APPENDIX D
ANALYSIS OF EXISTING TRANSPORTATION COST DATA

INTRODUCTION

The purpose of this appendix is to briefly describe the process undertaken in the Upper Mississippi River, Illinois Waterway (UMR-IW) Navigation System Feasibility Study to estimate existing transportation costs and alternative transportation costs for commodity movements currently utilizing the UMR-IW navigation system. The transportation cost estimates encompass the total costs incurred for existing system use including access and transfer costs as well as the total transportation costs that would be incurred if existing system movements were forced to use some alternative mode of transportation.

DATA

The Tennessee Valley Authority (TVA) provided 1994 data regarding transportation cost information for 1,331 individual water movements that originated or terminated on the Upper Mississippi River, Illinois Waterway navigation system in 1991. The TVA data included transportation line haul cost estimates for existing water routings, estimates of line haul costs for alternative non-water routings, and access charges for both water and non-water routings. The 1,331 movements represent a stratified random sample taken from all such movements that occurred in 1991. The stratification was accomplished by aggregating the movements into fifteen unique origins and destinations yielding 225 possible pairings of origins and destinations. The movements were further stratified by the quarter of the calendar year in which the movement began. A movement was randomly chosen from each non-empty combination of origin and destination groups, and each quarter for each of eleven commodity groups. The commodity groups are:

1. Corn
2. Beans
3. Wheat
4. Other Grains
5. Coal
6. Petroleum
7. Chemicals
8. Fertilizer
9. Iron and Steel
10. Aggregates
11. Miscellaneous

This classification scheme yielded 1331 non-empty cells. In order to analyze the 1,331 sample movements and extrapolate the data into the full population of existing movements, a multi-variable regression analyses was conducted on portions of this data.

REGRESSION ANALYSIS OF WATER LINE HAUL COSTS

Each data record in the sample data of 1331 movements contained unique information about the movement such as port origin and destination, river origin and destination, line haul charges (river), river miles traveled, costs for river access, and similar information

regarding total transportation costs for alternate routes. The alternate route data will be discussed later in this summary.

All sample data were imported into Statistica for Windows, Statsoft Corporation, for a set of regression analyses. Subsequent to stratifying the population of movements, the, spring, summer, and fall quarters were aggregated into one "season" for the system NED model which made some sampled movements redundant. For purposes of the regression analysis, such redundant movements were eliminated. An initial set of regressions was run using total water trip miles as the independent variable and water line haul charge as the dependent variable for each commodity group. The results were unsatisfactory in that the model did not adequately explain the variability in water line haul charges. The data was further refined and the water miles were partitioned into miles on individual river segments. The river segments were the Upper Mississippi, Lower Mississippi, Missouri, Illinois, Ohio, Tennessee, Tennessee-Tombigbee, Kaskaskia, Arkansas, Yazoo, Red, Green, Cumberland, Gulf Intercoastal Waterway (East and West), and the Atlantic Intercoastal Waterway. A set of multiple regressions were run again utilizing water line haul charges as the dependent variable and miles traversed on individual segments as the independent variables for each commodity group. These regressions demonstrated significant explanatory power with the exception of three commodity groups, Fertilizers, Other Farm Products, and Iron and Steel. Examination of the data representing these commodity groups revealed markedly different transportation costs for similar origins and destinations within each group. These commodity groups were then further partitioned to account for different transportation costs. Other Farm Products (Group 4) were split into Up-bound and Down-bound subgroups. Fertilizer (Group 8) was split into Dry Fertilizer and Liquid Fertilizer commodity subgroups as these utilize different type of equipment for water transportation. Movements with partially filled barges were omitted from the analysis of the Iron and Steel group (Group 9), since the costs for these movements were not representative of a normal movement.

REGRESSION RESULTS

Table 1 summarizes the results of the regressions for all commodity groups and subgroups. The intercepts range from 1.2339 for Coal to 3.0357 for Corn, excluding Upbound Grain, which had a negative intercept (-7.6435). The intercept represents the fixed portion of water transportation line haul costs which do not vary with distance of travel. Note that there were only ten observations of upbound barge movements of grain. The negative intercept coefficient, which is not statistically significant, is likely the result of the very small sample size. R-squared values represent the proportion of the variation in line haul charge explained by the miles traversed on the various river segments. R-squared values ranged from 0.8680 for Iron and Steel to 0.6298 for Miscellaneous, again excluding Upbound Grain, which had an R-squared value of 0.4900. Upbound Grain, with a sample size of ten observations, exhibits unusual regression coefficients for miles traversed.

