SECTION 3 - SYSTEM ANALYSIS

INTRODUCTION

A system approach is required to evaluate the National Economic Development (NED) benefits of potential navigation improvements to the Gulf Intracoastal Waterway System. This analytical approach explicitly recognizes that individual locks are only components in a complete navigation system, and that alterations of the traffic processing characteristics of specific components will have impacts throughout the navigation system. The General Equilibrium Model described below is used to perform the systems analysis.

GENERAL EQUILIBRIUM MODEL RATIONALE AND METHODOLOGY

The General Equilibrium Model (GEM) is used to evaluate the existing conditions, the future without-project conditions, and the future conditions with alternative system configurations in effect. GEM is a tool used for the economic evaluation of potential changes to various components of a navigation system. The model estimates the total transportation costs, including congestion costs, incurred by individual movements desirous of using all or portions of a navigation system. System transport costs for these individual movements are then compared to the total transport costs of that movement via the least-cost alternative mode or alternative non-system water route. If the alternative means of transport has lower costs than water system transport for a given movement, then that movement is presumed to be diverted from the navigation system to the alternative mode/non-system route. This potential movement enjoys no transport cost reductions resulting from the navigation system. Conversely, movements enjoying less costly transportation on the navigation system are presumed to use the navigation system, realizing net savings of the difference between the costs of system transport and the next least costly alternative means of movement. The sum of all these transportation costs savings represents the total resource savings to the Nation attributable to the navigation system.

The navigation system transport costs are dependent on three general classes of parameters: first, the operating characteristics of waterway carriers and shippers; second, the operating characteristics of the navigation system itself; and, third, the physical traffic carrying capacities of the components of the navigation system. For the purposes of this study, the first two parametric classes are assumed to be fixed through time. This analytical effort focuses exclusively on the impact on the levels of navigation system transport costs of carrying capacity constraints at system locks.

For a given level of traffic, the greater the carrying capacity of the navigation system the lower the total unit transport costs. This is a consequence of decreased levels of congestion in the system, allowing potential movements quicker and more efficient transport from origin to destination. Hence, the navigation system transportation costs of individual movements are explicitly dependent on total system traffic. In other words, individual movement system transportation costs depend not only on the economics of each individual movement, but also on the levels of congestion on those portions of the transportation system used by each individual movement. The levels of congestion for each component of the navigation system are increasing functions of the total volume of traffic processed by each component of the system.

Each individual potential system movement is assumed to transit the navigation system if, and only if, it has economic incentive to do so. Here, economic incentive to use the navigation system means that a movement is assumed to use the navigation system if system transport provides the least cost total transportation costs including the congestion costs resulting from carrying capacity constraints.

The total real costs of shipping any given movement via alternative non-system means of transportation are assumed to be constant through time. Explicitly modeling the costs of alternative modes of transportation is beyond the scope of this study. In order to reduce the size of the GEM problem to be solved, only those system locks that could possibly sustain significant increases in levels of congestion are explicitly included in the model. Consequently, the 1200 ft x 110 ft Leland Bowman Lock, which was placed into service in 1985, is excluded from the model because projected traffic at this location is not expected to cause significant changes in system congestion costs at any time during the planning horizon. This allows traffic using only this structure to be eliminated from the direct system modeling and reduces the size of the GEM problem with minimal distortion of the analytical results.

The input requirements of the GEM model are as follows:

a. Individual Movement Data: For individual potential system commodity movements, this input requires a waterway routing vector (indicating which system locks the movement will transit if it utilizes the navigation system), the annual volume of the movement measured in kilotons (ktons), the gross transportation cost savings of the movement (defined as the difference between the total uncongested system transportation costs and the total transportation costs of the next least costly non-system alternative means of transit for that movement), and an indication of whether or not alternate system water routings are possible.

b. Congestion Costs: Costs per kton per hour of delay for each commodity movement at each system lock transited are inputs required by the GEM model. The model allows these costs to be input by aggregated commodity groupings for each system lock.

c. Lock Delay Parameters: Capacity in annual ktons and expected delay in hours per ton at 50 percent utilization for each lock in the system are required by the model. For solution, the model requires that delay be an monotonic nondecreasing function of tonnage. The configuration of the delay function used in the model is:

$$D = k * T / (C - T); \text{ where}$$

D = delay per ton in hours; k = delay per ton in hours at 50% utilization of capacity; T = annual lock tonnage; and C = annual lock capacity in tons.

