Graphical Display Program for SIMCAT

WRc plc

R&D Project Record 202/1/A

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EXECUTIVE SUMMARY

SIMCAT is a mathematical model which predicts the quality of river water throughout a river catchment. The model can be used to help plan the measures needed to improve water quality by modelling the behaviour of summary statistics of water quality such as the mean and 95 percentile. The current versions of SIMCAT have no direct method of producing graphical displays of the model simulation. The graphical display package for SIMCAT, known as CATGRAPH, has been developed under the UNIX operating system using X-windows/MOTIF packages. This provides a graphical environment with pull down menus and resizeable windows. It has been designed to run on a Personal Computer with a Intel 30386 chip.

Two new graphical datafiles have been developed. These provide the link between SIMCAT and CATGRAPH. The structure of these datafiles and the changes to the SIMCAT code to produce them have been fully documented.

CATGRAPH can generate a longitudinal profile of water quality or the distributional plot of water quality at a particular location. The various options and features within the package have been described. These include the plotting of observed versus simulated distributions and showing the confidence limits around percentile values.

This prototype version of CATGRAPH requires a number of improvements before it can be fully released. Whether this work should be undertaken depends on the future development of SIMCAT. However, CATGRAPH could be used for other water quality models such as the Stochastic Estuary Model. Alternatively it could provide the design specification for a similar package running under the DOS operating system using some newly available software packages.

KEY WORDS

Model, river water quality, consents, statistical approach

1. INTRODUCTION

1.1 Background to project

This section provides a brief outline to the previous work undertaken at WRc on the mathematical model SIMCAT. It describes SIMCAT and the developments that have been undertaken in the past few years.

1.1.1 What is SIMCAT?

SIMCAT is a mathematical model which predicts the quality of river water throughout a river catchment. SIMCAT is used to help plan the measures needed to improve water quality by modelling the behaviour of summary statistics of water quality; such as the mean and 95 percentile. Hence, SIMCAT takes due account of the fact that quality standards must be defined by summary statistics in order to allow a correct audit of performance. SIMCAT has special features, like auto-calibration, which enable it to produce results quickly. SIMCAT also controls the effect of the statistical uncertainties associated with water quality data in decision making. SIMCAT has been developed over the last ten years by Dr A E Warn, now of Anglian Region of the National Rivers Authority (NRA).

1.1.2 Previous work

During 1989/1990 WRc undertook a research project involving SIMCAT (Crockett and Crabtree 1990). This work had three major components. These were:

- the production of a User Guide;
- the development of a user interface; and
- the enhancement of the original code

The User Guide was produced as a separate document (Crockett *et al* 1990) in order to ease the application of the revised version of SIMCAT.

The user interface improved the screen displays for SIMCAT. During the course of the research project, a number of modifications were made to the original computer code. These included removing a number of errors from the computer code and an improved method of auto calibration.

1.1.3 Development of current project

A number of recommendations for further work were recommended at the end of this previous work. One of these recommendations was the development of a post non-graphical generation program. This project was undertaken in response to that requirement.

1.2 Project outline

A copy of the Project Investment Appraisal for this project is given in Appendix E.

1.2.1 Project objectives

The overall project objective was to provide an effective tool for calculating the action needed to meet Water Quality Objectives in a river system. The specific project objective was to test SIMCAT and to provide graphical output of results.

1.2.2 Project strategy

The methodology involved modifying SIMCAT to provide a number of output datafiles as input for a graphics package. This graphics package was developed under the UNIX operating system using the X-windows/MOTIF packages. The graphics package was given the working name of CATGRAPH.

1.2.3 Project outputs

There are three main outputs from this research project. These are:

- the modified version of SIMCAT to produce the new graphical output datafiles;
- the graphics generation package CATGRAPH;
- the project report.

The source code for the modified version of SIMCAT and the graphics generation package CATGRAPH have been made available to the NRA by WRc.

1.3 Structure of report

The project was divided into two main parts, the production of the graphical output datafiles from SIMCAT and the development of the graphics programme CATGRAPH.

The structure of the graphical output datafiles is covered in Section 2. This also includes details of the various changes to SIMCAT.

The development of CATGRAPH is covered in Section 3. This reviews the various options in the package and gives examples of various outputs.

Section 4 provides recommendations for further work resulting from this project.

2. STRUCTURE OF GRAPHICAL DATAFILES

2.1 Why new datafiles?

The version of SIMCAT developed in the previous work and described in the User Guide (Crockett *et al* 1990) produced two graphical data output files. These consisted of a series of comma separated variables. One file contained the longitudinal data for the main river section (i.e. beginning of the first headwater) while the remaining tributary information was placed in the second datafile.

