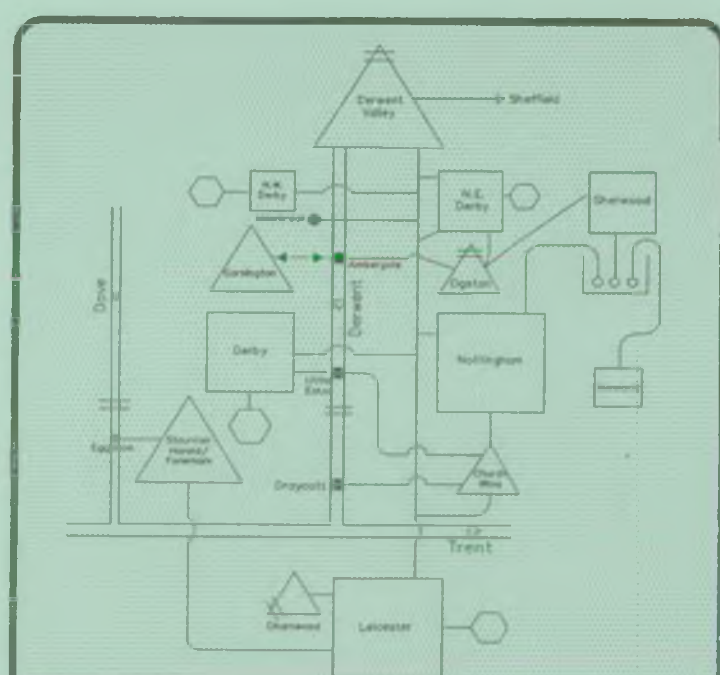
NRA-WATER RESOURCES 63

NRAM

User - Guide

National Rivers Authority
Resource
Allocation
Model

NRA



Water Resources (Planning & Operations)

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NRAM

User - Guide

Contents

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ENVIRONMENT AGENCY

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1 INTRODUCTION

This document provides a description of and running instructions for the National Rivers Authority - Resource Allocation Model (NRAM). The original version of this model, called the Regional Resources Allocation Model, was developed by Severn-Trent Water Authority in 1980. Such a model became desirable when possibilities for interlinking command areas and demand centres made necessary the consideration of the Water Authority's area as a whole. The model is designed to show how the present or projected water resource system of the Severn and Trent River Basins would react to a wide range of hydrological conditions under varying operational rules.

During the period 1980-87 the model was used to assess the feasibility of many major capital schemes including re-building of the Carsington Dam, the East-West link, and major treatment work enhancements. It was also used for general resource optimisation throughout the region, resource allocation during droughts, design and assessments of resource control rules, assessment of standards of service, and for revenue forecasting purposes.

The NRA, after their formation in 1989, took over the use of the model and made significant enhancements and corrections to the model and data during the period 1990-91 to produce the version that is now called NRAM. However it is important to note that unit cost values have not been updated and are still set at 1980-81 prices.

Recently NRAM has been used for the River Severn Control Rules project to assess the various options that are currently being proposed.

The specification of the model and control of its use is under the direction of Gordon Davies.

2 MODEL DESCRIPTION

2.1 The program - general

The program is written in Fortran 77 for use on the Authority's DEC VAX 3100 computer. The program, including all segments, is some 3,500 lines long, of which 600 are taken up in the four BLOCK DATA segments. There are five other segments of which four form the allocation derivation routine while the fifth controls the listing of allocation details. Data input not performed by BLOCK DATA segments is handled on six channels and there are five types of results listing, one run information file and one channel for the storage of allocations, ready for re-input. Fig 1 shows the organisation of these components, which are described in more detail below. The passing of information between segments is accomplished mainly by common blocks. Table 1 shows which common blocks are used by each of the segments. Listings of all program segments, together with definitions of all variables, are available as an appendix. These listings should be considered as examples only, as versions in use at any one time may differ in some details.

2.2 The modelled system

2.2.1 General remarks

The difficulty in a general simulation model is to reach a compromise between the unwieldyness of a highly detailed model and the unacceptable loss of accuracy with an over simplified model. The degree of simplification of the physical system and of the operating rules and practices, and the choice of timestep to be used in the simulation all have a role in this compromise. The approach to the physical system used in formulating this model was a flexible one, in that the decision on whether to include a component was made on grounds not of size but of importance to the system. A schematic diagram of the modelled system is shown in Figure 2.

2.2.2 Sources

Water resource sources are split into four categories:

(i) Strategic reservoir systems
(ii) Major river abstractions
(iii) Strategic groundwater abstractions
(iv) Local sources.

These are described in more detail in the following sections. The Source Numbers and Names currently used in the model are:

Source No.	Source Name
1	Elan Valley
2	Lake Vyrnwy
3	Tittesworth
4	Dove Scheme
5	Derwent Valley
6	Ogston
7	Church Wilne
8	Charnwood
9	Blithfield
10	Shustoke

11	Draycote
12	Stanford
13	Groundwater (See 2.2.5)
14	Wyelands
15	Shelton
16	Hampton Loade
17	Trimpley
18	Ombersley
19	Upton and Worcester
20	Mythe
21	Willes Meadow
22	Homesford
23	Little Eaton
24	Local Sources (See 2.2.6)

2.2.3 Reservoirs

The reservoirs simulated in the model have several different combinations of purpose and modes of operation, making a general reservoir module impractical. There are certain basic elements of operation common between reservoirs however and where possible these are treated in the same way from reservoir to reservoir. All direct supply reservoirs have two 'supply curves' which define three levels of output. In most reservoirs one or both curves have secondary functions, also controlling prescribed flows, compensation releases or hands-off flows at refill abstraction points. All pump filled reservoirs have filling targets, specified as a curve, which are sometimes used in conjunction with other rules. The major reservoirs have flood drawdown curves designed to lessen the risk of excess spillages. Certain groups of reservoirs which are, or can be assumed to be, operated together are treated as one reservoir in the model, the operating rules being defined on the sums of the volumes in the separate reservoirs.

2.2.4 River abstractions

There are three types of river abstractions in the model; direct supply, refill, and major abstractions by other bodies. The quantities abstracted for direct supply are determined by the allocation routine, except that in some cases the upper limits are controlled by river flow or reservoir volume. Refill abstractions are determined within the simulation with reference to licences, river flows and filling targets. The third class of abstractions includes major industrial abstractions, spray irrigation abstractions and abstractions by other water companies. These are determined outside the simulation and are specified as either a fixed quantity or by the interaction of a 'profile' over the year and a factor, between 0 and 1, for each year.

2.2.5 Aquifers

All but one of the aquifer units identified as part of the modelled system are used solely for direct supply. Their use will vary little with climatic conditions and thus their effect on river flows will also be fairly constant. Because of these considerations, and because of the complex nature of groundwater modelling, the integration into the model of simulations of these direct supply units has not been undertaken. Since the direct supply units are not simulated, they are all treated as a single source by the allocation routine.

The Shropshire Groundwater Scheme is of a different type with the quantities abstracted being dependent on the flows in the River Severn. It is desirable that this should be simulated so that the effect on the river of abstractions can be determined, but at the moment the model does not attempt to simulate any interaction between river and aquifer.

2.2.6 Local Sources

These are sources which can only supply a single demand centre usually at a fairly constant rate. They may be small local reservoir or river abstractions, or they may be borehole or spring sources, or some combination of these. Since the local source units are not simulated, they are all treated as a single source by the allocation routine.

2.2.7 Links

The presence in the model of a link between a source and a demand centre implies either an aqueduct exists or that the existing network can carry such a supply. Specified for each link are a lower bound on the flow in that link, an upper bound and a peak week upper bound. These are used to ensure that operational requirements, as well as physical limitations, are reflected in the allocations of water. In addition, power and chemicals unit costs (to enable the derivation and listing of cost information) and a 'dummy' unit cost (to facilitate further the enforcement on the allocations of operational requirements) are specified.

Links which currently exist are identified by a '1' in Table 1.

2.2.8 Demand centres

The area supplied by the Severn Trent Water Ltd, South Staffordshire Water Company and East Worcestershire Waterworks Company has been split into twenty four demand centres. These are either identifiable centres of population or areas which have, effectively, a separate water supply. The demands used in a particular simulation are based on the projected normal average demands for the year being studied. A more accurate representation of reality is introduced by identifying pentads in the duration of the historical record where 'peak week demands' were likely to have applied or did apply and imposing higher demands at these times. These higher demands are calculated by using a peak week factor for each demand centre, based on recent demand figures. The demands can be further affected by the behaviour of reservoirs. It is assumed that a demand can and will be reduced if the storage in a reservoir important in supplying the demand centre is unduly low. Each reservoir has an associated list of demand centres dependent on it (directly or indirectly) and if the reservoir enters one of the two lower output states then demands at all the associated demand centres are reduced. Reductions are 5,10 or 20% of average annual demand, depending on the reservoir state and the importance of the source.

The demand centre numbers and names currently used in the model are:

Demand Centre No.	Name
1	Shrewsbury
2	Telford
3	Ludlow
4	Montgomery
5	South Staffs WC
6	Wolverhampton
7	Birmingham
8	Nuneaton
9	Coventry
10	Rugby
11	South Warwickshire
12	Gloucestershire

13	Worcester
14	Kidderminster
15	East Worcester WC
16	Sherwood
17	Nottingham
18	North West Derbyshire
19	North East Derbyshire
20	Derby
21	Leicester
22	Rutland
23	Upper Trent
24	Newark

2.2.9 Rivers and inflows

The data on river flows and reservoir inflows is in the form of pentad averages derived from daily naturalised flows, either as measured or simulated by the HYSIM catchment model or correlated with another site or generated by another Rainfall/Runoff model. Residual flows are only calculated at a limited number of important gauging points on rivers used for public supply. The flows are affected by reservoir releases and spillages, abstractions, and effluent returns. Effluents are assumed to be a constant proportion of direct supply river abstractions.

2.3 The main segment

The main segment of the program performs most of the data input, all the simulation and most of the manipulation and listing of results. Fig 3 is a flow diagram of the important steps. The detail of the program is easy to follow as efforts have been made to use comment statements throughout and to use meaningful variable names. This is made more comprehensive, without losing generality, by using EQUIVALENCE statements to enable common attributes to be referenced individually or together as an array. EQUIVALENCE statements have also enabled reservoir curves with more than one function to be accessed with different names when the separate functions are in use.

2.4 The allocation routine

2.4.1 The allocation model

The water available from all sources is allocated among demand centres by using a linear programme solution sub-routine. Although the technique is nominally one of cost-minimisation, the constraints are often such as to make the set of feasible solutions fairly small. The main criterion for choosing linear programming rather than a specially developed more heuristic technique was the ease with which new links, sources and demand centres could be incorporated without knowledge of the techniques used.

The basic form of the linear programming of the problem is made up of three types of constraint:

(i) $\sum_{j\ D(i)} q_{ij} \leq Oi$ for each i

(ii) $\sum_{j\ S(j)} q_{ij} \geq Dj$ for each j

(iii) $q_{ij} \leq UB_{ij}$) for each i,j such that the link
$q_{ij} \geq LB_{ij}$) i j exists

where q_{ij} is the flow in the link i-j

O_i is the maximum output from source i

D_j is the demand at demand centre j

UB_{ij}, LB_{ij} are the upper and lower bounds on the flow in the link ij

D(i) is the set of demand centres supplied by the source i

S(j) is the set of sources supplying demand centre j

Minimising a simple cost function, $\Sigma c_{ij} q_{ij}$, with respect to these constraints yields the required solution in most cases. If there is insufficient water to meet any of the demands, however, there will be no solution to the above problem and, automatically, a new problem will be solved. The new constraints are as follows.

(i) $\sum_{j\ D(i)} q_{ij} \leq Oi$ for each i

(ii) $\sum_{i\ S(j)} q + S_j \geq D_j$ for each j

(iii) $q_{ij} \leq UB_{ij}$) for each i,j such that the link
$q_{ij} \geq LB_{ij}$) i j exists

(iv) $\frac{Sj}{Dj} - M \leq O$ for each j

The objective function is $\sum_{ij} c_{y} q_{ij} + \sum_{j} a_j S_j + bM$

where S_j is the shortage at demand centre j

M is a dummy variable

a_j,b are arbitrary numbers such that $b >> a_j >> c_{ij}$ for all i,j

This problem can be seen to be similar to that above except that shortfalls at demand centres can be made up by shortages S_j. In addition M is defined by constraint type (iv) to be an upper bound on shortages. A solution to this problem will attempt to do two things; the total shortfall in the system will be kept to a minimum and any unavoidable shortfall will be spread among as many demand centres as possible, and evenly in relation to the size of the demands.

In addition to these basic forms of constraint, the model has a facility to incorporate additional constraints, explicitly specified by the user. Non-standard situations which can be dealt with using this facility include limitations on the mix of water from different sources at a particular demand centre and those cases where supplies from several sources are treated at a common site whose capacity is less than the sum of the maximum flows from those sources.

In order to speed up the solution of the Linear Program problem, the problem which is actually solved is the 'DUAL' of the problem specified above. This can be described as a transposition of the original form.

2.4.2 Control and solution

Runs of the model with river flow sequences for forty seven years have shown that as few as two hundred different allocations are required, with most of these being repeated many times. It is important that each allocation should only be derived once, but since there are many thousands of possible allocations it is not feasible to derive them before the simulation is carried out. A system has been developed where allocations are derived in the model run but are stored so that they can be reused if identical conditions reoccur. They are also written to a file as they are created, in order to store them from run to run. In order to facilitate this process each combination of conditions, that is each allocation, is given a unique identifier. Fig 4 is a flow diagram of the steps, performed each pentad, which make up these controls.

The routine used to solve the Linear Program problem requires the coefficient matrix to be set up explicitly. Much of this matrix is the same from allocation to allocation and can be set up at the start of the run. A flow diagram for this is shown in Fig 5. The rest of the matrix is set up at the time of solution, as it depends on the outputs and demands, as well as whether a shortfall in supply is present. A flow diagram of this part of the solution process is shown in Fig 6. The solution is performed by a subroutine from the National Algorithms Group (NAG) library by subroutines. Details of the routine, called H01ADF, can be found in the NAG Manual, or in the NRAM correspondence file.