To use this formulation, Capacity (C) and expected delay at 50 percent utilization (k), for each lock in the system, are required input parameters.

Output from the GEM model includes total system transportation costs including congestion costs, expected delay times at each modeled system lock, annual tonnages moved through each lock, and the net system transportation cost savings for each movement. The net system transportation cost savings are defined as the transportation resource cost savings attributable to the navigation system for that movement accounting for the effects of system congestion on system transportation costs.

Benefits for navigation projects consist of two distinct components: first, transportation resource cost savings to existing system traffic from reduced levels of systemic congestion; and, second, transportation savings over an alternative means of transport for movements now induced to utilize the navigation system because of the reduced total transportation costs. This idea is graphically demonstrated in Figure 3 - 1. The demand curve DD shows

CONCEPTUAL MODEL FOR
WATERWAY ECONOMIC ANALYSIS

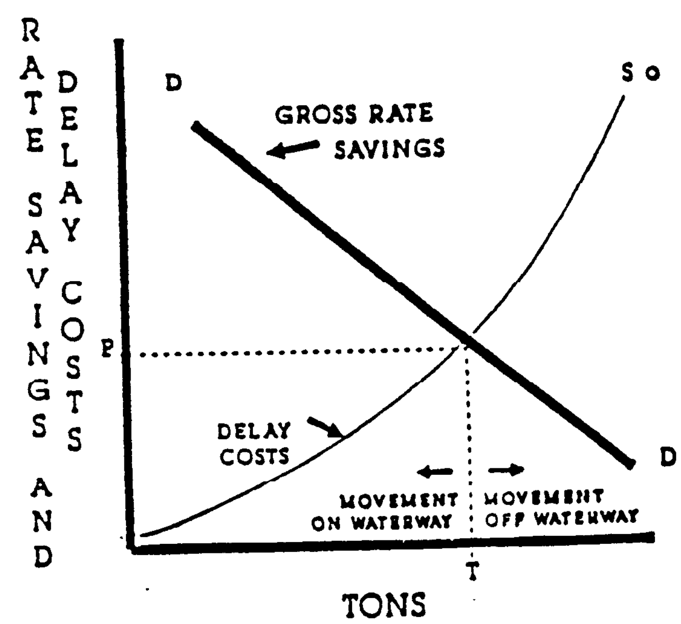

Figure 3-1.

for each potential ton of commerce the difference between system total transportation costs (with no congestion costs) and the total costs of movement via the next least costly alternative non-system means of shipment. This difference is termed the gross cost savings of that ton's potential movement via the waterway system. The curve S0 represents the congestion costs incurred by each movement as different levels of tonnage transit the system. It is upward sloping to represent the notion that as more tons pass through the navigation system, greater levels of congestion occur, and, consequently, higher unit costs of transportation are incurred by each ton transiting the system. The system equilibrium congestion cost is given at P with tonnage of T actually transiting the system. All tonnage to the "left" of T find it still cheaper to move on the system than by the next cheapest alternative means, whereas all tonnage to the "right" of T find it economically more advantageous to use some non-system alternative. Hence, in equilibrium, T tons will pass through the lock and incur delay costs of P dollars.

Now, consider the impact of a system change (such as the installation of a new lock chamber at one lock) on the level of system traffic and shipping costs. Figure 3 - 2 illustrates the effect of the change and the measurement of resulting benefits.

The provision of the new chamber increases the carrying capacity of the system and reduces the unit cost of congestion for any given level of system traffic. The curve labeled S1 depicts the with-project relationship between system traffic levels and the reduced with-project levels of congestion. The new equilibrium level of traffic increases from T0 to T1, with a reduction in congestion costs due to the improvement from P0 to P1. The resulting benefits for this system change may be broken into two components: (1) the cost savings on the pre-improvement level of traffic, T0 x (P0 - P1) (the shaded area to the left of T0); and (2) the benefits to the new traffic that can now move on the waterway, [(T1 - T0) x (P0 - P1)] (the shaded triangle to the right of T0).

The difference in the total transportation costs between with and without-project conditions represents the NED benefits of the proposed inland navigation improvement.