The structure of these two files was considered unsuitable as an interface between SIMCAT and the graphics generation program CATGRAPH. The main reasons for this were:

- there were no data output on the distribution of flow and quality at any specified location;
- it was difficult to use the data in the second graphical output file as it contained data from a mixture of tributaries; and
- there was no flexibility built into the datafile structure (e.g. only mean and 95 percentile).

To overcome these problems and to provide defined datafile structures for CATGRAPH, it was decided to develop two new output files for SIMCAT. These two output datafiles are given the file name convention of **filename**.SLG and **filename**.SDG. The .SLG file contains data required to plot the longitudinal profile plots. The .SDG files contain the data required for the distributional plots at selected locations in the river system. The structure of each of these files is detailed in Sections 2.2 and 2.3, respectively.

It is anticipated that this output structure could be produced by a variety of stochastic water quality programs such as MONTEQUAL (estuary water quality model) and TOMCAT (an alternative to SIMCAT). This will enable them to make use of the same graphics generation package.

2.2 Longitudinal output datafile structure

The datafile has been split into two sections:

(a) the header; and

(b) the sequential data sections.

The header contains information required for the graph headers (e.g. title, date, etc.) The data in this section is written to this file at the beginning of a SIMCAT model simulation. The sequential data section contains the relevant data for each point in the river system. Data is written to this section as the SIMCAT model progresses down the river system. Finally, the names of the various reaches and headwaters referenced in the simulation are written. This

final section will only be produced if the simulation has been successful. An example of the longitudinal (.SLG) datafile structure is shown in Appendix A.

2.2.1 Header section

An example of a header section and details are given in Table 2.1.

2.2.2 Sequential data section

As an example, a few lines of this section are given in Table 2.2. The basic structure is a line of text giving information about the position, type and name of the river feature. Then lines of data follow, one for each of the determinands simulated. The amount of information contained in each of these lines relates to the number of percentile values. The example given below is for four determinands and three percentiles (as indicated in the header section example). Due to the size of the page not all the data section can be displayed. The program should allow up to around 100 river feature data sections.

All the values are written using the FORTRAN format **1PE10.4** and are comma separated. There will be a maximum of 12 data values. This is shown in Table 2.3.

Table 2.1 Example of the header section of a graphical datafile

1	"SIMCAT v3.0 run mode 0
2	"Example datafile for use with SIMCAT user guide"
3	040490 1200 100 5 3 50 80 95
4	1,"FLOW (m^3/d)" ,"Flow","m^3/d"
5	2,"Chloride..." ," Cl","mg/l"
6	3,"B.O.D....." ," BOD","mg/l"
7	4,"Ammonia...." ," Amm","mg/l"
8	5,"Diss.Oxygen" ,"

Notes:
- Line 1 gives the name of the program used to produce the output datafile (maximum 30 characters)
- Line 2 gives the title of the simulation run (maximum 70 characters)
- Line 3 this contains 8 integer values which are:
  - date as DDMMYY
  - time HHMM (24 hour clock)
  - number of shots in simulation run (maximum 1500)
  - number of determinands (up to 10)
  - number of percentile values (maximum 3)
  - percentile 1
  - percentile 2 (if required)
  - percentile 3 (if required)
- Line 4-7 these lines contain the data for the number of determinands given above:
  - the determinand number
  - the long determinand name (maximum 16 chars)
  - the shortened determinand name (maximum 4 chars)
  - the determinand units (maximum 10 chars)

Table 2.2 Example of the sequential data section from a .SLG datafile

```
1,1,10,0.0,"U/S Head of Upper Ouse                "
3.0230E+00,0.0000E+00,0.0000E+00,0.0000E+00,6.1896E+00,...
5.0120E+01,4.7860E+01,5.2340E+01,6.5671E+02,1.1341E+02,...
6.0345E+00,5.5023E+00,7.0123E+00,8.7651E+00,1.2021E+01,...
5.0122E-01,4.0234E-01,6.2341E-01,5.1011E-01,1.0011E+00,...
8.9732E+00,7.3456E+00,1.2034E+01,7.0767E+00,5.0127E+00,...
1,1,4,4.0,"U/S Pig Farm Gauging Station               "
3.1270E+00,0.0000E+00,0.0000E+00,0.0000E+00,6.2376E+00,...
5.0120E+01,4.7860E+01,5.2340E+01,6.5671E+02,1.1341E+02,...
6.0345E+00,5.5023E+00,7.0123E+00,8.7651E+01,1.2021E+01,...
5.0122E-01,4.0234E-01,6.2341E-01,5.1011E+00,1.0011E+00,...
8.9732E+00,7.3456E+00,1.2034E+01,7.0767E+00,5.0127E+00,...
.          .          .          .          .
.          .          .          .          .
```

Notes: Line 1 - Feature data
Value 1 - the reach number (maximum 40)
Value 2 - the headwater number (maximum 30)
Value 3 - feature type number:
- 0 - downstream of discharge or end of reach;
- 1 - quality monitoring station;
- 2 - stream/tributary;
- 3 - sewage discharge;
- 4 - river flow gauge;
- 5 - industrial discharge;
- 6 - plotting point;
- 7 - flow abstraction;
- 8 - weir;
- 9 - flow regulation point;
- 10 - upstream boundary;
- 11 - bifurcation;
- 12 - intermittent discharge;
- 13 - diffuse pollution start (river type);
- 14 - diffuse pollution end (river type);
- 15 - diffuse pollution start (effluent type);
- 16 - diffuse pollution end (effluent type);
- 17 - distribution plotting point.