Each river segment coefficient represents the cost per ton for a barge to traverse one mile on that particular river segment. The positive river segment coefficients ranged from 0.0016 per ton-mile for the Lower Mississippi River and Yazoo River for Dry Fertilizer to 0.0444 per ton-mile for the Tennessee River and Tennessee-Tombigbee River for Petroleum movements. Some anomalous negative river segment coefficients were generated for the Kaskaskia River for Soybeans, and the Gulf Intercoastal Waterway-East for Petroleum, Chemicals, and Miscellaneous. It is likely that these coefficients were anomalous and not significant because there were very few observations for these secondary river segments for these commodity groups., the regression results were also spurious. The regressions generating these negative coefficients also generated highly significant positive coefficients for the connecting segments of the Upper or Lower Mississippi River. This indicated that there may be "overcompensation" for primary river segments with many observations by secondary river segments with few observations. For all commodity groups, the regressions reveal a significant correlation between line haul charge and river miles traversed.

Another set of regressions was run to test the residuals for collinearity, with the residuals as the dependent variable and each separate river involved as the independent variable. Results for all commodity groups showed most residuals were within two standard deviations of the mean with nearly all residuals within three standard deviations of the mean. Omitting the outlying observations in subsequent regressions did not significantly alter the results.

EXTRAPOLATING THE EXISTING WATER COST ANALYSIS INTO THE FULL POPULATION OF 1992 BARGE MOVEMENTS

The regression analysis of the TVA data was completed so that cost information from the sample could be extrapolated to all the barge movements on the Upper Mississippi River Navigation System during 1992 (including the Illinois Waterway and the Missouri River). The original database of all 1992 barge movements had no information on river miles traversed on each of the river segments as defined for the sample regressions. These data fields were estimated using the following procedure.

As the regressions estimated for water line haul costs in the previous step employed the miles traversed on each river segment as explanatory variables, mileage on segments was computed for observations in the full set of 1992 barge movements before the next stage of the analysis could be completed. To do this, the complete movement database was examined to develop a listing of all water origins and destinations. From this list, all possible water routes were manually inspected to identify all rivers traversed for each possible route. The movements were assigned routings. Most system routings were obvious, but in a few cases, where multiple routings were possible, routings were assigned utilizing knowledge of industry operations. A computer program was developed which, dependent on the water origin, the water destination, and the commodity group of a movement, assigned the appropriate routing to the movement, and then, based on that

routing and the estimated mileage on each river segment for the routing, applied the appropriate regression coefficients to estimate the water line haul costs for that movement.

The full population of 1992 movements now had the line haul portion of the water route costs estimated. However, costs to access the river which were incurred by a movement such as transfer costs, rail costs, truck costs were not yet calculated for the full population of movements. The appropriate river access costs were assigned to all 79,500 records in the full population by comparing sample movement characteristics of origin, destination, and commodity group to the same characteristics of movements in the full population and then copying the associated water route access costs of a matching sample movement to the 1992 full population database. When making the comparison, several movements in the TVA sample could theoretically have met the matching criteria. The movement meeting the criteria and nearest to the 1992 movement's route was selected and the data from that sample movement was copied into the corresponding 1992 record. This completed the extrapolation of the sample data for water transportation costs into the full population of 1992 movements yielding total water route costs including access costs for each movement.

ALTERNATE ROUTE ANALYSIS

The TVA sample data also contained transportation cost information for alternate routes for the 1,331 water movements. The alternate routes examined for each sampled movement depended on the commodity group, water origin, and water destination of the movement. All movements had a complete land routing between the ultimate origin and destination identified. All movements passing through Lock 27 had a land and water combination routing identified that bypassed the pooled portion of the navigation system. Corn, Soybeans, Wheat, and Other Grains export movements had additional routings identified to alternate ports of export (Houston/Mobile, the Pacific Northwest, and Duluth), and to an alternate non-export destination. Fertilizer movements had land routings identified for alternative origins to the ultimate destination.

To identify and add the alternate route data to the full population of 1992 movements, a technique similar to that employed in the previous step (water route access cost extrapolation) was employed. For each of the 79,500 records in the full 1992 movement database, all corresponding TVA sampled movements with the same water origin, water destination, and commodity group were identified. The water line haul miles (water route) were compared and the TVA record that most closely matched the 1992 full population record was identified and all the applicable alternate route data were copied from the sampled movement to the 1992 record. The process was repeated for all 79,500 movements in the 1992 movement database. The final comparison was made utilizing water line haul mileage as the 1992 database contained no information on alternate route miles. Therefore, in order to identify the TVA sample movement that came closest to having the same origin, destination, and commodity, the movement with the most similar water line haul distance was utilized.