The routine H01ADF is not now supported in the latest NAG library, therefore NAG have provided the source code of the routine, and it has been included as a subroutine at the end of the model code.

2.5 The parameter list

The parameter list is designed to be a complete and convenient list of all the physical, legal and operational parameters used in a particular run. It will enable people not used to the structure of the model to see the assumptions made without studying the data files. The parameters listed are as follows:-

(i) Output control curves. These are given in graphical form for each direct supply reservoir.

(ii) A table of output levels for all direct supply reservoirs. These give the maximum output permissible in each of the three defined bands of storage.

(iii) Direct supply abstractions. Gives the daily maximum and annual average maximum abstractions, the factor which controls any change in maximum abstraction, and the effluent return factor for each direct supply river abstraction.

(iv) Maintained flow targets and groundwater abstractions. Gives the total maximum direct supply output, the maximum discharge from the Shropshire Groundwater Scheme, and the maintained flow targets at up to three points on the river Severn.

(v) Demands and peak week factors. Gives the annual average demand for each demand centre used in the model, together with the peak week factor assumed.

(vi) Demand reduction factors. For each reservoir assumed to affect demands, gives the reduction factor associated with each output band and a list of the demand centres affected by the reservoir. The direct supply reservoirs are listed first followed by the others.

(vii) Link bounds and costs. The links are identified by demand centre name and source name and grouped by demand centre. Listed for each one are its peak week upper bound, normal upper bound, lower bound, unit cost (power and chemicals) and dummy unit cost. Note that the real unit cost is used solely to calculate the costs of supply for selected years (see Results File 2), whereas the "Dummy" unit cost is used by the allocation routine. By manipulating the Dummy cost it is possible to force a non optimal allocation, and see the true cost displayed in the results.

The unit cost values are currently set at 1980/81 prices ie. they have not been updated as the remainder of the model has been.

(viii) Control curves for ancillary reservoir functions. For each reservoir where some functions are controlled by curves which do not coincide with the output control curves, the independent curves are given, again in graphical form.

(ix) Refill abstraction details. For each pumped refill reservoir, gives the pumping station(s) with their maximum abstractions, higher and lower prescribed flow, and any assumed dirty water cutoffs.

(x) Compensation releases. Gives, for each impounding reservoir, upper and lower compensation release rates and notes on any special rules.

(xi) Miscellaneous river abstractions. Gives details of spray irrigation, British Waterways Board and CEGB abstractions from the Severn.

(xii) Major bulk water supplies. Gives details of supplies to other water companies from sources within the Severn-Trent region, and details of supplies from other water companies to the Severn-Trent region.

2.6 The simulation results

Examples of the output described in sections 2.6.1 to 2.6.5 are given in Appendices 1-5.

2.6.1 Results file 1

Results file 1, gives in concise tabular form, a pentad record of supply, demand and reservoir information. Each table consists of a matrix with 73 columns and a row for each year of the run, each element being a single symbol (or a space). Associated with each table is a table of frequencies of occurrence of each symbol for each year and for the run as a whole. The tables give information on the following aspects.

(i) Reservoir volumes; digits 1 to 7 indicate whether the reservoir is full, in one of the five 20% bands or empty.

(ii) Reservoir output states; digits 1, 2, 3 indicate which output band the reservoir is in.

(iii) Demand reduction factors at demand centres; a blank indicates no demand reduction in force and digits 1 to 4 indicate 5, 10, 15 and 20% reductions.

(iv) Demand shortfalls; a blank indicates no shortfall at that demand centre, digits 1-9 cover 2% bands up to 18% shortfall. Greater shortfalls than this are indicated by an exclamation mark.

2.6.2 Results file 2

Results file 2 gives the costs of supply for selected years. The annual average supply and the total cost of power and chemicals is given for each link in each of the years, together with the total average supply and total cost for that year. The averages over the run of supplies and costs for each link are also given.

2.6.3 Results files 3, 4 & 5

Again for the selected years, these files give pentad records of selected reservoir volumes, reservoir releases, river flows and refill abstractions. The files cover (i) the Dove and Derwent reservoirs, including the Charnwood group, (ii) the Severn and Wye reservoirs, excluding those in the Avon (iii) the Avon reservoirs and those in the Trent catchment not covered by (i).

2.6.4 Results files 6 - 15

Provision has been made for ten files to be used for lists of certain aspects of the allocations used in the selected years. Up to five of the files can be used for details of supplies allocated to chosen demand centres. the choice of which demand centres and how they are to be grouped together being under the control of the user. The other five files are available for details of how the supply from chosen sources is allocated among demand centres. The choice of sources and their arrangement between files is again under the control of the user. This output is handled by a subroutine (ALLOCOUT) which sets up all file headers and column headings automatically. This is achieved by using long and short versions of names input via a BLOCK DATA segment and the matrix of connections set up for the allocation derivation routine.

2.6.5 Results file 23

For the years where a detailed output is requested this file summarises the average use of water for each source and quotes this as a percentage of annual licensed quantity. Averages for the period of the whole run are also provided.

2.6.6 System state information

If no simulation results are requested, information is given on the allocations used in each pentad of the run. This information consists of the states of all parameters, such as reservoir output bands, river flows, and demand level, which determine the allocation used, together with the unique identifier of that allocation. In addition a warning is given whenever an allocation is worked out which involves a shortfall in supply. This information enables an experienced user to identify anomalies in the results.

2.7 Recent Developments

The original Regional Resource Allocation Model has been substantially changed to:-

(i) reflect recent changes to the water resource/supply system.

(ii) to correct a number of anomalies.

(iii) to more accurately represent river regulation operations on the River Severn.

(iv) to improve run time efficiency.

(v) to update the Severn Data Bank to 1990.

Also a limited amount of validation has been undertaken on the Severn data bank.

The model that has resulted from these changes has been renamed the NRA Resources Allocation Model (NRAM).

Details of the changes and data validation are described in the River Severn Control Rules - Progess Notes Nos. 2-6 (which are in the NRAM correspondence file) and to a limited extent in comment statements within the code.

3 RUNNING THE MODEL

3.1 General procedure

Shown in Fig 7 is the general flow of operations performed in completing a run of the model. If major changes are required, thorough checks should be carried out early in the flow of operations and the first runs of the model with the new data should be carried out on short flow sequences. This will prevent waste of time and computing resources.

3.2 Block data segments

Block data segments are used to initialise variables within a program, and avoid the necessity of reading large amounts of data from files. The variables are initialised in DATA statements and transferred in common blocks.

3.2.1 NAMES

This block initialises arrays with long (16 character) and short (4 character) versions of all source and demand centre names. Common-block CB7 is used to transfer the values to the main segment. Changes to this segment will be required if the name of an existing location is to be changed or sites are to be added or deleted from the model.

3.2.2 ABSTDAT

This block initialises the variables with controlling parameters for river and aquifer abstractions. These are

(a) upper limits and effluent return factors for direct supply river abstractions

(b) upper limits and controlling flow levels for refill abstractions from rivers

(c) upper limits on aquifer abstractions for supply and river regulation.

Transfer of these parameters (except the effluent return factors which use CB10) is accomplished by common block CB8. Changes to this segment will be required if licences or effluent return factors change, or if abstractions are added to or deleted from the model.

3.2.3 RESSUPDAT

Initialises the output levels, output control curves, demand reduction factors and demand centres affected for each direct supply reservoir. Common block CB5 is used for the transfer of this data. Changes to this segment will be needed if output levels, control curves or demand reduction factors change, or if demand centres are added to or deleted from the model.

3.2.4 RESOPDAT

Initialises those parameters needed to describe the operation of reservoirs other than the control of direct supply. These include capacities, maximum releases, compensation releases, prescribed flows etc together with those reservoir curves which do not coincide with output control curves. The capacities are transferred on their own, in common block CB9, while the rest of the data is transferred in common block CB6. Changes will be needed in this segment if any reservoir operating procedures are altered, or if reservoirs are added to or deleted from the model.

3.3 Data files

3.3.1 Steering file

This holds information to control the results from the model and the length and initial values of the run. The information should be set out as follows:

(i) Three title lines, of up to 72 characters each, on each results file

(ii) First and last years of the simulation

(iii) A O:1 switch indicating if all simulation results are to be suppressed

(iv) Three O:1 switches to control the listing of each of results files 3, 4 & 5

(v) The number of years for which pentad results are required

(vi) A list of those years for which pentad results are required

(vii) The initial volumes in store in the reservoirs

(viii) The number of files of allocations to demand centres that are required

(ix) For each file, and on separate lines

- (a) the number of demand centres for which allocations are required on that file
- (b) a list of those demand centres

(x) The number of files of allocations from sources that are required

(xi) For each file, and on separate lines

- (a) the number of sources for which allocations are required on that file
- (b) a list of those sources.

Up to and including (vii) the data is read at the start of the run in REGSIM. The rest of the data is read in ALLOCOUT, again at the start of the run. This file will require alterations whenever changes in the type of results are required, or changes in the length of the run or in the initial conditions are required.

3.3.2 Demand file

This file holds information relating to the demand centres within the Severn and Trent Basin areas, together with information on the bulk supplies to or from other water companies, and major private abstractors. The file should be made up as follows:

(i) The year that the demand values relate to.

(ii) For each demand centre, the demand centre number, the demand and the peak week factor.

(iii) A profile, over the year, of irrigation abstractions from the River Severn.

(iv) A factor, for each year of the historical record, by which to multiply the profile in (iii).

(v) A second factor for each year of the historical record, by which to multiply the profile in (iii). Whilst the First Factor is based on climatic conditions for each year, this second factor is necessary to correct double counting in the flow naturalisation process, and is based on the potential spray irrigation that actually could have occurred (ie. annual licensed totals). Further details are given in the River Severn Control Rule - Progress Note No. 4 and its Appendix.

(vi) A profile over the year of the BWB abstractions for the Gloucester to Sharpness Canal.

(vii) A factor, for each year of the historical record, by which to multiply the profile in (vi).

(viii) The CEGB abstraction at Ironbridge (summer and winter values).

(ix) The abstractions by Welsh Water plc from the Wye, upper and lower figures.

(x) Supplies to Yorkshire Water plc from the Derwent Reservoirs - one figure for each of the three output levels and the extra entitlement when the reservoir storage is above the flood drawdown curve.

3.3.3 Links data file

This file holds flow constraints and cost information for each link in the system. It can also be used for specifying additional constraints. The file should be structured as follows:

(i) For each link making up the system, and on separate lines

- (a) Source number and demand centre number
- (b) Dummy cost and unit cost
- (c) Upper bound, peak week upper bound and lower bound

(ii) -1 -1 : to end the list of links

(iii) For each multiple constraint required

- (a) The number of links in the constraint
- (b) SNO DNO COEFF REL RHS

  repeated for each
  link in constraint
  where SNO is the source number
  DNO is the demand centre number
  COEFF is the coefficient for that link
  REL is -1, 0 or 1 to signify a > = or < constraint
  RHS is the right hand side

For example: Upton to Leicester + Dove to Nuneaton > 4 Ml/d is specified as:

(a) 2
(b) 19 21 1 4 8 1 -1 4

(iv) -1 : to end the list of extra constraints.

This file is read in at the start of the run by DUALMATRIX. The unit costs are transferred to REGSIM as a parameter of DUALMATRIX. Changes will be needed in this file if any bounds or costs change, if links are to be added to or removed from the model, or if changes to the multiple constraints are required.

NOTE Each time a change is made to the links file it is suggested that a new allocations file is used to prevent the model 'locking' itself with an old allocation that cannot actually meet all the demands, or perhaps other problems may occur.

3.3.4 Flow files

The flow data used by the model is held in two files, one covering the Severn catchment and the other the Trent. Each is made up of seven columns and there is one line for each pentad with the years separated by a single line carrying the year. The columns are as follows:

(i) Severn catchment:- Elan inflow, Redbrook flow, Vyrnwy inflow, Clywedog inflow, Bewdley flow, Haw Bridge flow, Stareton flow.

(ii) Trent catchment:- Tittesworth inflow, Marston flow, Yorkshire Bridge flow, Longbridge Weir flow, Ogston inflow, Charnwood inflow, Hamstall Ridware flow.

Currently the data bank is complete for the 14 components over the period 1932 to 1978. From 1979 to 1990 data for the five records relating to the River Severn exist ie. Vyrnwy inflow, Clywedog inflow, Bewdley flow, Haw Bridge flow and Stareton flow. Data for Redbrook from 1979 to 1982 are included. Data for Redbrook from 1983 to 1990 and Elan Reservoir Inflows from 1979 to 1990 are missing.

To enable the model to continue running over periods where there is missing data, records of existing years have been substituted in the files. Latest details of substitutions and changes are listed as comments at the end of the data files.

The Charnwood data bank incorrectly represents inflow to Cropston, Swithland, Thornton and Blackbrook reservoirs up to 1975. For 1976 to 1978 only Cropston and Swithland are correctly included. The model has been amended so that 1932-1975 inflows are reduced by the catchment area of Cropston and Swithland relative to the total catchment area for the four reservoirs. This fault has been dealt with by reducing the 1932-75 inflows by factoring by the ratio of the Cropston and Swithland catchment areas to the total area for the four reservoirs.

The integrity of three of the data records which have been derived using HYSIM has been questioned, due to the occurrence of many zero values during dry spells. These are Ogston, Tittesworth and Charnwood inflows. Alternative records have been derived and proved for Tittesworth and Charnwood using a fairly simple rainfall/runoff model developed by T Harrison for Water Resources purposes. Monthly totals of reservoir inflow have been derived using historical rainfall, with the values residing in the files:-

$DISK2:[FFS.DEVTH.STATS.RP12.DATA] CRS23278.DAT
$DISK2:["] TITT3283.DAT

Use of the program CHARNDAT (within [.STATS.RP12.FOR]) will convert monthly data to pentad values. However, at the moment, these alternative records have not replaced the originals and the limited progress that had been made updating the Ogston record is lost somewhere in Richard Douglas' filing system.