The important analytical assumptions employed in this analysis are:

(a) Movements will divert from the waterway when the total system transport costs including expected congestion

SYSTEM BENEFITS FOR
LOCK IMPROVEMENT

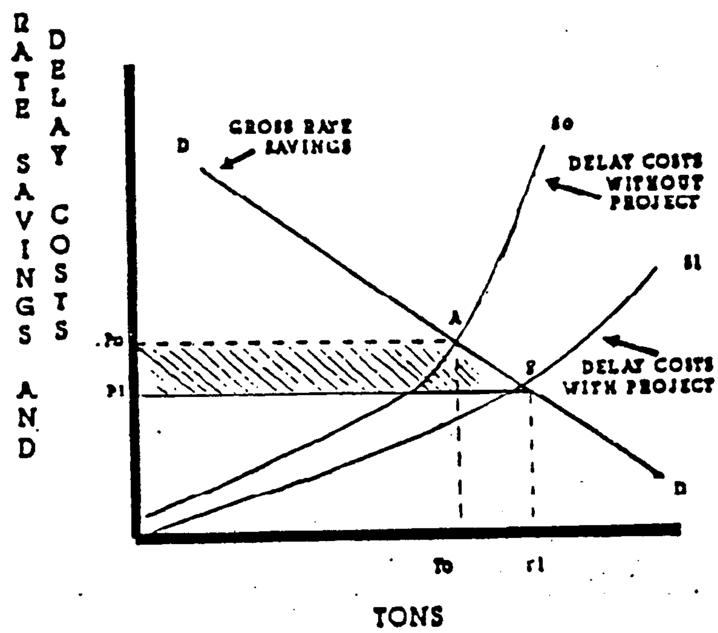

Figure 3-2.

costs exceed the total costs of shipment via a non-system alternative means; and

(b) The expected levels of delay and traffic for each component for the system must be logically consistent with the delays and traffic computed for all other components in the system. This requires that the equilibrium calculation at all system locks take place simultaneously.

DATA REQUIREMENTS AND SOURCES

COMMODITY MOVEMENT DATA BASE

a. Transportation Cost Analysis: The benefits of a navigation improvement are computed as the difference between the transportation costs to the shipper by the various modes available to the shipper, hence the determination of transportation costs is of the highest importance in this economic study.

In brief, this process involved the development of transportation costs for a sample of movements which traveled any portion of the waterways within the defined system and represented a wide cross section of system movements.

The transportation costs were then expanded to the population of movements. This entailed several levels of matching sample movements to population movements based on common attributes. When a match occurred, the transportation costs associated with the sample movement would be applied to the population movement.

A more detailed discussion of the procedures and methods used in this analysis is contained in Section 4 of this appendix.

b. Reconciliation of LPMS and WCSC: The two primary data sources used in the analysis of inland traffic are the Lock Performance Monitoring System (LPMS) database and the WCSC database. Each of these two databases is essential in evaluating the systems economics of traffic flows because each provides necessary information that is not a feature of the other. LPMS provides information concerning the physical characteristics of lock operations and tow configurations, while WCSC provides origin-destination and route information.

Each data source provides information that allows for the determination of traffic volume through each lock in the system. These traffic volumes at any given lock are invariably different, with WCSC volumes historically below

LPMS volumes. This difference is due primarily to the manner in which each is collected. WCSC data is submitted to the Center from the shippers. Despite the legal requirements of shippers to report to WCSC, the Center must rely, to a significant extent, on the efforts of industry to provide complete reporting. Given the vastness of the inland transportation system, a certain element of underreporting is to be expected. LPMS data, by contrast, are collected at each lock from every user and therefore are, at least, not subject to errors introduced into WCSC data because some shippers fail to report. However, being in a position to record all movements does not alone insure the accuracy of LPMS traffic volumes as will be seen in subsequent discussion.

Table 3 - 1 provides a comparison of LPMS and WCSC total tonnages at each modeled lock for the year 1990. As is readily obvious, there were some significant differences between the data sources. In addition to apparent significant WCSC underreporting at Bayou Sorrel, Algiers, Bayou Boeuf and Calcasieu (25.3, 20.0, 16.0 and 14.8 percent respectively), WCSC traffic at Port Allen exceeded the LPMS totals. In order to have a reliable traffic base that can be used as a starting point in the economic modeling effort, these significant differences in the two data sources first had to be reconciled to insure an accurate and consistent set of model inputs.

