WATERWAY ANALYSIS MODEL

(WAM)

USER MANUAL

SHALLOW DRAFT VERSION

DECEMBER 2007

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Waterways Analysis Model Users Manual

Shallow Draft Version

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Shallow Draft Version

Waterway Analysis Model

User's Manual

A. INTRODUCTION

The purpose of this manual is to provide the user with documentation on the use of the shallow-draft version of the Waterway Analysis Model (WAM).

1. History

The Waterway Analysis Model (WAM) is a system simulation model originally developed to determine the impact of tow movements on the inland waterway system. It was developed as part of the U. S. Army Corps of Engineers Inland Navigation Systems Analysis Program (INSA) for the Office of the Chief of Engineers by CACI, Inc.[1] This version was tested, modified and calibrated by the Pittsburgh District for the Ohio River Division of the U. S. Army Corps of Engineers in 1982[2]. In 1982, the model was extensively modified and data requirements simplified by Dr. Larry Daggett of the U. S. Army Waterways Experiment Station at Vicksburg, Mississippi and Mr. David Weekly of the U. S. Army Corps of Engineers, Huntington District, Huntington, West Virginia. This version also made provisions for restricted channels (bends). Other modifications were developed by Louisville, Nashville and Huntington District personnel from 1982 through the present.

2. Summary

Section B presents material necessary for understanding the simulation model. Included are discussions relative to how the model defines and represents the waterway network, the vessels that move on it and the cargo that is carried. The various operations performed within the model to simulate the movement of these vessels through the network are then logically related.

Section C deals exclusively with input data and how it controls model operations. The rules which apply to input data in general are presented first. This is followed by a detailed description of the input data, including the format of each of the numerous record types.

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[1]Bronzini, M. S., et al., Inland Navigation Systems Analysis, Vol. V, Waterway Analysis, CACI, Inc., Arlington, VA, for U. S. Army Corps of Engineers, Washington, D.C., July 1976.

[2]U. S. Army Corps of Engineers, Pittsburgh District, Waterway Analysis Model, Pittsburgh, PA., January 1982; draft modifications by the Huntington District, January 1983.

Section D relates information relative to error detection and correction. The error messages printed by the WAM as part of its data checking feature are discussed and a table of the error codes is provided.

Section E discusses model output. Samples of the input playback reports and the simulation performance reports are shown and discussed. The formats for several optional output data files are also given.

Section F describes the installation of the model with emphasis on a personal computer. It also describes the SIMSCRIPT II.5 Simlab work environment and displays examples of run procedures.

B. MODEL COMPOSITION

1. Overview

An overview of the composition of the Waterway Analysis Model is presented in Figure 1. The four major components are:

a. System Description Input Data

This is a set of input records which describes the waterway network (ports, locks, bend terminators, and interconnecting bends and reaches), the tow fleet and the commodity classes to be transported.

b. External Event Input Data

These input records are read into the model during the simulation process and trigger occurrence of events. Since the events are caused by data from outside the model they are called external events and the data are called external event data. There are three types of external event input: 1) shipment data, 2) lock down time data and 3) run control data. The shipment data are a set of arrivals for shipment of commodities. The lock down time data identifies specific times and duration of chamber outages. The run control records cause such events as the resetting of accumulated statistics, the printing of intermediate output reports, the saving of optional data and the end of simulation.

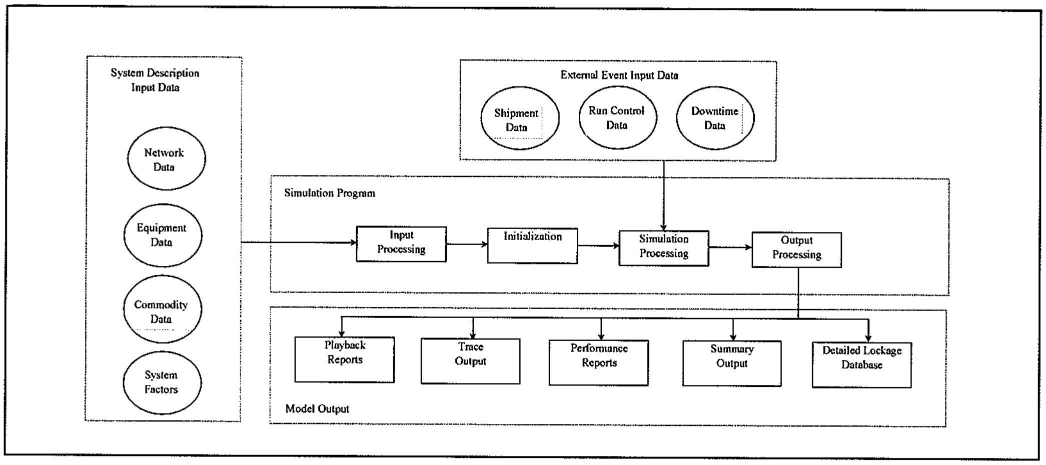
c. Simulation Program

The simulation program is the operational heart of the model. It processes the input data, produces playback reports, initializes the waterway system, processes each shipment from origin to destination, records statistics for generation of performance output reports and creates files for post-processing by other programs.

d. Model Output

Playback reports are produced by the input processing routines of the simulation program. These reports echo the system description input data in a convenient format for user data checking. The output processing routines of the program use statistics gathered during the simulation process to generate performance reports on network elements and equipment. Additional output includes a resource usage file containing detailed information on each shipment, several types of trace output for debugging and detailed movement analysis, and a comma separated file that can be imported into spreadsheets for further analysis.

Figure 1. Composition of the Waterway Analysis Model



2. Waterway System Representation

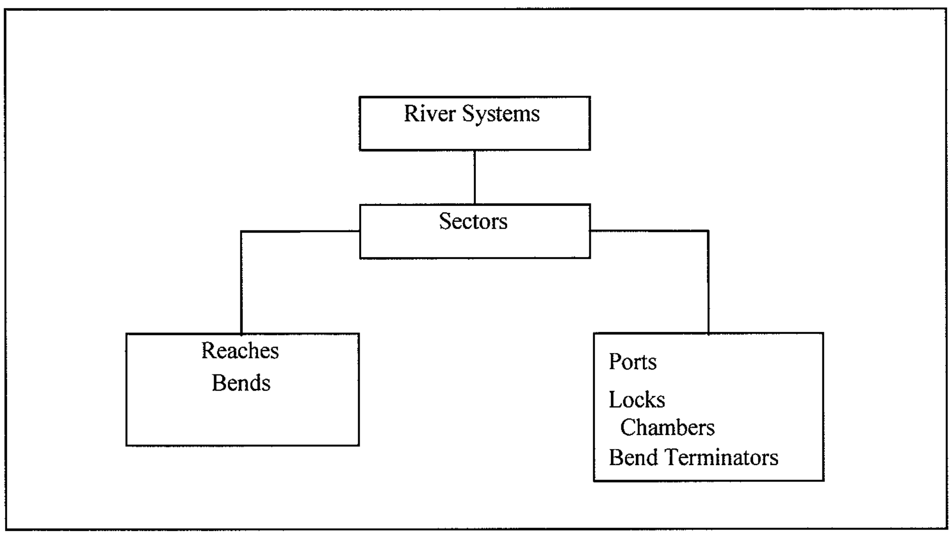
The following paragraphs describe the way in which the various elements of the navigation system are represented in the simulation model. Waterways and waterway facilities are discussed first, followed by sections on vessel and cargo representations. More insight and information on these concepts will follow, primarily in Section C.

a. The Waterway Network

(1) Network Structure

The waterway network is represented in the simulation model as a hierarchy of elements shown in Figure 2.

Figure 2. Waterway Representation



In model terminology, ports, locks, bend terminators, and reaches and bends between them are called links. These links represent the physical waterway features with which tows directly interact. Ports, locks and bend terminators are also often referred to as nodes because they represent points as opposed to bends and reaches which have length. Sectors and river systems serve to organize these lower level elements into convenient units for processing and analysis.

(2) River System

In the hierarchy of a waterway network, the river system is the highest element. The system is a collection of sectors used to collect statistics and organize the output. A river system is arbitrarily defined by the user and can be used to divide the network into convenient segments to give flexibility for collecting and displaying information.

A river system is described by a numeric identifier, a 20-character alphanumeric name, and a 2-character alphanumeric code. All the input parameters are user-defined with no restriction except that the river system numbers must be sequential starting with 1.

Model operations are not affected by the number of river systems defined in the waterway network. However, the use of river systems enables the user to collect and display statistics for selected segments of the total network by requesting only the desired output on the model run control records. (See Section D.5.c.)

(3) Sectors

A sector is defined as an unbranched section of the network on which certain tow operating limitations are uniform. Typically, a sector extends from one junction to another or to a system endpoint; although, such a segment can be divided into two or more sectors with significant differences in characteristics existing along its length. Sectors always begin and end at ports. Each sector in the system is assigned a sequential numeric identifier. This sector number is used to organize the playback and output reports. For example, in the Traffic Reach Report (R-4), the average tow speeds are computed by sector as well as by reach or bend.

Each sector has a maximum tow size and average tow speed. The maximum tow size is the largest size tow allowed on the sector, expressed in nominal units. (Nominal units are explained in this section under the heading of "Vessels") The average tow speed is used only to estimate the speed of a tow when the model must select the shortest route according to the routing table option. It is best that this value represent the average tow speed being computed by the WAM during previous runs. This value is displayed in the R-4 output report. (See Section E)

(4) Reaches

A reach, as the term is used in the simulation model, is an unrestricted section of waterway between two ports, two locks, two bend terminators, a port and a lock, a port and a bend terminator, or a lock and a bend terminator. A reach, along with a bend, are the only network elements with a non-zero length. The physical characteristics of actual reaches influence tow traffic in two principal ways: through the time required to travel a reach (a function of its length and the tow speed attainable), and by limiting the size and draft, and hence tonnage capacity of tows. Only the former is represented in the model.

The physical characteristics of a reach which affect tow speed include current velocity, depth, channel width, radius of bends and presence of obstacles. The first two of these are represented explicitly in the model. All other influences are aggregated into a pair of coefficients called tow speed coefficients, one for each direction of travel. These coefficients may be estimated by comparing theoretical and observed tow speeds, and taking into account the specific channel conditions. In addition to implicitly representing river characteristics, the tow speed coefficients are used to account for proper turn around times for tows in aggregated areas where locks have been omitted.

The size of a tow may be limited by the dimensions of the navigation channel. In the model, a tow size limit is specified for each sector. Tow drafts, and hence loadings, are limited by the minimum channel depth along the route. Such limitations are not represented directly in the model since the size of each individual tow is provided as input along with the tonnage. If the data input for a particular tow exceeds the limitations during any portion of its routing, an informative message will be output. A particularly restricted portion of the waterway may be modeled by changing that portion of the waterway from a reach to a bend.

(5) Bends

A bend, as the term is used in the simulation model, is a restricted section of waterway between two bend terminators. A bend may not necessarily have a radius of curvature; a narrow channel may also be represented in the model by a bend. The physical characteristics of actual bends (which include narrow channels) influence tow traffic in three principal ways: through the time required to travel a bend (a function of tow length, speed attainable, and speed of preceding traffic); by limiting the size and draft, and hence capacity, of tows; and by delaying a tow from entering a bend (a function of tow size, bend characteristics, and other traffic on the waterway). As with reaches, the limitation on size and draft of a tow is not represented in the model.

The physical characteristics of a bend which affect tow speeds include current velocity, depth, channel width, radius of the bend, and presence of obstacles. The first two are modeled explicitly while all other influences are aggregated into four coefficients called tow speed coefficients, one for each direction of travel and two sizes of tows, based on tow length. The channel width, radius of bend, required clearance for two-way traffic, tow length, and tow width are all explicitly represented in the model in order to determine whether or not a tow is delayed from entering a bend or narrow channel and, once delayed, when a tow may enter the bend or narrow channel.

Bends are modeled assuming that a tow in a bend cannot overtake and pass another tow in the bend that is traveling in the same direction. The model further assumes that the following tow will maintain a separation distance of at least two tow lengths.

It should be noted that most uses of the bend feature have been in modeling one and two way areas. This has been controlled by setting the bend radius to zero and selecting bend widths and tow passing clearance to represent actual tow transit experience. If the user desires to use actual radius and bend dimensions, the equations in the analytic routine (WD.IN.BEND) must be modified for tows. The equations determine the path the tow sweeps out when the radius is not equal to zero. The equations presently represent 600-foot and 1200-foot inland waterway tows.

(6) Ports

On the waterway system, docks and associated port facilities are distributed along the rivers. Many facilities, though by no means all, are concentrated around cities, but even here they may stretch over many miles with no clearly defined starting or ending points. Since there may be too many docks to be represented individually in the simulation model, and since port operations on the waterways are not of primary concern in its envisioned use, groups of docks are abstracted as points or network nodes which serve as "port equivalents" in the model. The main idea is that port equivalents can be located in such a manner that traffic through the locks, bends, and reaches of primary interest to waterway planners is closely approximated, even through the exact origins and destinations of cargo shipments may not be known. Each port equivalent (PE) has been defined so that the entire set of port equivalents completely spans the waterway system and every dock is included in one PE or another. Most PE's are defined to represent all the docks in one "pool," the reach of river between two locks.

Ports are, by definition, the only points in the network where barges can load or unload. It follows that all commodity movements must originate and terminate at ports. Ports appear at all endpoints and sector junctions of the network. In some cases it may be necessary to define ports at sector junctions which neither originate nor terminate cargo. These "junction ports" thus differ conceptually from ports, since they do not necessarily represent a collection of docks. In all other respects, junction ports are identical to ports and they are represented as "ports" in the model.

Port operations are as abstract and as aggregate as the ports themselves. It is clearly inappropriate to attempt to deal explicitly with internal operations at a port, when it actually represents a large number of different facilities scattered over a wide area. Hence port operations are represented only through average processing times. Only two types of activities occur at a port, barge loading and unloading and barge pickup and drop-off by towboats. These operations are independent of each other.

Each port in the system is described by numeric identifiers, port name, river mile, tow stopping delay, barge pickup/drop-off delay and the port's loading and unloading rate. The numeric identifiers, port name, and river mile are used to identify and locate the port. The tow stopping delay simulates the time required by a towboat to drop off or pickup barges. It represents an "overhead" time to secure a fleet of barges to the towboat to form a tow. The barge pickup/drop-off delay represents the time in hours per barge to reconfigure a group of barges when being picked up or dropped off by a towboat. The total delay at a port for a towboat is the sum of the tow stopping delay plus the product of the barge pickup/drop-off delay and the number of barges involved in the exchange.

The final input parameters are the loading/unloading rates. Two possible loading/unloading rates can be input for each port. The first, or the general port handling rate, is input on the same record as the previously discussed input parameters. The second is optional and is input on separate records placed directly after the Port Data. Optional port handling rates can be given for any or all commodity groups. If the optional rates are specified then commodities identified will be processed at this specified rate. If the optional rates are not specified, then commodities arriving at the port are processed at the lower value of the general port loading/unloading rate and the general commodity loading/unloading rate. The later value can be entered on the commodity data records.

Ports, including junction ports, also require unique port and junction numbers. Relative to the naming of junction ports, care must be taken when coding the name on each of the two or more input records required (one for each sector in which it exists) so that the names are identical and that each character is in the same column as its equivalent character on the other record(s).

(7) Bend Terminators

A bend terminator is that point on a section of waterway where a reach (unrestricted as far as the tow traffic is concerned) becomes a bend (restricted as far as the tow traffic is concerned). Bend terminators are represented by number and river mile location.

When a tow arrives at a bend terminator entering a reach (exiting a bend), the tow simply continues on the reach. When a tow arrives at a bend terminator entering a bend, the simulation model makes a determination as to whether or not the tow may enter the bend based upon other tow traffic in the bend or approaching the bend and the characteristics of the bend. If the tow is not allowed to immediately enter the bend, it is queued at the bend terminator point until such a time as the tow may enter the bend. The shallow draft version of WAM has the basic assumption that downbound boats have priority over upbound boats.

(8) Locks

Lock and dam facilities are generally a waterway element of direct interest to navigation planners because of the large expenditure of public funds they represent, because they are frequently the bottlenecks of the system and because they are an element amenable to federal improvement. Consequently, locks are represented at a comparatively detailed level relative to the rest of the waterway network. Nevertheless, the model imposes a degree of abstraction which, by absolute standards, may appear rather severe. The central abstraction employed is to represent lock operations by random processing time distributions.

Lock data are inserted into the network in order of appearance of the lock within each sector and locks are treated as specific points in the network. Locks are represented by name, number, and river mile location. Another input is the estimated average delay, which is the average time required by a tow to transit the lock system. It includes average delay and processing time. This value is used to determine the estimated travel time for the routing algorithms.

Recreation traffic can also be represented at a lock. Its input consists of a recreational lockage policy and a recreational traffic rate. The lockage policy specifies the maximum number of tow lockages a recreation vessel could wait, before having access to the lock, while the recreation traffic rates give the average number of recreation vessels locked daily.

When a lock consists of two or more chambers, chamber selection is made using a chamber selection bias input number. It is used to determine whether a tow should use a small chamber when it is available or wait for the large chamber in order to lock through in fewer cuts.

(9) Lock Chambers

Each lock consists of one or more lock chambers. Chamber data are input to the network immediately following the lock data. The input consists of a chamber number, dimensions (width and length) in feet, the normal operating policy designation, the probability of a lockage being a setover, and towboat types excluded from the chamber under normal operating conditions. Other entries on the data record identify operating options which are available to the user. These options are described in Section C along with the other input data.

Immediately following the chamber data records, lockage time distributions for the chamber are input. The time required to complete the movement of a vessel through the lock is determined from this information. At an actual lock, this time varies with a large number of factors including size and configuration of the tow, maneuverability, water level, current speed, presence of interfering traffic, weather conditions and pilot skill. Accounting for all such factors explicitly in a model is clearly infeasible. A common simulation tactic is therefore employed. A small subset of the most important factors is selected for explicit representation, then the influence of the remaining factors is treated as a random variation described by a probability distribution.

Lock processing time is subdivided into four components; approach, entry, chambering, and exit. These are the same components for which times are recorded under the Corps of Engineers Lock Performance Monitoring System (LPMS). Probability distributions for each component under the various conditions given above are input to the model as data. The user may specify common statistical distributions (such as Gamma or Weibull), or may enter tabulated empirical frequency distributions. (See Section C.3.o.) Section 3.e.2 provides a detailed explanation of the lockage process.

The preceding discussion has been concerned with modeling the actual passage of vessels through a lock. An equally important facet of lock operations involves the queuing of vessels which cannot be passed immediately and the associated rules for determining the order of service and selection of chambers at a multi-chamber facility. Once again, simplifications are required for computational feasibility. The model supports "first come-first serve," "N-Up/N-Down," and "one-way" operating policies for each chamber. A queue is maintained for the lock facility as a whole. Tows are assigned chambers as they become available.

An option exists for each chamber whereby detailed lockage statistics may be kept to produce the Detailed Lockage Report described in Section E. Selection of this option will increase the memory requirements of the model.

(10) Other Features

Other features and facilities present in the actual waterway system, such as marinas, docks, navigation aids, etc., are substantially less significant to navigation and are not explicitly represented in the model. Their effects can often be implicitly accounted for through such parameters as port processing times and reach speed coefficients.

b. Vessels.

Towboats and barges are the active elements of inland waterway transportation because they move through the waterway network to deliver cargo to its destination. Towboats and barges are organized into classes with all vessels of the same class treated as being identical. Since there is a relatively high limit (99) of types which may be defined, it is possible in principle to represent a fleet in fine detail. However, computational limitations make the aggregation of vessel characteristics into a relatively small number of standard classes desirable. This also makes it much easier for the model user to input and observe the effects of changes in fleet characteristics.

(1) Towboats

Each class of towboat represented in the model is described by its horsepower, dimensions, towing capacity, area of operation, a 20-character name, and a one or two digit numeric identifier. The first two characteristics are used in the computation of tow speed. The towing capacity places an upper limit on the size of tow that can be moved by the boat. It will be recalled that a similar limit applies to each sector. The effective maximum tow size on any sector in the system is determined by the smaller of these two values. The alphanumeric name is used for identification by the user and the numeric identifier is used internally by the model for identification of towboats.

It is often observed in practice that a particular towboat operates in only a certain region of the waterway network. In particular, smaller boats tend to operate in more restricted regions, while larger and more powerful vessels may travel only relatively open portions of the network. These restrictions arise for economic rather than physical reasons. There is no point in operating a very powerful (and expensive) towboat on a river where channel restrictions make large tows infeasible. Conversely, in an area such as the Lower Mississippi, large tows requiring correspondingly large towboats offer economies of scale not available to smaller boats.

In the simulation model, this phenomenon is represented by specifying a list of network sectors on which each towboat class is permitted to operate. Note that it may be necessary to define two or more towboat classes which are physically identical but which operate in different areas of the waterway network. Furthermore, areas of operation may overlap, so that if some towboats of a particular class operate on, say, only the Ohio River, while others travel both the Ohio and the Mississippi, both operations may be represented.

Towboat classes and all parameters describing a particular class are user input. Therefore, it is possible to simulate many types of unique towboats. Currently the model limits to ninety-nine (99) the total number of towboat classes which can be represented. This limit can be extended with some program modification; however, it is unlikely that such a need will arise.

(2) Barges

Barge classes are described by their size and the amounts of various classes of cargo they can carry. The manner in which barge size is measured represents an important abstraction in the model. For purposes of computing towing speeds and fitting tows into lock chambers, the actual dimensions - length, width and draft, are employed. However, with respect to tow size limits on sectors and with respect to towboat towing capacity, the assumption is made that the size of each barge (and by extension the size of a tow) can be represented by a single number. This number is referred to as the tow size in nominal barge units.

The nominal barge unit is not defined within the model itself; it is left to the user to determine an appropriate scale and to specify barge sizes and tow size limits relative to it. An approach which appears to give good results is to select one barge type as a standard and assign it a size of one nominal barge unit. The sizes of other barges are calculated proportionally relative to that of the standard selected. Caution is advised, however, in the selection of nominal barge unit representations for certain types of barges. This is to insure that the tow size limit on each sector is appropriate for each barge type.

The representation of tow size by a single number, the sum of the nominal barge units of the individual barges, implies that the specific configuration of a tow is not relevant. This admittedly leads to a compromise in determine towing speeds, but the computational complexity and cost involved in explicit representation of tow configuration is not warranted by the related change in results.

The model permits the capacity of each type of barge to be specified separately for each class of commodity. A capacity of zero indicates a mismatch between barge and commodity class (a tank barge will not carry wheat, for example). In addition the model takes the depth along the route of shipment into account when simulating the loading of barges. If the barge cannot be loaded to its full draft, its capacity is reduced proportionally.

c. Recreation Craft

Tows share the waterways with other vessels, all of which are classified as recreation craft in the model. The model is not concerned with these vessels per se, but only with their influence on commercial traffic. The most significant interaction occurs at locks and this is the only place where the model takes notice of recreation traffic.

Recreation craft can be represented in the model by two different methods. Method 1 involves assigning a specific towboat type or types as recreation vessels with the appropriate horsepower and dimensions. These tows are then scheduled for arrival in the system by listing them in the shipment list. This allows the user more control over their exact arrival patterns, especially if there are seasonal characteristics. The code of the model was changed for the 2003 Ohio River Main Stem System Study, System Investment Plan (SIP). Prior to the SIP, recreation craft were treated as tows, and were subject to the queuing discipline assigned to commercial vessels. With the code change, vessels with towboat type 9 and zero barges are considered recreation craft. As recreation craft, if they are unable to start lockage immediately, they are placed in the Recqueue. Recreation craft are removed from Recqueue based on rules described in Section 3.e.3.

Deleted: The disadvantage of this method is that recreation craft are treated as tows and are subject to the queuing discipline assigned to commercial vessels.¶

Method 2 involves invoking the models internal recreation arrival routines and is discussed in the following paragraphs. The user is cautioned that method 2 has not been thoroughly tested and may cause errors.

In method 2, recreation craft are assumed to appear randomly, at a specified average rate, at locks where they are to be simulated. Each vessel is represented explicitly during the time it waits for and accomplishes its lockage; thereafter, as far as the model is concerned, it disappears from the system. Movement of recreation craft between locks is not represented. The influence of recreation traffic at one lock is thus independent of that at other locks. There is no differentiation among sizes or types of recreation vessels.

The arrival rate of recreation craft is specified separately for each lock where they are to be taken into account. Separate rates for weekends and weekdays are provided, as well as for upstream and downstream directions of travel. Arrivals may be limited to a specific period during the day (daylight hours, for example) to further represent the uneven distribution of recreation traffic.

d. Cargo

The transportation of cargo is the central purpose of the waterway system. Correspondingly, cargo shipments provide the driving force for the simulation model with response to which all other activity that takes place. The stream of shipments is an external input to the model.

(1) Commodity Classes

The many commodities transported in the actual system are aggregated in the model into commodity classes. As with towboats, the number of such classes is unlimited in principle but subject to practical limits. Each commodity class requires input information relative to the types of barges which may move the commodity, the density of loading of the class and whether or not the class is considered hazardous cargo. No barge containing hazardous cargo may be locked through with any other vessel. Each commodity class is assigned to a commodity group.

(2) Commodity Groups

Commodity classes are further aggregated into commodity groups to reduce the amount of computer storage required. Commodity groups are used to assign loading/unloading rates for all commodity classes contained in the group. These handling rates are developed by the user from historical data and altered as necessary during calibration. They are specified for each group and optionally, for any commodity group and port combination.

The loading/unloading rate for the group will be used if it is less than a general all-commodity loading/unloading rate at the originating or destination port and if a commodity loading/unloading rate at the port has not been specified. If one has been specified, it automatically overrides any other rates.