Some flows are transformed to give flows at points with records of insufficient length or quality. The transformations are as follows:-

Princes Drive flow = (Stareton flow - 12.1) * 0.855
Stanford inflow = (Stareton flow - 12.1) * 0.1
Brownsover flow = (Stareton flow - 12.1) * 0.23 + 2.1
Derwent Valley inflow = 1.17 * Yorkshire Bridge flow
Blithfield inflow = 0.79 * Hamstall Ridware flow
Blythe flow = 2.85 * (Stareton flow - 8.0) ** 0.7
Bourne flow = 0.07 * (Blythe flow ** 1.2) + 2.4

Dolwen flow = 3.028 * Clywedog inflow - 7.298E-4 * (Clywedog inflow) ** 2

Lower Parting flow = $\frac{(10075 + 334 - 9895)}{9895}$ * 0.95 * Hawbridge flow + Hawbridge flow

3.3.5 Demand profile

The demand profile is on a file in yearly blocks, each block preceded by the year to which it pertains. Each of the 73 numbers in a block is either a '2' signifying an average demand pentad, or a '4' signifying a peak demand pentad.

3.4 Running the Programs

Access to the code is gained through user TH, on the Microvax 3100. Fortran files are in the directory. [.REGSIM.FOR] and parameter and data files are in the directory [.REGSIM.DATA].

For ease of handling all the code and parameter files associated with NRAM have been split into three groups.

1) The four block data files used by NRAM and PARLIST are grouped together under the filename PARAM2.FOR.

2) All Fortran code other than the block data mentioned above associated with the model is grouped under the filename REGSIM3.FOR.

3) All Fortran code other than the block data mentioned above associated with the Parameter Listing is grouped under the filename PARLIST3.FOR.

Any edit of 1 or 2 will then necessitate a rebuild of REGSIM using the command @BUILDNRAM.

Any edit of 1 or 3 will necessitate a rebuild of Parlist using the command @BUILDPARLIST.

To run PARLIST use the command @PARLIST. If the run is successful a parameter listing will automatically be produced.

To run the NRAM model use the command @THREGSIM. The results files may then be printed.

Each source code or data or output file is listed below and cross referenced to the appropriate descriptive sections in the text.

FILE	Section in Text
THREGSIM.COM	3.1
PARLIST.COM	3.1
BUILDNRAM.COM	3.1
BUILDPARLIST.COM	3.1
PARAMS.FOR	3.1/2.5
REGSIM.FOR	3.1/2.3
PARLIST.FOR	3.1/2.5
RUNA1990.DAT	3.3.1
DEMA1990.DAT	3.3.2/2.2.8
LINKA90.DAT	3.3.3/2.2.7
SEVERN90.DAT	3.3.4/2.2.9
TRENT.DAT	3.3.4/2.2.9
DEMPROF90.DAT	3.3.5/2.2.8
ALLOC90A.DAT	2.4
ALL OUTPUT RESULT FILES	2.6

TABLE 1

DEMAND CENTRE NUMBER	SOURCE NUMBER																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1													1		1									
2													1											
3																	1							1
4																								1
5									1				1			1							1	1
6													1			1								
7	1															1								
8	1			1						1									1					
9					1					1			1						1					
10											1	1												1
11																			1		1			1
12														1						1				1
13																			1					1
14													1				1							
15													1					1	1					1
16						1							1											
17					1		1						1											
18					1																			1
19						1																1		1
20					1		1															1	1	1
21				1	1		1	1											1					1
22																								1
23			1										1											
24													1											

TABLE 2 USE OF COMMON BLOCKS

	CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8	CB9	CB10
REGSIM	1	1			1	1	1	1	1	1
NAMES							1			
ABSTDAT								1		1
RESOPDAT						1				
RESSUPDAT					1					
DUALMATRIX		1	1	1						
DUALPREP	1	1	1	1						
DUALSOLV				1						
ALLOCOUT		1					1			

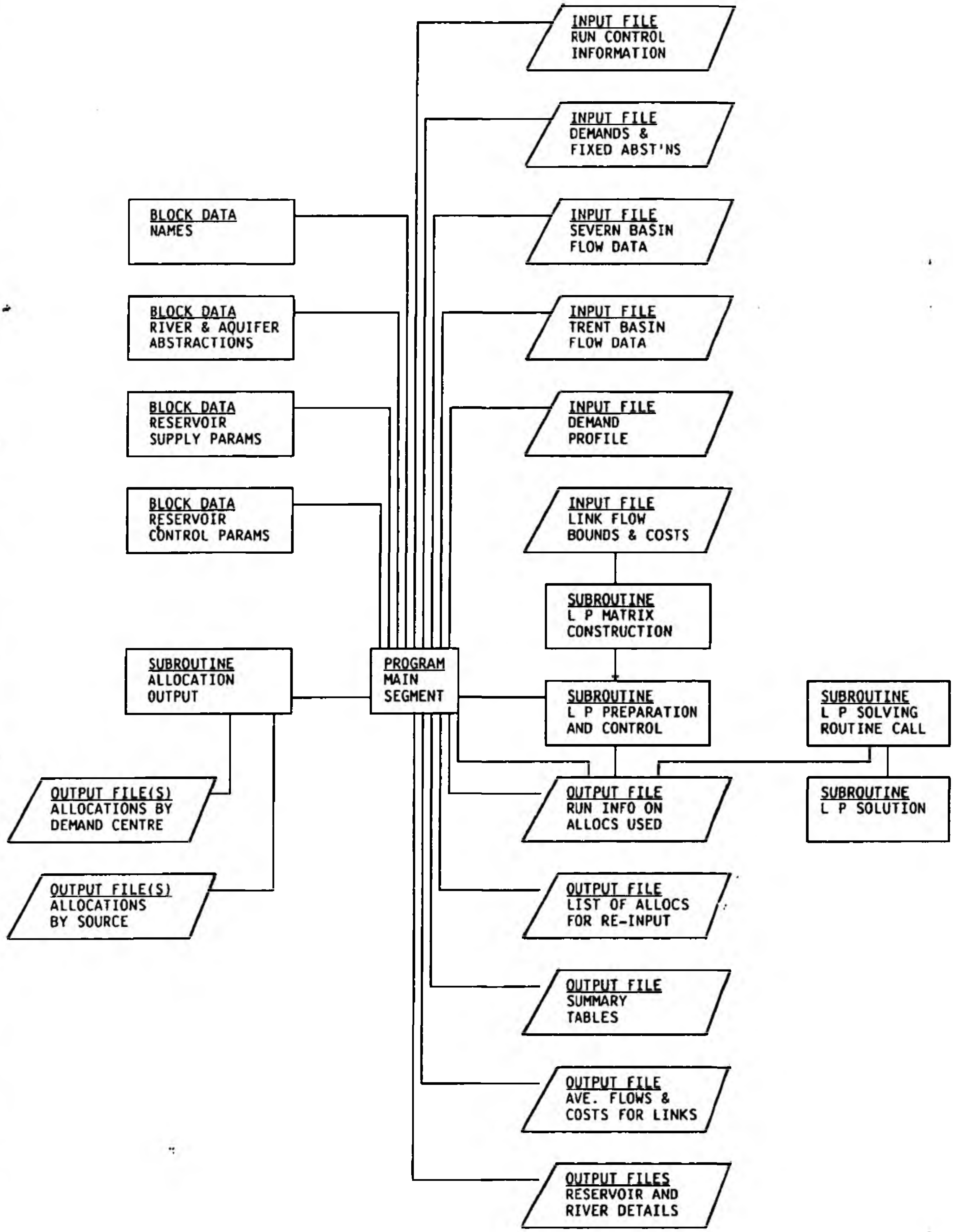

FIG 1 ORGANISATION OF PROGRAM COMPONENTS

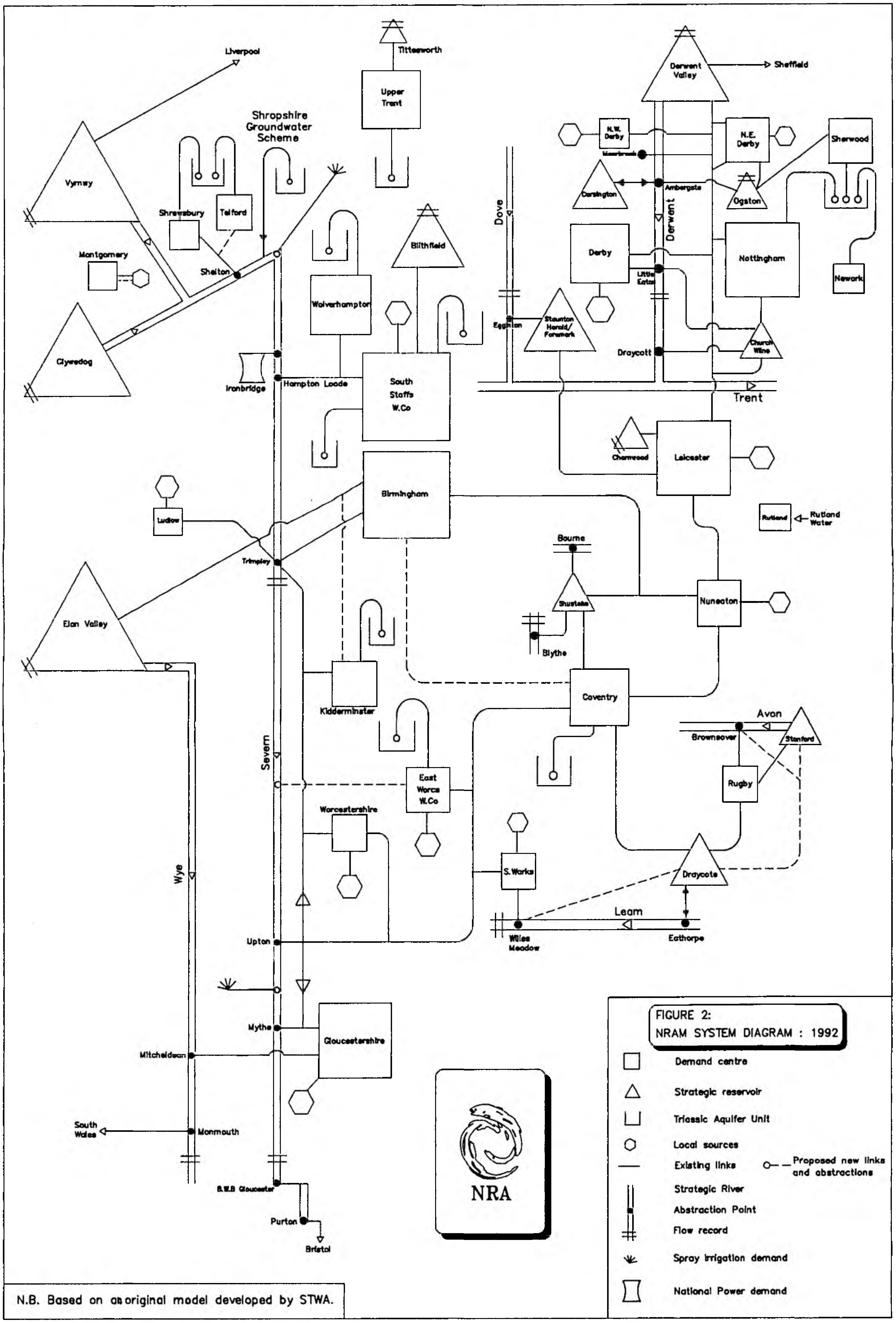

FIGURE 2:
NRAM SYSTEM DIAGRAM : 1992

N.B. Based on an original model developed by STWA.