Value 4 - distance from headwater (km)
Value 5 - feature name (maximum 40 characters)

The last line of the data section should have a reach number of zero. If this is not the case, the simulation run will have been ended in an uncontrolled fashion. If the reach number is zero, but the headwater number is not zero, the feature name will contain an error statement indicating why the simulation run failed at that point. If the reach number and headwater number are both zero, it has been a completely successful run.

Lines 2-6

These contain the summary statistics for flow and the simulated quality determinands (1 line for each). The structure of each data line is detailed below.

Notes for Table 2.2 (continued)

The first line of data is always flow. The determinand number given in the header section defines the order in which the quality data appears (i.e. line number).

In the example above there are no associated error limits or target values for the various flow percentiles. This is designated by a zero value for the upper and lower confidence limits and the target values. Where there is no target value for a percentile, for a quality determinand, a zero value is given.

Table 2.3 Details of the layout of data in the sequential data section

Value	Variable	Notes
1	Percentile value 1	There is always at
2	Lower CL	least one percentile
3	Upper CL	
4	Target value	
5	Percentile value 2	If required:
6	Lower CL	i.e. no. of percentile
7	Upper CL	values >= 2
8	Target value	
9	Percentile value 3	If required:
10	Lower CL	i.e. no. of percentile
11	Upper CL	values = 3
12	Target value	

Notes: CL - Confidence limit

2.2.3 End of run data

This is the last section of the sequential datafile. The names of reaches and the header have been placed here because, for certain programs, such as TOMCAT, this information is not known until the program has been completed. This section comes after the last line of the data section and indicates the end of a simulation. Hence, this section will not be produced if the simulation has not been successful. An example of the layout of the End of Run section is given in Table 2.4.

Table 2.4 Example of an End of Data Section of a graphical datafile

```
1     5     3
2     "Upper Ouse          "
3     "River Avon          "
4     "Middle Ouse         "
5     "Black Brook         "
6     "Lower Ouse I        "
7     "Head of Upper Ouse                "
8     "Head of River Avon                "
9     "Head of Black Brook               "
10 ================================================================
```

Notes: The details of the structure of this data section are given below:

Line 1	Value 1 is the number of reach names (maximum 40)
	Value 2 is the number of headwater names (maximum 30)
Line 2-6	The reach names (maximum 20 characters)
Line 7-9	The headwater names (maximum 30 characters)
Line 10	Line of ==== to designate the end of the datafile.

2.3 Distributional output datafile structure

This datafile contains the distributional data for selected points in the catchment. The data can come in a number of layouts depending on how many determinands are output and whether or not there are comparison data. The information given for each location in the longitudinal datafile (.SLG) is also reproduced for the relevant location in the datafile.

The distribution datafile is split into three sections:

- the header section;
- the data section;
- the end of data section.

The details of each of these sections are given below. An example of the distributional (.SDG) datafile structure is shown in Appendix B.

2.3.1 Header section

The header section of the datafile is exactly the same as in the longitudinal datafile structure detailed in Table 2.1.

2.3.2 Data section

An example of a portion of a data section is given in Table 2.5.

Table 2.5 Example of the initial portion of a .SDG datafile

1,1,10,0.0,"U/S Head of Upper Ouse "
1,100,0

Notes:

Line 1 The first line of the input datafile is the same as in the first line of feature data in the data section of the .SLG file.

Line 2 The second line contains three comma separated integers:
value 1 - determinand number (note 1 = flow)
2 - number of simulated values (maximum 1500)
3 - number of observed values (maximum 750)

Line 3 onwards ...
The data for each determinand flow and/or quality are written out individually (in sequence) from 1...NSHOTS (number of model shots) using the format 10(1PE10.4). The values are comma separated. If comparison data has been produced this will follow immediately after the simulated data, using the same format.

Line 2 is then repeated for each determinand simulated
When the number of simulated and observed values are set to zero, no data for that determinand has been output.

2.3.3 End of data section

The data section will finish by the same method as detailed in the sequential datafile; i.e. an end of simulation line of data. If the simulation has been successful, the end of simulation data section is written to the output file.

