)*

Plant**	Weighted Average Price: Existing	Wyoming Coal via E. St. Louis	Utal Coal via Metropoles
JOPPA	94.00	92.02	103.49
SHWNE	79.40	92.14	103.03
CLMN	46.70	96.73	109.32
GLLGHER	56.30	98.78	111.27
CLFTYCRK	61.20	99.59	112.01
GHENT	58.90	99.96	112.34
TNNRSCRK	50.70	100.62	112.92
MIAMIFT	68.20	100.68	112.98
BCKJRD	75.50	101.26	113.48
STUART	101.20	101.98	114.11
KYGRCRK	65.50	104.14	115.94
GAVIN	102.10	104.13	115.93
BURGER	103.70	106.08	117.55
TORONTO	80.40	106.65	118.02
CRDNL	81.60	106.40	117.81
SAMMIS	93.20	106.70	118.06
PHILLIPS	96.10	107.17	118.44

*Source: FPC Form No. 423 (unpublished) data - column 1 columns 2 and 3: constructed data based on 1975 western f.o.b. mine prices, rail haul to river, transfer costs and barge to utility.

**Plant name abbreviations are explained in Table 41.

TABLE 22

1975 DELIVERED COAL PRICES ASSUMING POLLUTION CONTROL REQUIREMENTS: OHIO RIVER UTILITIES (¢/M.BTU)

Plant	Weighted Average Existing Price & FGD	Wyoming Coal via E. St. Louis	Utal Coal via Metropoles	West Virginia Low-Sulfur Coal*
JOPPA	135.06	92.02	103.49	74.71
SHWNE	114.38	92.14	103.03	74.66
CLMN	88.53	96.73	109.32	72.44
GLLGHER	90.39	98.78	111.27	71.11
CLFTYCRK	93.46	99.59	112.01	70.49
GHENT	98.20	99.96	112.34	70.19
TNNRSCRK	98.43	100.62	112.92	69.63
MIAMIFT	87.11	100.68	112.98	69.58
BCKJRD	107.89	101.26	113.48	69.04
STUART	138.66	101.98	114.11	68.29
KYGRCRK	108.45	104.14	115.94	66.00
GAVIN	125.19	104.13	115.93	65.98
BURGER	141.87	106.08	117.55	68.68
TORONTO	126.28	106.65	118.02	69.34
CRDNL	129.35	106.40	117.81	69.05
SAMMIS	135.93	106.70	118.06	69.40
PHILLIPS	124.97	107.17	118.44	69.92

*Delivered price constructed assuming a $15/ton minehead cost of low-sulfur coal, a fifty-mile rail haul to Kanawha River, and barge haul to utilities.

to existing cents per million Btu coal costs. Other factors equal, Wyoming and Utah coal become cost-effective versus FGD retrofit. However, the final column represents costs of delivering low-sulfur eastern coal from West Virginia via Kanawha River origins. If supplies are forthcoming from low-sulfur fields in the east, the coal would be less expensive than both FGD retrofit and western low-sulfur coal. Depending on the availability of low-sulfur coal from eastern fields, coal traffic patterns on the Ohio may or may not be altered by a tightening of emissions allowed by utilities. Table 23 indicates that present coal used at Ohio River utilities is high in sulfur content and that substantial conversion of utilities to low-sulfur coal or FGD rtrofit would be required.

In the context of above relative market price effects on future utility operations, impacts of user charges on coal prices can now be examined. Table 24 estimates the impacts on existing delivered coal prices of segment and fuel taxes assuming 100% OM&R Corps and Coast Guard cost recovery. Impacts are greatest for utilities on the western portion of the Ohio River. Length of barge haul to utility along the Ohio falls substantially in the Huntington and Pittsburgh Corps districts of the river accounting for the lower tolls. Maximum impacts on delivered price of waterway fuel taxes averages less than two percent for coal traffic on the Ohio River.

Table 25 estimates segment and fuel tax impacts on Wyoming and Utah coal delivered price to Ohio River utilities. Wyoming coal, with an almost 200 mile longer river haul than Utah coal is more adversely affected by user charges, although the relative price advantage enjoyed by low-sulfur Wyoming coal is maintained. However, high-volatile Utah coal may be

TABLE 23

SULFUR CONTENT BY WEIGHT AT OHIO RIVER UTILITIES: 1975*

Plant	% by Weight
JOPPA	2.79
SHWNE	3.14
CLMN	3.29
GLLGHER	3.25
CLFTYCRK	3.36
GHENT	3.32
TNNRSCRK	3.70
MIAMIFT	2.82
BCKJRK	2.79
STUART	1.88
KYGRCRK	4.17
GAVIN	2.48
BURGER	2.99
TORONTO	2.89
CRDNL	2.61
SAMMIS	2.85
PHILLIPS	1.92

*Source: FPC Form No. 423 data (unpublished).

TABLE 24

NAVIGATION COST RECOVERY IMPACTS ON
EXISTING DELIVERED COAL PRICES:
OHIO RIVER UTILITIES (¢/M.BTU)

Plant	Existing Coal Price	Change Due to Fuel Tax	Change Due to Segment Toll
JOPPA	94.00	.83	.61
SHWNE	79.40	.82	.60
CLMN	46.70	.25	.18
GLLGHER	56.30	.78	.50
CLFTYCRK	61.20	1.20	.78
GHENT	58.90	1.21	.79
TNNSRCRK	50.70	1.18	.81
MIAMIFT	68.20	1.17	.89
BCKJRD	75.50	1.30	.88
STUART	101.20	.65	.58
KYGRCRK	65.50	.35	.31
GAVIN	102.10	.35	.31
BURGER	103.70	.10	.07
TORONTO	80.40	.46	.54
CRDNL	81.60	.45	.53
SAMMIS	93.20	.38	.31
PHILLIPS	96.10	.36	.68

TABLE 25

USER CHARGE IMPACTS ON DELIVERED PRICE OF WESTERN COAL TO OHIO RIVER UTILITIES (1975 - ¢/M.BTU)

Plant	Wyoming Coal Price	Change Due to Fuel Tax	Change Due to Segment Toll
I. Wyoming Coal via E. St. Louis			
JOPPA	92.02	.93	1.20
SCWNE	92.14	.95	1.22
CLMN	96.73	1.92	1.80
GLLGHER	98.78	2.43	2.11
CLFTYCRK	99.59	2.65	2.24
GHENT	99.96	2.75	2.30
TNNRSCRK	100.62	2.94	2.41
MIAMIFT	100.68	2.96	2.42
BCKJRK	101.26	3.13	2.52
STUART	101.98	3.34	2.65
KYGRCRK	104.14	4.02	3.06
GAVIN	104.13	4.02	3.06
BURGER	106.08	4.67	3.45
TORONTO	106.65	4.87	3.57
CRDNL	106.40	4.79	3.52
SAMMIS	106.70	4.89	3.58
PHILLIPS	107.17	5.06	3.69
II. Utah Coal via Metropoles, IL			
JOPPA	103.49	.69	.01
SHWNE	103.03	.71	.00
CLMN	109.32	1.43	.42
GLLGHER	111.27	1.82	.70
CLFTYCRK	112.01	1.98	.76
GHENT	112.34	2.06	.81
TNNRSCRK	112.92	2.20	.89
MIAMIFT	112.98	2.21	.90
BCKJRD	113.48	2.34	.97
STUART	114.11	2.50	1.07
KYGRCRK	115.94	3.01	1.38
GAVIN	115.93	3.00	1.37
BURGER	117.55	3.50	1.67
TORONTO	118.02	3.65	1.76
CRDNL	117.81	3.58	1.72
SAMMIS	118.06	3.66	1.77
PHILLIPS	118.44	3.78	1.84

preferred to Wyoming coal if boiler conversion costs are included in the cost of the latter coal. Table 26 estimates fuel and segment toll impacts on low-sulfur eastern coal from West Virginia delivered to Ohio River utilities. Although eastern low-sulfur coal already enjoyed a substantial price advantage over western coal, user charges further favor eastern coal in Ohio River utility markets.

In summary, waterway user charge impacts on present delivered prices at Ohio River utilities average less than a two percent price increase. Given that conversion costs to rail delivery average three times user charge impacts on a typical Ohio River utility, modal diversion appears unlikely. The next section examines the question of traffic impacts for rail and water served Ohio River plants.

2.7.3 Coal Traffic Impacts

Substantial costs to convert water-served utilities to rail shipments of coal make modal diversion at 100 percent waterborne delivery plants unlikely. Table 41 indicates that five utilities currently receive coal by rail as well as water celivery via the Ohio River.

Time limitations on this study permits analysis only of the TVA Shawnee plant, located in Kentucky, forty miles up the Ohio River from the Mississippi River. The plant receives coal from Illinois via ICG volume movements and low-sulfur coal from Montana via BN unit trains. Existing barge coal originates in Kentucky and is delivered to Shawnee at 72.8 cents per million Btu. Illinois rail coal averages 71.7 cents per million Btu. User charges would increase barge coal delivered price by almost one cent per million BTU. As

TABLE 26

USER CHARGE IMPACTS ON LOW-SULFUR WEST VIRGINIA COAL: OHIO RIVER UTILITIES (1975 - ¢/M.BTU)

Plant	Existing W. Virginia Coal Price	Change Due to Fuel Tax	Change Due to Segment Toll
JOPPA	74.71	2.17	1.84
SHWNE	74.66	2.16	1.83
CLMN	72.44	1.53	1.46
GLLGHER	71.11	1.20	1.25
CLFTYCRK	70.49	1.05	1.17
GHENT	70.19	.99	1.13
TNNRSCRK	69.63	.87	1.06
MIAMIFT	69.58	.86	1.05
BCKJRD	69.04	.75	.99
STUART	68.29	.61	.90
KYGRCRK	66.00	.26	.69
GAVIN	65.98	.26	.69
BURGER	68.68	.68	.94
TORONTO	69.34	.81	1.02
CRDNL	69.05	.75	.99
SAMMIS	69.40	.82	1.03
PHILLIPS	69.95	.93	1.09

contracts for barge coal are renewed and if stricter air quality standards enforced, the utility may switch to lower sulfur (rail delivered) Illinois coal, resulting in traffic loss on the river. Similar changes may also occur at other rail-served utilities along the river, although overall diversion appears minimal. A more thorough analysis of the Ohio River utilities coal demand and potential diversion due to user charges is underway.

2.8 MONONGAHELA, ALLEGHENY, AND KANAWHA RIVERS

2.8.1 Background

River-served utilities on the Monongahela, Allegheny and Kanawha Rivers generated thirty percent of the electric power output for West Virginia and Pennsylvania in 1975. Major delivery mode to the plants is barge with short-haul truck moving a significant portion in some cases. The Appalachian Power Amos plant was the only utility in the region receiving coal via both rail and water in 1975.* Amos plant is one of the largest utilities in the U.S., consuming 6.54 million tons of coal in 1975, much of it delivered via the Kanawha River.

To meet strict air quality regulations, both the Kanawha and Amos plants burn low-sulfur, high volatile West Virginia coal. Plant delivered costs for this coal varied between 75 and 95 cents per million Btu in 1975, comparing favorably with previous estimates of low-sulfur eastern coal costs. The Amos and Kanawha facilities consume over seventy percent of West Virginia coal districts 7 and 8 low-sulfur coal production.

Average barge-haul for coal moving on the three rivers was between twenty-five and one-hundred miles, with much traffic going ten miles or less. Although actual user charge segment tolls are relatively high compared to the U.S. average uniform ton-mile tax,** short river hauls and high coal tonnage spread the impact. Most segment tolls for coal traffic average less than ten cents per ton, or .4 cent per million Btu impact on delivered prices of 80 to 100 cents per million Btu.

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*The Fort Martin and Riversville plants of Monongahela Power have rail facilities but have received no coal via rail for over 5 years.

**Segment tolls on the Monongahela, Allegheny and Kanawha Rivers are .17, 1.43 and .20 cents per ton-mile respectively compared to the national average of .080 cents per ton-mile.

Table 44 indicates that West Virginia mines are the major source of coal to utilities located on the three rivers. River coal originations have not changed substantially over the past three years, making analysis of user charge impacts with 1972 CoE waterborne data credible.

2.8.2 Coal Price Analysis

The price analysis will concentrate on user charge impacts on delivered coal prices to plants on the three rivers. Table 27 presents segment and fuel tax impacts on 1975 delivered prices at the utilities.

Impacts on delivered coal prices are negligible with the exception of the Duquesne Power Cheswick Plant on the Allegheny River. Under a segment toll recovery option, delivered price via water would increase two percent to the plant. Barge transportation costs would increase less than five percent for the movement to Cheswick.

2.8.3 Coal Traffic Impacts

Although Cheswick plant experiences the most substantial impact on delivered price due to user charges, chances for modal diversion due to navigation cost recovery appear minimal. The facility has no rail unloading equipment and construction costs of rotary dumpers range from six to eight cents per million BTU of coal, depending on land acquisition costs. Even if rail and barge rates for final delivery to Cheswick are currently equal, user charges would increase barge-delivered coal costs by two cents per million BTU of coal delivered.

The only other plants with potential rail service are the Fort Martin and Rivesville plants of Monongahela Power, located on the Monongahela River in West Virginia. Neither

TABLE 27

1975 DELIVERED PRICE IMPACTS DUE TO WATERWAY USER CHARGES (¢/M.BTU)*

Plant**	Existing Cost	Change Due to Segment Toll	Change Due to Fuel Tax
MTCHLL	80.50	.40	.16
ELRAMA	82.16	.42	.24
HTFLDFRY	87.92	.14	.07
FTMRTN	75.02	.05	.02
RVSVLL	102.90	.08	.04
CHSWCK	88.92	1.77	.35
AMOS	99.55	.21	.09
KANAWA	78.58	.07	.03

*Source: FPC Form No. 423 data (unpublished).

**Name abbreviations explained in Table 39.

plant has received coal by rail since 1972 and substantial reconstruction of existing rail dump facilities would be necessary prior to accepting volume shipments by rail. Table 27 indicates that these two plants would be the least affected by user charges of all plants studied on the three rivers.

Impacts on delivered price of segment tolls are less than one-tenth of one percent. Switch to rail is unlikely as the result of waterway user charges.

In summary, no traffic loss or modal diversion for Monongahela, Allegheny or Kanawha River utilities is forecast to result from user charges. Although segment tolls in cents per ton-miles are high relative to other rivers, coal hauls are generally very short, making the price impacts minimal to utilities.

2.9 DEMAND FOR FOSSIL FUELS BY UTILITIES

2.9.1 Background

Consider a utility that consumes energy (coal and other fuels) from distinct and spatially separate markets under conditions of imperfect competition in the supply of factors. In addition to having distinct supply functions due to varying recovery costs (strip vs. deep mining for example), each coal market has varying product characteristics (Btu content [heat value], percent sulfur, ash content). In an industry with minimal vertical integration into factor supply, the utility deals in exogenous factor and transportation markets. Due to high fixed investments in unloading facilities, coal-burning utilities are generally constrained to a single transportation mode for final delivery to plant.

Except in certain utilities expressly designed to burn more than one type of fuel, short-run fuel use is limited to a single fuel variety. Even conversion to other coal fields with different product characteristics is difficult since most utility boilers are designed to burn coal with a fixed set of standards. A utility may have peak-load gas or oil-fired turbine facilities but these fuels would not be part of its base-load energy consumption decision.

The decision on fuels consumption by a utility can be viewed as a two-stage process. The utility, faced with rate of return regulation, is considered a price taker that seeks to minimize total costs, subject to production relationships and relative factor prices. The first stage in the process determines total fuel (all kinds) demand relative to other factors of production, fuels prices and electricity output in kilowatt-hours.

Assuming homothetic separability in the production relationship; e.g., weak separability in the inputs - capital, labor, energy and materials, the cost minimizing mix of energy inputs is independent of other factors. For example, the marginal rate of substitution between energy inputs E_i and E_j is independent of the quantities of capital K or labor L demanded. Thus, the fuels purchasing manager allocates utility fuel demands to various (separated) fuels markets, subject to burn mix, EPA clean-air restrictions on sulfur content, among other constraints. A typical utility located in the Northern Great Plains states consumes coal from Kentucky, Illinois, Montana, Wyoming and even Utah. In this manner, the utility blends a variety of coals to arrive at optimal fuel input at a cost-minimizing set of prices. The second stage derives unique fuels market demand curves for a particular utility and may be employed in a variety of analyses. The major objective in this report is to evaluate the effect of waterway user charges on relative coal prices from different sources and to predict regional changes in coal market demands by utilities. Finally, variations in modal traffic densities and revenues are predicted, based on the maintenance of existing distribution systems.*

The above approach is preferable to a fuel-choice probabilistic model (logit for example) because the process is directly derived from the utility production decision without information loss that occurs in the alternative modelling forms. Logit specification requires a distinct alternative for each observation at every utility. In the case where

*Substantial changes in relative modal prices would have to occur to have a utility consider shifting modes. For example, the annualized cost of a new rail rotary dump facility is at least $1.50 per ton of coal throughput, less than existing rail/barge rate differentials of up to $3.00 per ton.

a utility consumes fuel from only one source, estimation is difficult with a logit approach. In a more macro energy modeling environment, logit procedures work quite well.*

Although the distribution system associated with coal flows to utilities is assumed exogenous and fixed for present, such variations could easily be adopted into the scheme as a related submodel. For example, the continued use of rail/barge instead of all-rail service to Upper Mississippi River utilities would be a typical question to analyze. Relative modal delivered prices for a particular coal source to a utility would serve as the decision metric. Such analyses are possible in the existing model, although distribution systems are not explicitly compared to determine optimality after relative price shifts.

2.9.2 Model Specification

Previous studies** of the electric utility industry have found that cost minimization is a plausible behavioral model, treating output and factor prices as exogenous. The following models extend prior work using more generalized functional forms to allow examination of substitution considerations among many (energy) inputs. The assumption of weak separability among major inputs - energy, capital, labor and resources, allows disaggregation of input decisions among factors. In

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*See, for example, Baughman, M.L. and P.L. Joskow. Interfuel Substitution in the Consumption of Energy in the United States. Report MIT-EL-74-002 (May 1974). MIT Energy Lab, Cambridge MA.

**See Section 6 for examples.

this particular case, the energy input decision process by a utility is examined. The procedure draws upon a recent approach devised by Hudson and Jorgenson.* The following development is based on an article by Fuss in the Journal of Econometrics (January 1977).

Assume the utility faces a number of differentiated energy supply markets, E_i , $i = 1,...,n$. The basic production relation is

$$Q = f\ (E_1,.., E_n, L, M, K). \tag{1}$$

Weak homothetic separability in energy markets implies

$$Q = f\ (E\ (E_1,.., E_n), L, M, K), \tag{2}$$

where E is an aggregator function to determine total energy input. Although ignored in the present study, this aggregator function is a complex combination of subenergy market characteristics (Btu content, sulfur percent, etc.). A complete theory would include these extensions. For present, it is assumed that coal sources are perfect substitutes and can be summed in BTU units.

Shephard** has shown that quality in cost and production imply that the cost function corresponding to (2) is also weakly separable and can be written as

$$C = g(P_E\ (P_{E_1},...., P_{E_n}), P_L, P_M, P_K, Q], \tag{3}$$

where P_E is also an aggregator function or an aggregate price index and P_{Ei}, P_L, P_M, and P_K are input prices. As before,

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*Hudson, E.A. and D.W. Jorgenson. "U.S. Energy Policy and Economic Growth, 1975-2000." Bell Journal of Economics and Management Science (Autumn 1974). Page 461.

**Shephard, R.W., Cost and Production Functions. Princeton University Press, Princeton NJ. 1953.

unless energy inputs are perfect substitutes, the price index is more than a simple weighted average. P_E is the price per unit of energy and the cost to a utility fuel manager of coal or other fuel inputs. Representing the cost by a translog cost function yields:

$$\ln P_E = \ln B_o + \Sigma_i B_i \ln P_{E_i} + 1/2 \Sigma_i \Sigma_j B_{ij} \ln P_{E_i} \ln P_{E_i}. \tag{4}$$

Following cost minimizing behavior by the utility fuels manager allows specification of individual coal source demand functions. Optimization yields energy input functions in terms of cost shares of the aggregate energy budget, or

$$S_{E_i} = B_i + \Sigma_j B_{ij} \ln P_{E_i} \quad i,j = 1,..,n, \tag{5}$$

where S_{E_i} is the percent share of cost of the i^{th} energy input.

So that the system of energy demand equations (5) satisfy basic "adding-up" criteria as well as properties of neo-classical production theory require the following parameter restrictions:

$$\begin{aligned} &\Sigma_i B_i = 1, \\ &\Sigma_j B_{ij} = \Sigma_{i'} B_{ij} = 0, \\ &B_{ij} = B_{ji'} \quad i \neq j. \end{aligned} \tag{6}$$

Estimation may proceed by employing a systems approach that allows for cross and intra-equation constraints of parameters. The price elasticities can be calculated using the Allen-Uzawa partial elasticities of substitution ($\not{\sigma}_{ij}$):

$$\not{\sigma}_{ij} = \frac{B_{ij} + S_{Ei}^2 - S_{Ei}}{S_{Ei}^2}, \quad i,j = 1,...,n,$$

$$\not{\sigma}_{ij} = \frac{B_{ij} + S_{Ei} S_{Ei}}{S_{Ei} S_{Ei}}, \quad i \neq j. \tag{7}$$

Following Berndt and Wood,* translog price elasticies are as follows:

$$E_{ij} = S_{Ei} \not{Z}_{ij}, \qquad (8)$$

$$E_{ij} = S_{Ei} \not{Z}_{ij}.$$

The elasticities provide evidence on changes in energy market shares due to changes in relative delivered coal prices from waterway user charge imposition.

2.9.3 Estimation

As mentioned earlier, an equation system estimation approach is necessary, given that parameter restraints are needed to assure consistent share (energy) calculation. The Zellner "seemingly unrelated" efficient estimation procedure has been used. Basically, the model is specified with parameter constraints "built-in" to the equations, one equation is dropped from the system and the remaining estimated as a group.

The data base consists of FPC Form No. 423 utility reports on fuel consumption by month, plant and fuel source since 1972. Using annual data for Upper Mississippi River utilities (Northern States Power, Dairyland Power Coop, and Interstate Power) by plant, equation system (5) can be estimated. Given that insufficient multiple (greater than two) fuel source data for water-served utilities is available, only two equations (western vs. eastern coal) were specified. Since one equation can be eliminated, cross equation constraints need not hold and OLS estimation can be used in the abbreviated model for this study.

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*Berndt, E.R. and D.W. Wood. "Technology, Prices and the Derived Demand for Energy" RE STAT 57 (August 1975) P. 259.

Table 28 contains symbol definitions and basic model equations used in the initial estimation of the model. Tables 29 and 30 contain various estimated equation forms. Table 29 contains the western coal cost share equation for these Upper Mississippi utilities with a single constant term and a covariance approach using multiple utility dummy variables. Table 30 contains first the same equation with coal prices in cents per million BTU (instead of $ per-ton in the initial equations) and a logit specification of the model for comparison. Table 31 presents calculated elasticities for both models using (7) and (8) above and elasticity concepts from Baughman and Joskow. EII and EIJ are Allen-Uzawa partial elasticities of substitution, E1 and E2 are demand own and cross-price elasticities, respectively; using Table 31, price elasticities are calculated, using 1975 western coal share as a percent of energy budgets for Upper Mississippi utilities listed in Table 28.
These measures of price responsiveness are used to calculate effects of changing relative coal delivered prices to utilities due to user charges on western versus eastern coal market shares. (See Tables 32-44.)

In summary, the above model is an initial attempt to determine market demands for a commodity as a function of relative prices of competing supply sources. The demands are then translated into model traffic in a distribution system context. The explicit aim is to determine changes in model shares due to changes in supply prices from competing markets.

TABLE 28

SYMBOL DEFINITIONS AND MODEL EQUATIONS

I. Symbols

WCOST = WESTERN COAL SHARE OF TOTAL COAL COST
TOTAL = COAL COST OF UTILITIES
WPTON = PRICE PER TON OF WESTERN COAL.
EPTON = PRICE PER TON OF EASTERN COAL
CWMBTU = PRICE PER MILLION BTU OF WESTERN COAL
CIMBTU - PRICE PER MILLION BTU OF EASTERN COAL
NS = DUMMY FOR NORTHERN STATES POWER PLANTS
DAIRY = DUMMY FOR DAIRLYLAND POWER PLANTS
INTER = DUMMY FOR INTERSTATE POWER PLANTS
SW = WESTERN COAL AS A PERCENT OF TOTAL COAL USE
SE = EASTERN COAL AS A PERCENT OF TOTAL COAL USE

II. Symbol Declarations

III. Endogenous:

SE SW TCOST WCOST

IV. Exogenous:

CIMBTU CWMBTU DAIRY EPTON INTER NS WPTON

V. Coefficient:

B1 B11 B12 B22 B3 C1 C2 C3 C4 C5

VI. Equations

1: WCOST/TCOST = B1+B11*LOG(WPTON)+B12*LOG(EPTON)
2: WCOST/TCOST = C1(NS+C2*DAIRY+C3*INTER+BILL*LOG (CWMBTU)+B12*LOG(CIMBTU)
3: WCOST/TCOST = C1*NS+C2*DAIRY+C3*INTER+C4*LOG (WPTON)+B12*LOG(EPTON)
4: LOG(SW/SE) = C1*NS+C4*DAIRY+C5*INTER+C2*WPTON+ C3*EPTON

TABLE 29

WESTERN COAL COST SHARE EQUATIONS; UPPER MISSISSIPPI RIVER UTILITIES: SINGLE CONSTANT AND UTILITY DUMMIES

1: WCOST/TCOST = B1+B11*LOG(WPTON)+B12*LOG(EPTON)

NOB = 27	NOVAR = 3		
RANGE = 1 TO 27			
RSQ = 0.49455	CRSQ = 0.45243	F(2/24) = 11.741	
SER = 0.1911	SSR = 0.877	DW(0) = 2.12	

COEF	VALUE	ST ER	T-STAT
B1	0.87712	0.35816	2.44895
B11	-1.28746	0.27148	-4.74228
B12	0.96671	0.26871	3.59755

3: WCOST/TCOST = C1*NS+C2*DAIRY+C3*INTER+C4*LOG(WPTON)+B12*LOG(EPTON)

NOB = 27	NOVAR = 5		
RANGE = 1 TO 27			
RSQ = 0.63125	CRSQ = 0.56421	F(4/22) = 9.415	
SER = 0.1705	SSR = 0.639	DW(0) = 2.14	

COEF	VALUE	ST ER	T-STAT
C1	0.21680	0.39512	0.54868
C2	-0.05012	0.46071	-0.10879
C3	-0.07072	0.46101	-0.15340
C4	-0.83005	0.29038	-2.85849
B12	0.85584	0.24298	3.52221

TABLE 30

WESTERN COAL COST SHARE EQUATION: ¢ PER MILLION BTU (INSTEAD OF $/TON) AND LOGIT FORMULATION

2: WCOST/TCOST = C1*NS+C2*DAIRY+C3*INTER+B11*LOG(CWMBTU)+B12*LOG(CIMBTU)

NOB = 27	NOVAR = 5				
RANGE =	1 TO 27				
RSQ =	0.64514	CRSQ =	0.58062	F(4/22) =	9.999
SER =	0.1672	SSR =	0.615	DW(0) =	2.14

COEF	VALUE	ST ER	T-STAT
C1	0.42366	0.68159	0.62158
C2	0.12504	0.74122	0.16870
C3	0.13825	0.74769	0.18490
B11	-0.88668	0.29004	-3.05711
B12	0.89935	0.24259	3.70734

4: LOG(SW/SE) = C1*NS+C4*DAIRY+C5*INTER+C2*WPTON+C3*EPTON

NOB = 27	NOVAR = 5				
RANGE =	1 TO 27				
RSQ =	0.5323	CRSQ =	0.44726	F(4/22) =	6.260
SER =	1.3183	SSR =	38.236	DW(0) =	2.12

COEF	VALUE	ST ER	T-STAT
C1	-2.13597	1.15376	-1.85131
C4	-4.09123	1.63904	-2.49612
C5	-4.30343	1.62950	-2.64095
C2	-0.36749	0.18257	-2.01287
C3	0.45113	0.13252	3.40430

TABLE 31

PRICE ELASTICITY CALCULATIONS: 1975 COAL COST SHARE VALUES FOR UPPER MISSISSIPPI UTILITIES*

EII				
1	-1.5252	-2.94448	-14.4114	-12.6532
5	-15.4886	-17.793	-0.915111	-0.915111
9	-49.3872	-33.1371	-0.915111	-0.915111
EIJ				
1	7.17492	4.81087	5.51887	5.33494
5	5.62928	5.85908	91.9092	91.9092
9	8.34505	7.19191	91.9092	91.9092
E1				
1	-1.25505	-1.81855	-3.95641	-3.72161
5	-4.09263	-4.36783	-0.90596	-0.90596
9	-7.06101	-5.84885	-0.90596	-0.90596
E2				
1	1.27085	1.8396	4.00376	3.7658
5	4.14182	4.42079	0.919091	0.919091
9	7.15194	5.9225	0.919091	0.919091
LEII				
1	-0.533239	-1.33333	-3.26058	-4.39114
5	-5.2811	-4.66988	-5.2614	-4.0393
9	-4.12653	-3.49162	-0.756601	-3.15829
LEIJ				
1	0.995822	2.29797	4.76793	6.65537
5	6.73507	7.42788	7.04756	6.89901
9	6.84156	5.60473	1.20261	3.87643

*Utilities elasticities are listed by plant in the same order, Table 28 in 2.

TABLE 32

MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): UPPER MISSISSIPPI RIVER

Port Equivalent (PE)	Company and Plant & State	KWH Production (millions)	Total Coal Usage (000's of tons)	% Coal	% Western Coal	% Water Delivery	Name Abbreviation
	Northern States Power (MN)						
356	High Bridge	1780.6	886	.40	.85	.15	HGHBRDG
358	Black Dog	2533.4	1042	.68	.68	1.00	BLCKDG
352	Allan King	3268.0	1668	1.00	.31	.99	ALLNKNG
	Dairyland Power Coop (WS)						
348	Alma	951.4	608	1.00	.34	1.00	ALMA
338	Genoa	1973.1	1107	1.00	.32	1.00	GENOA
	Interstate Power Co (IA)						
338	Lansing	246.3	163	1.00	.29	1.00	LNSNG
	Dairyland Power Coop						
334	Stoneman	169.8	108	1.00	.00	1.00	STNMN
	Wisconsin Power & Light						
334	Nelson Dewey	1126.5	577	1.00	.00	1.00	NLSNDWY
	Interstate Power Co.						
332	Dubuque	375.0	149	.51	.18	1.00	DBQE
328	Milton Kapp	1043.0	604	.97	.23	.75	MLKAPP
	Eastern Iowa Light						
324	Montpelier	248.2	74	.52	.00	.99	MNTPLR
322	Muscatine	495.2	292	.82	.00	.75	MSCTNE

TABLE 33
BN UNIT TRAIN COAL TARIFF DATA, 1975
(RATE IN DOLLARS PER TON)

ORIGIN	DESTINATION	ROUTE	TOTAL MILEAGE	OWNERSHIP OF CARS	TRAINLOAD MINIMUM	TARIFF ANNUAL MINIMUM TONNAGE	RATE	REV. PER TON MILE (CENTS)	TARIFF AUTHORITY
Colstrip, MT	Minneapolis, MN	BN	759.9	RR	4690	700	6.23	.820	BN Tariff 5-B, 9, 200A
Kuehn, MT	Northtown, MN	BN	818.5	RR	4690	700	5.97	.729	BN Tariff 5-B, 9, 200A
Colstrip, MT	Becker, MN	BN	749.8	RR	10290	2,800	4.99	.665	BN Tariff 231, 2, 200
Kuehn, MT	St. Paul, MN	BN	818.5	RR	4690	400	6.24	.762	BN Tariff 57-A, 11,200
Belle Ayr, WY	E. St. Louis, IL (Transfer-Water)	BN	1088.6	RR		1,000	8.55	.785	
Decker, MT	Havana, IL (Transfer-Water)	BN, Peoria, IL, CIM	956.3	RR	10550	3,300	10.54	1.102	BN, Tariff 110,10,200
Colstrip, MT	Plains, IL	BN, Chicago, ICG	1274.6	RR	10290	900	11.50	.902	BN Tariff 227, 200
Decker, MT	Sommers, IL (Peoria)	BN, TPW	1290.1	RR		2,200	10.54	.817	
Decker, MT	Waukegan, IL	BN, EJE, Chicago	1257	RR		1,000	11.74	.934	
Decker, MT	Plains, IL (7M. Joliet)	BN, Chicago, ICG	1281	RR	9500	1,000 1,500 2,000	11.52 11.46 11.42	.899 .895 .894	BN Tariff 199, 200
Kuehn, MT	Sommers, IL	BN, TPW	1290.1	RR	8000	800	13.14	1.020	BN Tariff 228-A, 200
Belle Ayr, WY	Amarillo, TX	BN, Denver, C&S, Sixela, NM, FWD	941.1	RR	10780	750	6.16	.655	BN Tariff 232, 200

TABLE 33 (CONTINUED)
BN UNIT TRAIN COAL TARIFF DATA, 1975
(RATE IN DOLLARS PER TON)

ORIGIN	DESTINATION	ROUTE	TOTAL MILEAGE	OWNERSHIP OF CARS	TRAINLOAD MINIMUM	TARIFF ANNUAL MINIMUM TONNAGE	RATE	REV. PER TON MILE (CENTS)	TARIFF AUTHORITY
Decker, MT	Allouez, WS (transfer to Lakes)	BN	1133.9	RR	10290	1,300	6.43	.567	BN, Tariff 201, 200
Belle Ayr, WY	Pueblo, CO	BN, Denver, CS	594.6	RR	12000	1,670	4.23	.711	BN, Tariff 165, 200
Sesser, IL	Oak Creek Power Plant, WI	BN, Virden IL,	431.3	RR	9500	1,000	4.18	.970	BN Tariff 62-B, 200
Colstrip, MT	Columbia, WI	BN, St. Paul, MN MILW	1046.1	RR	10500	1,900	6.65	.636	BN Tariff 215, 200
Colstrip, MT	Cohasset, MN	BN	778.1	RR	10200	1,500 1,750	4.88 4.57	.627 .587	BN Tariff 38-B, 200,10
Decker, MT	Minneapolis/ St. Paul, MN (Reship via Barge)	BN	1109.9 1118.0	RR	5300	1,600	6.75 6.75	.608 .604	BN Tariff 152-B, 9-200
Colstrip, MT	Billings, MT	BN	125.7	RR	2000	250 350 450 550 650	1.61 1.56 1.46 1.39 1.37	1.281 1.241 1.161 1.106 1.090	BN Tariff 32-A, 200
Castle-gate, UT	Metropolis, IL	D&RGW	1530.0	RR	-	1,300	12.32	.805	D&RGW 7560, Item 170

TABLE 34

STEAM COAL PURCHASES BY UPPER MISSISSIPPI UTILITIES BY ORIGIN: 1972 AND 1975*

	1975 Coal Purchases in 000's of tons. Origin:				1972 Coal Purchases in 000's of tons. Origin:		
Plant	Illinois	Kentucky	Montana	Wyoming	Illinois	Kentucky	Montana
HGHBRDG	123	8	755	0	172	19	444
BLCKDG	335	0	707	0	303	48	0
ALLNKNG	1083	66	519	0	928	100	0
ALMA	220	180	107	101	258	197	0
GENOA	351	407	150	199	336	407	0
LNSNG	115	0	48	0	114	0	0
STNMN	108	0	0	0	50	0	0
NLSNDWY	577	0	0	0	439	67	17
DBQE	122	0	27	0	106	0	0
MLKAPP	467	0	137	0	404	54	0
MNTPLR	69	5	0	0	45	40	0
MSCTNE	292	0	0	0	143	36	0
TOTAL	3862	666	2450	300	3298	968	461**

*Source: FPC form 423 data (unpublished).

**Wyoming coal accounts for another 20K tons.

TABLE 35

MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): ILLINOIS RIVER

Port Equivalent (PE)	Company, Plant and State	KWH Production (millions)	Total Coal Usage (000's of tons)	% Coal	% Western Coal	% Water Delivery	Name Abbreviation
	Central Illinois Public Service (IL)						
500	Meredosia	1,565.1	739	1.00	.00	.98	MRDSA
	Central Illinois Light (IL)						
510	Wallace	796.7	508	.74	.60	.00*	WLLCE
	Illinois Power Co. (IL)						
510	Hennepin	1,356.3	700	.99	.03	1.00	HNNPN
	Commonwealth Edison (IL)						
535	Will County	5,127.9	2544	1.00	.93	1.00	WLLCNTY
540	Crawford	2,726.3	1369	.92	1.00	1.00	CRWFRD
540	Fisk	1,548.5	1338	.98	1.00	1.00	FISK
	TOTAL	13,030.8	7198	-	-	-	

*The Wallace plant of Central Illinois Light formerly used water delivery (1972). Coal now moves in unit trains from Illinois and Montana fields although water service could be reinitiated.

TABLE 36

UNIT TRAIN ICG BITUMINOUS COAL TARIFF DATA, 1975
(Rates in dollars per ton)

ORIGIN	DESTINATION	ROUTE	TOTAL MILEAGE	OWNERSHIP OF CARS	TRAINLOAD MINIMUM	TARIFF ANNUAL MINIMUM TONNAGE	RATE	REV. PER TON MILE (CENTS)	TARIFF AUTHORITY
Orient 5, ILL.	Oak Creek Power Plant, Wisc.	ICG, Chicago, BRC, C&NW	353.4	Shipper	11,500 tons	1,000,000 tons	4.08	1.156	ICG Tariff 706, Item 200
Orient 6, ILL.			353.4				4.08	1.156	
River Queen, KY			514.4				4.65	.905	
Percy, ILL	Plaines, IL (Joliet Power Plant)	ICG	207	Shipper	6000 " " " "	3,300,000 2,600,000 2,000,000 1,000,000 500,000	1.66 1.81 1.95 2.65 3.05	.541 .590 .635 .863 .993	ICG Tariff 710, Items 200 & 300
Percy, ILL	Federal, ILL	ICG, Wood River, ILL. ILL. Terminal RR	84.4	Shipper	3500	1,050,000	1.01	1.202	ICG Tariff 3896-F, Item 5-C
Latta, IN	Indianapolis, Indiana	Milwaukee, Linton, Indiana, ICC	103.3	Shipper	2400	1,100,000	2.61	2.534	CMStP+P Tariff 18721-B, Item 200
ICG West Kentucky Mines	Louisville, KY Kosr sdale, KY (Cane Run/ Mill Creek Plant)	ICG	109 165	Railroad	7000	1,300,000	1.58 1.58	1.450 .958	ICG Tariff 3353-B, Item 200
Inland Mine, ILL	Indiana Harbor, IN	ICG, Riverdale, ILL,	279	Shipper	9500	2,000,000	1.94	.695	ICG Tariff 3351-D, Item 200-B
Orient 3, ILL		IHB	275				2.11	.767	
Orient 6, ILL			276				2.11	.767	
Sesser, ILL			283				2.11	.746	
Sesser, ILL	Eagle Pass, TX (Export - Mexico)	ICG, New Orleans SP, Eagle Pass, ND, ME	1472	Railroad	7600	-	17.34	1.178	SWL Tariff 36-V Item 3530 Series

TABLE 37

STEAM COAL PURCHASES BY ILLINOIS RIVER UTILITIES
BY ORIGIN: 1973 and 1975*

Plant	1975 Coal Purchases in 000's of tons. Origin: Illinois	Kentucky	Indiana	Montana	1973 Coal Purchases in 000's of tons. Origin: Illinois	Kentucky	Indiana	Montana
MRDSA	739	0	0	0	783	0	57	0
WLLCE	205	0	0	303	379	0	0	0
HNNPN	561	121	12**	18	540	39	15	0
WLLCNTY	166	0	0	2378	895	0	0	1703
CRWFRD	0	0	0	1369	1	0	0	1343
FISK	0	0	0	1338	3	0	0	1038
TOTAL	1671	121	12	5406	2601	39	72	4084

*Source: FPC Form No. 423 data (unpublished).

**Includes 9,000 tons from Ohio.

TABLE 41 (CONTINUED)

Port Equivalent (PE)	Company, State and Plant	KWH Production (millions)	Total Coal Usage (000's of tons)	% Coal	% Sulfur	% Water Delivery	Name Abbreviation
	Ohio Edison (OH)						
266	Burger	2798.6	1333	1.00	2.99	1.00	BURGER
272	Toronto	765.1	306	1.00	2.89	1.00*	TORONTO
	Cardinal Operating (OH)						
272	Cardinal	5647.9	2110	.99	2.61	.61	CRDNL
	Ohio Edison (OH)						
274	Sammis	11508.1	4942	1.00	2.74	.80	SAMMIS
	Duquesne Light (PA)						
280	Phillips	2120.1	1360	1.0	1.92	1.00	PHILLIPS
	TOTAL	101330.2	47403	-	-	-	

*Estimated.

TABLE 42
STEAM COAL PURCHASES BY MAJOR U.S. UTILITIES IN 1975: OHIO RIVER*

1975 Coal Purchases in 000's in tons. Origin:

Plant**	Illinois	Indiana	Kentucky	Western***	W. Virginia/ Virginia	Ohio	Pennsylvania
JOPPA	2404	129	882	9 (W)	0	0	0
SHWNE	1969	0	2007	170 (M)	0	0	0
CLMN	0	98	1393	0	0	0	0
GLLGHER	0	896	691	0	23	0	0
CLFTYCRK	0	1741	2232	231 (M)	0	0	0
GHENT	0	1322	0	9	0	0	0
TNNRSCRK	0	0	2007	130 (U)	26	0	0
MIAMIFT	0	0	1061	0	19	529	74
BCKJRD	0	9	1022	0	217	945	234
STUART	0	0	1741	0	974	2381	0
KYGRCRK	0	0	0	0	1929	1416	0
GAVIN	0	21	763	{938 (W) 339 (U)	874	2498	0
BURGER	0	0	296	0	227	761	49
TORONTO	0	0	0	0	132	174	0
CRDNL	0	0	44	23 (U)	756	1281	7
SAMMIS	0	0	205	0	557	3331	850
PHILLIPS	0	0	0	0	111	0	1020
TOTAL	4373	4186	15350	1840	5845	13316	2234

*Source: FPC Form No. 423 data (unpublished).

**Plant Name abbrevaitions are found in Table 44.

***Western: Montana (M), Wyoming (W), Utah (U).

TABLE 43

MAJOR U.S. UTILITIES WITH WATERBORNE FUEL DELIVERY (1975): MONONGAHELA, ALLEGHENY AND KANAWHA RIVERS*

River and Port Equivalent (PE)	Company, State and Plant	KWH Production (millions)	Total Coal Usage (000's of tons)	% Coal	% Sulfur	% Water Delivery**	Name Abbreviation
I. Monongehela River	West Penn Power (PA)						
725	Mitchell	1771.9	675	1.00	2.69		MTCHLL
	Duquesne Light (PA)						
725	Elrama	3171.5	1360	1.00	2.34		ELRAMA
	West Penn Power (PA)						
735	Hatfield Ferry	6680.1	4363	1.00	1.99		HTFLDFRY
	Monongehela Power						
745	Ft. Martin	5007.2	2988	1.00	2.56		FTMRTN
760	Rivesville	698.9	230	1.00	2.12		RVSVLL
II. Allegheny River	Duquesne Power (PA)						
610	Cheswick	3131.2	1620	1.00	2.11		CHSWCK
III. Kanawha River	Appalachian Power (WV)						
805	Amos	16447.8	6540	.99	.90		AMOS
810	Kanawha	3018.3	1123	1.00	.83		KANAWA
	TOTAL	39926.9	18899	-	-	-	

*Source: FPC unpublished Form No. 423 data NCA <u>Steam-Electric Plant Factor</u>/1975.