Before proceeding with a description of the procedure employed to reconcile the two data sources, it would be useful to describe the overall objective of the reconciliation process. Owing to the fact that WCSC contains origin-destination information necessary for rate assignment, WCSC must be the foundation of the base year traffic. As such, the objective of the reconciliation process was to establish a target tonnage value at each lock and then make adjustments, as necessary, to the WCSC data in an attempt to hit the target values. Adjustments typically take the form of adding constructed movements to the WCSC data in an effort to account for underreporting.

Initial efforts to reconcile LPMS and WCSC focused on the locks where WCSC was significantly lower than LPMS. Investigation of these locations revealed that underreported WCSC traffic was not the only factor at work. At Bayou Sorrel, a comparison of the reported LPMS average load per barge by commodity group with the WCSC average load per barge revealed that the LPMS loads were consistently and significantly higher. The explanation for this condition is in the fact that the exact load is not always known by the carrier. When tonnage is unknown, estimates are submitted at the lock. Estimation of this

Table 3 - 1

Comparison of 1990 WCSC and LPMS Tonnage
(Thousands of Tons)

Lock	WCSC	LPMS	LPMS - WCSC as a Percent of PMS
Port Allen	28,210	27,565	-2.3
Bayou Sorrel	27,781	37,168	25.3
IHNC	22,723	23,414	3.0
Algiers	19,856	24,819	20.0
Harvey	3,538	3,612	2.0
Bayou Boeuf	23,200	27,628	16.0
Calcasieu	39,450	46,301	14.8

type introduces the potential for error, especially when less than a full barge load is involved. At Bayou Sorrel this situation was in evidence. The systematic overestimation of loads, when exact loads were unknown, resulted in an overstatement of the recorded LPMS tonnage.

To address this situation, and to generate a reasonable target tonnage estimate, a convention was adopted that took advantage of the strength of each data source. Because of the manner in which it is collected, the LPMS barge count is considered to be more accurate than WCSC since LPMS is not subject to underreporting. WCSC on the other hand, is much less likely to be subject to load misstatement since this reporting is handled directly by the shipper with the full advantage of all relevant documentation. By taking the LPMS barge count by commodity group, and multiplying by the WCSC commodity group average load per barge, a reasonable estimate of total tonnage can be made. The adjusted tonnage estimate, the target tonnage, for Bayou Sorrel using this procedure yielded 26,401,000 tons. For Bayou Sorrel, the revision represents a 29.0 percent reduction from the original LPMS value, but also a reduction from the original WCSC estimate, equal to 5.0 percent. This result was produced by the fact that the WCSC barge count exceeded the LPMS barge count. This development was related to the case of Port Allen where the WCSC estimate exceeded the LPMS estimate.

Further detailed inspection of the two sources revealed a problem with the WCSC data. The nature of this problem involved the assignment of alt codes. For particular origin-destination combinations, it is not possible to know which lock(s) a movement used without the additional information provided by the alt code. This condition arises when the geography of the system provides for multiple routes. Alt code information submitted to the Center is not always accurate, because while it may be provided as the originally intended route, the actual route selected at times may change in transit. This condition can occur especially if the diversion involves only a minor change in route distance, or if unscheduled or unknown repairs or maintenance require that a lock be taken out of service.

The problem of misassigned alt codes was present at Port Allen, Algiers and Harvey. These are the three locations within the modeled system that, due to multiple routing possibilities, require an alt code to correctly route the movement. It was the misassignment of alt codes within WCSC that caused the WCSC tonnage at Port Allen (and by routing implication at Bayou Sorrel) to exceed the LPMS tonnage. This over-assignment at Port Allen was, conversely, the primary reason for the extreme deficiency of WCSC tonnage at Algiers.

When Port Allen, Algiers and Harvey are considered in aggregate, the magnitude of the LPMS - WCSC difference is modest, approximately 7.8 percent, and the difference is in the relative direction as typically observed, i.e., LPMS higher than WCSC (55,997,000 LPMS tons vs. 51,604,000 WCSC tons).