2.4 Changes to SIMCAT

The SIMCAT code used as a basis for this project was that described in the SIMCAT User Guide (Crockett *et al* 1990). In order to produce the graphical output files described in Sections 2.2 and 2.3, it was necessary to modify this SIMCAT code and to write some new FORTRAN subroutines. This section summarises these changes and the additions to the SIMCAT code.

2.4.1 Modification to original code

The various modifications to the SIMCAT code are detailed in Appendix C. There were two main reasons for these modifications. Firstly, the headwater information had to be remembered by SIMCAT, in order to appear as output at the end of the graphic datafiles (Section 2.2.3). It was, therefore, necessary to introduce a new common block array to make this possible. The second source of changes was the need to remove the old graphical output code and replace it with calls to the new graphical output subroutines.

2.4.2 New source code

In order to produce the new graphical output datafiles, it was necessary to write some new FORTRAN source code. This new source code was placed within the file called GRAHEAD.FOR. A full listing of this new source code is given in Appendix D.

The new source code consists of five subroutines. The names and functions of these subroutines are given in Table 2.6.

Table 2.6 New SIMCAT subroutines

Name	Function
GRAHEAD	Writes out header section to both graphical datafiles.
GRAEND	Writes out the end of simulation section of both graphical datafiles.
GRADT1	Writes out the sequential data section for the longitudinal graphical datafile SLG.
GRADT2	Controls the output of the distributional data section for the .SDG graphical datafile
DISOUT	Subroutine called by GRADT2 to write out the distributional data.

The header section for both graphical output files is generated at the beginning of a SIMCAT simulation. The end section data are written to each datafile at the end of a successful SIMCAT simulation.

GRADT1 writes out a line of data for each simulated quality determinand at each location along a river system.

SUBROUTINE GRADT2 controls the output of data to the distributional graphic datafile. Distributional data are only output at locations where calibration data are available. Commonly, this is at gauging stations and quality monitoring sites. Where the flow or quality data sets have been automatically calibrated by SIMCAT the observed data distribution is not written to the .SDG datafile.

2.5 Future improvements

In developing the structure of the graphical output datafiles care has been taken to ensure a large amount of flexibility. The number of determinands can be increased easily, as can the number of summary statistics (i.e. means, percentiles, etc.) It would, however, be beneficial to build in the facility to store the observed values of summary statistics at various locations where this information is known. This would require an adjustment to the structure of the longitudinal graphic datafile .SLG.

The output of all simulated values of particular locations can lead to large datafiles if a large number of shots has been used. A method of summarising the simulated distribution accurately by using a smaller number of output values to summarise the distribution would reduce the size of these datafiles.

3. DEVELOPMENT OF GRAPHICS DISPLAY PROGRAM - CATGRAPH

The graphical data package CATGRAPH has been developed as an independent program. The graphics datafiles described in Section 2.2 and 2.3 provide the link with SIMCAT. This section covers the background to the development, plus a description of the various options within the package. A number of examples of its use is also given, as well as recommendations for potential further developments.

3.1 Background

CATGRAPH has been written in the programming language "C" to run under the UNIX operating system. The X-windows/MOTIF development packages have been used to provide the screen handling capabilities.

The advantages of the UNIX operating system, compared to DOS are given in Table 3.1. At the start of the project it was anticipated that the future development of SIMCAT might enable a large shot version (more than 1000 shots) to be developed to run under UNIX. Initially the graphical datafiles will have to be transferred from SIMCAT, while running in a DOS window under UNIX, to the UNIX environment required by CATGRAPH.

The minimum hardware requirements for CATGRAPH are given in Table 3.2. These can be met by a wide range of personnel computers currently in the market place. In the future, this version of CATGRAPH could be transferred to a UNIX workstation with only minor modifications.

The software requirements for CATGRAPH are also given in Table 3.2.

Table 3.1 Advantages of UNIX operating system as compared to DOS

1.	Allows much larger executable code sizes
2.	Better memory management
3.	Provides a consistent graphical user-interface
4.	Enables use of multiple resizeable windows
5.	Several applications can be run concurrently
6.	DOS applications can be run concurrently within a UNIX window

Table 3.2 Hardware and Software requirements of CATGRAPH

(a)	Minimum Hardware Requirements - Intel 80386 processor - 4 Mbytes of Random Access Memory - 60 Mbytes Hard Disk (preferably 80) - Mouse
(b)	Software Requirements - SCO Open Desktop/UNIX runtime operating system - CATGRAPH - New version of SIMCAT

3.2 CATGRAPH description

This section gives a brief description of the major features of CATGRAPH. In order to reduce the possible confusion when a CATGRAPH option is in the text they have been put in italics.