**All utilities receive an unknown percentage by truck except Amos which receives via C&O RR.

TABLE 44

STEAM COAL PURCHASES BY MAJOR U.S. UTILITIES IN 1975: MONONGAHELA, ALLEGHENY AND KANAWHA RIVERS*

1975 Coal Purchases in 000's of Tons. Origin:

Plant	Kentucky	Ohio	Pennsylvania	W. Virginia	Virginia
MTCHLL	6	17	6	646	0
ELRAMA	0	0	1317	42	0
HTFLDFRY	769	0	1752	1841	0
FTMRTN	0	0	172	2816	0
RVSVLL	0	0	7	223	0
CHSWCK	0	0	1459	161	0
AMOS	1098	0	0	4087	635
KANAWA	0	0	0	1123	0
TOTAL	1873	17	4713	10939	635

*Source: FPC Form No. 423 (unpublished).

3. GRAIN TRAFFIC IMPACTS

3.1 THE GRAIN MARKET

Inland elevators sell their grain and soybeans through the most profitable channel available. Grain is transported by barge only if the bid at the barge terminal less transpota-tion costs to that terminal exceeds the margin available from sale to a local processor, sale to a nearby rail termimal, or direct shipment to a distant market (export or domestic). The market share of grain moving by barge at any time is, there-fore, a function of not only relative barge and rail rates to export points (the dominant outlet for barge grain), but also of accessorial costs to the river and the relative strength of alternative markets, especially domestic processors and feeders.

At any point in time, rail and barge rates to export points define a hinterland along the waterway from which barge terminals have an economic advantage in attracting grain. Consider an example in which the bid for export corn at the Gulf is $3.50 per bushel, and the barge rate from an upriver barge terminal is 15¢ per bushel (plus transfer costs of 4¢ per bushel at the terminal including handling and shrinkage), and the rail rate to the Gulf from inland terminals is 30¢ per bushel. An inland elevator will ship export grain to the river terminal in this case only if the cost of transporting grain to the river terminal is less than eleven cents (see Table 45). Since eleven cents is sufficient to truck a bushel of grain about 80 to 90 (highway) miles, the export grain would move by barge only from elevators within this distance of the river in this hypothetical case.*

As indicated earlier, the inland elevator manager will also be aware of the net revenue available from shipment and sale to alternate markets -- domestic processors or feeders or

*Section 3.4 describes the source of trucking cost estimates used in this chapter.

alternative export ports. Major processing facilities dot the hinterland and compete for grain with barge and rail export terminals. Many of these are located at or even within the edge of the barge "territory."

Because barge transportation of grain is exempt from I.C.C. regulation, barge rates fluctuate over the course of the year in response to the demand for transportation. These fluctuations are reflected in the differential between the bid at the river elevator and the bid for export at the Gulf* (we shall call this the river margin). Table 46 indicates that the river margin for Illinois River barge terminals in 1975 fluctuated between 12¢ in the Spring to over thirty cents per bushel at harvest.** Because railroads currently cannot alter their rates seasonally, the competitive area for rail and barge shipments for export differs from season to season. In our hypothetical example above, a ten cent increase in the barge rate at harvest would have the effect of making rail shipments to the Gulf dominant almost to the bank of the river. In the slack season, on the other hand, the river terminal's reach would extend another twenty to thirty miles from the river.

In fact, several factors operate to stabilize grain shipping patterns somewhat. In the first place, if railroads and shippers had enough equipment to carry the supplies forthcoming from the substantially-increased "rail territory" at harvest time (when barge rates are very high) there would be excess equipment at other times of year, when the "barge

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*This differential also includes the margin for handling at the river terminal which also fluctuates seasonally.

**A significant fraction of barge grain is shipped under annual contract which guarantees a certain number of barges per month to a shipper at a fixed cost. Although the barge rate does not fluctuate for this portion of shipments, the price paid for the grain at the barge terminal is the same as for grain loaded on barges purchased at the spot rate. Also, since the shipper has the option of re-selling his contract barges, the opportunity cost of the transportation is equal to the spot rate.

TABLE 45

ALTERNATIVE MARKETS FOR INLAND ELEVATORS

Shipment Through Barge Terminal		Rail Shipment to Gulf	
Gulf Bid	$3.50	Gulf Bid	$3.50
Barge Transport and Handling	.19	Rail Shipment to Gulf	.30
Barge Terminal bid (f.o.b. truck).	$3.31	Net to Inland Elevator*	$3.20

Net to Inland Elevator[1] $3.31 - (transport cost to river)

*The actual net would also include a deduction for transfer at the inland elevator to a truck or rail car in the barge case and to a rail car in the all-rail case. These are approximately offsetting and do not affect the analysis.

TABLE 46

AVERAGE PRICE DIFFERENTIALS ON CORN -- GULF VS. ILLINOIS RIVER BARGE TERMINAL (¢ bu)*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1974	19.6	19.0	14.25	15.1	14.7	14.6	15.5	18.9	14.1	20.4	25.8	23.3
1975	15.1	12.3	16.0	12.9	12.1	14.6	15.9	17.9	18.8	31.8	15	
1976	14.8	13.6	14.3	14.4	16.4	17.1	14.4	12.5	**	-	-	-

*Grain Market News, Chicago Region weekly newsletter gives Thursday night to arrive bids for these points. The figures in this table are a simple average of Thursday night bids for each month.

**Under low water conditions in mid-September 1976, these differentials jumped to 30-40¢.

territory" expands. Therefore, at harvest time there is a relative shortage of transportation equipment (rail, barge, and truck) which leads to grains moving wherever transportation is available.

With their limited rate flexibility, railroads have responded with innovative rate concepts which act to stabilize rail grain flows over the course of a year. First, they frequently provide special rates (or mileage allowances) for grain moving in shipper-owned (or -leased) cars. The logic behind this practice is that shippers will tend to use their cars (and demand rail transportation of their grain) on a more constant basis if they must bear the capital cost of idle equipment in slack periods. As compensation, the shipper gains more certainty of equipment availability in peak season. (This and not lower rates or mileage allowances provides the benefit from shipper-owned equipment.) Secondly, some roads publish tariffs under which the rate per ton varies in accordance with the volume of traffic shipped in some interval (9 months or one year). Under ICG tariff 605, a shipper who ships at least fifty-two 115 car trains (in shipper-owned cars) per year between points covered by the tariff (including several Illinois points south of the Illinois River) and certain Gulf ports, receives a rate of $4.85 per ton (approximately equal to the barge contract rate).* That same shipper would pay $6.90 1/2 per ton if he shipped only half that volume, and $7.39 as a casual rail shipper (10 one hundred car trains). This rate structure encourages continuous rail shipment throughout the year because a shipment each week is required to meet the volume minimum (two trains may be used), and once the requirement is met, the rate is extremely attractive from many inland points even when barge rates are at or below annual contract rates.

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*Add $1 to $1.20 to account for the ownership costs of the cars.

3.2 USER CHARGE IMPACTS -- AN OVERVIEW

As indicated briefly in the previous section the bid for grain at the river elevator reflects fairly accurately the bid for grain at the export terminal (f.o.b. inland mode) and the barge rate and transfer cost at each point in time. At the end of this section, there are tables and charts indicating the relationship between Gulf bids and Illinois River bids for corn and soybeans from 1974 to 1976 on a weekly basis.) Additional information from private sources indicates that the bids at different points on the river reflect barge rate differentials to the Gulf. For example, the bid for corn at river elevators in the vicinity of Peoria is one cent per bushel higher than the bid in the vicinity of Morris, Illinois, and the bid at Muscatine, Iowa is two cents better than the bid at McGregor, Iowa - 200 miles up the Mississippi River. The constancy of this relationship day in and day out and from year to year reflects the fact that elevators at all points in the system compete with each other for sales to the Gulf, for barge transportation, and for grain from inland elevators.

The first order impact of waterway user charges would be an increase in barge transportation costs and, in light of the relationship illustrated above, a decline in the bid at the river elevator. Whether the bid would decline by the full amount of the user charge would depend on a number of factors -- chiefly, the amount of traffic diverted from the river. If the user charge led to a significant reduction in river traffic, excess capacity would be experienced by barge owners, and competition would tend to push barge rates down -- at least until retirement of old equipment brought the fleet back into equilibrium. Similarly, significant declines in barge traffic would lower throughput at river terminals creating a situation in which competition would lead to lower margins at these points in the distribution system. In both of these cases, parties would be realizing capital losses on fixed investments whose value had been depreciated by a decrease in the expected revenue stream. In the very long-run, in which all capital is replaceable, all such absorption of user charges by river operators or terminal elevators would be eliminated. A phased implementation of user charges would limit absorption of the tolls by barge and terminal operators by allowing natural traffic growth to offset any traffic diversion caused by the tolls and by permitting the orderly retirement of uneconomic facilities and equipment (if necessary).

Finally, significant diversion of grain traffic would decrease congestion when and where it exists on the system - either in ports or at locks and dams - leading to decreased operating costs which would be partially offsetting to the tolls, mitigating somewhat the impact of user charges on barge costs and river terminal bids.

Whether significant traffic diversion would occur in response to river bid changes depends on the actions of other elements of the grain distribution system, including inland elevators, railroads and the domestic market. Faced with a decrease in the bid for grain at barge terminals, inland sellers of grain would have to re-evaluate their existing sales patterns - considering whether sales to rail export terminals or domestic markets (or for a larger elevator, direct shipment to export) would be more profitable than sales to the river. An elevator whose next best alternative is worse than a sale to a barge terminal even after the user charge will continue to sell to the river and lower his bid price to farmers by an amount equivalent to the decline in the barge bid. A seller further inland, whose margin between the river bid and the next best alternative was less than the amount of the user charge will (<u>all other things being equal</u>) now sell to that alternative channel. The price he offers for grain will also fall, but by less than the amount of the user charge.

Table 47 provides a hypothetical case to illustrate this point. In this example, two inland elevators which face the same alternative bids at a barge terminal and an inland processor, but which experience different trucking costs to the two outlets due to different locations, both currently sell their corn to the barge terminal. Both earn the same return per bushel throughput (assumed for this example only to be 10¢), but the elevator further from the river is able to pay farmers two cents less than elevator #1. (This does not mean that farmers in the vicinity of elevator #1 are earning a higher return, however, since their location nearer the higher price market would be reflected in the cost of their land -- i.e., they have to get more for their corn to earn an equal return of their investment in land). After the imposition of a user charge of 3¢ per bushel and an equivalent decline in the bid for corn at the river terminal, elevator #1 still sells to the river, but offers farmers 3¢ less for their corn. Elevator #2 now ships to the inland processor (where the margin after the user charge is 1¢ better than at the river) and lowers his bid to his customers by only 2 cents. Inclusion of a grain seller right at or beyond the boundary of the barge-competitive region would show no change in sales pattern and no change in the bid to farmers in that area.

In sum the net impact of user charges - if prices at other markets hold - would be diversion of that portion of barge traffic which currently enjoys a competitive advantage over alternative markets equal to or less than the decline in the bid at the barge terminal, and a decrease in the price received for their grain by farmers whose product currently moves by barge. The farm bid would decrease by the full amount of the user charge for farmers captive to that market, with lesser impacts on farmers whose alternative marketing channels are relatively more favorable, and no impact at all on farmers beyond the boundary of the barge terminal procurement area.*

The critical assumption in the above example is that the bid price at alternative markets will remain fixed. If, at the other extreme, the demand in domestic grain markets (for processing, feed, etc.) is perfectly inelastic - i.e., the volume to be purchased is fixed with the demand price absorbing all market changes - and if railroads were to respond to the new competitive situation by raising their rates in barge-competitive markets by an amount equal to the user charge, then the net impact would be quite different. In this case, the competitive situation between alternative markets would remain unchanged - meaning no diversion of sales or traffic - but the price offered to farmers would fall by the full amount of the user charge over a much wider area.

Each of these scenarios represents a limiting case and, as such, is obviously somewhat naive for such a complex market. Railroads are in the business of making money, and if the optimal response is perceived to be a rate increase on export traffic, then such an increase will be forthcoming. Railroads have taken frequent general rate increases in recent years (see Table 48) which have all eventually applied to the export grain tariffs. These increases have evidently been as much in response to increasing costs and the general market situation -- which in the export boom years for grain created very strong excess demand for rail transportation to

*Section 3.5 outlines the method utilized to calculate the dimensions of the procurement area.

ports* -- as to any apparent increase in barge rates (as reflected in the year-to-year Gulf-river bid differentials in Tables 46 and 60 to 65).

Similarly, railroads must compete for export grain not only with the barge export option, but also with domestic markets and, to a certain extent, with each other. For example, soybean processors have a strong presence in Central Illinois including major facilities at Decatur, Gibson City, and Champaign -- points in the area of effective rail-barge export competition, at least during some periods of the year. To the east and south of the Illinois River, the competition to rail export for grain becomes the major southeast poultry markets served by different roads, who may wish to strengthen this market against growing competition from competing poultry in the Arkansas area. Also, within any producing area there are railroads with no direct Gulf export outlets who exert a competitive influence on the port-serving roads for traffic from the common hinterland. Thus, it must be assumed that the fifty-car river terminal gathering rates published by the Chicago and Northwestern and Chicago, Milwaukee, and St. Paul Railroads (which also publish export tariffs in conjunction with other roads) have been a major factor in the extension of 115 car rates to Iowa by the ICG. Further, in some of these markets, railroads rates are determined by truck (not barge) competition, reducing somewhat their flexibility in juggling rates.

Finally, use of grain for local or on-farm feeding for dairy or meat herds is a significant outlet for corn in Northern Illinois and Iowa. If railroads increase export rates, they risk some loss of existing traffic to this outlet.

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*In 1973 and 1974 rail picked up the lion's share of increased deliveries of grain to export ports, and as a corollary, suffered the much-publicized equipment shortages.

In summary, the ultimate impact of user charges on the grain market will be some combination of impacts of decreased incomes to farmers, diversion of traffic from the waterways, increased supplies and lower prices to domestic markets, and increased rail traffic and/or revenues. The precise mix of impacts will be determined by the responses of grain carrying railroads and the ability of the domestic grain market to absorb increased supplies without significant price declines.

TABLE 47

FARM SALE STRATEGY BEFORE AND AFTER IMPLEMENTATION OF A USER CHARGE

	Before User Charge (3¢)	After User Charge (3¢)
		Elevator I
Barge Terminal bid	$3.00	$2.97
Truck cost to River	.06	.06
net	$2.94	$2.91
Alternative bid (e.g. Processor)	$2.95	$2.95
Truck Cost to alternative market	.10	.10
net	$2.85	$2.85
Bid to farmer (best bid - 10¢ for elevator margin)	$2.84	$2.81
		Elevator II
Barge terminal bid	$3.00	$2.97
Truck Cost to river	.08	.08
net	$2.92	$2.89
Alternative bid	$2.95	$2.95
Truck Cost to Alternative market	.05	.05
net	$2.90	$2.90
Bid to farmer	$2.82	$2.80

TABLE 48

GENERAL RAIL RATE INCREASES

Exparte	Date	Increase
318	February, 1976	7%
313	June, 1975	7.5%
310	April, 1975	7%
305	June, 1974	10%
303	March, 1974	4%
299	March, 1974	2.8%
295	October, 1974	3%

3.3 TRAFFIC IMPACTS

3.3.1 Illinois River Traffic

Illinois River barge terminals originated between ten and eleven-and-a-half million tons of barge traffic in grains and soybeans annually in the years 1972 to 1974 (see Table 49). (Although the amount declined significantly between 1972 and 1974, preliminary indications - based on U.S. Department of Agriculture data - are that 1975 was more on a par with the earlier years). This volume includes between 7.5 and 9 million tons of corn, 1.9 to 2.3 million tons of soybeans, and only 100 to 200 thousand tons of wheat. The bulk of these shipments (about 90%) were destined for export at the Gulf, accounting for between forty and fifty percent of total barge receipts of corn for export, twenty to thirty percent of barge soybean receipts at those ports, and less than ten percent of the wheat.

The flows of grain and beans from the Illinois River accounted for an estimated 13.9 billion ton-miles of barge traffic in 1972, approximately 8 percent of total Mississippi River system ton-miles in all commodities.

3.3.1.1 User Charges

The user charge (100% OM&R) for barge shipment to export facilities at New Orleans ranges from 44.5 cents per ton to 66.5 cents per ton (at Naples, Illinois and Chicago, respectively) under the segment toll approach and from 88 cents a ton to $1.09 per ton (for the same points) under the fuel tax option -- Table 50. This table also lists the user charge per bushel for corn and (the more-dense) soybeans.

3.3.1.2 Rail Competition

The production area south and east of the Illinois River (the major procurement area for the barge terminals) enjoys multiple-car export rates to both the Atlantic and Gulf Coasts.

TABLE 49

ILLINOIS RIVER* BARGE SHIPMENT PATTERNS (1000 SHORT TONS)

CORN

	1972	1973	1974
Lower Mississippi Ports	7740.8	7810.1	6950.3
Other Gulf Ports	142.3	116.9	21.9
Chicago	40.0	60.9	104.6
Mississippi River (Cairo-Baton Rouge)	452.0	267.1	191.9
Tennessee River	540.1	392.8	342.8
Other	100.0	14.2	15.3
TOTAL	9015.2	8661.20	7626.8

SOYBEANS

	1972	1973	1974
Lower Mississippi Ports	1761.5	1964.2	1586.5
Other Gulf Ports	135.5	116.4	27.8
Chicago	39.4	36.3	64.4
Mississippi River (Cairo-Baton Rouge)	117.0	63.6	33.1
Tennessee River	77.5	115.2	150.8
Other	4.1	-	10.2
TOTAL	2135.0	2295.7	1872.8

WHEAT

	1972	1973	1974
Lower Mississippi Ports	163.9	69.2	157.3
Other Gulf Ports	30.3	22.9	31.5
Chicago	9.0	7.2	16.6
Tennessee River	1.2	5.4	-
Other	-	-	-
TOTAL	204.4	104.7	205.4

*This does not include shipments by barge from the Port of Chicago.

TABLE 50

USER CHARGE FROM SELECTED ILLINOIS POINTS TO NEW ORLEANS (¢)

	Per Ton		Per Bushel			
			Corn		Wheat, Beans	
	ST	FT	ST	FT	ST	FT
Naples	44.5	88.0	1.25	2.46	1.34	2.64
Peoria	52.5	94.0	1.47	2.63	1.58	2.82
Morris	60.5	102.0	1.69	2.86	1.82	3.06
Chicago	66.8	109.0	1.87	3.05	2.00	3.27

Most of the large rail exporters in this area are located at the junctions of roads serving both the Atlantic and Gulf Coasts, but currently the Gulf move dominates in Illinois. This is true not only because the rate itself tends to be lower, but because the bid at the Atlantic has reportedly been lower on average than that at the Gulf (by as much as 10¢ at times), and because equipment turn-around is also said to be better to the South.

Table 51 indicates the most relevant export rail rates from this area. The ICG volume rate applies only when shipper-owned or -leased equipment is used. This means that the capital cost of car ownership must be accounted for - $1.00 to $1.10 per short ton, on average. As any fixed cost, however, its allocation to actual traffic will vary over time. Thus, in order to keep the equipment active, and to meet export obligations at the Gulf, the shipper may accept less than full cost recovery when the market is slack - when the barge rate falls - while the return may be much greater than average when the transportation market is tight.* This has the effect of smoothing the seasonal fluctuations in the barge procurement area considerably.

The 100 car - 10 trip rate is competitive with the 115 car rate for shippers who cannot meet the higher minimum volume categories of that tariff, or for occasional shipments with different sets of equipment by high volume shippers. This rate cannot compete year-round with barge except at greater distances from the river than the 115 car rate (about 40-50 miles farther), but because it calls for only 10 trips annually, it can compete seasonally at reasonable distances from the river if equipment is available.

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*If demand fell off sufficiently, the shipper would accept negative returns on the equipment until the lease expired or until owned-equipment wore out.

TABLE 51

CURRENT MULTI-CAR RATES FOR EXPORT FROM ILLINOIS POINTS

Gulf Coast

115 cars, shipper equipment, no mileage (ICG tariff 605)

	(a)	(b)	(c)
Rate ($/short ton):*	485 1/2	531	690.5
Minimum Volume: (during 9 of any 12 consecutive months)	598,000 tons** (52 trains)	517,500 - 597,999 (45-52 trains)	98,000 - 517,500 (9-45 trains)

100 cars, 10 trip annual minimum (ICG tariff 19611B)***

Railroad Equipment:	$8.48
Shipper Equipment:	$7.39

5 cars, rail or shipper equipment, mileage paid (ICG tariff 602)

$11.00 per ton (corn only).

Atlantic Coast

100 cars, no mileage paid (TC-CTR 794-E, ICC C-918)

Rate ($/short ton)	(a)	(b)	(c)	(d)	(e)
Rail Equipment:	$8.07	$8.19 1/2	$8.39	$8.63	$8.93
Shipper Equipment:	$6.88 1/2	$7.02 1/2	$7.21	$7.46	$7.72 1/2
Minimum Volume: (12 months)	441,000 tons (45 trains)	343,000 tons (35 trains)	294,000 tons (30 trains)	197,000 tons (20 trains)	49,000 tons (5 trains)

65 cars, Chessie System only 8 trips annually (T1-CTRTB Tariff 600-N, I.C.C. C-861, Item 250)

Rate: To Baltimore - same as column (a) above.
To other E. Coast Ports - same as column (c).

*These 115 car rates are at the X-313 rate and will increase by 7% in January 1977.

**Within 12 months.

***This is at X-318 level and will correspond with column (c) above for shipper equipment in January when tariff 605 takes that general increase.

Although they account for a small share of export traffic in the barge competitive area, five car shipments are more competitive than they appear at first glance. The ability of most country elevators to handle 5 car shipments means that they can ship directly to the Gulf, rather than shipping to a larger terminal elevator. This affords a saving of roughly 8 cents in total transport and handling costs (4 cents for transfer at the rail or barge terminal and a minimum of 4 cents trucking costs to the terminal) by avoiding an extra link in the distribution chain. A shipper using this option in the area relevant to this study would be using it on a seasonal basis and when equipment is available.

The estimated annual contract rate for barge transportation of grain to the Gulf ranges from about $4.58 below Havana to about $5.17 at Joliet, IL. (Table 52 converts these to bushel terms for corn and soybeans). As discussed earlier, spot barge rates fluctuate about these contract levels during the year, from as little as 75 percent (10¢ per bushel of corn at Peoria) in the slack season, to as much as 200 percent or more at harvest.

The rail rates (including shipper equipment cost allocation) to the Gulf out of this same producing area are shown in Table 53. When barge rates are about equal to the estimated contract level, the barge terminal is able to compete for corn with the 52 trip - 115 car rate as far as 58 to 65 (highway) miles from the river at Peoria.*

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*In Illinois, the major rail export terminals purchase grain predominantly from country elevators - just as is the case for barge terminals. Once the grain is at a terminal with the option of direct rail shipment to the Gulf, its likelihood of shipment to a barge terminal is diminished because of the extra-handling implicit in an extra transfer. Thus, if every country elevator in this area could handle 115 car trains, none would send grain to the river, because the cost of trucking alone would make the margin on that sale lower than the direct export sale.

TABLE 52

PER BUSHEL ESTIMATED CONTRACT BARGE RATES - EARLY 1976.
(ILLINOIS RIVER POINTS)

	CORN	SOYBEANS
Havana	12.8¢	13.7¢
Peoria	13.3	14.2
Hennepin	14.0	15.0
Joliet	14.5	15.5

Source: Illinois River shippers.

TABLE 53

GULF-BOUND EXPORT RAIL RATES FROM ILLINOIS

	$ ton*	¢/bu. Corn	¢/bu. Soybeans
115 car:			
52 trip	6.00 1/2	16.8	18.0
45 trip	6.46	18.1	19.4
100 car:			
10 trip (rail equipment)	8.48	23.75	25.4

*Includes $1.15 per ton for shipper-equipment costs.

This procurement area expands by 4 to 5 miles below Havana, and shrinks by 10 to 12 miles upriver from Morris, IL. (River procurement areas are about 10 miles wider at the 45 trip rate.)

At contract barge rate levels, the river procurement area for corn includes such points as Springfield, Bloomington, and Pontiac - see Figure 1. When barge rates are 3 cents below the contract rate the procurement area expands to include such major rail terminals as Gilman (Continental), Gibson City (Cargill), and Decatur. It is at such times, of course, that shipper margins (return of terminal handling and rail equipment) fall to preserve traffic flows.

During periods of high demand the barge procurement area tends to move in toward the river. At 3 cents over contract levels, the river drawing area contracts almost 25 miles. During these periods, rail and processor bids also include larger-than-average margins which tend to soften this inward shift somewhat.

User charges for recovery of 100% OM&R on the waterways would effectively increase barge rates and reduce the ability of barge terminals to bid for grain at the procurement boundary. Segment tolls would have the least impact, because the grain moves long distances on low cost rivers. The impact of the segment tolls shown in Table 52 would be to pull in the boundary by about 10 miles at Naples (1.25¢), 12 miles from Havana to Peoria, almost 14 miles at Morris. Fuel taxes would decrease the procurement area an additional 10 miles along the full length of the river (see Figure 2).

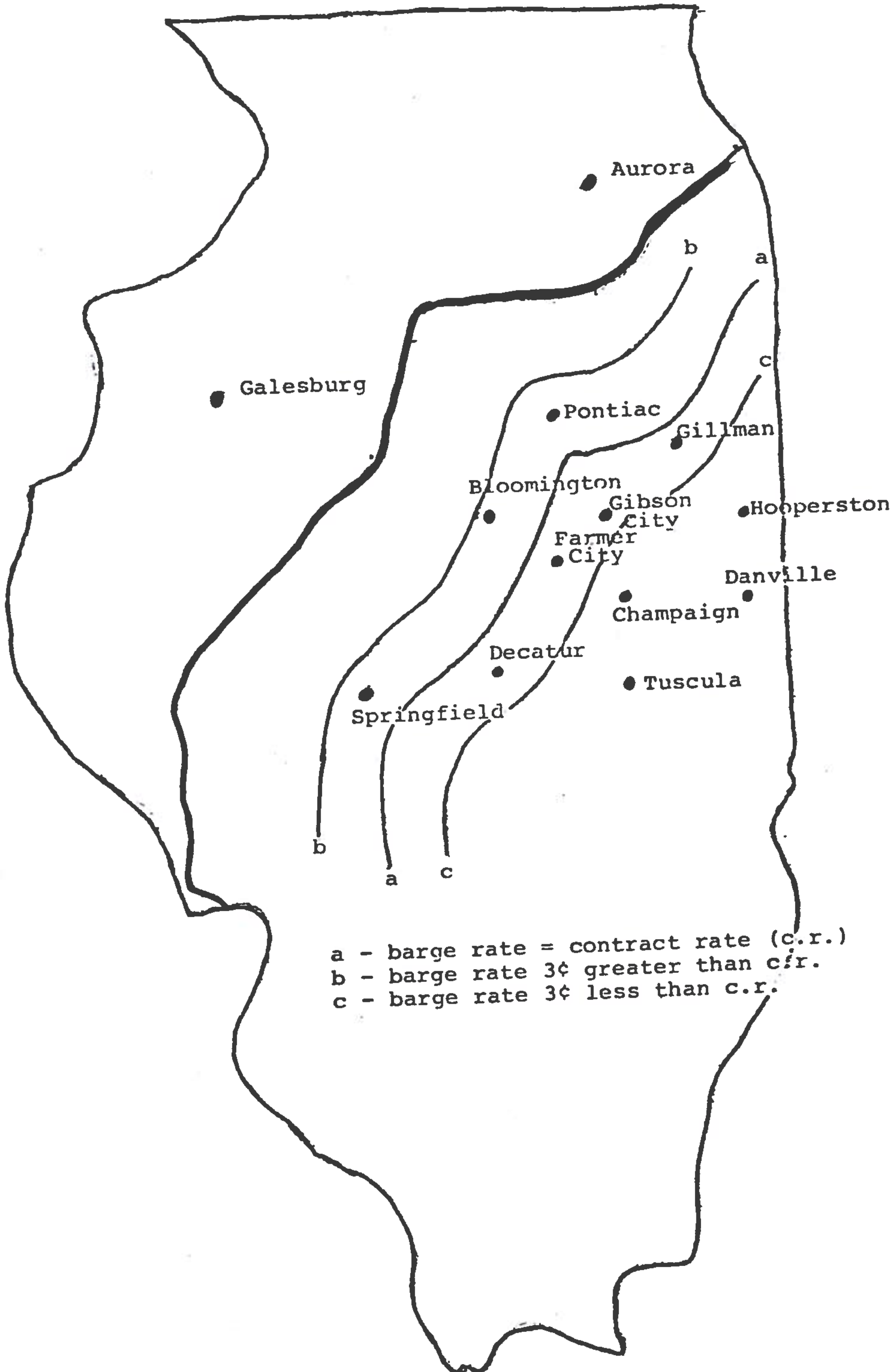

FIGURE 1. ILLINOIS RIVER PROCUREMENT AREA FOR CORN

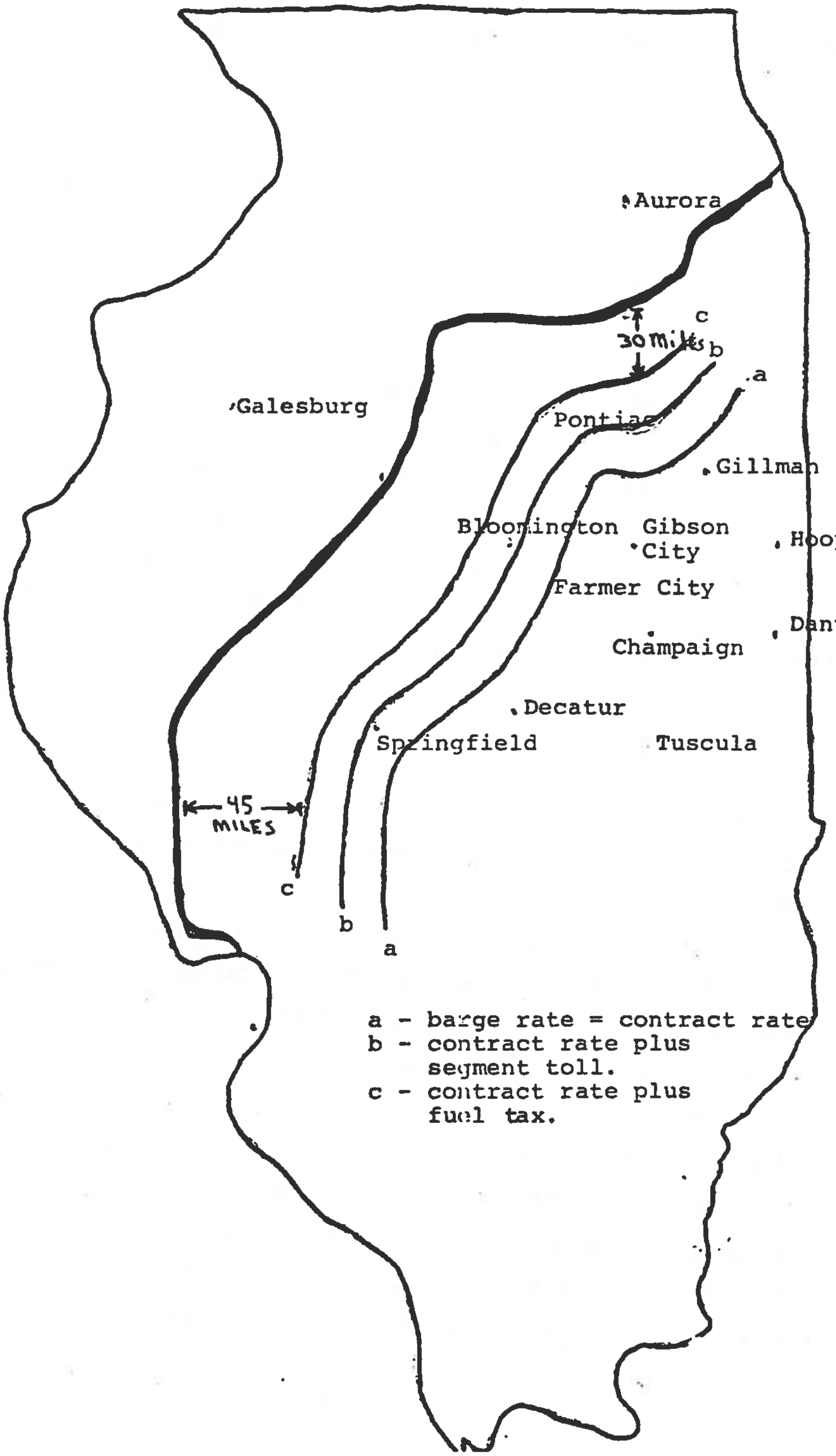

FIGURE 2. SHIFTS IN PROCUREMENT AREA DUE TO USER CHARGES

Potential traffic diversion under these tolls is substantial if prices at alternative outlets do not respond.

A survey of barge terminals by the Army Corps of Engineers (St. Louis District) reveals the annual procurement pattern for grain shown in Table 54, which was roughly corroborated in discussions with a multi-facility barge shipper in that area.

Given this procurement pattern, the procurement area under a segment toll - 46-52 miles in the vicinity of Peoria and downstream - would still include approximately 90 percent of existing traffic. Upstream, where tolls are higher (and rail export more competitive), a greater share of existing traffic is threatened - as high as 20 percent or more. Under the fuel tax, the additional contraction of the river procurement area threatens an additional 10 percent of existing barge corn traffic.

Although a similar analysis could be performed for export soybeans, it appears that soybean processors represent the effective competition for barge terminals for this commodity. Bids for soybeans at Central Illinois processors, as reported in Grain Market News, regularly exceed bids at Illinois River barge terminals by 5¢ or more per bushel. It is a common phenomenon to find a country elevator in the river procurement area for corn shipping 100 percent of its corn to barge terminals by truck, and 100 percent of its soybeans to Decatur or another major processing center by rail or truck. Industry analysts have suggested that the processor bid is set to maintain a desired level of throughput in light of the barge terminal bid which is determined by the fixed export price and

TABLE 54

GRAIN PROCUREMENT PATTERN FOR ILLINOIS RIVER BARGE TERMINALS

Distance from River Terminal (miles)	Percentage of Receipts
less than 10	25
10 - 20	20
20 - 30	20
30 - 40	15
more than 40	20

the level of barge rates at any particular point in time.* The implication is that domestic demand for soybean products is relatively inelastic and that user charges would thus have relatively minor impacts on barge-processor competition for beans. In light of this industry description and because the barge terminal procurement data does not distinguish between corn and beans, we will assign percentage diversion estimates for corn as an upper bound for soybeans.

3.2.1.3 Summary

The analysis of Illinois River grain procurement patterns suggests potential diversion ranging from between 10 percent (Peoria and downstream) and 20 percent (at Morris) of existing barge traffic under a segment toll approach, to between 20 and 30 percent (or more) of traffic under a fuel tax approach. We feel these estimates are on the high side for several reasons. In the first place, these levels of diversion would apply only when there was no shift in prices at alternative demand centers. Most industry analysts express the opinion that increased barge rates (due to user charges or any other cause) would lead to increases in rail rates. While there are market factors which may limit the extent of rail rate response, the likelihood of some rail rate increases on barge competitive traffic is significant.

Secondly, capacity considerations would counteract major traffic diversion in the near term (as long as five to ten years). Significant fixed capacity in both barge equipment and barge terminal facilities would lead to some absorption of user charges into barge rates and river bids before even

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*At least one source described the situation as follows: "the export prices sets the bid, but the processor takes what he wants."

as much as 10 percent of grain traffic would leave the river. This would not be a conscious decision on the part of operators, but a market response to excess capacity.

Similarly, grain shippers themselves have fixed investments in facilities which will have an impact on export patterns for many years to come. The largest grain exporters are committed to a multi-modal export strategy. They own barge operations, rail cars, rail and barge terminals in the producing areas and port facilities which are constructed to throughput both barge and rail grain. Although some flexibility is obviously possible, especially as time passes, the responses of these shippers would tend to soften traffic impacts.

Actual traffic diversion as high as 50 percent of our estimates of potential diversion would be extremely surprising to most grain industry analysts even in a 10 year time frame. Many expect market responses to cancel most of the potential diversion, which would mean the impact of the user charge policy would spread to a broader group of grain producers (see section on farm impacts below) with correspondingly less import on the barge industry.

3.3.2 Upper Mississippi River

Upper Mississippi River and Minnesota River barge terminals originated almost 15 million tons of grain and soybean traffic on the waterways in 1974 (See Table 55). The bulk of the traffic originated above St. Louis -- mostly in Iowa and Minnesota. As in the case of the Illinois River, most of the shipments (over 90%) were destined for export - about forty percent, fifty percent, fifty-five percent of total barge receipts of soybeans, corn, and wheat, respectively, at Gulf ports were from this area. Most of this grain is procurred from the west of the river, from Iowa, Minnesota, and (for wheat) Dakotas farmers, and so it is this area that will receive the closest scrutiny.

Upper Mississippi River grain traffic accounted for about 14.5 billion ton-miles in 1972.

Several characteristics of this area make analysis of user charge impacts more complex than for the Illinois River. In the first place, the river is normally closed for up to three months each year due to freezing north of the Missouri border. Secondly, and perhaps in part because of the seasonal character of barge transport, the best rate for direct rail export is a full 14¢ per bushel higher than for Illinois. Thirdly, multi-car gathering rates to barge terminals extend river procurement areas most of the way across the state of Iowa in normal times.

3.3.2.1 User Charges

The user charge for barge shipment to export at New Orleans ranges from 21.7 cents (below St. Louis) to $1.14 (at Minneapolis) under the segment toll, and from 71.3 cents to $1.33 (for

TABLE 55

THE UPPER MISSISSIPPI RIVER BARGE SHIPMENT PATTERN - 1974 (1000 SHORT TONS)

	Mississippi River						Minnesota River			TOTAL		
	St. Louis - Cairo			Minneapolis - St. Louis								
	Corn	Wheat	Beans	Corn	Wheat	Beans	Corn	Wheat	Beans	Corn	Wheat	Beans
Lower Mississippi Ports	471.9	312.8	626.3	6146.0	590.5	2290.7	1754.1	751.4	459.7	8372.0	1654.7	3376.7
Other Gulf Ports	8.7	97.9	44.2	58.7	75.4	11.1	-	24.7	23.8	67.4	198.0	79.1
Tennessee River	7.2	31.6	35.5	165.2	127.5	51.6	79.3	74.5	-	251.7	233.6	87.1
Other	3.0	32.7	7.6	79.3	127.3*	73.7	26.7	149.4*	44.1	109.0	309.4	125.4
TOTAL	490.8	475.0	713.6	6449.2	920.7	2427.1	1860.1	1000.0	527.6	8800.1	2395.7	3668.3

*Most to points on the Mississippi River.

the same origins) under a fuel tax -- Table 56. This table also relates the user charge per bushel of each major crop from selected key shipping points. The river area which originates the heaviest grain shipments (between Burlington, Iowa and Minneapolis) would bear tolls of between 2 and 3 cents per bushel under the segment toll, and between three and four cents under a fuel tax.

3.3.2.2 Rail Competition

Until this autumn, the dominant rail export rate was a 50 car - 5 trip rate to the Gulf. The rate for this movement was 61.5 cents per cwt (X-313) through Setpember, 1976 from most of Iowa and somewhat higher at the northern and western fringes (see Figure 3). At ex-parte 330 levels, this rate is 66¢ per cwt. Above the southern tier of counties in Minnesota, the rate rises somewhat more rapidly - it is 75 cents per cwt. at Minneapolis - and the 50 car export rate to Duluth-Superior begins to dominate the Gulf outlet (when the Great Lakes are open to shipping).

On September 1, 1976, the I.C.G. extended 118 car rates to the points it serves in Iowa. The rate is 55¢ per cwt. (shipper equipment, mileage paid) if twenty-five trips are made annually, and 58¢ per cwt. for 10 trips. The other roads in the area are expected to publish 75 car rates in December, 1976 at an X330 level rate of 58¢ per cwt. Presumably this rate will be structured roughly along the territorial lines of the existing 50 car rates (see Figure 3).

One factor in the implementation of these new rates is the 50 car barge terminal gathering rates published by the C&N.W. RR and the Milwaukee Road. These rates extend the

TABLE 56

USER CHARGES FOR UPPER MISSISSIPPI GRAIN SHIPMENTS TO NEW ORLEANS (100% OM&R)

	Segment Toll			Fuel Tax		
	¢/ton	Corn	Wheat & Beans	¢/ton	Corn	Wheat & Beans
Cape Girardeau	21.7	0.6	.65	71.3	2.0	2.0
St. Louis	37.9	1.1	1.2	82.1	2.3	2.5
Davenport	71.1	2.0	2.14	104.2	2.9	3.1
Dubuque	83.0	2.3	2.5	112.1	3.1	3.3
Winona	100.4	2.8	3.0	123.7	3.5	3.7
Minneapolis (and Minnesota River)	113.9	3.1	3.4	132.7	3.7	4.0

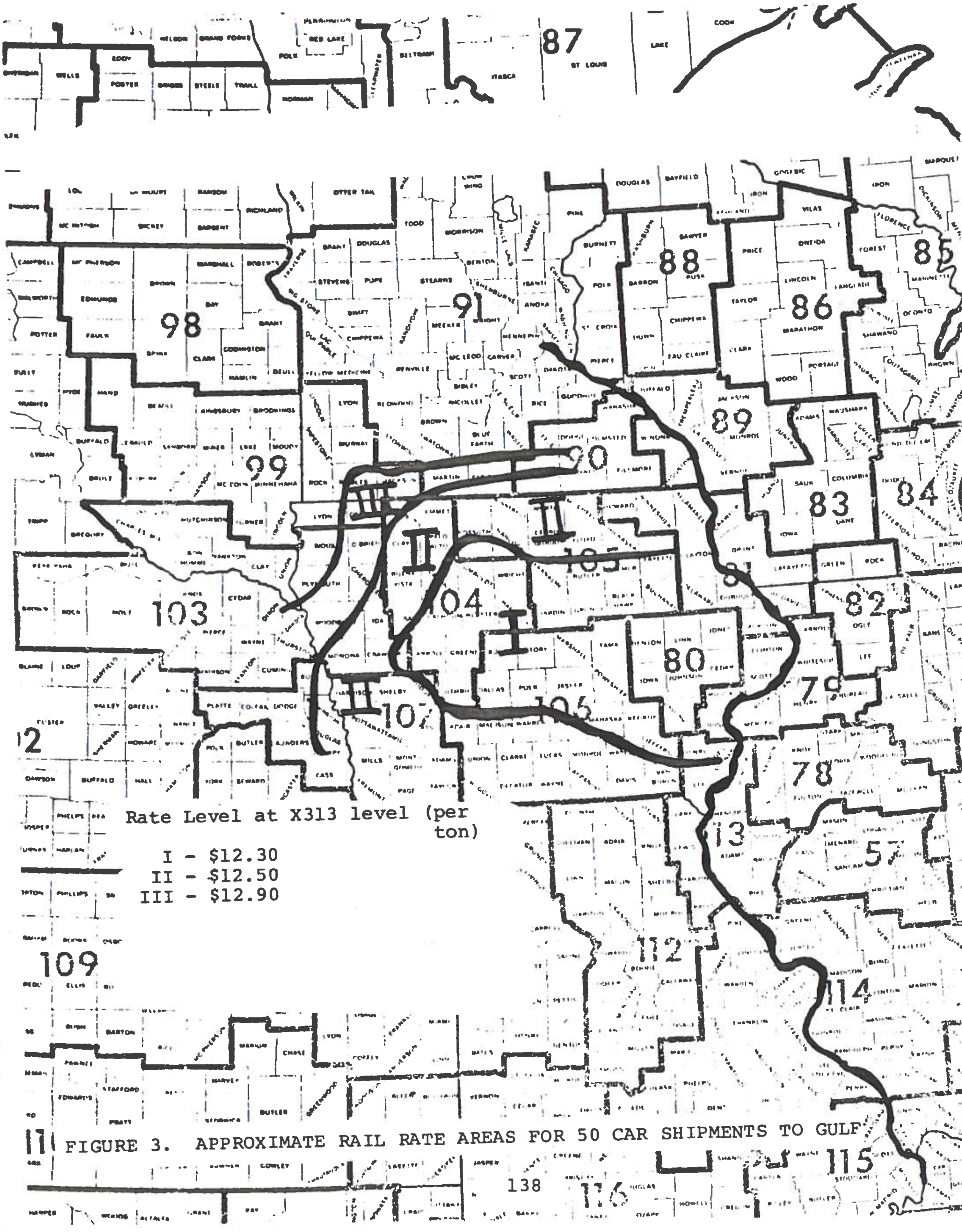

FIGURE 3. APPROXIMATE RAIL RATE AREAS FOR 50 CAR SHIPMENTS TO GULF

river procurement area far beyond the truck-barge procurement boundary (see analysis below) and allow these roads to participate in export grain traffic even when barge rates are relatively low. The fact that these railroads have no direct haul to the Gulf is probably a factor in their creation of these rates. Thus, when barge rates are high, these carriers can participate in the direct export shipments, while they can still participate in the export grain by hauling to the river when barge rates are lower.