The port activity report of the model output (R-3) specifies tonnage originating, loaded, shipped and received by commodity group. If the number of classes is small, the user can let each group represent one class, thereby enabling the port activity report to be presented by commodity class.

(3) Shipment List

The shipment list is a stream of shipment arrivals, which are input to the model during execution. Each shipment is associated with a commodity class, tonnage amount, shipment segment origin, shipment segment destination, movement origin, movement destination, time of arrival, type of barge, and whether the barges are loaded or empty. The origins and destinations of shipments are the ports discussed earlier. Thus, cargo flows are generalized to the same extent that ports represent a generalization of the actual terminal facilities distributed along the waterways.

The form in which commodity flow data are available to the user will generally be as a set of shipment demands, such as an origin-destination matrix giving the total flows (by commodity) between pairs of ports over a period of time. A preprocessor program is used to convert such a matrix to the separate vessel shipments needed by the model.

3. Model Operations

This section describes the operations of the WAM. The discussion is at a logical, rather than at the program level. The reader will find it helpful to have a knowledge of basic simulation concepts, particularly that of representing system activities as a sequence of events scheduled by a simulated time clock. Also, to aid the interested reader in relating the discussion to the program listing, the names of the principal simulation routines of the programs are included with the descriptions of their functions as, for example, (STARTLOCKAGE).

a. Cargo Operations.

(1) Cargo Arrival

The activity of the simulated system begins when cargo arrives at a port for shipment to another port. The SIMSCRIPT II.5 external event mechanism invokes the corresponding processing routine (SHIP) automatically at the simulated time when each shipment is due to enter the system. (Note that the term "shipment" refers, in the model, to the cargo described by a single shipment data record. This cargo may not be divided, it is considered a single shipment.) A data record describing the shipment is created and added to a set of such records maintained at the origin port. This record exists until the shipment has been delivered to its destination, at which time the record is no longer of interest and is destroyed.

(2) Cargo Loading and Unloading

A basic assumption of the model is that the barges of the type specified are available at the origin port at the time the cargo is available. The key computation here is the capacity of each barge. A maximum capacity for each feasible combination of barge class and commodity type is available from the input data; however, it may be necessary to reduce this figure because inadequate depth along the shipping route limits the usable draft of the barges. As part of the initial processing of each shipment, the minimum depth on the anticipated route is located and stored. With this information, plus the barge attributes of empty draft, fully loaded draft, and required bottom clearance, it is a straightforward calculation to obtain the maximum permissible loading, assuming that draft increases linearly with tonnage (DRAFTLIM).

With the capacity in hand, determining the number of barges required to load the available cargo is straightforward. Loading continues with computation of the time required. If a specific loading rate has been input for the port and commodity group involved, it is used; if not, the smaller of the default rate at the port and the default rate for the commodity group is selected. The tonnage to be loaded is divided by the applicable rate to get the loading time for the barge. The entire group of barges being considered is assumed to be loaded as a unit, all barges becoming available for pickup at the same time.

Although the process by which barges are moved to their destination has not yet been discussed, it is appropriate at this point to consider the activity which takes place upon their arrival (DELIVER). If barges are loaded, the first task is to unload them and record the delivery of the cargo. Unloading is similar to loading with respect to selecting the appropriate unloading rate and computing the time required. Delivery of the entire shipment is thereby completed and the shipment record is removed from the list of active shipments (maintained at the origin port) and destroyed.

Some shipments do not require cargo loading or unloading. These shipments may be associated with those passing through, only originating, or only destined to a particular waterway system being modeled. Also, a complete commodity movement may consist of one or more than one shipment segments. The model has the capability to bypass the loading/unloading calculations by requiring two ports each for the origin and destination. The port activities are bypassed when either the shipment segment origin port differs from the movement origin port or the shipment segment destination port differs from the movement destination port. For example, if the origin of the movement and the origin of the shipment segment are identical, a delay for loading and starting will occur and the barge movement will follow the delay. If the movement origin and the shipment segment origin are different, only a starting delay will occur. In both cases, barge movement follows the respective delay. If the user wishes to ignore the loading/unloading and start/stop port times, these values can be set so that all shipments appear at the arrival time on the shipment list and disappear when they reach their destination.

b. Tow Movements

The movement of shipments through the waterway network is in many ways the heart of the model. The basic mechanism (MOVE) involved is a process of scheduling simulated events and advancing a location indicator associated with the movement of each shipment through all the elements (i.e., ports, locks, and channels). The appropriate processing is invoked in each network element based on the passage of simulated time. Statistics for each element and shipment are recorded as the system clock advances. The processing at each type of network element is described in the following sections.

There is no central scheduling mechanism for barges in the model. A basic assumption of the model is that a barge of the type specified is available at the shipment segment origin port at the time the external shipment list is read. Destinations are determined by the shipment list. The shipment list contains two origin and destination ports. If the origin ports or destination ports are identical, loading/unloading occurs, respectively. If different, only the barge start/stop delay occurs at the ports.

When a tow en route to some port reaches a junction in the network, a means of determining which way to go is required

(SETCOURSE). There are two methods used by the model to determine the routing. One is based on a routing table, and the other is based on a least cost method. The second method is known as the dynamic method. It can be enabled by marking column 47 on the "A" card.

The default method used by the model is based on a routing table. Recall that a junction is, by definition, the junction of two or more (often three) network sectors. Suppose that a tow arrives at the end of sector i enroute to a destination located in sector j. Then the (i,j) entry in the routing table gives the next sector on the route, that is, the sector on which to depart the junction. By repeated reference to this table, the complete route between pairs of sectors may be obtained.

Within a sector there are, by definition, no branches and hence there is generally no routing problem. The one exception occurs when a shipment is ready for movement from the shipment segment origin. It is then necessary to determine which direction to travel to reach the shipment segment destination. The answer is again obtained from a table which indicates, for each pair of sectors i and j, the direction to travel on sector i to reach sector j.

When a tow arrives at the end of sector en route to a destination located in sector j. Then the (i,j) entry in the routing table gives the next sector on the route, that is, the sector on which to depart the junction. By repeated reference to this table, the complete route between any pair of sectors may be obtained.

The routing tables are computed as part of the initialization procedure for a run. In most cases, the route between a given pair of sectors is unique. This is a result of the generally tree-like structure of the waterway network; however, there may be cases where two or more routes exist between a pair of sectors. The default method, this situation is resolved by selecting the route which yields the shortest distance between the midpoints of each pair of sectors. Provision is made however, for the model user to override the computed route choices and, if necessary. To specify the routes to be selected. The dynamic method determines the route by calculating the costs (travel times) associated with each route, and selects the least cost route.

c. Port Operations

The basic activity at a port is the delivery and pickup of barges. Additional processing is required if the port is also a junction of two sectors, as described in a separate section below.

(1) Cargo Delivery

Upon arrival of a shipment at a port, the only activity is the delivery of barges if the tow is at the shipment segment destination. If not, the tow continues on the next link. If the shipment segment destination is the same as the movement destination, the barges are unloaded. If the shipment segment destination is different than the movement destination, this indicates that the shipment has not reached its final destination yet and fleeting operations will occur.

(2) Discussion of Fleeting Operations

The amount of time required for barge fleeting is, in reality, a function of several variables. One of the most important of these is the efficiency of the carrier. Large, well organized tows may drop off and pickup barges without ever coming to a complete stop. This operation, accomplished with the aid of a helper boat, may take only minutes. Other less organized carriers may tie off the entire tow, break out the towboat, perform the necessary tow reconfiguration, and then continue the trip. This operation could take several hours. The fleeting time parameters input to the model must be the average of all types of fleeting operations which normally occur at the port of question.

Until such time as port fleeting operations become of critical concern to Corps planners, and until better port data become available, the representations of port operations described above will be adequate, and will not significantly limit the usefulness and accuracy of the model.

d. Junction Operations

A junction is the boundary between two sectors in the simulated network. It is convenient to define network endpoints as junctions; however, every sector begins and ends at a junction. As noted previously, a port must be located at every junction; hence, all port operations described in the previous section also take place at junctions. The transition from one sector to another requires additional processing (JCTSTOP). Two special problems arise: the need for a routing choice; and the possibility that the tow may be unable to proceed at all due to operating area restrictions.

A routing decision must be made if the junction is a branch point of the network, that is, a junction of three or more sectors. The procedure for determining which sector to travel next, given the current sector and the destination, has already been described.

The most severe effect of a junction occurs when the tow reaches the boundary of its allowed operating area. The simulation is terminated with an error message since the tow may not proceed.

e. Lock Operations

Operations at a lock facility can be divided into two relatively independent areas: queuing, with its associated priority and chamber usage logic, and the actual passage of vessels through the lock.

(1) Queuing Policy

The logic used to remove vessels from queue is known by several names, i.e service policy, lockage policy, or queuing policy. There are three basic types of queuing policy used, FIFO, NUP-NDown, and One-Way. FIFO is an abbreviation for First-In First-Out. It is also known as first come first served. Most uncongested locks operate with this policy. Nup-Ndown are policies more often used at congested locks because it is generally more efficient. If a 3Up-3Down policy is in effect, 3 upbound vessels will be served followed by 3 downbound, followed by 3 upbound, etc. A One-Way policy is generally used at locks with twin chambers. Generally, one chamber will be dedicated to upbound tows, and the other will be dedicated to downbound tows. It should be noted that the model uses these policies as preferences, not unbreakable rules. For example, if a One-Way policy is in effect, and there are several tows traveling the same direction waiting in queue, the model will use the chamber that generally serves the other direction, if it is idle.

(2) Basic Tow Lockage

The basic concept of representing lockages by processing time distributions has been discussed previously. This section elaborates on the sequence of simulated operations which takes place when a vessel reaches a lock. The model first determines whether a suitable chamber is available for immediate use. At a lock with more than one chamber, this also involves a decision as to whether an available small chamber should be used or rejected in favor of waiting for the large chamber (USECHAMBER). Use of the large chamber may permit the tow to lock through faster, than if a small chamber were used. The small chamber is used only if the tow can lock through faster than the anticipated number of large chamber lockages ahead of the given tow. This rule generally results in the selection of the chamber which permits the tow to complete its lockage sooner. If both chambers are available, tows will choose the small chamber in order to minimize water use. If both chambers are the same size, the chamber designated as chamber 2 will be considered the small chamber. This logic will result in chamber 1 being the preferred one for tows of all sizes.

If a suitable chamber is available, the model next determines whether interference from an adjacent chamber, if there is one, prevents this vessel from making its approach. If interference does not exist, the lockage begins immediately with a fly approach (STARTLOCKAGE). If the chamber is not available, or interference exists, the tow joins a queue of vessels waiting to use the lock. Eventually a chamber will become available and the tow will be removed from the queue to start its lockage. This is described below in more detail in connection with end-of-lockage processing. At any rate, either immediately or after some delay, the tow is ready to begin its lockage (STARTLOCKAGE).

The first action is to determine the type of lockage, i.e. single, double, etc. (CLASSIFY). The determination uses a procedure which attempts to arrange the barges into the available chamber space (PACK). The possibility of a multiple-vessel lockage is next considered if the input option permitting them has been specified for the chamber. In this case, the queue of vessels awaiting lockage is searched (the number considered can be limited) for vessels which are going the same direction and can fit into the chamber with the first tow. When considering multi-tow lockages, a global clearance distance between vessels is applied. Also, tows carrying hazardous cargo are not permitted to execute multiple-tow lockages.

All information is now available to compute lockage times. The times for approach, entry, chambering, and chamber turnback (if required), are calculated (LKGTIME). Exit time cannot be determined until later because it depends on the type of exit, which in turn depends on the selection of the next vessel to use the chamber. This selection is deferred until the tow is ready to begin its exit, since the queuing situation at the lock can change during the lockage. After lockage times are computed, certain interference related parameters are set, and a END.APPROACH event is scheduled. For a full description of how interference between chambers is modeled see Section B.3.e.5, Interference.

Processing resumes when the approach ends. At this time, interference parameters are set, an END.ENTRY event is scheduled, and, if this a single cut lockage, a search is made for the next vessel to use this chamber. If a next vessel is found, and it is traveling the same direction as this lockage, its pre-approach is initiated.

The END.ENTRY event serves three main purposes. First, if the vessel is moving upbound, it checks to see whether the chamber can be filled. Second, if this is a single cut lockage, it schedules a BEGINEXIT event and looks for the next vessel to use this chamber if one wasn't found by the END.APPROACH event. If this is a multi-cut lockage, an EXTRACT.CHECK event is scheduled.

If the lockage is a multi-cut lockage, the EXTRACT.CHECK event executes next. This event serves three main purposes. First, it checks the interference situation to see if the cut in the chamber can be extracted. Second, it checks to see if the chamber can be turned back without interference. Third, it schedules a CUT.ENTRY event, which will start the next cut's entry into the chamber. The CUT.ENTRY event serves essentially the same purpose as the END.ENTRY event.The cycle of EXTRACT.CHECK - CUT.ENTRY events progress until the final cut is served. At that point, the BEGINEXIT event is executed.

The BEGINEXIT event serves several purposes. It looks for the next vessel to use this chamber, if one wasn't found previously, it determines the exit time for this lockage, and it determines whether the lockage can begin its exit without interference. It also schedules an ENDLOCKAGE event.

The ENDLOCKAGE event is the last event in the lockage sequence. It serves two main purposes. First, lockage statistics are updated to include this lockage. Second, events associated with the next lockage are initiated.

(3) Recreation Traffic

As noted previously, recreation craft can be accounted for by assigning them a towboat type and scheduling their arrivals in the shipment list. The lockage of recreation boats differs from that of tows in only a few respects. A separate chamber entry/exit time distribution replaces the approach, entry, and exit times applicable to tows. Recreation boats do not have entry or exit types. When the lockage of a tow precedes or follows a lockage devoted exclusively to recreation boats, the tow is considered, for the purpose of computing lockage time, to make a turnback exit or entry regardless of the actual travel directions. The basis for this is recreation boats usually cause negligible interference with tow approaches and exits.

Deleted: This discussion only applies if recreation arrival rates have been specified at a lock.

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Recall that recreation traffic is strictly local to each lock where its presence has been specified. A separate queue (Recqueue) is maintained for recreation vessels awaiting lockage. Recreation vessels and tows compete for lockage according to the following rules:

Deleted: . Arrivals of recreation vessels are generated in a self-rescheduling manner for each lock; that is, the processing of each arrival includes the determination of the time of the next recreation arrival at the lock (RECARRIVAL). Arrivals are scheduled randomly in accordance with the average arrival rates included in the input data for the lock. "Randomly" here means specifically that arrivals form a Poisson process or equivalently, that the time between arrivals is exponentially distributed. It should be noted that the primary intent of this representation is to simulate recreation use interference at the specific facility. The primary concern is the number of recreation lockages that take place rather than the number of crafts. For this reason model users should be aware that the model will tend to distribute recreation craft throughout the specified recreation lockage time period uniformly and that it is best to begin calibration runs with a representation of the desired number of recreation lockages used as the number of craft input and adjust as necessary after the initial run. As noted earlier, there is no distinction among types of recreation craft.¶
¶

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- Tows have priority over recreation craft except as provided below.

- If a recreation vessel is forced to wait through a specified number of tow lockages, it is given first priority for the next lockage.

- Recreation vessels can lock through with non-hazardous tows if space permits. This is allowed regardless of whether multiple-tow lockages are permitted. If they are, tows have first priority at sharing the chamber, but the small size of recreation vessels obviously gives them a strong advantage in ability to utilize excess chamber space.

- Recreation vessels may also obtain service in a manner not open to tows -- by locking through on a chamber turnback. Whenever an otherwise empty chamber turnback is required, recreation vessels traveling the proper direction are permitted to make their lockage with the turnback.

(4) Open Pass

Periods of open pass or navigable pass operations may be included for any lock by means of an input schedule which specifies the starting and ending times of each such period. In an open pass condition a lock acts as a narrow channel through which vessels may pass. A navigable pass operation occurs during periods of high water at certain locks when vessels can navigate over the dam without going through the lock chamber. In both cases, only one direction of traffic can be accommodated at a time. Not only can tows pass the lock more quickly in these states, but successive tows traveling in the same direction can follow each other closely, their passages overlapping so that the total time required is less than the summation of times of each tow taken separately.

In representing these situations in the model a slight artificiality is introduced, in that the model treats the passage of vessels as separate non-overlapping processes. When a group of vessels passes through the lock in the same direction, the first requires the full passage time to make the trip. Succeeding vessels, however, require only an incremental amount of time representing the separation between successive vessels. The shorter passage time is compensated for by a longer wait to begin passage. The total time for a vessel to pass a lock is thereby correctly represented.

With this convention established, simulation of open pass and navigable pass lockages proceeds in exactly the same way as normal lockages. The only difference is in the calculation of "lockage" time, which is now based on the open/navigable pass distributions. Transitions between normal and open/navigable pass conditions are made, in accordance with the specified schedule, at the start of a lockage. As far as the model is concerned, the vessel always goes through a lock chamber. This occurs during open pass, but navigable pass is effectively simulated by inputting nominal times (e.g., one minute) for "lock processing." As used in this report and in model output headings, "open pass" may refer to either open pass, navigable pass or both.

(5) Chamber Interference

The shallow draft version of WAM has the capability to model two basic categories of interference at multi-chamber locks. The first type considers interference between vessels moving in the constrained areas near a lock. The second type considers interference between the actual operation of the lock chambers.

Interference between moving vessels can occur in two ways. Approach area interference generally occurs between the lock structure itself and the arrival point. At most dual chamber locks, this is a "one tow at a time" area. Gate area interference occurs when barges waiting at the gates of one chamber interfere with an operation at the other chamber. Barges can be found waiting at gates during two different times, when waiting to make a turnback approach, and when waiting after being extracted during multi-cut lockages.

Interference between the operation of lock chambers generally occurs when both chambers cannot be filled simultaneously. McAlpine Lock and Dam on the Ohio River is an example where two 1200' chambers cannot be filled at the same time because there is not enough water in the upstream surge basin and canal.

f. Bend Terminator Operations

Operations at a bend terminator can be divided into two independent areas: operations occurring when a tow arrives at a bend terminator prior to entering a bend, and operations occurring when a tow arrives at a bend terminator after having transited a bend. Some sections of the waterway may have two or more bends in succession separated by bend terminators. Tows arriving at these bend terminators will cause operations to occur from both areas.

(1) Effective Width of a Tow

Due to the geometry of bends and rectangular tows, a tow has an effective width in a bend that is greater than its actual physical width. This effective width is a function of bend radius, tow length, tow width, and direction of travel. A narrow channel can also be modeled as a bend. In this case, however, the effective width of a tow is the actual physical width. Each bend or narrow channel has a required clearance. If there is opposing traffic in a bend, the effective width of the upbound tow plus the effective width of the downbound tow plus the required clearance for the bend must be less than the width of the bend.

The model uses an analytic routine (WD.IN.BEND) to determine the effective width of a tow. Most recent uses of the bend feature of the model have been in modelling one and two way areas. This has been controlled by setting the bend radius to zero and selecting bend widths and tow passing clearance to represent actual tow transit experience. If the user is going to use actual radius and bend dimensions, the equations in this routine must be modified for tows. The equations determine the path the tow sweeps out when the radius is not equal to zero and they presently represent 600-foot and 1200-foot inland waterway tows.

It should also be noted that this version of the model does not contain the downbound tow priority that is in the inland waterway version.

(2) Prior to Entering a Bend

When a tow arrives at a bend terminator prior to entering a bend, a decision is made (PERMISSION.TO.ENTER) as to whether the tow may immediately enter and transit the bend or whether the tow must be queued and delayed. If there is a queue of tows, join the queue. If not, and there are no tows transiting in the opposite direction, move the tow. If there are tows transiting the bend, then determine whether or not the arriving tow may move two-way considering his effective width, the effective width of other tows already in the bend, the required clearance, and the bend width. If the arriving tow may move two-way, move the tow. Otherwise, queue the tow.

(3) After Transiting a Bend

When a tow arrives at a bend terminator after having transited a bend, the model checks the queues in both directions. If there are tows in both queues, an attempt is made to start the tow with the longest delay through the bend. If this tow cannot move due to width restrictions of all the other tows in the bend, the other queue is checked. If this tow can move, then the model starts moving tows as long as the next in the queue can move two-way. Once a tow in the queue cannot move two-way, no attempt is made to move any more of the queued tows. If there are tows in only one of the queues, all the tows are started as long as they satisfy the width restrictions of any other tows in the bend.

g. Reach Operations

The transit of a network reach, between two ports and/or locks and/or bend terminators, is represented in the simulation by an interval of simulated time. The only processing associated with this is the computation of the tow speed and thereby the reach transit time required. The calculation begins by determining the resistance of the tow to movement through the water. An empirical formula relating resistance to vessel dimensions determines the resistance of each tow. Calculation of tow resistance is based on its draft, as determined by its current load.

The tow resistance and the towboat horsepower determine, through a force equilibrium condition, the tow speed achievable in still water of unlimited depth. This speed is then reduced by restricted channel dimensions. The most significant restriction on the waterways, and the only one taken into account explicitly, is depth. A shallow water coefficient is computed from the depth of the channel and the draft of the tow and applied to the previously computed speed to produce the theoretical still water speed.

At this point an empirical factor specified for each reach and direction of travel is applied to take into account all the local conditions not explicitly represented in the model. Finally, the speed of the current is added or subtracted as appropriate, and the travel time is obtained from the final speed and the length of the reach.

h. Bend Operations

The transit of a bend, is identical to a reach with two exceptions. The first exception is that tows in bends may not overtake and pass another tow traveling in the same direction. The second exception is that the computation of tow speed incorporates two sets of speed coefficients: one for direction and one for small and large tows. The user can divide large and small tows by specifying the length on the bend description.

4. Simulation Support

The preceding sections describe the central flow of simulated operations in the model; however, as with most large simulations, a significant portion of the program is devoted to support functions. Included in this subsection are input processing, initialization of the simulated system, statistics collection and output production.

a. Input Processing

The WAM simulator requires a rather large amount of input data and a substantial portion of the program is devoted to reading the data and checking for errors. The data formats required by the model with examples of the input records will be covered in Section C.3. The processing of these records is the first task of the model.

An input control routine (INPUT) reads the data records, produces an echo listing if desired, determines the type of each record and invokes the appropriate routine to process the data. The order of input is generally flexible, with some important exceptions in the data describing the waterway network (This is covered in detail in Section C.). The various input routines read and store the information on each record, thus setting up the system representation for the simulation.

An important facet of input processing is checking for errors in the data. Such problems as format errors (a non-numeric character in a numeric input field, for example), out of range errors (such as specifying a negative value for an inherently positive quantity), missing data and inconsistencies are detected and diagnosed. Errors detected in the initial input phase of model operation prevent the actual simulation from taking place; however, the program continues to read and check data. The program produces a set of "playback" output reports on completion of input processing.

b. Initialization

On completion of input processing, the waterway network representation has been established and the fleet defined. In a simulation study, the analyst is generally interested in the steady state behavior of the system before useful information can be obtained; therefore, it follows that the system must be in a steady state condition. Ideally, the simulated system would be initialized to a steady state condition before beginning the run. In practice this is impossible since the steady state probability distributions for the system are unknown. To circumvent this difficulty, the standard approach of initializing the system to some convenient state, and then running the model for a "warm-up" period to bring the system into approximately steady state before starting actual collection of output statistics, is adopted. Determining the required length of the warm-up period is a problem which can be approached only by experimentation; however, the closer the initial state of the system approximates steady state the shorter the unproductive period.

c. Output Preparation

The statistics gathering function is distributed throughout the model and effectively operates in parallel with the simulated activity. The data structures representing the components of the system include, in addition to the various descriptive attributes input for each, a number of statistical counters, accumulators and the like. For example, associated with each lock chamber are counters for the tow types using it and accumulators for totalling the chamber usage time. The program modules which carry out the simulation of lockage operations include program statements which correspondingly update these statistical attributes. The particular variables recorded by the model are determined by the desired content of the output reports.

Preparation of reports from the accumulated statistics is a generally straightforward data processing task. One special consideration is that certain statistics need to be "closed out" before they are used. For example, the time a lock chamber is in use is normally incremented at the end of each lockage. When a chamber is in use at the end of a run, the total time does not include that of the current lockage. It is therefore necessary to update the total by including the time the chamber was in use for the last lockage before reporting the statistic.

A second special consideration for statistical attributes is that of resetting them, as at the end of the warm-up period. During the warm-up period no statistics actually need be gathered. Rather than treating this period as a special case and bypassing statistics collection, it is simpler to let the model run normally and then reset the counters, etc., at the end of the warm-up. Subsequent reports will reflect only the ensuing time. The mechanics of a reset operation are straightforward, most values simply being set to zero. The output reports themselves are described in Section E.

C. MODEL INPUT

1. Introduction

The following paragraphs describe the input data elements, their formats, and other information in detail to facilitate model use. The model requires three input data files, and may include an optional fourth file. These are:

- System Description Data - Describes the waterway network, the vessels using it, the commodities carried and other aspects of the system to be simulated.

- Shipment Data - A list of commodity flows (shipments) to be moved by the system. This data effectively "drives" the model.

- Run Control Data - Controls the run length, statistics collection, output production and related aspects of the simulation run.

- Down Time Data (Optional) - Controls chamber closures by specifying particular down time events and duration of closure.