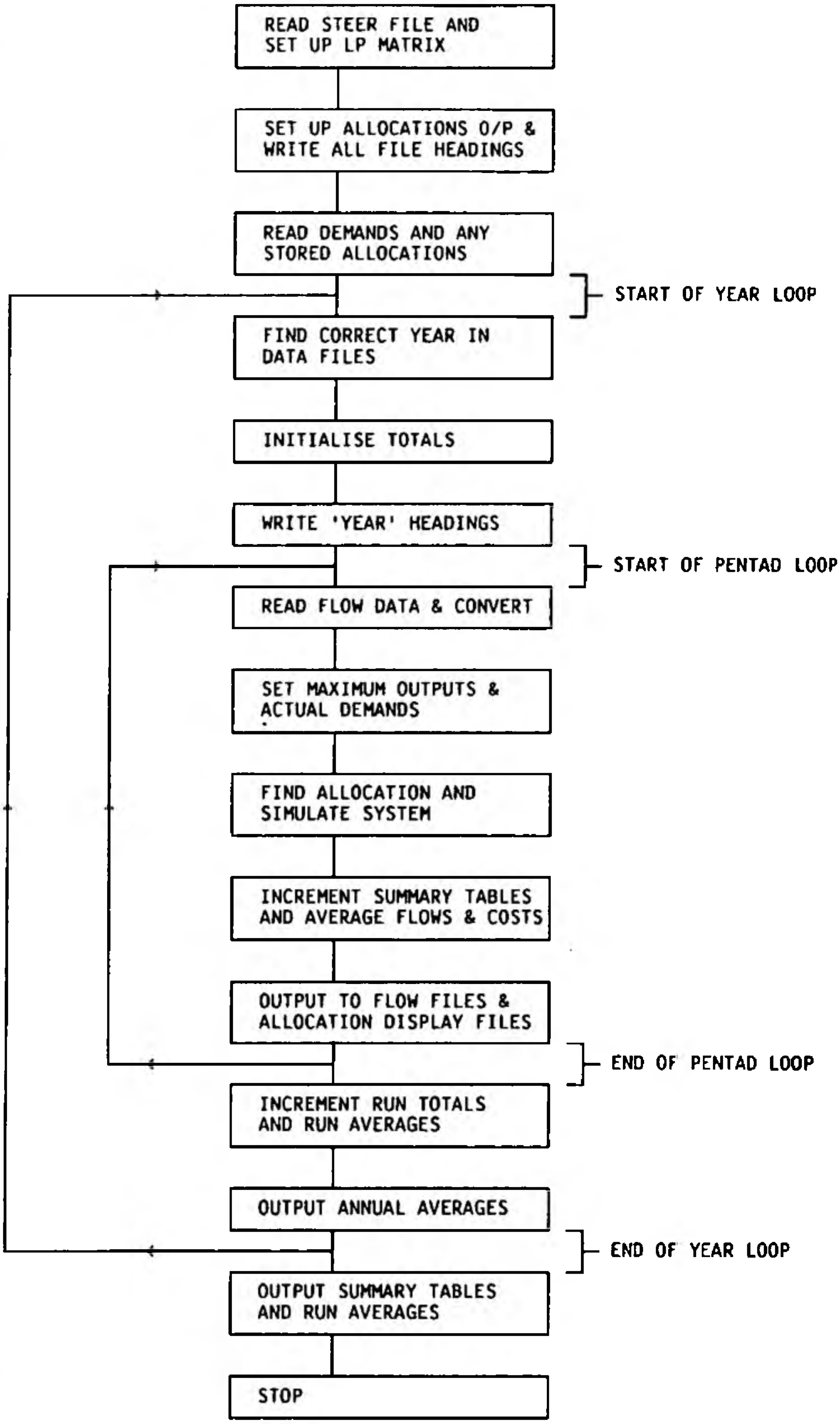

FIG 3 MAIN SEGMENT - GENERAL

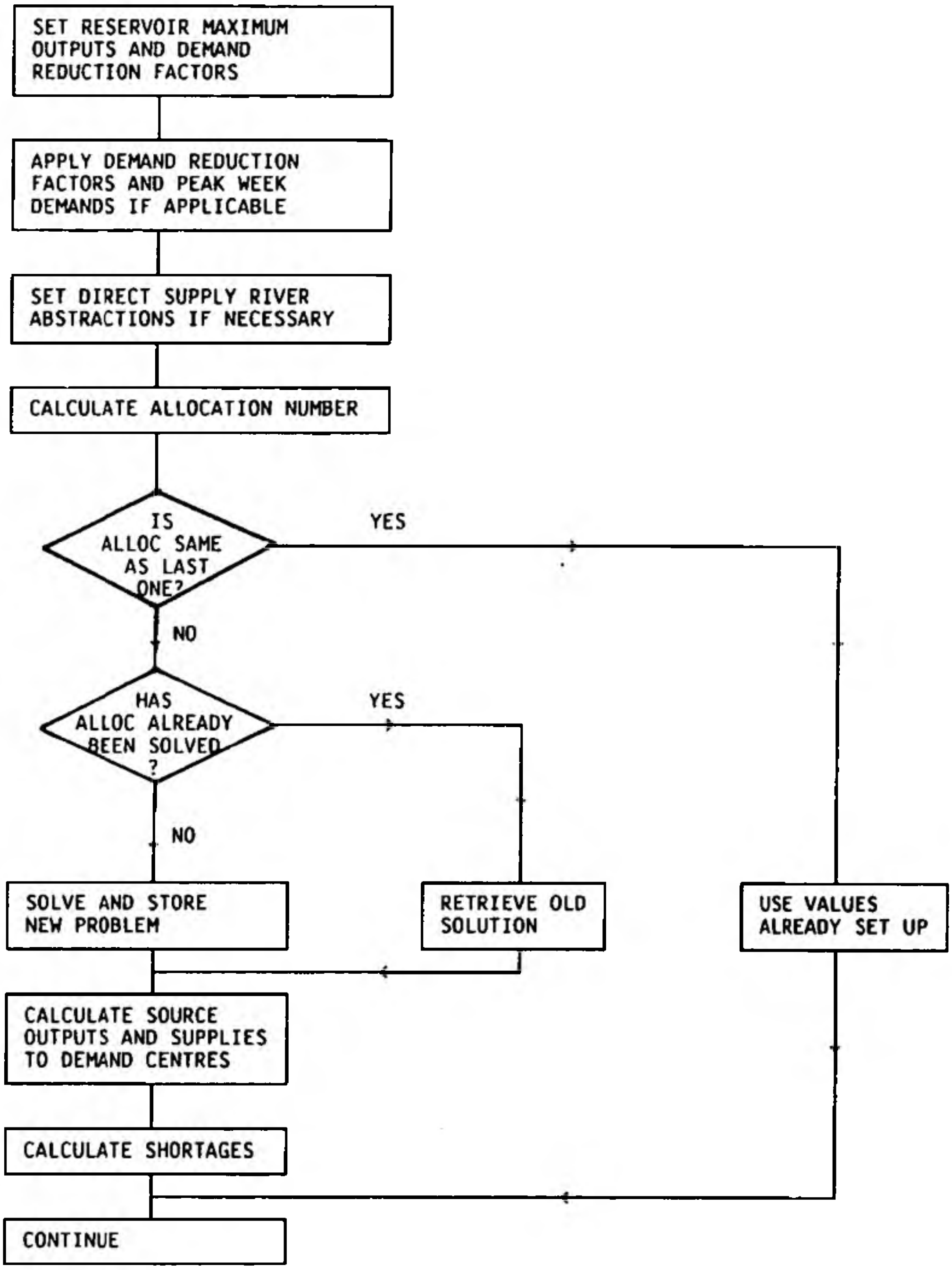

FIG 4 ALLOCATION DERIVATION CONTROL

READ LINK INFOR-
MATION FILE

SET UP CONNECTION MATRIX
WITH '1' WHERE A LINK EXISTS
AND ZERO ELSEWHERE

READ FORM OF EXTRA
CONSTRAINTS

NUMBER LINKS IN CONNECTION
MATRIX

SET UP COEFFICIENTS OF THE
MAXIMUM OUTPUT CONSTRAINTS

SET UP COEFFICIENTS OF THE
STANDARD FORM OF THE DEMAND
SATISFACTION CONSTRAINTS

SET UP COEFFICIENTS FOR THE
FLOW LIMITATION CONSTRAINTS

SET UP COEFFICIENTS OF
THE EXTRA CONSTRAINTS

SET UP, IN THE RIGHT HAND
SIDE OF THE DUAL, THE OBJ.
FUNCTION OF THE PRIMAL

FIG 5 LINEAR PROGRAMME - START OF THE RUN PROCEDURE

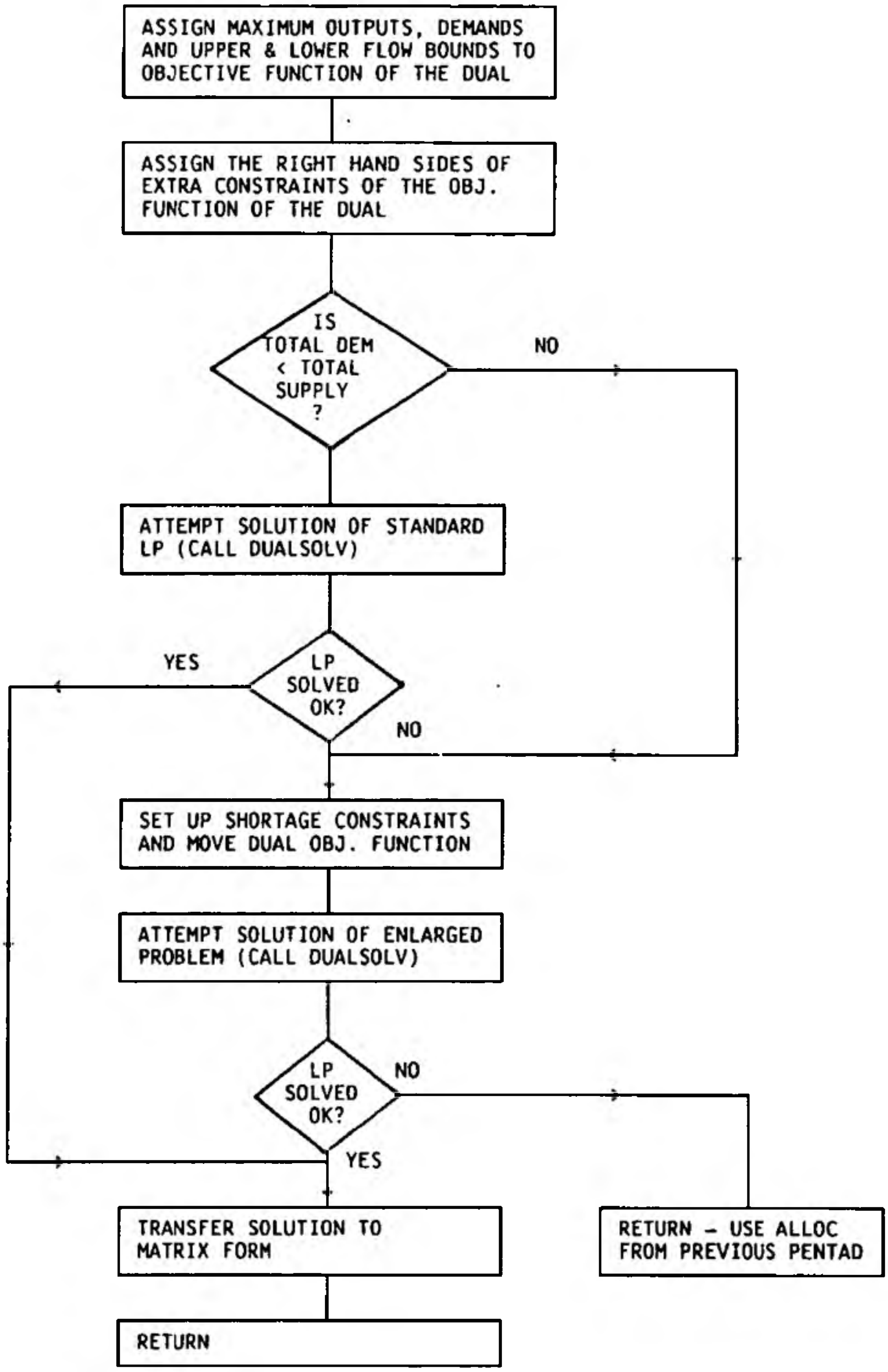

FIG 6 LINEAR PROGRAMME - SOLUTION PROCEDURE

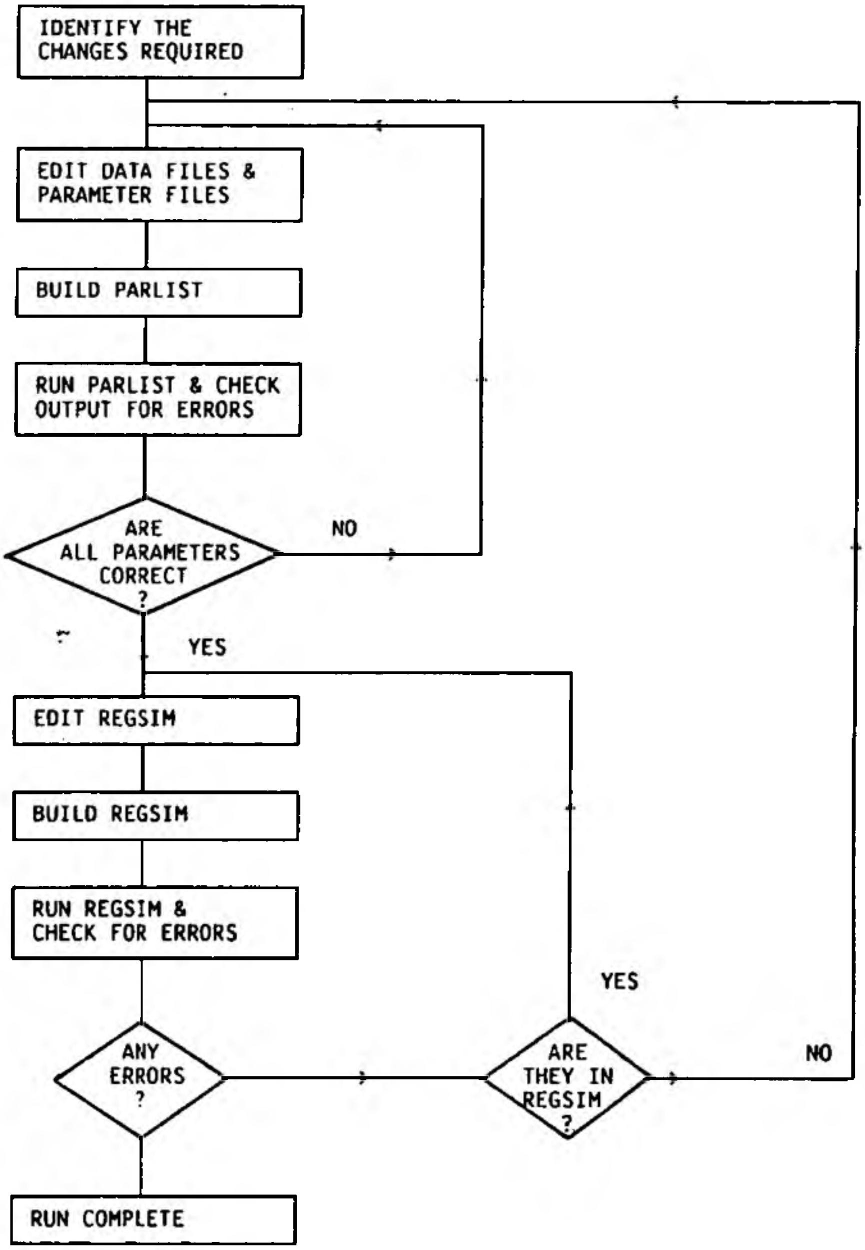

FIG 7 RUNNING THE MODEL - GENERAL PROCEDURE

APPENDIX 1.

```
************************************************************
*                                                          *
*   N A T I O N A L   R I V E R S   A U T H O R I T Y      *
*   R E S O U R C E   A L L O C A T I O N   M O D E L      *
*                                                          *
************************************************************
```

1932-81 SIMULATION,1979 IS 1989,1980 IS 1990,1981 IS 1990(A).