The estimated annual contract rate for barge transportation of grain to the Lower Mississippi River ports is about $5.30 per short ton from Muscatine, $6.00 from McGregor and $6.20 from Minnesota terminals. At these rate levels, truck-barge shipment is competitive with direct rail shipment to the Gulf (50 cars - 5 trips) up to a distance of 125 miles in the Muscatine area, and from 110-120 miles north of Dubuque (see Figure 4). The 50 - car gathering rates discussed above extend the competitive area of the river terminal 80-100 miles farther to the west (as shown in Figure 5).

The geographic structure of the gathering rates adds to the complexity of the analysis in this area. In Central Iowa, the rate to the river varies only about 1 1/2 cents per bushel from Waterloo to Jefferson, a distance of over 120 miles. Therefore, it is theoretically possible that an increase in barge rates (due to user charges) or a decrease in direct rail export rates (due to new volume tariffs) as small as 2¢ a bushel could shift the procurement area as much as 125 miles at any particular season. Under the proposed 75 car rates, the barge-truck area contracts by about 15 miles, while it draws in another 30 miles under the 118 car-25

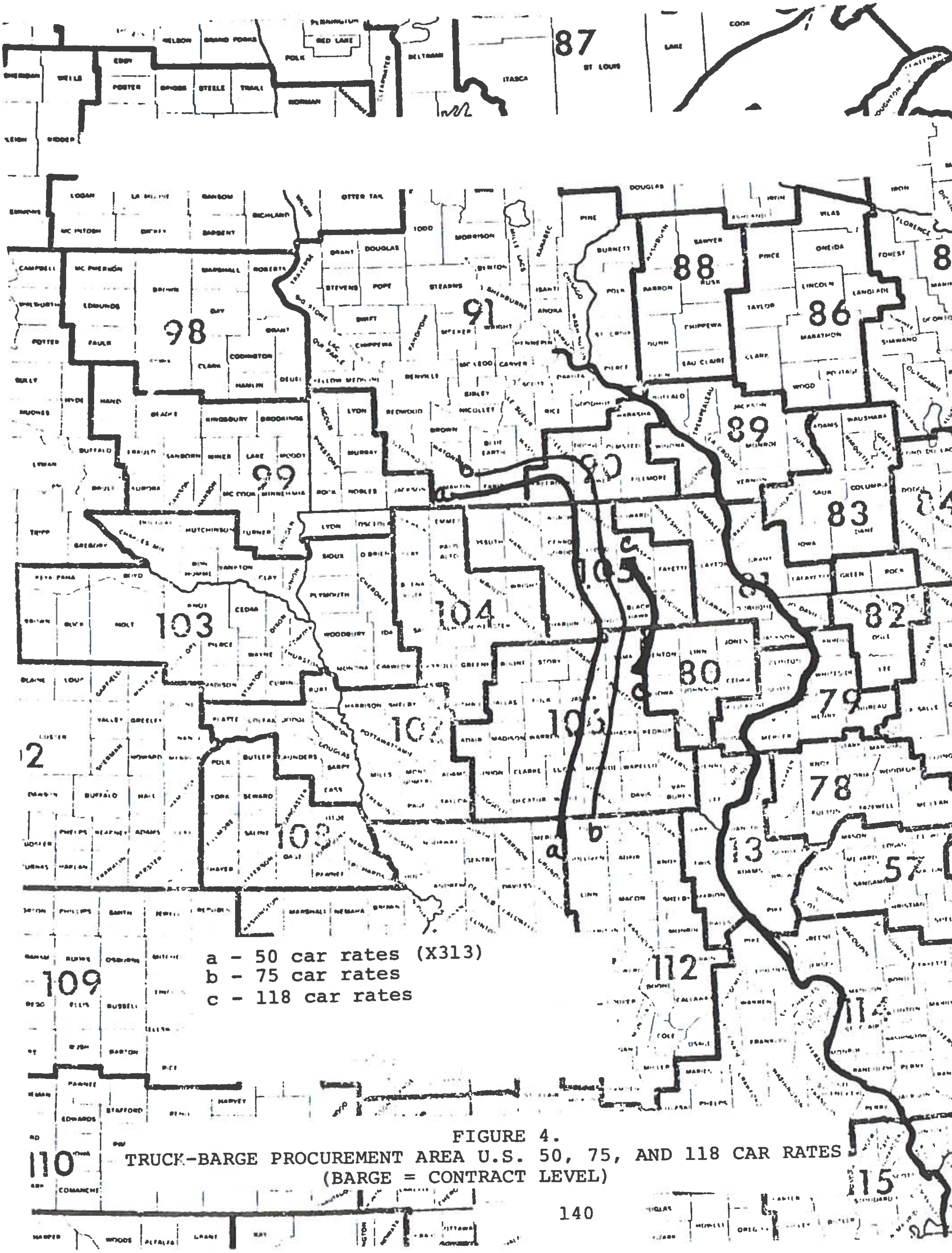

FIGURE 4.
TRUCK-BARGE PROCUREMENT AREA U.S. 50, 75, AND 118 CAR RATES
(BARGE = CONTRACT LEVEL)

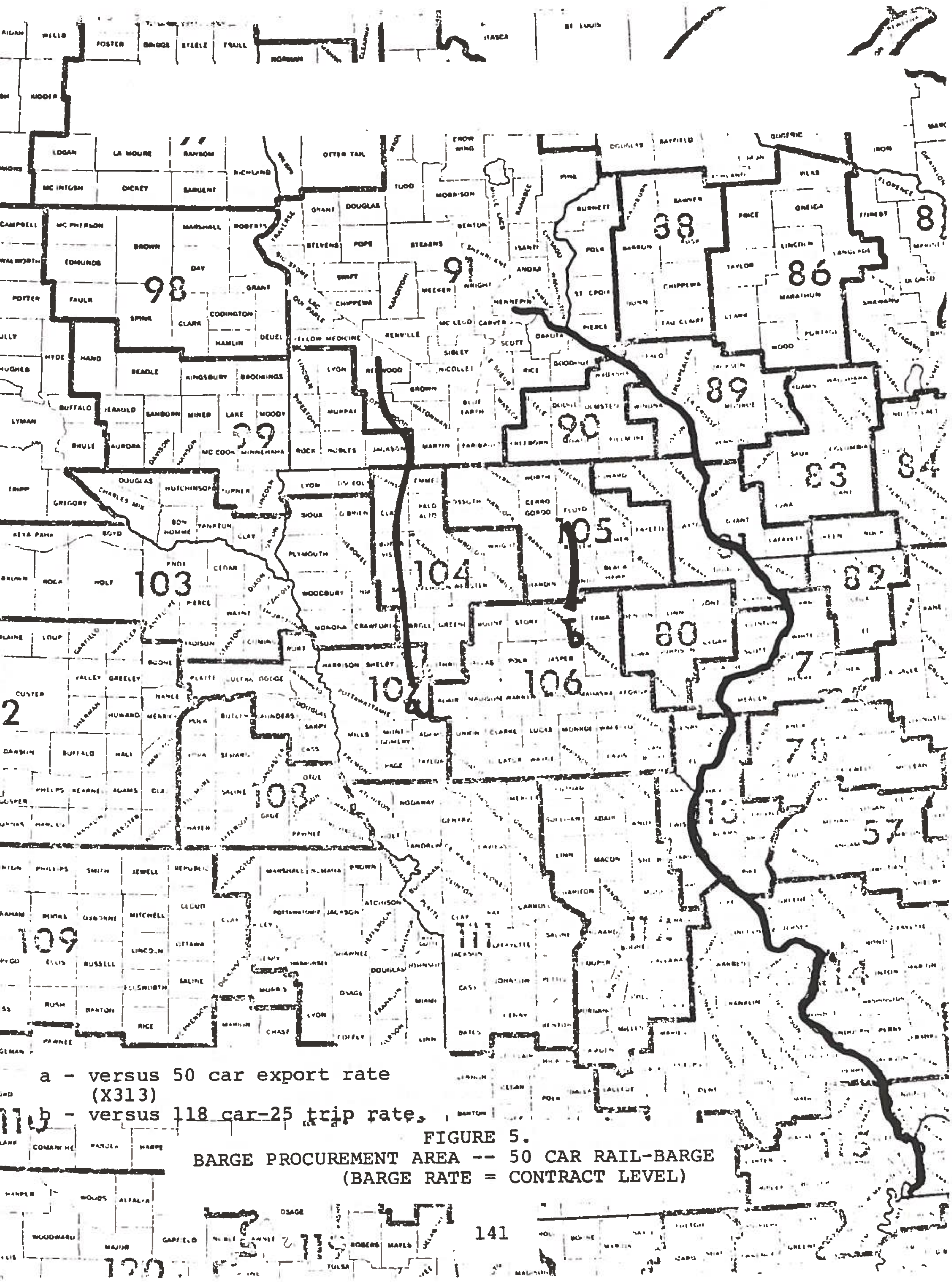

FIGURE 5.
BARGE PROCUREMENT AREA -- 50 CAR RAIL-BARGE
(BARGE RATE = CONTRACT LEVEL)

The narrowness of these existing grain patterns relative to their territory of economic advantage suggests that the impacts of user charges in the 2 to 3 cents per bushel range (the equivalent of 15 to 25 miles of trucking cost) would be relatively small. Combined with 1 1/2 to 3 cent per bushel declines in rail export rates in the new multi-car tariffs, however, the user charges would probably go far toward nullifying the impact of the multi-car barge terminal gathering rates during much of the year.

Because of the dynamic nature of the grain transportation situation in this area, it is difficult to make definitive estimates of traffic diversion. Obviously, as discussed above, if the railroads or other parties in the grain market respond in kind to user charge-induced price changes, the barge traffic impacts would be minimal. If such response is not forthcoming, we would expect the traffic originating on the Upper Mississippi to be less divertible than the Illinois River traffic because of the less rigorous rail export competition. If, in conjunction with the new 75 and 118 car rates, the user charge policy were to significantly shorten the season during which the rail gathering rates brought the Central Iowa producing area into the river procurement picture (as seems likely), the policy would have a greater impact on potential river traffic development than on existing traffic flows.

A larger share of these barge wheat shipments is oriented toward domestic markets (or at least to destinations away from the Gulf) than is true of corn or beans. In recent years, around 600-700 thousand tons were destined for such areas as Memphis, and the Ohio and the Tennesse Rivers, with the major fluctuations in traffic accounted for by movements to port areas.

Other characteristics of the wheat market also distinguish it from the corn and bean markets and complicate the analysis. In the first place, there are several classes of wheat (duram, hard red spring, white, etc.) and different protein contents within classes, which are normally recognized in the transportation data. These classes of wheat are not perfectly substitutable in use, they have relatively distinct growing areas, and may vary widely in price -- e.g., a 1% protein differential may mean as much as 20-50¢ in the price per bushel. Discussions of the "wheat" market are thus very tentative.

Secondly, the major competing export outlet from Minnesota and the Dakotas is not through the Gulf, which draws most of its wheat by rail from farther south, but through Duluth-Superior.* This is in part because the wheat growing areas are somewhat farther from Gulf and closer to Duluth, and because multi-car grain export rates to the Gulf have generally not been extended to wheat.

At the same time, the barge terminal procurement area for wheat is broader and more dispersed than for corn and beans. If all or most of the wheat comes to the river by truck, it might be possible to generalize that the traffic diversion impact of any given user charge would be smaller on wheat than on corn or beans, because the resultant shrinkage in the truck procurement area would include a smaller fraction of receipts.

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*In 1972, wheat exports through Duluth-Superior were 2.3 million tons compared to about .8 million tons of barged from the Upper Mississippi to Gulfport areas. Although Duluth-Superior exports had grown to 3.4 million tons by 1975, Upper Mississippi River shipments to Gulf export areas had increased 300% to 2.4 million tons.

As seen in the case of rail gathering rates in Iowa (above), however, an extra cent per bushel impacts the rail procurement area more dramatically than for truck.* Unfortunately, more of the data concerning river procurement patterns include modal detail. In fact, the wider procurement area was cited by at least one grain transportation executive as a factor which would make wheat traffic less sensitive to user charges.

In light of these uncertainties, only the most general conclusions concerning wheat traffic impacts can be made. Obviously, as with the other grains in this producing area, the fuel tax appraoch would have a greater impact either on barge traffic or farm prices, than a segment toll because of the origination of the traffic toward Lower Mississippi ports. Any significant diversion which does take place will be to Great Lakes ports or to domestic milling, not to the Gulf. Diversion of existing rail-barge traffic to Great Lakes export will not create new traffic for the railroads involved -- some of the roads must route via Minneapolis to reach Duluth. Only diversion from truck-barge channels will provide obvious net gains for the wheat-carrying roads. Again, as for corn and beans, the final impact of user charges on wheat will depend on railroad rate responses and the ability of the domestic market to absorb incrdased supplies without price declines. In the worst case, traffic losses up to 10 to 15 percent under a segment toll and 20 to 30 percent under a fuel tax are possible, although smaller traffic impacts might be expected.

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*This of course reflects the relatively lower capital costs and higher operating costs of trucks. Even the trucker's contribution to right-of-way costs is at least partially tied to direct operation costs through highway fuel taxes.

3.3.3 Other Traffic

Because of limitations on information at the time of this writing - particularly concerning existing procurement patterns for barge terminals - this analysis cannot be extended to the less-important (in volume terms) Missouri and Ohio River shipping areas. Preliminary indications are that a segment toll (between five and eight dollars per ton) would make the Missouri River totally unviable as a grain (mostly wheat) outlet and suggest that a fuel tax ($1.10 to $1.30 per ton to export for the same area) would have nearly as large an impact on traffic.* Missouri River (originating) grain traffic accounted for about 1.1 billion barge ton-miles (993 million, 126.8 million, and 30 thousand for wheat, soybeans, and corn respectively) in 1972. The impacts of this traffic loss on other segments - particularly the Lower Mississippi - are treated in Chapter 8 of Volume I.

Ohio River shipping points generated only 1.1 billion ton-miles of grain traffic in 1972, but this traffic has been growing steadily in recent years. This river, whose main competition is Altantic Coast export and the Southwestern feed market, would probably suffer only small traffic losses under a segment toll (.6¢ per bushel at Evansville and 1¢ at Cincinnati), but would face user charges three to four times that magnitude under a fuel tax.

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*Draft limitations and short shipping season make barge rates on this river significantly higher than on the other rivers treated.

3.3.4 Farm Impacts

3.3.4.1 Background

As outlined in the introductory sections, the impact of user charges will affect farmers differently as a function of their dependence on the waterway, the level of tolls in the area, and the response of other participants in the grain distribution system. Thus, a farmer located near the barge terminal whose most profitable outlet direct or via a country elevator is a barge terminal will most likely bear the full amount of the user charge in the price he receives for his grain at the farm. A farmer in the broader producing area whose best marketing channel is away from the river (via rail) both before and after user charges will bear no impact from the policy unless the price bid by other demand outlets in the area responds to the decreased barge terminal bid with decreased bids of their own. Obviously farmers between these two extremes bear an intermediate burden.

The immediate impact of a user charge policy and concomitant price declines to farmers (at least to those affected) will be a decline in gross receipts relative to what they would have been otherwise. While this will be partially offset by decreased income tax obligations there will be a decline in net after tax receipts. This will be further manifested in the longer term by a decline in value of the land, which is a function of the income producing potential in the land. This process will, in effect, remove a portion of the capital value in the land conferred on it by its economic proximity to markets as a result of the waterways.*

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*Proximity to a barge terminal is frequently listed in advertisements as a selling point for agricultural (and industrial) property.

In the case of rented cropland, the tenant farmer would escape the user charge-induced income loss upon renegotiation of the lease, leaving the burden of the user charge on the land owner. The owner-operator, as his own landlord, would bear the ultimate burden in the value of his farm for sale for agricultural production, and a lower cash income in the meantime.

3.3.4.2 Impact Estimates

Farm imcomes have fluctuated substantially in recent years. Average soybean prices received by farmers fell from $7.50 per bushel in the fourth quarter of 1974 to $4.50 in early 1976 climbing back to almost $7.00 by the beginning of 1977. Price swings of this magnitude ($2.50 to $3.00) have an impact on farm incomes 100 to 300 percent greater than the 1 to 3 cent per bushel user charges discussed in this chapter. Similarly, corn prices have fallen in the same period from about $3.30 per bushel to around $2.50 or lower (25-80 times the user charge impact).

In light of such fluctuations, it is difficult to describe "the" impact of user charges on the prosperity of farmers. Although the absolute dollar impact on farm receipts is fairly insensitive to the state of the market (it is determined in the first instance by the amount shipped by barge and the level of the user charge, and not the overall level of prices), the sensitivity of the farmer to the income loss is clearly greater when he is netting 50 cents per bushel than when he is making $3.00 per bushel over costs.

In this section, we will illustrate the farm impacts of the user charge recovery levels treated in this paper in two ways; first by calculating the absolute income loss on the "average" 100 acres for each crop, and second, by comparing the user charge-induced price decrease to the estimated net margins for each crop. Because crop costs and farm incomes are measurable in many different ways, (depending particularly on the measure of land costs) and since they vary widely from region-to-region and year-to-year, these illustrations may only be considered as suggestive of the actual effects in any area.

Based on "normal" national average yields per acre of 93.0 bushels for corn, 28.2-33.9 bushels for wheat, and 27.1 bushels for soybeans.* The income loss from a one cent price decline on the product of 100 acres in each crop is $93.00 $28.20-$33.90, and $27.10, respectively. (Greater average yields or larger price declines would obviously mean higher absolute losses.) Actual income loss to the farmer would be less according to his marginal income tax rate.

Although receipts from crop sales account for only part of the income of farm families - dairy and livestock production, non-farm earnings, and other sources contribute to family income - it is of some interest to compare potential user charge-induced crop price declines to net revenues from crop sales. Table 58 shows the unit costs of production for corn, wheat, and soybeans in 1974 - the most recent year for which comprehensive data are available - under different methods of treating land costs. It should be noted that these costs do not necessarily represent the out-of-pocket costs to the farmer, since they include imputed compensation for the labor of the farmer and his family, an imputed return for the managerial activities of the farmer, and other costs which are essentially compensation to the farmer. Land costs are calculated in two ways - first, as the estimated mortgage interest payment for the cropland valued at its original acquisition cost to the farmer, and second, based on existing (1974) cash rental costs for cropland. Clearly, each of

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*<u>Costs of Producing Selected Crops</u> in the United States - 1974, prepared by the Economic Research Service of the U.S.D.A. for the Committee in Agriculture and Forestry, U.S. Senate, 1/18/76.

TABLE 58
UNIT COSTS OF PRODUCING SELECTED GRAINS IN 1974 - U.S. AVERAGE PER BUSHEL

	Corn		Wheat		Soybeans	
	1974 Yield	"Normal"[e] Yield	1974 Yield	"Normal"[e] Yield	1974 Yield	"Normal"[e] Yield
Direct Cost	$1.31		$1.57		$2.16	
Management and Overhead	.31		.46		.63	
Land Cost I[a]	.44		.60		1.18	
Land Cost II[b]	.55		.99		1.48	
Total Cost I[c]	2.06	$1.69	2.63	$2.17	3.97	$3.61
Total Cost II[d]	2.17	1.78	3.02	2.49	4.27	3.78

Source: Costs of Producing Selected Crops in the United States - 1974, ibid.

[a]Estimated cost of land at time of acquisition by owner multiplied by current rate of interest on Federal Land Bank mortgage loans.

[b]Based on average cash rent payments per acre of cropland.

[c]Direct Cost & Management and Overhead & Land Cost I.

[d]Direct Cost & Management and Overhead & Land Cost II.

[e]The year 1974 yields were below normal, making unit costs per bushel higher than trend levels since most costs are sensitive to acreage planted and harvested, not volume harvested.

these methods understates the out-of-pocket land cost payments of a farmer who purchased cropland in the most recent years when land prices were inflated (cropland values rose an estimated 21.5 percent between 1973 and 1974 due to high crop prices), while they overstate land-related payments for an owner-operator who purchased his land many years ago.

The unit cost of producing the "average" bushel of corn in 1974 was $2.06-2.17 ($1.69-1.78 at trend yield levels). The average farm price of corn in that year was $3.02 (including grazing and sileage value), exceeding unit production costs by 85-96 cents ($1.24-1.33 at trend yields). User charge-induced price declines of between 1 and 3 cents would have meant approximately 1-3 percent declines in the net return on a bushel of corn in that year. Recall that this overstates the overall percentage impact on the farmer's compensation for corn production since some elements of cost represent the compensation for self-provided labor and management services. Additionally it overstates the impact on total farmer income because it treats only one source of family income-crop sales.

Presently, the farm price of corn has fallen below $2.50. Ignoring any production cost increases since 1974, this puts the margin on a bushel of corn more in the range of 50 to 75 cents.* This obviously makes the relative impact of user charge-induced price declines greater.

It is interesting to note that if market prices were to decline below support price levels or if support prices are increased to or above market prices, the U.S. Department of Agriculture might find itself compensating farmers for any user charge-induced income losses.

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*At 1974 yields, positive margins would be eliminated for many farmers at current prices.

Wheat production costs in 1974 stood at \$2.63-\$3.02 (\$2.17-\$2.49 at trend yields) according to the estimates in Table 58. This compared to an average price received by farmers for wheat in that year of \$4.12 (including the value of grazing) and the current price closer to the \$2.50 to \$3.00 range. While 1-3 cent shifts would have exerted a small percentage impact on wheat prices in 1974, the relative impact would clearly be much greater in the current year.

Finally, the farm price of soybeans is currently in the vicinity of \$7.00 per bushel, more than \$3.00 in excess of "normal" unit product costs. If this price is at all representative of the market in future years, any impacts of user charges on farm incomes from soybeans should be negligible.

One final perspective on user charge impacts on agricultural producers is obtained by estimating the total income loss to barge-served regions from potential grain price declines. Assuming full pass-through of user charges to farm prices, and assuming no diversion of shipments to more profitable marketing channels, the income leakage from the Illinois River, Upper Mississippi River, and Ohio River procurement areas are calculated in Table 59.

Several observations are possible: first, income leakage is considerably greater under a fuel tax, exceeding losses under a segment toll by \$3.5 million, \$2.9 million, and \$.8 million in the Illinois, Upper Mississippi, and Ohio River regions, respectively. Second, leakages are small relative to the total regional income generated by the same crop sales. For example the \$5-\$10 million in the Illinois procurement area compares to a total value of the barge shipped grain of about \$1.0 billion at current prices, and a considerably greater value of total farm production in the area.

TABLE 59

POTENTIAL INCOME LEAKAGES FROM GRAIN SHIPPING REGIONS

	Illinois River		Upper Mississippi River		Ohio River	
1974 Barge Shipments						
Corn	7626.8		6939.8		483.6	
Wheat	205.3		1395.7		328.1	
Soybeans	1872.8		3140.7		657.5	
Unit toll/ton	Segment Toll	Fuel Tax	Segment Toll	Fuel Tax	Segment Toll	Fuel Tax
Corn	.58	.94	.85	1.11	.24	.80
Wheat	.47	.85	.94	1.00	.31	.90
Soybeans	.55	.92	.70	1.01	.24	.76
Total Collections ($1000's) = Shipment & Toll						
Corn	4423.5	7169.2	5898.8	7703.2	116.1	386.9
Wheat	96.5	174.5	1312.0	1395.7	101.7	295.3
Soybeans	1030.4	1723.0	2198.5	3172.1	157.8	499.7
TOTAL	5550.4	9066.7	9409.3	12,271.0	375.6	1181.9

3.3.4.3 Summary

Farm incomes in barge served areas will be impacted by a waterway user charge. While any level of income deterioration will certainly be politically unpopular, particularly when farm receipts are down due to depressed markets as they are now, potential user charge-induced impacts will play a much lesser role in the prosperity of the farm sector than other factors - e.g., the course of world market prices.

In any case, the magnitude of farm sector impacts will depend on the collection approach implemented and the response of other grain market participants. As demonstrated above, a fuel tax would have greater impact on Upper Midwest farmers than a segment toll because of the long haul movement on relatively low cost waterways. If grain prices in alternative marketing channels remain firm after user charges, then some farmers will be able to avoid some of their burden. If, on the other hand, domestic market prices weaken and export rail rates rise, the income effects will be extended to some non-barge shippers.

The impact of waterway user charges on barge grain traffic is bearly dependent on the response of other parties in the grain distribution system -- exporters, railroads, processors, feeders, etc. -- to the eased competitive situation. If, as many industry analysts argue, railroads respond to barge rate increases with comparable rate increases on competing grain traffic, potential traffic diversion will be reduced significantly. If, on the other hand, bid prices of other marketing outlets remain fixed at pre-user charge levels, potential diversion would be substantial. Under a segment toll for the recovery of 100% of OM&R, diversion of up to 10 percent of corn and soybean traffic on the Illinois (slightly higher at the lower-volume upstream areas) and Upper Mississippi Rivers is possible. (Existing dynamics make estimates for the latter area more uncertain). This level os diversion would account for about three billion ton-miles of barge traffic.

Grain shipments from these areas travel significant distances on the low-cost Lower Mississippi River resulting in significantly higher burdens under a fuel tax than under a segment toll. Potential diversion is from 50-100% higher under the fuel tax - especially on the Illinois River.

Educated opinion suggests that traffic impacts from user charges would not be as large as the potentials outlined above. Although fully offsetting responses to user charges are unlikely, much of their impact would be mitigated in the short-run by capacity considerations, and in the long-run by rail export responses and natural traffic growth.

To the extent that user charge impacts are not manifested in waterway traffic losses, the impact on farm grain prices will be extended to a broader group of producers. A brief analysis of farm impacts suggests that while farm price declines of the magnitude of 1 to 3 cents per bushel would result from user charges, these impacts are quite small when compared to other market forces (particularly the world grain situation) which will determine the future welfare of the American farmer.

3.4 TRUCKING COSTS

An accurate estimation of the cost of transporting grain by truck is essential in determining whether a country elevator operator's location makes his most profitable market a barge terminal facility, a terminal utilizing rail, or an inland processor. The relationship between distance to each of these facilities, trucking costs, and the bid offered at each of these points will dictate the direction in which the elevator operator will ship his grain on a given day. For example, assume a country elevator operator located 50 miles from the Illinois River sees an offer of $2.60/bushel at the barge terminal. He is also 20 miles from a rail facility offering $2.55/bushel and 40 miles from a processor bidding $2.58/bushel. His marketing decision will depend on the price he will receive after subtracting his trucking costs to each facility. In this case, according to our estimates of trucking costs, his profit-maximizing decision would be to sell to the barge terminal.

The importance of trucking costs in understanding the procurement area of each river led to several approaches in obtaining estimates. First, several traffic analysts at large grain companies were contacted and questioned about the costs of trucking. Second, the same subject was discussed with several important farmer cooperatives in the Midwest. After having acquired a consistent range of trucking costs, a sample was taken of country elevators in the relevant areas. Information was sought from each operator concerning the distance and per bushel trucking costs to the river and the alternative marketing channels in looking for the most profitable bid. These figures were examined for consistency with the general cost rules we had established and were found to fit well.

Figure 6 represents the range of trucking costs from country elevators for 0 to 120 miles in terms of cents/bushel.* A large fixed cost completely dominates the influence of variable cost for what appears to be a minimum of 25 to 30 miles (note the substantial variability in the estimate of the level of fixed cost). At the originating elevator a truck must first be weighed empty and then loaded and re-weighed. Upon arrival at the destination facility a trucker must often cope with long waiting lines, the truck is then weighed and the grain sampled, and then more waiting time is involved in the dumping process. After unloading, the truck must return to the weigh scale. When variable costs begin to have significant effect the slope of the cost function varies from roughly 1 to 1 1/4 cents per bushel for ton miles.

These figures indicate the cost of trucking for 1976. There are no available statistics for trucking costs in previous years and apparently no historical record of such data exists. Inquiry has led us to believe that 15% inflation for each of the past two years may be a reasonable estimate. A very essential point regarding inflation in the trucking industry is that rapidly rising costs could have a major influence of the relative shares of truck-barge and rail traffic - this is potentially as important as increases in either barge or rail costs.

Two considerations in an elevator operator's decision as to the market to which to truck his grain are the impact of harvest time and the use of truck back-hauls of other commodities. In harvest period the shortage of barges and railcars combined with storage capacity limitations at

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*Trucking costs to country elevators may vary due to differences in equipment such as tractor-wagon transport or small farm trucks.

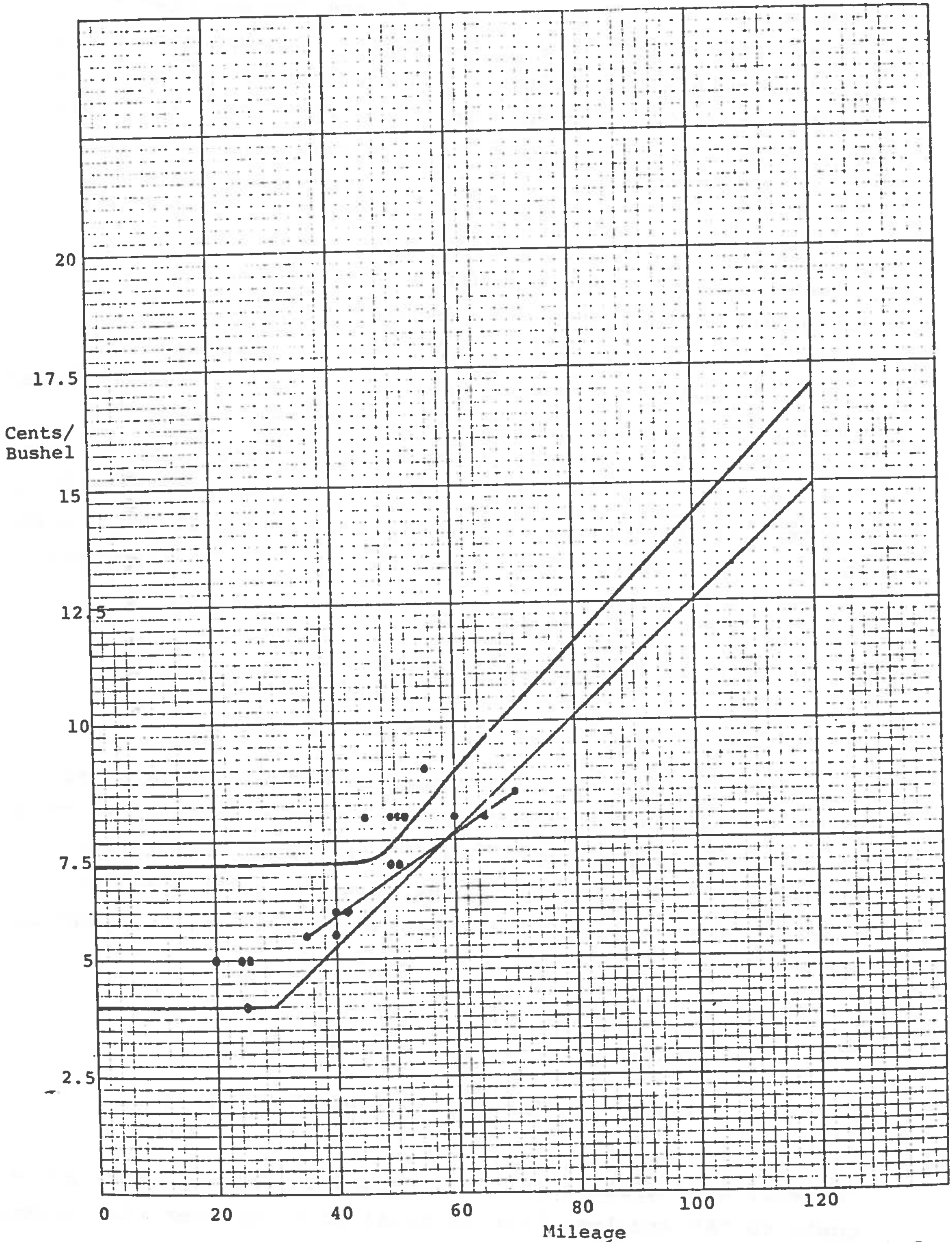

FIGURE 6. TRUCKING COSTS TO COUNTRY ELEVATORS

terminal facilities means that bids are low and elevators may not have the ability to buy grain. At this time of year 25 miles will make little or no difference in the market a country elevator supplies. In a very real sense the grain will be delivered to anyone who is willing and able to purchase it.

The costs identified above have little relevance to the situation in which truck hauls of grain are the back-hauls of movements of some other dominant commodity. Hennepin, Illinois on the Illinois River is a major steel shipping point with significant traffic to the "Steel Triangle" (Cedar Rapids, Waterloo, and Des Moines IA) and other points as far as Nebraska. Similarly, lumber moves east by truck from the lower Columbia River into Idaho and Montana in significant volumes. In such cases, truckers will often haul grain back to their home base at very low cost to defray the expenses of the return trip.

3.5 ESTIMATING THE BARGE PROCUREMENT AREA

3.5.1 When Bid Prices at Two Points Are Known

If bid prices at all key points (barge terminals, rail terminals, and major processors are known), then all we need to know is relative accessorial costs (truck and/or rail gathering rates) to estimate the barge terminal drawing area. In Figure 7 below, the bid at point A is \$3.00 and the bid at point B (100 miles away) is \$2.95.

FIGURE 7. GRAIN PRICE BIDS AT TWO POINTS

"A" will draw grain from all intermediate points whose access costs to "A" are less than or equal to 5¢ greater than access costs to "B". The trucking cost estimates derived from our survey of shippers (Section 3.4) tell us that "A" will draw from 70 miles toward "B", while "B" will be able to draw only 30 miles in the direction of "A" - with no effect from "A" in the opposite direction. At a point 30 miles toward "A", the trucking cost to "B" are four cents per bushel (the minimum for thirty miles or less), while the trucking cost to "A" is 9 cents per bushel (4 + 4 X 1.25). The trucking cost differential at this point (X) is exactly offsetting to the bid differential. Any closer to "A" and the trucking cost differential is less than the bid differential. If "B" were within 70 miles of "A", it would draw no grain from between itself and "A" - at a 5¢ bid differential - and if it were within 50 miles, it would draw no grain at all. It would pay shippers to truck their grain right past "B" and on to "A".

3.5.2 When Bid Price Information Is Limited

For export grain, the barge procurement boundary can be estimated as long as transportation costs and handling patterns are known. In figure 8, "A" and "B" compete for grain from country elevators for transhipment to "P".

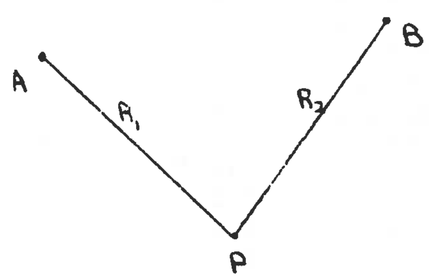

FIGURE 8. GRAIN TRANSSHIPMENT COMPETITION BETWEEN TWO POINTS

The procedure is equivalent to that in the previous example, except that transport costs to "P" are used to construct bids at "A" and "B". If handling costs at "P" are insensitive to the origin of the grain, and if throughput costs at "A" and "B" are comparable, then the transport cost differential will be equal to the bid differential and estimation of procurement areas proceeds as before.

TABLE 60. 1974 CORN BIDS - CENTS/BUSHEL

	Bid at Gulf	Bid at Illinois River	Differential
1/3/74	285.00	266.00	19.00
1/10	300.00	280.50	19.50
1/17	306.75	285.25	21.50
1/24	296.75	277.75	19.00
1/31	314.25	295.25	19.00
2/7	307.25	288.75	18.50
2/14	317.75	299.75	18.00
2/21	324.25	309.75	14.50
2/28	322.25	297.25	25.00
3/7	315.25	304.75	10.50
3/14	306.75	291.25	15.50
3/21	309.25	295.25	14.00
3/28	293.75	276.75	17.00
4/4	268.75	252.75	16.00
4/11	269.75	254.25	15.50
4/18	275.25	259.50	15.75
4/25	292.75	279.75	13.00
5/2	281.00	268.25	12.75
5/9	265.25	251.00	14.25
5/16	283.00	268.00	15.00
5/23	275.50	260.00	15.50
5/30	283.75	267.75	16.00
6/6	292.75	277.25	15.50
6/13	292.00	279.00	13.00
6/20	296.25	282.75	13.50
6/27	304.25	287.75	16.50
7/3	314.25	299.75	14.50
7/11	320.00	304.00	16.00
7/18	339.25	324.25	15.00
7/25	364.25	347.75	16.50
8/1	379.50	364.00	15.50
8/8	369.00	354.00	15.00
8/15	364.50	348.50	16.00
8/22	366.25	354.50	11.75
8/29	371.25	338.25	33.00
9/5	338.50	325.50	13.00
9/12	364.50	349.50	15.00
9/19	348.00	334.50	13.50
9/26	373.50	358.50	15.00
10/3	397.50	379.00	18.50
10/10	NA	NA	NA
10/17	381.50	365.50	16.00
10/24	370.00	349.00	21.00
10/31	381.25	355.25	26.00
11/7	378.25	357.25	21.00
11/14	375.75	353.25	22.50
11/21	350.50	316.50	34.00
11/28	NA	NA	NA
12/5	376.75	350.25	26.50
12/12	372.25	347.25	25.00
12/19	361.75	343.25	18.50

TABLE 61. 1975 CORN BIDS - CENTS/BUSHEL

	Bid at Gulf	Bid at Illinois River	Differential
1/2/75	352.75	333.75	19.00
1/9	340.00	326.00	14.00
1/16	330.25	316.25	14.00
1/23	315.25	300.25	15.00
1/30	323.75	310.25	13.50
2/6	319.75	307.25	12.50
2/13	NA	NA	NA
2/20	NA	NA	NA
2/27	278.50	266.50	12.00
3/6	297.25	280.75	16.50
3/13	304.00	286.00	18.00
3/20	298.50	284.50	14.00
3/27	309.50	294.00	15.50
4/3	308.75	295.75	13.00
4/11	296.00	282.00	14.00
4/17	295.00	283.50	11.50
4/24	297.75	284.75	13.00
5/1	288.00	275.50	12.50
5/8	285.25	272.75	12.50
5/15	285.75	274.75	11.00
5/22	289.50	278.00	11.50
5/29	284.25	271.25	13.00
6/5	295.25	281.75	13.50
6/11	301.75	285.25	16.50
6/19	302.75	289.25	13.50
6/26	302.25	287.25	15.00
7/2	295.50	279.50	16.00
7/10	299.25	282.25	17.00
7/17	301.00	283.50	17.50
7/24	312.75	298.75	14.00
7/31	305.00	290.00	15.00
8/7	339.25	319.25	20.00
8/14	329.00	314.00	15.00
8/21	335.00	315.50	19.50
8/28	323.00	306.00	17.00
9/4	311.50	294.50	17.00
9/11	301.50	283.50	18.00
9/18	302.25	300.25	2.00
9/25	307.75	286.25	21.50
10/2	294.75	271.75	23.00
10/9	302.00	274.00	28.00
10/16	296.25	265.25	31.00
10/23	283.00	244.00	39.00
10/30	279.25	241.25	38.00
11/6	272.25	249.25	23.00
11/13	254.75	244.75	10.00
11/20	262.00	245.00	17.00
11/26	279.25	269.25	10.00
12/4	NA	NA	NA
12/11	265.00	250.00	15.00
12/18	265.25	239.25	26.00
12/26	NA	NA	NA

TABLE 62. 1976 CORN BIDS - CENTS/BUSHEL

	Bid at Gulf	Bid at Illinois River	Differential
1/2	NA	NA	NA
1/9	270.75	255.75	15.00
1/16	NA	NA	NA
1/23	274.50	260.00	14.50
1/30	273.50	259.00	14.50
2/6	274.50	259.50	15.00
2/13	280.25	265.75	14.50
2/20	279.25	265.25	14.00
2/27	279.50	266.00	13.50
3/6	283.00	270.50	12.50
3/13	283.50	269.50	14.00
3/20	283.75	269.25	14.50
3/27	278.25	264.25	14.00
4/3	276.75	262.25	14.50
4/11	277.25	263.25	14.00
4/17	278.00	262.50	15.50
4/24	276.50	262.00	14.50
5/1	280.75	267.25	13.50
5/8	286.50	272.50	14.00
5/15	298.75	282.25	16.50
5/22	295.50	276.50	19.00
5/29	304.50	288.25	16.25
6/5	305.00	268.00	37.00
6/11	316.00	299.50	16.50
6/19	293.25	275.75	17.50
6/26	306.50	288.50	18.00
7/2	304.00	287.50	16.50
7/10	309.50	292.50	17.00
7/17	311.50	296.00	15.50
7/24	NA	NA	NA
7/31	300.00	285.50	14.50
8/7	294.25	283.25	11.00
8/14	279.75	273.25	6.50
8/21	291.50	280.50	11.00
8/28	288.25	274.25	14.00
9/4	295.25	282.75	12.50
9/11	301.25	283.25	18.00
9/18	302.50	270.00	32.50

TABLE 63. 1974 SOYBEAN BIDS - CENTS/BUSHEL

	Bid at Gulf	Bid at Illinois River	Differential
1/3/74	607.50	588.50	19.00
1/10	635.75	614.75	21.00
1/17	642.50	619.50	23.00
1/24	641.00	618.00	23.00
1/31	659.50	635.50	24.00
2/7	648.50	627.50	21.00
2/14	655.00	633.50	21.50
2/21	659.50	639.50	20.00
2/28	617.75	608.75	9.00
3/7	652.75	630.75	22.00
3/14	644.00	625.50	18.50
3/21	648.50	631.50	17.00
3/28	617.75	600.75	17.00
4/4	576.00	559.50	16.50
4/11	550.00	531.00	19.00
4/18	569.00	550.00	19.00
4/25	586.00	565.00	21.00
5/2	564.25	542.25	22.00
5/9	553.50	531.50	22.00
5/16	571.50	552.50	19.00
5/23	563.00	545.00	18.00
5/30	567.00	548.00	19.00
6/6	550.00	532.00	18.00
6/13	563.00	534.00	29.00
6/20	560.00	541.00	19.00
6/27	583.00	564.50	18.50
7/3	630.50	613.00	17.50
7/11	631.50	614.50	17.00
7/18	723.50	708.00	15.50
7/25	810.00	789.00	21.00
8/1	883.50	865.00	18.50
8/8	823.50	802.50	21.00
8/15	795.00	772.00	23.00
8/22	764.50	740.00	24.50
8/29	746.50	739.50	7.00
9/5	741.50	719.50	22.00
9/12	791.00	766.00	25.00
9/19	764.50	747.00	17.50
9/26	848.00	827.00	21.00
10/3	939.50	918.00	21.50
10/10	NA	NA	NA
10/17	833.00	818.00	15.00
10/24	800.00	762.00	38.00
10/31	803.50	775.50	28.00
11/7	839.00	820.00	19.00
11/14	790.50	771.00	19.50
11/21	727.50	683.50	44.00
11/28	NA	NA	NA
12/5	768.00	743.00	25.00
12/12	746.00	724.00	22.00
12/19	759.00	742.00	17.00
12/26	NA	NA	NA