3.2.1 Program window

The Program window is displayed when the CATGRAPH program is executed. An example of the Program window of CATGRAPH is given in Figure 3.1. There are six options on the Program window menu bar, these are:

- *Help*
- *Newfile*
- *Overlay*
- *Save*
- *Pscreen*
- *Exit*

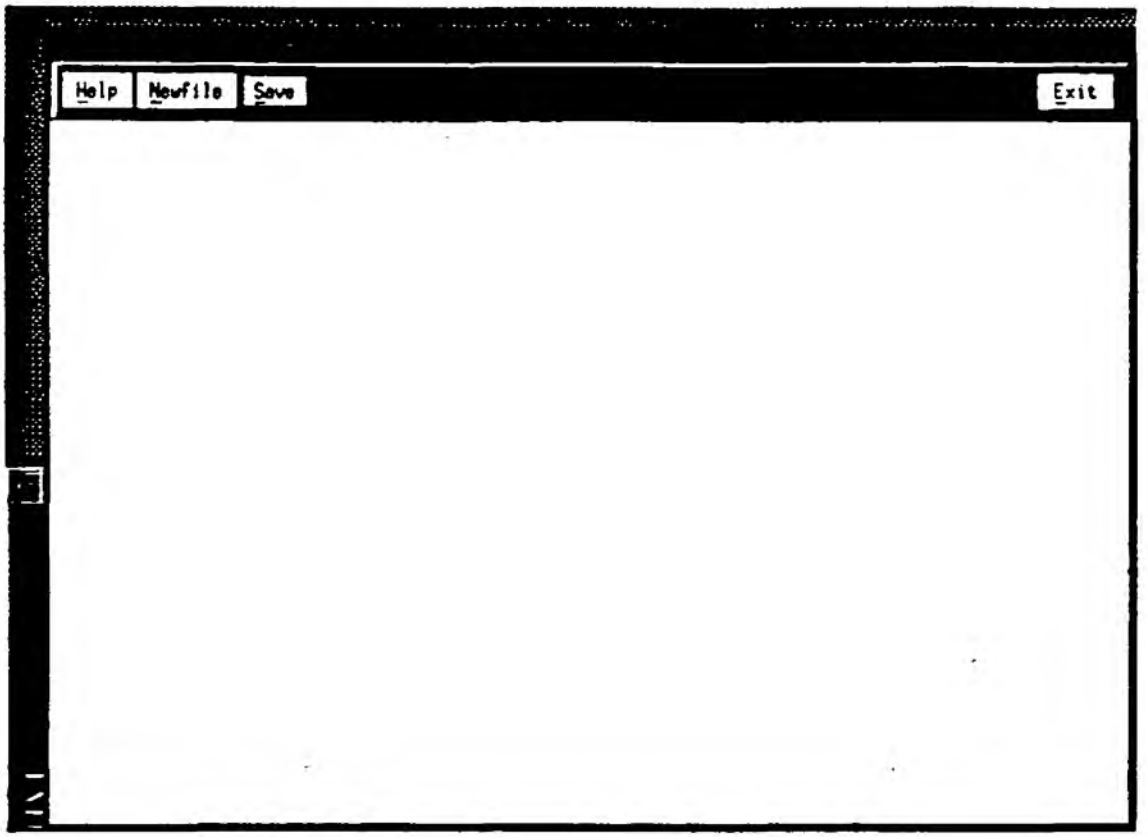


Figure 3.1 Example of a CATGRAPH program window

These options are selected by placing the mouse cursor over the option name and clicking the mouse.

(a) *Help*

This option has not been fully implemented. On selecting this option a help window is display in the middle of the screen. The text within this window is read from a datafile. Currently, the text displayed is not relevant to this option.

(b) *Newfile*

This option is used to define the graphics datafile to be displayed by CATGRAPH. The operation of this option is described in more detail in Section 3.2.2.

(c) *Overlay*

This option is designed to enable data from different datafiles to be plot against each other. This option has not been implemented in this version of CATGRAPH.

(d) *Save*

The *Save* option allows a display window to be copied to a file. There are three options Save, these are:

- save the current display window

- save all the display windows

- save a selected display window

However, this option has not been fully implemented in this version of CATGRAPH.

(e) *Pscreen*

The *Pscreen* option prints a copy of the current screen display to an output device. Again, this option has not been fully implemented in this version of CATGRAPH.

(f) *Exit*

When this option is selected a confirmation window is displayed. The text requests the user to confirm the *Exit* option. By clicking the mouse to move to the *YES* option, the user will exit CATGRAPH. On selecting the *NO* option, the user is returned to the program.

3.2.2 Selecting a Datafile

When the *Newfile* option is selected from the programme window menu bar, a file selection window is generated on the terminal screen. An example of this file selection window is given in Figure 3.2. The file selection window is divided into four portions, the file filter, the datafile list, the file selection display and along the bottom the menu bar.