While comparison of tonnages and barge trips indicated that misassignment of alt codes had occurred, it is impossible to identify which individual movements are misassigned. While this may initially seem to represent a major problem, the consequences of this development are not dire, and indeed, the situation can be handled satisfactorily within the context of the economic modeling. Because most traffic that uses any one of Port Allen, Algiers or Harvey Locks is costed and permitted the option, within the economic model, to use both of the other two locks as an alternate route, it is not necessary that the original route be known. The model, in finding an equilibrium solution, will correctly allocate traffic as long as the relative costs of using each route are properly specified.

For all locks except Bayou Sorrel, the LPMS tonnage was used as the target tonnage. The targets used for Bayou Sorrel were as previously described. For Port Allen, Algiers and Harvey the meaningful target was the aggregate LPMS tonnage for the three for the reason of alt code misassignment described above. With these target tonnage levels established, WCSC traffic volumes and traffic patterns were evaluated for the purpose of constructing movements to make up the difference between the target and WCSC. To reemphasize, this process was undertaken with Port Allen, Algiers and Harvey considered in aggregate. As a result, all constructed movements generated to reconcile Port Allen/Algiers/Harvey were assigned Algiers as an original routing.

The results of the reconciliation process are summarized in table 3 - 2. Added traffic totaled 10.2 million tons for the system and 0.8 million tons at IHNC, representing increases of 13.9 percent and 3.4 percent, respectively, from original WCSC tonnage. Table 3 - 3 shows the added tons by commodity group for the overall system and for IHNC movements only.

c. Alternative System Routes and Movement File Aggregation: Due to the configuration of the mainstem GIWW and the GIWW Morgan City - Port Allen Alternate Route, alternate water routings are possible for virtually all

Table 3 - 2

Summary of 1990 WCSC and LPMS Tonnage Reconciliation
(Thousands of tons)

Lock	WCSC	LPMS	Target Tonnage	Added Traffic	Adjusted WCSC	Added Traffic as % of WCSC	Target minus Adjusted as % of Target
Port Allen	28,210	27,565	n.a.	0	28,210	0.0	n.a.
Bayou Sorrel	27,781	37,168	26,401	0	27,781	0.0	-5.2
IHNC	22,723	23,414	23,414	770	23,493	3.4	-0.3
Algiers	19,856	24,819	n.a.	4,772	24,628	24.0	n.a.
Harvey	3,538	3,612	n.a.	0	3,538	0.0	n.a.
Bayou Boeuf	23,221	27,628	27,628	4,624	27,845	19.9	-0.8
Calcasieu	39,450	46,301	46,301	7,051	46,501	17.9	-0.4
P.A./Alg/Hvy	51,604	55,996	55,996	4,772	56,376	9.2	-0.7
Total System	73,400	n.a.	n.a.	10,202	83,600	14	n.a.

Note: Added traffic at each lock does not sum to the total system because of common traffic between locks.

Table 3 - 3

Reconciliation of WCSC and LPMS
Summary of Added Tonnage
(Thousands of Tons)

Commodity Group	Total Added Movements	IHNC Movements
Farm Products	593.002	188.893
Metallic Ores & Products	231.286	0
Coal	150.495	0
Crude Petroleum	4,601.793	0
Non-Metallic Minerals	2,632.951	580.707
Forest Products and Pulp	9.126	0
Industrial Chemicals	0.000	0
Agricultural Chemicals	1,334.434	0
Petroleum Products	0.000	0
All Others	648.666	0
Total	10,201.753	769.600

movements operating on the GIWW west of the Mississippi River and the IHNC.

The waterway "triangle" formed by the Mississippi River between Baton Rouge and New Orleans (approximately 130 miles), the mainstem GIWW between New Orleans and Morgan City (approximately 94 miles) and the GIWW Morgan City - Port Allen Alternate Route between Morgan City and Baton Rouge (approximately 64 miles) provides the basis for multiple routing possibilities for through traffic as well as for traffic that is strictly local. For a local movement, i.e., a movement with an origin or destination on the "triangle", transit can be achieved by two alternate water routes in addition to the original route. This is so because Port Allen, Algiers and Harvey locks all provide for access from the Mississippi River to the western GIWW. For a through movement, i.e., traffic moving between a point above Baton Rouge and west of Morgan City, in addition to Port Allen, Algiers and Harvey routings, the Atchafalaya River also represents a viable alternate route. The Atchafalaya River provides access between the Mississippi River at mile 304, approximately 76 miles above Baton Rouge, and the mainstem GIWW at Morgan City, a distance of approximately 123 miles.