TABLE 64. 1975 SOYBEAN BIDS - CENTS/BUSHEL

	Bid at Gulf	Bid at Illinois River	Differential
1/2/75	719.00	699.50	19.50
1/9	687.00	664.00	23.00
1/16	640.75	611.25	29.50
1/23	616.00	596.00	20.00
1/30	635.00	616.00	19.00
2/6	619.25	599.25	20.00
2/13	NA	NA	NA
2/20	NA	NA	NA
2/27	529.75	511.25	18.50
3/6	561.00	542.50	18.50
3/13	584.00	563.00	21.00
3/20	576.00	556.00	20.00
3/27	620.50	597.50	23.00
4/3	596.50	581.50	15.00
4/11	592.00	577.00	15.00
4/17	604.50	588.00	16.50
4/24	583.25	560.75	22.50
5/1	562.75	539.75	23.00
5/8	531.00	515.00	16.00
5/15	538.00	519.00	19.00
5/22	558.25	540.25	18.00
5/29	524.50	506.50	18.00
6/5	525.00	507.50	17.50
6/11	524.50	512.50	12.00
6/19	527.00	522.00	5.00
6/26	542.75	524.75	18.00
7/2	525.75	509.50	16.25
7/10	566.75	547.75	19.00
7/17	575.00	549.50	25.50
7/24	593.25	576.25	17.00
7/31	611.00	574.50	36.50
8/7	638.00	623.00	15.00
8/14	619.25	601.25	18.00
8/21	608.00	599.00	9.00
8/28	576.25	548.75	27.50
9/4	575.50	555.50	20.00
9/11	562.50	538.00	24.50
9/18	602.50	577.50	25.00
9/25	583.75	561.75	22.00
10/2	551.25	524.25	27.00
10/9	548.75	520.25	28.50
10/16	528.25	495.25	33.00
10/23	491.25	455.25	36.00
10/30	489.50	453.50	36.00
11/6	499.50	473.50	26.00
11/13	485.25	471.25	14.00
11/20	462.00	449.50	12.50
11/26	487.75	474.25	13.50
12/4	NA	NA	NA
12/11	464.75	452.75	12.00
12/18	452.75	438.75	14.00
12/26	NA	NA	NA

TABLE 65. 1976 SOYBEAN BIDS - CENTS/BUSHEL

	Bid at Gulf	Bid at Illinois River	Differential
1/2	NA	NA	NA
1/9	480.25	461.25	19.00
1/16	NA	NA	NA
1/23	483.50	463.50	20.00
1/30	476.50	459.00	17.50
2/6	489.25	471.25	18.00
2/13	489.00	473.50	15.50
2/20	496.50	478.50	18.00
2/27	486.50	468.50	18.00
3/6	489.25	472.25	17.00
3/13	487.25	469.75	17.50
3/20	480.75	463.75	17.00
3/27	476.75	459.25	17.50
4/3	477.75	459.25	18.50
4/11	486.75	467.75	19.00
4/17	491.75	473.25	18.50
4/24	492.75	472.75	20.00
5/1	489.75	472.25	17.50
5/8	507.75	486.75	21.00
5/15	535.75	513.75	22.00
5/22	549.75	526.25	23.50
5/29	583.00	561.50	21.50
6/5	583.25	563.25	20.00
6/11	647.75	626.75	21.00
6/19	623.50	591.00	32.50
6/26	653.25	632.25	21.00
7/2	688.00	665.00	23.00
7/10	725.00	707.00	18.00
7/17	712.00	691.50	20.50
7/24	NA	NA	NA
7/31	628.25	610.25	18.00
8/7	629.75	611.25	18.50
8/14	636.50	621.00	15.50
8/21	654.00	638.00	16.00
8/28	670.50	668.00	2.50
9/4	710.00	688.50	21.50
9/11	742.00	720.00	22.00
9/18	694.50	662.50	32.00

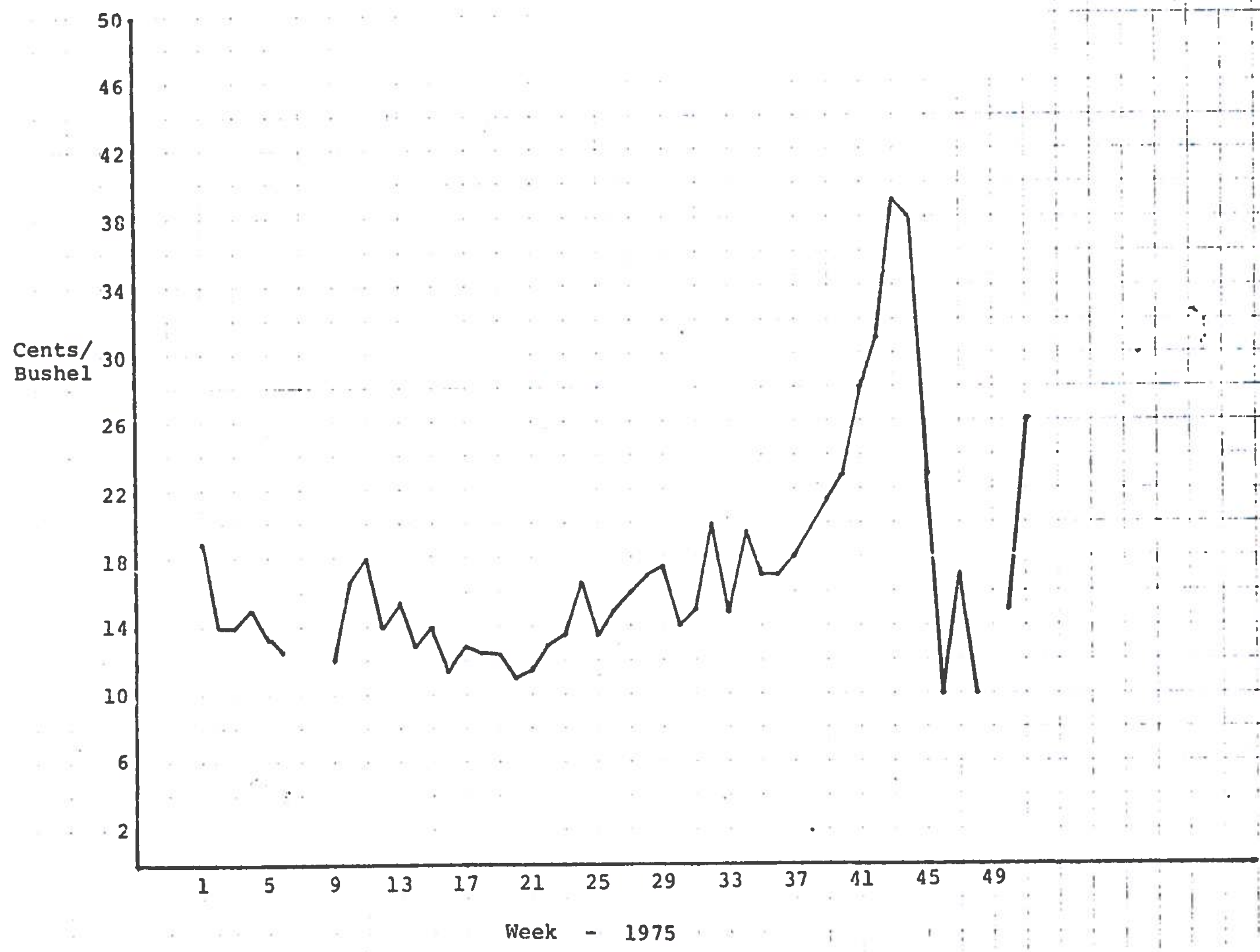

FIGURE 9. DIFFERENTIAL BETWEEN GULF AND ILLINOIS RIVER BIDS FOR CORN

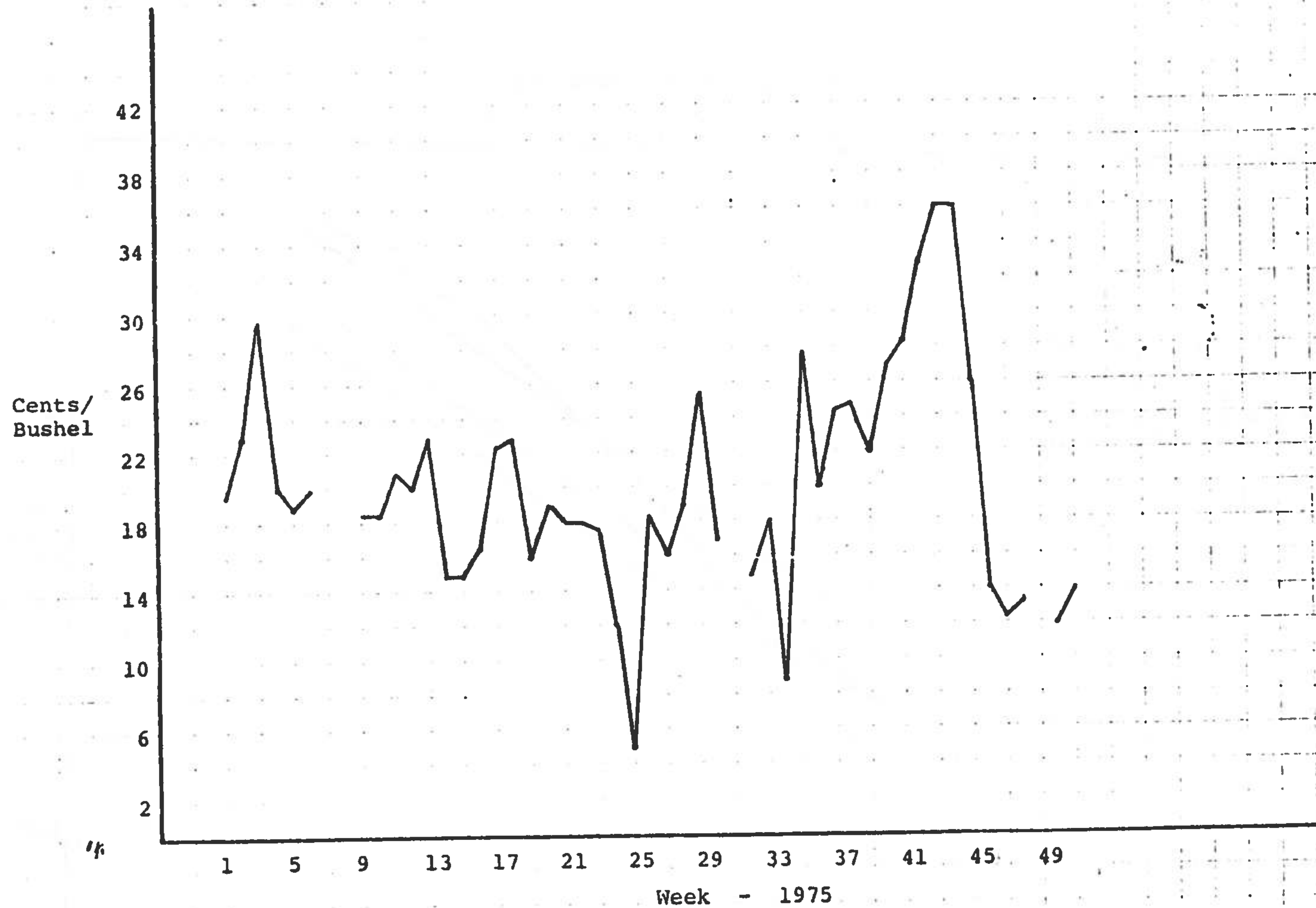

FIGURE 10. DIFFERENTIAL BETWEEN GULF AND ILLINOIS RIVER BIDS FOR SOYBEANS

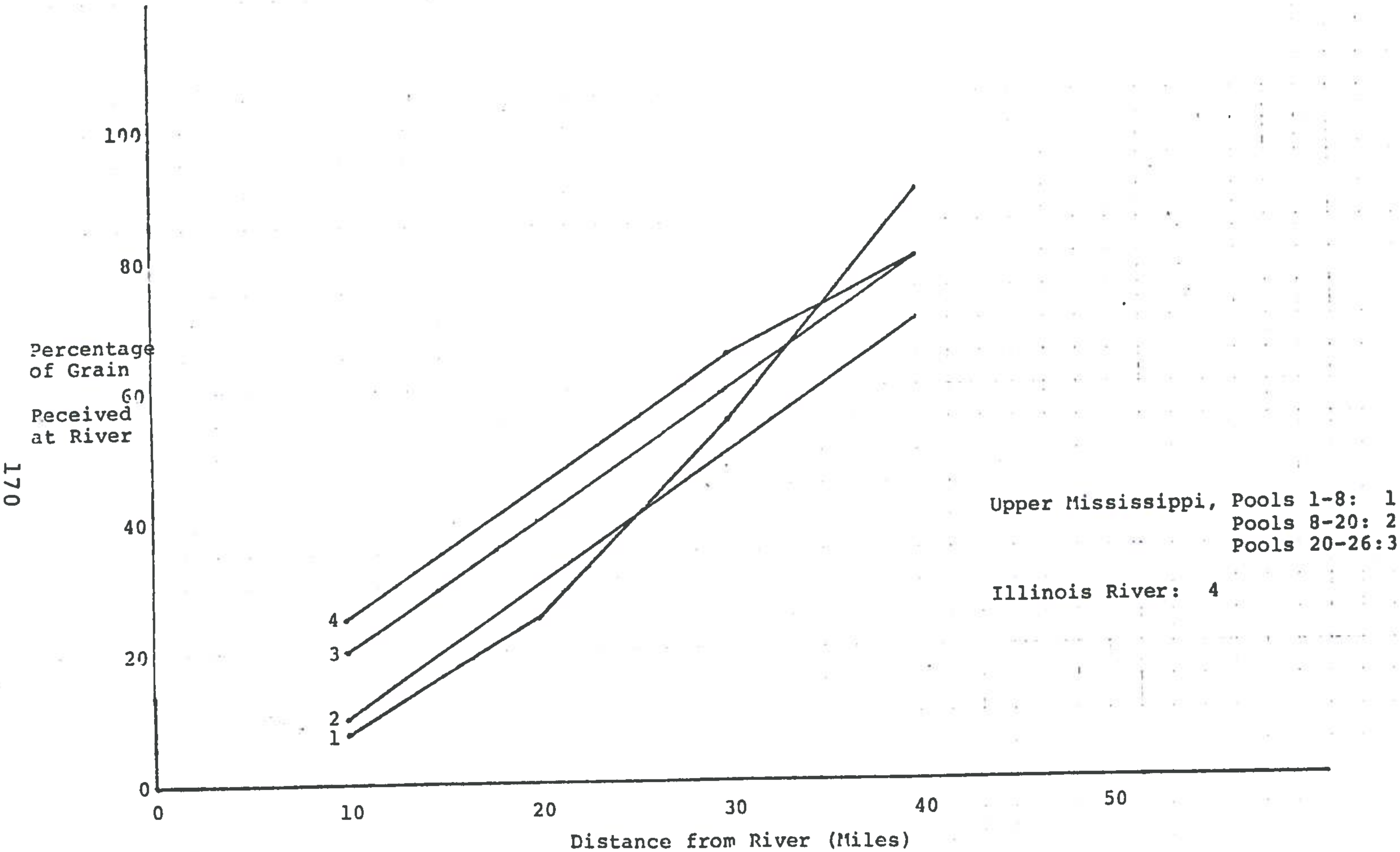

FIGURE 11. GRAIN PROCUREMENT AREAS - CUMULATIVE PERCENTAGE OF GRAIN RECEIVED FROM DIFFERENT DISTANCES

4. FERTILIZER TRAFFIC IMPACTS

4.1 INTRODUCTION

Fertilizer materials travel long distances from the originating site of raw materials to the final consuming area. The great majority of phosphates are obtained in Florida while New Mexico and Saskatchewan are responsible for all potash production. Nitrogenous fertilizers originate primarily in regions in the periphery of the U.S. such as Louisiana and the Southwest, although the geographic distinction is not as pronounced as in the case of phosphates and potash. The Midwest (defined as Illinois, Iowa, Missouri, Indiana, Minnesota, Ohio, Michigan, and Wisconsin) consumes 1/3 of the fertilizer products. These origin-destination patterns result in commodity flows that demand cheap bulk transportation. Rail, water, and pipeline handle practically all of the long-distance carriage.

In 1973, approximately 43.3 million product tons of commercial fertilizers were consumed in the U.S. These fertilizers consisted roughly equally of direct application materials (anhydrous ammonia, urea, triple superphosphate, etc.) and mixtures (18-46-0, 6-24-24, 5-10-15, etc.). Application of fertilizers in terms of nutrient content for 1973 were 8.3 million tons of nitrogen (N,46%), 5.1 million tons of available phosphate (P_2O_5, 28%), and 4.6 million tons of potash (K_2O, 26%).

The majority of the shipments of fertilizer on the Mississippi River System occur on the main stem of the Mississippi and the Illinois Rivers. This is due to the fact that almost all of the production facilities relying on water transport are located in Central Florida or in the Delta area. Of all states having the capability of utilizing water transportation Illinois and Iowa consumed by far the largest quantities (the two states together purchased 14% of all fertilizers sold in the U.S. in 1974). This origin-destination linkage accounts for the importance of the Mississippi and Illinois Rivers in the distribution of fertilizer. The following tolls would be applicable to these rivers:

O-D	Distance (miles)	Cost: Dollars Per Ton Segment Toll	Fuel Tax
Delta Area - Cairo	800	.14	.64
Cairo-Ft. Madison IA	400	.48	.32
Cairo-Upper Illinois	400	.41	.32

The total move on the Mississippi River would thus cost $.62 per ton by the segment toll while the fuel tax would mean an additional cost of $.96 per ton. The fuel tax would be the same to the Upper Illinois River (identical distances were selected) whereas the segment toll amounts to $.55 per ton. The heavy traffic and low cost on the Lower Mississippi (2/3 of the distance involved in these moves) means that generally the segment toll would have the lesser effect on the fertilizer industry - under a fuel tax fertilizer shipments on the river system would be forced to subsidize other commodities.

The fertilizer industry is a highly concentrated industry with probably no more than 10 companies heavily utilizing barge transport. There is some market dominance in different areas and distribution strategy (mainly involving the location of production facilities and their integration with the transportation system) is unique to each company. As a result modal choice does not readily lend itself to analysis through an examination of the rate structures of major line-haul modes. Large capital investments in both production facilities and expensive transportation equipment (due to the nature of fertilizer materials) clouds the diversion picture. Data essential to providing an accurate quantification of potential diversion would thus require extensive inputs from individual companies and is not presently available.

4.2 PHOSPHATES

Phosphorous content in fertilizer is measured in terms of tons of P_2O_5. All fertilizers providing this nutrient rely on phosphate rock as a source. In 1972, over 40 million tons of marketable phosphate rock were produced in the U.S. Of this total, 81% is attributable to Florida and North Carolina, with the western states producing only 12%. Water traffic generated by phosphate rock shipments from Florida was on the order of 21.7 million tons in 1972, about 60% of which was bound for foreign countries, with the remaining 7.5 million tons moving coastwise - almost entirely to the New Orleans area (5.6 million) and Houston (1.1 million). Only about 1/5 of the rock arriving in New Orleans continues up the river in that form (destined for Illinois and Iowa) for processing at plants located on the waterways. Rock received in the New Orleans area is converted to intermediate and final products and then shipped to the midwest. A large pecentage of phosphate rock is made into higher analysis material in Florida near mining sites.

Table 66 shows the total tonnage of rock consumed domestically in 1973 (tons of P_2O_5) and the products which were derived.

TABLE 66. USES OF PHOSPHATE ROCK

Total Rock Consumed Domestically	Intermediate or Final Product	Tonnage*
6653	Wet-Process Phosphoric Acid	5915
1450	Phosphorous	1204
688	Normal Superphosphate	619
481	Triple Superphosphate	457
149	Phosphatic Feed	145
9421		8344

*Some P_2O_5 is lost in each conversion process.

The important products in fertilizer use that need to be considered individually are wet-process phosphoric acid, triple superphosphate, and normal superphosphate.

Wet-process phosphoric acid is produced in such large volume because it is the most economical way of incorporating phosphorous content into other final products. In 1973, slightly more than 2/3 of the wet-process phosphoric acid produced was consumed in fertilizers. Table 67 demonstrates the final product mix.

Wet-process phosphoric acid is produced by combining phosphate rock with sulfuric acid and water. Gypsum is a by-product. This raw production acid is generally 28-30% P_2O_5 by weight and must be concentrated prior to being used in the manufacture of ammonium phosphates and triple superphosphate. Almost all phosphoric acid is consumed at the site of production with no shipment to other locations.

Wet-process phosphoric acid is combined with phosphate rock to produce triple superphosphate (45-47% P_2O_5 by weight). About 2/3 of the product is a granular grade while the remainder is a run-of-pile (ROP) material. The granular material consists of large particles that are used for direct application or in bulk blends. Run-of-pile material is much finer and is consumed in the chemical manufacture of ammoniated fertilizers. These products are shipped extensively by water and need to be considered in a potential diversion framework.

Normal superphosphates are produced in the same manner as triple superphosphates except that phosphate rock is combined with sulfuric rather than phosphoric acid. This product, though once the most popular source of phosphorous for farmers, is gradually being phased out due to its poor competitive position. The economics of production and transportation make it very expensive per ton of P_2O_5 content relative to other products such as triple superphosphate. About 1/10 of

TABLE 67. WET-PROCESS PHOSPHORIC ACID DISPOSITION IN FERTILIZER USE

Final Product	Tonnage
Solid Ammonium Phosphates	1972
Triple Superphosphate	930
Fluid Ammonium Phosphates and Mixtures	555
Direct Application	39
Other Mixed Fertilizers	613
	4109

the normal superphosphate is applied directly while the remainder goes into other mixtures. Normal superphosphate plants are located in many areas since this product has lower P_2O_5 content than the raw material inputs. As a result the marketing areas are small, hence the plants are of relatively small size. They are barely competitive with large-scale plants that produce higher analysis materials. They continue to be fairly widespread in the southeast, however, due to minimal transport costs for raw materials (phosphate rock from Florida and sulfuric acid from Louisiana) and the nature of demand. The southeast is characterized by many small farms that do not require fertilizer in large quantities. Tonnage of normal superphosphate moving on the waterways is insignificant.

An analysis of user charge impacts on the phosphate segment of the fertilizer industry requires a detailed look at modal choice in the shipment of triple superphosphate. Phosphate rock will also be considered. Other products moving by water account for a very small percentage of tonnage. (Diammonium phosphate is shipped extensively by barge and will be considered after a discussion of nitrogenous products.)

4.3 NITROGENOUS PRODUCTS

The primary feedstock in all nitrogenous fertilizers is natural gas. Two chemical reactions release hydrogen for use in the production of anhydrous ammonia. Natural gas is first combined with water:

$$CH_4 + H_2O \longrightarrow CO + 3H_2.$$

The by-product carbon monoxide is then recombined with water to produce carbon dioxide and hydrogen:

$$CO + H_2O \longrightarrow CO_2 + H_2.$$

The available hydrogen is then reacted with nitrogen in the production of anhydrous ammonia:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3.$$

Anhydrous ammonia is 82% nitrogen by weight - it is popular as a direct application material and is the most commonly used nitrogenous fertilizer.

Along with anhydrous ammonia the important nitrogenous fertilizers that should be discussed are urea, ammonium nitrate, and nitrogen solutions. All are derivatives of anhydrous ammonia.

In 1974 the total domestic consumption of urea was 4.37 million product tons. Approximately 3.00 million of these tons were consumed as fertilizers. About 1/2 of this tonnage was directly applied as solid material while the balance served as an input to nitrogen solutions. Production of urea simply involves the reaction of ammonia with carbon dioxide and the subsequent extraction of water.

The growth of urea consumption between 1970 and 1975 was 118% while changes in consumption of anhydrous ammonia, nitrogen solutions, and ammonium nitrate were 16%, 26%, and -1% respectively. The swift rate of growth is expected to continue due to its high analysis, 45-46% nitrogen by weight (ammonium nitrate is only 34%). This makes transportation and storage costs less per ton of nitrogen than for competitive materials. Another consideration is advantages with pollution control problems. The majority of urea manufacturing facilities are located in Louisiana and the Delta area (this is due to the proximity of natural gas sources). Substantial quantities of urea are shipped by barge. The diversion question needs to be carefully considered for this material, especially in light of the expected growth patterns.

U.S. consumption of ammonium nitrate in 1974 totaled 8.28 million product tons. Fertilizer demand accounted for 7.00 million of these tons. As noted above, the demand has been declining due to the better economics of applying nitrogen in the form of anhydrous ammonia or urea. An insignificant amount of this material is shipped on the waterways due to the danger involved in transport. Large quantitites are potentially explosive (the Texas City accident in the 1940's virtually put an end to barge shipments of ammonium nitrate). Whereas the majority of anhydrous ammonia and urea plants are located in the Delta area, ammonium nitrate facilities tend to be more widely distributed throughout the midwest closer to the points of final consumption.

In 1974, nitrogen solutions were the second largest direct application nitrogen product. The 4.04 million tons of product ranked slightly behind anhydrous ammonia. The most common solution (88% of all nitrogen solutions in 1974) is a combination of urea and ammonium nitrate and water. The remaining solution is a mix of ammonia (it is pressurized and thus less common) and ammonium nitrate. Pesticides may be added to solutions; therefore there are economic advantages in reduced application costs.

The capacity to manufacture nitrogen solutions correlates closely with consumption by region. Most long-haul shipment occurs only for the inputs, anhydrous ammonia and urea, while ammonium nitrate is generally produced near consumption areas. Thus the important nitrogenous fertilizers that may be affected by the imposition of a user charge are anhydrous ammonia and urea.

Diammonium phosphate (DAP) is useful in incorporating both the nutrients nitrogen and phosphorous in a single product. Anhydrous ammonia is reacted with phosphoric acid (produced from phosphate rock) to yield the desired product. Often potash is added near the site of consumption.

Shipment of DAP is important on the waterways in contrast to other blends we have seen. The reason for this is the shipping economics of this fertilizer - per ton of nutrient, DAP is one of the cheapest materials to transport and store. As a result many large manufacturing facilities operate in Florida and the Delta area. It is less expensive to ship anhydrous ammonia and sulfur (for wet-process phosphoric acid production) from the Delta area to Florida than it is to ship phosphate rock to Louisiana. There is a tradeoff involved here however since DAP manufactured in the Delta area is closer to the large consuming areas of the midwest.

4.4 POTASH

Potash accounts for 26% of the input into commercial fertilizers but the waterway system does not play a significant role in its movement. Eighty-three percent of U.S. produced potash is mined in New Mexico with the remainder coming from Utah and California. This accounts for only 35% of the potash consumed in the U.S.; the balance is imported from Saskatoon, Saskatchewan. The location of the originating mines dictates the need for shipment by rail.

Some potash does move on the Gulf. It is received by rail in the Houston area and shipped to plants along the Gulf Intracoastal Waterway East for processing. This allows shippers to take advantage of a reduced rail rate from Carlsbad, New Mexico to Houston that is applicable only for cargo if the ultimate destination does not involve points along the Mississippi River System. Some potash has been identified moving south on the Mississippi - it moves from Saskatoon by truck and train to Minneapolis where it is loaded onto barges. The tonnage has has a negligible effect on Mississippi River traffic; thus user charges are not a concern for potassic fertilizers.

4.5 TRANSPORT AND TRAFFIC DIVERSION OF PHOSPHATE ROCK, TRIPLE SUPERPHOSPHATE, ANHYDROUS AMMONIA, UREA, AND DIAMMONIUM PHOSPHATE

The basic assumption in any traffic diversion scenario is that rail and pipeline rates do not increase proportionally with barge rate increases due to user charges. Discussions with shippers indicate that this would be highly unlikely. Most claim that it is the barge transportation system which is the price-setter in many regions. They offer evidence that multiple-car rates for fertilizer and low pipeline rates in areas adjacent to the river are due only to the existence of cheap barge transport. For the purpose of diversion analysis however, it will be assumed that rail and pipeline rates do remain at their current level.

The imposition of user charges probably will result in changes in marketing strategy causing substantial diversion of phosphate rock traffic from the river system. Almost all crude rock moving on the river originates in Florida and is shipped to Ft. Madison, Iowa or the Upper Illinois River to serve as input in diammonium phosphate. Profit margins in the fertilizer business have been declining in recent years due to low fertilizer prices and several plants in the Midwest have been forced to close - a user charge may particularly jeopardize the remaining plants whose operations are based on relatively poor shipping economics. A toll imposed on crude rock is in effect 2 to 2.5 times greater than on diammonium phosphate. These plants are designed to receive rock shipments by water and it may be virtually impossible for some of them to convert to using rail. The only viable alternative may be to expand plant capacity at minesite or at production facilities in the Delta area. Shipments to processing points along the upper river system would probably fall significantly.

An important issue is whether the particular user charge mechanism implemented impacts the almost 7.5 million tons of phosphate rock moving on the cross-Gulf leg. The exact effects of such a measure are not determinable at this time but it is obvious that this needs to be carefully studied given the amount of tonnage in question.

Triple superphosphates face potential modal diversion rather than relocation of production facilities. There are only 10-15 large scale plants in the country and the vast majority are at the site of phosphate rock mining, that is, in Central Florida. The distribution option is basically barge shipment across the Gulf and up the Mississippi vs. rail shipment direct. Rail shipment has two advantages over barge. First, rail involves only one loading at the plant in Florida and one unloading at the retailer or farm. A barge shipment must begin with rail or truck pickup at the plant and delivery to the port. Transfer to barge occurs at the port. The possibility exists for transfer to another barge in the Delta area depending on the circumstances and the size of the barges involved. The barge must be unloaded upriver and the triple superphosphate delivered by truck or rail to the final location. Shrinkage can be costly in a barge distribution system - it is preferable to handle the material as little as possible. Second, many receivers of triple superphosphate have limited storage capacity and the logistics of receiving several railcars throughout the year are preferred to those associated with receipt of a barge load. In spite of these advantages shipment remains faily price sensitive - historically rail rate increases have been met with a reduced share of traffic to the midwest. An analysis of rail rates to the Illinois, Iowa, and Missouri region demonstrates the existence of multi-car rates for triple superphosphate to areas that can be served by barge transport, for example, Peoria and St. Louis. At this time it is not possible to quantify potential diversion, but $.60 - $1.00 per ton would probably have some effect. One issue is railcar availability - this would impose one constraint on increased rail shipments, especially because of the seasonality of fertilizer distribution and the associated peak load problem.

Large volumes of anhydrous ammonia are shipped long distances both for direct application and as input into other fertilizers. Most of the anhydrous ammonia production capacity is in the Louisiana and Texas area near the source of natural gas. Very little anhydrous ammonia is shipped north from these points by rail. There is a severe problem with tank car shortages in the southwest and railroads apparently refuse to invest in new specialized equipment - they are encouraging shipper-owned cars for this movement. The rail rates for shipping ammonia to the Midwest are very high, reflecting this shortage and the danger involved in shipping this fertilizer by rail. Many companies do not even consider this to be a viable option for shipping to consumption areas. The railroads inability to effectively handle this traffic means the diversion question must be answered in terms of pipeline vs. barge competition.

The Gulf Central Pipeline originates in Southeastern Louisiana and serves the Corn Belt area, specifically the states of Indiana, Illinois, Iowa, Missouri, and Nebraska. The pipeline has two major advantages compared to barge transport. First, it has been built to have access to areas distant from the river that cannot utilize cheap barge transportation. Second, there is no delay in transport - since the pipeline is always full, a producer need only inject ammonia into the pipe and it can immediately be removed at a designated terminal. The pipeline does have capacity constraints however. There are restrictions on the amount of anhydrous ammonia that can be injected into the pipeline as well as terminal constraints and storage limitations. Furthermore, not all companies that are located on the river are hooked into the pipeline and have the option of utilizing that mode. The pipeline has proved successful though and substantial increases in capacity are planned - the May 3, 1976 issue of Traffic World reports the following:

> The volume of traffic moving through Gulf Central has increased from 247,000 tons at start-up in 1970 to 865,000 tons in 1975, and 1976 throughput should reach 1.1 million tons... Plans call for installation of four new pumping stations and modification of four existing stations by the end of 1976, raising annual pipeline system capacity from 1.2 to 1.7 million tons. Installation of an additional 10 new pumping stations by September, 1977, will increase capacity to about 2.25 million tons annually. Annual capacity of the line is expected to be 3.0 million tons by 1980.

Barge has historically been an important mode in the transport of anhydrous ammonia. All the production facilities in Louisiana have been constructed with access to water transportation. Terminal and loading facilities are very expensive due to the nature of the material (anhydrous ammonia is a gas at room temperature and must be refrigerated or kept under pressure). Barges that can handle this product also involve a high cost. Equipment requirements have dictated the need for long-term contracts, often on the order of 10 years. Companies with substantial investment in these operations will not abandon their facilities in favor of pipeline - much of the cost is fixed and the intelligent decision is for the company to maximize its throughput with existing equipment.

Both modes are essential in handling the large volume of anhydrous ammonia shipments that are generated each year. This becomes especially true in the Spring when demand is the highest for application on the farm. Barge will continue to maintain its share of the traffic in the short-run due to investment in the current distribution system as well as distinct advantages in serving specific markets that the pipeline has not penetrated (for example, Minnesota and Eastern Iowa). In the long run there is some potential for diversion to pipeline when companies must face the issue of new investment and replacement in barge facilities. Barge will probably lose some traffic in the long run but it will still be the dominant mode - in many areas.

Rail and barge compete for urea traffic moving to the Midwest from the Delta area and for diammonium phosphate from both the Delta area and Central Florida. Barge plays a significant role in the transport of these fertilizers to points of consumption. These materials are not identifiable as separate items in waterborne data provided by the Army Corps. Little is known about the competitive zone of rail shipments vs. the barge-truck and barge-rail distribution systems. This type of information appears to be available only from industry sources and cannot be obtained at this time.

Some diversion will likely occur since the rate differential must be within \$.60 - \$1.00 a ton in certain areas. The question of railcar availability would be a major factor in determining tonnage that could be carried by this mode.

An important issue that should be discussed in regard to traffic diversion, and one that has particular relevance to urea and DAP, is the possibility of producing at other locations as the transport economic situation dictates. These forms of fertilizer are among the least expensive in terms of transportation costs per ton of nutrients; however, shipment of anhydrous ammonia is much more economical. The profit-maximizing decision for the fertilizer producer may be to move production sites for urea and DAP to points in the Midwest and ship anhydrous ammonia by pipeline or barge. This is not as likely for DAP as for urea due to the phosphate rock requirements of DAP. Urea, on the other hand, requires only carbon dioxide in addition to anhydrous ammonia and expanded production in the Midwest seems to be a feasible option. This alternative could mean a loss in urea tonnage on the river system, but it may also mean an increase in anhydrous ammonia traffic. It is unlikely that this scenario would occur as a result of the imposition of user charges at the level being proposed.

4.6 FINAL DEMAND

In light of the above discussion, it is important to understand how the user charge may impact final demand with respect to increased input costs for farmers, the elasticity of fertilizer application, and the impact on crop production levels. Our findings show that in the short run, a large percentage phosphate rock may leave the river, anhydrous ammonia will continue to be shipped by barge, and some triple superphosphate, urea, and DAP may be diverted from water to rail but capacity constraints and peak loading temper the possible level of diversion. Additional transport costs of \$.60 - \$1.00 for traffic on the river system and some percentage of that increase for traffic diverted to other modes will be passed on directly to fertilizer consumers.

Ratios of fertilizer and lime costs to the price received by farmers for specific grains are as follows: corn, 15.4%; wheat, 5.7%; and soybeans, 1.0%. These percentages of input costs for fertilizer are national aggregate figures and do not take into account the variation in application rates in different regions of the country. Obviously, user charges will have the most adverse affect on producers of corn, particularly on those farmers who own farms reasonably close to the river and rely on barge transport for the delivery of practically all their required fertilizer.

In any case, impacts on farm operations will be minimal. Farmers will not alter their crop mix by choosing to grow soybeans instead of corn, nor will crop production levels fall due to increased fertilizer costs. An increase of $.60 to $1.00 for each ton of fertilizer is only about 1/2 of 1 percent increase in the cost of fertilizer. Fertilizer is a high value commodity as evidenced in Table 68.
If the farmer has to absorb this additional cost and is not able to pass it on as an increase in his selling price for each crop, then the farmers percentage of costs directed to fertilizer purchase would increase by 0.075% for corn, that is 0.5% multiplied by 15% (this is the worst case, assuming all fertilizer is transported by water, and an estimate for the grain most highly affected - the increase in soybean fertilizer costs would be .005% as a ratio of input costs to output price). This amount is insignificant in the decision-making process of the farmer. His application rates would remain the same, along with his crop mix and production level. Wildly fluctuating prices are commonplace in the fertilizer business currently due to shifts in supply and demand and the influence of the export market. Table 69 shows changing prices over the past three years. An increase of $.60 to $1.00 would have a negligible effect on the farmer and his ability to operate at a profitable level.

TABLE 68. FERTILIZER MATERIALS: AVERAGE PRICE PER TON PAID BY FARMERS, BY STATES, APRIL 15, 1976*

Dollars Per Ton

	Anhydrous Ammonia	Urea	Triple Superphosphate	DAP
Illinois	190	160	155	180
Indiana	195	160	165	195
Iowa	185	160	160	195
Minnesota	190	150	160	180
Missouri	185	150	150	205

*Agricultural Prices: Released April 30, 1976. Crop Reporting Board, Statistical Reporting Service, U.S. Department of Agriculture, pp. 40-42.

TABLE 69. PRICES PAID BY FARMERS PER TON FOR SELECTED COMMERCIAL FERTILIZERS, UNITED STATES*

	Anhydrous Ammonia	Urea	Triple Superphosphate	DAP
April 15, 1974	183	183	150	181
September 15, 1974	229	232	188	228
April 15, 1975	265	244	214	263
October 15, 1975	219	203	179	216
April 15, 1976	191	166	158	189

*Agricultural Prices, p. 40.

4.7 SUMMARY

Seasonal fluctuations in fertilizer prices are commonplace making price increases due to user charges of negligible significance to farmers purchasing products at upriver locations. Production decisions and modal choice will be affected however due to a significant percentage increase in transport costs resulting from user charges (long-haul shipments characterize the industry, most often originating in the Delta area and terminating on the Upper Mississippi or Illinois Rivers).

Phosphate rock, anhydrous ammonia, triple superphosphate, urea, and DAP are the most important fertilizers distributed via the Mississippi River system. Phosphate rock is the most highly divertable of these fertilizers - the combination of relatively low value and bulk product make for a high cost of transport per ton of nutrient. Production may be altered by expanding manufacturing facilities for DAP in the Delta area and Central Florida (this may result in increased barge shipments of DAP). Anhydrous ammonia will continue to move in large volume by barge in the short-run due to the substantial investment in facilities required to handle this commodity and the associated long-term contracts. In the long-run expanding pipeline capacity will result in diversion of some fraction of anhydrous ammonia barge traffic. Some shift can be expected from water to rail transport for the delivery of triple superphosphate, urea, and DAP to certain areas. The peak demand periods for fertilizer in the agricultural industry insures that all modes are necessary in an efficient fertilizer distribution system. Barge may lose a small share of traffic but will basically continue in its current role as an essential mode moving a large volume of fertilizer annually.

5. PETROLEUM TRAFFIC IMPACTS

5.1 BACKGROUND

Water transportation of petroleum can be both complementary and a substitute for other transportation modes. For larger shipments, coastwise tankers deliver petroleum to areas not directly served by pipeline. Similarly, barges are utilized to deliver smaller shipments or non-pipeable petroleum products to Mississippi River locations. Along the Gulf coast, barges are used extensively to transfer crude and products between wells, refineries and terminals. In both cases, pipelines are the dominant mode for either long haul or gathering operations. Barge transportation primarily serves as a peak-load delivery system, for shipments to or from isolated locations or for smaller shipment sizes. Railroads also deliver small shipments and non-pipeable products, generally well away from the river system (due to lower barge rates on petroleum).

Table 70 contains estimates of relative modal petroleum traffic for 1973. Although the data contains substantial double-counting of tonnage due to multi-mode activity, the data is representative of model traffic densitites due to petroleum. Pipeline (excluding gathering lines) dominates petroleum distribution of crude oil and handles a major portion of final product delivery. Almost one-half of the domestic river system deliveries via barge are residual fuel oil and other non-pipeable products. Although rail ton-miles of petroleum products are large, these represent long-haul (over 1000 miles) delivery of small shipment, specialized petroleum products to industrial firms. Tanker delivery, especially along the West coast and Gulf-to-East coast routes represents flows of gasoline, distillate and residual fuel oil in shipments of fifteen thousand tons and larger.

TABLE 70. COMPARATIVE MODAL TONS AND TON-MILES: CRUDE OIL AND PETROLEUM PRODUCTS (1973)*,***

Commodity Class	Pipeline Flows	Rail Flows	Water Coastwise	Water Internal
		I. Tonnage (000's)		
Crude Oil	568,694	1,816	34,860	55,649
Products	133,121	26,826	139,015	154,667
		(20,242)**	(103,006)	(83,731)
		II. Ton-Miles (Billions)		
Crude Oil	246	1	49	9
Products	177	13	199	39
		(10)	(148)	(28)

*The year 1973 is the latest year for full pipeline data. Coastwise moves include many non-competitive to pipeline flows. Table 70 includes substantial double-counting of tons in that petroleum is inherently multi-mode in delivery.

**Numbers in parentheses exclude residual oil (non-pipeable).

***Sources: The Pace Company Energy and Hydrocarbons in the U.S. to 1985. Corps of Engineers Waterborne Commerce of the U.S. (1973) 1973 ICC One-Percent Rail Waybill Data.

Petroleum pipelines tend to have higher average shipment size and lower transportation costs than other modes. For example, a four to six-hour runoff from the Capline pipeline serving the Midwest delivers over 15,000 tons of petroleum. A rail carload of petroleum averages 400 tons with five carloads being a large shipment. The typical barge shipment ranges from one to three thousand tons. Coastwise tanker movements from Gulf coast to East coast ports move fourteen to fifteen thousand tons per shipment. Tables 71 and 72 illustrate comparative modal shipment costs for crude and petroleum products by pipeline, barge and rail for 1975.* In most cases, the pipeline rate dominates both short and long-haul costs via other modes. Barge rates average over two and one half times pipeline rates for a typical point-to-point flow with rail rates as much as seven times higher per barrel than pipeline. Since transportation costs are a large percentage of final delivered price, Table 70 modal traffic data suggests pipeline usage whenever feasible.

Relatively lower costs, minimum congestion and delays and links to major demand centers imply high capacity utilization factors for the pipeline network. In 1973, the crude oil pipelines between U.S. PAD districts had an estimated capacity of 3220 MBCD (thousand barrels of crude per day). Crude oil throughput on inter-PADD pipelines averaged 3095MBCD or a capacity utilization factor of over ninety-six percent. Comparatable statistics for product pipelines are not readily determined. Products and LPG (liquid propane gas) share the same lines and due to differeing product-gas compression

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*See Figure 9 for a definition of PAD Districts.

TABLE 71. REPRESENTATIVE CRUDE AND PETROLEUM PRODUCT SHIPMENT COSTS BY PIPELINE*

PAD Origin	PAD Destination	Rate (1975 dollars)** cents per barrel	dollars per ton
	I. Crude Oil		
3 (Texas Gulf)	2A (Chicago)	48.3¢	$3.14
3 (East Texas)	3 (S. Louisiana)	23.0	1.61
(Offshore Louisiana)	3 (Texas Gulf)	24.2	1.57
	II. Products		
3 (Port Arthur, TX)	2A (Wood R., IL)	34.5	2.42
2B (Tulsa, OK)	3 (Little Rock, AK)	28.8	2.02
2A (Toledo, OH)	1A (Pittsburgh, PA)	21.1	1.47

*The PACE Company. op cit. Tables F-55-59.