Table 1
Regression Summary

Commodity	Intercept	Rivers Traversed: UMR	LM	MO	IL	KAS	OHIO	TENN	T-TOM
Corn	3.03573	0.00577	0.00168	0.01036	0.00389	0.00502	0.00142	0.00607	0.00502
Soybeans	2.39684	0.00589	0.00268	0.01155	0.00750	-0.12521	0.00749	0.00749	0.00475
Wheat	1.71504	0.00723	0.00283	0.01065	0.00829	0.00588	0.00435	0.00851	0.00588
Upbd Grain	-7.64347	0.01171	0.01171	0.01171	0.01171	0.01171	0.01171	0.01171	0.01171
Dnbd Grain	1.23385	0.00794	0.00316	0.01198	0.00951	0.00601	0.00206	0.00206	0.00601
Coal	1.70251	0.00582	0.00334	0.00480	0.00645	0.02227	0.00466	0.06242	0.00480
Liquids	2.40563	0.01024	0.00638	0.01332	0.01040	0.00909	0.00695	0.00837	0.04444
Chemicals	1.94905	0.01699	0.00872	0.01448	0.01304	0.00878	0.00782	0.00689	0.00836
Fertilizer-Dry	2.66043	0.00504	0.00158	0.01071	0.00951	0.00597	0.00532	0.01041	0.00433
Fertilizer-Liq	1.54928	0.01133	0.00683	0.01753	0.01631	0.00948	0.01033	0.01033	0.00948
Iron & Steel	1.74618	0.00749	0.00246	0.00863	0.00927	0.03835	0.00461	0.00618	0.01747
Aggregates	2.01930	0.00485	0.00137	0.00942	0.00606	0.00506	0.00661	0.00661	0.00506
Misc.	2.45754	0.01014	0.00209	0.01490	0.00688	0.00610	0.00753	0.00753	0.00610

Commodity	GREEN	ARK	YAZOO	RED	GIW: W	GIW: E	CUMB	N	R-squared
Corn	0.00502	0.00661	0.00168	0.00502	0.01548	0.01611	0.00502	73	0.7046
Soybeans	0.00475	0.00475	0.26058	0.00475	0.01483	0.00409	0.00475	65	0.6971
Wheat	0.00588	0.01198	0.00283	0.00589	0.01786	0.01524	0.02379	77	0.7965
Grain-Up	0.01171	0.01171	0.01171	0.01171	0.01171	0.01171	0.01171	10	0.4901
Grain-Dn	0.00601	0.00601	0.00316	0.00601	0.00601	0.00601	0.00601	25	0.7892
Coal	0.00180	0.00480	0.00334	0.00480	0.00480	0.00480	0.02126	57	0.8426
Liquids	0.00909	0.00934	0.00638	0.00615	0.01486	-0.04566	0.02577	160	0.7722
Chemicals	0.00878	0.00431	0.00872	0.00878	0.00557	-0.01191	0.00878	126	0.6383
Fertilizer-Dry	0.00597	0.01990	0.00158	0.00597	0.02272	0.03960	0.00676	106	0.8645
Fertilizer-Liq	0.00948	0.01003	0.00683	0.00948	0.00948	0.00948	0.00948	22	0.8621
Iron & Steel	0.00639	0.00682	0.06896	0.03456	0.01368	0.01850	0.01096	175	0.8680
Aggregates	0.03306	0.02795	0.00137	0.02037	0.01388	0.02761	0.00639	103	0.8024
Misc.	0.00610	0.00679	0.00209	0.00610	0.01729	-0.00567	0.00610	94	0.6298
								1093	

Notes:

UMR= Upper Mississippi River (Cairo to Minneapolis/St. Paul)
LM= Lower Mississippi River (New Orleans to Cairo)
MO= Missouri River
IL= Illinois River
KAS= Kaskaskia River
OHIO= Ohio River
TENN= Tennessee River
T-TOM= Tennessee-Tombigbee River
GREEN= Green River
ARK= Arkansas River
YAZOO= Yazoo River
RED= Red River
GIW: W= Gulf Intercoastal Waterway: West

GIW: E= Gulf Intercoastal Waterway: East
CUMB= Cumberland River
N= Number of tow movements - duplicates ignored for analysis