The availability of these alternate routings is important for system modeling. As tonnage in the system increases over time, so will congestion costs. The likely result of increased congestion costs will be a change in the relative desirability of one route over another for at least some movements. If alternative routings are specified for each movement within the movement file, the model will be able to evaluate all possibilities and select a route based on the costs associated with each choice.

In an effort to control the size of the problem to be solved by the model, alternative routings were limited to those that represented the most reasonable candidates; however, all original routes that had potential alternate routes were provided at least one alternate. In constructing the system alternate routings the following rules were used. (1) For through movements using the GIWW Morgan City - Port Allen Alternate Route, one alternate was constructed, the Atchafalaya River. (2) For through movements using the mainstem GIWW via Algiers or Harvey Locks, two alternatives were constructed, one via Harvey Lock and the mainstem GIWW and the other alternate via Port Allen Lock and the GIWW Alternate Route. (3) For GIWW West movements with an original route including Port Allen, Algiers or Harvey Locks, two alternatives were constructed, one each involving the use of either Port Allen, Algiers or Harvey locks depending on the original routing. (4) For local movements with an original route not including Port Allen, Algiers or Harvey Locks, two alternatives were constructed, one each involving the use of Port Allen and either Algiers or Harvey Locks depending on the original routing.

The assignment of transportation cost to the alternate water routings was accomplished in the following manner. Barge costs per mile were calculated for all original movements having alternate routings. This barge cost per mile was multiplied by the mileage associated with the alternate route to produce an adjusted alternate barge cost for the alternate route. Given the mileages of the original routing and the associated alternate, the adjusted alternate barge cost could be higher or lower than the original route barge cost. Using the alternate route barge cost and the same least cost non-system alternative associated with the original movement (since this in unchanged for the system alternate), the transportation cost savings for the system alternate route was computed. When all alternative routings were constructed, the movement file consisted of 16,455 total records representing 7,194 original movements.

The next step in the development of the movement file was to aggregate the file to a level more suitable for the analysis. Reducing the size of the movement file lowers the level of complexity that a large number of records can create for modeling purposes. To accomplish this, while still maintaining a level of detail necessary for realistic traffic routing, movements with common origin Port Equivalent, destination Port Equivalent, 10-group commodity code and system lock usage were aggregated into individual movements, with their transportation rates becoming a weighted average figure. The result of this process was a movement file that consisted of 5,460 total records representing 2,590 unique movements.

To further improve the efficiency of model operation, records of less than 1,000 tons, generally less than one full barge load, were also deleted from the file. These records consisted of a total of 459 records which included 263 alternate system routings and 196 original movements. Removing these movements only reduced lock system tonnage by approximately 80,000 tons. At this level of operation these small movements represented approximately 7.6 percent of original movements but only 0.1 percent of original movement tonnage.

d. Future Traffic Levels: From the final movement file, additional movement files were constructed to estimate future traffic demands by applying commodity group specific high, medium and low annual growth rates, previously discussed in Section 2 of this appendix, to the 1990 movement tonnages. The medium annual rates of growth were used to generate the most likely future system traffic demands at system locks.

CONGESTION COSTS

At this point, the transportation cost savings estimated for each of the movements in the WCSC data base include any congestion costs movements may have encountered as they traveled through the modeled locks. However the GEM requires these gross savings to be delay free, as the model itself calculates these costs. As a result an adjustment needs to be made to these estimates before proceeding any further.

To make the adjustment to gross savings estimates it is necessary to calculate a costs per hour of delay. There are three components that comprise the commodity-specific hourly delay costs at system locks. These components are barge cost, towboat cost, and commodity or inventory cost.

The first component, barge cost, is determined by the tow sizes and barge types employed in the movement of specific commodities. Tow size and barge type affect delay costs due to the differing capital and operating costs of the distinct equipment.

The average number of barges per tow for each commodity type transiting each lock was estimated and hourly barge costs for covered hopper barges, open hopper barges, and tank barges were used for the appropriate commodity groups in determining average barge costs per ton. Hourly barge costs were obtained from the Corps of Engineers Institute for Water Resources shallow draft vessel costs for Fiscal Year 1991.