**Includes trunkline rate and 6.5 cents per barrel gathering charges.

TABLE 72. REPRESENTATIVE RAIL AND BARGE PETROLEUM SHIPMENT COSTS *
(1975$)

Origin	Destination	Barge Rate cents per barrel	Barge Rate $ per ton	Rail Rate cents per barrel	Rail Rate $ per ton
		I. Crude Oil			
Texas Gulf	Chicago	132.3¢	$8.63	344.3¢	$22.41
East Texas	Louisiana	50.4	3.28	117.2	7.63
		II. Petroleum Products			
Houston	St. Louis	119.1¢	$7.75	210.5¢	$13.70
Louisiana	Pittsburgh**	123.6	8.05	175.9	11.45

*Specific point-to-point movements.

**Rail rate is a proposed unit-oil train rate between New Orleans and Pittsburgh based on substantial annual volumes to steel mills of residual fuel.

factors, make capacity difficult to estimate. However, it is accepted industry knowledge that product lines are also running near full capacity, although not quite as high utilization as crude lines.

5.2 FUTURE MARKET CONDITIONS: PETROLEUM

A recent study prepared by PACE Company for the Department of Transportation, "Pipeline Transportation to 1990," forecast pipeline use in the U.S. PACE employed a sophisticated energy market and production simulation model to analyze a number of energy futures. The macro results of the analysis are found in Table 73.

PACE indicates that natural gas pipeline traffic will decline due to a fall in domestic production but will increase in the 1980's due to supply from Alaska and offshore wells. Crude oil pipeline traffic (and capacity) will be larger due to flows from Alaska, transferred to the upper midwest via west coast ports and the Gulf.* Petroleum product pipeline flows from the Gulf to Great Lakes area is predicted to fall through 1980 in that Alaskan crude will flow directly to Upper Midwest refineries for processing to reduce transportation costs. After 1980, all petroleum traffic via pipeline returns to long-term growth patterns. Reduction in flows of Canadian crude oil to West North Central refineries will be replaced by Alaskan (via Gulf) crude flows by 1985.

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*Crude oil capacity exists between Long Beach, California and Midlands, Texas from which direct transfer to Upper Midwest refineries can occur.

TABLE 73. U.S. PIPELINE TRAFFIC TO 1990 (BILLIONS OF TON-MILES)*

Commodity	1973	1977	1980	1985	1990
Natural gas**	347	312	295	329	333
Crude oil***	246	302	387	520	552
Petroleum Products	171	227	219	238	261
TOTAL	770	841	901	1087	1146

*Source: PACE Co. Pipeline Requirements to 1990. (January 1976). p.2

**Exculdes distribution.

***Excludes gathering.

5.3 FUTURE MARKET CONDITIONS: TRANSPORTATION

5.3.1 Pipelines

Major waterborne-competitive pipeline movements occur between PAD Districts 3 (Gulf) and 2 (Upper Midwest). Based on demand predictions, substantial crude oil pipeline capacity increases are forecast between PADD 3 and PADD 2 (see Figure 12). Table 91 contains crude oil pipeline capacity between PADD 3 and PADD 2. By 1980, capacity will be increased by 726 thousand barrels per day or thirty-four percent. In all, new crude oil pipeline capacity between PADD 5 (West coast) and PADD 2 of 1.2 million barrels per day (for Alaskan oil) will be necessary. Conversion of existing natural gas lines from California to Gulf to crude movements is also possible. No substantial increase is planned for Gulf coast intra-PAD crude oil capacity.

In petroleum products, PACE indicates that traditional product distribution patterns from Gulf, mid-continent and mountain states to eastern and midwest states will change in the future. Direct importation of products to East coast and Great Lakes ports, for example, could replace existing Gulf - Great Lakes/East coast flows. In general, pipeline product transfers from PADD 3 to PADD 2 will increase to capacity limits in 1977 but will fall as Alaskan crude is transferred directly to Mid-continent refineries in the 1980's. Gulf-originating product flows will increase to capacity again by 1985 with some new expansion requirements by 1990. Table 92 details existing product-line capacities.

5.3.2 Barge

No major technology advances for inland waterborne petroleum traffic are anticipated in the 1980's. Barge will continue to serve the intermediate and small shipment market unless pipelines (faced with excess capacity) reduce required shipment size. A typical petroleum tow may be one to three barges or an integrated tow with six or more barges. Increased safety requirements such as double-skinned (bottom) barges may further escalate already high petroleum transportation costs via barge. Petroleum traffic on the inland waterway system has declined substantially from 1971 (pre-energy crises) to 1974, reflecting reduced demands and barge operations as a peak-load delivery system.

5.3.3 Railroads

U.S. railroads have never been competitive in large or intermediate petroleum shipment markets due to high transportation costs relative to pipeline and barge.

The majority of petroleum traffic on railroads has been small-shipment delivery of specialized petroleum products (such as lube oil) to industrial plants not served by water or pipeline. Although concepts such as unit oil trains have been widely discussed in industry publications, the economics appear not to exist for modal diversion from water. For example, MOPAC RR recently proposed a unit oil-train (residual oil) rate from New Orleans to Pittsburgh (steel mills) of $11.45 per ton. Existing barge rates for the same movement are less than $10.00 per ton. MOPAC is pessimistic about receiving the movement and states that the $11.45 rate is the minimum rate that can be charged and a profit made. Railroads see some traffic gain in petroleum products if user charges are imposed but these are to points well away from the river (served now by distribution via truck or distribution pipeline from river terminals).

5.3.4 Outline of User Charge Analysis

The following sections will examine in detail predicted user charge impacts on waterborne (inland) petroleum traffic. Crude oil, distillate fuel oil, residual fuel oil, gasoline and jet fuel/kerosene are the major products evaluated. The analysis will examine existing petroleum traffic patterns on the inland waterway system, develop a transportation price analysis to determine user charge impacts on relative modal costs and predict potential traffic diversion due to both market and user charge factors. PACE generated predictions of waterways - competitive pipeline traffic in the near term will be employed to evaluate direct market influences on waterways petroleum flows. Time limitations prevent an in-depth transportation demand analysis using modelling procedures although necessary data is mostly available.

5.3.5 Crude Oil Flow Impacts

In 1972, waterborne crude oil movements on the inland river systems of the U.S. produced over 19 billion ton-miles, or 12 percent of total system ton-miles. By 1974, crude oil ton-miles had fallen to just over 10 billion, or less than six percent of system totals. The reduction in demand due to the energy crisis reduced the need for transferring crude oil via water to handle peak-load refinery requirements. Pipeline flows replaced waterborne movements. Table 74 details the waterborne traffic decline by river sector. Well-to-terminal/refinery transfer fell by half in the bayou and offshore region of Louisiana to New Orleans and Baton Rouge plants. The major transfer of crude along the Ohio River via barge was replaced by pipeline movement.

TABLE 74

1972 AND 1974 WATERBORNE CRUDE PETROLEUM TRAFFIC BY SECTOR (000's OF TONS)

Sector	1972 Traffic Outflows*	1974 Traffic Outflows**
BRMOP	24670	12593
CAIROBR	4052	115
MINCAIRO	465	989
ARK	1	5
OHIO	9380	544
MON	176	36
ALL	291	14
TENN	841	17
CUMB	177	-
KAN	148	292
ILL	874	23
GIWWW	32857	24796
MORGPA	63	-
GINNE	1828	5886
ALA	-	24
WARTOMMO	1344	1702
MO	3	-
APCHAPFL	76	-
ATCH	128	260
TOTAL	77374	47296

*Source: TSC Waterway Traffic Impact model

**Source: Corps of Engineers. Waterborne Commerce Statistics. 1974.

In 1973, an estimated 258 million tons of crude oil moved in pipelines within PADD 3 (Gulf Coast). By 1977, PACE Co. has estimated that the pipeline tonnage will fall to 201 million tons with a slight increase to 222 million tons by 1980. In that 91 percent of crude oil waterborne movements occurred in the lower Mississippi or GIWW sectors during 1974, the reduction does not aid the fortunes of a declining business in waterways oil transfer. The reason for the decline in crude oil movements is the fall in domestic production due to declining reserves. The decline in domestic crude supplies will be replaced in the short-term by increased foreign imports into PADD 3 (an estimated 56 million tons per year by 1980) and an infusion of Alaskan crude via PADD 5 (West Coast) of almost 30 million tons per year by 1980. Neither imports or Alaskan flows require much waterborne movement. Much of this crude is destined to be directly transferred via pipeline to Mid-continent refineries. Appendix Tables 3 and 4 document the dominance of both intra and inter regional flows of crude oil by pipeline. It is unlikely that future market conditions will favor increased use of water transportation for inland river and coastal barge movements of crude oil.

Table 74 data indicate that the GIWW-West, Lower Mississippi, GIWW-East and Warrior River Systems are the major (95 percent of traffic) sectors involved in crude oil transfer via barge. Within each of the river sectors, a detailed barge cost analysis was performed. Using the TSC Waterway Traffic Impact Model, barge rates per ton for major sectoral flows were estimated. Costs of pipeline shipment to barge terminal and load/unload costs were then added to barge rates to determine total shipment costs. Table 75 contains the

TABLE 75

BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF CRUDE PETROLEUM (1975$)

Origin and PE	Destination and PE	1972 Tons (000's)	River Miles	Barge Rate($/ton)	Total Shipment Cost ($/ton)	Cents/ Ton-Mile	Cents/bbl	% Increase Segment	Fuel
I. GIWW- West(2700's)									
2705	2705	1521	44	.66	1.02	2.32	15.7	.05	.05
New Orleans - 400	2725	2267	298	2.54	2.90	.97	44.6	.09	.09
2705	2725	1430	241	2.19	2.55	1.06	39.2	.08	.09
2715	2725	1987	169	1.71	2.07	1.22	31.8	.08	.08
2720	2725	2022	74	.96	1.32	1.78	20.3	.06	.06
2725	2725	2870	25	.50	.86	3.44	13.2	.04	.04
2705	2750	1451	364	2.92	3.28	.90	50.4	.08	.10
2715	2750	1797	292	2.51	2.87	.98	44.1	.07	.09
2725	2750	1390	123	1.37	1.73	1.41	26.6	.04	.07
2735	2750	1101	239	2.18	2.54	1.06	39.0	.07	.09
II. Lower Mississippi (PE415-400)									
400	400	6736	44	.67	1.03	2.34	15.8	.01	.05
400	415	2187	140	1.50	1.86	1.33	28.6	.01	.07
400	410	5526	42	.65	1.01	2.40	15.5	.01	.05
2705	410	1585	89	1.09	1.45	1.63	22.3	.04	.06
400	415	819	140	1.50	1.86	1.33	28.6	.01	.07
III. GIWW-East (2600's)									
2610	2620	436	76	.98	1.34	1.76	20.6	.05	.06
415	2620	264	292	2.51	2.87	.98	44.1	.05	.09
2600	2620	258	127	1.40	1.76	1.39	27.0	.06	.07
IV. Warrior River									
2105	2115	812	135	1.46	1.82	1.35	28.0	.08	.07

estimates of crude oil shipment costs for major (1972) waterborne movement for each river sector. Due to high pre and post-river flow costs, barge costs per ton-mile decline rapidly with mileage increases. Note that the maximum mileage for crude flows is just over 350 miles, quite short compared to a typical 500 to 1000 mile river movement.

User charge impacts on the major waterborne crude oil flows are also recorded. The short distances of barge crude flows hold the increase to less than 10 percent in all cases.

It has been previously argued that barge delivery of crude oil serves as a peak-load system when pipeline capacity is not available, the shipment is of less than minimum size for pipeline, or no pipeline service is available. Under these conditions, changes in relative modal prices should not significantly alter modal shipment decisions unless dramatic shifts occur. Table 76 contains comparative modal shipment costs for pipeline, barge, and rail among major origin/ destination points for existing crude oil waterborne traffic. Pipeline is clearly the cost-effective mode with barge the next most expensive and rail six times as expensive as pipe-line. Imposition of a user charge, either segment or fuel tax has little, if any, impact on relative prices. Note that actual river miles traveled in deliver exceeds rail or pipe-line mileage, raising both total cost and energy consumed.

Table 77 examines the impact of user charges on crude petroleum traffic by river sector. All incoming flows to a sector are combined in a weighted average to determine the representative barge rate per ton and percent user charge impacts. The sectors with the largest in-flows (BRMOP, OHIO, GIWW) tend to have the lowest average user charge impact.

TABLE 76

MODAL SHIPMENT COSTS FOR CRUDE PETROLEUM: SELECTED ORIGIN/DESTINATIONS

Origin	Destination	River miles	Rail Miles	Pipeline Miles	Barge Rate (Cents per barrel)	Barge & Fuel (Cents per barrel)	Rail Rate (Cents per barrel)	Pipeline Rate (Cents per barrel)
I. Texas (Port Arthur - pipeline) (Houston - rail/ barge)	Baton Rouge, LA.	427	278	306	50.4	54.4	117.2	18.6
II. Louisiana New Orleans	Baton Rouge, LA.	140	77	70	28.6	30.6	49.6	11.0
III. GIWW - East New Orleans	Mobile, AL	166	101	137	40.1	42.1	52.9	11.4

TABLE 77

1972 WATERBORNE CRUDE PETROLEUM
TRAFFIC BY SECTOR: SEGMENT AND
FUEL TAX IMPACTS*

Sector	Tonnage (000's) Origin	Tonnage (000's) Destination	Average Rate In ($/ton)	% Increase Segment	% Increase Fuel
BRMOP	24670	25669	1.74	.04	.10
CAIROBR	4052	148	2.68	.02	.10
MINCAIRO	465	877	4.76	.13	.13
ARK	1	19	6.31	2.17	.14
OHIO	9380	8469	2.85	.06	.10
MON	176	151	3.36	.08	.14
ALL	291	19	9.21	.11	.16
TENN	841	21	6.34	.07	.14
CUMB	177	38	4.80	.12	.13
KAN	148	6	5.34	.08	.14
ILL	874	237	3.63	.12	.12
GIWWW	32857	34539	1.94	.08	.10
MORGPA	63	1520	1.46	.06	.09
WATROMMO	1344	958	1.75	.09	.08
ALA	-	24	2.92	.20	.10
MO	3	-	-	-	-
APCHAPFL	76	-	-	-	-
ATCH	128	678	1.98	.03	.09

*Source: TSC Waterway Traffic Impact Model.

As previously explained, the length of haul in these sectors is relatively short compared to, perhaps, a 1700 mile movement from New Orleans to Chicago. Under a segment toll, the 19,000 tons of crude oil moving up the Arkansas River would experience a rate increase of 217 percent, the highest recorded. In general, no systematic difference exists between a fuel tax and segment toll with regard to rate impact on waterborne crude oil flows.

Traffic impacts due to user charge imposition on waterways crude oil flows can now be evaluated. Previous evidence indicated a long-term decline in domestic, Gulf Coast crude oil production. Imports and Alaskan crude supplies will likely replace reduced domestic supplies. The decline in intra-PADD 3 crude oil pipeline traffic and the relatively lower cost of pipeline movements may divert traffic away from barge regardless of user charges. Finally, it is unlikely that foreign or Alaskan oil will require extensive waterborne moves. User charges would increase Gulf coast barge crude flow costs by between two and five cents per barrel. Conversations with marine traffic managers for major oil companies indicated that pipeline was clearly the preferred mode and that user charges would not impact traffic allocation decisions.

Barge movements of crude oil have traditionally served as a collection/distribution system for smaller facilities (wells, terminals, refineries) not directly served by gathering or distribution pipelines. As domestic crude traffic declines, it is expected barge flows will also fall. Given that few options are available to smaller oil shippers, absorption of user charges is probable. Construction of new crude oil lines are expensive and railroads are very high cost modes. The weight of evidence indicates that given the specialized nature of barge crude oil operations, little (if any) diversion to alternative modes due to user charges will occur. Pipelines are substantially cheaper than barge and move all the traffic up to system capacities. In the future, declining domestic oil supply will increase the competition between barge and pipeline for intra-PADD 3 transfers. Such factors would clearly overwhelm maximum 10 percent increases in barge rates due to user charges.

5.3.6 Residual Fuel Oil Traffic Impacts

Residual fuel oil is primarily used as boiler fuel at utilities and for heating or reduction at industrial plants. Being a lower distillate oil, residual fuel has a high viscosity and is generally a non-pipeable product (except for short distances from refinery to storage). Final distribution of the product is generally by water (coastwise tanker or barge) and rail, although water flows dominate. Total U.S. rail tonnage of residual fuel oil was 5.8 million in 1974 versus 18.2 million via inland barge systems.*

Waterways residual fuel oil traffic is one of the few petroleum products to increase barge tonnage and tonmiles since 1972. During 1972, residual oil traffic accounted for 8.2 billion ton-miles or slightly over five percent of inland waterway ton-miles. By 1974, residual oil waterborne ton-miles rose to over 10.3 billion or six percent of inland ton-miles. Table 78 summarizes 1972 and 1974 residual fuel oil traffic patterns by major river sector. As in the case of crude oil, the lower Mississippi and GIWW sectors account for over seventy-five percent of residual fuel oil traffic. A major increase in residual fuel usage is along the Mississippi River from the mouth of the Ohio River to Baton Rouge, La. Substitution of residual oil for increasingly scarce and expensive natural gas

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*Total domestic movement of residual fuel oil by water, including coastwise and Great Lakes, totaled over 112 million tons in 1974.

TABLE 78

1972 AND 1974 WATERBORNE RESIDUAL FUEL OIL TRAFFIC
BY SECTOR (000's OF TONS)

Sector	1975 Traffic Originations*	1974 Traffic Originations**
BRMOP	3531	3640
CAIROBR	963	3226
MINCAIRO	640	480
ARK	176	3
OHIO	927	621
MON	255	20
ALL	40	0
TENN	86	0
CUMB	8	0
KAN	4	0
ILL	2729	120
GIWWW	3317	8745
GIWWE	1414	1207
ALA	13	0
WARTOMMO	117	130
APCHAFL	211	0
ATCH	112	0
TOTAL	14543	18192

*Source: TSC Waterways Traffic Impact Model.

**Source: <u>CoE Waterborne Commerce of the U.S.</u> National Summaries. Part 5 (1974). Table 4.

at utilities is the major factor in the increase from 1972 to 1974. Table 75 lists major water-served utilities on the lower Mississippi River, their fuel consumption and costs for 1974.

Overall market conditions that may affect waterborne residual flows depend heavily on importation policies and ports for foreign petroleum products. Substantial importation of foreign products will mainly go to PADD1 (East coast) consumers. Given that it is less expensive to process crude oil at existing refineries and move products to consumers, existing refinery location will tend to fix petroleum distribution patterns through the 1980's. Since pipelines are not competitive to barge for residual oil traffic, distribution patterns will depend on existing and future demands. In general, barge traffic of residual either along the Gulf or to inland waterway utilities appears unaffected by existing market conditions unless oil prices rise dramatically in the future, forcing interfuel substitution by users to reduce costs.

For major inland waterborne movements of residual oil, Table 79 contains estimated barge shipment costs, including, fuel and segment tax impacts on cents per ton-mile. As before, shorter moves of residual are expensive with costs falling off rapidly as miles-to-final-destination increase. Many of the major tonnage flows are short-haul transfers of residual along the Gulf coast and bear higher costs of transportation. Given that residual oil movements are longer water distances than crude oil, transportation price impacts are larger. Increases in barge rates for residual oil due to user charges are in the eleven to fifteen percent range. Using fuel delivered price data from Table 75, as-burned fuel costs increase approximately one cent for lower Mississippi utilities, or .6 percent (six-tenths of one percent) and slightly more for Chicago area utilities.

TABLE 79

BARGE SHIPMENT COSTS: RESIDUAL FUEL OIL (1975)

Origin & PE	Destination & PE	Miles	Major Waterway Flows: Pipeline to Barge Terminal ($/ton)	Barge Rate ($/ton)	Load/ Unload ($/ton)	Total Shipment Cost ($/ton)	cents per ton-mile: Existing	(100% OM&R) & Fuel	& Segment
I. Houston, TX (2725+2750)	E. Liverpool, OH. (274)	2104	1.39	9.98	.36	11.73	.56	.64	.60
	St. Louis, MO. (302)	1361	1.39	7.36	.36	9.11	.67	.75	.75
	Baton Rouge, LA (415)	460	1.39	3.44	.36	5.19	1.13	1.21	1.19
	Chicago, IL. (540)	1709	1.39	8.63	.36	10.38	.61	.69	.66
	Florida (2615)	766	1.39	4.92	.36	6.67	.87	.95	.93
	Internal	125	1.39	1.37	.36	3.12	2.50	2.58	2.54
II. New Orleans, LA (400+405)	Internal	25	.39	.67	.36	1.42	5.68	5.70	5.68
	Greenville, MO. (455)	433	.39	3.30	.36	4.05	.94	1.02	.95
	Chicago, IL. (540)	1408	.39	7.54	.36	8.29	.59	.67	.64
	Houston, TX. (2725)	398	.39	2.54	.36	3.29	1.10	1.10	1.18
III. Baton Rouge, LA. (410+415)	New Orleans (400)	140	.54	1.50	.36	2.40	1.71	1.79	1.73
	Helena, AK. (470)	531	.54	3.81	.36	4.71	.89	.97	.90
	Chicago, IL. (540)	1366	.54	7.38	.36	8.28	.61	.69	.66
	Burmingham, AL. (2130)	639	.54	4.34	.36	5.24	.82	.90	.90
	Houston, TX. (2750)	457	.54	3.43	.36	4.33	.95	1.03	1.01

TABLE 79 (CONTINUED)

BARGE SHIPMENT COSTS: RESIDUAL FUEL OIL (1975)

			Major Waterway Flows				cents per ton-mile (100 % OM&R)		
Origin & PE	Destination & PE	Miles	Pipeline to Barge Terminal ($/ton)	Barge Rate ($/ton)	Load/ Unload ($/ton)	Total Shipment Cost ($/ton)	Existing	& Fuel	& Segment
IV. Ashland, KY. (244)	Portsmouth, OH. (242)	59		.82	.40	1.22	2.07	2.15	2.12
	E. Liverpool, OH. (274)	286		2.47	.40	2.87	1.00	1.08	1.05
	Monogehela River (725)	361		2.91	.40	3.31	.92	1.00	.98
V. GIWW-East (2600)	Houston, TX. (2750)	456		3.42	.40	3.82	.84	.92	.90
VI. Chicago, IL. (540)	St. Louis, MO. (302)	327		2.71	.40	3.11	.95	1.03	1.04
	Internal	12		.50	.40	.90	7.50	7.58	7.58

Effects of user charges on comparative modal shipment costs for major waterway movements of residual oil are an important determinant of potential traffic impacts. Table 80 summarizes relevant modal (rail and barge) shipment costs for existing residual oil flows via barge. In general, rail costs for the same movements average two to three times total barge costs prior to user charge imposition. Introduction of navigation cost recovery reduces the differential by a maximum of ten percent. As before, barge flows tend to be longer in total mileage than rail movements but still substantially cheaper. Tables 96 and 97 detail the sources of the rail rate data for residual oil. Conversations with rail petroleum traffic managers indicated that the rail rates quoted in table 80 were low in comparison to present levels, implying a wider rail/barge price differential for petroleum traffic.

Table 81 summarizes user charge impacts on waterborne residual fuel oil traffic. Longer length of haul for residual versus crude oil implies higher increases in barge rates due to user charges. The fuel tax raises rates an average of between ten and fifteen percent while segment tolls average from six to ten percent increases. If impacts on traffic were to occur as a result of user charges, the fuel tax would affect residual oil barge traffic more severely.

Traffic impacts of user charges on residual oil flows moving by water appear minimal. Barge rate increases barely close the substantial gap between water and rail transportation costs for petroleum products. In general, little if any residual oil moves by rail in competition with barge. Rail deliveries of residual are to inland industrial plants not served by the waterways. Further, locational decisions by utilities burning residual fuel are predominately based towards river plants to minimize fuel costs. The slight increases in delivered fuel prices (less than half of one percent in many

TABLE 80

MODAL SHIPMENT COSTS FOR RESIDUAL FUEL OIL:
SELECTED ORIGIN/DESTINATIONS*

(Cents per Barrel - 1975)

Origin	Destination	River Miles	Rail Miles	Barge Rate	Barge & Fuel Tax	Rail Rate[1]
I. Houston, TX	Pittsburgh, PA	2104	1426	189.8	217.9	461.5
	St. Louis, MO	1361	921	147.4	165.2	256.3
	Baton Rouge, LA	460	278	84.0	90.1	135.0
	Chicago, IL	1709	1205	167.9	190.8	341.2
	Florida	766	599	107.9	117.8	213.2
II. New Orleans, LA	Memphis, TN	531	394	76.2	83.3	171.8
	Chicago, IL	1408	921	134.2	152.7	260.8
	Houston, TX	398	363	53.2	66.3	146.8
III. Baton Rouge, LA	New Orleans, LA	140	90	38.8	40.6	51.0
	Memphis, TN	391	367	64.7	68.7	178.2
	Chicago, IL	1366	831	134.1	152.5	258.9
	Birmingham, AL	639	355	84.8	103.5	143.6
	Houston, TX	457	303	70.1	76.2	159.3
IV. Ashland, KY	Pittsburgh, PA	286	250	46.4	49.9	131.5
V. Chicago, IL	St. Louis, MO	327	284	50.3	54.5	149.4

*Source: Railroad Petroleum Tariff Information.

TABLE 81

1972 WATERBORNE RESIDUAL FUEL OIL IMPACTS DUE TO USER CHARGES BY SECTOR*

Sector	Tonnage (000's) Origin	Destination	Average Rate In ($/ton)	% increase segment	fuel
BRMOP	3531	6349	$3.56	.08	.13
CAIROBR	963	29	3.51	.07	.11
MINCAIRO	640	357	2.65	.11	.12
ARK	176	-	-	-	-
OHIO	927	719	3.09	.08	.11
MON	255	16	2.18	.06	.09
ALL	40	-	-	-	-
TENN	86	1	6.99	.11	.15
CUMB	8	-	-	-	-
KAN	4	1	2.70	.11	.10
ILL	2729	575	1.65	.10	.10
GIWWW	3317	5300	4.16	.14	.13
GIWWE	1414	1351	2.34	.34	.11
ALA	13	-	-	-	-
WARTOMMO	117	16	3.54	.12	.11
APCHAPFL	211	-	-	-	-
ATCH	112	-	-	-	-

*Source: TSC Waterways Traffic Impact Model.

cases) will clearly not cause a modal shift to rail.

Future marketing decisions on production points for residual fuel oil could be somewhat affected by user charges, although it is difficult to imagine refinery location decisions affected by an increase in product delivery costs of ten percent. In summary, residual fuel movements are closely tied to water operations and, aside from increase in delivered prices, will not be affected by user charges.

5.3.7 Distillate Fuel Oil Traffic Impacts

Distillate No. 2 fuel oil is used as a boiler fuel for utilities, as diesel fuel in transportation and for various home and industrial heating applications. As a middle distillate oil, No. 2 is a pipeable product and one of the major flows via product pipelines in the U.S. Waterways have been the major competitor to pipeline flows of distillate fuel oil in the past, serving midwest population centers and utilities. As with other petroleum fuels, Gulf coast and GIWW transfer operations dominate water traffic (sixty-three percent in 1974).

Waterborne distillate fuel oil traffic has experienced a decline in total tonnage since 1972, especially on the inland river system. System tonnage and ton-miles closely approximate residual oil waterborne statistics. Table 82 indicates river sector distillate oil traffic changes between 1972 and 1974. A major increase in traffic occurred along the Western portion of the GIWW. Unlike previous petroleum fuels examined, upper river system movements are important traffic generators. Ohio River and Upper Mississippi River above Cairo IL. flows are substantial and fairly stable over time.

TABLE 82

1972 AND 1974 WATERBORNE DISTILLATE FUEL OIL TRAFFIC BY SECTOR (000's OF TONS)

Sector	1972 Traffic Outflows*	1974 Traffic Outflows**
BRMOP	5817	3573
CAIROBR	1129	783
MINCAIRO	1543	1597
OHIO	2217	2179
MON	394	42
ALL	111	33
TENN	110	28
CUMB	225	0
KAN	218	79
ILL	1164	538
GIWWW	2488	5209
GIWWE	763	272
WARTOMMO	19	74
MO	9	0
APCHAPFL	17	4
TOTAL	16224	14411

*Source: TSC Waterway Traffic Impact Model.

**Source: Corps of Engineers, Waterborne Commerce of the U.S. (1974). National Summary. Part 5. Table 4.

The major petroleum market uncertainly is whether predicted declining product pipeline traffic from Gulf coast to Great Lakes users will affect waterborne flows. Smaller average shipment sizes and direct delivery to certain customers (utilities) may protect some traffic but susceptability to diversion to pipeline is probable for other flows. Although direct delivery of foreign product imports is more likely to affect coastwise tanker operations, distillate oil imports via Gulf deep-water ports would probably move north via pipelines. Vertical integration in industry ownership of ports, tankers, and pipelines makes such an event highly probably.

Barge shipment costs for major waterborne distillate oil flows are found in Table 83. As in the case of residual oil flows, water-delivered distillate products move substantial distances on the river system. In general, major flows tend to be shorter haul interfacility transfers along the Gulf coast and Ohio Rivers, averaging less than 300 miles. Utilities on the Upper Mississippi and Illinois Rivers are major consumers of Waterborne flows of distillate fuel oil. Table 95 lists the various plants and consumption levels for 1974 as well as delivered prices. As before, impacts of user charges on final delivered prices average less than one percent.

Table 84 illustrates comparative modal shipment costs for major waterborne flows of distillate fuel oil in 1975 dollars. Pipeline movements (where point to point service is available) is substantially cheaper than barge or railroad. Previous discussions of barge as a peak-load or smaller shipment delivery system are supported by these relative modal costs. If product pipelines are and continue to operate at practical capacity between Gulf and Great Lakes regions, distributions patterns will be unaffected since barge handles the excess over pipeline flows and smaller shipments.

TABLE 83

BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF DISTILLATE FUEL OIL (1975$)

Origin and PE	Destination and PE	River Miles	Pipeline to Barge/ load/unload ($/ton)	Barge Rate ($/ton)	Total Shipment Cost ($/ton)	cents per ton-mile (100% OM&R) (existing)	& fuel	& Segment
I. Houston, TX (2725+2750)	Louisville, KY (230)	1538	$1.75	$7.18	$8.93	.58	.66	.62
	St. Louis, MO (302)	1361	1.75	6.59	8.34	.61	.69	.66
	Baton Rouge, LA (415)	427	1.75	2.93	4.68	1.10	1.18	1.15
	Memphis, TN (480)	947	1.75	5.12	6.87	.72	.80	.76
	Chicago, IL (540)	1709	1.75	7.73	9.48	.55	.63	.61
	Florida (2615)	776	1.75	4.41	6.16	.79	.87	.86
	Internal	125	1.75	1.23	2.98	2.38	2.46	2.43
II. Baton Rouge, LA (410+415)	New Orleans,LA (400)	140	.90	1.34	2.24	1.60	1.68	1.61
	Louisville, KY (230)	1097	.90	5.67	6.57	.60	.68	.63
	Memphis, TN (480)	508	.90	3.31	4.21	.83	.99	.85
	Pittsburgh, PA (700)	1716	.90	7.75	8.65	.50	.58	.55
	Charleston, WV (805)	1496	.90	7.04	7.94	.53	.61	.57
	Florence, AL (1310)	1005	.90	5.33	6.23	.62	.68	.65
	Florida (2615)	475	.90	3.16	4.06	.85	1.03	.90
	Houston, TX (2750)	457	.90	3.07	3.97	.87	1.06	.93
III. Ashland, KY/ Huntington, WV (246)	Cincinnati, OH (238)	164	.40	1.50	1.90	1.16	1.24	1.21
	Rochester, PA (278)	286	.40	2.21	2.61	.91	.99	.96
	Monongahela R. (725)	339	.40	2.49	2.89	.85	.93	.91
IV. Mt. Vernon, IN (216)	Cincinnati, OH (238)	357	.40	2.58	2.98	.83	1.07	.88
	Kanawha, R. (250)	563	.40	3.55	3.95	.70	.78	.75
	St. Louis, MO (302)	348	.40	2.54	2.94	.84	.93	.93
	Chicago, IL (510)	696	.40	4.13	4.53	.65	.73	.74
	Monongahela R. (730)	879	.40	4.86	5.26	.60	.68	.65
	Houston, TX (2725)	1326	.40	6.47	6.87	.52	.60	.55
V. St. Louis, MO (302)	Evansville, IN (220)	392	.79	2.76	3.55	.91	.98	.99
	Cairo, IL (300)	126	.79	1.24	2.03	1.61	1.69	1.73
	Davenport, IA (326)	292	.79	2.25	3.04	1.04	1.12	1.16
	Minneapolis, MN (356)	623	.70	3.82	4.61	.74	.83	.86
	Peoria, IL (510)	1.82	.79	1.82	2.61	1.20	1.28	1.29

TABLE 84

MODAL SHIPMENT COSTS FOR DISTILLATE FUEL OIL:
SELECTED ORIGIN/DESTINATIONS

(Cents per barrel)

Origin	Destination	River Miles	Rail Miles	Pipeline Miles	Barge Rate	Barge & Fuel Tax	Rail Rate	Pipeline Rate
I. Texas (Port Arthur pipeline). (Houston-Rail & Barge).	Louisville, KY	1538	996	834	127.6	145.0	298.0	51.7
	St. Louis, MO	1361	921	743	119.1	134.2	210.5	62.7
	Baton Rouge, LA	427	278	306	66.9	72.0	117.2	18.6
	Memphis, TN	949	616	528	98.1	108.5	220.0	42.3
	Chicago, IL	1709	1205	952	135.4	153.8	344.3	74.2
	Florida	776	599	543	88.0	96.5	213.9	45.3
	Pittsburgh, PA	1716	1426	1284	123.6	142.2	407.4	74.0
II. Louisiana (Lake Charles-Pipe). (New Orleans-Rail & Barge).	Memphis, TN	508	394	386	60.1	71.9	163.2	33.1
	Kentucky River	1052	636	534	78.7	90.6	227.1	45.3
III. St. Louis, Mo.	Ohio River (Evansville, IN-Barge & Rail). (Mayfield, KY-Pipeline)	392	166	190	39.4	43.9	68.8	14.6
	Cincinnati, OH	705	338	399	59.4	67.4	165.3	23.0

Mineapolis, MN - Served by Pipeline Flows from Canada, N. Dakota origins.

Table 85 summarizes river sector user charge impacts on distillate fuel oil traffic. For major traffic sectors, fuel taxes would impact barge rates substantially more than segment tolls.

Projected declines in product pipeline traffic from Gulf coast to Midwest regions may further impact waterborne distillate fuel oil traffic. Imposition of user charges coupled with lower pipeline rates and reduced pipe shipment size requirements to attract new business may divert traffic away from waterways. Barge traffic may still serve upper Mississippi and Illinois users but distillate could be delivered via pipeline to St. Louis and off-loaded to barge for final delivery. Tables 98 to 102 indicate that pipeline flows clearly dominate the transportation market from the gulf coast to the midwest.

If reduced petroleum product traffic by pipeline due to declining domestic production threatens, diversion from water to pipeline of distillate oil traffic will most likely occur. Either flows will entirely be replaced by pipeline movements or substantial portions of the journey will move via pipeline. Gulf coast to Illinois and Upper Mississippi River origins would be most affected. Apparently a substantial amount (over half) of the Upper Mississippi traffic originates at St. Louis, Mo. already. At maximum, seven percent of the waterborne distillate oil flows would be affected with diversion being in terms of ton-miles rather than actual tonnage. Worst-case impacts in ton-mile reduction on the lower Mississippi River due to pipeline diversion from barge of distillate oil are estimated at 300 million ton-miles, or less than .1 percent of total Cairo to Baton Rouge ton-miles in 1974. In summary, tonnage and ton-mile diversion to pipeline may occur due to product pipeline market conditions that will be accentuated by user charges (e.g. relative modal prices increasingly favoring pipeline).

TABLE 85

1972 WATERBORNE DISTILLATE FUEL OIL TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS*

Sector	Tonnage (000's) Origin	Destination	Average Rate in ($/ton)	% Increase Segment	Fuel
BRMOP	5817	7079	$1.55	.05	.11
CAIROBR	1129	607	2.35	.07	.12
MINCAIRO	1543	1533	2.03	.14	.11
OHIO	2217	1992	2.12	.08	.11
MON	394	8	.65	.09	.08
ALL	111	40	1.16	.24	.08
TENN	110	10	6.12	.12	.16
CUMB	225	3	2.69	.20	.11
KAN	218	1	2.88	.14	.12
ILL	1164	701	1.25	.14	.12
GIWWW	2488	3820	2.98	.11	.14
GIWWE	763	485	4.03	.11	.15
WARTOMMO	19	1	3.75	.14	.13
MO	9	-	-	-	-
APCHAFL	17	-	-	-	-

*Source: TSC Waterways Traffic Impact Model.

5.3.8 Gasoline Traffic Impacts

Gasoline movements on the inland river system are second only to crude oil flows in total volume for petroleum flows. Table 86 indicates waterway gasoline traffic by river sector for 1972 and 1974. Although a substantial amount of gasoline traffic occurs as inter-facility transfers along the Gulf coast (fifty-one percent), Ohio River and Upper Mississippi flows are also substantial. Traffic patterns for gasoline flows are quite similar to distillate fuel oil flows. Large flows exist from Gulf coast origins to Ohio and Upper Mississippi River destinations via barge, although substantial amounts of gasoline enter the river system at St. Louis for final delivery by river.

Table 87 documents barge shipment costs for gasoline on major waterborne delivery routes. Most major flows move relatively short distances and represent refinery to distribution terminal movements, both on the Ohio River and Gulf coast. A table of comparable modal costs for gasoline flows is not presented in that costs and origin/destination patterns are almost identical to distillate fuel oil.

If petroleum product pipelines become more competitive for long-haul gasoline flows by water, approximately five percent of the water-delivered gasoline flows would be affected. These are movements to pipeline-served destinations over 1000 miles from original source. The potential market advantage of pipelines would only be increased by user charge imposition. Table 88 indicates that imposition of fuel taxes would increase barge rates for gasoline by ten to fifteen percent, segment tolls somewhat less (for major flows). Coupled with declining total product flows from the Gulf due to declining production, long-haul gasoline movements may fall up to a maximum of five percent in total tonnage. Other gasoline traffic via water is

TABLE 86

1972 AND 1974 WATERBORNE GASOLINE TRAFFIC BY SECTOR
(000's OF TONS)

Sector	1972 Traffic Outflows*	1974 Traffic Outflows**
BRMOP	5185	5821
CAIROBR	3055	1167
MINCAIRO	3822	3648
OHIO	7095	5287
MON	942	66
ALL	62	3
TENN	658	28
CUMB	979	2
KAN	590	315
ILL	1598	933
GIWWW	2600	4153
GIWWE	2279	2033
WARTOMMO	52	79
MO	63	0
APCHAPFL	109	8
ATCH	9	160
TOTAL	29098	23703

*Source: TSC Waterways Traffic Impact Model.

**Source: Corps of Engineers, <u>Waterborne Commerce Statistics</u> (I

TABLE 87

BARGE SHIPMENT COSTS: MAJOR WATERBORNE FLOWS OF GASOLINE (1975$)

Origin and PE	Destination and PE	1972 tons (000's	River Miles	Barge Rate ($/ton)	Total Shipment Cost ($/ton)	Cents/ Ton-mile	Cents/ bbl.	% Increase segment	fuel
I. Lower Mississippi (PE 400-415)									
410	400 New Orleans	2058	42	.58	1.44	3.43	18.4	.01	.06
415	400 New Orleans	1133	140	1.34	2.20	1.57	28.2	.01	.08
II. Ohio River (PE 200's)	230 Louisville, KY								
216	230	255	219	1.84	2.70	1.23	34.6	.06	.09
246	230	208	302	2.30	3.16	1.05	40.5	.06	.10
246	238 Cincinnati	486	164	1.50	2.36	1.44	30.2	.05	.09
238	246 Huntington	136	164	1.50	2.36	1.44	30.2	.05	.09
2750	285 Pittsburgh	271	2152	9.09	9.95	3.67	127.4	.10	.19
III. Upper Mississippi River (PE 300's)									
302	300 Cairo, IL	202	126	1.25	2.11	1.67	27.0	.12	.08
302	301 St. Louis	185	20	.50	1.36	6.80	17.4	.70	.05
2725	301 St. Louis	184	1218	6.10	6.96	.57	89.1	.09	.16
405	302 St. Louis	106	1050	5.50	6.50	.62	83.2	.07	.15
2725	302 St. Louis	157	1238	6.17	7.20	.58	92.2	.10	.16
301	326 Davenport	347	312	2.35	3.30	1.06	42.3	.16	.11
2725	326 Davenport	60	1530	7.16	8.26	.54	105.8	.13	.17
IV. GIWW-West									
2725	2725	246	25	.50	.86	3.44	11.0	.05	.05
2740	2740	380	72	.84	1.20	1.67	15.4	.06	.07
2740	2750	225	382	2.71	3.07	.80	39.3	.09	.11

relatively short-haul transfer operations, mostly immune to pipeline competition because pipes presently do not serve many of the plants.

In summary, reductions in tonnage and ton-miles of gasoline traffic on the waterways may occur as the result of user charges. Existing market competition for traffic among the modes will increase due to a decline in total available product for distribution. However, since only five percent of gasoline tonnage represents long-haul, competitive moves to pipeline, diversion estimates are limited to that figure.

5.3.9 Jet Fuel/Kerosene Impacts

Table 89 indicates that the majority (55 percent) of the jet fuel movements on inland waterways occur as inter-facility transfers along the Gulf coast and similar moves along the Ohio River. Movements of over 300 miles are rare. Table 90 contains segment and fuel tax impacts on jet fuel traffic by major river sector. In general, fuel taxes impact barge rates more severely than segment tolls. Diversion of longer haul traffic to pipeline is clearly possible, as in other petroleum products. Detailed examination of origin/destination data for waterborne jet fuel indicates that as much as twenty percent of traffic may be partially divertable to pipeline (i.e. major origins at St. Louis instead of the Gulf coast, with pipeline delivering to St. Louis). Given the small size of existing flows relative to system traffic in petroleum products (less than two percent of petroleum flows), total system traffic impacts are minimal.

TABLE 88

1972 WATERBORNE GASOLINE TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS*

Sector	Tonnage (000's) Origin	Tonnage (000's) Destination	Average Rate In ($/ton)	% Increase segment	% Increase fuel
BRMOP	5185	10043	$2.86	.06	.14
CAIROBR	3055	1627	2.76	.08	.12
MINCAIRO	3822	4061	1.73	.14	.11
OHIO	7095	5747	2.13	.08	.11
MON	942	13	.95	.15	.07
ALL	62	3	.85	.27	.07
TENN	658	42	5.56	.06	.15
CUMB	979	-	-	-	-
KAN	590	5	1.57	.13	.09
ILL	1598	310	1.61	.14	.11
GIWWW	2600	5567	3.81	.10	.15
MORGPA	-	178	1.86	.08	.10
GIWWE	2279	2194	2.45	.19	.12
WARTOMMO	52	1	.79	.07	.06
MO	63	3	1.58	1.41	.09
APCHAPFL	109	-	-	-	-
ATCH	9	209	2.57	.07	.11

*Source: TSC Waterways Traffic Impact Model.

TABLE 89

1972 AND 1974 WATERBORNE JET/FUEL KEROSENE
TRAFFIC BY SECTOR
(000's OF TONS)

Sector	1972 Traffic Outflows*	1974 Traffic Outflows**
BRMOP	813	872
CAIROBR	261	100
MINCAIRO	309	133
OHIO	887	749
MON	63	1
ALL	6	3
TENN	7	-
CUMB	67	-
KAN	54	-
ILL	257	-
GIWWW	799	531
MORPA	-	-
GIWWE	430	130
ATCH	29	-
WARTOMMO	-	290
TOTAL	3982	2809

*Source: TSC Waterway Traffic Impact Model.