2. General System Description Data

The system description data file is the most complex of the three input data files. A number of different types of data records are required and each type has specific format requirements. Some general instructions and conventions which are applicable to all types of records included in the system description data are worthy of mention:

a. Format

Data are input via character records stored on disc. In general, column 1 of each record contains a code letter which identifies the type of input record. An "L" denotes lock data for example. Frequently it is impossible to place all the input data for one record type on one record. When two or more records are required to contain the data for one record type, the first record has the code letter in column 1 and the others have a "+" in column 1 to indicate continuation.

b. Input Record Types

The following record types are used in the system description data set:

A - Array Dimensions and Miscellaneous Parameters

G - Commodity Group Specification

C - Commodity Class Specification

B - Barge Class Data

F - Empirical Distribution Input

N - Major River System Specification

S - Network Sector Data

P - Port Data

L - Lock Data

H - Chamber Data

I - Interference Data (Optional)

R - Network Reach Data

B - Bend Data

E - Bend Terminator Data

W - Route Specification Data

NOTE: Record types A, B, P, L, H, F and W may require continuation records with a "+" in column 1.

c. Order of Input Record Types

The A records must be the first two records in the system description input data. Record types N, S, P, L, H, I, R, B (Bend) and E describe the waterway network. This network data is ordered according to the structure of the network, (see the discussions of network representation later in this section and Table 1). Record types G, C, B (Boat or Barge), D and F may be assembled without regard to order. These records may be placed before or after the network data. If W records are used they must follow all of the network data.

TABLE 1

ORDER OF NETWORK INPUT DATA

Record Type Code	Sequence Number	Description
N	1	First major river system in network.
S	1	First sector in river system 1.
P	1	First port in sector 1, at the upstream end of the sector. Would be a junction port except in the case that it is at an endpoint in the system.
R	1	First reach in sector 1 connecting the first port and the next sector node which may be another port, lock, or a bend terminator.
.	.	.
.	.	.
.	.	.
P	i	Ports, reaches, locks, bends, and bend terminators are listed in order of appearance from
R	i	the upstream end to the downstream end of the sector. A reach may appear between each node
P	i + 1	(lock, port or bend terminator). A bend may only appear between two bend terminators.
R	J = 1	
L	k	Lock Number k in sector 1.
I		Lock Interference (Optional)
H	1	Chambers 1 and 2, lock k. Chamber 1 is larger than or the same size as chamber 2.
H	2	
R	j + 2	
P	i + 2	
.	.	.
.	.	.
.	.	.
P	n	The last port in the sector, at the downstream end. Would be a junction port except in the case that it is the last port

		on a river flowing into the ocean.
S	2	Second sector in network and in N1.
.	.	.
.	.	.

d. Numeric Input Data

When numeric data are required, it may be placed anywhere in the appropriate field. Both leading and trailing blanks are ignored. Real numbers may be written with or without a decimal point (the latter being applicable only to whole numbers, of course). Exponential notation is not permitted. All numbers must be unsigned. There is no need for negative values in the input data.

It should be noted that the rules outlined herein are not standard SIMSCRIPT II.5 input conventions. The program performs its own numeric input processing in order to prevent aborts resulting from an attempt to read bad data. Thus, it can continue to read and check the remaining data after such an error has been detected and a warning has been issued.

e. Name Input

Many system elements are assigned 20-character names, principally to provide descriptive identification in output reports. Such names are arbitrary character strings in which all characters (including blanks) are considered significant.

f. Random Variable Input

Certain system parameters are described as random variables rather than fixed constants. The input for such variables defines a probability distribution. The general format for a random variable is "D P1", "D P1, P2", "D P1, P2, P3", or "D P1, P2, P3, P4" where "D" is a code identifying the type of distribution and P1, P2, P3 and P4 are parameters. Table 2 lists the distribution codes which may be used and describes the parameters for each variable. Within the field allocated for input of a random variable the data are placed in a free format. For example, a normally distributed random variable with mean 15 and standard deviation 2.5 would be coded as "N15, 2.5". Random variable input data are specified as such by (D) to the right of the data field on applicable input forms.

Table 2
Random Variable Distributions

Code	Distribution	Param 1	Param 2	Param 3	Param 4
B	Beta	Low EndPt	Hi EndPt	Shape 1	Shape2

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Deleted: Code Distribution Parameter 1 Parameter 2 Parameter 3¶ ¶ K. Constant Value ------- -------¶ U. Uniform Lower Limit Upper Limit -------¶ N. Normal Mean Std Deviation -------¶ L. Lognormal Mean Std Deviation Location¶ X. Exponential Mean Location -------¶ E. Erlang Mean K (order) Location¶ F. Empirical Dist. Number Multiplier -------¶ G. Gamma Mean Shape Location¶ W. Weibull Shape Scale Location¶ ¶

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A	Chi-Square	Degrees of Freedom	Location		
K	Constant	Value			
F	Empirical	Dist #	Multiplier		
E	Erlang	Mean[1]	Shape	Location	
X	Exponential	Scale	Location		
G	Gamma	Mean[1]	Shape	Location	
I	Inverse Gaussian	Scale	Shape	Location	
V	Inverted Weibull	Scale	Shape	Location	
H	Johnson SB	Low EndPt	Hi EndPt	Shape 1	Shape 2
L	Lognormal	Mean[1]	Std Dev	Location	
M	Log-LaPlace	Scale	Shape	Location	
D	Log-Logistic	Scale	Shape	Location	
N	Normal	Mean	Std Dev		
J	Pareto	Scale	Location		
P	Pearson Type 5	(1/Scale)*Shape	Shape	Location	
Q	Pearson Type 6	Scale	Shape 1	Shape 2	Location
R	Random Walk	Scale	Shape	Location	
S	Rayleigh	Scale	2.0	Location	
U	Uniform	Lower Limit	Upper Limit		
W	Weibull	Scale	Shape	Location	

1. This is an adjusted mean which equals the sample mean minus the location.

The empirical distribution, denoted by the "F" code, is inputted as histogram type tables. (See the discussion of the "F" format later in this section). Each distribution so defined is assigned an

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identifying number. The first parameter of the "F" distribution refers to one of these numbers. The second is a factor which multiplies the random value drawn from the specified distribution before it is used.

g. Data Type Specification on Input Form

The data elements on each input form have a code letter, in parentheses, to the right of the input entry. These codes indicate the type of data entry and are as follows:

(R) - Input is a real, non-negative number.
(I) - Input is a non-negative integer.
(A) - Input may be numeric or alphabetic or mixed.
It is treated as alphanumeric data.
(D) - A random variable input as listed in Table 2

NOTE: An integer may be used in place of a real whole number in (R) type data, i.e. "1" for "1.0".

h. Comments

Comments may be intermixed with input data by placing a "*" in column 1 of such records. Comments are echo printed with the data but otherwise ignored. Comment records are listed even if echo printing of the actual records has been suppressed. Therefore, they provide a means of documenting the data used for a run without listing it in its entirety.

3. Specific System Description Data

This section describes each item of input data in detail.

a. "A" Input Format - Array Dimensions and Miscellaneous Parameters

"A" data consists of two records specifying the numbers of certain system entities and values for certain miscellaneous parameters. These two records must be first in the input deck (with the exception of comments which may appear anywhere). These records should be completed last since the parameters depend on the rest of the network.

(1)	"A" Input Designation - "A"	1 (A)
(2)	System Dimensions (Number of):	
(a)	River Systems	3-6 (I)
(b)	Sectors	8-11 (I)
(c)	Links	13-16 (I)
(d)	Commodity Classes	18-21 (I)

(e)	Commodity Groups	23-26 (I)
(f)	Towboat Classes	28-31 (I)
(g)	Barge Classes	33-36 (I)
(h)	Empirical Frequency Distributions	38-41 (I)
(i)	Lock Chambers (total) in System	43-46 (I)
(j)	Flag for Routing using TCM Costs	47-47 (I)

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These values should be self-explanatory with the exception of "Links." A link is a port, a lock, a bend terminator, a bend or a reach, and the value required is the total number of these for the entire system. (Each appearance of a junction port is counted separately). The number may be overestimated, however, with the only penalty being a small amount of additional reserved, but unused memory space. Exact values should be given for the other items on this record.

(3)	Continuation Record Designator - "+"	1 (A)
(4)	Travel Time Limit for Light Boats (HR)	3-7 (R)
(5)	Loaded/Empty Tow Cutoff Tonnage	9-13 (I)
(5)	Recreation Traffic Start and Stop Times	
(a)	Start Time (HR of Day)	15-19 (R)
(b)	Stop Time (HR of Day)	21-25 (R)

At locks where recreation traffic is generated internally (see Section B.2.c), these values specify the portion of the day during which vessels may arrive. The values are written as the hour within the day. For example, if recreation traffic is to occur between 7:00 A.M. and 8:30 P.M., the values entered will be "7" and "20.5".

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(9)	Recreation Vessel Size (FT)	27-31 (R)

All recreation vessels are assumed to be of the same length. That length in feet is entered here.

(10)	Day of Week at Start of Simulation (Monday=1)	33 (I)

This value specifies the day of the week for the first day of the simulation. This is an integer between 1 and 7 with 1 indicating Monday. The only aspect of the model for which the day of the week is significant is recreation traffic arrival.

(11)	Utilization Cutoff on Lock Report-%	35-39 (R)

Part Two of the Lock Utilization and Delay output report (see

Section E) is a list of the most congested locks, ranked by their main chamber utilization. Locks with utilization rates below this cutoff value will be excluded from the report. Entry of zero in this parameter will result in a listing of all locks.

b. "G" Input Format - Commodity Group Specification

Commodity classes, as defined by the "C" input data, are aggregated into commodity groups for the purpose of specifying loading and unloading rates for a set of commodity classes with common physical properties and handling characteristics, and for collecting statistics. The "G" input data lists the commodity groups and the associated loading and unloading rates. The attributes of each commodity group are as follows:

(1) "G" Record Designator - "G" 1 (A)

(2) Commodity Group Number 3-4 (I)

This is a user assigned sequential integer from 1 to the number of commodity groups, to be included in the system.

(3) Commodity Group Name 6-25 (A)

(4) Commodity Loading Rate (100 TON/HR) 27-31 (R)

This input is expressed in units of 100 tons per hour and reflects the rate at which commodities in the group may be loaded aboard a single barge.

(5) Commodity Unloading Rate (100 TON/HR) 33-37 (R)

This input is expressed in units of 100 tons per hour and reflects the rate at which commodities in the group may be unloaded from a single barge.

NOTE: The barges within a shipment at a port are loaded (or unloaded) sequentially at these rates. Two or more shipments at a port at the same time are loaded (or unloaded) simultaneously.

c. "C" Input Format - Commodity Class Specification

Commodity movements are entered in the model by ports of origin and destination and commodity class number (see "SHIP" input record description in this section). The "C" input data lists each commodity class to be recognized by the model. The attributes of each commodity class are as follows:

(1) "C" Record Designator - "C" 1 (A)

(2) Commodity Class Number 3-4 (R)

This is a user assigned sequential integer from 1 to the number of commodity classes to be included in the system. These numbers are used to identify the commodity class in the shipment list.

(3) Commodity Class Name 6-25 (A)

(4) Commodity Group Number 27-28 (I)

This is the commodity group to which the commodity class belongs according to the loading and unloading rates of the class. (See description of "G" input format, above.)

(5) Hazardous Cargo Flag 30 (A)

Any non-blank character in this field indicates that the commodity class should be handled as hazardous cargo. Multiple vessel lockages are prohibited if one of the tows contains hazardous cargo.

d. "T" Input Format - Towboat Class Data

The user defines the towboat classes in the "T" input data. Each class requires at least two records of input, one for the definition and one or more for the areas of operation. The data elements are as follows:

(1) "T" Card Designator - "T" 1 (A)

(2) Towboat Class Number 3-4 (I)

The classes are numbered sequentially from 1 through the number of towboat classes in the fleet. This value cannot exceed 99.

(3) Towboat Class Name 6-25 (A)

(4) Length 32-35 (R)

(5) Width 37-39 (R)

(6) Block Coefficient 41-43 (R)

This is the ratio of actual displacement (cubic feet) to the product of length, width, and draft. This quantity is used in towboat speed calculations.

(7) Draft (ft) 45-47 (R)

(8) Horsepower 49-53 (R)

(9) Maximum Tow Size 55-59 (R)

This is the maximum tow size which can be handled by the towboat class (in nominal barge units).

(10) Continuation Card Designator – "+" 1 (A)

(11) Sectors of Operation 6-7,9-10, … 66-67,69-70 (I-A)

This is a record of waterway network sectors on which the towboat class may operate. A maximum of 22 sectors may be listed individually in columns 6-7, 9-10, 12-13, … with columns 8,11,14 … left blank. A range of sectors such as "22-28" may be entered by placing a dash, "-", in column 8, 11, 14 … as appropriate. Individual sector entries and sector string entries may be interspersed. As many cards as required may be used.

e. "B" Input Format - Barge Class Data

The user defines the barge classes in the "B" input data. The input data forms for each barge class include the barge class definitions and the barge class capacities. The data elements of these input records are as follows:

(1) "B" Record Designator - "B" 1 (A)

(2) Barge Class Number 3-4 (I)

The classes are numbered sequentially from 1 through the number of barge classes in the fleet. This value cannot exceed 99.

(3) Barge Class Name 6-25 (A)

(4) Length (FT) 33-35 (R)

(5) Width (FT) 37-39 (R)

(6) Block Coefficient 41-43 (R)

This is the ratio of actual displacement (cubic feet) to the product of length, width, and draft. This quantity is used in calculating the tow speed.

(7) Draft, Empty (FT) 45-47 (R)

(8) Draft, Fully Loaded (FT) 49-51 (R)

This is the draft of a barge loaded to its nominal capacity, in feet.

(9) Bottom Clearance (FT) 53-55 (R)

This is the required clearance between the barge and the river bottom, in feet. It is used with the draft data and the maximum depth figures for network reaches to determine the maximum tonnage a barge can carry over a particular route.

(10) Nominal Capacity (TONS) 57-61 (I)

This is the normal maximum capacity, in tons, of a barge. This value is used only to establish the relationship between tonnage and draft.

(11) Size (Nominal Barge Units) 63-67 (R)

See discussion on nominal barge units.

(12) Integrated Barge Flag (Non-Blank = Yes) 69 (A)

This is used simply as a descriptor in playback reports. It serves no explicit purpose within the model.

(13) Continuation Record Designator - "+" 1 (A)

(20) Barge Class Capacities 6-7,9-13 (I)
15-16,18-22
.
.

Starting on the second record of the barge class description, and continuing for as many records as necessary, is a list of the commodity class numbers of commodities that can be carried by the barge class. The maximum barge capacity, in tons, for each commodity class is also listed. Only the commodities which can be carried need be included and they need not be listed in order. The separate specification of capacities for each commodity class allows adjustment due to different commodity density. The actual capacity of a barge is computed by the model as the minimum of the value input here and the tonnage which would bring the barge to the maximum draft usable on the projected shipping route. Note that capacities are integers.

f. "N" Input Format - Major River System Specifications

One or more waterway network sectors may be aggregated to a major river system. These are defined only for output report generation. The output relative to locks, ports and reaches can be requested by river system, limiting the printing of output reports to only areas of interest as opposed to getting output for the entire system (as explained in Section C.5). In the network data the major river system is specified by placement of an "N" record before the first sector or "S" record in the river system. See Table 1 for a summary of network output data order. The following are attributes of each major river system:

(1) "N" Record Designator - "N" 1 (A)

(2) River System Number 3-4 (I)

River systems are numbered sequentially from 1 through the number of river systems.

(3) River System Name 6-25 (A)

(4) River System Code 27-28 (A)

This is a two character alphanumeric code assigned by the user.

g. "S" Input Format - Network Sector Data

The waterway network may consist of several sectors. All waterway junctions must be at sector endpoints and a new sector must be defined when one of the following sector attributes changes; maximum tow size, average tow speed upstream, average tow speed downstream. The sector or "S" record must precede all other network data associated with the sector. For a summary of network input data order see Table 1. The following data items are to be provided for each sector:

(1) "S" Record Designator - "S" 1 (A)

(2) Sector Number 3-4 (I)

Sectors are numbered sequentially from 1 through the number of sectors in the network.

(3) Sector Name 6-25 (A)

(4) Maximum Tow Size (Nominal Barge Units) 27-31 (R)

This is the size, in nominal barge units, of the largest tow permitted on the sector. The effective tow size limit for a towboat operating on this sector is the minimum of this value and the limit for the appropriate towboat class. (See towboat data description).

(5) Average Tow Speed, U/S (MPH) 33-37 (R)

(6) Average Tow Speed, D/S (MPH) 39-43 (R)

The above tow speeds are used to estimate travel time from origin to destination and hence determine the shortest path through the network. It is best that these estimates are the same as the average tow speed calculated within the model. The user should consider comparing this value with the output average tow speed on the Reach Report (R-4) after the initial run.

h. "P" Input Format - Port Data

The waterway network must include a port at the end points of each sector (junction ports) and at each point where cargo may be loaded into or unloaded from barges. For a summary of ordering of port data within the network input data see Table 1. The following data items must be provided:

(1) "P" Record Designator - "P" 1 (A)

(2) Port Number 2-4 (I)

Ports are numbered sequentially within each sector, the most upstream port being port 1. The numbering of ports on one sector is independent of port numbering on any other sector.

(3) Port Name 6-25 (A)

At junction ports, which are identified by at least two "P" records, it is of critical importance that the 20-character name be identical on each record, including its relative location within the 20-character field. Matching port names is the only way the model can identify junction ports and consequently; establish a correct routing table.

(4) River Mile 27-31 (R)

Any river mileage numbering system may be used, if it is consistent within each sector so that reach lengths can be calculated.

(5) Tow Stopping Delay (HR) 33-37 (R)

This is the minimum time spent by a towboat while picking up or dropping off barges at the port. This time is independent of the number of barges and may be treated as "overhead" time required for stopping at the port.

(6) Barge Pickup/Drop-off Delay (HR per Barge) 39-43 (R)

This is the time spent per barge by a towboat while picking up or dropping off barges at a port. This quantity times the number of barges to be handled is added to the tow stopping delay (above) to calculate the total elapsed time the towboat is engaged in the tow pick-up or drop-off activity at a port.

(7) Port Loading Rate (100 TONS/HR) 45-49 (R)

(8) Port Unloading Rate (100 TONS/HR) 51-55 (R)

The above two inputs reflect the maximum rate at which commodities are loaded or unloaded at the port. See discussion of loading/unloading rates, below.

Note that if open pass option is used, the P card must be padded through column 63 with blank characters.

(9) Continuation Record Designator - "+" (Optional) 1 (A)

(10) Specific Port Loading/Unloading Rates (Optional)

Commodity Group Number	Loading Rate (100 TONS/HR)	Unloading Rate (100 TONS/HR)
6-7 (I)	9-13 (R)	15-19 (R)
21-22 (I)	24-28 (R)	30-34 (R)
36-37 (I)	39-43 (R)	45-49 (R)
51-52 (I)	54-58 (R)	60-64 (R)

Loading/unloading rate information for the port may be provided for four commodity groups on each record. As many records as required may be used. These specific rates take precedence over the more general port loading/unloading rates (see "P" input format) and commodity group loading/unloading rates (see "G" input format). These rates are an optional input. If they are omitted, the lower of the two general rates (port and commodity) will be used.

i. "L" Input Format - Lock Data

Lock data are inserted into the network input data in the order of appearance of locks within each sector. For a summary of this ordering see Table 1. Lock definition input data are required for each lock in the network. If open pass or interference operations are to be simulated at the lock, one or more open pass schedule records must follow the lock definition record first, then the interference, "I" record. The following data items must be provided:

(1) "L" Record Designator - "L" 1 (A)

(2) Lock Number 2-4 (I)

Like ports, locks are numbered sequentially within each sector from upstream to downstream.

(3) Lock Name 6-25 (A)

(4) River Mile 27-31 (R)

(5) Estimated Average Delay (HR) 33-37 (R)

This is an estimate of average time required by a tow to transit the lock. It includes the queue delay while awaiting lockage and the lock processing time. This value can be used in the determination of the movement travel time estimate for the routing algorithms.

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(6) Sign for Chamber Selection Bias 38 (A)

This input may be a minus sign to indicate that chamber selection bias is a negative value.

(7) Chamber Selection Bias 39-40 (I)

This parameter is used when deciding whether a tow should use a small chamber (chamber 2) when it is available or wait for the large chamber (chamber 1) in order to lock through sooner. The small chamber is chosen if the number of lockages required plus the bias is less than the number of lockages waiting to use the large chamber ahead of the tow in question. A bias of zero will generally result in selection of the chamber which will allow the tow to complete its lockage sooner. Increasing the bias value will tend to discourage use of the small chamber.

(8) Recreation Lockage Policy 42 (I)

This is the maximum number of commercial lockages through which a recreation vessel may be forced to wait before using the lock. This may be omitted only if there is no recreation traffic utilizing the lock during the simulation period. It must be included if recreation traffic is included in the external shipment list. If left blank, the model assumes no recreation traffic and does not read traffic rates, 0 is invalid, at least "1" must be used.

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(9) Recreation Traffic Rates (Boats/Day)

(a) Weekday Upstream 44-48 (R)

(b) Weekday Downstream 50-54 (R)

(c) Weekend Upstream 56-60 (R)

(d) Weekend Downstream 62-66 (R)

These four arrival rates give the average number of recreation vessels per day for upstream and downstream directions of travel for weekday and weekend day. All of these data are omitted if there is no recreation traffic, or recreation traffic is included in the external shipment list. (See caution provided in Section B.3.e.(3).)

(10) Interference Flag 68 (A)

A non-blank character indicates interference data will be provided on "I" record. To use this data, there must be two chambers at a lock. These data should follow the open pass data on the "+" record or the "L" record if there is no open pass schedule.

(11) Maximum Cuts in Auxiliary 70-71 (I)

The maximum number of cuts allowed in the auxiliary chamber. This number can be used to limit the auxiliary to serve only small tows. This number is overridden when the main chamber is unavailable.

(12) Number of Tows Considered When Packing 73-74 (I)

This value is used to limit how far into the queue the model looks for vessels during the packing process. Vessels without barges and vessels traveling the other direction are not counted against this limit.

(13) Recs Boats and Tows Can Lock Together 76 (A)

A non-blank character indicates rec boats and towboats can lock together.

(14) Lock Data - Open Pass Schedule

These data apply only to locks where open pass operations are to be simulated for all or part of the run. They consist of the beginning and ending times (in days from the start of the simulation) for each period of such operations. For example, if open pass operations are to be in effect from day 3 at 8:00 A.M. to day 5 at 6:00 P.M., the entries would be 2.33 and 4.75, respectively, since day one is represented by time zero. Five periods may be specified per record. As many records as required may be used. It is important that these values are in pairs to avoid a fatal input error.

(a) Continuation Record Designator - "+" 1 (A)

(b) Open Pass Schedule (All entries are in days)

Start of Open Pass Period	End of Open Pass Period
6-10 (R)	12-16 (R)
18-22 (R)	24-28 (R)
30-34 (R)	36-40 (R)
42-46 (R)	48-52 (R)
54-58 (R)	60-64 (R)

This entry is optional. If used, it must follow the appropriate lock definition record. As many records as required may be used.

j. "I" Input Format - Interference Data (Optional)

The model has the capability to account for the interference that may occur between vessels at multi-chamber locks. Interference tends to reduce the capacity of the facility. Interference parameters are site specific, and are generally determined through interviews with people that know the facility very well, such as lock operators and lock masters, or pilots that transit the area frequently. Two general types of interference are modeled, approach area interference, and gate area interference.

Approach area interference occurs in the area between the arrival point and the lock walls. In most cases this "approach area" is a "one-tow-at-a-time" area. For example, if a downbound tow is making an approach to the main chamber, an upbound tow will usually not be able to make an exit from the auxiliary chamber until the approaching tow is on the guard wall, and is therefore, out of the approach area. Approach area interference is a Yes or No proposition, either a prudent navigator will take the action, or they will not.

Gate area interference occurs when a tow, or part of a tow, is waiting along the wall near the gates. This occurs during turnback approaches, and during multi-cut lockages. Gate area interference is not a Yes or No proposition. The determination of whether an action can occur is associated with the length of vessel that is waiting at the gates. For example, it may be reasonable for a downbound vessel to approach the main chamber if a vessel is waiting at the upper gates of the auxiliary chamber, but only if the vessel at the auxiliary is less than 600 feet long.

Note that interference can only occur between two tows. Recreational vessels and light boats cannot cause, and are not affected by, interference. Also note that these answers should reflect what a prudent navigator would usually do.

The following data items must be provided:

(1) <u>"I" Record Designator - "I"</u> 1 (A)

Items 2 through 9 specify the parameters used for gate area interference. They represent the maximum length of vessel that can be waiting at a gate without interfering with an action.

(2) Length waiting at upper auxiliary gates and upbound can exit the main chamber 2-5 (I)

(3) Length waiting at lower auxiliary gates and downbound can exit main chamber 7-10 (I)

(4) Length waiting at upper main gates and upbound can exit auxiliary chamber 12-15 (I)

(5) Length waiting at lower main gates and downbound can exit auxiliary chamber 17-20 (I)

(6) Length waiting at lower auxiliary gates and upbound can approach the main chamber 22-25 (I)

(7) Length waiting at upper auxiliary gates and downbound can approach main chamber 27-30 (I)

(8) Length waiting at lower main gates and upbound can approach auxiliary chamber 32-35 (I)

(9) Length waiting at upper main gates and downbound can approach auxiliary chamber 37-40 (I)

Items 10 through 13 specify the parameters used for approach area interference. A non-blank character indicates the described action would be taken by a prudent navigator.