The second major factor in estimating delay costs is the hourly cost of the towboat. The hourly cost of the towboat is directly related to its horsepower. Therefore, average towboat horsepower for each commodity type transiting each system lock was estimated and the operating costs were obtained from the Corps of Engineers Institute for Water Resources shallow draft vessel costs for Fiscal Year 1991. A significant adjustment to full towboat operating costs was necessary to more accurately estimate towboat costs accrued while waiting. Full operating costs are inappropriate for measuring delay costs since full costs contain a fuel component that reflects underway operations. To adjust for this, the fuel component of towboat costs was reduced by 75 percent for tows idling on the slack water

MR-GO side of the IHNC Lock, while use was made of information provided by towboat industry sources concerning hourly fuel cost of towboats idling against river currents while waiting on the Mississippi River side of the lock. In this instance, the full towboat cost of operation was used. These hourly fuel cost were then averaged to produce an overall estimate. This methodology was also used on Port Allen Lock, Algiers Lock and Harvey Lock, due to the fact that traffic queues waiting at these locks are also affected by Mississippi River currents. Traffic using Bayou Sorrel Lock, Bayou Boeuf lock and Calcasieu Lock are unaffected by river currents, consequently their overall fuel costs were reduced by 75 percent.

Using this information, an average tow operating cost was determined for each system lock for the ten commodity groupings used in this analysis.

The final component of the hourly cost of delay is commodity or inventory costs. These costs are typically such a small percentage of tow operating costs (less than 1 percent) that they have been ignored in this analysis.

For each of the ten commodity groups, barge and towboat cost per tow hour of delay were converted to costs per ton per hour by using average tons per tow. The final step in calculating cost per ton per hour of delay was to adjust for the empty backhauls of dedicated movements. The commodity mix of traffic on the GIWW is heavily weighted towards crude petroleum, refined petroleum products, and chemicals. For these commodities it was assumed that all traffic has empty backhauls. As such, delay costs are incurred twice, once with loaded barges and once with returning empty barges. The cost per ton per hour of delay was therefore doubled to reflect the empty backhaul. A 70 percent empty backhaul was assumed for the rest of the commodities so that delay costs are incurred 1.7 times, therefore the cost per ton per hour of delay was multiplied by 1.7 to reflect the appropriate level of empty backhaul. These calculations represent the estimates utilized by the GEM as it calculates lock congestion costs for each movement transiting each system lock. These hourly cost per kiloton by commodity and lock are shown in table 3 - 4.

In order to calculate delay free gross cost savings for each of the movements in the WCSC file, the original water transportation cost estimates were decreased (which increased the gross cost savings) by the product of these hourly wait cost per ton estimates and the average delay per hour the movement had to incur as it traveled through the modeled locks from its origin to destination.

Table 3 - 4

Hourly Costs of Delay for
Commodities at System Locks
(Dollars per 1,000 Tons)

Commodities	Port Allen	Bayou Sorrel	IHNC	Algiers	Harvey	Bayou Boeuf	Calcasieu
Farm Products	66	63	56	66	66	63	63
Metallic Ores	55	53	55	55	55	53	53
Coal	55	53	55	55	55	53	53
Crude Petroleum	51	49	51	51	51	49	49
Non-Metallic Minerals	49	46	49	49	49	46	46
Forest Products	55	52	55	55	55	52	52
Industrial Chemicals	82	77	82	82	82	77	77
Agricultural Chemicals	75	70	75	75	75	70	70
Petroleum Products	51	49	51	51	51	49	49
All Others	64	61	64	64	64	61	61

LOCK CAPACITY AND DELAY ANALYSIS

Essential to the economic analysis of improvements to the lock structures on the navigation system is the ability to quantify the relationship between tonnage moving through a lock and the resulting delays at the lock. In this study, two methods were employed for this purpose.

Due to the fact that a simulation analysis can be employed to detail the impact of any number of specific operational practices on the traffic - delay relationship, it was decided that this method of estimating lock capacity would be most appropriate to use on the IHNC Lock. As for the rest of the system locks, a more simplified analytical approach was used. The discussion of these two methods can be found in Section 5.