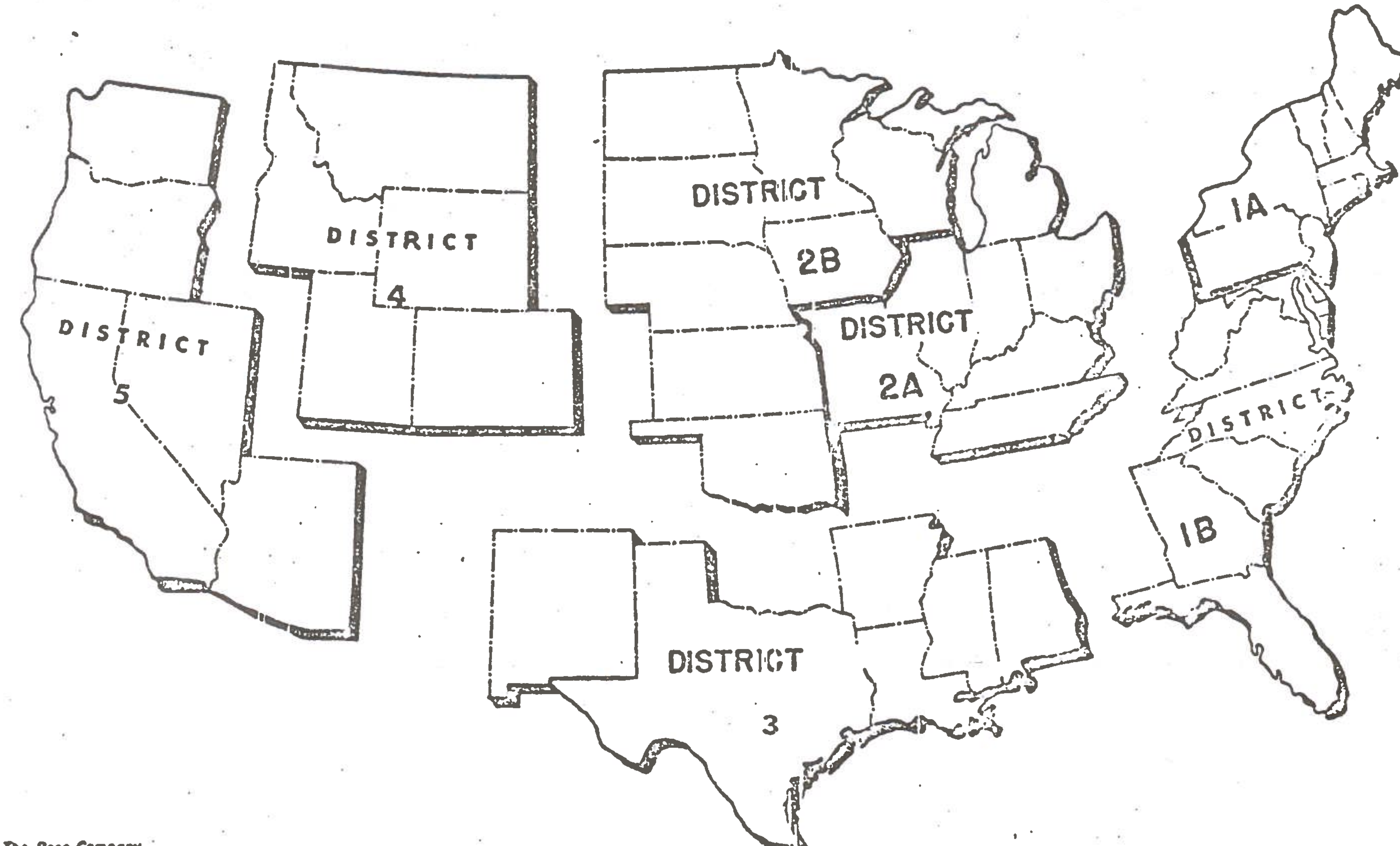
**Source: Corps of Engineers, Waterborne Commerce Statistics (1974). Part 5. Table 4.

TABLE 90

1972 WATERBORNE JET FUEL/KEROSENE TRAFFIC BY SECTOR: SEGMENT AND FUEL TAX IMPACTS*

Sector	Tonnage (000's) Origin	Destination	Average Rate In ($/ton)	% Increase Segment	Fuel
BRMOP	813	1522	$2.82	.06	.14
CAIROBR	261	163	2.62	.04	.12
MINCAIRO	309	97	3.08	.16	.12
OHIO	887	744	2.21	.09	.11
MON	63	2	2.47	.07	.11
ALL	6	-	-	-	-
TENN	7	-	-	-	-
CUMB	67	-	-	-	-
KAN	54	-	-	-	-
ILL	257	5	1.78	.18	.14
GIWWW	799	1258	3.04	.11	.15
MORGPA	-	1	.92	.03	.07
GIWWE	430	273	1.22	.08	.08
ATCH	29	5	1.73	.02	.09

*Source: TSC Waterway Traffic Impact Model.



Source: The Pace Company

TABLE 91

CRUDE OIL PIPELINE BETWEEN PADDS - 1973*

PADDS:	Pipeline	Size (Inches)	Capacity MBCD**	Capacity MTCY***
3 and 2	Capline	40	560	31,397.9
	Mid-Valley	22	250	14,016.9
	Mobile	16,20	340	19,063.0
	Amoco	8,12,16,16	370	20,745.0
	Texas	8	35	1,962.4
	Arco	8,12	110	6,167.4
	Continental	12	75	4,205.1
	Shell	10	50	2,803.4
	Basin	24	310	17,381.0
	Phillip	10	50	2,803.4
	Total		2,150	120,545.3

*Source: The PACE Company. Energy and Hydrocarbons in the U.S. to 1985. Table F-58.

**Thousand barrels of crude per day

***Thousand tons of crude per year

TABLE 92

PETROLEUM PRODUCT PIPELINES
BETWEEN PADDS - 1973*

PADDS:	Pipeline	Size (Inches)	Capacity MBPD**	Capacity MTY†	Comment
3 and 2	Phillips	8,12	121.9	6,356.2	LPG and Produ
	Mapco	10,6,8	159.4	8,311.6	LPG only
	Emerald	6	17.2	896.9	
	Arco	8	33.0	1,720.7	
	Cherokee	8	33.0	1,720.7	LPG and Produ
	Mobil	4	7.6	396.3	
	Explorer	28	300.0	15,642.9	
	Sun	12	84.9	4,426.9	
	Sub Total		757.0	39,472.1	
Spurlines from PADD 3 to 1 lines terminating in 2					
	Colonial	12	85.0	4,432.1	
	Plantation	8	33.0	1,720.7	
	Texas Eastern	-	242.0	12,618.6	LPG and Produ
	Sub Total		360	18,771.4	
	Total		117.0	58,243.6	

*Source: The PACE Company, Energy and Hydro-carbons in the U.S. to 1985. Table 5-54. See Figure 12 for PAD Districts.

**Thousand barrels per day

†Thousand tons per year

††LPG - Liquid Propane Gas

TABLE 93

1972 CRUDE PETROLEUM FLOWS ORIGINATING IN BEA 138 (NEW ORLEANS/BATON ROUGE)*

Destination BEA	Name	Pipeline flows	Water flows	Total flows	Average Shipment (Water)
46	Memphis TN	-	1431	1431	11
55	Evansville IN	4309	16	4325	2
77	Chicago IL	10671	-	10671	-
135	Jackson MS	-	2040	2040	8
138	New Orleans	35732	14520	50252	5
139	Lake Charles	-	2394	2394	5
140	Port Arthur TX	-	4241	4241	8
141	Houston TX	-	3245	3245	4
	BEA 139 (Lake Charles LA)				
137	Mobile AL	4100	-	4100	-
62	Cincinnati OH	2342	-	2342	-
138	New Orleans	-	1064	1064	4
139	Lake Charles	6306	3823	10129	3
140	Port Arthur TX	-	1979	1979	3
141	Houston TX	7388	4243	11635	3

*Source: TSC Bulk Commodity Flow Data Base: 1972.

TABLE 94

1972 CRUDE PETROLEUM FLOWS
ORIGINATING IN BEA 140 (PORT ARTHUR TX)

Destination BEA	Name	Pipeline Flows	Water Flows (000's of tons)	Total Flows (000's of tons)	Average Shipment (Water)
135	Jackson MS	-	36	36	9
137	Mobile AL	-	3	3	1
138	New Orleans LA	-	12	12	2
140	Port Arthur TX	-	83	83	5
139	Lake Charles LA	-	74	74	5
141	Houston TX	-	846	846	5

BEA 141 (Houston TX)

Destination BEA	Name	Pipeline Flows	Water Flows	Total Flows	Average Shipment (Water)
138	New Orleans LA	-	202	202	6
139	Lake Charles LA	-	83	83	4
140	Port Arthur TX	-	200	200	8
141	Houston TX	18406	649	19055	3

BEA 142 (San Antonio TX)

Destination BEA	Name	Pipeline Flows	Water Flows	Total Flows	Average Shipment (Water)
141	Houston TX	5549	141	5690	3
142	San Antonio TX	181	-	181	-
143	Corpus Christi	227	418	645	3

BEA 143 (Corpus Christi TX)

Destination BEA	Name	Pipeline Flows	Water Flows	Total Flows	Average Shipment (Water)
137	Mobile LA	-	69	69	34
138	New Orleans	-	254	254	36
140	Port Arthur TX	-	564	564	6
141	Houston TX	-	1697	1697	4
143	Corpus Christi	10275	393	10668	2

TABLE 95

MAJOR U.S. UTILITIES RECEIVING PETROLEUM PRODUCTS VIA WATER (1974): ILLINOIS AND UPPER MISSISSIPPI RIVERS

River and Port Equivalent (PE)	Company, State and Plant	KWH Production (millions)	Type of Fuel	Total Tons Used (000's)	% Oil	% Sulfur	¢/M.BTU (1976)
I. Illinois River	Commonwealth Edison (IL)						
540	Ridgeland	2,558.4	No. 6 oil	733	100	.85	200.0
	Crawford	2,726.3	No. 2 oil	4	1	.27	230.0
	Fisk	5,127.9	No. 2 oil	2	1	.11	245.0
	Illinois Power (IL)						
505	Havana	291.8	No. 6 oil	104	100	.72	197.2
II. Upper Mississippi River	Iowa-Illinois Gas & Electric (IL)						
324	Moline	172.9	No. 2 oil	26	37	.27	241.4
	Illinois Power (IL)						
302	Wood River	2,318.4	No. 2 oil	54	9	.02	237.4
	Union Electric (IL)						
301	Cahokia	84.4	No. 2 oil	42	100	.30	240.0
III. Missouri River	Union Electric (MI)						
100	Labadie	10,561.1	No. 2 oil	15	1	.40	246.0

TABLE 95 (CONTINUED)

MAJOR U.S. UTILITIES RECEIVING PETROLEUM PRODUCTS VIA WATER (1974): LOWER MISSISSIPPI RIVER*

Port Equivalent (PE)	Company, State and Plant	KWH Production (millions)	Type of Fuel	Total Tons Consumed (000's)	% Oil	% Sulfur	¢/M.BTU (1976)
	Arkansas Power (AK)						
470	Robert Richie	3,409.6	No. 6 oil	450	50	.85	196.9
	Mississippi Power and Light (MI)						
465	Delta	683.9	No. 6 oil	150	75	2.72	159.0
440	B. Wilson	2,854.4	No. 6 oil	543	66	2.10	170.0
430	Natchez	139.3	No. 6 oil	37	80	2.87	162.0
	Gulf States Utilities (LA)						
415	Widow Glen	5,565.5	No. 6 oil	370	24	.45	157.6
415	Louisiana #2	1,156.4	No. 6 oil	27	7	.45	158.0
	New Orleans Public Service (LA)						
405	Michaud	2,628.6	No. 6 oil	392	51	.90	179.2
405	A. B. Patterson	463.9	No. 6 oil	43	27	1.00	178.1
	Louisiana Power and Light (LA)						
405	Nine Mile Point	8,928.2	No. 2 & 6 oil	177	8	.25	225.0 154.0
1610[1]	Sterlington	1,913.3	No. 6 oil	39	7	.25	153.0

*Located on the Ouachita River.

TABLE 95 (CONTINUED)

MAJOR U.S. UTILITIES RECEIVING PETROLEUM PRODUCTS VIA WATER (1974): ARKANSAS AND GIWW

River and Port Equivalent (PE)	Company, State and Plant	KWH Production (millions)	Type of Fuel	Total Tons Consumed (000's)	% Oil	% Sulfur	¢/M.BTU (1976)
I. Arkansas River	Arkansas Electric Coop (AK)						
1550	Fitzhugh	86.7	No. 6 oil	24	93	N/A	152.2
II. GIWW - East	Mississippi Power (MI)						
2600	Jack Watson	4,644.2	No. 2 oil	214	20	.50	215.0
III. GIWW - West	Gulf States Utilities (LA)						
2725	R. S. Nelson	2,188.1	No. 2 oil	163	28	.20	196.6

TABLE 95 (CONTINUED)

MAJOR U.S. UTILITIES RECEIVING PETROLEUM PRODUCTS VIA WATER (1974): OHIO AND TENNESSEE RIVERS

River and Port Equivalent (PE)	Company, State and Plant	KWH Production (millions)	Type of Fuel	Total Tons Consumed (000's)	% Oil	% Sulfur	¢/M.Btu (1976)
I. Ohio River	Southern Indiana Gas and Electric (IN)						
220	Ohio River	235.8	No. 2 oil	18	23	N/A	144.0
	Indiana and Michigan Electric (IN)						
236	Tanners Creek	5,738.5	No. 2 oil	15	1	N/A	228.0
	Cincinnati Gas and Electric (OH)						
238	Miami Fort	4,163.0	No. 2 oil	36	1	.30	234.2
	Beckjord	4,323.5	No. 2 oil	3	1	.30	235.0
II. Tennessee River	Tennessee Valley Authority (TN)						
1305	Johnsonville	6,085.5	No. 2 oil	13	1	.70	220.5
1310	Colbert	6,715.8	No. 2 oil	12	1	.70	223.5
1335	Widow Creek	5,025.2	No. 2 oil	1	1	.70	244.0

FUEL OIL - DONLEY STUDY*

Origin	Destination	Rate ($/ton)	Rail Miles	¢/ton-mile	Tariff Citation
Hartford, IL	Peru, IL	$7.40	209	3.54	IFA 1-107B
Mount Vernon, IN	Cicero, IL	7.80	232	3.36	IFA 1-107B
Violet, LA	Cicero, IL	15.80	890	1.78	SFA 945
Baton, Rouge, LA	Cicero, IL	15.40	872	1.77	SFA 945
Baton Rouge, LA	Havana, IL	14.40	763	1.89	SFA 945
Memphis, TN	Peru, IL	11.00	467	2.36	SFA 945
Hartford, IL	Cicero, IL	8.40	276	3.04	IFA 1-107B
Hartford, IL	St. Paul, MN	11.60	524	2.21	WTL 442C
Beaumont, TX	St. Paul, MN	18.00	1209	1.49	SWL 125Q
Texas City, TX	Cicero, IL	17.80	1035	1.72	SWL 125Q
Dolton, IL	Hartford, IL	8.40	276	3.04	IFA 1-107B
Corpus Christi, TX	Havana, IL	17.20	1115	1.54	SWL 125Q

*Source: U.S. Army Corps of Engineers, Donley Rate Study for Locks and Dam 26 Replacement (1975).

TABLE 97

RAIL RATES - RESIDUAL

FUEL OIL - PACE COMPANY (1974)*

Origin	Destination	Rail ($/ton)	Rail Miles	¢/ton-mile
Philadelphia, PA	Toledo, OH	14.03	585	2.40
Chicago, IL	Omaha, NB	14.03	488	2.87
Chicago, IL	Pittsburgh, PA	13.72	468	2.93
St. Louis, MO	Denver, CO	20.21	914	2.21
Houston, TX	Louisville, KT	2033	996	2.04
Houston, TX	Omaha, NB	2021	976	2.07
Houston, TX	Denver, CO	2188	1099	1.99

*Source: PACE Co. <u>Energy and Hydrocarbons in the U.S. to 1985</u>. Table F-56.

TABLE 98

1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 138
(NEW ORLEANS/BATON ROUGE, LA.)*

(000's of tons)

Destination BEA	Name	Pipeline flows	Water flows	Total flows	Average Shipment Size (water)
15	Philadelphia, PA	3050	266	3316	14**
22	Norfolk, VA	1250	7	1257	7**
25	Greensboro, N.C.	800	-	800	-
28	Greenville, S.C.	600	-	600	-
46	Memphis, TN	550	124	674	1
49	Nashville, TN	650	61	711	1
52	Ashland, NV	0	79	79	1
54	Louisville, KY	-	87	87	2
55	Evansville, IN	-	41	41	1
77	Chicago	-	31	31	3
66	Pittsburgh, PA	-	84	84	2
135	Jackson, MO	-	229	229	2
137	Mobile, AL	-	310	310	2

*Source: TSC Commodity Flow Data Base - 1972 Bulk File.

**Tanker (coastwise) shipments.

TABLE 99

1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 140 (PORT ARTHUR, TX)

Destination		Modal Flows (000's of tons)			
BEA	Name	Pipeline	Water	Total	Average Shipment Si (water)
14	New York, NY	300	582	882	8
15	Philadelphia, PA	3400	402	3802	10
17	Baltimore, MD	500	69	569	12
18	Washington, DC	1900	69	1911	11
46	Memphis, TN	-	19	19	2
52	Ashland, WV	-	38	38	2
77	Chicago, IL	-	66	66	2
114	St. Louis, MO	-	123	123	2
115	Cairo, IL	-	55	55	2
138	New Orleans, LA	-	459	459	2
141	Houston, TX	-	169	169	4

TABLE 100

1972 DISTILLATE FUEL OIL FLOWS ORIGINATING
IN BEA 139 (LAKE CHARLES, LA)

Destination		Modal Flows (000's of tons)			
BEA	Name	Pipeline	Water	Total	Average Shipment Size (water)
14	New York, NY	-	143	143	14
54	Louisville, KY	-	8	8	2
55	Evansville, IN	-	12	12	2
60	Indianapolis, IN	1300	-	1300	-
62	Cincinnati, OH	650	-	650	-
63	Dayton, OH	650	-	650	-
143	Corpus Christi, TX	850	-	850	-

TABLE 101

1972 DISTILLATE FUEL OIL FLOWS ORIGINATING IN BEA 141 (HOUSTON, TX)

Destination		Modal Flows (000's of tons)			
BEA	Name	Pipeline	Water	Total	Average Shipment Size (water)
15	Philadelphia, PA	5200	1719	6919	28
17	Baltimore, MD	-	711	711	22
46	Memphis, TN	-	19	19	1
52	Ashland, KY	-	1	1	1
54	Louisville, KY	-	48	48	2
55	Evansville, IN	-	33	33	2
66	Pittsburgh, PA	-	44	44	1
114	St. Louis, MO	-	49	49	2
137	Mobile, AL	-	13	13	2
140	Port Arthur, TX	-	632	632	3

TABLE 102

1972 DISTILLATE FUEL OIL FLOWS ORIGINATING
IN BEA 52 (ASHLAND, KY)

Destination		Modal Flows (000's of tons)			
BEA	Name	Pipeline	Water	Total	Average Shipment Size (water)
52	Ashland, KY	-	185	209	1
54	Louisville, KY	-	73	73	2
62	Cincinnati, OH	-	232	232	2
64	Columbus, OH	600	49	649	1
66	Pittsburgh, PA	-	392	392	1
115	Cairo, IL	-	10	10	2

St. Louis
Mt. Vernon
} No pipeline flows out.

TABLE 103

1972 RAIL FLOWS OF DISTILLATE FUEL OIL:
SELECTED BEA MOVEMENTS
(1972 ICC RAIL WAYBILL DATA)

Origin	Destination	Tons (000's)	Average Revenues ($/ton)	Average Shipment size (tons)	Cents per Barrel
134 (Greenville, MS)	62 (Cincinnati, OH)	3	22.30	400	318.6
	108 (Lincoln, NB)	2	15.66	300	224.0
	117 (Little Rock, AK)	5	3.56	300	50.9
136 (Meridian, MS)	138 (New Orleans,LA)	7	3.08	400	44.0
140 (Port Arthur, TX)	140	28	.80	470	11.0
	141 (Houston, TX)	10	3.33	500	47.6
141 (Houston, TX)	141	42	2.52	470	36.0
143 (Corpus Christi, TX)	105 (Waterloo, IA)	3	16.10	430	230.0
46 (Memphis, TN)	117 (Little Rock, AK)	3	4.16	430	59.4
52 (Ashland, KY)	52	24	3.96	400	56.6
77 (Chicago, IL)	77	11	2.52	400	36.0
77	84 (Milwaukee, WS)	3	3.56	400	50.9
132 (Shreveport,LA)	62 (Cincinnati, OH)	3	21.63	300	309.0
132	114 (St. Louis, MO)	1	13.33	100	190.0

6. IRON AND STEEL TRAFFIC IMPACTS

The iron and steel industry is a potential heavy user of the inland waterway system because of its consumption of large quantities of bulk inputs (coal, iron and manganese ores, flux, scrap), its location on or adjacent to the Mississippi River system, and the relatively low value of its output (semi-finished and finished iron and steel products and by-products such as slag).

Of the 116.6 million short tons of raw steel produced in the United States in 1975, nearly half was produced on or near the inland waterway system, including approximately 20 million tons in the Pittsburgh area (Upper Ohio and Monongahela Rivers), 25 million in the Chicago - Northwest Indiana complex, 4 to 5 million tons on or near the Ohio River in Kentucky and Ohio, 3 to 4 million in the Warrior River producing area, and about 3 million on the Houston Ship Channel. The bulk of the remaining capacity is located on the Great Lakes (25-30 million tons in 1975 from Detroit to Buffalo) and Atlantic and Pacific Coasts.

In producing 116.6 million tons of raw steel in 1975, the industry consumed 78.6 million tons of coal, 29.5 million tons of fluxes (mostly limestone), 118.9 million tons of iron ore and agglomerates, 62.6 million tons of iron and steel scrap (about half of which was purchased, the rest deriving from in-plant operations), and 1.4 billion gallons of fuel oil; and produced, in additional to the steel, large amounts of by-products and wastes -- the greatest volume of which is slag. As is easily imagined, access to raw materials and energy has always been a major factor in the location of iron and steel production. The raw material procurement situation of each production center and the waterways role in the delivery system for each area will be discussed below.

6.1 IRON ORE

Of the 119 million short tons of iron ore (defined to include concentrates and agglomerates shipped from mining operations) consumed at U.S. iron and steel plants in 1975, 79.3 million tons (66%) originated at U.S. mines, with the remainder imported.* Ores from the Great Lakes ore-producing region - both U.S. and Canadian - generally move by lakes bulker from the mining areas to lower Lakes ports where they are either consumed in iron and steel production or trans-shipped by rail to interior steel centers. This ore, which provides the overwhelming share of ore consumed in the Great Lakes and Ohio River Valley steel areas, seldom moves to plants south of the Ohio River or west of the Mississippi, and never moves in significant volume on the inland river system.** Ores from the other domestic mining regions usually move by rail from mine to furnace and seldom move great distances except in the West.

Eastern Canadian and other non-Canadian imports account for the lion's share of ore consumed at East Coast iron and steel plants. Small amounts of these imported ores also move from the Atlantic coast to plants in the interior - even as far west as Chicago - but their exact volume is difficult to determine.

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*About 67.8-million tons of the domestic ore originated in the Lake Superior area, 3.2 million in the "Southern" Region - mostly Missouri and N. Central Texas, 1.7 million tons in the Northeast, with the remainder coming from, and consumed in, the West. Forty-three percent of imports were from Canada with the rest coming from Latin America and Africa.

**A few barge loads of ore of unknown origin move out of the Illinois waterway each year.

With the exception of a single operation in North Central Texas which produces steel in the vicinity of a captive mining operation, Gulf Coast steel production is almost entirely import-dependent for iron ore. In the Texas Gulf area most of the production is in the port area -- particularly Houston -- and none of it relies significantly on barge transport of ore.* Alabama iron and steel production, on the other hand, takes place in the Birmingham-Gadsden belt, near the metallurgical coal sources, and thus requires transportation (300-400 miles) beyond the port area (Mobile). One-half to two-thirds of that ore (destined to U.S. Steel at Fairfield) moves up the Warrior River by barge -- a move which will be discussed in some detail below. The remaining two to three million tons moves by rail from Mobile to a Birmingham iron producer and Republic Steel at Gadsden on the proposed Coosa River extension.

The only other movement of iron ore relevant to this study is iron ore which is imported at the Lower Mississippi port complex and moves up the Mississippi River by barge. This movement, which has remained relatively constant—in the vicinity of 500 thousand tons—in recent years, turns east at Cairo and terminates along the Ohio and Monongahela Rivers. This volume accounts for less than two percent of the estimated 25 to 30 million tons of ore consumed in that area, although it may loom somewhat larger in the procurement picture of some individual plants.**

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*There are sporadic, low volume moves in the Gulf area.

**Several explanations for the flow were volunteered. Some made reference to special handling characteristics which made rail delivery from the Atlantic unfavorable. Another source mentioned it as an alternative to the Great Lakes when that delivery route is closed. None described the flow as a critical pattern for existing or expected scenarios.

6.2 COAL

A total of 75.5 million tons of coal was carbonized in the production of coke for the iron and steel industry in 1975* It is generally necessary to blend coals at oven-coke plants because coals from individual mines do not have all of the properties required for the production of high-quality coke. High volatile (low fixed carbon) coals alone produce low yields and weak coke. Too high a proportion of low volatile coals would damage oven walls because they are highly expanding.

Over 90% of oven coke is produced at furnace plants - i.e., at the location the iron blast furnace - owned by or affiliated with iron and steel corporations. The remaining coke is produced at merchant plants for sale on the open market - generally to smaller and/or specialty producers. More than half the coal carbonized at oven-coke plants is produced at mines owned by or affiliated with iron and steel companies. For some large companies, captive coal accounts for a much larger percentage of total coal. The phenomenon of captive coal plays a potentially interesting role in the user charge analysis. Maintenance of production at captive mines appears to be a key factor in the overall procurement strategy of the steel producer. Therefore, when steel production is depressed - as in 1975 - a producer in the Texas Gulf area may bring most of its coal in from its West Virginia mine (a 1500 to 2000 mile haul). When production is up, and the company's northern plants are able to consume the output of the company mine, the Texas Gulf facility may look more heavily to open market coal purchases in Arkansas, Oklahoma, and Alabama. Therefore, a coal procurement strategy at a single

*Another 3.1 million tons were used for the production of steam and other purposes (including lime production).

plant which may appear irrational from a short-term economic point-of-view may be optimal from a longer-run corporation point-of-view.

Although thirteen states produce coal for shipment to coke plants, three states account for over three quarters of shipments. West Virginia provides 35% of the nation's coking coal, with significant production of high, medium, and low volatile grades particularly in the southern half of the state. Pennsylvania produces 27% of the coal carbonized in U.S. oven-coke plants, with high volatile coals coming principally from the counties along the Monongahela, and low volatile coal from the Johnstown area to the east. Kentucky produces 15% of U.S. consumption of metallurgical coal, all high volatile and all from counties in Eastern Kentucky (bordering West Virginia). Coals from these fields provide most of the metallurgical coal for the steel industry between the Ohio River and the Great Lakes with the exception of Illinois coal (4.3% of national coking consumption) which goes to Illinois and Indiana plants and some Virginia coal which enters the area.

The location of coking coal deposits in the north is not conducive to major, long-haul moves on the waterway. Although the Pittsburgh area receives nearly all of its coke oven input from the waterways, the average length of haul on the river is only about 75 to 125 miles from the Monongahela, Ohio, and Kanahwa Rivers. [Some of this coal is then moved beyond the river by rail to Youngstown, but this is not the dominant pattern for off-river plants.] In the middle Ohio River Valley, dependence on river delivery of coal varies widely depending on such factors as whether captive mines are involved and where they are located, and how far the plant is from the river. One major off-river producer (25 miles) sold its barges recently and went to all-rail delivery. Another company, which has two coke facilities directly across the river from each other receives 90 percent of its coal by barge at one plant and only 25 percent at the other. The northern Illinois-Indiana producing area receives virtually all of its coal by rail, due in large part to the circuitous route from the coal producing regions through the Illinois Waterway.

Alabama, which produces seven percent of the coal carbonized in the U.S., consumes most of its own production and imports some high volatile coal from the Kentucky-Virginia producing belt. No metallurgical coal moves to the Alabama steel producing area by barge.*

6.3 FLUXES

Fluxes are added to the hot metal during the blast and steel furnace processes. In 1975, 29.5 million tons of flux were consumed in iron and steel production. Limestone accounted for 20.9 million tons, including 11.6 million tons used directly in blast furnace (pig iron) production, 7.1 million in agglomerated products, and 2.2 million used directly in steel furnaces. Other fluxes, which were consumed predominately in steel making furnaces, were lime (7.1 million tons), fluorspar (534 thousand tons), and miscellaneous fluxes (891.5 thousand tons).

Because fluxes such as lime and fluorspar have multiple uses (e.g. in water purification and fluoridation, respectively), and because waterborne commodity flow data combines fluorspar with other non-metallic minerals, precise

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*Possibly some of the northern coal coming to Alabama comes off of the Tennessee River, but it is unlikely to be a significant factor.

treatment of these inputs is difficult. A few generalizations are possible, however. First, as in the case of iron ore, the Great Lakes play a significant role in the delivery system for limestone and lime to the Northern steel producing areas, in this case because of the major limestone and dolomite quarrying activity in Michigan. Second, as in the case of ore and coal, vertical integration of the industry may impact delivery systems. Thus, major producers of lime include U.S. Steel and Bethlehem Steel. In the case of U.S. Steel, limestone is processed at a subsidiary on Lake Erie and shipped to Pittsburgh via the (U.S. Steel-owned) Bessemer and Lake Erie RR. Excess demand at Pittsburgh is met with market purchases east of Pittsburgh -- by land. Third, limestone is relatively ubiquitous and so importation to a region is less of a factor than for ore. The Ohio River producers are the only steel makers who depend in any significant way on inland water transportation of limestone and lime, and even here, long expensive hauls are not dominant.

Fluorspar is one flux which seems to move into all waterway served steel areas by barge. Imports (particularly from Mexico) provide a sizeable fraction of U.S. consumption of this mineral and barge transport from as far as Brownsville, Texas to Chicago or Pittsburgh (2500 miles) is not unheard of.

6.4 MANGANESE

Manganese enters the steel production process in two forms -- as manganese ore directly charged to the blast furnace in pig iron production, and in the form of ferromanganese in the steel furnace. About 3 pounds of direct-charge ore (1.3 pounds of contained manganese) is input per short ton of steel produced, while about 13 pounds are input as manganese alloys (most in the form of ferromanganese).

Manganese alloy production, which consumed about 75 percent of all manganese ore in 1974, is concentrated heavily in a belt including West Virginia, Pennsylvania, Ohio, Kentucky, and Tennessee. The major source of this ore in recent years has been importation through the Lower Mississippi ports (about one half million tons in 1974), with movement by barge into the Ohio, Kanawha, Tennessee, and Monongahela Rivers. Another 433 thousand tons were imported through Baltimore in that same year, most of which moved away from the coast by rail. Manganese ore was also imported at Mobile (97 thousand tons) for processing at facilities there.

Table 104 summarizes the manganese statistics for recent years. In the first place, there is a trend toward importation

TABLE 104 —SALIENT MANGANESE STATISTICS IN THE UNITED STATES (SHORT TONS)

	1970	1971	1972	1973	1974
Manganese ore (35% or more Mn):					
Production (shipments)	4,737	142	578	239	--
Imports general	1,735,055	1,914,264	1,620,252	1,509,793	1,225,033
Consumption	2,363,037	2,155,454	2,331,459	2,140,058	1,880,176
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	368,302	198,834	147,161	203,055	272,908
Ferromanganese:					
Production	835,463	759,896	800,723	683,075	544,361
Exports	21,747	4,526	6,842	5,574	7,011
Imports for consumption	290,946	242,778	348,539	r 390,591	421,222
Consumption	1,000,611	899,011	967,965	1,116,602	1,115,395

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MINERALS YEARBOOK, 1974

of manganese alloys rather than ores, and a corresponding decline in the importation of ore (and presumably its transportation). This trend has a two-fold explanation: political - raw material producing nations wish to perform more processing as part of long-term development strategies - and economic - manganese alloys have about one-third the bulk of manganese ore and, therefore, economize on transportation costs (both ocean and domestic).

For purposes of analysis below, we assume that all manganese is received in producing regions by barge. Although this is obviously not entirely accurate, it makes little difference to the total cost impact to steel producers, and it was decided to make the most conservative assumptions - i.e., those which bias the apparent costs upward. In fact, it is difficult to get a handle on the manganese distribution system. Most producers purchase their alloys from other firms or from other corporate facilities.

6.5 SCRAP

Iron and steel production consumed 62.6 million tons of scrap in 1975, forty-four percent of which was purchased, with the remaining share (39.9 million) consisting of "home" scrap -- scrap derived from worn out ingot molds and mill machinery, trim from mill products, etc. Although some scrap arrives at most of the riverside steel plants by barge, the waterways are a very minor source of scrap for most. For example, net movements of scrap on the Warrior River have been outbound for several years, feeding the scrap export trade out of Mobile.

6.6 SUPPLEMENTAL ENERGY

Although the BOP steel process provides much of its own energy beyond the coking stage with coke gas and pitches providing fuel for other stages of production, and oxygen-injection reducing energy requirements in the steel furnace, some supplemental energy is required. Natural gas supply curtailments in Northern areas have pushed many steel manufacturers to heavy (#6) residual fuel oil. At times, when gas supplies are temporarily freer, they will switch back to gas, but most of the time they are forced to barge in oil from the Gulf (or to a lesser extent from upriver refineries, such as Mt. Vernon, Indiana.) In the analysis below, we assume pass-through of a user charge on a move from the Gulf to each upriver plant with no diversion.

Heavy residual fuel oil is not pipeable, nor, according to the purchasing agents, would it be an economic move by rail -- even with currently discussed user charge add-ons.

6.7 PRODUCTION COST IMPACTS AND TRAFFIC DIVERSION

Figure 13 shows the relationships of major inputs to output in the steel making process. Although it is conceivable that each stage of processing could occur at a geographically separate spot - with each arrow in Figure 13 representing transportation of intermediate goods - in practice they tend to be located at a common site, with coking by-product gases often being used to fuel the iron blast furnace, and pig iron moving to the steel production stage in molten form to avoid remelting. Raw steel ingots may also move to on-site rolling mills for primary processing to sheet, tube, rods, etc.

There is also strong vertical integration back through the raw material extraction and transportation process. Steel corporations may control coal and iron ore mines, the railroads and water transportation lines which transport the raw materials, and may even maintain the lakes ports used in ore transportation.

To assess the impact of waterway user charges on production costs in this industry it is necessary to identify the distribution system (geographic and modal) for iron and steel inputs and outputs of producing areas on or near the waterways. Each move which is touched by user charges can then be assessed with respect to the impact on the total production process and the probability of modal shift to alternative shipping patterns.

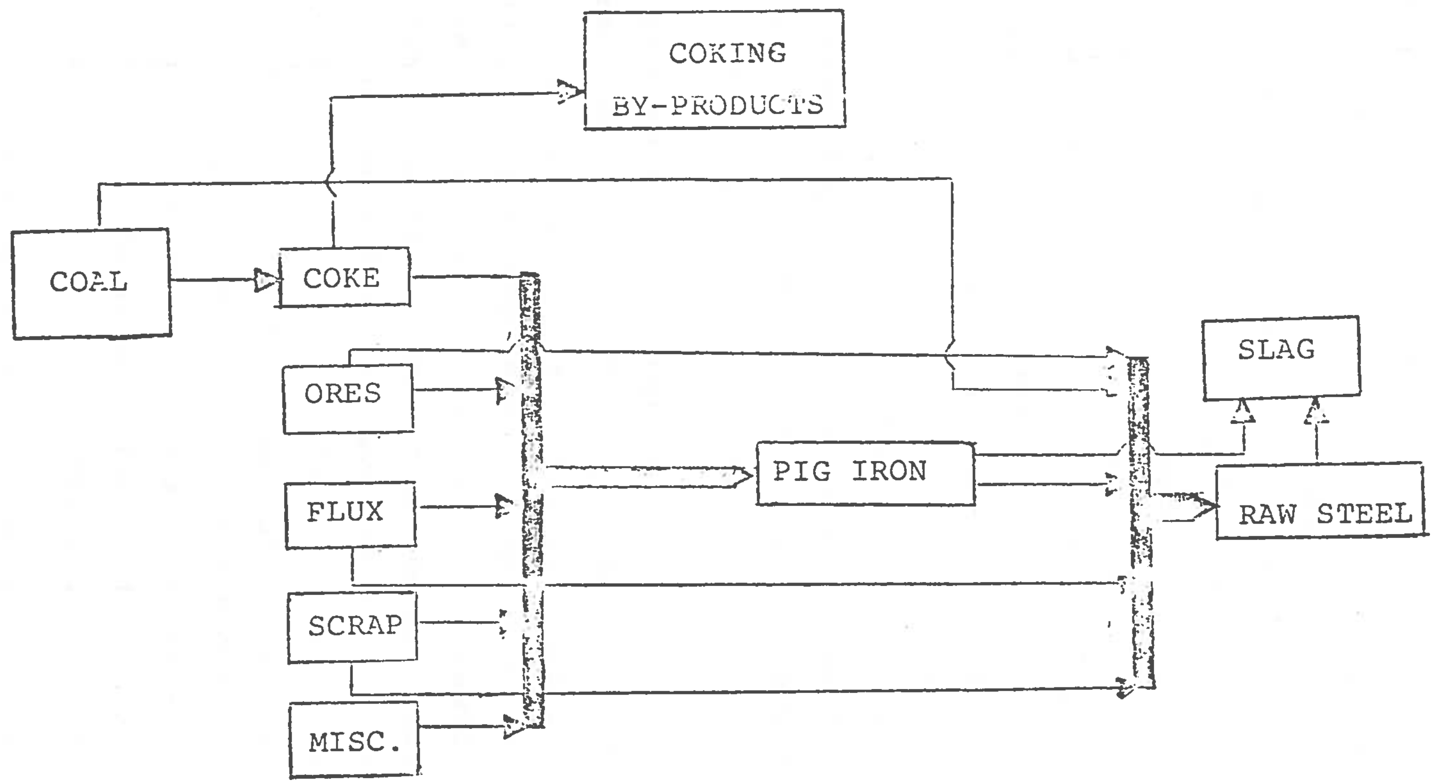

FIGURE 13. INPUT OUTPUT RELATIONSHIPS IN THE IRON AND STEEL INDUSTRY.

Table 105 gives the volume of inputs per ton of steel output for each major steel making process. The first column gives the direct input of each material into the steel furnace for each ton of production. The second column shows the requirements for each ton of raw steel production including direct and indirect raw material inputs. For example, although direct iron ore inputs to the BOP process totaled only about .013 tons for each ton of raw steel produced, an additional 1.33 tons of ore were consumed in producing the pig iron for input to the steel furnace -- making a total of 1.343 tons of ore for each ton of steel produced. No precise data is available on direct consumption of ore, residual oil, and coal in each steel furnace type, so total direct consumption for each was allocated proportionately to production. In fact, this assumption is probably invalid. For example, the open hearth process has greater requirements for supplemental energy than the basic oxygen process. These inputs are small enough, however, to have insignificant impact on the scenarios analyzed.

In the following paragraphs, we will examine the geographic and modal pattern of raw materials delivery to each water-related steel producing area. Any water-received input is assumed to bear the full user charge for its delivery and the cost increase is passed on to the price of steel. Because of incomplete information on the mix of steel making processes in each area, increased costs for BOP steel will be analyzed. This process, which accounted for 62% of total U.S. production (and a greater share for our study area) in 1975, economizes on scrap (not a heavy-volume waterway commodity) at the expense of increased pig iron input (which utilizes more waterway flows for inputs). This exaggerates cost impacts where other technologies are used.

In each case below, the raw materials procurement pattern analyzed is a composite picture gained from examination of estimated consumption of raw material in the area and waterway

TABLE 105. INPUTS PER TON OF RAW STEEL PRODUCTION BY PROCESS-1975 NATIONAL AVERAGES.

Raw Material Input	Basic Oxygen Process		Open Hearth		Electric Furnace	
	(a)	(b)	(a)	(b)	(a)	(b)
Pig Iron	.829		.662		.038	
Scrap	.326	.366	.543	.575	1.037	1.039
Flux	.114	.308	.070	.226	.046	.055
1. Fluorspar	1) .006	.006	1) .003	.003	1) .003	.003
2. Limestone	2) .015	.209	2) .043	.198	2) .009	.018
3. Lime	3) .084	.084	3) .015	.015	3) .032	.032
4. Misc.	4) .009	.009	4) .010	.010	4) .002	.002
Iron Ore	.013	1.344	.013	1.076	.013	.074
Manganese	.007	.003	.007	.008	.007	.007
Fuel Oil	.030	.045	.030	.042	.030	.031
Coal	.027	.810	.027	.653	.027	.063

(a) Direct input to steel furnace.
(b) Direct and indirect (through pig iron) inputs - See Table 106.

Source: Tables from the American Iron and Steel Institute 1975 Annual Report were used to derive this table.

TABLE 106

INPUTS PER TON OUTPUT OF PIG IRON

Input	Tonnage
(coke)*	(.632)
Coal	.945
Iron Ore	1.606
Limestone	.234
Scrap	.048
Manganese Ore	.002
Residual Fuel Oil	.018

*Since most coke is consumed on-site, we represent this commodity by its coal input.

data provided by the Army Corps of Engineers as well as discussions with purchasing executives of the major producers. Cost impacts are biased upward by the use of worst case assumptions. For example, because most metallurgical coal moves into the Pittsburgh area by water and because the largest users receive all or nearly all of their coal by barge, a barge delivered share of 100% is used in assessing user charge cost impacts in this area.

6.7.1 Pittsburgh

Steel producers in the Pittsburgh area* receive most of their coal—15 to 16 million tons in 1975 — on the river, from origins on the Monogahela, Kanahwa, and upper Ohio Rivers (as far as Huntington, WV.). The average length of haul (weighted by volume) for the plants varies from as little as 50 miles to as far as 130 miles, with individual flows ranging from less than twenty miles (over 2 million tons on the Monongahela) to 350 miles (a small flow to the same plant from the Kanahwa). The average user charge on barge coal in this region would be between 6.7 and 12.2 cents under the segment toll and between 4.0 and 10.9 cents for a uniform fuel tax. This compares to a delivered price of metallurgical coal in this area of forty-five to fifty-five dollars in 1976 - including transportation costs of $1.50 to $2.50 per ton. These increases in the delivered cost of coal would add between three to ten cents to the cost of producing one ton of steel, depending on the plant and the form of the user charge. (See Table 107).

Significant diversion of metallurgical coal traffic from the waterways in this region is unlikely. Although some restructuring of purchasing patterns is possible, coal blending

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*We define this area to include the producers on the Monongahela River and the upper Ohio River as far as Wheeling/Pittsburgh's E. Steubenville plant--milepost 68.8.