(10) An upbound vessel will approach or exit

the main if a vessel is approaching or exiting the auxiliary — 42 (A)

(11) An upbound vessel will approach or exit the auxiliary if a vessel is approaching or exiting the main — 44 (A)

(12) A downbound vessel will approach or exit the main if a vessel is approaching or exiting the auxiliary — 46 (A)

(13) A downbound vessel will approach or exit the auxiliary if a vessel is approaching or exiting the main — 48 (A)

The next four items are not interference questions per se, but they do affect lockages, and are input on a continuation card. If the "I" card is used, the continuation card must be used. Items 14 through 17 specify the maximum length of tow that can wait at a gate. These lengths are important when a lock has short guide or guard walls. Long tows, therefore, cannot wait at the gates for a turnback approach, so their turnback approach times are very long. If a tow arrives that exceeds the length specified, the model uses long approach times even if the tow is making a short approach.

Continuation Record Designator - "+" — 1 (A)

(14) The longest upbound vessel that can wait at the lower main chamber gate for a turnback approach — 2-5 (I)

(15) The longest downbound vessel that can wait at the upper main chamber gate for a turnback approach — 7-10 (I)

(16) The longest upbound vessel that can wait at the lower auxiliary chamber gate for a turnback approach — 12-15 (I)

(17) The longest downbound vessel that can wait at the upper auxiliary chamber gate for a turnback approach — 17-20 (I)

k. <u>"H" Input Format - Lock Chamber Data</u>

Lock chamber data are inserted into the network input data immediately following the lock data. Chambers must be ordered by decreasing size (area). Time distributions are entered as random variables. To determine the proper method to code these frequency distribution parameters see the explanation, "Random Variable Input"

- Section C.

The model provides three methods for inputting the time distributions, simplified, normal, and detailed. Each method will be described later in this section.

The following data elements must be provided for each of the lock chamber input records:

(1) <u>H Record Designator - "H"</u> 1 (A)

(2) <u>Chamber Number</u> 3-4 (I)

At dual chamber locks, the larger should be designated Chamber 1, which will be referred to in model output as the main chamber.

(3) <u>Length (FT)</u> 6-10 (R)

(4) <u>Width (FT)</u> 12-16 (R)

(5) <u>Operating Policy, Normal</u> 18-19 (A)

The following codes may be specified:

F - First-come-first served (regardless of direction)

Nn - n-up/n-down. "n" is a one digit integer

U - One-way upstream

D - One-way downstream

The F, U, and D codes should be left justified in the field. The "one-way" policies are intended for use at locks with twin chambers and are treated as a preferred direction under queuing conditions rather than an absolute restriction.

(6) <u>Operating Policy, Open Pass</u> 21-22 (A)

This uses the same codes as above, but applies during periods of open pass operation.

(7) <u>Multi-Vessel Lockage Permission</u> 24 (A)

This indicates that multiple vessel lockages are permitted. A combination of one or more recreation craft and one commercial tow is not considered a multiple-vessel lockage with respect to this option. Any non-blank character may be used.

(8) <u>Ready to Serve Option</u> 26 (A)

A non-blank character selects the ready-to-serve (RTS) operating policy option, under which all tows are required to be configured for a single-cut lockage before they may approach the chamber.

Reconfiguration or breakup of a tow into single lockage components must be accomplished where it will not interfere with other lock operations. This contrasts with the common practice of carrying out tow reconfiguration in the chamber or chamber approach, thereby reducing the rate at which lockages can be performed. An RTS policy is often associated with the use of a helper or switchboat to perform such tasks as handling the second half of a double lockage while the original towboat controls the first cut.

The use of a ready-to-serve option is implicitly represented when the simplified lockage time policy is selected. For example, under an RTS policy, a setover lockage will require no more time than a straight single and a double lockage no more time than two straight singles, since the reconfiguration is assumed to have been accomplished in advance. This approach to representing RTS lockages does have some drawbacks however. The method fails to account for the time spent reconfiguring tows away from the lock. As a result, although usage of the lock is accurately represented, the time for individual tows to complete their lockages may be underestimated. Finally, the model cannot represent operations such as one tow being locked through between the cuts of another tow.

(9) <u>Detailed Lockage Times</u> 27 (A)

A non-blank character must be entered in this column. This method used to be optional, but it is now mandatory.

(10) <u>Simplified Lockage Times</u> 28 (A)

This method is no longer available.

(11) <u>Detailed Lockage Report</u> 30 (A)

A non-blank entry requests the model to collect the statistics necessary to produce the Detailed Lockage Report for the chamber. The Detailed Lockage Report gives a detailed account of lockage types, entry types, and exit types.

(12) <u>Probability of Setover</u> 32-36 (R)

This parameter is used to randomly choose between setover and straight single lockages. It is applied only in the case in which a tow's barges fit into the chamber in a single cut, but there is insufficient space for the towboat to occupy a separate row behind all the barges. It allows for the lockage possibilities which can occur due to different tow configurations which take place in actual practice, but are not represented in the model.

(13) <u>Switchboat Flag</u> 38 (A)

Any non-blank entry enables this option. If this option is enabled, cuts extracted from a chamber during multi-cut lockages are assumed to be removed from the gate area. This means that intermediate cuts can not cause gate area interference. The actual removal of the cut from the gate area is not simulated, i.e. the extracting vessel does occupy the approach area.

(14) Towboat Type Not Allowed 39-40 (I)

It is possible to exclude any towboat type specified on the "B" record from a chosen chamber. This may be of use when trying to force a towboat type to an auxiliary chamber. This is especially useful at locks with different sized chambers and the smaller one is used primarily for recreation boat lockages.

(15) Number of Lockage Types 42-43 (I)

This is the number of cuts defined in the continuation cards that follow this card. This value is used only when detailed lockage times are specified.

(16) Filling Interference Time 45-46 (I)

If a value is entered here, this parameter represents the time that must elapse from the beginning of the filling cycle of one chamber, to the beginning of the filling cycle of the other chamber.

(17) Must Tie to Wall Flag 48 (A)

A non-blank character indicates that the tow or rec boat must tie it to the wall. Essentially, this forces the width of the vessel to be ½ the width of the chamber.

(18) Lockage Time Distribution Data

The data required is described below. Note that the distributions shown in items 18, 19, and 20 are required for each cut defined. For example, if the number of lockages types indicated in item 15 above is 6, there must be 6 sets (18 records) of the information shown in items 18, 19, and 20.

(19) Lockage Time Distribution Data 1

Continuation Record Designator - "+"	1 (A)
Approach Time Distribution-Fly/Exchange, Upstream	3-20 (D)
Approach Time Distribution-Fly/Exchange, Downstream	22-39 (D)
Approach Time Distribution-Turnback, Upstream	41-58 (D)
Approach Time Distribution-Turnback, Downstream	60-76 (D)

(20) Lockage Time Distribution Data 2

Continuation Record Designator - "+"	1 (A)
Entry Time Distribution Upstream	3-20 (D)
Entry Time Distribution Downstream	22-39 (D)

Chambering Time Distribution-Upstream	41-58 (D)
Chambering Time Distribution-Downstream	60-76 (D)

(21) Lockage Time Distribution Data 3

Continuation Record Designator - "+"	1 (A)
Exit Time Distribution-Fly/Exchange, Upstream	3-20 (D)
Exit Time Distribution-Fly/Exchange, Downstream	22-39 (D)
Exit Time Distribution-Turnback, Upstream	41-58 (D)
Exit Time Distribution-Turnback, Downstream	60-76 (D)

Items 21, 22 and 23 below are needed only once.

(22) Lockage Time Distribution Data 4

Continuation Record Designator - "+"	1 (A)
Chamber Turnback Distribution, Upstream	3-20 (D)
Chamber Turnback Distribution, Downstream	22-39 (D)
Extra Time for Setover Distribution Turnback	41-58 (D)
Extra Time for Setover Distributions Fly/Exchange	60-76 (D)

(23) Lockage Time Distribution Data 5

Continuation Record Designator - "+"	1 (A)
Entry/Exit Time for Light Boat Distribution	3-20 (D)
Entry/Exit Time for First Rec. Vessel Distribution	22-39 (D)
Entry/Exit Time for Following Rec. Vessels Distribution	41-58 (D)

Two distributions are required for recreation craft because they tend to follow one another rather closely into and out of the lock chamber during a multi-recreation vessel lockage. This is accounted for in the model by using lower values for entry/exit times for all but the lead boat.

(24) Lockage Time Distribution Data 6

Continuation Record Designator - "+"	1 (A)
Additional Time for Multi-Tow Lockages, Upstream	3-20 (D)
Additional Time for Multi-Tow Lockages, Downstream	22-39 (D)

(25) Lockage Time Distribution Data 7, Open Pass

Four additional distributions must be provided if open pass for the lock is indicated for any period during the simulation. See the lock data input on open pass scheduling.

Continuation Record Designator - "+"	1 (A)
Distribution for Open Pass Transit, Upstream	3-20 (D)
Distribution for Open Pass Transit, Downstream	22-39 (D)
Distribution for Extra Transit Time/Vessel, Upstream	41-58 (D)
Distribution for Extra Transit Time/Vessel, Downstream	60-76 (D)

The extra transit times are used when one vessel follows another in the same direction during open pass conditions. The following vessel's lockage cycle partly overlaps that of the leading vessel. To properly account for this overlap, the lockage time used for the following vessel is the difference between the total time for an open pass lockage and the overlap time.

1. "R" Input Format - Network Reach Data

The waterway network includes a reach between any two nodes (locks, ports or bend terminators). See Table 1 for a summary of the ordering of network input data. The following data items must be specified for each reach:

(1) R Record Designator - "R" 1 (A)

(2) Reach Number 3-4 (I)

Reaches are numbered sequentially within each sector from 1 through the number of reaches in the sector.

(3) Average Depth (FT) 6-10 (R)

This value is used in the calculation of tow speeds.

(4) Minimum Depth (FT) 12-16 (R)

This is the controlling depth of the reach.

(5) Current Speed (MPH) 18-22 (R)

(6) Speed Coefficient, Upstream 24-28 (R)

(7) Speed Coefficient, Downstream 30-34 (R)

The speed coefficients are empirical factors used in the calculation of tow speed. They take into account all the local conditions which are not explicitly represented in the model. A speed coefficient of 0.5, for example, would cause the model to use one-half the calculated speed.

m. "E" Input Format - Bend Terminator Data

The waterway network must include a bend terminator node at the transition point between a reach and a bend and between two bends. See Table 1 for a summary of the ordering of network input data. The following data items must be specified for each bend terminator:

(1) "E" Record Designator - "E" 1 (A)

(2) Bend Terminator Number 3-4 (I)

Bend terminators are numbered sequentially within each sector from 1 through the number of bend terminators in the sector.

(3) Bend Terminator Name 6-25 (A)

(4) River Mile 27-31 (R)

This is based on the established mile numbering system.

n. "B" Input Format - Bend Data

The waterway network may include bends. See Table 1 for a summary of the ordering of network input data. The following data items must be specified for each bend:

(1) "B" Record Designator - "B" 1 (A)

(2) Bend Number 2-4 (I)

Bends are numbered sequentially within each sector from 1 through the number of bends in the sector.

(3) Average Depth (FT) 6-10 (R)

This value is used in the calculation of tow speeds in the bend.

(4) Minimum Depth (FT) 12-16 (R)

This is the controlling depth of the reach.

(5) Current Speed (MPH) 18-22 (R)

(6) Small Speed Coefficient, U/S 24-28 (R)

(7) Small Speed Coefficient, D/S 30-34 (R)

The speed coefficients are empirical factors used in the calculation of tow speed. They take into account all the local conditions which are not explicitly represented in the model. A speed coefficient of 0.5, for example, would cause the model to use one-half the calculated speed. Two sets of speed coefficients are used; one for small tows and another for larger tows. The size is distinguished by the flanking length, item (13) below.

(8) Bend Radius (FT) 36-40 (R)

If modeling a straight, narrow channel rather than a bend, the bend radius should be input as zero. If anything other than zero is used, the model logic is set up to determine the effective width of the tow based on 600-foot and 1200- foot inland tows. If zero is used the effective width is the width of the tow.

(9) Bend Width (FT) 42-46 (R)

(10) Required Clearance Width (FT) 48-52 (R)

Total clearance required when two tows traveling in opposite directions are passing in a bend. This clearance is the sum of the minimum required distance from the bank to the upbound tow, the minimum required distance from the opposite bank to the downbound tow, and the minimum required distance between the two tows as they pass.

(11) Large Speed Coefficient, U/S 54-58 (R)

(12) Large Speed Coefficient, D/S 60-64 (R)

(13) Flanking Length (FT) 66-70 (R)

This is the maximum length of a tow that uses the small speed coefficients.

o. "F" Input Format - Empirical Frequency Distribution

The "F" form defines the probability distribution of a random variable. As previously discussed, distributions defined by "F" data records may be referenced wherever a random variable is required on other data records.

It will also be recalled that when an empirical distribution is referenced, a multiplying factor may also be specified. This permits a single distribution to be used for a random variable having a common shape but different scale.

(1) "F" Record Designator - "F" 1 (A)

(2) Distribution Number 3-4 (I)

This is an identifying number for the distribution by which it is referenced on other data records. Distributions are numbered from 1 through the number specified on the "A" record.

(3) Values and Probabilities

The actual distribution is described by a list of alternating values and probabilities:

$$v_o\ p_1\ v_1\ p_2\ v_2\ \ldots\ p_n\ v_n$$

where

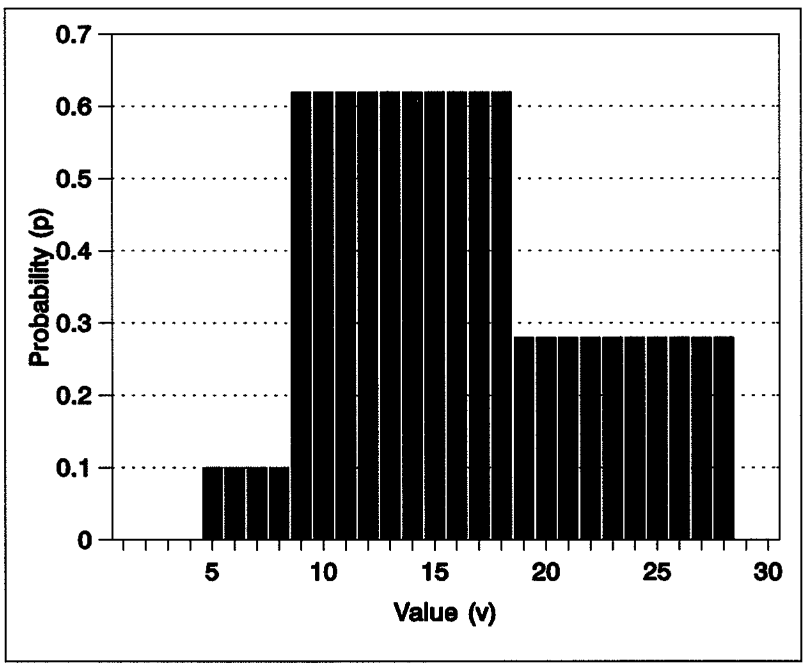
p_i = Prob $(v_{i-1} \leq x < v_i)$

"x" denotes the random variable here.

Value	Probability
6-10 (R)	12-16 (R)
18-22 (R)	24-28 (R)
.	.
.	.
.	60-64 (R)
66-70 (R)	

The values in the list must be in ascending order. They need not be at uniformly spaced intervals however. The probabilities must, of course, sum to unity. This is most easily visualized as a histogram. For example, if $v_o = 5$ $p_1 = .10$, $v_1 = 9$, $p_2 = .62$, $v_2 = 18$, $p_3 = .28$, and $v_3 = 28$, the probability distribution, illustrated in Figure 3 would be created.

Figure 3. An Empirical Probability Distribution



It is possible to describe the frequency distribution on one form, however, if there are more "steps" to the distribution, two or more input records are required. In these cases, the first record will use the form shown with an "F" in column 1. The second and successive records for the distribution, if required, will have a "+" in column 1 and no entry is made in columns 6-10, as shown below.

(4) Continuation Record Designator - "+" 1 (A)

(5) Additional Values and Probabilities

Value	Probability
	12-16 (R)
18-22 (R)	.
.	.
.	.
.	60-64 (R)
66-70 (R)	

p. "W" Input Format - Route Specification Data

As part of its initial processing, the model calculates a routing table for the destination in sector j. The (i, j) entry of the routing table will indicate: (1) which direction the tow should travel (on sector i); and (2) which sector to enter next when it reaches the end of sector i. When the new sector is entered, the table is consulted again for directions from it to j. In this manner, the complete route between any two sectors may be obtained.

If there are portions of the network where more than one route exists between two sectors, the shortest route, based on the estimated tow speeds and lockage times of the S and L records, will be stored. The W record permits the user to override the calculated route in such a case. If used, W records must follow all network data. The entries are:

(1) W Record Designator - "W" 1 (A)

(2) Origin Sector 3-4 (I)

The route modification will apply to tows located on this sector and travelling to one of the below destination sectors.

(3) Destination Sectors (I)

One or more sectors may be specified. They are placed in columns 6-7, 9-10, 12-13, . . . as integers. A range of sector numbers may be entered by placing a "_" in columns 8, 11, 14, ... as appropriate. If there are too many sectors to fit on one record, a continuation record may be used.

(4) Initial Direction of Travel 69 (A)

This is the direction to travel on the origin sector to reach the destination. Enter a "U" for upstream or a "D" for downstream.

(5) Next Sector 71-72 (I)

The number of the next sector to enter when the end of the origin sector is reached.

4. Shipment Data

a. General Input

The Waterway Analysis Model requires as input a set of shipments to be moved over the waterways by the fleet of barges and towboats. The data are treated as external events by the SIMSCRIPT II.5 simulation. Each shipment is a demand on the system and in effect "drives" the model. The set of shipments must be ranked in chronological order. The data elements are as follows:

(1) "SHIP" Record Designator - "SHIP" 1-4 (A)

The word "SHIP" in columns 1-4 is required.

(2) Event Time (Days) 6-12 (R)

This is the time in days, at which the shipment arrives at the port ready for loading into barges. The simulation starts at time 0.0. An entry of 3.5 would make the shipment available for loading at noon on the fourth day. The shipments must be listed in chronological order starting from event time 0.0.

(3) Commodity Class Code 14-15 (I)

The commodity class code is a one or two digit numeric code to identify the commodity class of shipment.

(4) Shipment Size (TONS) 16-21 (I)

(5) Shipment Segment Origin Port Number 22-24 (I)

(6) Shipment Segment Destination Port Number 25-27 (I)

(7) Movement Origin Port Number 28-30 (I)

(8) Movement Destination Port Number 31-33 (I)

If the origin ports or destination ports are identical, loading/unloading occurs, respectively. If different, only the barge start/stop delay occurs at the ports.

(9) Towboat Type 34-36 (I)

(10) Barge Type 37-39 (I)

(11) Number of Loaded Barges 40-42 (I)

(12) Number of Empty Barges 43-45 (I)

(13) Trace Flag 47 (A)

Any non-blank character will, under certain run control conditions, outlined in Section C.5, generate an output report which traces the events concerning this shipment as they occur during the simulation.

(14) Tow Length (FT) 61-64 (R)

(15) Tow Width (FT) 66-68 (R)

(16) Asterisk 70 (A)

An asterisk, "*", is required in column 70 to indicate the end of the external event input record.

b. WAM Shipment List Development

As indicated above, the Waterway Analysis Model is driven by a series of "SHIP" external events input by the user in the form of a shipment list. This list may be developed from historical commodity movement data such as Waterborne Commerce Statistics Center data, or from a shipment generator program which requires an actual or a projected commodity-origin-destination matrix to be input.

5. Run Control Data

Run control input consists of one or two run setups followed by a set of "CTRL" event records which control statistics collection, output production, and termination of the simulation.

a. Run Setup Data

The first run setup input record is mandatory. It includes the following data elements:

(1) "RUN" Record Designation - "RUN" 1-3 (A)

(2) Run Identifier 5-8 (A)

This is a four character alphanumeric identifier which will be printed in the upper left corner on each page of output. It is selected by the user.

(3) Title 10-79 (A)

The title is a 70 character title which is centered and printed at the top of each page of output. If it is desired to include more descriptive information about the run than will fit in the title, it is suggested that comment records be inserted at the start of the system description data, where they will be listed with the echoed input data.

The second run setup record is optional. Its omission implies acceptance, by the user, of default values. The following data elements are included:

(4) Playback Report Suppression Switches 1-12 (A)

The program normally echoes all input data records and produces formatted playback reports, D-1 through D-10 before beginning the simulation. (Sample output is included in Section E.) Since this can be quite lengthy and repetitious from run to run, these playback reports can be selectively suppressed by marking the appropriate columns. Any non-blank character will suppress the playback report. Table 3 indicates which reports may be suppressed and the associated column which must be marked. If data echo is suppressed (switch 1), comment records will still be listed. This provides a means of documenting the data used for a run without listing each record. Records on which errors are detected will also be echoed regardless of the switch setting.

TABLE 3

PLAYBACK SUPPRESSION SWITCHES

Column Marked	Playback Report Suppressed
1	Data Echo. Input data are printed in same format as read into model.
2	Array Dimensions and Miscellaneous Parameters
3	Waterway Network Data
4	Port Data
5	Lock Data
6	Lockage Time Distribution Data
7	Commodity Class and Group Data
8	Towboat Data
9	Barge Data
11	Empirical Distributions
12	Network Routing Table

(5) Simulation Suppression Switch 14 (A)

It is occasionally useful to allow a check of the input data without actually making a simulation run. A non-blank entry for this parameter will suppress simulation operations. The program will read and check all input data, including run control and shipment data. (If checking of the shipments is not necessary, simply substitute an empty shipment file.) To insure checking of all data, both maximum error parameters (described below) should be set to 99.

(6) Maximum System Errors 16-17 (I)

This is the maximum number of errors in the system description data which will be tolerated before canceling the simulation. The default value is zero which will prevent the simulation from beginning if any errors are detected. A higher value should be specified only with extreme caution. The program does not normally attempt to correct errors, so if a run is allowed to continue in their presence, the results are unpredictable. When an input error is detected, the program issues a warning but continues reading and checking the remainder of the data. It is only after the entire system file has been read and checked that the error counter is tested and the run halted if necessary. If 99 is entered an unlimited number of system errors will be permitted.

(7) Maximum Simulation Errors 19-20 (I)

This is the maximum number of errors which are permitted to occur during the simulation portion of a run before the run is aborted. This is independent of the above system errors. However, as with the system errors, caution should be exercised when raising this value above zero. If 99 is entered an unlimited number of simulation errors will be permitted. Most simulation phase errors are related to external event record data. It should be noted that erroneous event names, time fields or illegal numerical input data will generally be detected by the SIMSCRIPT II.5 system which will abort the run regardless of the error limit specified here.

(8) Random Number Seed - Stream 1 (Setup) 22-36 (I)

(9) Random Number Seed - Stream 2 (Simulation) 38-52 (I)

The program uses two independent streams of random numbers, Stream 1 is used for initialization of the system and Stream 2 for random values needed during the simulation. The random number seeds initialize the respective stream. If the fields are left blank, the standard SIMSCRIPT II.5 supplied seeds will be used. Changing the seeds provides the means for replicating runs, that is, making runs which are identical except for the random numbers used in order to estimate the impact of randomness on the system. At the end of a simulation the current values of the seeds are printed. These are suitable starting values for a subsequent run. Before using other values it is suggested that the appropriate SIMSCRIPT II.5 User's Manual be consulted for any restrictions which may apply.

(10) Start-up Time (MIN) 54-58 (R)

This is the time required for a tow to start after having been queued at a bend. If the field is left blank, the default value of 5 minutes will be used.

b. "CTRL" Event Records

Run control functions during the actual simulation are effected by CTRL external event records which follow the run setup data. The general form of these records is:

CTRL time action data *

The data are free format in that there are no fixed columns for the fields. Therefore, there is no input form for these input records. Table 4 shows a sampling of each type.

TABLE 4

EXAMPLE SET OF CTRL EVENT RECORDS

	Time	Action Data	
CTRL	5.0	RESET *	(end of warm-up; reset statistics)
CTRL	5.0	TRACE ON *	(turn trace flag on)
CTRL	15.0	TRACE OFF *	(turn trace flag off)
CTRL	15.0	PRINT 1 3 *	(intermediate output: reports 1 & 3)
CTRL	25.0	TRACE TER *	(turn on queue reporting)
CTRL	25.0	PRINT 1 3 *	(intermediate output: reports 1 & 3)
CTRL	35.0	TRACE TER *	(turn off queue reporting)
CTRL	35.0	PRINT 1 3 *	(intermediate output: reports 1 & 3)
CTRL	45.0	TRACE DB *	(turn on database output)
CTRL	45.0	PRINT 1 3 *	(intermediate output: reports 1 & 3)
CTRL	55.0	TRACE DB *	(turn off database output)
CTRL	55.0	PRINT 1 3 *	(intermediate output: reports 1 & 3)
CTRL	65.0	END *	(end; print all reports)

"CTRL" and the trailing "*" are required by the SIMSCRIPT II.5 external event mechanism. Note that a space is necessary between each element of data and the trailing "*". "Time" specifies the simulation time at which the indicated action is to take place. It may be written in either of two ways in accordance with SIMSCRIPT II.5 conventions. First, and generally simpler, it may be written as a real number of days such as "4.354" or "10.0". Note that the decimal point is always required in this format. Alternatively the time may be written as three integer values giving the day, hour, and minute. The examples given above could be equivalently input as "4 8 30" and "10 0 0". (The SIMSCRIPT II.5 calendar time format may not be used).

It should be noted that the fields described so far are read and processed by the SIMSCRIPT II.5 external event mechanism. Errors detected here will result in an immediate program abort regardless of the error limit specified in the run setup data.