USING 1989/90 DEMANDS, 1990 LINKS & SYSTEM CONSTRAINTS

OUTPUT FILE 1 :- SUMMARY TABLES OF VARIOUS FEATURES OF ALL RESERVOIRS AND DEMAND CENTRES

```
*******************************************
*                                         *
*  THIS MODEL IS SUPPORTED BY :-          *
*                                         *
*  WATER RESOURCES SECTION                *
*                                         *
*  CATCHMENT MANAGEMENT                   *
*                                         *
*  NATIONAL RIVERS AUTHORITY              *
*                                         *
*  SEVERN-TRENT REGION                    *
*                                         *
*******************************************
```

SECTION 1 :- RESERVOIR VOLUMES
****

EACH DIGIT FROM 1 TO 7 INCLUSIVE COVERS A RANGE OF VOLUMES AS FOLLOWS :-

1	-	100% FULL
2	-	80% - 99%
3	-	60% - 79%
4	-	40% - 59%
5	-	20% - 39%
6	-	1% - 19%
7	-	EMPTY

DERWENT VALLEY

YEAR

YEAR	/ JAN / FEB / MAR / APR / MAY / JUN / JUL / AUG / SEP / OCT / NOV / DEC /
1932	2122222222222222222221211122211222222222222222333333333333322222222222222222
1933	2222222112221111222222222222222223223333333333344444444455444444444444444455
1934	5544444444444444433344443333333333344444444444444444555555444444333333322222
1935	2222222111111222122221122222222222223333333334444444444444433332222222222222
1936	2222222222211111111222222222222222223322222222222222222333333222222222222222
1937	2222222111112111111211222222222222222322333333333444444455555555554444444
1938	4433332222222222322233333333333333333322233333333344444332222222222222222222
1939	2222222111111222112232222222222222222222222222223333333333333322222222
1940	2222333333222221121221122222222222333333333334444444444444444444432222222222
1941	2222222111111111111111222222222222222233333222222233333332223322222222222
1942	2222222212222211221112222222222222222333332323223333333333332222222223322222
1943	2222222111222222222222222222222222222333333333333333333333333333332222222
1944	2222122222222222222222222222222222222222222222222222222232222222222222222
1945	2222221112222222222222222222222222222223333333333 344444322233333333322
1946	22222221111122?1122222222222222333222222222222222222222 4233333333222222222222
1947	2222222222222221111112111222222222222222333333334444 444555555554444444443
1948	3212222111222222222222222222222322222222222222222222222333333333333333333333
1949	2222222222222222222112222222222222222333333333444444445555555555443332222222
1950	2222222211121222222221112222222222222223333333333333333322222333332222222222
1951	2221222221111211111111222222222222222333333333333333333333333332222222222222
1952	2222222211122122222222222222222222222222233333333333333222222222222222222222
1953	2222222221122222221222222222222222222222222222222222222333333333323333333333
1954	3322222222211112222122222222222222222222222222222222222333333333222222222222
1955	2222222122222222112122222222112222222222222222233333333344444444444444444544443
1956	3332222122221222222222222222222223333333222221222222222223323333333333222222
1957	2222222111212111112222222222223333333333333333433322222222233333222222222222222
1958	2222222111111222122222222222222222212222222222222222322222222233333333222
1959	2223222222222222222222222222222222333333333344444444555555556555565555444433
1960	3333221122211212222222222222222222233333322222222222222222322222222222222122222
1961	2222222112222222222222222122222222222222222222222222222333332222222222222222
1962	2222222111222222222111112222222222222223333333333333332222333333333322322222
1963	2222223333333222222221111222222222222222222222222222232222223333222222222222
1964	2233332233333322222222222222222222222222222222222222223333333333333444433332222
1965	2222222222222222222221222122222222222222222222222222222222233333333332221112
1966	2222222111111122222111112222212222222222222222222222222232222222222222222222
1967	2222222222211122222222222222111222222222233333222222223222222222222222222222
1968	2221222222222221111222222221122222222222222222222222233332222222222222222222
1969	2222222222222222211111112122221222222222222223333333333333333343222222222222
1970	2222222111112211111111111222222222222223333333332222222333333322222222222222
1971	2222222221122222112222222222222222222222223332222233333333333333333322222222222
1972	2222222111221122211112222222222211112122222222222223333333333444433332222222
1973	2222222222211122222222222222222222222223332222222222222333333333222322222222222
1974	2222222111122211222222222222233333333333333333333333333332222222222222222222222
1975	2222222222222222222221121222222222222222333333333444444444555555555555555555
1976	3332222222222222222222222222222222222223333333444444455555554444333333333333333
1977	33?222211111122112122211111222222222222??2233333333333333333333332222222222222
1978	2222222122111211111122222222222222222222222222222223333233333333332222222221
1979	2222222222222222222222222222222222333333333344444455555555556555565555444433
1980	2232222222222222222222222222222222223333333333344444455555555565556555444433
1981	2232222222222222222222222222222222333333333334444445555555556555565555444433

FREQUENCIES OF OCCURENCE

1	2	3	4	5	6	7
7	53	13	0	0	0	0
6	28	12	23	4	0	0
0	5	19	41	8	0	0
9	39	13	12	0	0	0
8	58	7	0	0	0	0
14	26	10	13	10	0	0
0	33	33	7	0	0	0
9	50	14	0	0	0	0
5	32	18	18	0	0	0
14	45	14	0	0	0	0
6	48	19	0	0	0	0
3	41	29	0	0	0	0
1	71	1	0	0	0	0
3	44	21	5	0	0	0
7	55	11	0	0	0	0
9	32	9	15	8	0	0
4	45	24	0	0	0	0
2	39	12	10	10	0	0
7	44	22	0	0	0	0
12	36	25	0	0	0	0
4	54	15	0	0	0	0
3	51	19	0	0	0	0
5	59	9	0	0	0	0
6	38	9	19	1	0	0
3	47	23	0	0	0	0
8	42	22	1	0	0	0
9	55	9	0	0	0	0
0	32	12	11	16	2	0
6	56	11	0	0	0	0
3	65	5	0	0	0	0
7	41	25	0	0	0	0
3	58	12	0	0	0	0
0	42	27	4	0	0	0
6	58	9	0	0	0	0
13	59	1	0	0	0	0
6	61	6	0	0	0	0
7	62	4	0	0	0	0
9	46	17	1	0	0	0
15	42	16	0	0	0	0
4	50	19	0	0	0	0
14	41	14	4	0	0	0
3	58	12	0	0	0	0
6	41	26	0	0	0	0
3	34	9	9	18	0	0
0	33	23	11	6	0	0
14	35	24	0	0	0	0
10	50	13	0	0	0	0
0	32	13	10	16	2	0
0	31	14	10	16	2	0
0	31	14	10	16	2	0

SECTION 2 :- RESERVOIR OUTPUT STATES
****

EACH DIRECT SUPPLY RESERVOIR HAS THREE OUTPUT STATES. THESE STATES HAVE ASSOCIATED WITH THEM MAXIMUM OUTPUTS AND DEMAND REDUCTION FACTORS. DETAILS CAN BE FOUND ON THE PARAMETER FILE

OGSTON

YEAR	/ JAN / FEB / MAR / APR / MAY / JUN / JUL / AUG /
1932	11111111111111111111111111111111111111111111111111
1933	11111111111111111111111111111111222111211111111111
1934	11111111111112111111111111111112222222222222222222
1935	11111111111111111111111111111122111111111111111111
1936	11111111111111111111111111111122111111111111111111
1937	11111111111111111111111111111111111111111111111111
1938	11111111111111111112222222333333322222222222222111
1939	11111111111111111111111111111112222222221111111111
1940	1111111111111111111':11111111122222222222222111111
1941	11111111111111111111111111111111111111111111111111
1942	11111111111111111111111111122211111111222112112111
1943	11111111111111111111111112211122111122222221111111
1944	11111111111111111111111111112222222222111111111111
1945	11111111111111111111111111111121111111111111111111
1946	11111111111111111111111111122222222111221111111111
1947	11111111111111111111111111111111111111111111111111
1948	11111111111111111111111111111221111111111111111111
1949	11111111111111111111111111112222222222221111111111
1950	11111111111111111111111111111111111222:22221111111
1951	11111111111111111111111111111111111111111111111111
1952	11111111111111111111111111111111111111111111111111
1953	11111111111111111111111111111111111111111111111111
1954	11111111111111111111111111111111111111111111111111
1955	11111111111111111111111111111111111111111111111111
1956	11111111111111111111111111112222221111111111111111
1957	11111111111111111111111111122222222222221111111111
1958	11111111111111111111111111111111111111111111111111
1959	11111111111111111111111111111112222222222211111111
1960	11111111111111111111111111111111122222211111111111
1961	11111111111111111111111111111111111111221111111111
1962	11111111111111111111111111111111111111222221221111
1963	11111111111111111111111111111111121111111111111111
1964	11111111111111111111111111111111111111111111111111
1965	11111111111111111111111111111111111111111111111111
1966	11111111111111111111111111111111111111111111111111
1967	11111111111111111111111111111111111111111111111111
1968	11111111111111111111111111111111111111111111111111
1969	11111111111111111111111111111111111111111111111111
1970	11111111111111111111111111111111111111111111222111
1971	11111111111111111111111111111111111111111111111111
1972	11111111111111111111111111111111111111111111111111
1973	11111111111111111111111111111111111111111111111111
1974	11111111111111111111111111122222222222222222211111
1975	11111111111111111111111111111111111222222111111111
1976	11111111111111111111111222222222222222222222111111
1977	11111111111111111111111111111111111111111111111111
1978	11111111111111111111111111111111111111111111111111
1979	11111111111111111111111111111112222222222221111111
1980	11111111111111111111111111111112222222222221111111
1981	11111111111111111111111111111112222222222221111111

	FREQUENCIES OF OCCURENCE		
	1	2	3
SEP / OCT / NOV / DEC /			
11111111111111111111111	73	0	0
11111111111111111111111	69	4	0
21111111122111111111111	50	23	0
11111111111111111111111	71	2	0
11111111111111111111111	71	2	0
11111111111111111111111	73	0	0
11111111111111111111111	45	21	7
11111111111111111111111	64	9	0
11111111111111111111111	59	14	0
11111111111111111111111	73	0	0
22221111211111111111111	60	13	0
11111111111111111111111	62	11	0
11111111111111111111111	63	10	0
11111111111111111111111	72	1	0
11111111111111111111111	63	10	0
11111111111112111111111	72	1	0
11111111111111111111111	71	2	0
11111111111111111111111	61	12	0
11111111111111111111111	65	8	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	67	6	0
11111111111111111111111	60	13	0
11111111111111111111111	73	0	0
12222223332222111111111	49	21	3
11111111111111111111111	67	6	0
11111111111111111111111	71	2	0
11111111111111111111111	66	7	0
11111111111111111111111	72	1	0
11111111112222211221111	66	7	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111112222111111111111	66	7	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	73	0	0
11111111111111111111111	55	18	0
11111111211122222111111	61	12	0
222222111111111'1111111	46	27	0
111111111111111`1111111	73	0	0
111111111111111.1111111	73	0	0
11122222232222!11111111	50	22	1
11122222232222:11111111	50	22	1
11122222232222111111111	50	22	1

TOTALS FOR RUN :- 3301 336 13

SECTION 3 :- DEMAND REDUCTION FACTORS

****

THE DEMAND REDUCTION FACTORS ASSUMED TO APPLY ARE DENOTED AS FOLLOWS :-

BLANK	- NO REDUCTION
1	- 5% REDUCTION
2	- 10% REDUCTION
3	- 15% REDUCTION
4	- 20% REDUCTION

SHERWOOD

YEAR	/ JAN / FEB / MAR / APR IAY / JUN / JUL / AUG / SEP / OCT / NOV / DEC /	FREQUENCIES OF OCCURENCE 1	2	3	4
1932		0	0	0	0
1933	1111111111111 2	13	1	0	0
1934	2222 2222222222222222222222222222222222111111111111111111	17	38	0	0
1935	11 1	3	0	0	0
1936		0	0	0	0
1937	11111	5	0	0	0
1938	22222221111111 11111111111111111	24	7	0	0
1939		0	0	0	0
1940	1111111111111	13	0	0	0
1941		0	0	0	0
1942		0	0	0	0
1943		0	0	0	0
1944		0	0	0	0
1945	11	2	0	0	0
1946		0	0	0	0
1947	1111111	7	0	0	0
1948		0	0	0	0
1949	11111111111111111111111111	26	0	0	0
1950		0	0	0	0
1951		0	0	0	0
1952	1	1	0	0	0
1953		0	0	0	0
1954		0	0	0	0
1955	1 1	2	0	0	0
1956		0	0	0	0
1957		0	0	0	0
1958		0	0	0	0
1959	1111111111111122222211221111111	23	8	0	0
1960		0	0	0	0
1961		0	0	0	0
1962		0	0	0	0
1963		0	0	0	0
1964	1	1	0	0	0
1965		0	0	0	0
1966		0	0	0	0
1967		0	0	0	0
1968		0	0	0	0
1969		0	0	0	0
1970		0	0	0	0
1971		0	0	0	0
1972		0	0	0	0
1973		0	0	0	0
1974	111	3	0	0	0
1975	111111111111111122211 22	18	5	0	0
1976	2 1111111111111111111111111	25	1	0	0
1977		0	0	0	0
1978		0	0	0	0
1979	11111111111111112222211221111111	25	7	0	0
1980	11111111111111112222211221111111	25	7	0	0
1981	11111111111111112222211221111111	25	7	0	0
TOTALS FOR RUN :-		258	81	0	0