TABLE 107

STEEL PRODUCTION COST IMPACTS FROM
WATERWAY USER CHARGES (100% OM&R, BASIC OXYGEN PROCESS)

Pittsburgh Producing Area

Raw Material	% Water Delivered	Average Haul	Average User Charge (¢ per ton)		Production Cost Impact (¢/ton of raw steel)	
			ST	FT	ST	FT
Coal	100	50-130	6.7-12.2	4.0-10.9	5.4-9.9	3.2-8.8
Iron Ore	2	1725	62.6	137.3	1.7	3.7
Manganese	100*	1725	62.6	137.3	.6	1.2
Fluorspar	100*	1725	62.6	137.3	.4	.8
Fuel Oil	100	1395	60.0	111.1	2.8	5.0
				Total	10.9-15.4	13.9-19.5

*We assume 100% procurement through Lower Mississippi River ports.

is an important part of coke production, making major shifts unlikely - especially given the size of the average user charge discussed above. The Pittsburgh area receives most of its low volatile (LV) coal from West Virginia mines. Although Pennsylvania LV coal (from the central part of the state) might theoretically be substituted, this coal is not of sufficient scale (especially considering other demands on it) to replace West Virginia coal to any significant extent.* The fact that much coal movement is from captive mines further discourages major shifts in procurement patterns.

Another factor is that major investments in facilities and equipment would be required to switch from barge to rail. At least one reciever - the largest consumer of metallurgical coal in the world - requires barge delivery as a part of its entire coke-oven process. Even a total user charge bill of 750 thousand dollars a year on 8 million tons of coal would probably not justify the magnitude of investment required for rail delivery. In some cases, similar investments would also be required at the mine. The analysis of utility coals in this report suggests costs of one to two dollars per ton of coal for construction of a coal-receiving facility capable of handling coal in the volumes consumed by a large (greater than 1 million tons per year) coke producer.

A more subtle form of diversion would involve continuing to deliver coal to the plant by barge, but shortening the haul on the river (i.e., loading barges closer to the plant). For example, eighteen cents per ton of user charge could be avoided by putting coal from the Upper Kanahwa region on the Ohio River instead of the Kanahwa. Most of the metallurgical coal from this region is already railed up to the Ohio River (in the Huntington area), with the barge movements

*West Virginia supplies about 3 times as much LV coal to the steel industry than Pennsylvania. Any attempt to replace it to any significant degree would lead to price shifts far in excess of 5 to 10¢ per ton.

confined to mines immediately adjacent to the river. The savings from a shift to rail-barge in this case would be a small fraction of the user charge - at best - and might well require significant new investment in handling facilities. Finally, coal frequently passes through a captive cleaning plant at the river loading point. A change in delivery pattern would, in these cases, require new investment in cleaning facilities far in excess of five to ten cents per ton.

Little, if any, barge traffic in metallurgical coal to Pittsburgh will be diverted by the user charge proposals analyzed in this report. This opinion received ex post verification from several steel industry executives queried.

As discussed earlier in this chapter, significant volumes of imported manganese ore and ferroalloys are received in this region by barge - flows for which it appears there is competition from Atlantic ports via rail. The user charge on a movement from the Lower Mississippi ports to Pittsburgh amounts to about 60 cents under the segment toll approach and almost $1.40 for a uniform fuel tax. (Manganese ore prices were about $150 per short ton, c.i.f. port, in 1974). The difference is due to the fact that the Lower Mississip and Ohio Rivers are much cheaper than the average river. These tolls would add between .6 and 1.2 cents to the cost of producing a ton raw steel.

Although the total cost impact to producers is rather small this understates the importance of the commodity flow to the barge industry. For example, one-half million tons of manganese from New Orleans to Pittsburgh generate over 850 million ton-miles of barge traffic, compared to 1.5 - 2.0

billion ton-miles generated by 15-20 million tons of metallurgical coal traffic. Although this in turn overstates the relative revenue importance of this traffic to the carriers, it does demonstrate the need for further consideration.

Several forms of traffic diversion are possible here. In the first place, the trend toward importation of alloys, as opposed to ore, might be accelerated since the ore for production of 1 ton of alloy would carry a toll roughly double that for the barge movement of one ton of alloy between the same points. [Counteracting such a shift is the fact that the duty on imported ore has remained suspended in recent years, while that for ferromangenese has remained upwards of $5 per ton except when suspended because of domestic shortage.]

A similar effect could be accomplished by an increase in the capacity of alloy production in the Gulf area, whereby ore would continue to be imported there, with a lower volume of product flow moving up the river. This is unlikely to be a significant factor in the foreseeable future due to the large existing capacity upriver.

The final, and more likely possibility, is a mode/port shift, with an increasing share of manganese ore (and ferroalloys) entering the region by rail from the Atlantic (or even possibly the Gulf) coast. The apparent existence of ore flows from Baltimore to at least some receivers in this region accents this possibility. The purchasing agents we spoke with did not find diversion of their manganese traffic from the river highly likely, especially under the segment toll, but we are unable to put an objective probability on its occurance on the basis of information we now have.

Much the same may be said of the iron ore flows from the Lower Mississippi area to the Pittsburgh area. Our telephone survey of purchasing executives revealed that some iron ore (obviously a relatively small amount) moves as far west as Illinois and Indiana from East Coast ports by rail. This suggests that diversion of the Gulf flows to such a pattern might be economically feasible for at least some receivers, but this would depend on a number of factors including the rail connections available, the desirability of this traffic to the particular railroads involved, and the role of these flows in the overall ore procurement strategy of the producers. Because of the relatively small role the river flow plays in the total ore procurement picture in the Pittsburgh area (only about 2 percent), the total impact on steel production costs would have been between 1.7 and 3.7 cents per ton of output under the segment toll and fuel tax respectively.

The steelmakers in all Northern regions, faced with natural gas curtailments, are reluctant long-haul shippers of residual fuel oil. Wherever possible, they have increasingly utilized coking by-products such as coke oven gas, pitches, and asphalt, for supplemental energy needs, but they still require an estimated 900,000 thousand tons of residual (#6) fuel oil in the Pittsburgh most of which comes in by barge from the Gulf area. Because of the impossibility of piping this oil, and the relatively high rail costs, we see little impact from user charges on this flow. The flow does remain extremely sensitive to changes in energy or environmental policy which may make other fuels more economical (or available).

The waterway plays a relatively minor role in the movement of fluxes and metal scrap to the Pittsburgh area. Although increases to the production cost from a user charge of these flows (assuming 100% of flourspar is by barge from the Gulf) are calculated in table 107, their volumes are too low to merit a diversion analysis.

6.7.2 Ohio River Production Area

The procurement pattern for raw materials in this region (defined to include southern Ohio and Kentucky) is somewhat more varied than that for Pittsburgh. Particularly, we identified three major coke-oven plants with widely differing modal patterns for metallurgical coal. One, about thirty miles from the river, sold its barges recently and now receives all of its coal by rail. Two others-merchant plants on opposite sides of the Ohio River at Ashland, Kentucky - receive 25 and 90 percent of their respective coal inputs by water. The major criterion in mode choice for these two plants would appear to be rail connectivity between captive mining operations and the oven plants. The facility on the south side of the river, which receives 25 percent of its coal by water, is on the Chessie System and receives coal from its own mine and the mines of Armco Steel to whom it sells all its coke at that site - inland mines which are served by that road. The water-received coal comes from the corporation's mine on the Kanahwa River which is served by Conrail and which ships by rail when shipments are destined to off-river company facilities, but by barge to the Ohio River plant. The user charge for this flow would be 20.3 cents per ton under the segment toll and 12.0 cents under the uniform fuel tax. Diversion would entail either a multi-road haul direct to plant or a rail-barge move with the coal being put on barge at the Ohio. Neither can be considered very probably.* Maintenance of existing patterns would add

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*A shift to the multi-mode haul would imply that a Conrail haul to the Ohio plus an additional transfer (about 50 cents per ton) is priced within 10 to 20 cents per ton of the line-haul portion of the barge move which occurs on the Kanahwa. The second option would require an interline haul at a rate within 10 to 20 cents per ton of the existing all water rate.

between 1.4 and 2.2 cents to the price of raw steel produced at this site (see plant b in Table 108).

The sister plant on the north side of the river is more water dependent than the Kentucky plant because it lacks single line connectivity with its captive mining operations (it is on the N&W). Therefore, it receives coal by water from the Kanawha River mine as well as by rail-barge moves from its inland mines. Once again we see little possibility for coal diversion here. The only real incentive to leave the river would be for the Kanawha River coal, and the logic applied above argues against diversion here also. Pass-through of this increased coal cost to steel would increase production costs of between 4.9 and 7.9 cents per ton. The fact that this facility is a merchant plant (i.e., selling its coke on the open market rather than using it for on-site steel production) imposes some additional hardship. Instead of absorbing 5 to 8 cents per ton on a $350 per ton product (steel), they must absorb a 7.5 to 12 cent charge* on a product of lower value (coke).

The logic of the discussion of other inputs for the Pittsburgh area above can be extended to this area with two caveats. First, the volumes of traffic under consideration are smaller - in absolute terms - and therefore less critical to the waterway industry. Second, and more importantly, being 300 to 500 miles downstream means that the user charges from the Lower Mississippi ports are smaller, and the rail rates from the Atlantic coast are somewhat higher and, therefore, less competitive.

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*Recall that about 1.5 tons of coal are carbonized in producing 1 ton of coke.

TABLE 108. STEEL PRODUCTION COST IMPACTS FROM WATERWAY USER CHARGES (100% OM&R, BOP PROCESS)

Ohio Valley

Water-carried input	%Barge	Average Mileage	User Charge ST	User Charge FT	Cost Impact per ton of steel ST	Cost Impact per ton of steel FT
Coal	a) 0	-	-	-	-	-
	b) 25	62.9	10.9	6.7	2.2	1.4
	c) 90	62.9	10.9	6.7	7.9	4.9
Iron Ore	2	1385	43.9	110.1	1.1	3.0
Manganese*	100	1385	43.9	110.1	.4	1.0
Fluorspar*	100	1385	43.9	110.1	.3	.7
Other fluxes**	50	200	10	16	1.5	2.4
Fuel Oil	100	47	30.2	63.5	1.4	2.9
					a) 4.7	a) 10.0
					b) 6.9	b) 11.4
					c) 12.6	c) 14.9

*These inputs are assumed to be 100% Gulf-imported.

**Because of the difficulty of identifying the fluxes in ACE data, this procurement pattern is synthesized from discussions with industry sources.

Finally, since some lime and other fluxes do move on the river in this region, Table 108 includes a synthesized item for these moves. The total steel production cost increase in this region ranges from 5 to 15 cents per ton for recovery of 100% of Federal OM&R on the waterways (Table 108).

6.7.3 Illinois - Indiana

The Northern Illinois-Indiana steel complex is not dependent on the inland waterways for any of its receipts of coal, iron ore, or limestone fluxes. One small flow of coal (100 thousand tons from the Tennessee River) is moving under a 3 year contract which is in the process of being terminated because it is currently uneconomical. The producers look to the Great Lakes for their ore and fluxes, and to rail deliveries from Illinois, Kentucky, Pennsylvania, and West Virginia for coal. Although the waterway may exert some influence over the level of unit train rates for coal, this factor was minimized by the purchasing executives we contacted in this area.

Receipts of manganese, fluorspar, and fuel oil by water would result in total cost increases of 3.9 to 6.2 cents per ton of raw steel produced (Table 109). As in the case of the previous regions, the long-hauls of these commodities from the Gulf bear larger user charges under a fuel tax than under a segment toll, but the difference is less pronounced because the Upper Mississippi and Illinois Rivers are relatively more costly than the Ohio River. Some possibility of diversion of the manganese ore traffic to Great Lakes delivery is conceivable (small amounts are currently imported in this channel), but this is of questionable probability especially if lakes traffic faces any increases tolls due to future Federal cost recovery.

TABLE 109

STEEL PRODUCTION COST INCREASES IN ILLINOIS-INDIANA PRODUCTION AREA (100% OM&R BOP PROCESS)

Water carried input	% Barge delivered	Average MIleage	User Charge ST	User Charge FT	Cost Increase Per Ton Steel ST	Cost Increase Per Ton Steel FT
flourspar*	100	1366	66.5	108.7	.4	.7
manganese*	100	1366	66.5	108.7	.6	1.0
fuel oil	100	1245	64.5	99.1	2.9	4.5
					3.9	6.2

*The flows are assumed to be 100% from the Gulf.

This area has been a net shipper of metal scrap by water in recent years and so procurement of that input should be little affected by waterway user charges.

The overall cost impact of user charges in this area ranges from 3.9 to 6.3 cents depending on the method of taxation (Table 109).

6.7.4 Alabama

In a reversal of the pattern seen in the Pittsburgh and Ohio Valley cases above, the Warrior River System plays a significant role in iron ore procurement in Alabama iron and steel production, and no role at all in the delivery of metallurgical coal. One of the three major producers in the region (Republic Steel) is located at Gadsden on the proposed Coosa River extension. Its location - 75 miles from the Warrior River - puts it out of that river's reach.* The other two major producers in the region - United States Steel (by far the largest) and U.S. Pipe and Foundary (an iron producer) - are located in the Birmingham area, but not directly on the river.

All three producers mentioned above import the bulk of their iron ore through the port of Mobile. Republic Steel and U.S. Pipe ship their ore from port to plant by rail - at a rate of $4.47 per net ton in 1800 ton minimum shipments. United States Steel receives its ore via a barge move (on the U.S. Steel-affiliated Warrior and Gulf Barge Line) to Port Birmingham from which it moves by rail twenty miles (on the U.S. Steel-owned Birmingham and Southern Railroad) to the

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*In fact, this facility is closer to the Tennessee River with which it has some small interaction.

steel mill's receiving point. The rail move from Port Birmingham to the plant costs $1.23 per ton, which, when coupled with a barge-to-rail transfer cost of approximately 40 to 50 cents, and an estimated barge rate of $3.00* makes this procurement channel as expensive as the all-rail movement from Mobile -- $4.60 - $4.70 as opposed to the $4.47 rail rate which is also available to the U.S. Steel plant. This is true even without the user charge of 29 to 33 cents for the barge haul. Maintenance of this procurement pattern after user charges would mean U.S. Steel would be absorbing from 30 to 50 cents per ton of iron ore consumed over the cost of all-rail ore. In 1974, this would have amounted to between 1.5 and 2.1 million dollars. The rate analysis above suggests that it may already be absorbing up to twenty cents per ton for this move.

A degree of caution is called for here. Although the barge rate was verified verbally with the barge line, it is a private, contract rate, and so its level cannot be established with certainty. If the barges delivering ore upstream participate heavily in the downbound coal traffic, this would create an unusually well-balanced flow pattern with concomitant revenue benefits to the carrier -- and shipper. In this case, the estimated rate would be overstated. In any case, however, the all-rail move would be highly competitive under a user charge, if it isn't already.

Although this appears to be a serious candidate for large scale diversion to rail, several factors must be considered. In the first place, this iron ore flow accounts for a significant portion of the ton-miles on the Black Warrior and

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*This rate was estimated using the TSC barge rate simulator and verified in a phone conversation with a Warrior and Gulf employee.

Tombigbee Rivers - 32 and 36 percent respectively, in 1973 and 1974. It provides a significantly larger share of the traffic base of U.S. Steel's two transportation operations in the area -- the barge and rail lines described above. Elimination of the ore traffic on the river would seriously threaten the viability of U.S. Steel's southern barge operation, and possibly even the viability of the river as a commercial waterway. This would have implications on other traffic patterns for the firm and industry in the area. U.S. Steel also receives manganese, fluorspar, and (possibly) fuel oil via the river, and a portion of its own and the other producers' finished products move back downstream to Mobile and beyond. The corporation would lose whatever transportation savings (or earnings) it derives from this traffic as well as any revenues gained from downbound coal traffic.

Elimination of its river operations would also have a somewhat more intangible disbenefit -- loss of full control of its raw materials procurement system. The corporation not only controls the barge and rail lines involved, but operates the shipping company which carries the ore from overseas (Navios), and has an interest in the foreign mining operation. Ownership of the entire distribution system provides a degree of certainty which would be voided by the elimination of one link in the mine-to-plant chain. For these reasons, we judge that the probability of a U.S. Steel cessation of ore operations on the Warrior River to be highly unlikely.

A related issue is the role the river plays in the level of the competing rail rate on ore. The familiar argument states that the existing rail rate is as low as it is only because there is a competing river delivery pattern. This argument is related to the issue of control discussed above;

i.e., "in the long run U.S. Steel couldn't really have the existing rail rate because it would rise as soon as the barge delivery pattern was abandoned." A corollary argument claims that the other ore receivers in the area benefit by getting a lower rail rate, even though they don't ship by barge.

Given the existing rate structure, however, the rail-barge option is nowhere near the all-rail rate for other producers. Whereas the barge-rail and all-rail moves are competitive for U.S. Steel, the other receivers must pay at least an additional $2.09 for the haul beyond the Birmingham and Southern RR. This implies that the railroads hauling ore direct from port could theoretically raise the rates on that traffic without losing it to the river.

The modal pattern for other inputs (other than coal) is similar to that for iron ore, with U.S. Steel receiving manganese, flourspar and fuel oil by water, with the other producers relying in the main on rail. The disposition of these flows on the water would likely depend on the decision made with respect to ore (viz., if the iron ore stays on the river, so probably will the others).

Table 110 outlines the impact of user charges (100% OM&R) on the cost of producing a ton of steel. The increased costs apply only to U.S. Steel's river-based procurement strategy, unless rail rates to the other producers rise in response to the barge cost increase, in which case the increases would apply to all receivers.

6.7.5 Houston

The two major steel producers in the Galveston Bay area have different raw material requirements because they utilize different steel-making processes. U.S. Steel utilizes the electric furnace process which inputs very little pig iron

TABLE 110

STEEL PRODUCTION COST IMPACTS FROM
WATERWAY USER CHARGES (100% OM&R, BASIC OXYGEN PROCESS)

Birmingham - U.S. Steel

Water Carried Input	% Barge delivered	Average haul	User Charge ST	User Charge FT	Cost Increase per ton steel ST	Cost Increase per ton steel FT
Iron Ore	100	368	33	29	44.4¢	39.0¢
Manganese	100	368	33	29	.3	.3
Fluorspar	100	368	33	29	.2	.2
Fuel Oil	100	580	43.9	44.0	2.0	2.0
					46.9	41.5

and subsequently generates limited demand for iron ore, coal, and limestone (see Table 104). The Galveston Bay area is both a receiver and exporter of scrap - in relatively small volume - with the waterways playing no significant role in the U.S. Steel's scrap procurement for that plant.

The other major steel producer in the area, Armco, does not operate electric furnaces and, therefore, must procure large volumes of raw materials. As in the case of the Alabama producers, Armco relies on imported ore, but, because its facility is located in the port area, no barge haul is involved. Texas provides no metallurgical grade coal, however, so this input must be shipped into the region. Although Oklahoma and Arkansas can provide some metallurgical grade coal - particularly high volatile - Armco has brought in most of its coal by barge from Ceredo, West Virginia (1950 miles). This move would carry a user charge of 70 cents under the segment toll appraoch, and $1.47 under a uniform fuel tax - on top of a barge rate of five to five-and-a-half dollars and total transportation changes (including rail from mine to river and handling) of ten to eleven dollars. The likelihood of diversion of this flow would depend on a number of factors including the level of demand for coal at the West Virginia mines from Armco's other facilities, the price of suitable open market metallurgical coal and the cost of bringing coal from that other source to Houston (by rail or barge). Barge coal from Alabama is an unlikely option because user charges would add an additional 70 cents to the barge cost of that move of almost 1000 miles. Rail deliver would depend on the ability to negotiate a suitable volume rate with railroads involved. Existing rail rates from the West Virginia area are prohibitive. The most likely expectation would be for Armco to switch some fraction of its coal - especially its high volatile requirements -

to Oklahoma coal brought in by rail. The decision would be at least as sensitive to market conditions, such as the tightness of coal supplies in the Northern producing areas, as it would be to a user charge of 70 cents

6.8 FINISHED PRODUCTS

Analysis of the flows of steel products on the inland waterways is considerably more complex than that for raw material inputs. Steel mill products come in dozens of forms and specifications -- ingots, blooms, pipe, bars (hot rolled, cold finished, etc.), wire, rails, etc. -- and several grades (carbon, alloy, and stainless) each of which is sold in a unique market. Waterborne traffic data is available for only five broad categories on an originations or destinations basis for each river, and for two categories - "pipe and tube" and "finished products" - on an origin-destination (river-to-river) basis.* The analytical problems caused by this aggregation are illustrated by the fact that in 1973 we find 154.8 thousand tons of "finished products" moving by barge from New Orleans to Chicago area, and 163.4 thousand tons moving by barge between the same two areas in the opposite direction.

Additional problems relate to the way in which iron and steel products are produced and distributed. A large steel producer will not produce all products at each of its facilities - e.g., pipe and tube production is relatively concentrated in the Pittsburgh area - yet it is expected to sell most products in each major market. This leads to situations in which shipments may occur on a very large scale to a producer's distribution yard in the market area rather than in smaller shipments directly to purchasers. The former situation favors barge shipment, while the latter would favor rail or truck. When steel supplies are tight, more purchases take place on an f.o.b. plant basis, favoring non-barge shipment, while in normal or slack times, the opposite may be true.

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*On a port equivalent to port equivalent basis, not even this information is available.

In light of such analytical problems, our approach will be to describe (within the limits of the data) the patterns of barge flows of iron and steel products, to estimate their importance in the overall production and shipments of each area, and to provide subjective insights into the impact of user charges on these flows. Table 111 shows the total barge shipments of iron and steel products (averaged over 1973 and 1974) from each producing area and computes the estimated barge share of total shipments.* Although the estimates are admittedly rough, they show that barge shipments account for approximately 10% of total product shipments in these areas - somewhat higher for Pittsburgh because of its pipe traffic to the Gulf area (for the oil industry).

Table 112 shows the distribution of destinations of products other than pipe and tube from each of our production areas.** The table reveals that - as in the case of raw materials - the bulk of the iron and steel moves occur on relatively low cost, main stem rivers, meaning fuel taxes would exceed segment tolls under user charges. Thus, for shipments to the Cincinnati area, barge transportation from the Pittsburgh area would cost an additional 23 cents per ton under the segment toll and 38 cents under the uniform fuel tax. The same figures for shipments to the Galveston Bay area would be 85 cents and $1.72, respectively. It is clear that a fuel tax would act to relative detriment of the industry given the existing structure of waterway expenditures and traffic.

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*Raw steel production in each area is estimated by using state or regional production and raw materials consumption data. Steel mill product shipments were then calculated as 72% of raw steel production -- approximately the national average over the five years.

**Although the market shares shown are for 1974, the patterns have remained relatively stable in recent years.

TABLE 111

BARGE SHIPMENTS RELATIVE TO ESTIMATED TOTAL SHIPMENTS
BY REGION - AVERAGE 1973 AND 1974*

	(k tons)			(million tons)	
	Pipe & Tube	Other Finished Products	Total	Total Shipments (etc.)	% Barge
Pittsburgh	549	1646	2195	18.0	12
N.Ill-Ind.	52	1351	1403	25.0	6
Ohio Valley	7	270	277	3.6-4.3	6-8
Alabama	18	233	251	2.9-3.2	8-9
Galveston	107	297	404	NA	NA
New Orleans	106	1102	1208	NA	NA

*Barge shipments are taken from Waterborne Commerce of the U.S.. Total shipments are estimated as described in textual footnote(*) on the previous page.

TABLE 112

MARKET SHARES BY DESTINATION FOR BARGE TRAFFIC FROM MAJOR PRODUCING AREAS 1974

Producing Area	Pittsburgh	Ohio Valley	Illinois - Indiana	Birmingham	Galveston
Market					
"Local"*	10%	12.4%	14%	42%	76%
Cincinnati/ Louisville	31	("Local")	4	-	-
Galveston and GIWW West	14	33.2	20	24	("Local")
Tennessee/ Cumberland	11	2	14	-	-
St. Louis Area	8	2	13	-	-
New Orlenas/ Delta	9.5	22	15	28	5
Other	16.5	28.4	20	6	19

*"Local" shipments here mean shipments to the immediate area - the Monongahela and Upper Ohio Rivers for Pittsburgh, the Huntington and Louisville districts for the Ohio River, Chicago and the Illinois River for N. Illinois-Indiana, the Warrior River for Alabama and the W. Texas Gulf for Houston.

In the northern water-served markets, the impact of user charges will be some combination of increased freight absorption by producers and increased product prices to steel buyers.* Since the user charges on these flows do not exceed 50 cents per ton on products whose values range from $195 per ton (for steel billets, 1975, Pittsburgh) to $320 per ton (cold finished steel bars, 1975, f.o.b. Pittsburgh) and higher, these impacts are quite small.

Southern markets - particularly along the Gulf between New Orleans and Galveston Bay - received in excess of 1.5 million tons of steel products (including pipe and tube) by barge from the northern producing areas in 1974. (This accounted for an estimated 3 to 4 percent of total shipments from the plants in the producing areas along the northern waterways). This market area is a deficit steel production area which imports large volumes of iron and steel from abroad as well as from other domestic producing areas. 1.8 million tons of steel products were imported through the Houston Ship Channel alone in 1974.

The ability of the producers to pass user charge-related price increases through to customers in this market depends on a number of factors, including the expected response of foreign producers - e.g., whether they would recongnize voluntary import quotas and possibly raise their prices in this market as opposed to seeking an increased market share.**

Diversion of traffic from the waterway could take a number of forms including reallignment of distribution patterns to economize on river transportation as well as shifting modes for delivery to existing markets. Although some traffic shifts

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*Since imports through New Orleans must pay user charges to move upriver into these markets, the net effect on domestic/import competition should be minimal.

**It has been claimed that Japanese producers accept a lower return in U.S. markets in order to maintain high capacity utilization. In such a case, they might take the opportunity to increase prices slightly, especially if they fear that increasing their share of the U.S. market would lead to formal restrictions on their exports to the U.S.

can be expected - obviously more under a uniform fuel tax than under a segment toll - it would be surprising if these were to exceed ten percent of iron and steel ton-miles in a normal year.

There are several reasons for this. In the first place, a large but undeterminable share of steel shipments on the river are moving to distributors, from which smaller lots are shipped to ultimate consumers by truck or rail. Diversion of these flows from water would most likely require movement of the distribution center closer to the plant - a change which would entail increase costs of doing business which would be at least partially off-setting to potential transportation savings. Secondly, because different plants specialize to a certain degree in different products, a fairly high degree of interregional transportation will be forthcoming if corporations wish to compete in broad markets. Thus, U.S. Steel will continue to produce pipe at its Pittsburgh mill, and the Gulf area oil market will continue to be a prime outlet for these goods. Modal diversion for shipments between existing origins and destinations should be minimal. Transportation markets in which the origin and ultimate desitnation of a move are both river points are the least favorable to modal shift.

Unfortunately, the short-comings of the waterborne data and the complexity of steel distribution and pricing make more than these subjective estimates impossible at this time. Most of the user charge impact for iron and steel should manifest itself in market prices and net revenues to producers on this portion of their sales.

6.9 SUMMARY

User charges for the recovery of 100% of Federal OM&R expenditures on the inland waterway system would have small impacts on the cost of producing steel in the areas bordering the river system--a fraction of one percent of total costs even for the worst case. For a variety of reasons, institutional as well as economic, potential diversion from the river of raw material inputs to this industry is small although three major flows which might be susceptible to mode or source shifts are identified. These include the flow of ores, ferromanganese, and from the Gulf to the northern producing areas (2 million tons and 3 billion ton-miles in 1972), metallurgical coal from West Virginia to Houston (a quarter to a half million tons annually), and iron ore on the Warrior River (3-4 million tons and 30 percent of that river's ton miles).

Multi-plant production strategies and the nature of the steel distribution system will act to prevent most of the iron and steel products moving on the river from diverting to other modes. The bulk of the impact of user charges on the iron and steel industry will be manifested in localized price effects (in water served) markets and/or losses in net revenue to the producers for those shipments. The balance of impacts between market price and producer's revenue will be specific to each producer, product, and market, but in any case, the impact will be small-a fraction of one percent of the value of most products.

Because most of its traffic (especially the long-haul portion) in both raw materials and finished products is on main stem rivers with lower-than-average segment tolls, the iron and steel industry would be impacted much more adversely by a uniform fuel tax than by a segment toll. For most moves--with the prominent exception of the Warrior River traffic, which is indifferent between the two schemes--the uniform fuel tax is 50-100 percent higher. The long haul flows of ore, coal, and products discussed above would be impacted hardest by this differential.

7. SAND AND GRAVEL TRAFFIC IMPACTS

7.1 INTRODUCTION

In 1974 the amount of sand and gravel consumed in the United States totaled 979 million tons. Ninety-seven percent of this material was used in the construction industry. Table 113 presents a detailed breakdown of the final uses of sand and gravel in construction projects.

Due to the highly competitive nature of the industry (sand and gravel supplies are abundant in most areas) and the low value of the material ($1.50 to $2.50 per ton depending on the quality and region of the country), sand and gravel distribution occurs in very localized markets; thus traffic generated consists almost entirely of short-haul shipments. It follows that water and rail transport play a minor role relative to trucking. The share of each mode in sand and gravel deliveries to site of use is demonstrated in Table 114,

The vast majority of water shipments of sand and gravel originate at dredging facilities. Generally, the short-haul nature of shipments does not make it economically feasible to quarry on land, deliver to barges, ship by water, unload barges, and transfer to truck again. The cost of two transfers coupled with the shrinkage factor usually makes such an operation prohibitively expensive. The sand and gravel produced from navigable riverbeds is the major concern of this report.* Responses to a Bureau of Mines Survey indicated

*The supply for Minneapolis, the Quad Cities, and Chicago are exceptions to this.

TABLE 113. FINAL USES OF SAND AND GRAVEL*

Use	Quantity (000's tons)	Percent
Processed:	727018	77
Concrete Aggregate:		
Nonresidential and residential construction:	224842	24
Highway and bridge construction;	73515	8
Other construction (dams, waterworks, airports, etc.);	19615	2
Concrete products (cement blocks, bricks, pipe, etc.):	71762	8
Bituminous paving (asphalt and tar paving):	143764	15
Roadbase and subbase:	147342	15
Fill:	31290	3
Other:	14888	2
Unprocessed:	222671	23
Fill:	109670	11
Roadbase and subbase:	113001	12

*Preprint from the 1974 Bureau of Mines Minerals Yearbook - Sand and Gravel, United States Department of the Interior, Page 10.

TABLE 114. METHOD OF TRANSPORTATION TO SITE OF USE*

	1973		1974	
	000's Tons	Percent	000's Tons	Percent
Truck	904,864	92	856,996	88
Rail	41,641	4	54,158	5
Barge	32,686	3	24,421	2
Not shipped, used at site	-		36,382	4
Unspecified	4,438	1	6,797	1
TOTAL	983,629	100	978,754	100

*Preprint from the 1974 Bureau of Mines Mineral Yearbook - Sand and Gravel, United States Department of the Interior, p. 19.

Note that this table accounts only for the mode of delivery to the consumption site. Total barge shipments are thus understated since many dredging operations ship material to land and then to site of use by truck.

that 62 percent of sand and gravel production in 1974 came from dry pits, 27 percent from wet pits on land, 6 percent from non-navigable riverbeds, 4 percent from navigable riverbeds, and the remaining 1 percent from lakes, bays, and oceans. Total shipment of sand, gravel, and crushed stone on the Mississippi River system was 33.31 million tons in 1974 (as reported by the Army Corps of Engineers). Tonnage of crushed stone is not separable in this data. Crushed stone requires a different framework of analysis than sand and gravel since, as previously noted, almost all sand and gravel moving on the waterways is dredged whereas crushed stone is quarried on land, transported to barge, and then shipped. Shipments of crushed stone generally move longer distances and marketing patterns are not easily identifiable. This analysis will be devoted mainly to sand and gravel; crushed stone will be only briefly considered.

The cost of barge transport relative to trucking costs is the main determinant of whether a sand and gravel company will find it profitable to dredge. Dredging is a much more expensive means of obtaining sand and gravel than is drilling and blasting at land based operations. In addition to the high cost of extraction there are at least three other costs associated with working a riverbed. First, a company is often required to go through a fairly lengthy and expensive process to acquire a permit. For example, a company first has to file application with the Army Corps of Engineers. Next, they have to seek approval from the state which may consist of consultations with the Water Quality Division, the Fish and Game Department and the Department of Conservation. Federal approval (Department of the Interior) has to be obtained. The company must also deal successfully with any objections by private citizens in the affected area. Recently, the additional task of filing an environmental impact statement has been imposed. Permits must be renewed every one, two, or three years depending on the original conditions set forth. Policies for obtaining a permit vary from state to state but they can contribute significantly to fixed costs in dredging. A second cost associated with working a riverbed is the leasing of property for mineral rights. It is often the case that a company must pay property owners on the waterfront for the privilege of dredging in their area of the river. Third, payment of royalties to the state legally owning the river is required in many areas. This may add 2 to 3 cents a ton to the cost of production depending on the specific river segment and the quality of material. Extraction costs for land based operations are much less in comparison to dredging costs; the level of associated costs are also much higher when the waterways are the source of supply rather than inland quarries. Companies that dredge are able to compete in the same market areas with companies that drill and blast since the cost of barge transport is very inexpensive relative to trucking costs. The differential in transportation costs creates a balancing effect for the differential in production costs making the two types of operations price competitive in major market areas.

Diversion impacts resulting from the imposition of user charges vary greatly depending on the river segment in question. There are two important general scenarios which are unique to the market area being studied. First, consideration must be made of the existence of competition from inland sources, that is, landlocked pits and quarries (this relates directly to the previous discussion of comparable delivered price by barge and truck). In many urban areas pits are located sufficiently close to the site of consumption so to be very competitive with sand and gravel supplied by people utilizing water transport. In many cases, one cent a ton may mean the difference as to which producer obtains the contract. User charges in several areas are high enough to drive a good portion of sand and gravel tonnage off the river. Two important factors exert an influence on how smoothly this transition could occur - these are capacity and quality. Capacity constraints exist in some areas since inland quarries within the competitive range do not always have the ability to expand to a desired level of output. Quality constraints may also be a problem since river sand is often of much higher quality than land sources and it is often the case that specification standards will dictate the choice of the source.

The second scenario pertains to the market area in which delivered price is determined by competition from other water sources and not from inland pits. This occurs when sand and gravel supplies are scarce in a given area. Within certain limits a price increase will simply be passed on to consumers of sand and gravel resulting in an inflationary effect in that particular region. The impact may not be the same on all suppliers of sand and gravel however. The increased cost will be greater for someone whose production is based on a 30 mile move than for someone who ships only 20 miles; he will in turn lose some fraction of his market share. A second area of concern regarding differential impacts for water based operations is when industrial complexes with high demand are located at the junction of two rivers with very different segment tolls. For example, the major supply of sand and gravel in the Pittsburgh area comes from the Allegheny and Ohio Rivers. It would cost 72 cents per ton to transport sand and gravel 50 miles on the Allegheny River but only 2 cents per ton to ship the same distance on the Ohio. Theoretically, dredging operations would be phased out on the Allegheny and moved to the Ohio. The reality of this situation will be discussed in a later section.

In our second scenario if the price increase due to increased barge costs becomes great enough, a tipping point will be reached at which time inferior products will be substituted for sand and gravel in the construction industry (this is also important in scenario one when capacity and quality constraints preclude the ability for land based operations to overtake the entire sand and gravel market). For the most part, limestone, sandstone, and manufactured sand can be used interchangeably with sand and gravel. The major exception to this is when construction specification standards require the highest quality inputs. The difficulty with limestone is that it is not suitable in highway surface material since it has a tendency to polish and be slippery when wet. Anti-skid requirements must be met by reducing the calcium carbonate content to the desired level through mixing with high quality material. There is currently also some question regarding the durability of cement which has been manufactured from limestone. Manufactured sand, ground from stone, has problems with hardness specification although a wet process sand has proved to be very successful (it is quite expensive to produce however). In a very small percentage of cases, inferior products may not be substituted for river sand and gravel because of aesthetic considerations (brown is considered more desirable than a whitish tint in surface material). Generally, for most construction projects, limestone, sandstone, and manufactured sand are considered substitutable for the higher quality river sand and gravel.

The Missouri River is probably the classic example for demonstrating how operations and maintenance by the Army Corps has adversely affected the sand and gravel industry. Control of the river* has ruined sand deposits; the industry could not only survive but would be improved were the Army Corps to cease work on the Missouri River.

7.3 THE ARKANSAS RIVER

On the Arkansas River 36% of tonnage is accounted for by the sand and gravel industry (2.19 million tons of 6.00 million). The market situation closely parallels that of the Missouri River: sand is scarce; limestone dominates the major portion of the gravel market; hauls are very short, probably averaging about 4 miles. Several companies operate at the source of the river, that is, in the Tulsa area. The river is not navigable in this area but it is interesting to note that some companies dredge at a maximum of 300 feet from their yard. This may be due to several factors but one that should not be overlooked is the fact that the river is not maintained.

In the Ft. Smith region sand dredged from the river serves as an input for asphalt. Shipments may move a distance of 7 to 8 miles which would cost on the order of 25 cents a ton under the imposition of a segment toll. The availability of an alternative supply for sand is dubious however and traffic diversion would be unlikely.

Shipments in the Little Rock area move a maximum of 2-3 miles, an additional cost of 7 to 10 cents under a segment toll recovery scheme. Sand is very scarce in this region; competition is thus supplied by other producers dredging

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*COE channel maintenance activities are concentrated in areas of sand accumulation on the river.

the river. Gravel, only 10% of the production of the river, would probably be affected by substitution of limestone and sandstone. Sand is shipped from the Little Rock area by truck up to distances of 100 miles. This is indicative of the lack of an alternative source for a sand supply. Pits have a product of much lower quality and at this time lack the capacity to meet the construction demand. It is thus likely that the additional cost would be added on to the delivered price with no significant change in distribution patterns. The tipping point when inferior products will be largely substituted for sand and gravel cannot be estimated but if other traffic leaves the river due to high tolls it may well be within range. It is safe to speculate that the uniform fuel tax would have no effect.

If the river were not maintained dredge operators would benefit as in the case of the Missouri River. People noted that they were operating on the river before locks and dams had been constructed.

7.4 THE UPPER MISSISSIPPI

The Upper Mississippi (Cairo to Minneapolis) is used for the transport of construction aggregates rather than simply as a source as in the case of the Missouri and Arkansas Rivers. Sand and gravel represents a small share of tonnage moving on this segment, only 3 percent (3.60 of 131.47 million tons). Ton-miles generated by sand and gravel traffic are estimated to be less than 1/2 of one percent of all ton-miles on this segment.

In the Minneapolis-St. Paul area about 1/4 of the sand and gravel demand is supplied by material moving on the river (approximately 2 million tons). This sand and gravel is quarried on land at distances ranging from 10 to 30 miles and shipped by conveyor systems to barges that then carry the material to docks in the metropolitan area to be unloaded and transported by truck. The vast majority of it is consumed in redi-mix concrete and blocks. An abundant supply of sand and gravel exists on land and competes in this market. The sand and gravel is of the same quality and quarries are able to expand their capacity quite easily. In short, the market for sand and gravel in the Minneapolis-St. Paul area is intensely competitive.

Added barge costs on the order of 1 to 3 cents would make a significant difference in this area. Sand and gravel being supplied from downstream by barge holds the inland quarries supplying the metropolitan area at their current capacities. Passing these costs on to customers would divert this traffic from the river. One option would be absorption of these costs by the downstream producers. The extent to which this could and would be done is not known.

The second market region that needs to be analyzed on the Upper Mississippi is the Quad City area (Davenport, Bettendorf, Moline, and Rock Island). The river in this area is again used only for the purpose of transport. Dredging is the source of supply but it occurs on private property adjacent to the river. Barges may be filled with dewatered sand moving on a conveyor system or filled directly and moved onto the waterway. Shipment distance is generally 20 to 30 miles.

About 2/3 of the sand and gravel serves as input in the concrete market while the remainder is consumed for fill sand and gravel. The fill sand and gravel moving on the river appears to be easily divertable since pits and quarries in the area are already competitive and limestone plays a major role in the market. Quality considerations indicate that inland producers are not a major threat in the sand market - water competition dominates as a supply source.* A certain level of user charge would bring manufactured sand into the market though it is doubtful that an increase of 2 to 3 cents per ton for river sand would cause this shift.

7.5 THE ILLINOIS RIVER

The situation for the Illinois River is analogous to that of the Upper Mississippi. It functions as a transport mode for the most part and not as an area for dredging activity. Sand and gravel contributes a relatively small share to total tonnage moving on this waterway - the 2.31 million tons in 1974 accounted for 6 percent of the traffic. A third similarity is that sand and gravel supplied by barge to the Chicago area is intensely competitive with truck delivery as was found to be the case in Minneapolis.

Most of the sand and gravel moving on the river is dredged on private property, loaded onto barges, and shipped on the river to stockpiles in the Chicago area. Transportation plus transfer costs coupled with loss due to shrinkage in this operation makes delivery from stockpiles barely competitive with direct delivery by truck from outlying areas.

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*One shipper expressed concern over a lockage fee since he moves through two locks while his competitor uses only one lock although they ship approximately the same distance.

The length of haul on this river is much greater than any we have discussed so far. Sixty miles is probably a good estimate of the average shipping distance into the Chicago area. This is equivalent to a 5 cent increase in barge transport by either a uniform fuel tax or a segment toll. The quality of sand is apparently not a significant factor in the determination of the supply source. Capacity problems appear to be nonexistent since there are a large number of quarries in the Chicago area that can be easily expanded while several untapped sources are available. Implementation of a user charge on this river would probably mean a large amount of traffic diversion from the river to land based sources utilizing truck delivery.

7.6 THE OHIO RIVER AND ITS TRIBUTARIES

The Ohio River and its tributaries serve the sand and gravel industry as both a source of material and an important mode of transport (this is in contrast to the Missouri and Arkansas which serve only as a source and the Upper Mississippi and Illinois which are used only for transportation). Operations on these rivers usually involve a plant on the dredge for processing and direct loading of a barge with finished product. Barges then commonly ship the material 60 to 100 miles to stockpiles. Trucks are used to move the material to consuming sites. Table 115 lists the Ohio and four tributaries* with the tons of sand and gravel on each river, the percentage of total tonnage of all commodities, the rank of sand and gravel among commodities moving on each river, and the percentage of total ton-miles. All data are for 1974.

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*The Cumberland and Tennessee Rivers will be discussed separately.

TABLE 115. THE OHIO RIVER AND ITS TRIBUTARIES.

River	Tons (millions)	Percent of Total Tonnage	Rank Among Commodities	Percent of Total Ton-Miles
Ohio	17.21	12	2	3-5
Allegheny	1.63	29	2	28-47
Monongahela	1.56	4	2	2
Kanawha	1.64	13	3	14-17
Kentucky	.65	100	1	100

The Ohio River is by far the major source of sand and gravel among the navigable waterways. The interaction of the rivers (many producers dredge the Ohio to supply urban areas located on the other rivers) makes discussion by market region the most fruitful approach. The most important region is the Pittsburgh area at the junction of the Ohio, Allegheny, and Monongahela. About 1/2 of the sand and gravel dredged on the Allegheny moves into the Pittsburgh area while the remainder is consumed along the Allegheny. Sometimes shipments may go as far as 50 miles but 25 miles is probably closer to average - the destination in most cases is concrete plants. The segment toll would be on the order of about 35 cents a ton for most of these shipments. There are many land-based operations in the Pittsburgh area; one estimate was that 1/2 of the traffic would be diverted to these facilities while another company speculated that a toll of this magnitude would make sand and gravel shipped by water totally non-competitive in the Pittsburgh region. Another important supply area for Pittsburgh is the Ohio River in Hancock and Beaver Counties. The segment toll for this river would be 2-3 cents per ton. Inland sources would again pose a threat to this traffic but it is doubtful that they would lose very much of their market share. One important point is the fact that a segment toll may tip the markets so that sand and gravel supplied by water comes entirely from the Ohio and none is shipped on the Allegheny. In reality it appears that the market competition of inland sources dominates this situation and the scenario just described would not be feasible for two reasons. First, there is limited dredging capacity on the Ohio in the area that potentially can serve Pittsburgh. Tha area does not offer an indefinite supply of material for natural reasons as well as because of the large amount of dredging that has gone on there. Second, the length of haul that would be necessary to meet the demand would tie up the barges for such long periods of time that the operation would not be profitable. In sum, it appears that a substantial amount of traffic on the Allegheny would be diverted to inland sources while land operations would also reduce traffic on the Ohio to some extent but the effect would not be nearly as severe.