The available action and the data associated with each are described in the following:

(1) END

The END action terminates the simulation run. An END record is always required. Care should be taken that there are no errors which could prevent it from being recognized. Otherwise the run could continue indefinitely. The data portion of the END record designates the output reports to be printed. Each report is assigned a number, as given in Table 5. The numbers of the desired reports are listed in free format following the END keyword. If no numbers are specified, all reports will be printed. If it is desired to suppress all reports enter a "0" (zero).

TABLE 5

OUTPUT REPORTS

Report	Number
Lock Utilization and Delay	1
Detailed Lockage Report for Specified Chambers	2
Port Activity	3
Detailed Traffic Summary by Reach	4
Equipment Utilization	5
Detailed Bend Utilization and Delay	6
Detailed Interference Statistics	7

Reports 1 through 4 may be requested for selected river systems by entries of the form "K.rs," where "K" is the report number and "rs" is a two digit river system number. For example, "3.05" designates the Port Activity report for river system 5. The special river system code "99" may be used to request only the final summary section of a report. (The summary is automatically produced whenever a report is requested for one or more river systems). Examples:

```
CTRL  40.0  END 1 5 *
```

The Lock Utilization and Equipment Utilization reports are printed for all river systems.

```
CTRL  40.0  END 1.07 1.10 1.12 3.99 *
```

Lock Utilization is reported for river systems 7, 10 and 12. Only the summary of Port Activity is output.

```
CTRL  40.0  END *
```

All reports are produced in full.

(2) RESET

A RESET event "wipes out" all statistics previously accumulated by the model. Output reports thus reflect only statistics gathered since the most recent RESET. The normal use of this record is to terminate a warm-up period at the start of a run, during which the system is allowed to come to approximately steady state conditions before beginning collection of the "real" run statistics. There is no data associated with the action.

(3) PRINT

The PRINT option requests the printing of intermediate output reports during a simulation run. The data portion of the record is identical to that of the END record. Note that a PRINT record is not required and should not be used at the end of a run.

(4) TRACE

TRACE output is discussed and illustrated in Section E. The TRACE option of the CTRL event is used to turn the trace of shipments and detailed output of model events on and off, or to change its scope. In addition, the TRACE option can also be used to provide information about the vessels in queue each time the queue length changes. This option is useful for providing input to an environmental impacts model (QUEPAT). The TRACE option can also be used to activate an output option that writes detailed lockage information in a semicolon delimited format, which can then be imported into a database program.

The trace is controlled by a system master switch which must be on to obtain any output, and an individual switch for each shipment, port, lock, bend terminator, bend, and reach in the system. The trace switch for a shipment is set by a flag on the SHIP input data record (see Section C.4.a.). All other switches are controlled by the data portion of a CTRL TRACE record. This consists of the word "ON" or "OFF" optionally followed by a list of codes designating the switches to be affected as follows:

(a) S Shipment arrivals. This is a special switch which causes all shipment arrivals to be traced regardless of the trace flag setting on the SHIP record. Only the arrival of the shipments at their origin is traced, not the subsequent processing.

(b) P i j Port number j of sector i. If i and j are omitted the change applies to junction port, all designations for that port must be used in the request. Failure to do this will result in an incomplete port trace.

(c) L i j Lock j of sector i. Similar to P.

(d) E i j Bend terminator j of sector i. Similar to P.

(e) R i j Reach j of sector i. Similar to P.

(f) B i j Bend j of sector i. Similar to P.

(g) D This is a special switch which causes all shipment arrival,

shipment delivery and shipment
completion trace output messages to
be printed.

The master switch is turned on by a TRACE ON action. It is turned off only by a TRACE OFF record which contains no other data. The individual switches are not affected in this case so the trace may be resumed simply by a subsequent TRACE ON record. Example:

CTRL 0.0 TRACE ON S *

The master switch is turned on and a trace of shipment arrivals requested. The only other trace information printed will be for shipment movements if so requested on the individual SHIP records.

CTRL 3.0 TRACE ON P 7 1 R 7 1 L 7 1 R 7 2 P 7 2 *

Activity for the designed ports, locks and reaches will be traced starting on the 4th day of the simulation. Previously requested traces will continue.

CTRL 5.0 TRACE OFF *

After two more simulated days the master switch is turned off, suppressing all trace output.

CTRL 10.0 TRACE ON *

The master switch is turned back on, resuming the trace of the same elements as before.

CTRL 12.0 TRACE OFF P L R *

CTRL 12.0 TRACE ON B *

The trace switches for all ports, locks and reaches are turned off (All except those on sector 7 were off anyway). Then the switches for all bends are turned on. Note that the master switch S resumed at 10.0 and is still on.

6. Downtime Event Data (Optional)

The external downtime event data allow the user to shut down chambers, or cause them to fill and empty slowly, at any time for a designated duration. If a lockage is occurring at the time of the scheduled downtime event, the downtime event is re-scheduled to start at the end of lockage without affecting the duration. The downtime events must be sorted chronologically and reside on SIMU unit number 10. The data are input as follows:

(1) "DWNTM" Record Designator - "DWNTM" 1-5 (A)

The word "DWNTM" must appear in columns 1-5 and the rest of the input items are free-format.

(2) Event Time (Days) (R)

(3) Sector Number (I)

(4) Lock Number (I)

(5) Chamber Number (I)

(6) Duration (Days) (R)

(7) Slow Fill-Empty Indicator Character (A)

Formatted: Indent: Left: 0.3"

If an "S" is entered in this field, it causes the model to double the chambering time. This is useful at locks where there are two filling or emptying valves, and one valve becomes inoperable. The chamber can serve traffic, but at a slower filling or emptying rate. This field can also be used to indicate that this record serves as notice of an upcoming closure at some future time. For example, the 4th line below shows that on day 124.000 Notice is given of a closure which will occur at time 200.000. This "notice" is recognized and used by the queue limit program.

(8) Asterisk (A)

Deleted: 7

An example is provided below

```
DWNTM    122.000  1  1 2      .3333  * *
DWNTM    122.000  1  2 2      .3333  S *
DWNTM    122.000  1  3 2      .3333  * *
DWNTM    124.000  1  3 2   200.0000  N *
DWNTM    200.000  1  3 2    30.0000  * *
```

7. Computer System Considerations

The WAM program can be run in a variety of environments. The key requirement is a SIMSCRIPT II.5 compiler for the environment.

Input and output to SIMSCRIPT II.5 programs are accomplished by using file names in the control records of the form, SIMUn, where **n** is the device number used in the READ and WRITE statements in the model code. In its present state, the Waterway Analysis Model recognizes twelve different input/output file names. Although each is discussed in detail in other sections of this manual, they are listed below for the convenience of the user:

Input Files

SIMU01 - Shipment list input file

SIMU03 - System description input file

SIMU50 - Run control file (CTRL records)

SIMU10 - Lock chamber downtime input file

<u>Output Files</u>

SIMU08 - Lockage Trace output file

SIMU12 - Detailed Event Trace File

SIMU13 - Resource usage output file

SIMU20 - Upbound Queue Information

SIMU30 - Downbound Queue Information

SIMU40 - Detailed Lockage Info (input to database)

SIMU60 - Standard Output Report

SIMU89 - End of run output (1 line per chamber)

D. ANALYZING ERRORS AND OTHER TERMINATIONS

1. Errors Detected by WAM

Errors occurring during execution of the WAM are classified by whether they are detected by the program or by the processing system. Errors in the first category which occur during the initial data input phase of a run are flagged by a message of the form:

***ERROR x-y

"x" denotes the type of record on which the error occurred and "y" an error number as given in Table 6. The special code "I" denotes general errors not associated with a particular record type. From some errors an additional explanatory message will follow the coded one.

The message is normally printed following the image of the erroneous record in the input data listing. If the listing has been suppressed, records with errors will still be printed. However, it should be noted that in a few cases the error may not be detected until one or more following records have been read and listed.

With a few exceptions noted in the table, the program will continue to read and check data after an error has been detected. Normally, the simulation will then be canceled. The user may choose to continue a run in the presence of data errors by specifying more than zero maximum allowable input errors permitted (on the second run setup record), but does so at considerable risk.

Errors detected by the program during the simulation phase of the run are indicated by the message:

***ERROR X-Y - LAST INPUT RECORD = ON UNIT m: . . .

As before, "Y" is an error number keyed to the accompanying table. The last input record is then listed. In most cases, this will be the source of the error. The program will continue to run after such an error if the maximum allowable simulation errors has not been exceeded. The corrective action in each case is noted in the table.

All errors normally detected by the program can be eliminated prior to a simulation run by making a separate data checking run with the simulation suppression switch on and with the maximum input errors and the maximum simulation errors both set equal to 99. These specifications are made on the optional second run setup record as explained in Section D.5.b. The user is strongly encouraged to use this option whenever more than a few changes are made to any of the input.

The model developers included this data checking feature to save the user time and money. It provides the capability of uncovering common input errors usually associated with coding. Many kinds of less common errors are not flagged however. If the simulation proceeds with one or more of these errors in the data, it could result in either bad output or a premature termination when the error is detected by the operating system.

One error which cannot be detected by a separate checking run involves the attempted routing of a tow to a sector on which the boat is not allowed to operate. This error demonstrates a basic incompatibility between input files and will cause the simulation to terminate with an error message.

TABLE 6

ERROR CODES

A-1 "A" record not found. The "A" record must be the first data record. The run is terminated.

A-2 Zero rivers, sectors, network elements, commodity classes, commodity groups, towboat classes, or barge classes were specified. The run is terminated.

A-3 The second "A" data record was not found. The run is terminated.

A-4 Error in recreation traffic start or stop time. Time was greater than 24 hours or stop time was less than start time.

A-5 The day of the week at the start of the run was not between 1 and 7.

B-1 Barge class number is not within the range specified on the "A" record.

B-2 Duplicate definition of a barge class.

B-3 The empty draft specified for a barge class is greater than the loaded draft.

B-4 A barge block coefficient equal to or greater than 1 was specified.

B-5 An invalid commodity class was specified on a barge capacity data record.

B-6 No capacity data found for a barge class.

C-1 Commodity class number is not within the range specified on the "A" record.

C-2 Duplicate definition of a commodity class.

C-3 Invalid commodity group specified for a commodity class.

F-1 Frequency distribution number is not within the range specified on the "A" record.

F-2 Duplicate frequency distribution definition.

F-3 A probability less than zero or greater than one was specified.

F-4 The values for a frequency distribution are not in ascending order as required.

F-5 Probabilities for a frequency distribution do not sum to one. (An error of up to .01 is accepted).

F-6 An undefined frequency distribution has been referenced. This message is printed only after all data has been read. An additional message will identify the distribution number.

G-1 Commodity group number is not within range specified on the "A" record.

G-2 Duplicate commodity group definition.

H-1 The first continuation record for chamber data (approach and entry distributions or simplified lockage distributions) was not found.

H-2 The second continuation record for chamber data (chambering and exit distributions) was not found.

H-3 The third continuation record for chamber data (miscellaneous distribution) was not found.

H-4 Simplified lockage time computation was specified for a chamber where recreation traffic is present.

H-5 Simplified lockage time computation was specified for a chamber where multi-vessel lockages are permitted.

H-6 No open pass distributions were found for a chamber where open pass lockage will be in effect.

H-7 Simplified lockage computation specified for a chamber where the ready-to-serve option is in effect.

H-8 Operating policy code is invalid.

H-9 Detailed lockage computation specified for a chamber where the ready-to-serve option is in effect.

I-1 Unrecognized data record type. Column 1 contains an invalid type code.

I-2 Data record out of sequence. Record contains a type code in column 1 which was not expected here.

I-3 Invalid numeric data in an integer data field.

I-4 Invalid numeric data in a real data field.

I-5 Unrecognized or missing distribution type code in a random variable specification.

I-6 Number of parameters input for a random variable does not agree with the type of distribution specified.

I-7 Missing or invalid RUN setup record. The run is terminated.

I-8 Initialization from a status save file is being attempted; however, the system dimensions for the current run are different from those for the run which generated the file. Run is terminated.

L-1 Zero value specified for maximum waiting time for recreation craft.

L-2 Recreation traffic is present at lock but no or erroneous values for start and stop times were given on the "A" record.

L-3 The open pass schedule for a lock contains out of sequence time values.

L-4 Chamber number out of sequence.

L-5 Chambers are not ordered by decreasing area as required.

L-6 No chamber data found for a lock.

N-1 River system number not within range specified on "A" record.

N-2 Duplicate river system definition.

N-3 No sector data found following a river system definition.

P-1 Invalid commodity group specified in port loading/unloading rate data.

S-1 Sector number is not within range specified on the "A" record.

S-2 Duplicate sector definition.

S-3 More network elements (ports, locks, bend terminators, bends, and reaches) have been input than specified on the "A" record.

S-4 Port, lock bend terminator, bend, or reach index out of sequence.

S-5 Sector does not begin and end with a port as required.

S-6 No reach was specified between two ports and/or locks located at different river mile points.

S-7 Two reaches without an intervening port or lock appear in the network.

S-8 River mile point numbering is not consistent within a sector.

S-9 Bend terminator without a reach or bend upstream an downstream.

S-10 Missing bend terminator between a reach and a bend or between two bends.

S-11 Missing reach between lock or port and bend.

T-1 Towboat class number not within range specified on "A" record.

T-2 Duplicate towboat class definition.

T-3 Block coefficient greater than 1 specified for a towboat class.

T-4 Invalid sector number or range of sector numbers specified in towboat operating area data.

T-5 No operating area data was found for a towboat class.

W-1 Routing data was found before all network data has been read. It must follow the network data. (Note however that errors in the network data might make it appear that not all data was read).

W-2 Origin sector number is not within valid range.

W-3 Destination sector number is not within valid range.

W-4 In a range of sectors "m-n", "n" is less than "m".

W-5 Invalid direction code. Only "U" and "D" may be used.

W-6 Next sector to travel is not within valid range.

W-7 The specified next sector cannot be reached by travelling the origin sector in the specified direction.

W-8 No route exists between a pair of sectors. This message is printed after all data has been read. An additional message identifies the sectors involved. This problem can result from errors in the network data (most likely involving specification of junction points) as well as from "W" input.

X-1 Unrecognized action specified for a CTRL external event record. The record is ignored.

X-2 Invalid report number specified on a CTRL PRINT or CTRL TRACE record. All reports will be printed.

X-3 "ON" or "OFF" field of a CTRL TRACE or LPMS record missing or incorrect. The record is ignored.

X-4 Invalid trace switch code appears on a CTRL TRACE record. The code is ignored and processing of the record continues.

X-5 Missing or invalid entity specification on a CTRL TRACE record. The field is ignored and processing of the record continues.

X-6 Out of range entity specification on a CTRL TRACE record. The field is ignored and processing of the record continues.

X-7 Invalid commodity class specification on a SHIP external event record. The record is ignored.

X-8 Negative tonnage specified on a SHIP record. The record is ignored.

X-9 Invalid or non-existent origin port specified on a SHIP record. The record is ignored.

X-10 Invalid or non-existent destination port specified on a SHIP record. The record is ignored.

X-11 Origin and destination port on a SHIP record are the same. The record is ignored.

X-12 Zero or negative shipment length specified on a SHIP record. The record is ignored.

X-13 Zero or negative shipment width specified on a SHIP record. The record is ignored.

X-14 CTRL END record not found. This error is detected only when the simulation suppression (data checking) option has been requested.

Z-1 Interference of exiting ship is a single-cut lockage type.

Z-2 Interference used with a single chamber lock.

Z-5 No lock for a specified downtime event.

Z-6 No chamber for a specified downtime event.

2. Errors Detected by the SIMSCRIPT II.5 System

Errors detected by the computer's operating system are independent of the program and will always cause a run termination. The following sections discuss SIMSCRIPT II.5 run time error processing on a personal computer (DOS operating system) and a mini-computer (UNIX operating system).

a. DOS Operating System

When an error is detected on a personal computer, SIMSCRIPT II.5 activates an interactive debugger called SimDebug. For more information on the debugger and a comprehensive list of run time errors the PC SIMSCRIPT II.5 Introduction and User's Manual[3] should be consulted.

b. UNIX Operating System

When a run time error is detected under the UNIX operating system, the program aborts and the error is written to the standard error file, UNIT 98. Also, a TRACE statement will be executed that creates a simulation status report, a memory status report and an Input/Output status report to standard error file. If the error causes a core dump, it is possible to analyze the core file using the UNIX debugger, called "adb". For a list of UNIX run time error messages, see the UNIX SIMSCRIPT II.5 User's Manual[4].

---

[3]PC SIMSCRIPT II.5 Introduction and User's Manual, CACI Products Company, La Jolla, California, January 1991.

[4]UNIX SIMSCRIPT II.5 User's Manual, CACI Products Company, La Jolla, California, October 1989.

E. MODEL OUTPUT

1. Introduction

The Waterway Analysis Model simulates the transport of commodities on the waterways in sufficient detail to provide a wide range of statistical output data. A series of output reports designed to display the statistics most likely to be of interest to the waterway analyst are described in this chapter. Reports which display the model's input data in convenient, readable format are taken up first. The standard output reports which display the statistical results of a simulation run are then described.

2. Input Data Playback Reports

The first output function of the model is to "play back" the input data in a series of easily-interpreted reports. One is an echo check which merely lists the input records of the system input file in record-image form. Other playback reports show the input data in formats convenient for reading and interpretation. They show exactly how the data supplied by the user were interpreted by the program, which is very useful for detecting data errors. They also provide a record of the conditions simulated. The following reports are provided:

D-1 Echo Check
D-2 Array Dimensions and Miscellaneous Parameters
D-3 Waterway Network Data
D-4 Port Data
D-5 Lock Data
D-6 Lockage Time Data
D-7 Commodity Class and Commodity Group Data
D-8 Towboat Data
D-9 Barge Data
D-11 Empirical Frequency Distribution Data
D-12 Routing Tables

The printing of these reports can be selectively suppressed via the run control input data, as discussed in Section C.5.

The following pages provide examples of each playback report and a list of items contained in each.

a. Echo of System Description Data Set

Figure 4 is an example of the beginning of an echo check playback output. This report is simply a listing of the system description data file.

Figure 4, Example of Echo Check Playback

```
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D-1                                                            INPUT DATA

     1. A    1    1    9    9    2    9   12        2
     2. +    1.   100   6.0  20.0  20.  1   0.0
     3. C  1 COAL                   1
     4. C  2 PETROLEUM              2 X
     5. C  3 CRUDE                  2 X
     6. C  4 AGGREGATES             1
     7. C  5 GRAINS                 1
     8. C  6 CHEMICALS              2 X
     9. C  7 ORES AND MINERALS      1
    10. C  8 IRON AND STEEL         1
    11. C  9 ALL OTHERS             1
    12. G  1 NON-HAZARDS CARGO
    13. G  2 HAZARDOUS CARGO
    14. T  1  1200  HP TOWBOAT          82. 24. .75 5.7 1020.  4.0
    15. +     1
    16. T  2  1400  HP TOWBOAT          98. 29. .75 7.2 1190.  6.0
    17. +     1
    18. T  3  1800  HP TOWBOAT         115. 30. .75 8.0 1530.  9.0
    19. +     1
    20. T  4  2300  HP TOWBOAT         131. 31. .75 8.0 2185. 11.0
    21. +     1
    22. T  5  3400  HP TOWBOAT         141. 35. .75 7.8 3230. 14.0
    23. +     1
    24. T  6  5000  HP TOWBOAT         146. 38. .75 7.9 4750. 15.0
    25. +     1
    26. T  7  5600  HP TOWBOAT         162. 42. .75 8.0 5320. 25.0
    27. +     1
    28. T  8  8400  HP TOWBOAT         170. 45. .75 8.9 7980. 30.0
    29. +     1
    30. T  9 RECREATIONAL BOAT          20. 10. .75 2.0  100.  1.0
    31. +     1
    32. B  1 135x27 SAND FLAT           135  27 .98 1.5 9.5 1.0   637 .5341
    33. +     1  3000  2  3000  3     1  4     1
    34. B  2 175x26 REGULAR             175  26 .98 1.5 9.5 1.0  1069 .6667
    35. +     1  3000  2  3000  3     1  4     1
    36. B  3 195x26 STUMBO              195  26 .98 1.5 9.5 1.0  1121 .7429
    37. +     1  3000  2  3000  3     1  4     1
    38. B  4 195x35 JUMBO               195  35 .98 1.5 9.5 1.0  1669 1.000
    39. +     1  3000  2  3000  3     1  4     1
    40. B  5 195x35 COV JUMBO           195  35 .98 1.5 9.5 1.0  1764 1.000
    41. +     1  3000  2  3000  3     1  4     1
    42. B  6 245x35 SUP JUMBO           245  35 .98 1.5 9.5 1.0  2106 1.256
    43. +     1  3000  2  3000  3     1  4     1
    44. B  7 260x52 SUP SUPER           227  52 .98 1.5 9.5 1.0  3329 1.981
    45. +     1  3000  2  3000  3     1  4     1
    46. B  8 195x35 JUM TANK            195  35 .98 1.5 9.5 1.0  1454 1.000
    47. +     1  3000  2  3000  3     1  4     1
    48. B  9 147x52 147' TANK           147  52 .98 1.5 9.5 1.0  1711 1.120
    49. +     1  3000  2  3000  3     1  4     1
```

b. Array Dimensions and Miscellaneous Parameters

Figure 5 is an example of a D-2 report. The sources for each item are listed below:

Information Item	Source
System Dimensions	
Number of River Systems Number of Sectors Number of Network Elements	"A" input data
Number of Ports Number of Locks Number of Reaches Number of Bends Number of Bend Terminators Number of Unused Network Elements	(Tallied by the program)
Number of Commodity Classes Number of Commodity Groups Number of Towboat Classes Number of Barge Classes Number of Frequency Distributions	"A" input data
Parameters	
Loaded/Empty Tow Cutoff Tonnage	"A" input data
Recreation Traffic Start Time	"A" input data
Recreation Traffic Stop Time	"A" input data
Recreation Vessel Length (FT)	"A" input data
Day of Week at Start of Simulation	"A" input data
Utilization Cutoff (%) for Sorted Lock	"A" input data
Startup Time for Bend Queues (MIN)	Setup Data2(or default)
Choose Route Based on TCM Costs	"A" input data
Use Both Fixed and Variable TCM Costs	"A" input data
Maximum Input Errors Permitted	Setup Data2(or default)
Maximum Execution Errors Permitted	Setup Data2(or default)
Initial Random Number Seeds, 1 and 2	Setup Data2(or default)

Figure 5, Example of Array Dimensions and Miscellaneous Parameters Playback

```
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D-2

                                                       SYSTEM DIMENSIONS

                                                        1 RIVER SYSTEMS
                                                        1 SECTORS
                                                        9 NETWORK ELEMENTS
                                                            4 PORTS   (  4 DISTINCT)
                                                            1 LOCKS
                                                            4 REACHES
                                                            0 BENDS
                                                            0 BEND TERMINATORS
                                                            0 UNUSED
                                                        9 COMMODITY CLASSES
                                                        2 COMMODITY GROUPS
                                                        9 TOWBOAT CLASSES
                                                       12 BARGE CLASSES
                                                        0 FREQUENCY DISTRIBUTIONS


                                                           PARAMETERS

                                      LOADED/EMPTY TOW CUTOFF TONNAGE FOR LOCK PROCESSING       100
                                      RECREATIONAL TRAFFIC START TIME (HR OF DAY)              6.00
                                      RECREATIONAL TRAFFIC STOP TIME                          20.00
                                      RECREATIONAL VESSEL LENGTH (FT)                          20.0
                                      DAY OF WEEK AT START OF SIMULATION (MONDAY = 1)             1
                                      UTILIZATION CUTOFF (%) FOR SORTED LOCK REPORT               0
                                      START UP TIME FOR TOWS IN BEND QUEUES (MINUTES)          5.00
                                      CHOOSE ROUTE BASED ON TCM COSTS? (KY Lock)                  N
                                      USE BOTH FIXED & VARIABLE TCM COSTS @ KY/BY Locks?  Not applicable (used for KY Lock)

                                      MAXIMUM INPUT ERRORS PERMITTED                              0
                                      MAXIMUM EXECUTION ERRORS PERMITTED                          0
                                      INITIAL RANDOM NUMBER SEEDS          (1)        200000003  (2)        300000003
```

c. Waterway Network - Waterway Points, Reaches and Bends

Figure 6 shows the first format type of the D-3 report.

Information Item	Source
River System Number River System Name River System Code	"N" input data
Sector Number Sector Name	"S" input data
Port River Mile Port Number Port Name	"P" input data
Lock River Mile Lock Number Lock Name	"L" input data
Reach Number Length of Reach (MI)	(Calculated by the program)
Average Depth (FT) Minimum Depth (FT) Current Speed (MPH) Tow Speed Coefficients	"R" input data

Figure 6. Example of Waterway Network - Waterway Points, Reaches and Bends Playback

```
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D-3                                        WATERWAY NETWORK - RIVER POINTS, REACHES, AND BENDS


RIVER SYSTEM  1  Lower Ohio River0  3 (  )
==========================================

   SECTOR  1  Markland  Existing 1
   -------------------------------
        0.   PORT  1   Mc Alpine Pool       R-  1      .0   12.0  12.0    0.     1.00 1.00
         .0  PORT  2   Upper Pool           R-  2      .0   12.0  12.0    0.     1.00 1.00
         .0  LOCK  1   Markland  Existing   R-  3      .0   12.0  12.0    0.     1.00 1.00
         .0  PORT  3   D/S ARRIVAL POINT    R-  4      .0   12.0  12.0    0.     1.00 1.00
         .0  PORT  4   Markland  Pool
```

d. Waterway Network - Sector Data

Figure 7 shows the second format type for the D-3 report.