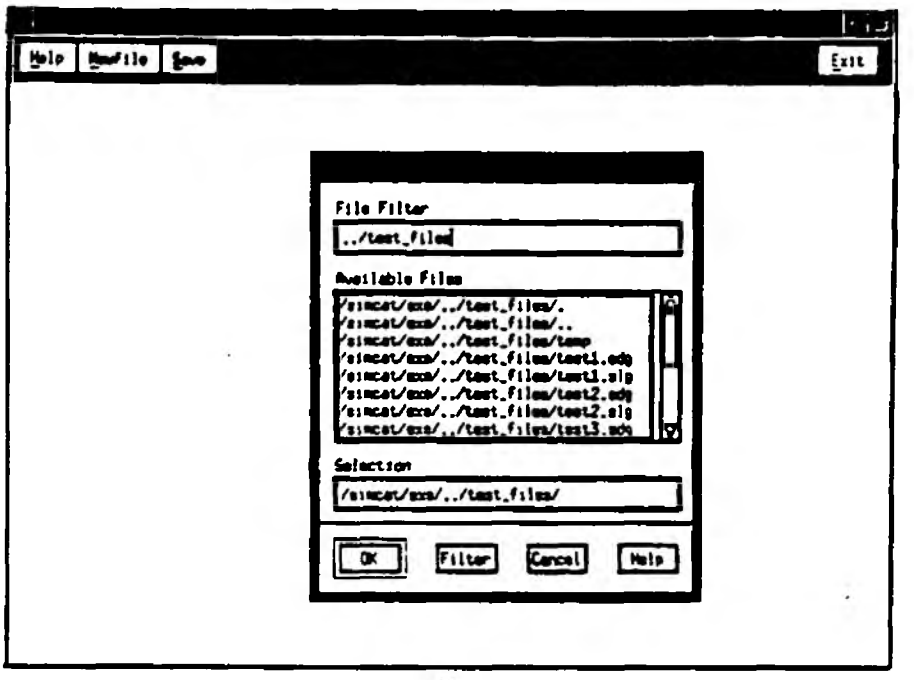


Figure 3.2 Example of the file selection window

The file filter box enables the user to define the directory of datafiles to be displayed. This is done by entering the name of the directory in the *File Filter box* and clicking the *Filter* option in the menu bar.

Once the directory has been selected, the datafile to be used can be selected from the scrolling available file window. The file selected will determine the type of graph to be displayed. For longitudinal displays a file with the file identifier .SLG should be selected. For distributional displays a .SDG file should be selected. A file is identified by clicking the mouse over its name. A double click will select and load the file. Alternatively, the datafile can be selected by clicking the mouse on the *OK* option on the Menu bar.

The file selection window can be cleared using the Menu bar *cancel* option.

The final option on the menu bar is the *Help* option. As with the Display window help option, the help window generated does not contain the help text in this version of CATGRAPH.

3.2.3 Longitudinal display window

An example of how a Longitudinal Display window looks on the selection of a .SLG datafile is shown in Figure 3.3. The Display window is divided into four areas, the title bar, the option menu bar, the graph area and the selection display area.