The Monongahela is a special case since little or no dredging is possible on this river. This is due to its soft shaly bed that is unfit to serve as a supply of sand and gravel. It appears that the source of sand and gravel on this river is both the Allegheny and the Ohio. Traffic diversion may again result due to competition from land-based operations.

As one moves south on the Ohio to the area of the river owned by WV. (particularly the region fed by the Kanawha) sand and gravel shipments are characterized by a longer length of haul, in some cases it may be as much as 300 miles. Most of this material moves into the St. Albans-Charleston area on the Kanawha. The Kanawha itself is not used as a source of sand and gravel for several reasons. First, it is a very dangerous river on which to operate. It is a fast river and is particularly hazardous during periods of heavy rain due to the swiftly rising Elk River which intersects the Kanawha at Charleston. Second, its ability to rise quickly leads to unpredictable depths. Often the river may be too deep for suction dredges to maintain contact with the bottom. A third deterent is that companies must lease mineral rights from land owners who own property along the Kanawaha and it appears that these are expensive and rarely can profitable leases be obtained. As a result sand and gravel producers must dredge on the Ohio and ship into the region served by the Kanawha. The need for this system of distribution dictates a minimum shipping distance of 75 river miles. Combined with the fact that sand and gravel supplies are poor near the mouth of the Kanawha, the total distance may be as much as 300 miles and probably averages 125-150 miles. Producers are currently developing land plants that will load barges and then ship similar distances. Capacity and quality insure the need for this long-haul. The poor transportation system in the Charleston area plays a major role in making this form of distribution feasible. Very little sand and gravel moves by rail in this area since the railroads find coal to be a much more profitable shipment. Trucking is not very popular either due to the poor roads that are not really able to handle the quantity of shipments that are demanded.

The heavy competition between suppliers of sand and gravel by water would mean that a user charge would probably be directly passed on to consumers of sand and gravel with little shift to alternate sources of supply. It is quite possible however, that the longer hauls may be phased out by more intensive dredging closer to the consuming area or by land quarrying with transfer to barges. A small percentage (one estimate is 10%) of the water traffic may be shifted to the trucking mode from alternative sources of supply.

On the lower Ohio River from Cincinnati south to the Cumberland River the average length of haul decreases to a range of 5 to 40 miles. Land based operations are a viable source of sand and gravel in this area but the competition is not as intense as that observed in some areas. Some traffic may be lost to this alternative supply but the extent to which this shift will occur cannot readily be determined.

The Kentucky River (the Frankfort region) relies on the Ohio River as a source of sand and gravel. The circumstances are much the same as those on the Kanawha River. Rail cars are not available and trucking is feasible but is not desirable in this area considering the volume of movement coupled with the highway circuity factor. The problem on the Kentucky River is the size of toll however. Whereas moving sand and gravel to Charleston would cost 15 cents per ton by a segment toll, shipping into the Frankfort area would cost $2.30 per ton. One customer receives all of the sand and gravel moving on the Kentucky River which is also the total tonnage moving on that river. As a result this movement must bear the cost of the entire river in spite of the fact that it utilizes only four of the thirteen locks and dams that have been constructed on the river. Modal diversion is almost a certainty in this case. Truck would be able to serve this market at a lower cost, especially since much of the traffic could be in the form of a coal back haul. Secondary impacts due to some traffic leaving the river and increasing the toll for the remainder of the traffic are dramatic due to the fact that 100 percent of the ton-miles are generated by this sand and gravel shipment. If 1/2 of the sand and gravel could be supplied at a lesser cost by truck than by barge when a user charge is added, then the segment toll for the remaining traffic would amount to $4.60 per ton. This would force additional traffic off the river and one can foresee that eventually this escalation process would drive all the tons of sand and gravel off the Kentucky River.

7.7 THE TENNESSEE AND CUMBERLAND RIVERS

The Tennessee River is an important source of sand and gravel for the major urban areas located on or near this river. However, it is not generally considered to be a good source due to the limited availability of sand and gravel deposits (the Cumberland is not dredged at all - it serves only in the transport of material). In many areas, high dams, constructed with the intention of pool formation, have resulted in lakes in which the depth is too great to allow ready recovery of sand and gravel. Dredging in the rivers is expensive and must compete with the alternative supply of tremendous limestone deposits in Central Tennessee.

Sand, gravel, and crushed stone shipments on the Tennessee River account for 14% of total tonnage on that river in 1974. In the vicinity of Perryville, Tennessee and Huntsville, Alabama, the average length of haul is approximately 5 miles. In the Chattanooga area producers must go about 65 miles from their yards to find ample deposits of the quality of sand they are seeking. Limestone quarries are intensely competitive in all three of these areas and producers believe that one cent a ton may result in traffic diversion from the river. Profit margins are very slight due to alternative supplies and some companies have reported that operating on the river is already becoming a losing proposition. The result is that consumers will turn to inferior quality materials (limestone) to meet their product demand at a low cost.

Sand, gravel, and crushed stone moving on the Cumberland River is dredged, processed, and loaded onto barges just a few miles below its confluence with the Ohio River. The barges are transported to several distribution points along the Cumberland River - the majority (85%) is delivered to the Nashville region, about 200 miles from the source of the material. Sand and gravel traffic amounted to 23% of total ton-miles on the Cumberland River in 1974. The segment toll would mean an additional cost of 40 cents a ton for the 200-mile haul. One company stated that a user fee of this magnitude would have wiped out all profit in 1974 - this cost represented 40% of the average delivered price of sand and gravel.

The real question regarding traffic diversion on the Cumberland, as well as on the Tennessee, is to what extent limestone is substitutable in the construction industry. It is safe to assume that the cheap mining and processing costs of limestone will create substantial diversion in these market areas but that river sand and gravel will continue to be used when high quality material is required.

7.8 GULF INTRACOASTAL WATERWAY

In 1974 sand, gravel, and crushed rock moving on the GIWW West totaled 2.17 million tons. About 84% of these shipments (1.81 million tons) originated in the Victoria, Texas harbor. The principal destination for this material was the large Houston, Texas market - a distance of approximately 150 miles by water. The uniform fuel tax and the segment toll are almost equivalent on the GIWW West - thus either charge would add an additional 12 cents to the cost of this shipment.

The two major suppliers in the Victoria region compete in Houston with limestone produced and shipped from the inland areas of New Braunfels and Georgetown (150-180 miles). Shipments from these areas are both by truck and rail (in some cases unit trains are utilized). Giving consideration to price and quality, the product received from both Victoria and inland areas is very competitive in the Houston market. It is the opinion of one of the major shippers utilizing the GIWW that any increase in water transportation costs would seriously curtail the water movement of sand and gravel.

7.9 THE COLUMBIA AND WILLAMETTE RIVERS

In the Northwest, specifically in the Portland-Vancouver area where most of the sand and gravel shipping occurs, the situation closely parallels that which was discussed in the Pittsburgh area. Two rivers, with very different user charge tolls, supply a major industrial complex with high demand for sand and gravel. Most of the competition is from alternative suppliers who utilize the river but the potential is there for competition from land-based operations. The average haul on the Columbia is about 10 miles (3.5 cents per ton) while the haul on the Willamette, although 1/2 the distance, is much more expensive (15 cents per ton). Sand and gravel tonnage is negligible as a proportion of total tonnage moving on the Columbia River whereas it is substantial on the Willamette representing about 70 percent in 1974 (in 1973 it was about 85 percent).

The level of diversion to inland sources cannot be determined at this time although it seems there would be some problem with capacity as well as with the ability to meet specification standards. As was found for the Pittsburgh area, the differential level of tolls would not divert traffic from the Willamette to the Columbia. The Columbia in the Portland area is a source of soft rock that has limited usefulness due to its inability to meet hardness specifications. A substitutable rock could be acquired on the Columbia River at some distance from Portland but the increased barge costs would not make this traffic competitive with that on the Willamette.

7.10 OTHER RIVERS WHERE SAND AND GRAVEL TRAFFIC WILL BE SIGNIFICANTLY IMPACTED BY USER CHARGES

On a few rivers other than those that have been analyzed it is quite obvious that a segment toll will significantly reduce the amount of sand, gravel and crushed stone traffic, thereby substantially affecting the total traffic on these rivers. Unfortunately, no contact has been made with firms utilizing the rivers in question but the impacts can be deduced by the size of the tolls being considered (when viewed relative to the value of the product).

The Kaskaskia is used only for the movement of sand, gravel, and crushed rock.* The level of the segment toll is .2344 dollars per ton-mile. The average length of haul on this river is 10 miles meaning that each ton would be forced to bear an additional cost of $2.30. This is more than the value of sand and gravel and all of the traffic would be forced to leave the river. This case may be analogous to that of the Missouri and Arkansas Rivers in which producers of sand and gravel using the Kaskaskia may benefit were the Army Corps to cease maintenance activities on the river.

In 1974 sand, gravel, and crushed stone accounted for 86 percent of the traffic on the Alabama-Coosa Rivers (1.8 of 2.1 million tons). The segment toll for these rivers is 8 cents for 10 miles. This is probably of great enough magnitude to eliminate a large portion of traffic but a definite statement cannot be made without determination of the average length of haul.

A third area that will be affected by user charges is the Apalachicola, Cattahoochee, and Flint Rivers. Almost 40 percent of the traffic on these rivers in 1974 was gen-

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*The Kaskaskia is also used to transport a small tonnage of waterway improvement materials but these amount to less than 1 percent of the traffic.

erated by the movement of sand and gravel. The toll calculated on a segment basis is .0342 dollars per ton-mile. As with the Kaskaskia, the magnitude of the toll insures a high probability (in light of the low value per ton) that the sand and gravel traffic will be diverted from the river.

7.11 RELATED PRODUCTS

Some discussion should be made of other commodities related to sand and gravel that are shipped on the river. Some moves of very long distance have been found: crushed stone shipped 600-700 miles on the Ohio to the Pittsburgh area; lightweight aggregate transported by water from the Illinois River (Chicago area) to St. Louis and Buffalo; sand shipped from the St. Louis area to Chicago and Memphis. Generally, this material is of high value of its characteristics make it useful for very specific functions, such as exterior building surfaces and as replacement for steel in certain structural designs. Its uniqueness allows it to be transported long distances and still be marketable in the consumption areas that have been identified. However, inquiries lead to the conclusion that user charges will drive these products from their markets and they will be replaced by substitutable materials though they may be of somewhat inferior quality. Tonnage figures of these special materials and an accurate quantification of potential diversion is not possible at this time.

7.12 SUMMARY

Strictly in tonnage terms, it appears that sand and gravel is a highly divertable commodity. Intense competition from inland quarries as well as from substitutable products jeopardize the current levels of water based traffic if a user charge is implemented. This is particularly true on the Upper Mississippi, Illinois, and Allegheny and on specific portions of the remaining rivers. Capacity and quality constraints assure that a certain percentage of dredging activity will continue.

Since sand and gravel are generally shipped very short distances on the waterways, the total ton-miles on most rivers should not decrease significantly if large tonnage losses occur. On the Missouri River a 43 percent reduction in tonnage means a 1 percent reduction in ton-miles (the Willamette, Allegheny, Kentucky, Kaskaskia, and the Apalachicola, Chattahoochee, Flint Rivers may be severely impacted however). If much of this traffic leaves the river system, secondary impacts due to increased tolls should be minimal.

It should be remembered that the sand and gravel industry assists the Army Corps of Engineers in their tasks of keeping our waterways navigable. In light of this fact, some thought should be given to the question of whether they should be charged on a basis similar to other industries.

In conclusion, traffic diversion estimates vary widely depending on the characteristics of each market region. Based on information acquired from producers the following reductions in sand and gravel tonnage on each river have been predicted: Arkansas and Kanawha Rivers, 10-15% loss in tonnage; Ohio, Columbia, and Willamette Rivers, along with the Upper Mississippi, 25-30% diversion; Missouri, Illinois, Allegheny, Monongahela, Cumberland, Tennessee, Gulf Intracoastal Waterway, and Alabama-Coosa Rivers, 50% loss in tonnage; and 100% of the sand and gravel traffic would probably be diverted from the Kentucky River, the Kaskaskia, and the Apalachicola, Chattahoochee, Flint. These estimates allow one to calculate corresponding reductions in total ton-miles on each river by using them in conjunction with data on the current percentage of ton-miles accounted for by sand and gravel (figured on the basis of average length of haul). Percentage decreases in total ton-miles on each river due to the predicted losses in sand and gravel traffic are as follows: Upper Mississippi, 0.1%; Columbia, 0.2%; Arkansas, 0.2-0.3%; Missouri, 0.5%; Illinois, 1.0%; Monongahela, 1.0%; Ohio, 1.0-1.5%; Kanawha, 1.5-2.5%; Tennessee, 2.0%; Cumberland, 12.0%; Allegheny, 15-25%; Willamette, 20-25%; Kentucky, 100%; and Kaskaskia, 100%.*

*Estimates cannot be made for the Alabama-Coosa and Apalachicola, Chattahoochee, and Flint since the average length of haul on these rivers has not been determined.

8. CHEMICAL TRAFFIC IMPACTS

8.1 PETROCHEMICAL

The petrochemical industry is particularly difficult to analyze because of its interrelatedness. There are various raw materials, a large number of intermediate products, and innumerable end use products which may reach the ultimate consumer in almost any form -- fabric, paint, plastics, drugs, detergents, anti-freeze, and packaging to name only a few very broad product categories. There are almost always alternative paths to a given final product (certainly to substitutable products), beginning with either LNG, crude petroleum, or, to a historically decreasing extent, coal; passing through differing chemical process chains with different intermediate inputs and by-product outputs. The relative economic values of the various by-products may be the decisive factor in choosing a route to a given final product.

The industry is also characterized by a high degree of vertical integration with consecutive processing steps often at one site or adjacent sites. A large share of the intermediate output of the petrochemical industry is, therefore, used within a single firm, and, because of the large fixed capital component of the industry, the long-term contract is the most desirable form of sale when products are sold to other parties.

For reasons of raw material access, the petrochemical industry is concentrated in the Gulf area, and to a lesser extent, on the other coasts. The pattern of inland waterway movements of petrochemicals, insofar as it is identifieable in the waterborne commerce data, is described below. Anhydrous ammonia and other nitrogenous fertilizer materials are dealt with in another chapter and so are not treated here.

8.2 BENZENE AND TOLUENE (Commodity Code 2817)

Benzene and toluene, members of the chemical group known as aromatics, are primarily derived from petroleum refining.* These two aromatics are closely related, not only because they are produced from the same coke oven and petroleum sources, but also because the principal chemical use for toluene is the manufacture of benzene. (Its chief use overall is as an octane booster for gasoline - especially given the removal of lead from the gasoline pool.)

Unlike toluene, benzene has a broad range of uses in petrochemical production including - styrene (for synthetic rubber), phenol, cyclohexane, and aniline.

Of the almost 3 million tons of benzene and toluene moving on the Mississippi River and GIWW system, about 90 percent originated in the Gulf area - from Baton Rouge to the Mexican border - with more than half originating between the Sabine-Neches Waterway and Galveston Bay alone. Most of this traffic is relatively short-haul between petrochemical facilities, with less than twenty percent leaving the Gulf area. The largest single flow of benzene and toluene identified in the waterborne data is within Galveston Bay, between the Houston Ship Channel and the Texas City Ship Channel.

Of the roughly ten percent of benzene and toluene traffic originating in the upper part of the river system (most at the extremities - Chicago, Pittsburgh, and Minneapolis), more than one-third is destined for the Gulf area. The rest is shipped relatively short distances within the Ohio, Upper Mississippi, and Illinois subsystems.

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*As much as 10% of the U.S. aromatics are still derived from coal tar, a by-product of coke production.

User charges would obviously vary widely depending on the nature of the move. The heavy intra-Gulf moves would bear tolls ranging from a few cents per ton for the very short transfers between facilities such as those in Galveston Bay up to twenty-five cents for the longer (300 mile) movements. There is little to chose between the segment toll and fuel tax approach in this area since the GIWW West carries a toll which is close to the average system toll (.76 mil per ton mile as opposed to .8 mil). (For Gulf area movements involving the Lower Mississippi River, the segment toll is slightly advantageous).

For the lower volume long-haul shipments on the other hand, the fuel tax imposes a distinct disadvantage because the flows include a long segment of the low cost Lower Mississippi River, and do not utilize the highest cost segments to any significant degree. Thus, while the segment toll from the Beaumont, TX area to the Pittsburgh area is 82 cents, the fuel amounts to $1.60 per ton. These tolls compare to a product value in 1976 of about $200 per ton for benzene and $150 for toluene.

Traffic diversion can potentially take many forms. In the first, and most traditional sense, the same origin-destination flows could be served by alternative modes. Several factors would seem to argue against this form of diversion in this case. First, the bulk of the moves appear to have true origins and destinations corresponding to waterway origins and destinations (i.e., unlike grains, the producers and consumers of the shipped commodity are both located at river points). Such moves are normally the least subject to competition from other modes except when extremely high value or inadequate shipment size dominate the modal decision.

In a 1974 study* for the Maritime Administration, A.D. Little, Inc. analyzed the economics of a short-haul, intra-Gulf benzene flow -- about 134,000 tons annually between Port Arthur, TX and Beaumont (26 miles). The shipment cost by barge was indicated to be $2.42, compared to complete shipment costs by rail and truck of $7.00 and $12.20, respectively. The two cent user charge for this move would appear to have a negligible impact on the modal economics of such a move.

The same study also analyzes a movement (200 thousand tons annually) of styrene, a benzene-based intermediate, from Galveston Bay to Addyston, Ohio, a distance of 1500 miles. While the barge costs were found to be relatively high (8.90-9.40) because of requirements for specially insulated barges, the study shows a rail cost of $25.00 per ton, presumably including the significant investment cost of specialized rail tank cars. These examples, and the fact of existing investments in private equipment and transfer facilities argue against significant diversion from water shipping and receiving patterns for existing facilities.

A second, more subtle form of diversion, would involve a restructuring of origin-destination patterns to economize on water transportation.** In this case, market purchases would be more sensitive to the transportation component of delivered price, and inter-facility, intra-firm barge shipments might conceivably be replaced by market purchases at the receiving end and sales on the shipping end. If there is

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*<u>A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk</u>, July, 1974.

**This would manifest itself in a decrease in barge ton-miles, but not necessarily in a decline of tons. Revenue losses would be less than proportional to ton-mile losses.

any possibility for this form of diversion, it would most likely occur on the long-haul moves, the potential savings on the intra-Gulf area movements being relatively small. This type of change would require the pre-existence of significant, unnecessary cross-hauling of similar commodities - a phenomenon which cannot be identified given existing waterborne data.

A final form of potential traffic loss would result from substitution among processes or commodities. This might involve increased use of coal based chemicals in the Ohio Valley (assuming there are unused, economic sources), or increased shipment of higher intermediates or final products by the same or other modes. Significant diversion of this sort, which is more probable in the long than the short term, is not highly likely at the user charge levels presently being proposed.

8.2.1 <u>Alcohols</u> (Commodity Code 2813)

The only other petrochemical group identified on an origin-destination basis in the waterborne commerce data are the alcohols. This group serves a wide variety of functions, especially as commercial and pharmaceutical solvents, as a source material for a broad range of organic chemicals, and as a component of anti-freeze mixtures.

Methanol, with 1976 production levels equal to about 2 1/2 million tons, is used throughout the synthetic fiber industry as well as in the production of formaldehyde - a key intermediate in the production of plastics. Methanol along with ethylene glycol (1.8 million tons produced in 1976 for use in anti-freeze and, to a lesser degree, polyester fibers, film, and latex paints), isopropanol (900 thousand tons used principally for acetone and miscellaneous chemical production), and ethanol (750 thousand tons) account for the greater part of synthetic alcohols production in the U.S.

As in the case of benzene and toluene, alcohols production is concentrated in Texas and Louisiana. This is reflected in waterway traffic originations, with more than 85 percent of originations occurring in the Gulf area, and most of that (80 percent of total barge originations) in three smaller areas - Galveston Bay (almost 40% of inland waterway originations), the Sabine-Neches waterway (about 18 percent), and the Mississippi River between New Orleans and Baton Rouge (24 percent). Unlike the aromatics discussed earlier, however, almost half the movements from Gulf origins are destined to points above Cairo, IL. About one-third of the alcohols from the Houston area go north, primarily to the Kanawha and Ohio Rivers and Chicago, while almost two-thirds of the Louisiana shipments were destined for the Lower Ohio River, Chicago, and, to a lesser extent, the Kanawha and Upper Mississippi Rivers.

As in the case of benzene and toluene, the segment toll approach puts a smaller burden on alcohols shipments than the fuel tax. On a shipment from Baton Rouge to Cincinnati, for example, the segment toll of 37 cents per ton compares to a uniform systemwide tax of 99 cents. Clearly, whatever potential traffic impacts or inflationary impacts might exist would be accentuated under the latter scheme.

The A.D. Little study referenced earlier analyzes two movements of alcohols - a long-haul (1700 mile) movement of methanol from Beaumont to Belle, W. Va (on the Kanawha), and a medium haul flow (335 miles) of ethylene glycol from Belle, WV to Pittsburgh. The methanol move bears an estimated shipment cost of $6.88 per ton compared to $37.00 for rail. Although this rail cost seems quite high, rail transportation between these areas has been found to be quite costly -- an all-rail coal move in the opposite direction was found to be non-competitive with a rail-barge-rail move costing almost twenty dollars per ton -- and although the rate might be negotiable downward if serious effort were extended, modal diversion of this move would appear highly unlikely. Heavy investment requirements in rail tank-cars and transfer facilities only reinforce this conclusion.

The A.D. Little estimates show a less dramatic, but nonetheless insurmountable margin for the medium haul ethylene glycol shipment. The estimated shipment costs by barge are $3.65 per ton compared to $14.37 by rail and $27.00 by truck. If these estimates are even approximately correct, there would be limited probability of modal diversion for this particular movement.

As in the case of benzene and toluene, diversion of existing flows is highly unlikely unless - contrary to our existing knowledge - the barge movements are only part of a multimode move.

Also as in the earlier case, more subtle forms of traffic loss due to substitution of inputs, products, or sources are possible, but these phenomena are beyond the scope of this study effort.

Potential inflationary impacts from a user charge on alcohols are small. Prices in 1976 range from about $125 for methanol to over $300 for ethanol. Under the worst case - a long-haul move of methanol under the fuel tax - the delivered price impact exceeds 1 percent, but under the segment toll and for other distances and commodities, price impacts are considerably smaller.

8.2.2 Other Commodities

The aggregation of most other petrochemical movements into a single category which encompases a whole spectrum of chemicals (petro and non-petro, organic and inorganic) including anhydrous ammonia which is analyzed elsewhere, makes intelligent analysis impossible. To the extent that these movements are of the pattern discussed earlier - in large volumes between riverpoint producing facilities - they must be considered to be unlikely candidates for modal diversion. Shifts in processes and sources remain a possiblity, but require an analytical effort beyond the scope of this study.

8.2.3 Conclusions

Relative modal economics and existing flow patterns do not favor the diversion of significant petrochemical traffic from the inland waterways at proposed user charge levels. While the heavy short haul traffic in the Gulf area is relatively indifferent between user charge approaches, the longer haul traffic between the Gulf and northern areas, particular to the Ohio River area - bear fuel taxes 50 to 150 percent higher than corresponding segment tolls.

Petrochemicals include many of the commodities which, because they are deemed hazardous, require varying degrees of Coast Guard inspection (under the Port and Waterway Safety Program) in their handling and transportation. If the costs of this program were charged to the commodity movements subject to the inspection requirements, then the toll impacts would be correspondingly increased. Similarly, double-bottom requirements on barges carrying hazardous cargos would decrease the current barge competitive advantage in these commodities.

8.3 SULFUR AND SULFURIC ACID

8.3.1 Background

There are many sources of sulfur in the United States but current production is dominated by extraction from salt domes in Texas and Louisiana along the Gulf Coast. Although sulfur is found virtually everywhere, it is only in these mineral formations that the concentration is adequate to justify mining. The Frasch mining process requires the drilling of wells in which extremely hot water under pressure is circulated to melt the sulfur that is present. The molten sulfur settles to the bottom of the well and is forced to the surface by the injection of compressed air. This supply requires continual drilling of a limited number of mines. Assuming the least costly mines were the first choice areas of production, the less profitable areas remain to be mined and production costs will eventually increase (the classic economic problem of marginal cost associated with a finite resource). In 1973 Frasch sulfur accounted for 70% of all forms of domestically produced sulfur. Production was from 12 mines owned by only 5 producers - the five largest mines accounted for 78% of the Frasch sulfur. The nature of this sulfur source makes this industry one that is highly concentrated economically as well as geographically.

The second largest domestic sulfur source is recovered sulfur from oil refineries and natural gas treatment plants. In 1973, 22% of the U.S. supply resulted from recovery processes. Crude oil must be desulfurized to meet air pollution standards while sulfur must often be removed from natural gas before it can be used (this may result in substantial supply depending on the H_2S content of the gas - Canadian natural gas is sixty times as sour as Louisiana natural gas). The quantity of sulfur provided by these sources is a function of exogenous factors (air pollution standards, natural gas requirements, etc.) rather than of sulfur demand. In 1973 more than 100 plants in 28 states were producing sulfur by recovery methods. This sulfur is generally sold in close proximity to the site of production.

Another 5% of the 1973 sulfur supply was contained in by-product sulfuric acid produced at copper, lead, and zinc smelting operations. Other potential sources of large quantities of sulfur that apparently have not been utilized extensively because they are currently not economically attractive are recovery from pyrites, anhydrite, gypsum, coal prior to combustion, and post-combustion stack gas emissions.

The Gulf Coast supply, which is currently responsible for meeting most of the U.S. sulfur demand, is conveniently located with access to cheap water transport. A review of the uses of sulfur and the regions of high demand will indicate the role of water transport and its importance in the sulfur industry.

The use of sulfur is widespread in the manufacturing sector. In 1973 the major channel was into sulfuric acid (90%) prior to production. Table 116 demonstrates sulfur consumption in 1966 when 87% of sulfur went into the production of sulfuric acid. Sulfur is very common, not because of its sulfur value, but due to its value in producing an inexpensive yet effective process chemical (sulfuric acid).

Unlike sulfur production facilities, sulfuric acid plants are scattered throughout the U.S. Little is to be gained from centralizing sulfuric acid at or near the Frasch sulfur mines.

TABLE 116

DISTRIBUTION OF DOMESTIC SULFUR CONSUMPTION IN 1966

Consuming Sector	Percent of Total Sulfur Consumption
Acid Users:	
Fertilizers	48
Chemicals	18
TiO_2 and Other Inorganic Pigments	6
Iron and Steel	3
Rayon and Film	3
Petroleum	2
Others	7
TOTAL ACID USES:	87
Nonacid Uses:	
Pulp and Paper	5
Carbon Bisulfide	3
Ground and Refined	2
Other	3
TOTAL NONACID USES:	13

This is tied closely to the relative transportation and handling costs of the two products, acid being nearly three times more expensive per unit of sulfur content. The result is that when a decision has to be made between long-haul shipment of sulfur vs. sulfuric acid, the choice will generally be to ship sulfur and produce the acid near the consuming site (it will be seen that both are shipped relatively short-haul distances since they are inputs to higher value commodities that are then shipped long distances, for example, diammonium phosphate).

The major receiving areas for sulfur are the large fertilizer producing regions, specifically the Tampa area and the Delta region. Some capacity to produce diammonium phosphate exists upriver and this requires the input of sulfur. Given that the major producing and receiving areas are both on the Gulf Coast, the Mississippi River System will have a limited role relative to the Gulf Intracoastal Waterway and the Gulf itself. The following figures indicate the percentage of sulfur consumed in five large regions in 1973:

Florida	30%
Other Southern States	39%
Western States	12%
North Central States	11%
New England	8%.

8.3.2 The Structure of the Sulfur Industry

A brief sketch of the economics of the sulfur industry is crucial to understanding the nature of sulfur distribution. As already mentioned, salt domes utilizing the Frasch mining process are concentrated on the Gulf Coast of Texas and the Louisiana delta area. From 1932 to 1966 four companies controlled almost the entire output of U.S. Frasch sulfur (the two largest accounted for 90% of the production). The intense concentration is due to the inability to locate salt domes of high enough quality to compete with the ones that are currently in operation. Low quality salt domes mean a higher water to sulfur ratio - water is the most significant variable cost input in the Frasch process and can raise unit costs substantially. It became virtually impossible for firms to enter into this industry given that a few companies acquired quick control over the major deposits.

The impact of this industry concentration is substantial on the resulting transportation patterns. The result has been centralization of handling and shipping facilities on the Gulf - specific terminals can be identified as originating the major shipments by water. This has had the effect of reducing handling and shipping costs by 30% to 40%.

8.3.3 Product Characteristics and Shipping Considerations

Until fairly recently, sulfur shipment was in the form of dry bulk. It originated at mining sites in liquid form and was shipped through steam-heated pipes to storage areas where it was sprayed into vats to solidify. In order to be shipped to consumers it had to be broken up and loaded onto the appropriate mode. At the delivery point it was stored as dry bulk and then melted prior to use.

The late 1950's and early 1960's brought on a major change in the sulfur distribution system. It was found to be more economical to maintain the liquid form of sulfur throughout distribution. Large facilities were constructed on the Gulf to serve as collecting points from major mines. Storage terminals were constructed in major consuming areas for receipt of the liquid sulfur. In 1959 shipments of sulfur in a liquid state were 15% of total shipments - by 1963 this had grown to 90%. The distributional advantages that have resulted from liquid movement are reduced handling costs, the reduction of loss due to a shrinkage factor, the elimination of fuel costs associated with sulfur melting, and the reduction of potential contamination, corrosion, and explosion.

A major impact of the changed distribution system has been the need for improved shipment scheduling and associated long-term contracts. The increased expense of liquid vs. dry storage has meant the need for reduction of inventories for both the producer and consumer. Longer-term contracts have been the result.

The transport of heated liquid sulfur accounts for all major distribution of Frasch sulfur in the U.S. today. Local delivery is made by rail tank-cars or tank-trucks. Sulfuric acid, on the other hand, is seldom shipped more than 150 miles due to the much higher transportation costs per unit of sulfur.

8.3.4 The Importance of Water Transport

The importance of the location of Frasch mines cannot be overlooked in the determination of mode of shipment. Their existence near the Gulf has resulted in a gathering system to centralized storage and distribution facilities located at major ports. Terminals have been constructed on the waterways to receive from these origins. Large tonnages of liquid sulfur and sulfuric acid are shipped on the waterways as indicated by the following data on internal waterborne movements:

	000's Tons	
	1972	1973
Liquid Sulfur	4969	4800
Sulfuric Acid	2551	2627.

The major destinations of barge shipments of liquid sulfur are shown in Table 117. Note the heavy concentration receipts in areas south of Baton Rouge. Substantial tonnages of liquid sulfur move on the Mississippi River System and GIWW but the length of haul does not generally exceed 250 miles.

Table 118 demonstrates the major origin-destination patterns of sulfuric acid. Almost one-half of the tonnage moves within the same segment. As with sulfur, sulfuric acid accounts for fairly large tonnages on the waterways, particularly on the Gulf, but the ton-mileage is not substantial.

8.3.5 The Effect of a User Charge

There is little or no possibility of modal diversion of domestically produced Frasch sulfur. Major shipping and receiving facilities are on the waterways, particularly in the Gulf area, and shipments can be characterized as relatively short-haul which minimizes the impact of a user charge. In addition to large sunk investments in terminal facilities, sulfur companies own their own barges that are highly specialized for shipment of liquid sulfur. Rail and truck cannot compete in these markets due to inadequate facilities and high transport costs. Traffic diversion needs to be considered in light of a potential shift to alternative materials (the elasticity of demand for sulfur) or alternative sulfur supplies (the elasticity of demand for Frasch sulfur).

The widespread importance of sulfur is due to its value as a process chemical rather than for the sulfur content itself. It is effective yet relatively inexpensive. Significant increases in its cost would mean that many manufactured

TABLE 117

DESTINATIONS OF BARGE SHIPMENT OF LIQUID SULFUR
ON THE MISSISSIPPI RIVER SYSTEM

Destination	Tonnage (000's tons) 1972	1973
Mouth of Passes to New Orleans	742	1003
New Orleans to Baton Rouge	1061	1042
Baton Rouge to Cairo (Helena, ARK).	55	50
Cairo to Mouth of Missouri (St. Louis)	133	123
Illinois River	34	11
Ohio River	189	159
Kanawha River	57	64
Monongahela River	59	43

TABLE 118

MAJOR INTERNAL BARGE SHIPMENTS OF SULFURIC ACID, 1972 AND 1973

Origin	Destination	Tonnage (000's) 1972	1973
Galveston	Same	597	546
	Corpus Christi to Galveston	380	370
	Baton Rouge to New Orleans	88	80
Mobile to New Orleans	Baton Rouge to New Orleans	113	124
Baton Rouge to New Orleans	Same	307	386
	Mobile to New Orleans	30	65
	Sabine-Neches	27	33
	Galveston	27	32
Mouth of Missouri to Cairo	Illinois River	212	184
	Cumberland River	57	69
	Tennessee River	38	33
	Baton Rouge to New Orleans	34	17
Ohio (Pittsburgh Area)	Same	56	60
	Kanawha River	51	61
	Monongahela River	7	40
Monongahela	Little Kanawha	38	44
		2068	2144
	Total Mississippi River System and Gulf	2347	2393

materials would make use of other strong acids and/or alternative processing methods. For example, wet process phosphoric acid consumed over one-third of U.S. produced sulfur. Consideration has been given to the increased use of nitric acid in fertilizer production. Farmer notes the following:

> If the sulfur shortage and accompanying high prices of the late 1960's had continued, there is no doubt that a boost would have been given to the construction of new nitrophosphate and electric phosphorous capacity. Plans of this kind were in preparation when the sulfur situation turned to oversupply in 1968.*

This essentially means that an effective ceiling exists on the price of sulfur at which point alternative production processes will come on stream. Whether a user charge would be able to increase costs to this point is dubious.

A second, and probably more important question, regards the elasticity of demand of Frasch sulfur. Several other sources of sulfur exist, as noted at the beginning of this chapter, and are progressively penetrating the sulfur market. Higher standards of air quality insure that fossil fuel emission will become a more important source of sulfur. Recovery from natural gas and refineries also stands to increase the market share of sulfur from this method. This will mainly be the result of improved and more efficient, as well as required, recovery techniques in combination with increased costs of dwindling Frasch sulfur supplies. This is an inevitable trend that will gradually phase out the dominance of Frasch sulfur in the market. The important question is whether this trend will be accelerated as a result of increased costs of barge transport due to user charges. An examination of the effect of alternative supplies on total barge traffic is also necessary.

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*Farmer, M.H., et al., Long Range Sulfur Supply and Demand Model, Linden, NJ, November 1971, p. 33.

The best insights into this problem come from current competition between U.S. Frasch sulfur and Canadian supplied sulfur. Sulfur extracted from natural gas in Alberta amounts to large tonnages since the gas is so sour. Moreover, the marginal cost of producing the sulfur into a usable product is very small since it is a secondary process. Sulfur mined on the Gulf Coast must command a much higher price due to the substantial differential in production costs. The result of this situation is that in a demand region such as the Midwest, Canadian sulfur can bear significantly higher transportation costs than U.S. produced Frasch sulfur. Canadian sulfur can and does compete in this market (unit trains currently deliver Canadian sulfur to Marseilles, Illinois and are expected to increase their share of the Midwestern market). New sources of sulfur will hurt the Frasch market but it is expected that the damage will occur principally in the Midwest (Chicago may eventually be a net shipper of sulfur). A user charge should not accelerate the change in distribution pattern since the growth of new supplies is primarily a function of demand for other products of specific quality. The demand for Canadian natural gas created a supply of sulfur for the Midwest. In the U.S. it does not appear that new individual sources will be sufficiently large to justify large volume shipments or cause additional supply for distant markets - new supply will probably be locally consumed with little or no increase in total barge traffic. Since the principal areas of Frasch demand are the Tampa and New Orleans regions, waterborne shipments of Frasch sulfur should remain fairly well protected from new sources and will probably continue at almost the same level. One question which needs to be considered is whether foreign countries, such as Mexico, that do not utilize the GIWW would be placed in a more competitive position and be able to supply some of the sulfur demand.

Sulfuric acid shipments are not jeopardized to the same extent. A switch to alternative production processes or materials, an unlikely scenario, would have significant effects but a switch to new sulfur sources, which we are now witnessing, would apparently have no impact. With new sulfur sources sulfuric acid plants located near consuming areas would continue to be fully utilized and the short-haul charcter of water shipments would continue as the most profitable mode of shipment.

8.3.6 Summary

A fairly large volume of relatively short-haul sulfur and sulfuric acid shipments occur on the inland waterways. Most of the activity is in the Gulf region on the Gulf Intra-coastal Waterway and the Mississippi River System below Baton Rouge. It does not appear that a user charge (the uniform fuel tax and the segment toll are almost identical on the GIWW West) would cause any significant loss in tonnage or ton-mileage.

Sulfur (90% of which goes into the production of sulfuric acid) is important as a process chemical and not for its sulfur value; thus substitutable materials exist and alternative production processes are a consideration. The magnitude of the user charge should not initiate this change.

Sources other than Frasch sulfur are progressively gaining a larger share of the sulfur market and will continue to do so. This is a function of many exogenous factors (increased consumption of fossil fuels, air pollution control, etc.) in conjunction with rising costs of Frasch sulfur. User charges will add to the delivered price of Frasch sulfur but it is not expected that this will do much to accelerate the already existing trend of a shift toward new sources. The effect of alternative supplies will be felt mainly in the Midwest. Along the Gulf, where the vast majority of shipment occurs, the proximity of the supply to the demand regions insures that the Frasch market will remain fairly well protected. With the continued use of sulfur, Frasch or otherwise, sulfuric acid shipments should remain unchanged.

9. OTHER WATERBORNE TRAFFIC

There were approximately 180.6 billion ton-miles of traffic on the Mississippi River System in 1972. A detailed analysis has been made of the three most important commodity groups which together account for 60.8% of total ton-miles (these include the following: petroleum products, 26.8%; coal, 17.8%; and grains, 15.8%). Fifteen commodities have been studied in considerable depth providing extensive coverage of waterborne traffic totaling 158.7 billion ton-miles or 87.8% of all ton-miles on the Mississippi River System in 1972 (see Table 119).

Some discussion will be made of the two largest commodity groups that have not been analyzed. Salt and Miscellaneous Products account for an additional 5.9% of total ton-miles. Consideration of these two groupings will increase coverage to 93.7% of Mississippi River System ton-miles. The remaining shipments are small (6.3%) and scattered (7 commodity groups) and an effort to analyze the impacts of user charges on these industries cannot be attempted within the scope of this study.

9.1 SALT

In 1972 4.89 million tons of salt moved on the inland waterways. The origin of 95% of these shipments was on the Gulf Intracoastal Waterway West in Louisiana. Most of the salt is moved long distances to consumption points on the Upper Mississippi, Illinois, and Ohio Rivers - the average length of haul for salt shipments is 1216 miles.

TABLE 119

MISSISSIPPI RIVER SYSTEM TON-MILES, 1972

Commodity		Ton-Miles (Millions)	% of Total
Analyzed in this report:			
1	Coal	32081	17.8
2	Crude Oil	19823	11.0
3	Gasoline	13280	7.4
4	Jet Fuel	1866	1.0
5	Distillate	5241	2.9
6	Residual	8232	4.6
7	Chemicals	17858	9.9
9	Fertilizer	3829	2.1
10	Other Dry Bulks	11157	6.2
11	Iron & Steel	7181	4.0
13	Sand & Gravel	3285	1.8
18	Corn	19903	11.0
19	Wheat	4400	2.4
20	Soybeans	8625	4.8
23	Phosphate Rock	1929	1.1
		158690	87.8
Not analyzed or only briefly considered:			
8	Synthetics	198	.1
12	Waste & Scrap	1252	.7
14	Salt	5680	3.1
15	Lime, Etc.	2221	1.2
16	Barley, Rye, Oats	1862	1.0
17	Flour, Etc. (Processed Agricultural Goods)	5039	2.8
21	Forest Products	304	.2
22	Paper/Pulp	378	.2
24	Miscellaneous	4970	2.8
		21904	12.2
		180594	100.0

Salt is used in a wide variety of industries ranging from chemicals and textiles to fishing and canning. It is produced and distributed in three different forms. Salt in brine was most common accounting for 59% of salt sales in 1973 ($3.57 per ton), rock salt amounted to 27% of salt sales ($6.36 per ton), while 14% of salt sold was the evaporated type ($23.09 per ton). Rock salt appears to be the only form distributed by barge; this is due to the location of salt mines in Louisiana. Rock salt is primarily used for highway deicing and is shipped to metropolitan areas such as Minneapolis, Chicago, Cincinnati, and St. Louis.

Historically, the waterway transportation of rock salt has been fairly well insulated from competition by other modes. Rail rates from the southern Louisiana region to the Midwest are too expensive relative to barge transport costs to pose a threat to that traffic. Rail does deliver to the same market areas from alternative sources, such as Utah or the Dakotas but the rail rate (for evaporated salt) has been found to be approximately equivalent to the total cost of producing rock salt in the Louisiana and transporting it to the site of consumption. Evaporated salt and rock salt are somewhat substitutable products. Evaporated salt produced in the West may be used for highway deicing but more often it is consumed in other industries, particularly the chemical industry. Rock salt, on the other hand, has penetrated new markets and is currently being processed and sold as a water softener or as an ingredient to feed mixes. The expanding demand for rock salt is indicative of the differential in the delivered price of both types of salt. The fact that the GIWW West is such a vast source of supply also provides evidence of the distinct cost advantage that salt mines utilizing barge transport have over mines that must rely on other modes.

It appears that a user charge could be easily absorbed in the salt market with little or no traffic diversion. Other modes are not competitive with the cost of barge transport and the success of marketing rock salt in the Midwestern market shows that other sources of supply are currently experiencing difficulty competing in consumption sites adjacent to the waterways. A user charge may slow the sale of rock salt to new consumers as the price of rock salt and rail delivered salt becomes more equalized and companies operating out of Western mines attempt to retain hold of their current market share.

Since the movement of salt occurs on the most heavily traveled rivers, the fuel tax would have a more serious effect on the distribution of salt than the segment toll. A segment toll calculated for the average shipment would amount to 87 cents a ton whereas the fuel tax would add an additional 97 cents to the cost of barge transport. This represents approximately 15-20% of the estimated barge rate but as previously discussed it seems that this would be insufficient to stimulate any real change in the major rock salt markets.

9.2 MISCELLANEOUS

The miscellaneous category includes such commodities as marine shells, sulfur, fresh fish, shellfish, flaxseed, tobacco manufactures, apparel, and machinery. Marine shells and sulfur account for the large majority of shipments in these categories. (For an analysis of sulfur, see Chapter 8--Chemicals.)

The situation concerning marine shells is similar in many respects to that of sand and gravel. Marine shells can serve in the same construction aggregate market when sand

and gravel is too expensive or not available. The shells are dredged from the ocean and transported to consumption sites at locations along the Gulf. Shipments on the inland waterway system tend to be very short-haul due to the low value of this commodity and the abundance of supply in the Gulf region. The short distances between the point where barges of marine shells enter the GIWW and the point where they are unloaded make the impacts of a user charge relatively minor. The dredging requirements in this industry mean that modal competition is non-existent in delivering shells to yards or plants.

Substitution of alternative materials for marine shells is not feasible in the construction aggregate market along the Gulf Coast. Marine shells are generally used instead of sand and gravel due to transportation costs - sand and gravel must also bear user charges and will be at the same relative market disadvantage as currently exists. The scarcity of sand and gravel in the Gulf region makes delivery by rail from inland points an unattractive alternative. Thus user charges should have little or no impact on the shipment of marine shells.

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