SECTION 4 :- DEMAND SHORTFALLS
****

NO ACTION IS TAKEN IN THE MODEL TO REMEDY A SHORTFALL. THEY ARE FLAGGED AS FOLLOWS :-

BLANK	- NO SHORTFALL
1	- 1 & 2% SHORTFALL
2	- 3 & 4% SHORTFALL
3	- 5 & 6% SHORTFALL
4	- 7 & 8% SHORTFALL
5	- 9 & 10% SHORTFALL
6	-11 & 12% SHORTFALL
7	-13 & 14% SHORTFALL
8	-15 & 16% SHORTFALL
9	-17 & 18% SHORTFALL
3	- SHORTFALL EXCEEDING 18%

NORTH EAST DERBS

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1	2	3	4	5	6	7	8	9	3
1932						11							2	0	0	0	0	0	0	0	0	0
1933						112		1 1					4	1	0	0	0	0	0	0	0	0
1934													0	0	0	0	0	0	0	0	0	0
1935							1 111	-1					5	0	0	0	0	0	0	0	0	0
1936					11								2	0	0	0	0	0	0	0	0	0
1937						111		11					5	0	0	0	0	0	0	0	0	0
1938				222									0	3	0	0	0	0	0	0	0	0
1939						2							0	1	0	0	0	0	0	0	0	0
1940						222 22							0	5	0	0	0	0	0	0	0	0
1941						1							1	0	0	0	0	0	0	0	0	0
1942						1							1	0	0	0	0	0	0	0	0	0
1943						1							1	0	0	0	0	0	0	0	0	0
1944					1								1	0	0	0	0	0	0	0	0	0
1945													0	0	0	0	0	0	0	0	0	0
1946													0	0	0	0	0	0	0	0	0	0
1947						1							1	0	0	0	0	0	0	0	0	0
1948													0	0	0	0	0	0	0	0	0	0
1949						2223							0	3	1	0	0	0	0	0	0	0
1950													0	0	0	0	0	0	0	0	0	0
1951						1							1	0	0	0	0	0	0	0	0	0
1952							1						1	0	0	0	0	0	0	0	0	0
1953													0	0	0	0	0	0	0	0	0	0
1954													0	0	0	0	0	0	0	0	0	0
1955							111						3	0	0	0	0	0	0	0	0	0
1956													0	0	0	0	0	0	0	0	0	0
1957						2							0	1	0	0	0	0	0	0	0	0
1958													0	0	0	0	0	0	0	0	0	0
1959						2 22	2						0	4	0	0	0	0	0	0	0	0
1960						1							1	0	0	0	0	0	0	0	0	0
1961						1 1							2	0	0	0	0	0	0	0	0	0
1962						11							2	0	0	0	0	0	0	0	0	0
1963													0	0	0	0	0	0	0	0	0	0
1964													0	0	0	0	0	0	0	0	0	0
1965													0	0	0	0	0	0	0	0	0	0
1966													0	0	0	0	0	0	0	0	0	0
1967						11							2	0	0	0	0	0	0	0	0	0
1968													0	0	0	0	0	0	0	0	0	0
1969							111						3	0	0	0	0	0	0	0	0	0
1970						1							1	0	0	0	0	0	0	0	0	0
1971							1						1	0	0	0	0	0	0	0	0	0
1972													0	0	0	0	0	0	0	0	0	0
1973						1							1	0	0	0	0	0	0	0	0	0
1974					22								0	2	0	0	0	0	0	0	0	0
1975						1222		2					1	4	0	0	0	0	0	0	0	0
1976							113	3					2	0	2	0	0	0	0	0	0	0
1977							1						1	0	0	0	0	0	0	0	0	0
1978													0	0	0	0	0	0	0	0	0	0
1979						22	11						2	2	0	0	0	0	0	0	0	0
1980							21	1					2	1	0	0	0	0	0	0	0	0
1981							21	1					2	1	0	0	0	0	0	0	0	0

The last 10 columns are headed "FREQUENCIES OF OCCURENCE".

TOTALS FOR RUN :- 51 28 3 0 0 0 0 0 0 0

APPENDIX 2.

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*************************************************************
*                                                           *
*   N A T I O N A L   R I V E R S   A U T H O R I T Y       *
*   R E S O U R C E   A L L O C A T I O N   M O D E L       *
*                                                           *
*************************************************************
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1932-81 SIMULATION,1979 IS 1989,1980 IS 1990,1981 IS 1990(A).

USING 1989/90 DEMANDS, 1990 LINKS & SYSTEM CONSTRAINTS

OUTPUT FILE 2 :- ANNUAL AVERAGE FLOW AND COST FOR EACH LINK IN EACH YEAR

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*******************************************
*                                         *
*  THIS MODEL IS SUPPORTED BY :-          *
*                                         *
*  WATER RESOURCES SECTION                *
*                                         *
*  CATCHMENT MANAGEMENT                   *
*                                         *
*  NATIONAL RIVERS AUTHORITY              *
*                                         *
*  SEVERN-TRENT REGION                    *
*                                         *
*******************************************
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1976

A. SUPPLY LINKS

DEMAND CENTRE	SOURCE	FLOW (HL/D)	POW
SHREWSBURY	GROUNDWATER	33	
SHREWSBURY	SHELTON	12	
TELFORD	GROUNDWATER	59	
LUDLOW	TRIMPLEY	8	
LUDLOW	LOCAL SOURCES	5	
MONTGOMERY	LOCAL SOURCES	18	
SOUTH STAFFS WC	BLITHFIELD	33	
SOUTH STAFFS WC	GROUNDWATER	181	
SOUTH STAFFS WC	HAMPTON LOADE	125	
SOUTH STAFFS WC	LITTLE EATON	2	
SOUTH STAFFS WC	LOCAL SOURCES	6	
WOLVERHAMPTON	GROUNDWATER	79	
WOLVERHAMPTON	HAMPTON LOADE	34	
BIRMINGHAM	ELAN VALLEY	308	
BIRMINGHAM	TRIMPLEY	0	
NUNEATON	DOVE SCHEME	4	
NUNEATON	SHUSTOKE	31	
NUNEATON	UPTON & WORCS	1	
COVENTRY	SHUSTOKE	8	
COVENTRY	DRAYCOTE	9	
COVENTRY	GROUNDWATER	30	
COVENTRY	UPTON & WORCS	46	
RUGBY	DRAYCOTE	11	
RUGBY	STANFORD	3	
RUGBY	LOCAL SOURCES	5	
SOUTH WARWICKS	UPTON & WORCS	21	
SOUTH WARWICKS	WILLES MEADOW	22	
SOUTH WARWICKS	LOCAL SOURCES	16	
GLOUCESTERSHIRE	WYELANDS	33	
GLOUCESTERSHIRE	MYTHE	87	
GLOUCESTERSHIRE	LOCAL SOURCES	21	
WORCESTER	UPTON & WORCS	37	
WORCESTER	LOCAL SOURCES	9	
KIDDERMINSTER	GROUNDWATER	43	
KIDDERMINSTER	TRIMPLEY	6	
EAST WORCS WC	GROUNDWATER	61	
EAST WORCS WC	OMBERSLEY	0	
EAST WORCS WC	UPTON & WORCS	4	
EAST WORCS WC	LOCAL SOURCES	7	
SHERWOOD	OGSTON	9	
SHERWOOD	GROUNDWATER	69	
NOTTINGHAM	DERWENT VALLEY	20	
NOTTINGHAM	CHURCH WILNE	43	
NOTTINGHAM	GROUNDWATER	109	
NORTH WEST DERBS	DERWENT VALLEY	16	
NORTH WEST DERBS	LOCAL SOURCES	9	

WER & CHEMICALS COST ($/ANNUM)
244185
90885
411720
141620
34310
173010
243920
1652355
1594685
15330
33580
861400
432160
460630
0
43070
344195
16790
91980
114975
274845
692770
124465
34675
50370
319740
236885
188340
328500
872350
229220
561735
132130
389090
104025
667585
0
60955
64240
97820
630355
47085
348210
915055
107310
92710

NORTH EAST DERBS	OGSTON	34	259515
NORTH EAST DERBS	HOMESFORD	30	309520
NORTH EAST DERBS	LOCAL SOURCES	11	80665
DERBY	DERWENT VALLEY	73	167900
DERBY	CHURCH WILNE	5	41610
DERBY	HOMESFORD	11	117895
DERBY	LITTLE EATON	44	342005
DERBY	LOCAL SOURCES	2	21900
LEICESTER	DOVE SCHEME	176	1791420
LEICESTER	DERWENT VALLEY	44	102200
LEICESTER	CHURCH WILNE	0	4745
LEICESTER	CHARNWOOD	10	84315
LEICESTER	UPTON & WORCS	0	0
LEICESTER	LOCAL SOURCES	12	133225
RUTLAND	LOCAL SOURCES	13	143445
UPPER TRENT	TITTESWORTH	22	162790
UPPER TRENT	GROUNDWATER	151	1381890
NEWARK	GROUNDWATER	16	147460
TOTALS :-		2347	19863665

B. MISCELLANEOUS FLOWS

DESTINATION	ORIGIN	FLOW (ML/D)	POWER COST (£/ANNUM)
CARSINGTON	AMBERGATE	0	0

RUN AVERAGES

A. SUPPLY LINKS

GROUNDWATER	SHREWSBURY	33
SHELTON	SHREWSBURY	13
GROUNDWATER	TELFORD	59
TRIMPLEY	LUDLOW	8
LOCAL SOURCES	LUDLOW	5
LOCAL SOURCES	MONTGOMERY	18
BLITHFIELD	SOUTH STAFFS WC	63
GROUNDWATER	SOUTH STAFFS WC	180
HAMPTON LOADE	SOUTH STAFFS WC	111
LITTLE EATON	SOUTH STAFFS WC	2
LOCAL SOURCES	SOUTH STAFFS WC	6
GROUNDWATER	WOLVERHAMPTON	78
HAMPTON LOADE	WOLVERHAMPTON	36
ELAN VALLEY	BIRMINGHAM	312
TRIMPLEY	BIRMINGHAM	0
DOVE SCHEME	NUNEATON	4
SHUSTOKE	NUNEATON	33
UPTON & WORCS	NUNEATON	0
SHUSTOKE	COVENTRY	9
DRAYCOTE	COVENTRY	9
GROUNDWATER	COVENTRY	30
UPTON & WORCS	COVENTRY	48
DRAYCOTE	RUGBY	6
STANFORD	RUGBY	8
LOCAL SOURCES	RUGBY	5
UPTON & WORCS	SOUTH WARWICKS	22
WILLES MEADOW	SOUTH WARWICKS	22
LOCAL SOURCES	SOUTH WARWICKS	16
WYELANDS	GLOUCESTERSHIRE	34
MYTHE	GLOUCESTERSHIRE	89
LOCAL SOURCES	GLOUCESTERSHIRE	20
UPTON & WORCS	WORCESTER	38
LOCAL SOURCES	WORCESTER	9
GROUNDWATER	KIDDERMINSTER	43
TRIMPLEY	KIDDERMINSTER	6
GROUNDWATER	EAST WORCS WC	62
OMBERSLEY	EAST WORCS WC	0
UPTON & WORCS	EAST WORCS WC	4
LOCAL SOURCES	EAST WORCS WC	7
OGSTON	SHERWOOD	11
GROUNDWATER	SHERWOOD	69
DERWENT VALLEY	NOTTINGHAM	25
CHURCH WILNE	NOTTINGHAM	42
GROUNDWATER	NOTTINGHAM	109
DERWENT VALLEY	NORTH WEST DERBS	16
LOCAL SOURCES	NORTH WEST DERBS	9
OGSTON	NORTH EAST DERBS	34
HOMESFORD	NORTH EAST DERBS	29
LOCAL SOURCES	NORTH EAST DERBS	11
DERWENT VALLEY	DERBY	73

242360
98915
415735
139795
36500
175200
458075
1646880
1416930
15330
33215
857385
460630
466835
0
43070
362445
4380
95630
114975
274115
713210
67525
92710
54750
333610
236885
187610
333975
891695
220460
573780
131765
395295
164025
680360
0
60590
64240
108770
631815
57305
334705
915055
106580
92345
261340
303680
80300
166805

CHURCH WILNE	DERBY	5	40515
HOMESFORD	DERBY	11	109500
LITTLE EATON	DERBY	45	347845
LOCAL SOURCES	DERBY	2	21900
DOVE SCHEME	LEICESTER	166	1639945
DERWENT VALLEY	LEICESTER	45	102200
CHURCH WILNE	LEICESTER	0	365
CHARNWOOD	LEICESTER	20	159870
UPTON & WORCS	LEICESTER	0	730
LOCAL SOURCES	LEICESTER	12	132130
LOCAL SOURCES	RUTLAND	13	142715
TITTESWORTH	UPPER TRENT	26	195640
GROUNDWATER	UPPER TRENT	145	1325315
GROUNDWATER	NEWARK	16	146730
TOTALS :-		2282	19924985

B. MISCELLANEOUS FLOWS

DESTINATION	ORIGIN	FLOW (ML/D)	POWER COST (£/ANNUM)
CARSINGTON	AMBERGATE	0	0

Appendix 3.

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**************************************************************
*                                                            *
*   N A T I O N A L   R I V E R S   A U T H O R I T Y        *
*   R E S O U R C E   A L L O C A T I O N   M O D E L        *
*                                                            *
**************************************************************
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1932-81 SIMULATION,1979 IS 1989,1980 IS 1990,1981 IS 1990(A).