Information Item	Source
Sector Number Sector Name	"S" input data
River System Code	"N" input data
Sector Length (MI)	(Calculated by the program)
Average Tow Speeds (MPH)	"S" input data
Average Lock Delay (HR)	"L" input data
Average Travel Time (HR)	(Calculated by the program)
Minimum Depth (FT)	"R" input data
Maximum Tow Size (Barge Units)	"S" input data

Figure 7, Example of Waterway Network - Sector Data Playback.

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D-3 WATERWAY NETWORK - SECTOR DATA

	LENGTH (MI)	AVG TOW SPEED (MPH) UPSTREAM	AVG TOW SPEED (MPH) DOWNSTREAM	AVG LOCK DELAY (HR)	AVG TRAVEL TIME (HR) UPSTREAM	AVG TRAVEL TIME (HR) DOWNSTREAM	MINIMUM DEPTH (FT)	MAX TOW SIZE (BARGE UNITS)
1 Markland Existing 1 ( )	.0	5.00	5.00	0.	.0	.0	12.0	32.00

e. Summary of Junctions

The program lists each junction port by name, and on the same line, adjoining sectors which includes this port as one of its end points. The numbers in the left column are simply sequentially assigned numbers for the junction ports. The port numbers for one junction port assigned on the "P" input form may differ from sector to sector. The adjoining sector is assigned an "I" or an "O" for inbound or outbound sector to the junction port, respectively. Figure 8 shows this playback.

Information Item	Source
Number of Junction Port	(assigned sequentially by program)
Name of Junction Port	"P" input data
Adjoining Sector Number	"S" input data
"I" or "O"	Determined by the program
Sector Name	"S" input data

Figure 8, Example of Summary of Junctions Playback.

D-3 SUMMARY OF JUNCTIONS

	JUNCTION PORT	ADJOINING SECTORS
1	Mc Alpine Pool	1O Markland Existing 1
2	Markland Pool	1I Markland Existing 1

f. Port Data

Information Item	Source
Sector Number	"S" input data
Sector Name	
Port Number	
Port Name	
Tow Stop Delay (HR)	"P" input data
Cargo Handling Rates (100 TONS/HR)	
Specific Cargo Handling Rates	
Commodity Group Number	"P" input data
Load Rate	
Unload Rate	

Figure 9, Example of Port Data Playback.

```
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D-4                                                   PORTS

                                             PICKUP/    CARGO HANDLING RATES         SPECIFIC CARGO HANDLING RATES
                                  TOW STOP   DROPOFF      (100 TONS/HR)        CMDTY                  CMDTY
          PORT                   DELAY (HR)  DELAY (HR)   LOAD      UNLOAD     GROUP  LOAD  UNLOAD    GROUP  LOAD  UNLOAD


SECTOR  1 Markland  Existing 1
------------------------------

   1  Mc Alpine Pool                .00        .00     9999.0    9999.0
   2  Upper Pool                    .00        .00     9999.0    9999.0
   3  D/S ARRIVAL POINT             .00        .00     9999.0    9999.0
   4  Markland  Pool                .00        .00     9999.0    9999.0
```

g. Lock Data

Information Item	Source
Sector Number	"S" input data
Sector Name	
Lock Number	"L" input data
Lock Name	
Chamber Number	
Chamber Length (FT)	
Chamber Width (FT)	
Operating Policy	"H" input data
Multi-Tow Option	
Detailed Statistics Option	
Start Relay Lockages Queue Chamber 1	
Start Relay Lockages Queue Chamber 2	
Start Relay Lockages Downtime (HR)	
Chamber Selection Bias	"L" input data
Recreation Traffic (Yes/No)	
Open Pass (Yes/No)	

Figure 10, Example of Lock Data Playback.

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D-5 LOCKS

LOCK	CHAMBER SIZE	OPER. POLICY	MULTI-TOW OPTION	READY-TO-SERVE OPTION	SIMPLE TIME CALC.	DETAILED STATS.	SETOVER PROB.	AVG DELAY (HR)	CHMBR SELECT BIAS	RECRE-ATIONAL TRAFFIC	OPEN PASS
SECTOR 1 Markland Existing 1											
1 Markland Existing								0.	0	NO	NO
CHAMBER 1	1200 X 110	N 6	YES	NO	NO	YES	0.				
CHAMBER 2	600 X 110	N 6	YES	NO	NO	YES	0.				

h. Lockage Times 1: Approach and Entry Distributions

In the following figures displaying lockage times, the "N" or "R" preceding the vessel number means normal or relay lockage times, respectively.

Information Item	Source
Sector Number	"S" input data
Lock Number	"L" input data
Chamber Number	"H" input data
Fly/Exchange Approach Turnback Approach Chamber Entry (by Vessel Type)	"H" input data, Lockage Time Distribution Data

Figure 11, Example of Lockage Approach and Entry Times Distributions Playback.

```
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D-6              LOCKAGE TIMES I: APPROACH AND ENTRY DISTRIBUTIONS  (*: indiates SIMPLE times option;   +: indicates DETAILED )

          ------------- APPROACH (OR SIMPLIFIED* LOCKAGE DISTRIBUTIONS) -------------   ----- ENTRY by LOAD/DIRECTION+ -----
                   FLY OR EXCHANGE                               TURNBACK
          UP (*:SINGLE)       DOWN (*:SETOVER)    UP (*:MULTICUT)     DOWN (*:TURNBACK)   LOADS [or UP+]     EMPTS [or DOWN+]
          -------------       ---------------     ---------------     -----------------   --------------     ----------------

SECTOR  1
---------

 LOCK  1
  CHMBR 1
   ( 1-cut) G24.30,7.65, 0.  +  G24.30,7.65, 0.  +  G 5.13,1.78, 0.  +  L 5.34,4.78, 0.  +  G10.50,3.38,3.50 +  L10.80,3.75, 0.
  CHMBR 2
   ( 1-cut) G18.60,6.65, 0.  +  G18.60,6.65, 0.  +  W 1.00,4.78, 0.  +  L 3.46,3.57, 0.  +  G 7.45,2.43,1.96 +  W 1.78,5.61,1.94  +
   ( 2-cut) W 1.20,20.6, 0.  +  W 1.20,20.6, 0.  +  G 4.18, .54, .96 +  G 3.93, .38, .95 +  G16.70,5.86, 0.  +  L16.60,6.47, 0.   +
   ( 3-cut) W 1.20,20.6, 0.  +  W 1.20,20.6, 0.  +  G 4.18, .54, .96 +  G 3.93, .38, .95 +  G16.70,5.86, 0.  +  L16.60,6.47, 0.   +
   ( 4-cut) W 1.20,20.6, 0.  +  W 1.20,20.6, 0.  +  G 4.18, .54, .96 +  G 3.93, .38, .95 +  G16.70,5.86, 0.  +  L16.60,6.47, 0.   +
```

i. Lockage Times 2: Chambering and Exit Distributions

Information Item	Source
Sector Number	"S" input data
Lock Number	"L" input data
Chamber Number	"H" input data
Chambering Time Fly/Exchange Exit Data Turnback Exit (by Vessel Type)	"H" input data, Lockage Time Distribution

Figure 12, Example of Lockage Chambering and Exit Times Distributions Playback.

```
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D-6                                    LOCKAGE TIMES II: CHAMBERING AND EXIT DISTRIBUTIONS

              - - - - CHAMBERING - - - -        - - - - - - - - - - - - - - EXIT - - - - - - - - - - - - - - - - -
                                                             FLY OR EXCHANGE                       TURNBACK
                UPBOUND           DOWNBOUND          UPBOUND           DOWNBOUND          UPBOUND           DOWNBOUND
             -------------     ---------------    --------------    -------------     -------------     ---------------

SECTOR  1
---------

LOCK  1
  CHMBR 1
   ( 1-cut) L13.20,2.78, 0.    W 3.05,9.73,4.97   W 2.24,6.16,3.00   G 8.65,3.47,3.00   G 7.81,7.25, 0.    G 8.07,7.70, 0.
  CHMBR 2
   ( 1-cut) L12.50,2.27, 0.    W 2.54,6.14,6.94   G 7.97,2.71,3.00   G 8.29,7.33, 0.    G10.60, .36,4.97   W 1.42,5.91,3.00
   ( 2-cut) W 1.70,16.2,47.90  G69.20,3.55,49.70  L19.50,8.50, 0.    G27.10,5.99, 0.    W 2.54,18.7, 0.    L23.60,10.7, 0.
   ( 3-cut) W 1.70,16.2,47.90  G69.20,3.55,49.70  L19.50,8.50, 0.    G27.10,5.99, 0.    W 2.54,18.7, 0.    L23.60,10.7, 0.
   ( 4-cut) W 1.70,16.2,47.90  G69.20,3.55,49.70  L19.50,8.50, 0.    G27.10,5.99, 0.    W 2.54,18.7, 0.    L23.60,10.7, 0.
```

j. Lockage Times 3 : Miscellaneous Distributions and Parameters

Information Item	Source
Sector Number	"S" input data
Lock Number	"L" input data
Chamber Number	"H" input data
Turnback Times Setover Times** Multi-Tow Times	"H" input data, Lockage Time Distribution Data

** Setover Times are not used in the Deep Draft Model.

Figure 13, Example of Lockage Miscellaneous Times Distributions Playback.

```
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D-6                                        LOCKAGE TIMES III: MISCELLANEOUS DISTRIBUTIONS


                    EXTRA TIME          MULTICUT, EXTRA        LIGHT BOAT
                    FOR SETOVER          TIME PER CUT          ENTRY/EXIT


SECTOR  1
---------

   LOCK  1
     CHAMBER 1      ----- NA -----      ----- NA -----       K 5.00
     CHAMBER 2      ----- NA -----      ----- NA -----       K 5.00
```

k. Lockage Times 4 : Miscellaneous Distributions and Parameters

Information Item	Source
Sector Number	"S" input data
Lock Number	"L" input data
Chamber Number	"H" input data
Entry/Exit for Lightboat** Entry/Exit for First Recreation Boat Entry/Exit for Next Recreation Boats	"H" input data, Lockage Time Distribution Data

** Light boat times are not used in the Deep Draft Model.

Figure 14, Example of Lockage Miscellaneous Times Distributions Playback.

```
D-6                                    LOCKAGE TIMES  4 : MISCELLANEOUS DISTRIBUTIONS


                  ENTRY/EXIT           ENTRY/EXIT           ENTRY/EXIT
                  FOR LIGHTBOAT        FOR FIRST REC.       FOR NEXT REC.


SECTOR  1
---------

   LOCK  1
     CHAMBER 1 N   K 4.00              K 4.00               K 3.00
     CHAMBER 1 R   K 4.00              K 4.00               K 3.00

SECTOR  3
---------

   LOCK  1
     CHAMBER 1 N   K 4.00              K 4.00               K 3.00
```

1. Lockage Times 5 : Open Pass Data

Information Item	Source
Sector Number	"S" input data
Lock Number	"L" input data
Open Pass Operating Policy	"H" input data
Passage Time (First Tow) Passage Time (Subsequent Tows)	"H" input data, Lockage Time Distribution Data
Open Pass Intervals	"L" input data, continuation

Figure 15, Example of Open Pass Lockage Times and Data Playback.

```
D-6                                         LOCKAGE TIMES 5 : OPEN PASS DATA

                OPER      PASSAGE TIME (FIRST TOW)     PASSAGE TIME (SUBSEQUENT TOWS)     OPEN PASS
INTERVALS
               POLICY       UPBOUND        DOWNBOUND        UPBOUND        DOWNBOUND       BEGIN    END      BEGIN
  END

SECTOR  1
---------

 LOCK  1                                                                                   2.33    4.75     8.33
 10.75
 CHAMBER 1      N 3         K10.00         K10.00           K 5.00          K 5.00        15.33   18.80
 CHAMBER 2      N 3         K10.00         K10.00           K 5.00          K 5.00
```

m. Commodity Classes and Commodity Groups

Information Item	Source
Commodity Class Number Commodity Class Name Group to Which Class is Assigned	"C" input data
Hazardous Cargo Indication Commodity Group Number Commodity Group Name Handling Rates (100 TONS/HR) Loading and Unloading	"G" input data

Figure 16, Example of Commodity Classes and Commodity Groups Playback.

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D-7 COMMODITIES AND COMMODITY GROUPS

COMMODITY	GROUP	HAZARDOUS	COMMODITY GROUP	HANDLING RATES (100 TONS/HR) LOADING	UNLOADING
1 COAL	1		1 NON-HAZARDS CARGO	0.	0.
2 PETROLEUM	2	YES	2 HAZARDOUS CARGO	0.	0.
3 CRUDE	2	YES			
4 AGGREGATES	1				
5 GRAINS	1				
6 CHEMICALS	2	YES			
7 ORES AND MINERALS	1				
8 IRON AND STEEL	1				
9 ALL OTHERS	1				

n. Towboat Class Data

Information Item	Source
Towboat Class Number	"B" input data
Towboat Class Name	
Horsepower	
Length (FT)	
Width (FT)	
Draft (FT)	
Block Coefficient	
Maximum Tow Size (Barge Units)	
KY Down Bias	
KY Up Bias	

Figure 17, Example of Towboat Class Data Playback.

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D-8 TOWBOATS

	TOWBOAT CLASS	HORSEPOWER	LENGTH (FT)	WIDTH (FT)	DRAFT (FT)	BLOCK COEFF.	MAXIMUM TOW SIZE	KYDOWN BIAS	KY_UP BIAS
1	1200 HP TOWBOAT	1020	82.0	24.0	5.7	.75	4.0	0	0
2	1400 HP TOWBOAT	1190	98.0	29.0	7.2	.75	6.0	0	0
3	1800 HP TOWBOAT	1530	115.0	30.0	8.0	.75	9.0	0	0
4	2300 HP TOWBOAT	2185	131.0	31.0	8.0	.75	11.0	0	0
5	3400 HP TOWBOAT	3230	141.0	35.0	7.8	.75	14.0	0	0
6	5000 HP TOWBOAT	4750	146.0	38.0	7.9	.75	15.0	0	0
7	5600 HP TOWBOAT	5320	162.0	42.0	8.0	.75	25.0	0	0
8	8400 HP TOWBOAT	7980	170.0	45.0	8.9	.75	30.0	0	0
9	RECREATIONAL BOAT	100	20.0	10.0	2.0	.75	1.0	0	0

o. Barge Class Data

Information Item	Source
Barge Class Number	"B" input data
Barge Class Name	
Length (FT)	
Width (FT)	
Empty Draft (FT)	
Loaded Draft (FT)	
Clearance (FT)	
Block Coefficient	
Size (Barge Units)	
Capacity (TONS)	

Figure 18, Example of Barge Class Data Playback.

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D-9 BARGES

			- - - - DRAFT	- - - - - -				
BARGE CLASS	LENGTH (FT)	WIDTH (FT)	EMPTY (FT)	LOADED (FT)	CLEARANCE (FT)	BLOCK COEFF.	SIZE (BARGE UNITS)	CAPACITY (TONS)
1 135x27 SAND FLAT	135.0	27.0	1.5	9.5	1.0	.98	.53	637
2 175x26 REGULAR	175.0	26.0	1.5	9.5	1.0	.98	.67	1069
3 195x26 STUMBO	195.0	26.0	1.5	9.5	1.0	.98	.74	1121
4 195x35 JUMBO	195.0	35.0	1.5	9.5	1.0	.98	1.00	1669
5 195x35 COV JUMBO	195.0	35.0	1.5	9.5	1.0	.98	1.00	1764
6 245x35 SUP JUMBO	245.0	35.0	1.5	9.5	1.0	.98	1.26	2106
7 260x52 SUP SUPER	227.0	52.0	1.5	9.5	1.0	.98	1.98	3329
8 195x35 JUM TANK	195.0	35.0	1.5	9.5	1.0	.98	1.00	1454
9 147x52 147' TANK	147.0	52.0	1.5	9.5	1.0	.98	1.12	1711
10 175x54 175' TANK	175.0	54.0	1.5	9.5	1.0	.98	1.38	2317
11 264x50 264' TANK	264.0	50.0	1.5	9.5	1.0	.98	1.93	2820
12 297x54 297' TANK	297.0	54.0	1.5	9.5	1.0	.98	2.35	3295

p. Empirical Frequency Distributions

Information Item	Source
Distribution Number Value Range Probability	"F" input data
Cumulative Probability Mean Standard Deviation	(Calculated by the program)

Figure 19, Example of Empirical Frequency Distributions Playback.

D-9 EMPIRICAL FREQUENCY DISTRIBUTIONS

DISTRIBUTION NUMBER	VALUE	PROBABILITY	CUMULATIVE PROBABILITY	VALUE	PROBABILITY	CUMULATIVE PROBABILITY	MEAN	STANDARD DEVIATION
1	6.00 - 10.00	.250	.250	18.00 - 22.00	.200	.800	15.50	5.72
	10.00 - 18.00	.350	.600	22.00 - 24.00	.200	1.000		
2	8.00 - 12.00	.300	.300	22.00 - 26.00	.250	.800	19.05	7.41
	12.00 - 22.00	.250	.550	26.00 - 32.00	.200	1.000		

q. <u>Routing Table</u>

An example of this playback is shown in Figure 20.

The routing table appears as a matrix whose (i,j) entry gives "directions" for reaching sector j from sector i. The entry is printed as "x-k-y" where:

- x indicates the direction to travel on sector i to reach sector j. "U" indicates upstream, "D", downstream.
- k is the number of the next sector to enter when the end of sector i is reached.
- y indicates the direction the new sector (sector k) will be travelled.

The routing table is computed internally, although specific entries may be overridden by "W" input data.

Figure 20, Example of Routing Table Playback.

D-10 ROUTING TABLE

FROM SECTOR	TO SECTOR 1	2	3	4	5	6	7
1		D- 2-D	D- 2-D	D- 4-U	D- 2-D	U- 6-U	D- 2-D
2	U- 1-U		D- 3-D	U- 4-U	D- 5-D	U- 1-U	D- 3-D
3	U- 2-U	U- 2-U		U- 2-U	D- 5-U	U- 2-U	D- 7-D
4	D- 1-U	D- 2-D	D- 2-D		D- 2-D	U- 6-U	D- 2-D
5	U- 2-U	U- 2-U	D- 3-U	U- 2-U		U- 2-U	D- 7-D
6	D- 1-D	D- 1-D	D- 1-D	D- 4-D	D- 1-D		D- 1-D
7	U- 3-U	U- 3-U	U- 3-U	U- 3-U	U- 5-U	U- 3-U	

3. <u>System Performance Reports</u>

The results of simulating the system are presented in six major reports:

R-1 Lock Utilization and Delay

R-2 Detailed Lockage Statistics for Selected Chambers

R-3 Port Activity

R-4 Traffic by Reach

R-5 Equipment Utilization

R-6 Bend Utilization and Delay

R-7 Interference

These reports are normally produced at the end of the simulation run. However, "CTRL" event records may be used to request reports at intermediate points during the run and to select only certain reports. This was described in the previous section. The report number by which each report is referenced on "CTRL" records appears in the upper left corner of each report heading.

Performance reports cover the interval between the most recent "CTRL RESET" operation, or the start of the run if there has been no reset, and the time at which the report is printed. This time period is printed as part of the heading for each report. Note that resets are independent of intermediate printing requests.

a. Lock Utilization and Delay

This report summarizes the utilization of lock facilities and the corresponding delays observed during the run. Figure 21 illustrates the format of the first part of the report.

Transit statistics for this report are based on vessels completing lockage during the period covered by the report. Vessels undergoing lockage at the time of printing of the report are not counted. Queue, delay and utilization statistics are current. The specific items presented in the report are the following:

(1) Chamber Operations

Number of times chamber was filled (upstream) and emptied (downstream). This includes empty chamber turnbacks. Note: this count assumes that each chamber is a single stage facility, with no intermediate gates and water levels.

(2) Tows

This does not include light boats.

(3) Barges - Full, Empty

Full and Empty Barges passing through the lock.

(4) Cargo (Ktons)

Tonnage passing through the lock.

(5) Light Boats

Towboats without barges.

(6) Recreation Craft

Number served. Does not include external shipment list vessels.

(7) Delay - Average and Maximum

Time from arrival at lock to start of lockage. This includes both towboats and light boats but not recreation craft. Note that delays are associated only with the lock as a whole and not with individual chambers at multi-chamber facilities.

(8) Queues - Average and Maximum

Number of vessels awaiting lockage, excluding recreation craft.

Figure 21, Example of Part 1, Lock Utilization and Delay Report (R-1)

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R-1 LOCK UTILIZATION AND DELAY: Lower Ohio River0 3 (365.0 DAYS)

LENGTH

LOCK	CHAMBER OPERATIONS	TOWS	BARGES FULL	BARGES EMPTY	CARGO (KTONS)	LIGHT BOATS	RECR. CRAFT	DELAY (HR) (TOWS ONLY) AVG	DELAY (HR) (TOWS ONLY) MAX	QUEUE (TOWS ONLY) AVG	QUEUE (TOWS ONLY) MAX
SECTOR 1 Markland Existing 1											
1 Markland Existing	12812	7474	48924	30594	80045	3302	0	.6	9.2	.5	11
DOWNSTREAM	6406	3949	30252	9441	49914	1636	0	.6	6.8	.3	6
UPSTREAM	6406	3525	18672	21153	30131	1666	0	.6	9.2	.2	7
CHAMBER 1	7845	5170	39034	23383	63381	1215	0				
DOWNSTREAM	3923	2630	24181	6482	39817	580	0				
UPSTREAM	3922	2540	14853	16901	23564	635	0				
CHAMBER 2	4967	2304	9890	7211	16664	2087	0				
DOWNSTREAM	2484	1319	6071	2959	10097	1056	0				
UPSTREAM	2483	985	3819	4252	6567	1031	0				

Figure 22 is an example of the second part of the utilization report, which displays the percent of time spent in various parts of the lockage cycle, and the number and average duration of chamber closure events.

(1) Lock

(2) Percent of Simulation Period

(a) Lockage - The percent of the total time spent locking tows. This value does not include any of the elements listed as (b) through (e). This value is equal to the sum of the approach, entry chambering and exit times divided by the total time.

(b) Interfere - The percent of time spent waiting for interference. This is the sum of the gate area, approach area and chamber filling interference events, divided by the total time.

(c) Wait 4 Tow - This event may occur between turnback lockages. The time is counted if the chamber is turned back and ready to serve the next tow, but the next vessel has not reached the chamber. In this case, the chamber is waiting for the tow, instead of the tow waiting for the chamber to be turned back. Generally, this event only occurs when there are quite restrictive interference conditions.

Deleted: is quite restrictive interference conditions

(d) Turnback - The percent of time spent turning the chamber back between turnback lockages.

(e) Downtime - The percent of time the lock, or indicated chamber, is unavailable to serve vessels.

(3) Unavailabilities

(a) Number of events - The number of unavailabilities read from the external downtime event list.

(b) The percent of time the lock, or indicated chamber is unavailable.

Figure 22, Example of Part 2, Lock Utilization and Delay Summary (R-1A)

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R-1A LOCK/CHAMBER UTILIZATION REPORT (365.0 DAYS)

LOCK	LOCKAGE +	INTERFERE +	WAIT 4 TOW +	TURNBACK +	DOWNTIME =	TOTAL UTILIZATION	UNAVAILABILITIES NUMBER OF EVENTS	UNAVAILABILITIES AVE DURA (DAYS)
	PERCENT OF SIMULATION PERIOD							
SECTOR 1 Markland Existing 1								
1 Markland Existing	47.1	1.8	.5	3.3	2.1	54.8	258	.0600
CHAMBER 1	53.7	2.0	.7	4.8	3.0	64.1	210	.0517
CHAMBER 2	40.5	1.5	.3	1.8	1.3	45.4	48	.0965

b. Detailed Lockage Statistics for Selected Chambers

For some of the locks in the network, a more detailed accounting of activity than that available in the Lock Utilization and Delay report may be desired. This report provides such information for those lock chambers for which detailed statistics collection was requested on the corresponding "H" format data record. A separate report is printed for each such chamber. Figure 23 illustrates the format.

The first part of the report contains the following statistics on the various types of lockages in each direction of travel:

(1) Lockage Type

Lockages are classified into the number of vessel types for the report. The "Multi-Tow" category includes all lockages in which two or more tows were served. A lockage in which one or more light boats or recreation vessels share the chamber with a single tow is classified under the category applicable to that tow. Lockages in which only light boats and/or recreation vessels were served are counted in the "Light/Rec" category even though another classification (e.g., "Open Pass") might apply.

(2) Number

This is the number of completed lockages.

(3) Tows

Number of tows served.

(4) Barges - Full, Empty, Total

Number of full, empty and total barges served

(5) Cargo

Tons of cargo which passed through the lock.

(6) Light Boats

Number of light boats served.

(7) Recreation Craft

Number served.

(8) Entries and Exits

The number of fly, exchange and turnback entries and exits made. It should be noted that light boats and recreation vessels have no entry or exit type associated with them. In addition, a lockage of a tow which immediately follows (precedes) a lockage in which only light or recreation boats are served is counted as a turnback entry (exit) regardless of the directions of travel involved.

(9) Time

The average and standard deviation of the processing times of lockages in the category.

The second section of the report expands on the delay statistics for the vessels using the chamber:

(10) Vessel Type

Vessels are categorized as tows or light boats.

(11) Number Delayed

(12) Delay Time

The average, standard deviation and maximum of the delays for vessels in the category. These are first presented based on all vessels, then based on only those which were actually delayed (that is, excluding zero delays).