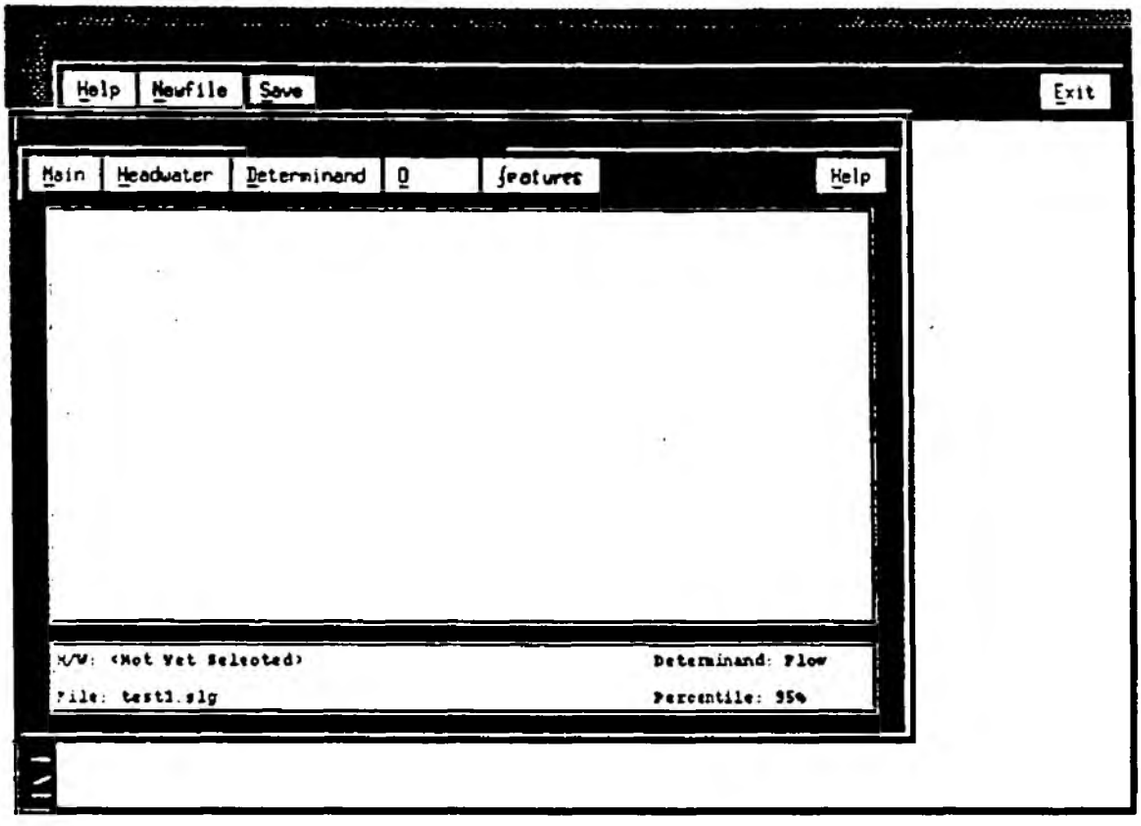


Figure 3.3 Example of the Longitudinal Display Window

At the top of the display is the screen title bar. This contains the simulation title from the SIMCAT input datafile. This is transferred to CATGRAPH via the Graphical datafile.

There are six options available in the menu bar, these are:

- *main*
- *headwater*
- *determinand*
- *options*
- *features*
- *help*

(a) *Main*

When the *main* option is selected a sub option window is shown containing four options. These are *new-display, display data, graph display* and *close*. *New-display* will start the drawing of a graph. However, an error message will be displayed if a headwater or a determinand has not been selected. *Display data* generates a scrolling window containing the data from the selected datafile for the headwater selected. *Graph display* allows the user to zoom and scale the graph within the display window. The *Graph display* options have not been fully implemented in this version of CATGRAPH. The *close* option will clear the current display window.

(b) *Headwater*

The *headwater* option enables the user to select the headwater from which the longitudinal plot should begin. When the option is selected a headwater selection window is generated. This displays a scrolling window containing a list of the headwaters selected in the datafile. A headwater is identified by clicking the mouse over the name of the required headwater. A double click over a headwater name will select it and the headwater window will be cleared. Alternatively, the headwater is selected by clicking the mouse over the *OK* option at the bottom of the window.

(c) *Determinand*

The *determinand* options allows the user to select the determinand to be plotted. When this option is selected a list of determinands available in the datafile is displayed in a window. The determinand is selected by clicking the mouse over the determinand name. The current selected determinand is identified by a square mark next to it. Only one determinand can be selected at any one time.

(d) Option

The selection of this option from the menu bar enables the user to adjust the nature of the graph drawn. When this option is selected a sub-menu of four options; *values, targets, flowgraph* and *confidence limits* is displayed. The *values* option enables the user to select which percentile should be plotted. The name and type of percentiles available depends on the data contained within the datafile. The *target* option is designed to enable the user to define a standard quality to be displayed on the graph. This option has not been fully implemented within this version of CATGRAPH. The *flow graph* option enables the user to generate a second line on the graph within a separate y axis on the right hand side of the graph showing the longitudinal changes in flow. This feature is useful when trying to make sense of a quality determinand plot. The *confidence limit* option allows the confidence limits of a determined simulation to be displayed on the graph.

(e) *Features*

This option has not been fully implemented within this version of CATGRAPH. If developed, this option would enable the user to add names of features to the graph.

(f) *Help*

The Help window text has not been added to this version of CATGRAPH.

(g) Selection display area

The selection display area is below the graph drawing area of the display window. This area shows the headwater, determinand, datafile name and percentile selected by the user. If a headwater has not been selected this is indicated by the message <Not Yet Selected> where the name of a headwater should be located.

3.2.4 Distribution display window

This option enables the user to display the simulated distribution of a determinand at selected locations within the catchment. These locations depend upon the simulation mode of SIMCAT and whether observed data are available or not.

An example of an empty distribution display window is shown in Figure 3.4. This is the display generated when a .SDG datafile has been selected.