USING 1989/90 DEMANDS, 1990 LINKS & SYSTEM CONSTRAINTS

OUTPUT FILE 4 :- PENTAD RECORD OF FLOWS , VOLUMES , ETC. IN THE SEVERN - WYE SYSTEM

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*******************************************
*                                         *
*  THIS MODEL IS SUPPORTED BY :-          *
*                                         *
*  WATER RESOURCES SECTION                *
*                                         *
*  CATCHMENT MANAGEMENT                   *
*                                         *
*  NATIONAL RIVERS AUTHORITY              *
*                                         *
*  SEVERN-TRENT REGION                    *
*                                         *
*******************************************
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1976

PDA NOA	VYRN VOL	VYRN REL	VYRN BANK	CLYW VOL	CLYW REL	SHRP ABST	DOLW RESPL	BEWD RESPL	HAWB RESPL	ALOWPARTA FLOW	MINLPRTA FLOW	SEVREGA AREQMENTA	ACTUALA RELEASEA	REG IND	STORM LOSSES	TOTAL LOSSES
1	47265	25	905	43800	135	0	1348	12772	12849	13567	12937	0	0	0	0	0
2	48780	45	905	44815	135	0	737	7483	11503	12071	11441	0	0	0	0	0
3	49000	45	905	45160	135	0	518	6561	9189	9623	8993	0	0	0	0	0
4	49335	45	905	45470	135	0	506	2642	4291	4484	3854	0	0	0	0	0
5	49860	45	905	45880	135	0	541	4350	5306	5552	4922	0	0	0	0	0
6	49620	45	905	45850	135	0	384	3589	4635	4836	4206	0	0	0	0	0
7	48875	45	905	45515	135	0	270	2425	3293	3420	2790	0	0	0	0	0
8	49960	45	905	45460	135	0	375	3163	4113	4302	3672	0	0	0	0	0
9	52795	25	1005	47595	135	0	1044	8053	9458	9949	9319	0	0	0	0	0
10	52425	45	1005	47585	135	0	392	6207	10759	11262	10632	0	0	0	0	0
11	52310	45	1005	47340	135	0	304	2844	4662	4864	4234	0	0	0	0	0
12	51800	45	1005	46970	135	0	256	3127	4571	4763	4133	0	0	0	0	0
13	50870	45	1730	46560	135	0	240	1790	2637	2729	2099	0	0	0	0	0
14	49925	45	1730	46110	135	0	225	1495	2249	2321	1691	0	0	0	0	0
15	49605	45	1730	45830	135	0	291	1647	2717	2820	2190	0	0	0	0	0
16	49755	45	1730	46220	18	0	206	2476	3963	4139	3509	0	0	0	0	0
17	52075	25	1830	48065	18	0	694	7460	10182	10700	10070	0	0	0	0	0
18	51875	45	1830	48235	135	0	457	6088	8712	9116	8486	0	0	0	0	0
19	51825	45	2555	48045	135	0	325	2920	4607	4806	4176	0	0	0	0	0
20	51060	45	2555	48115	18	0	82	2076	3315	3446	2816	0	0	0	0	0
21	50675	45	2555	48470	18	0	193	1439	2597	2549	2069	0	0	0	0	0
22	49805	45	2555	48670	18	0	133	1566	2945	2908	2428	0	0	0	0	0
23	48740	45	2555	48820	18	0	114	1127	1963	1875	1395	0	0	0	0	0
24	47625	45	2555	48910	18	0	90	950	1752	1652	1172	0	0	0	0	0
25	47015	45	3280	49215	18	0	174	896	1668	1571	1091	17	0	0	0	0
26	45835	45	3280	49355	18	0	110	1463	2467	2402	1922	0	0	0	0	0
27	45115	45	3280	49770	18	0	215	909	2008	1928	1448	4	0	0	0	0
28	44695	45	3280	49530	135	0	306	1164	2139	2062	1582	0	0	0	0	0
29	43980	45	3280	49265	135	0	296	1814	2799	2752	2272	0	0	0	0	0
30	42905	45	3280	49440	18	0	123	1085	2150	2072	1592	0	0	0	0	0
31	41860	45	4005	49520	18	0	86	912	1683	1281	1101	1	0	0	0	0
32	40690	45	4005	48980	135	0	189	1181	1323	895	715	0	0	0	0	0
33	39325	94	3760	47445	326	0	364	874	1300	859	679	396	420	1	0	24
34	37960	94	3515	46280	256	40	302	872	1496	1067	887	368	390	1	0	22
35	36645	94	3270	45395	190	40	216	868	1654	1236	1056	306	324	1	0	18
36	35170	94	3025	43605	363	40	373	878	1266	818	638	469	497	1	0	28
37	33660	94	3505	41370	500	40	605	842	1089	448	448	642	634	1	0	39

38	32155	94	3260	39740	357	40	419
39	30640	94	3015	37340	500	40	540
40	29425	94	2770	34840	500	40	500
41	28055	94	2525	32660	436	40	436
42	26675	94	2280	30160	500	40	500
43	25235	94	2760	27715	500	40	522
44	23805	94	2515	25215	500	40	500
45	22355	94	2270	22810	500	40	538
46	20910	94	2025	20320	500	40	504
47	19455	94	1780	17820	500	40	500
48	18020	94	1535	15320	500	40	500
49	16685	94	1290	12820	500	40	500
50	15335	94	1770	10360	500	40	516
51	15205	94	1525	7900	500	40	516
52	14550	95	1275	7955	24	40	94
53	14410	95	1025	6215	384	40	456
54	17960	75	775	6990	18	37	347
55	21110	25	875	7705	18	0	326
56	24060	25	1700	8900	18	0	491
57	25360	45	1700	10330	18	0	567
58	29075	25	1800	12625	18	0	819
59	30450	45	1800	13595	18	0	415
60	31530	45	1800	14700	18	0	461
61	31540	45	1800	15290	18	0	280
62	32450	45	1800	16430	18	0	473
63	32690	45	1800	17140	18	0	324
64	32275	45	1800	17655	18	0	253
65	31665	45	1800	18075	18	0	217
66	31005	45	1800	19370	18	0	524
67	33220	25	1900	21190	18	0	686
68	33485	45	1900	22660	18	0	580
69	35505	45	1900	24920	18	0	810
70	35240	45	1900	25615	18	0	318
71	34475	45	1900	26135	18	0	255
72	34270	45	1900	26835	18	0	320
73	33815	45	1900	27510	18	0	311

878	1181	551	551	463	491	1	0	28
881	1162	524	524	603	634	1	0	36
832	1186	551	551	652	634	1	0	39
882	1145	508	508	538	570	1	0	32
799	1015	368	368	685	634	1	0	41
798	1013	366	366	686	634	1	0	41
766	1000	352	352	718	634	1	0	43
740	941	290	290	744	634	1	0	45
701	885	233	233	783	634	1	0	47
709	871	216	216	775	634	1	0	46
725	878	222	222	759	634	1	0	46
852	2246	1658	1658	632	634	1	0	38
811	1237	598	598	673	634	1	0	40
674	1298	675	675	810	634	1	0	49
1031	1512	918	918	0	159	1	159	159
879	1506	901	901	490	519	1	0	29
5456	12730	12740	12740	0	130	1	130	130
9208	17216	17446	17446	0	0	0	0	0
6200	13091	13250	13120	0	0	0	0	0
9377	22644	23261	23131	0	0	0	0	0
13323	23765	24469	24339	0	0	0	0	0
8671	18120	18510	18380	0	0	0	0	0
7401	14802	15026	14896	0	0	0	0	0
4749	10052	10126	9896	0	0	0	0	0
4971	9748	9822	9592	0	0	0	0	0
5859	10946	11068	10838	0	0	0	0	0
3739	6562	6459	6229	0	0	0	0	0
4111	7529	7471	7241	0	0	0	0	0
2537	4689	4749	4269	0	0	0	0	0
5561	10514	10895	10415	0	0	0	0	0
7387	15291	15885	15405	0	0	0	0	0
12324	23504	24528	24048	0	0	0	0	0
5217	10420	10761	10281	0	0	0	0	0
4961	17617	18456	17826	0	0	0	0	0
5350	19981	20944	20314	0	0	0	0	0
4073	11010	11528	10898	0	0	0	0	0

APPENDIX 4.

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*************************************************************
*                                                           *
*   N A T I O N A L   R I V E R S   A U T H O R I T Y       *
*   R E S O U R C E   A L L O C A T I O N   M O D E L       *
*                                                           *
*************************************************************
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1932-81 SIMULATION,1979 IS 1989,1980 IS 1990,1981 IS 1990(A).

USING 1989/90 DEMANDS, 1990 LINKS & SYSTEM CONSTRAINTS

OUTPUT FILE 8 :- PENTAD RECORD OF ALLOCATIONS OF WATER FROM THE FOLLOWING SOURCES

SHELTON	HAMPTON LOADE	TRIMPLEY	OMBERSLEY	UPTON & WORCS
MYTHE	WILLES MEADOW			

```
*******************************************
*                                         *
*  THIS MODEL IS SUPPORTED BY :-          *
*                                         *
*  WATER RESOURCES SECTION                *
*                                         *
*  CATCHMENT MANAGEMENT                   *
*                                         *
*  NATIONAL RIVERS AUTHORITY              *
*                                         *
*  SEVERN-TRENT REGION                    *
*                                         *
*******************************************
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LIST OF THE ABBREVIATED NAMES USED IN THIS OUTPUT
****

SHREWSBURY	SHRW	ELAN VALLEY
TELFORD	TELF	VYRNWY
LUDLOW	LUDL	TITTESWORTH
MONTGOMERY	MGMY	DOVE SCHEME
SOUTH STAFFS WC	SSWC	DERWENT VALLEY
WOLVERHAMPTON	WOLV	OGSTON
BIRMINGHAM	BHAM	CHURCH WILNE
NUNEATON	NNTN	CHARNWOOD
COVENTRY	COVY	BLITHFIELD
RUGBY	RGBY	SHUSTOKE
SOUTH WARWICKS	SWAR	DRAYCOTE
GLOUCESTERSHIRE	GLOC	STANFORD
WORCESTER	WORC	GROUNDWATER
KIDDERMINSTER	KIDD	WYELANDS
EAST WORCS WC	EWWC	SHELTON
SHERWOOD	SHWD	HAMPTON LOADS
NOTTINGHAM	NGHM	TRIMPLEY
NORTH WEST DERBS	NWDB	OMBERSLEY
NORTH EAST DERBS	NEDB	UPTON & WORCS
DERBY	DRDY	MYTHE
LEICESTER	LEIC	WILLES MEADOW
RUTLAND	RTLD	HOMESFORD
UPPER TRENT	UTRT	LITTLE EATON
NEWARK	NEWK	LOCAL SOURCES

BLAN

VYRN

TITT

DOVE

DERW

DGST

CWLN

CHWD

BFLD

SHUB

DCTB

STAN

GWTR

WYEL

SHLT

HMPT

TRMP

OMBS

UPWC

MYTH

WLMD

HMFD

LBAT

LCLS

1976
****

PDA* NO*	SHLT * SHRW *	HMPT SSWC	HMPT * WOLV *	TRMP LUDL	TRMP BHAM	TRMP * KIDD *	OMBS * EWWC *
1 *	13 *	144	36 *	8	0	6 *	0 *
2 *	13 *	133	36 *	8	0	6 *	0 *
3 *	13 *	133	36 *	8	0	6 *	0 *
4 *	13 *	133	36 *	8	0	6 *	0 *
5 *	13 *	133	36 *	8	0	6 *	0 *
6 *	13 *	133	36 *	8	0	6 *	0 *
7 *	13 *	144	36 *	8	0	6 *	0 *
8 *	13 *	144	36 *	8	0	6 *	0 *
9 *	13 *	144	36 *	8	0	6 *	0 *
10 *	13 *	144	36 *	8	0	6 *	0 *
11 *	13 *	144	36 *	8	0	6 *	0 *
12 *	13 *	144	36 *	8	0	6 *	0 *
13 *	13 *	144	36 *	8	0	6 *	0 *
14 *	13 *	144	36 *	8	0	6 *	0 *
15 *	13 *	144	36 *	8	0	6 *	0 *
16 *	13 *	144	36 *	8	0	6 *	0 *
17 *	13 *	144	36 *	8	0	6 *	0 *
18 *	13 *	133	36 *	8	0	6 *	0 *
19 *	13 *	133	36 *	8	0	6 *	0 *
20 *	13 *	144	36 *	8	0	6 *	0 *
21 *	13 *	144	36 *	8	0	6 *	0 *
22 *	13 *	144	36 *	8	0	6 *	0 *
23 *	13 *	144	36 *	8	0	6 *	0 *
24 *	13 *	144	36 *	8	0	6 *	0 *
25 *	13 *	144	36 *	8	0	6 *	0 *
26 *	13 *	144	36 *	8	0	6 *	0 *
27 *	13 *	144	36 *	8	0	6 *	0 *
28 *	13 *	144	36 *	8	0	6 *	0 *
29 *	13 *	144	36 *	8	0	6 *	0 *
30 *	13 *	144	36 *	8	0	6 *	0 *
31 *	13 *	133	36 *	8	0	6 *	0 *
32 *	13 *	133	36 *	8	0	6 *	0 *
33 *	13 *	133	36 *	8	0	6 *	0 *
34 *	13 *	144	36 *	8	0	6 *	0 *
35 *	13 *	133	36 *	8	0	6 *	0 *
36 *	13 *	133	36 *	8	0	6 *	0 *
37 *	13 *	133	36 *	8	0	6 *	0 *
38 *	13 *	144	36 *	8	0	6 *	0 *
39 *	14 *	122	41 *	11	0	6 *	0 *
40 *	14 *	150	32 *	11	0	6 *	0 *
41 *	14 *	122	41 *	11	0	6 *	0 *
42 *	13 *	144	36 *	8	0	6 *	0 *
43 *	13 *	133	36 *	8	0	6 *	0 *
44 *	13 *	144	36 *	8	0	6 *	0 *
45 *	13 *	133	36 *	8	0	6 *	0 *
46 *	14 *	148	34 *	11	0	6 *	0 *
47 *	10 *	144	30 *	8	0	6 *	0 *
48 *	10 *	114	30 *	8	0	6 *	0 *
49 *	10 *	114	30 *	8	0	6 *	0 *
50 *	10 *	114	30 *	8	0	6 *	0 *

UPWC NNIN	UPWC COVY	UPWC SWAR	UPWC WORC	UPWC EWWC	UPWC LEIC	*	MYTH GLOC	*	WLMD SWAR	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*

0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	88	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	90	*	22	*
0	47	22	38	4	0	*	90	*	22	*
1	66	34	51	6	0	*	121	*	22	*
0	58	29	49	6	0	*	109	*	22	*
4	57	28	47	6	0	*	109	*	22	*
0	49	22	38	4	0	*	90	*	22	*
0	49	22	38	4	0	*	90	*	22	*
8	52	22	38	4	0	*	90	*	22	*
8	52	22	38	4	0	*	90	*	22	*
6	58	28	46	4	0	*	109	*	22	*
8	47	19	35	4	0	*	82	*	22	*
8	47	19	35	4	0	*	82	*	22	*
8	47	19	35	4	0	*	82	*	22	*
0	42	19	35	4	0	*	82	*	22	*

51 *	10 *	114	30 *	8	0	6 *	0 *	8	47	19	35	4	0 *	82 *	22 *
52 *	10 *	114	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	82 *	22 *
53 *	10 *	144	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	82 *	22 *
54 *	10 *	114	30 *	8	0	6 *	0 *	8	47	19	35	4	0 *	80 *	22 *
55 *	10 *	114	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
56 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
57 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
58 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
59 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
60 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
61 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
62 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
63 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
64 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
65 *	10 *	89	30 *	[illegible]	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
66 *	10 *	89	30 *	8	0	6 *	0 *	0	42	19	35	4	0 *	80 *	22 *
67 *	10 *	89	30 *	8	0	6 *	0 *	0	40	19	35	4	0 *	80 *	22 *
68 *	10 *	89	30 *	8	0	6 *	0 *	0	40	19	35	4	0 *	80 *	22 *
69 *	10 *	89	30 *	8	0	6 *	0 *	0	40	19	35	4	0 *	80 *	22 *
70 *	10 *	89	30 *	8	0	6 *	0 *	0	40	19	35	4	0 *	80 *	22 *
71 *	10 *	89	30 *	8	0	6 *	0 *	0	40	19	35	4	0 *	80 *	22 *
72 *	10 *	89	30 *	8	0	6 *	0 *	0	40	19	35	4	0 *	80 *	22 *
73 *	10 *	89	30 *	8	0	6 *	0 *	0	40	19	35	4	0 *	80 *	22 *

APPENDIX 5.