Figure 23, Example of Detailed Lockage Statistics for Selected Chambers

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R-2 DETAILED LOCKAGE REPORT FOR SECTOR 1 LOCK 1 Markland Existing - CHAMBER 1 (365.0 DAYS)

LOCKAGE TYPE	NUM-BER	TOWS	BARGES FULL	BARGES EMPTY	BARGES TOTAL	CARGO (KTONS)	LIGHT BOATS	RECR. CRAFT	ENTRIES FLY	ENTRIES EXCHG	ENTRIES TRNBK	EXITS FLY	EXITS EXCHG	EXITS TRNBK	TIME (MIN) AVG	TIME (MIN) STD
SINGLE	5154	5154	39005	23346	62351	63338	28	134	2219	1359	1576	2349	1230	1575	50.99	12.78
DOWN	2624	2624	24165	6478	30643	39793	17	79	1135	680	809	1178	642	804	51.43	12.91
UP	2530	2530	14840	16868	31708	23545	11	55	1084	679	767	1171	588	771	50.53	12.64
SETOVER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
DOWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
DOUBLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
DOWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
TRIPLE +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
DOWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
MULTI-TOW	8	16	29	37	66	43	0	1	0	4	4	2	2	4	50.88	11.84
DOWN	3	6	16	4	20	24	0	0	0	2	1	1	0	2	52.67	15.18
UP	5	10	13	33	46	19	0	1	0	2	3	1	2	2	49.80	11.23
OPEN PASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
DOWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	0.
LIGHT/RECR	803	0	0	0	0	0	139	913	0	0	0	0	0	0	23.57	3.02
DOWN	367	0	0	0	0	0	59	425	0	0	0	0	0	0	23.76	3.19
UP	436	0	0	0	0	0	80	488	0	0	0	0	0	0	23.41	2.87
TOTAL	5965	5170	39034	23383	62417	63381	167	1048	2219	1363	1580	2351	1232	1579	47.30	15.17
DOWN	2994	2630	24181	6482	30663	39817	76	504	1135	682	810	1179	642	806	48.04	15.16
UP	2971	2540	14853	16901	31754	23564	91	544	1084	681	770	1172	590	773	46.55	15.15

VESSEL TYPE	NUMBER DELAYED	DELAY TIME (HR) ALL VESSELS AVG	ALL VESSELS STD	ALL VESSELS MAX	DELAYED VESSELS AVG	DELAYED VESSELS STD
TOWS	3186	.63	.88	9.20	1.02	.93
DOWN	1623	.62	.84	6.80	1.00	.87
UP	1563	.64	.93	9.20	1.04	.99
LIGHT BOATS	126	1.17	1.99	13.18	1.56	2.16
DOWN	59	1.04	1.87	12.25	1.34	2.03
UP	67	1.29	2.08	13.18	1.75	2.26

c. Port Activity

This report summarizes the cargo, tow and barge movements associated with each port. Figure 24 illustrates the format. Note that statistics are collected and presented by the commodity groups defined in input data.

It should be noted that the values for tonnage, tows and barges originated, loaded, shipped and received are not directly comparable. For example, the tonnage shipped during the statistics collection period probably includes cargo loaded prior to it. Under steady state conditions this will tend to be balanced by tonnage loaded during the period but still awaiting shipment at the end of it, but it is unlikely that the balance will be exact. Similar conditions apply to the other values reported.

The specific items included in the report are the following:

(1) Originated Tonnage

Tons of cargo which arrived at the port to begin shipment.

(2) Loaded - Tonnage and Number of Barges

Cargo is counted as loaded when loading begins.

(3) Shipped - Tonnage and Number of Barges

Cargo is shipped when loading ends.

(4) Received - Tonnage and Number of Barges

Cargo unloaded at the destination port.

(5) Average Wait (Days) for Barges and Boat

(6) Empty and Transshipped - In and Out

Number of barges that arrived or departed the port empty. This shows all barge movements not associated with shipments originating or terminating at the port.

(7) Tows Served

Number of tows which stopped at the port.

Figure 24, Example of Port Activity Report (R-3)

```
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R-3                                               PORT ACTIVITY: Lower Ohio River0  3                            (365.0 DAYS)

                              ORIG.      LOADED         SHIPPED        RECEIVED      AVERAGE WAIT (DAYS)    EMPTY&TRNSHPD   TOWS
   PORT / COMMODITY GROUP     KTONS   KTONS BARGES   KTONS BARGES   KTONS BARGES   FOR BARGES  FOR BOAT     IN     OUT    SERVED
   ----------------------     -----   ----- ------   ----- ------   ----- ------   ----------  --------   -----  -----   ------

SECTOR  1 Markland  Existing 1

   1  Mc Alpine Pool          49941   49941  30267   49941  30267   30133  18672        0.          0.      21153  9441     3525
      1 NON-HAZARDS CARGO     47980   47980  29274   47980  29274   21849  14339        0.          0.
      2 HAZARDOUS CARGO        1962    1962    993    1962    993    8283   4333        0.          0.

   2  Upper Pool                  0       0      0       0      0       0      0        0.          0.          0      0        0
      1 NON-HAZARDS CARGO         0       0      0       0      0       0      0        0.          0.

   3  D/S ARRIVAL POINT           0       0      0       0      0       0      0        0.          0.          0      0        0
      1 NON-HAZARDS CARGO         0       0      0       0      0       0      0        0.          0.

   4  Markland  Pool          30133   30133  18672   30133  18672   49917  30252        0.          0.       9441 21168     3949
      1 NON-HAZARDS CARGO     21849   21849  14339   21849  14339   47955  29259        0.          0.
      2 HAZARDOUS CARGO        8283    8283   4333    8283   4333    1962    993        0.          0.
```

d. Traffic by Reach

This report summarizes the tow, barge and cargo movements on each reach or bend of the network. Figure 25 illustrates the format.

Reach statistics are recorded when a tow enters a reach or bend. No adjustments are made for vessels which have partially travelled a reach or bend at either the start or end of the statistics collection period. The ton-mile statistics in particular may be slightly in error as a result.

The values presented in the Reach Report are as follows:

(1) Tows

Number of tows, not including light boats, which travelled the reach or bend.

(2) Barges - Loaded and Empty

(3) Light Boats

(4) Cargo

Kilotons of cargo carried on the reach or bend.

(5) Kiloton-Miles

Kilotons of cargo multiplied by the length of the reach or bend. Note that this value is also totaled by sector.

(6) Tow Speed - Average and Standard Dev.

Speed statistics are tallied for tows using the sector. Light boats are excluded.

Figure 25, Example of Traffic by Reach Report (R-4)

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R-4 TRAFFIC BY REACH: Lower Ohio River0 3 (365.0 DAYS)

RIVER POINT	REACH OR BEND	LENGTH (MI)	TOWS	BARGES LOADED	BARGES EMPTY	LIGHT BOATS	CARGO (KTONS)	KTON-MILES	TOW SPEED AVG	TOW SPEED STD DEV
SECTOR 1 Markland Existing 1										
0. P 1 Mc Alpine Pool										
	R- 1	.0	7475	48939	30594	0	80070	80		
	DOWNSTREAM		3950	30267	9441	0	49939	50	6.91	1.64
	UPSTREAM		3525	18672	21153	0	30131	30	7.34	1.50
.0 P 2 Upper Pool										
	R- 2	.0	7475	48939	30594	3302	80070	80		
	DOWNSTREAM		3950	30267	9441	1636	49939	50	6.91	1.64
	UPSTREAM		3525	18672	21153	1666	30131	30	7.34	1.50
.0 L 1 Markland Existing										
	R- 3	.0	7475	48924	30609	3302	80045	80		
	DOWNSTREAM		3949	30252	9441	1636	49914	50	6.91	1.64
	UPSTREAM		3526	18672	21168	1666	30131	30	7.34	1.50
.0 P 3 D/S ARRIVAL POINT										
	R- 4	.0	7475	48924	30609	0	80045	80		
	DOWNSTREAM		3949	30252	9441	0	49914	50	6.91	1.64
	UPSTREAM		3526	18672	21168	0	30131	30	7.34	1.50
.0 P 4 Markland Pool										
	SECTOR	.0						320		
	DOWNSTREAM							200	6.91	
	UPSTREAM							121	7.34	

TOTAL TON-MILES = .3 MILLION

e. Equipment Utilization

This report is in two parts, covering time spent by function and time spent loaded/empty. Figures 26 shows examples of the output.

The statistics presented in the first section are the following:

(1) Number of Trips Completed

Number of shipments completed.

(2) Ktons Delivered

(3) Total Kton-Miles

Total value for tows in the class. Ton-mile statistics are taken when a tow enters a reach, with no adjustments for partially travelled reaches at the start or end of the period.

(4) Percent Time Spent on Reaches

Includes time spent transiting reaches and bends and time waiting to enter bends.

(5) Percent Time Spent in Lockage

Includes the actual lockage time, plus chamber turnback if required.

(6) Percent Time Spent Delayed at Lock

(7) Percent Time Spent in Port

Time spent in port operations, that is, loading/unloading. Does not include tow start/stop delay time.

(8) Average Tow Size (Nom Brgs)

Based on towboat class. Light boats are excluded from this statistic.

(9) Percent Time Light

Based on the time spent by boats on reaches, in lockage and delayed at locks.

The second section of the equipment usage report breaks down barge usage into three categories:

(10) Total Barges Utilized

(11) Percent Time in Use

A barge is considered to be in use when it is loaded or in the process of being loaded or unloaded.

(12) Percent Time Empty

Time spent moving empty. Due to the manner in which these statistics are obtained, errors may arise for barges which are being loaded or unloaded at the start and end of the statistics collection period.

Figure 26, Example of Equipment Utilization Report (R-5)

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R-5 EQUIPMENT UTILIZATION- TOWBOATS I (365.0 DAYS)

TOWBOAT CLASS	NUMBER OF TRIPS COMPLETED	KTONS DELIVERED	TOTAL KTON-MILES	PERCENT TIME SPENT ON REACHES	IN LOCKAGE	DELAYED AT LOCK	IN PORT	AVERAGE TOW SIZE (NOM BRGS)	PERCENT LIGHT TIME
1 1200 HP TOWBOAT	388	1217	5	.0	61.1	38.7	.1	6.1	16.3
2 1400 HP TOWBOAT	441	2880	12	.0	57.4	42.4	.1	10.5	24.7
3 1800 HP TOWBOAT	798	5660	23	.0	63.3	36.5	.2	8.4	1.1
4 2300 HP TOWBOAT	327	1919	8	.0	60.4	39.4	.2	9.0	4.5
5 3400 HP TOWBOAT	1807	14158	57	.0	60.4	39.3	.2	10.5	5.9
6 5000 HP TOWBOAT	1588	18772	75	.0	62.0	37.8	.2	13.2	1.9
7 5600 HP TOWBOAT	2511	33826	135	.0	63.1	36.7	.2	14.4	.9
8 8400 HP TOWBOAT	129	1614	6	.0	64.8	34.9	.2	13.9	.2
9 RECREATIONAL BOAT	2787	0	0	.0	40.8	59.2	0.	0.	100.0
TOTAL/AVERAGE	10776	80045	320	.0	58.0	41.9	.2	11.8	21.9

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R-5 EQUIPMENT UTILIZATION- BARGES (365.0 DAYS)

BARGE CLASS	TOTAL BARGES UTILIZED	PERCENT TIME SPENT IN USE	EMPTY
4 195x35 JUMBO	58121	62.6	37.4
5 195x35 COV JUMBO	10198	62.8	37.2
6 245x35 SUP JUMBO	420	100.0	0.
7 260x52 SUP SUPER	1824	55.8	44.2
8 195x35 JUM TANK	3827	59.6	40.4
9 147x52 147' TANK	1140	63.1	36.9
10 175x54 175' TANK	599	67.9	32.1
11 264x50 264' TANK	1083	65.5	34.5
12 297x54 297' TANK	2336	56.2	43.8
TOTAL/AVERAGE	79548	62.4	37.6

f. Bend Utilization and Delay

This report summarizes the utilization of the bends and the corresponding delays observed during the run. Figure 27 illustrates the format of the report.

As with the Lock Utilization and Delay Report, transit statistics for this report are based on tows completing transit of a bend during the period covered by the report. Queue and delay statistics are tallied as tows arrive and are current. The specific items presented in the report are the following:

(1) Number of Tows Delayed

The total number of tows that did not immediately enter the bend upon arrival at the entrance point to the bend, the bend terminator.

(2) Number of Tows Transited

The total number of tows completing transit of the bend. This does not include light boats.

(3) Light Boats

Number completing transit.

(4) Average Transit Time

Average time for all tows including light boats to transit the bend.

(5) Total Delay Time

Total time all tows were delayed.

(6) Cargo

Tonnage transiting the bend.

(7) Delay - Average and Maximum

Time from arrival at bend terminator to start of transit. If a tow must transit a bend at a lower speed than normal due to preceding traffic in the bend, the difference between the time the tow transits the bend and the time the tow would normally transit the bend is included in delay time.

(8) Queues - Average, Maximum and Standard Dev.

Number of tows awaiting transit.

At the end of each sector and river system, totals are output for Number of Tows Delayed and Total Delay Time.

Figure 27. Example of Bend Utilization and Delay Report (R-6)

R-6 BEND UTILIZATION AND DELAY: PANAMA CANAL SYSTEM (365.0 DAYS)

BEND	VESSELS DELAYED	VESSELS TRANSITS	VESSELS LIGHT	AVG TRANSIT TIME (HRS)	TOTAL DELAY TIME (HRS)	CARGO (KTONS)	DELAY (HRS) AVG	DELAY (HRS) MAX	QUEUE LENGTH AVG	QUEUE LENGTH MAX	QUEUE LENGTH STD
SECTOR TOTALS	0				0.						
DOWNSTREAM	0				0.						
UPSTREAM	0				0.						
SECTOR 2 Gatun Lake											
1 MILE 17.7 TO MILE 18.8	0	24655	0	0.09	0.	737396	0.	0.	0.	0	0.
DOWNSTREAM	0	13620	0	0.09	0.	450720	0.	0.	0.	0	0.
UPSTREAM	0	11035	0	0.09	0.	286676	0.	0.	0.	0	0.
2 MILE 23.3 TO MILE 24.4	0	24655	0	0.09	0.	737396	0.	0.	0.	0	0.
DOWNSTREAM	0	13620	0	0.09	0.	450720	0.	0.	0.	0	0.
UPSTREAM	0	11035	0	0.09	0.	286676	0.	0.	0.	0	0.
3 MILE 26.0 TO MILE 28.5	0	24655	0	0.20	0.	737396	0.	0.	0.	0	0.
DOWNSTREAM	0	13620	0	0.20	0.	450720	0.	0.	0.	0	0.
UPSTREAM	0	11035	0	0.20	0.	286676	0.	0.	0.	0	0.
4 MILE 30.8 TO MILE 32.5	0	24655	0	0.14	0.	737396	0.	0.	0.	0	0.
DOWNSTREAM	0	13620	0	0.14	0.	450720	0.	0.	0.	0	0.
UPSTREAM	0	11035	0	0.13	0.	286676	0.	0.	0.	0	0.
5 MILE 33.2 TO MILE 39.7	0	24655	0	0.79	0.	737396	0.	0.	0.	0	0.
DOWNSTREAM	0	13620	0	0.80	0.	450720	0.	0.	0.	0	0.
UPSTREAM	0	11035	0	0.77	0.	286676	0.	0.	0.	0	0.

g. Interference Report

The interference that occurs between tows using multi-chamber locks can reduce the capacity of a facility substantially. This report provides detailed information about such interference. Figures 28 and 29 are an examples of Interference Reports. The report has 4 sections that report on interference during a particular portions of the lockage cycle. The first part provides information on interference that occurs while tows are approaching a lock, the second part is about interference during chambering, the third part reports on interference during chamber turnbacks, and the fourth part is about interference while tows are exiting. Each of the four parts reports the statistics in a similar manner.

(1) Total # of Tows

This is the total number of tows that transited the facility, both those that experienced interference and those that did not.

(2) # of Tows, % of All, Ave Time (min)

The "# of Tows" shows the number of tows that experienced interference. The "% of All" statistic shows the percent that experienced interference. The "Ave Time" is the average interference time for those tows that experienced interference.

(3) Average Processing Time

These statistics show the measured average time with interference, what the average would have been if there had not been interference, and the difference, which is the additional time caused by interference. These times include all tows, not just those that experienced interference.

Figure 28, Example Interference Report

R-7 INTERFERENCE REPORT (365.0 DAYS)

INTERFERENCE OCCURRING WHILE TOWS ARE APPROACHING

LOCK	TOTAL # OF TOWS	APPROACH AREA # OF TOWS	APPROACH AREA % OF ALL	APPROACH AREA AVE TIME (MIN)	GATE AREA # OF TOWS	GATE AREA % OF ALL	GATE AREA AVE TIME (MIN)	AVERAGE APPROACH TIMES WITH INT (MIN)	AVERAGE APPROACH TIMES WITHOUT INT (MIN)	DIFFERENCE (MIN)
SECTOR 1 Markland Existing 1										
1 Markland Existing	7474	1105	14.78	14.23	32	.43	21.63	19.66	17.47	2.20
DOWNSTREAM	3949	585	14.81	13.46	19	.48	23.23	19.50	17.39	2.11
UPSTREAM	3525	520	14.75	15.10	13	.37	19.30	19.85	17.55	2.30
CHAMBER 1	5170	556	10.75	16.47	32	.62	21.63	20.32	18.41	1.91
DOWNSTREAM	2630	283	10.76	15.14	19	.72	23.23	20.20	18.40	1.80
UPSTREAM	2540	273	10.75	17.86	13	.51	19.30	20.45	18.43	2.02
CHAMBER 2	2304	549	23.83	11.97	0	0.	0.	18.19	15.34	2.85
DOWNSTREAM	1319	302	22.90	11.89	0	0.	0.	18.10	15.38	2.72
UPSTREAM	985	247	25.08	12.06	0	0.	0.	18.32	15.30	3.02

R-7 INTERFERENCE REPORT (365.0 DAYS)

INTERFERENCE OCCURRING WHILE TOWS ARE CHAMBERING

LOCK	TOTAL # OF TOWS	# OF TOWS	% OF ALL	AVE TIME (MIN)	AVERAGE CHAMBERING TIMES WITH INT (MIN)	AVERAGE CHAMBERING TIMES WITHOUT INT (MIN)	DIFFERENCE (MIN)
SECTOR 1 Markland Existing 1							
1 Markland Existing	7474	0	0.	0.	24.26	24.26	0.
DOWNSTREAM	3949	0	0.	0.	24.02	24.02	0.
UPSTREAM	3525	0	0.	0.	24.54	24.54	0.
CHAMBER 1	5170	0	0.	0.	15.54	15.54	0.
DOWNSTREAM	2630	0	0.	0.	15.58	15.58	0.
UPSTREAM	2540	0	0.	0.	15.49	15.49	0.
CHAMBER 2	2304	0	0.	0.	43.84	43.84	0.
DOWNSTREAM	1319	0	0.	0.	40.83	40.83	0.
UPSTREAM	985	0	0.	0.	47.86	47.86	0.

Figure 29, Example of Interference Report

R-7 INTERFERENCE REPORT (365.0 DAYS)

INTERFERENCE OCCURRING DURING CHAMBER TURNBACKS

LOCK	TOTAL # OF CHTB	# OF CHTB	% OF ALL	AVE TIME (MIN)	AVERAGE TURNBACK TIMES WITH INT (MIN)	WITHOUT INT (MIN)	DIFFERENCE (MIN)
SECTOR 1 Markland Existing 1							
1 Markland Existing	2715	0	0.	0.	12.81	12.81	0.
EMPTY	1307	0	0.	0.	12.84	12.84	0.
FILL	1408	0	0.	0.	12.78	12.78	0.
CHAMBER 1	1885	0	0.	0.	13.29	13.29	0.
EMPTY	939	0	0.	0.	13.21	13.21	0.
FILL	946	0	0.	0.	13.37	13.37	0.
CHAMBER 2	830	0	0.	0.	11.72	11.72	0.
EMPTY	368	0	0.	0.	11.87	11.87	0.
FILL	462	0	0.	0.	11.59	11.59	0.

R-7 INTERFERENCE REPORT (365.0 DAYS)

INTERFERENCE OCCURRING WHILE TOWS ARE EXITING

LOCK	TOTAL # OF TOWS	APPROACH AREA # OF TOWS	% OF ALL	AVE TIME (MIN)	GATE AREA # OF TOWS	% OF ALL	AVE TIME (MIN)	AVERAGE EXITING TIMES WITH INT (MIN)	WITHOUT INT (MIN)	DIFFERENCE (MIN)
SECTOR 1 Markland Existing 1										
1 Markland Existing	7474	714	9.55	11.20	60	.80	19.83	12.44	11.21	1.23
DOWNSTREAM	3949	398	10.08	12.04	32	.81	17.41	13.07	11.72	1.35
UPSTREAM	3525	316	8.96	10.15	28	.79	22.60	11.74	10.65	1.09
CHAMBER 1	5170	371	7.18	12.88	60	1.16	19.83	10.11	8.96	1.15
DOWNSTREAM	2630	189	7.19	14.63	32	1.22	17.41	10.32	9.05	1.26
UPSTREAM	2540	182	7.17	11.06	28	1.10	22.60	9.90	8.86	1.04
CHAMBER 2	2304	343	14.89	9.39	0	0.	0.	17.67	16.27	1.40
DOWNSTREAM	1319	209	15.85	9.70	0	0.	0.	18.56	17.02	1.54
UPSTREAM	985	134	13.60	8.90	0	0.	0.	16.48	15.27	1.21

4. Other Output Options

a. Trace Output

Two simulation trace outputs provide detailed, time-sequenced records of activity for the system or selected portions of it. Section C, describes the control records used to start and stop the traces and specify their scope. This section describes the output, which is written on logical units 8 or 12. Figures 30 and 31 show sections of each trace output. Figure 30 shows unit 8 output, Figure 31 shows unit 12 output. The output itself consists of a series of messages produced as various actions take place in the simulation.

The messages that appear in unit 12 are quite self-descriptive, and will not be elaborated upon further. Unit 12 messages are focused solely on the lockage process.

Unit 8 messages provide some lockage related information, but also include information related to movement through sectors, bends, loading and unloading, etc. Table 7 lists the 19 different messages which may appear in unit 8. Each of these is explained in detail, but some general comments are in order first:

(1) The first field in each message is the simulated time in days.

(2) Shipment ("SHIP") numbers are assigned sequentially by the program in order of shipment arrival.

(3) Ports, locks, bend terminators, bends and reaches are designated in the form "s-i" where s is the sector number and i the identification number within the sector as given by the input data. Note that ports located at network junctions may be designated by several different sector-index pairs.

(4) Groups of barges are coded as "n/b" where n and b are the barge class.

(5) A set of associated switches is given for each message. The message will be printed if any of the appropriate switches has been turned on either by a CTRL TRACE record or by a SHIP record. The switches are designated as follows:

- Sh Shipment Switch (set via SHIP record)
- S Shipment Arrival Switch (set via CTRL TRACE record)
- P Port Switch (set via CTRL TRACE record)
- L Lock Switch (set via CTRL TRACE record)
- E Bend Terminator Switch (set via CTRL TRACE record)
- R Reach Switch (set via CTRL TRACE record)

B Bend Switch (set via CTRL TRACE record)

D Special switch for all tow use. (set via CTRL TRACE record)

Figure 30, Example of Unit 8 Trace Output

```
335.0090 SHP 10030 COMM  1 ORIG   1 DEST   4 MV ORIG   1 MV DEST   4  23190 TONS
335.0090 SHP 10030 LOADING 15 BARGES/TYPE  4  23190 TONS - AVAIL 335.0100
335.0100 SHP 10030 AT  1-  1 PICKS UP  15 BARGES/TYPE  4  23190 TONS AT Mc Alpine Pool
335.0100 SHP 10030 AT REACH  1-  1 D END REACH AT 335.0100
335.0100 SHP 10030 AT PORT  Upper Pool          1-  2 D
335.0100 SHP 10030 AT REACH  1-  2 D END REACH AT 335.0100
335.0100 SHP 10030 AT LOCK Markland  Existing   1- 1 D
335.0560 SHP 10030 BGN LKG Markland  Existing   1- 1(1) TYPE 2 D
335.0560 SHP 10030 APPR=     3  ENTRY=    11  CHAMBERING=    16  EXTRA=     0
335.0899 SHP 10030 END LKG Markland  Existing   1- 1(1) TYPE 2 D
335.0899 SHP 10030 AT REACH  1-  3 D END REACH AT 335.0899
335.0899 SHP 10030 AT PORT  D/S ARRIVAL POINT   1-  3 D
335.0899 SHP 10030 AT REACH  1-  4 D END REACH AT 335.0899
335.0899 SHP 10030 AT PORT  Markland  Pool      1-  4 D
335.0899 SHP 10030 AT  1-  4 DELIVERS  15 BARGES/TYPE  4  23190 TONS AT Markland  Pool
335.0899 SHP 10030 COMPLETE
335.1340 SHP 10031 COMM  1 ORIG   1 DEST   4 MV ORIG   1 MV DEST   4  21028 TONS
335.1340 SHP 10031 LOADING 14 BARGES/TYPE  4  21028 TONS - AVAIL 335.1349
335.1349 SHP 10031 AT  1-  1 PICKS UP  14 BARGES/TYPE  4  21028 TONS AT Mc Alpine Pool
335.1349 SHP 10031 AT REACH  1-  1 D END REACH AT 335.1349
335.1349 SHP 10031 AT PORT  Upper Pool          1-  2 D
335.1349 SHP 10031 AT REACH  1-  2 D END REACH AT 335.1349
335.1349 SHP 10031 AT LOCK Markland  Existing   1- 1 D
335.1349 SHP 10031 BGN LKG Markland  Existing   1- 1(1) TYPE 2 D
335.1349 SHP 10031 APPR=    20  ENTRY=    16  CHAMBERING=    19  EXTRA=     0
335.1700 SHP 10032 COMM  9 ORIG   4 DEST   1 MV ORIG   4 MV DEST   1  17864 TONS
335.1700 SHP 10032 LOADING  4 BARGES/TYPE 12  17864 TONS - AVAIL 335.1707
335.1708 SHP 10032 AT  1-  4 PICKS UP   4 BARGES/TYPE 12  17864 TONS AT Markland  Pool
335.1708 SHP 10032 AT REACH  1-  4 U END REACH AT 335.1708
335.1708 SHP 10032 AT PORT  D/S ARRIVAL POINT   1-  3 U
335.1708 SHP 10032 AT REACH  1-  3 U END REACH AT 335.1708
335.1708 SHP 10032 AT LOCK Markland  Existing   1- 1 U
335.1750 SHP 10033 COMM  6 ORIG   1 DEST   4 MV ORIG   1 MV DEST   4      0 TONS
335.1750 SHP 10033 LOADING  0 BARGES/TYPE  8      0 TONS - AVAIL 335.1750
335.1750 SHP 10033 AT  1-  1 PICKS UP   3 BARGES/TYPE  8      0 TONS AT Mc Alpine Pool
335.1750 SHP 10033 AT REACH  1-  1 D END REACH AT 335.1750
335.1750 SHP 10033 AT PORT  Upper Pool          1-  2 D
335.1750 SHP 10033 AT REACH  1-  2 D END REACH AT 335.1750
335.1750 SHP 10033 AT LOCK Markland  Existing   1- 1 D
335.1750 SHP 10033 BGN LKG Markland  Existing   1- 1(2) TYPE 2 D
```

Figure 31, Example of Unit 12 Trace Output

```
335.0023 SHP    10029 Markland  Existing  CHM=2   UPSTREAM APPROACH SET IDLE
335.0023 SHP    10029 Markland  Existing  CHM=2   UPSTREAM GATE BUSY--APPR,TOW LENGTH= 552 FT
335.0023 SHP    10029 Markland  Existing  CHM=2 SCHEDULING AN END ENTRY AT       335.0094
335.0026 SHP    10027 Markland  Existing  CHM=1 DIR=U TYPE= 2 END OF CHAMBERING
335.0026 SHP    10027 Markland  Existing  CHM=1   UPSTREAM APPROACH SET BUSY
335.0085 SHP    10027 Markland  Existing  CHM=1 TYPE= 2 APP =  27  ENT =   4  CHA =  14  EXI =   8  PROC =  54
335.0085 SHP    10027 Markland  Existing  CHM=1 DIR=U TYPE= 2 END OF LOCKAGE
335.0085 SHP    10027 Markland  Existing  CHM=1   UPSTREAM APPROACH SET IDLE
335.0085 SHP    10028 Markland  Existing  DIR=D UPQ=  0 DNQ=  0 LEAVING Q
335.0085 SHP    10028 Markland  Existing  CHM=1 DIR=D TYPE= 2 START LOCKAGE
335.0085 SHP    10028 Markland  Existing  CHM=1   UPSTREAM APPROACH SET BUSY
335.0085 SHP    10028 Markland  Existing  CHM=1 SCHEDULING AN END.APPROACH AT    335.0220
335.0094 SHP    10029 Markland  Existing  CHM=2 SCHEDULING AN EXTRACT CHECK AT   335.0251
335.0100 SHP    10030 Markland  Existing  DIR=D UPQ=  0 DNQ=  1 JOINING Q
335.0100 SHP    10030 Markland  Existing  DIR=D ARRIVE AND BUSY--JOIN QUEUE
335.0100 SHP    10030 Markland  Existing  QUEUE=  1 JOINING Q
335.0220 SHP    10028 Markland  Existing  CHM=1   UPSTREAM APPROACH SET IDLE
335.0220 SHP    10028 Markland  Existing  CHM=1 SCHEDULING AN END ENTRY AT       335.0306
335.0220 SHP    10030 Markland  Existing  CHM=1 CHECK FOR USECHAMBER
335.0220 SHP    10030 Markland  Existing  CHM=1 SELECTED AS NEXT LOCKAGE
335.0220 SHP    10030 Markland  Existing  CHM=1   UPSTREAM APPROACH SET BUSY
335.0220 SHP    10030 Markland  Existing  CHM=1 STARTING PRE-APPROACH
335.0251 SHP    10029 Markland  Existing  CHM=2 DIR=D TYPE= 4 EXTRACTING CUT FROM CHAMBER
335.0251 SHP    10029 Markland  Existing  CHM= 2 DOWNSTREAM GATE BUSY--EXIT;TOW LENGTH= 585 FT
335.0271 SHP    10030 Markland  Existing  CHM=1   UPSTREAM APPROACH SET IDLE
335.0271 SHP    10030 Markland  Existing  CHM=1 FINISHED PRE-APPROACH
335.0271 SHP    10030 Markland  Existing  CHM=1   UPSTREAM GATE BUSY--APPR,TOW LENGTH=1137 FT
335.0271 SHP    10030 Markland  Existing  CHM=1 WAITING AT GATE FOR CHAMBER TO TURN BACK
335.0306 SHP    10028 Markland  Existing  CHM=1 SCHEDULING AN END CHAMBERING AT  335.0413
335.0408 SHP    10029 Markland  Existing  CHM=2   UPSTREAM GATE SET IDLE
335.0408 SHP    10029 Markland  Existing  CHM=2 DIR=D TYPE= 4 LAST CUT ENTERING CHAMBER
335.0408 SHP    10030 Markland  Existing  CHM=2 CHECK FOR USECHAMBER
335.0408 SHP    10030 Markland  Existing  CHM=2 CHECK FOR USECHAMBER
335.0413 SHP    10028 Markland  Existing  CHM=1 DIR=D TYPE= 2 END OF CHAMBERING
335.0413 SHP    10028 Markland  Existing  CHM=1 DOWNSTREAM APPROACH SET BUSY
335.0481 SHP    10028 Markland  Existing  CHM=1 DOWNSTREAM APPROACH SET IDLE
335.0481 SHP    10028 Markland  Existing  CHM=1 TYPE= 2 APP =  19  ENT =  12  CHA =  15  EXI =  10  PROC =  57
335.0481 SHP    10028 Markland  Existing  CHM=1 DIR=D TYPE= 2 END OF LOCKAGE
335.0481              Markland  Existing  CHM=1 STARTING CHAMBER TURNBACK
335.0560              Markland  Existing  CHM=1 CHAMBER TURNED BACK, LOCKAGE AT GATE
335.0560 SHP    10030 Markland  Existing  CHM=1   UPSTREAM GATE SET IDLE
335.0560 SHP    10030 Markland  Existing  DIR=D UPQ=  0 DNQ=  0 LEAVING Q
335.0560 SHP    10030 Markland  Existing  CHM=1 DIR=D TYPE= 2 START LOCKAGE
335.0560 SHP    10030 Markland  Existing  CHM=1 SCHEDULING AN END.APPROACH AT    335.0577
335.0565 SHP    10029 Markland  Existing  CHM=2 DIR=D TYPE= 4 END OF CHAMBERING
335.0565 SHP    10029 Markland  Existing  CHM=2 DOWNSTREAM APPROACH SET BUSY
335.0565 SHP    10029 Markland  Existing  CHM=2 DOWNSTREAM GATE SET IDLE
```

TABLE 7

TRACE OUTPUT MESSAGE FORMATS

(a)	ttt.tttt	SHP i COMM k ORIG p DEST p MV ORIG; MVDESTp qTONS
(b)	ttt.tttt	SHP i LOADING n/b q TONS AVAIL ttt.tttt
(c)	ttt.tttt	SHP i COMPLETE
(d)	ttt.tttt	SHP i AT BEND s-b d END BEND at ttt.tttt
(e)	ttt.tttt	SHP i AT REACH s-r d END REACH AT ttt.tttt
(f)	ttt.tttt	SHP i AT PORT s-p d
(g)	ttt.tttt	SHP i AT s-p PICKS UP n/b q TONS
(h)	ttt.tttt	SHP i AT s-p DELIVERS n/b q TONS
(i)	ttt.tttt	SHP i AT BEND TERMINATOR s-e d ENTERING BEND WITHOUT DELAY
(j)	ttt.tttt	SHP i AT BEND TERMINATOR s-e d JOINING QUEUE FOR BEND
(k)	ttt.tttt	SHP i WILL ENTER BEND s-b d FROM QUEUE
(l)	ttt.tttt	SHP i AT LOCK s-l d
(m)	ttt.tttt	SHP i BGN LKG s-l (k) TYPE t d
(n)	ttt.tttt	SHP i END LKG s-l (k) TYPE t d
(o)	ttt.tttt	REC BOAT AT LOCK s-l d
(p)	ttt.tttt	REC BOAT BGN LKG s-l (k) TYPE t d
(q)	ttt.tttt	REC BOAT END LKG s-l (k) TYPE t d
(r)	ttt.tttt	BGN OPEN PASS s-l
(s)	ttt.tttt	END OPEN PASS s-l

The trace messages of Table 7 will not be explained. Any of the indicated switch types will activate the printing of the particular message type.

(a) A new shipment, assigned sequence number i, has arrived at a port ready for loading. The commodity type, shipment segment origin, shipment segment destination, movement origin, movement destination, and tonnage are echoed from the SHIP external event record. Switches: Sh, S, D.

(b) q tons of cargo from shipment i are being loaded on b type barge. Switches: Sh, P.

(c) Shipment i has now been delivered to the segment destination. Switches: Sh, D.

(d) Shipment i is beginning transit of the specified bend. "d" indicates the direction of travel <u>Up</u> or <u>Down</u>. Switches: Sh, B.

(e) Shipment i is beginning transit of the specified reach. "d" indicates the direction of travel <u>Up</u> or <u>Down</u>. Switches: Sh, R.

(f) Shipment i has arrived at the specified port, travelling in the direction indicated by "d". Switches: Sh, P.

(g) Shipment i currently at the indicated port, of b type barge, carrying q tons of cargo. (Zero tonnage indicates empty barge being moved for use by the shipment). Switches: Sh, P.

(h) Similar to message (g) except that the barge is at the destination. Switches: Sh, P. D.

(i) Shipment i is at the indicated bend terminator. "d" indicates direction of travel. The tow will enter the bend with delay. Switches: Sh, E.

(j) Shipment i is at the indicated bend terminator. "d" indicates direction of travel. The tow will join the queue and will not enter the bend at this time. Switches: Sh, E.

(k) Shipment i will enter the indicated bend from the queue. "d" indicates direction of travel. Switches: Sh, B.

(l) Shipment i has arrived at the indicated lock. Its direction of travel is given by "d" - Up/Down. Switches: Sh, L.

(m) Shipment i is beginning a type t lockage in chamber k of the specified lock. The type codes are: 1 - open pass, 2 - tow type 1, 3 - tow type 2, 4 - tow type 3, 5 - tow type 4, etc. "d" indicates direction of travel. Switches: Sh, L.

(n) Similar to message (m) except that the tow has completed its lockage. Switches: Sh, L.

(o), (p), (q) These messages correspond to messages, (l), (m) and (n) except that they apply to recreation craft. Switches: L.

(r) Beginning of an open pass condition at the indicated lock. Switches: L.

(s) End of open pass condition. Switches: L.

b. Resource Usage Output File

Since a run of the WAM simulation model is very closely related to a corresponding run of the Tow Cost Model, it is desirable to have an output file from the WAM model that contains some of the same information as the Resource Usage File from the Tow Cost Model. The WAM model Resource Usage Output File provides that information. An output record is written to the file each time a shipment arrives at its shipment segment destination port. Figure 32 shows an example of the Resource Usage Output file. The file is formatted as follows:

Description	Columns	Format
Movement Origin Port	1-3	I 3
Movement Destination Port	4-6	I 3
Shipment Segment Origin Port	7-9	I 3
Shipment Segment Destination Port	10-12	I 3

Commodity Class Number	13-15	I 3
Barge Class Number	16-18	I 3
Loaded Barge (1=Yes,0=No)	22-24	I 3
Empty Barge (1=Yes,0=No)	25-27	I 3
Tonnage	28-34	I 7
Time Transiting Reaches(Days)	35-44	D(10,5)
Time in Lockage(Days)	45-54	D(10,5)
Time Awaiting Lockage (Days)	55-64	D(10,5)
Time Transiting Bends (Days)	65-74	D(10,5)
Time Waiting to Enter Bends (Days)	75-84	D(10,5)
Time in Fleeting Operations (Days)	85-94	D(10,5)
Time Loading and/or Unloading (Days)**	95-104	D(10,5)
Distance Traveled by Shipment (Miles)	105-114	D(10,1)
Shipment Number	115-124	I 10
Route Number (Sum of Sector Numbers)	125-129	I 5

** This time will appear as zero in the output if the start/stop port input time is zero.

Figure 32, Example of Resource Usage Output File

4	1	4	1	1	7	4	0	15	0	.00002	.04205	0.	0.	0.	.00017	0.	.0
4	1	4	1	1	7	4	15	0	22500	.00003	.03656	.05283	0.	0.	.00017	.00188	.0
1	4	1	4	1	4	4	16	0	25472	.00004	.08509	0.	0.	0.	.00018	.00212	.0
4	1	4	1	2	6	9	5	0	7705	.00002	.02180	.06576	0.	0.	.00008	.00064	.0
1	4	1	4	6	5	8	0	11	0	.00002	.03485	.01186	0.	0.	.00013	0.	.0
1	4	1	4	1	3	4	12	0	17736	.00004	.07243	.08682	0.	0.	.00014	.00148	.0
4	1	4	1	1	7	4	0	15	0	.00002	.03839	0.	0.	0.	.00017	0.	.0
4	1	4	1	6	2	8	6	0	10752	.00004	.03577	.01378	0.	0.	.00009	.00090	.0
4	1	4	1	6	3	12	2	0	4920	.00003	.02727	.00894	0.	0.	.00006	.00041	.0
4	1	4	1	6	6	12	4	0	13440	.00002	.04675	0.	0.	0.	.00008	.00112	.0
2	3	2	3	1	9	0	0	0	0	.00001	.01621	0.	0.	0.	.00004	0.	.0
4	1	4	1	5	5	5	0	16	0	.00002	.03844	.00402	0.	0.	.00018	0.	.0
1	4	1	4	6	5	8	12	0	17568	.00003	.08763	0.	0.	0.	.00014	.00146	.0
4	1	4	1	5	5	5	0	3	0	.00002	.02585	.04160	0.	0.	.00007	0.	.0
4	1	4	1	6	3	12	2	0	6716	.00003	.03612	.04113	0.	0.	.00006	.00056	.0
1	4	1	4	6	3	12	2	0	6600	.00003	.03887	.01818	0.	0.	.00006	.00055	.0
1	4	1	4	9	5	4	9	0	12681	.00003	.01943	.01492	0.	0.	.00012	.00106	.0
4	1	4	1	9	5	5	0	5	0	.00002	.03272	.00410	0.	0.	.00008	0.	.0
1	4	1	4	9	3	4	12	0	18528	.00004	.02603	.01075	0.	0.	.00014	.00154	.0
1	4	1	4	1	6	4	0	15	0	.00002	.02346	.03081	0.	0.	.00017	0.	.0
1	4	1	4	1	6	4	15	0	21885	.00003	.04189	0.	0.	0.	.00017	.00182	.0
1	4	1	4	1	2	4	10	0	15810	.00004	.09203	0.	0.	0.	.00013	.00132	.0
1	4	1	4	5	2	5	10	0	16110	.00004	.07766	.04954	0.	0.	.00013	.00134	.0
1	4	1	4	2	7	12	4	0	15600	.00002	.05271	.04930	0.	0.	.00008	.00130	.0
1	4	1	4	9	3	11	2	0	5490	.00003	.02003	.08039	0.	0.	.00006	.00046	.0
1	4	1	4	1	5	4	10	0	14780	.00003	.02292	.10143	0.	0.	.00013	.00123	.0
4	1	4	1	1	7	4	0	15	0	.00002	.02437	.06859	0.	0.	.00017	0.	.0
4	1	4	1	1	7	4	0	15	0	.00002	.08206	.00695	0.	0.	.00017	0.	.0
4	1	4	1	2	5	12	0	4	0	.00002	.06955	0.	0.	0.	.00008	0.	.0
4	1	4	1	6	5	5	15	0	23400	.00003	.06563	.07308	0.	0.	.00017	.00195	.0
4	1	4	1	6	6	8	13	0	18161	.00003	.08500	.11799	0.	0.	.00015	.00151	.0
1	4	1	4	5	5	5	14	0	21994	.00003	.04032	.07641	0.	0.	.00016	.00183	.0
1	4	1	4	6	3	11	0	3	0	.00002	.04215	.13479	0.	0.	.00007	0.	.0
1	4	1	4	6	6	8	0	15	0	.00002	.03639	0.	0.	0.	.00017	0.	.0
4	1	4	1	1	7	4	15	0	22500	.00003	.04102	.00145	0.	0.	.00017	.00188	.0
1	4	1	4	1	7	4	15	0	23715	.00003	.03576	.03941	0.	0.	.00017	.00198	.0
4	1	4	1	7	5	4	15	0	20235	.00003	.03783	.00631	0.	0.	.00017	.00169	.0
1	4	1	4	9	5	8	0	4	0	.00002	.02753	0.	0.	0.	.00008	0.	.0
4	1	4	1	6	7	8	13	0	19006	.00003	.03900	.00269	0.	0.	.00015	.00158	.0
1	4	1	4	8	7	4	16	0	22576	.00003	.03968	.03253	0.	0.	.00018	.00188	.0
4	1	4	1	8	7	4	0	16	0	.00002	.04027	.06216	0.	0.	.00018	0.	.0
1	4	1	4	1	4	4	10	0	15020	.00003	.03713	0.	0.	0.	.00013	.00125	.0

c. One Line Summary Output

The WAM automatically writes summary information at the end of a run to unit 89. One line per chamber is written to the unit in append mode. This means that if the file exists when the run is started, the results of the run will be appended to the end of the file. In this manner, the results of several separate runs can all be incorporated into one file.

The file is written in fixed width format, which can easily be imported into a spreadsheet application. Then the information can be graphed and summarized using the capabilities of the spreadsheet application.

The following information is written to the file, one line for each chamber.

Field #	Description
1	Escalation Factor Used (100 is double the base traffic)
2	Chamber #
3	Seed 1 (Seed used for initialization of the system
4	Seed 2 (Seed to be used next)
5	Chamber 1 utilization rate
6	Chamber 2 utilization rate
7	Average Delay per tow
8	Lock Name
9	Date run was made
10	Time tun was made
11	Tonnage processed (Ktons)
12	Duration of run (Days)
13	Number of Lockages
14	# of Tows Delayed
15	Total amount of tow delay time (hrs)
16	Average delay for all tows
17	Standard deviation in delay for all tows
18	Maximum delay experienced
19	Average delay for those tows that were delayed
20	Standard deviation for those tows that were delayed
21	Sum of Processing time for all vessels
22	Sum of Processing time for tows only
23	Sum of processing time for lightboats only
24	Total number of lockages
25	Total number of tow lockages
26	Total number of lightboat lockages
27	Total number of vessels processed
28	Total number of tows processed
29	Total number of lightboats processed
30	Average processing time for all vessels
31	Average Processing time for tows
32	Average processing time for light and rec boats
33	Total number of barges processed
34	Number of loaded barges processed
35	Number of empty barges processed
36	Percent of all barges that were empty
37	Average number of barges per tow
38	Total tonnage processed by entire lock, (last chamber)
39	Average Delay for entire lock (last chamber)

d. <u>Detailed Lockage Output</u>

This output<u>, which is written to unit 40,</u> is optional. It is requested by using a "TRACE DB" statement in the run control data input file. See Section C.5.b.
This information is output in semicolon delimited format. The following pieces of information are written for each lockage. It should be noted that this file can become very large.

Field #	Description
1	Lock Name
2	Chamber Number
3	Shipment Number
4	Direction
5	Total Number of Barges
6	Number of Loaded Barges
7	Number of Empty Barges
8	Tonnage
9	Vessel Length
10	Vessel Width
11	Lockage Type
12	Approach Type
13	Exit Type
14	Preapproach Time (minutes) if turnback approach
15	Approach Time (minutes)
16	Entry Time (minutes)
17	Chambering Time (minutes)
18	Exit Time (minutes)
19	Arrival Time (model time)
20	Start Preapproach Time (model time) turnbacks only
21	At Gate Time Time (model time) turnbacks only
22	Chamber Ready Time (model time) turnbacks only
23	Start of Lockage Time (model time)
24	End of Approach Time (model time)
25	End of Entry Time (model time)
26	End of Cut 1 Time (model time)
27	Start Cut 2 Entry Time (model time)
28	End of Chambering Time (model time)
29	End of Lockage Time (model time)
30	Clear exit approach are time (model time)
31	Approach area interference while approaching (minutes)
32	Gate area interference while approaching (minutes)
33	Filling interference (minutes)
34	Emptying interference (minutes) not applicable
35	Approach area interference while exiting (minutes)
36	Gate area interference while exiting (minutes)

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F. PC WAM INSTALLATION AND RUN PROCEDURES¶
¶
¶
It is recommended that this version of the WAM called DDAM8 be installed on a 486 PC operating at 33HZ or better. The model can be installed and run on a 386 PC, but it will take much longer to simulate 365 days of Canal operations. For that reason, the sample run included is setup to run for a simulated period of 30 days. It can be easily changed by using SimEdit (or any other editor) and changing the control file report entry from 30 days to the desired run length.¶
¶
The enclosed diskette contains a zip executable file called WAM.EXE. The file is .7 Mb, but explodes into approximately 3.7 Mb. It has the following directory structure:¶
¶

```
----SIM¶
    I----CONFIG¶
    I----EDIT¶
    I----LIST¶
    I----SIMLAB¶
    I----DDAM8¶
```

¶
¶
To execute or unzip the files under the same directories on the C drive, insert the diskette into the B drive and type the following under DOS while on the C drive:¶
¶
B:\wam.exe -d c:\sim\¶
¶
This will place the simlab run module under the \sim directory on the C drive and executable wam model under the sub-directory called \ddam8. All input files and two sample run files for the Panama Canal are included.¶
¶
To access and run the wam model type: "simlab" under the \sim directory. Note: This version of simlab is a run version only, but it does allow editing of files using SimEdit. See Attachment A for a list of SimLab and SimEdit commands. Next type: "se ddam8" to select the ddam8 program.¶
¶
Type: "@panrun14" to make the file assignments and run the existing Panama network. The panrun14 file contains:¶
¶
as 1 <
SHIPS90¶
as 3 <
NET9002¶ ... [1]

Page 122: [1] Deleted **Mark Lisney** **4/7/2003 11:21:00 AM**

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F. PC WAM INSTALLATION AND RUN PROCEDURES

It is recommended that this version of the WAM called DDAM8 be installed on a 486 PC operating at 33HZ or better. The model can be installed and run on a 386 PC, but it will take much longer to simulate 365 days of Canal operations. For that reason, the sample run included is setup to run for a simulated period of 30 days. It can be easily changed by using SimEdit (or any other editor) and changing the control file report entry from 30 days to the desired run length.

The enclosed diskette contains a zip executable file called WAM.EXE. The file is .7 Mb, but explodes into approximately 3.7 Mb. It has the following directory structure:

```
----SIM
    I----CONFIG
    I----EDIT
    I----LIST
    I----SIMLAB
    I----DDAM8
```

To execute or unzip the files under the same directories on the C drive, insert the diskette into the B drive and type the following under DOS while on the C drive:

```
B:\wam.exe -d c:\sim\
```

This will place the simlab run module under the \sim directory on the C drive and executable wam model under the sub-directory called \ddam8. All input files and two sample run files for the Panama Canal are included.

To access and run the wam model type: "simlab" under the \sim directory. Note: This version of simlab is a run version only, but it does allow editing of files using SimEdit. See Attachment A for a list of SimLab and SimEdit commands. Next type: "se ddam8" to select the ddam8 program.

Type: "@panrun14" to make the file assignments and run the existing Panama network. The panrun14 file contains:

```
as 1 < SHIPS9Ø
as 3 < NET9ØO2
as 5 < CONTRL14
as 6 > WAMOUT14
as 8 > TRACE14.OUT
as 9 < NUL
```

```
as 10 < DOWN14
as 13 > RUOUT14
RUN
```

The "<" file assignments are inputs and the ">" file assignments are outputs. The following table summarizes the inputs.

SUMMARY OF INPUTS

SIMU(TAPE)	FILE NAME	DESCRIPTION
1	SHIPS9Ø	Panama Canal Shipment List
3	NET9ØO2	Panama Canal Network
5	CONTRL14	Run Title and Report Control Records
9	NUL	DOS Empty File (Old Restore File)
10	DOWN14	Lock Down Time Data

The "RUN" runs the program. The output files should be created after the run is complete. DOS commands can be executed from within simlab by using the prefix "&".

Example: "&dir c:\sim\ddam8*.*"

Outputs for this run are written to the \ddam8 sub-directory and include the following files:

SUMMARY OF OUTPUTS

SIMU(TAPE)	FILE NAME	DESCRIPTION
6	WAMOUT14	Output Reports Requested By SIMU5
8	TRACE14.OUT	Trace Information (Each Movement)
13	RUOUT14	Detailed Time Summary (Each Movement)

The output can be viewed by using the SimEdit; type "e/d wamout14". Scroll through the output by using the arrow keys. To exit SimEdit, hit the escape key and type "quit". The output can be printed by typing "p/d wamout14"; it is in 132 column format and is lengthy.

To exit the simlab session type: "quit".

To run a future possible alternative for the Panama Canal, type "@panrun19". This run contains new locks at both ends of the existing canal. The output is called panrun19.