```
*************************************************************
*                                                           *
*   N A T I O N A L   R I V E R S   A U T H O R I T Y       *
*   R E S O U R C E   A L L O C A T I O N   M O D E L       *
*                                                           *
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1932-81 SIMULATION,1979 IS 1989,1980 IS 1990,1981 IS 1990(A).

USING 1989/90 DEMANDS, 1990 LINKS & SYSTEM CONSTRAINTS

OUTPUT FILE 6 :- PEN.AD RECORD OF ALLOCATIONS USED IN THE FOLLOWING DEMAND CENTRES

NUNEATON   COVENTRY   RUGBY   SOUTH WARWICKS   LEICESTER

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******************************************
*                                        *
*  THIS MODEL IS SUPPORTED BY :-         *
*                                        *
*  WATER RESOURCES SECTION               *
*                                        *
*  CATCHMENT MANAGEMENT                  *
*                                        *
*  NATIONAL RIVERS AUTHORITY             *
*                                        *
*  SEVERN-TRENT REGION                   *
*                                        *
******************************************
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LIST OF THE ABBREVIATED NAMES USED IN THIS OUTPUT
****

SHREWSBURY	SHRW	ELAN VALLEY	ELAN
TELFORD	TELF	VYRNWY	VYRN
LUDLOW	LUDL	TITTESWORTH	TITT
MONTGOMERY	MGMY	DOVE SCHEME	DOVE
SOUTH STAFFS WC	SSWC	DERWENT VALLEY	DERW
WOLVERHAMPTON	WOLV	OGSTON	OGST
BIRMINGHAM	BHAM	CHURCH WILNE	CWLN
NUNEATON	NNTN	CHARNWOOD	CHWD
COVENTRY	COVY	BLITHFIELD	BFLD
RUGBY	RGBY	SHUSTOKE	SHUS
SOUTH WARWICKS	SWAR	DRAYCOTE	DCTE
GLOUCESTERSHIRE	GLOC	STANFORD	STAN
WORCESTER	WORC	GROUNDWATER	GWTR
KIDDERMINSTER	KIDD	WYELANDS	WYEL
EAST WORCS WC	EWWC	SHELTON	SHLT
SHERWOOD	SHWD	HAMPTON LOADE	HMPT
NOTTINGHAM	NGHM	TRIMPLEY	TRMP
NORTH WEST DERBS	NWDB	OMBERSLEY	OMBS
NORTH EAST DERBS	NEDB	UPTON & WORCS	UPWC
DERBY	DRBY	MYTHE	MYTH
LEICESTER	LEIC	WILLES MEADOW	WLMD
RUTLAND	RTLD	HOMESFORD	HMFD
UPPER TRENT	UTRT	LITTLE EATON	LEAT
NEWARK	NEWK	LOCAL SOURCES	LCLS

1976
****

PD* NO*		NNTN DOVE	NNTN SHUS	NNTN UPWC	* *	COVY SHUS	COVY DCTE	COVY GWTR	COVY UPWC	* *	RGBY DCTE	RGBY STAN	RGBY LCLS	* *	SWAR UPWC
1	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
2	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
3	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
4	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
5	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
6	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
7	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
8	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
9	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
10	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
11	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
12	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
13	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
14	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
15	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
16	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
17	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
18	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
19	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
20	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
21	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
22	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
23	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
24	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
25	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
26	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
27	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
28	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
29	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
30	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
31	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22
32	*	4	33	0	*	9	9	30	47	*	12	2	5	*	22

SWAR WLMD	SWAR LCLS	*	LEIC DOVE	LEIC DERW	LEIC CWLN	LEIC CHWD	LEIC UPWC	LEIC LCLS	*
22	16	*	150	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*
22	16	*	175	45	0	10	0	12	*

33 *	4	33	0 *	9	9	30	47 *	12	2	5 *	22	22	16 *	175	45	0	10	0	12 *
34 *	4	33	0 *	9	9	30	47 *	12	2	5 *	22	22	16 *	175	45	0	10	0	12 *
35 *	4	33	0 *	9	9	30	47 *	12	2	5 *	22	22	16 *	175	45	0	10	0	12 *
36 *	4	33	0 *	9	9	30	47 *	12	2	4 *	22	22	16 *	175	45	0	10	0	12 *
37 *	4	33	0 *	9	9	30	47 *	12	2	3 *	22	22	16 *	175	45	0	10	0	12 *
38 *	4	33	0 *	9	9	30	47 *	12	2	3 *	22	22	16 *	175	45	0	10	0	12 *
39 *	4	38	1 *	4	9	32	66 *	14	2	4 *	34	22	18 *	211	48	2	10	0	15 *
40 *	4	36	0 *	4	9	[illegible]2	58 *	14	2	3 *	29	22	18 *	211	48	2	10	0	15 *
41 *	0	36	4 *	4	9	32	57 *	14	2	3 *	28	22	18 *	215	28	14	10	0	15 *
42 *	4	33	0 *	7	9	30	49 *	12	2	3 *	22	22	16 *	177	43	0	10	0	12 *
43 *	4	33	0 *	7	9	30	49 *	12	2	2 *	22	22	16 *	177	43	0	10	0	12 *
44 *	4	21	8 *	4	9	30	52 *	12	2	3 *	22	22	16 *	177	43	0	10	0	12 *
45 *	4	21	8 *	4	9	30	52 *	12	2	3 *	22	22	16 *	175	45	0	10	0	12 *
46 *	4	21	6 *	4	9	32	58 *	14	2	2 *	28	22	18 *	211	32	14	10	0	15 *
47 *	4	21	8 *	4	9	30	47 *	11	2	2 *	19	22	16 *	175	45	0	10	0	12 *
48 *	4	21	8 *	4	9	30	47 *	11	2	2 *	19	22	16 *	175	45	0	10	0	12 *
49 *	4	21	8 *	4	9	30	47 *	11	2	5 *	19	22	16 *	175	45	0	10	0	12 *
50 *	4	31	0 *	9	9	30	42 *	11	2	5 *	19	22	16 *	175	45	0	10	0	12 *
51 *	4	21	8 *	4	9	30	47 *	11	2	5 *	19	22	16 *	177	43	0	10	0	12 *
52 *	4	31	0 *	9	9	30	42 *	11	2	5 *	19	22	16 *	17[illegible]	43	0	10	0	12 *
53 *	4	31	0 *	9	9	30	42 *	11	2	5 *	19	22	16 *	177	43	0	10	0	12 *
54 *	4	21	8 *	4	9	30	47 *	11	2	5 *	19	22	16 *	177	43	0	10	0	12 *
55 *	4	31	0 *	9	9	30	42 *	11	2	5 *	19	22	16 *	175	45	0	10	0	12 *
56 *	4	31	0 *	9	9	30	42 *	11	2	5 *	19	22	16 *	175	45	0	10	0	12 *
57 *	4	31	0 *	9	9	30	42 *	11	2	5 *	19	22	16 *	175	45	0	10	0	12 *
58 *	4	31	0 *	9	9	30	42 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
59 *	4	31	0 *	9	9	30	42 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
60 *	4	31	0 *	9	9	30	42 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
61 *	4	31	0 *	9	9	30	42 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
62 *	4	31	0 *	9	9	30	42 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
63 *	4	31	0 *	9	9	30	42 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
64 *	4	31	0 *	9	9	30	42 *	4	9	5 *	19	22	16 *	175	45	0	10	0	12 *
65 *	4	31	0 *	9	9	30	42 *	4	9	5 *	19	22	16 *	175	45	0	10	0	12 *
66 *	4	31	0 *	9	9	30	42 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
67 *	4	31	0 *	11	9	30	40 *	8	5	5 *	19	22	16 *	175	45	0	10	0	12 *
68 *	4	31	0 *	11	9	30	40 *	4	9	5 *	19	22	16 *	175	45	0	10	0	12 *
69 *	4	31	0 *	11	9	30	40 *	4	9	5 *	19	22	16 *	175	45	0	10	0	12 *
70 *	4	31	0 *	11	9	30	40 *	4	9	5 *	19	22	16 *	175	45	0	10	0	12 *
71 *	4	31	0 *	11	9	30	40 *	4	9	5 *	19	2[illegible]	16 *	175	45	0	10	0	12 *
72 *	4	31	0 *	11	9	30	40 *	4	9	5 *	19	22	16 *	160	45	0	25	0	12 *
73 *	4	31	0 *	11	9	30	40 *	4	9	5 *	19	22	16 *	160	45	0	25	0	12 *

HOMESFORD	39.3	39.1	71.4[illegible]	54.[illegible]
LITTLE EATON	46.7	46.8	85.18	55.0

APPENDIX 6.

1978

SOURCE NAME	AVGE OUTPUT MAY-OCT(ML/D)	AVGE OUTPUT JAN-DEC(ML/D)	PERCENTAGE USE ANNUAL LICENCE	ANNUAL LICENCED AVGE(ML/D)
ELAN VALLEY	311.0	311.0	85.44	364.0
VYRNWY	0.0	0.0	0.00	208.0
TITTESWORTH	29.6	32.3	73.81	43.8
DOVE SCHEME	164.0	164.0	53.25	308.0
DERWENT VALLEY	160.8	161.9	66.08	245.0
OGSTON	45.0	45.0	42.86	105.0
CHURCH WILNE	45.1	44.0	26.85	164.0
CHARNWOOD	25.0	25.0	121.95	20.5
BLITHFIELD	65.0	65.0	102.20	63.6
SHUSTOKE	42.0	42.0	102.44	41.0
DRAYCOTE	14.9	15.1	30.14	50.0
STANFORD	8.1	7.9	88.13	9.0
WYELANDS	34.0	34.0	75.56	45.0
SHELTON	13.0	13.0	33.68	38.6
HAMPTON LOADE	144.0	144.0	79.21	181.8
TRIMPLEY	14.0	14.0	23.26	60.2
OMBERSLEY	0.0	0.0	0.00	41.8
UPTON & WORCS	111.0	111.0	111.00	100.0
MYTHE	88.0	88.0	80.73	109.0
WILLES MEADOW	22.0	22.0	88.35	24.9
HOMESFORD	39.1	39.1	71.27	54.8
LITTLE EATON	47.0	47.0	85.45	55.0

SOURCE OUTPUT STATISTICS FOR THE WHOLE RUN

SOURCE NAME	AVGE OUTPUT MAY-OCT(ML/D)	AVGE OUTPUT JAN-DEC(ML/D)	PERCENTAGE USE ANNUAL LICENCE	ANNUAL LICENCED AVGE(ML/D)
ELAN VALLEY	0.0	311.9	85.68	364.0
VYRNWY	0.0	0.0	0.00	208.0
TITTESWORTH	0.0	26.6	60.74	43.8
DOVE SCHEME	0.0	170.0	55.21	308.0
DERWENT VALLEY	0.0	159.1	64.93	245.0
OGSTON	0.0	44.5	42.43	105.0
CHURCH WILNE	0.0	46.1	28.12	164.0
CHARNWOOD	0.0	19.6	95.74	20.5
BLITHFIELD	0.0	62.6	98.46	63.6
SHUSTOKE	0.0	41.6	101.43	41.0
DRAYCOTE	0.0	14.7	29.37	50.0
STANFORD	0.0	8.3	92.74	9.0
WYELANDS	33.8	33.9	75.36	45.0
SHELTON	0.0	13.0	33.64	38.6
HAMPTON LOADE	0.0	147.0	80.83	181.8
TRIMPLEY	0.0	14.1	23.37	60.2
OMBERSLEY	0.0	0.0	0.00	41.8
UPTON & WORCS	0.0	112.3	112.34	100.0
MYTHE	89.6	88.8	81.43	109.0
WILLES MEADOW	0.0	22.0	88.35	24.9
HOMESFORD	0.0	39.5	72.12	54.8
LITTLE EATON	0.0	47.0	85.45	55.0