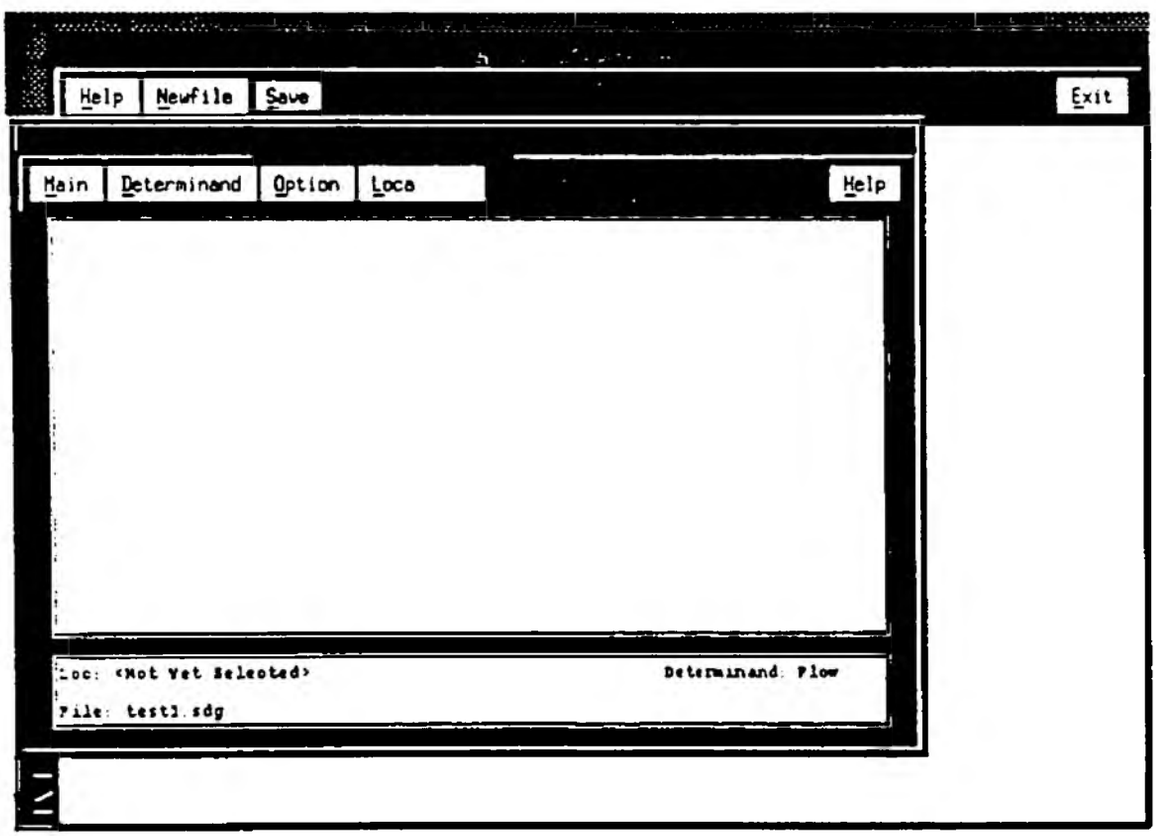


Figure 3.4 Example of the Distributional Display Window

The layout is very similar to that of the Longitudinal Display window described in Section 3.2.3. There is a title bar, a menu bar, a graph area and a option selected display area.

At the top of the display is the screen title bar. This contains the simulation title from the SIMCAT input datafile. This is transferred to CATGRAPH via the distribution graph datafile (.SDG).

The menu bar has five options, these are:

- *Main*
- *Determinand*
- *Option*
- *Location*
- *Help*

(a) *Main*

On selecting this option a sub menu is generated with four options, *new display, display data, graph display* and *close*. These are the same as the options in the longitudinal display described in Section 3.2.3.

(b) *Display*

The *determinand* option allows the user to select the determinand to be plotted. This option is the same as with the longitudinal graph display (see Section 3.2.3).

(c) *Option*

The *option* selection from the menu bar has three sub-options; linear, *cumulative* and *observed data*. Only the last of these three options is implemented in this version of CATGRAPH. The *linear* option will in future provide a choice between linear and logged plots. The *cumulative* option will provide a choice between cumulative and probability plots. Only linear/cumulative plots are produced in this version of CATGRAPH. The *observed data* option enables the observed distribution to be plotted against the simulated data. However, this option is not always available. If there are no observed data to be plotted, this option will only be displayed in a faded text.

(d) *Location*

The *location* option enables the user to select the location of the distributional plot. When the option is selected a location selection window is generated. This displays a scrolling window containing a list of the locations contained in the datafile. A location is identified by clicking the mouse over the name of the required location. A double click

over a location will select it and the location window will be cleared. Alternatively, the location can be selected by clicking the mouse over the *OK* option at the bottom of the window. If there are no data at a location, an error message will be displayed in the graph area when the *new display* option is selected.

(e) *Help*

The help window text has not been added in this version of CATGRAPH.

(f) Selection display area

This area shows the location, determinand and the datafile selected by the user. If a location has not been selected this is indicated by the message <Not Yet Selected> where the name of a location should be located.

3.2.5 Multiple displays

CATGRAPH has the facility to have multiple displays on a screen. This is done by having up to ten display windows overlaying each other. The actual number of overlaying displays depends on the size of the graphical datafiles. An example of overlaying displays is shown in Figure 3.5. The overlaying displays can be longitudinal or distributional.

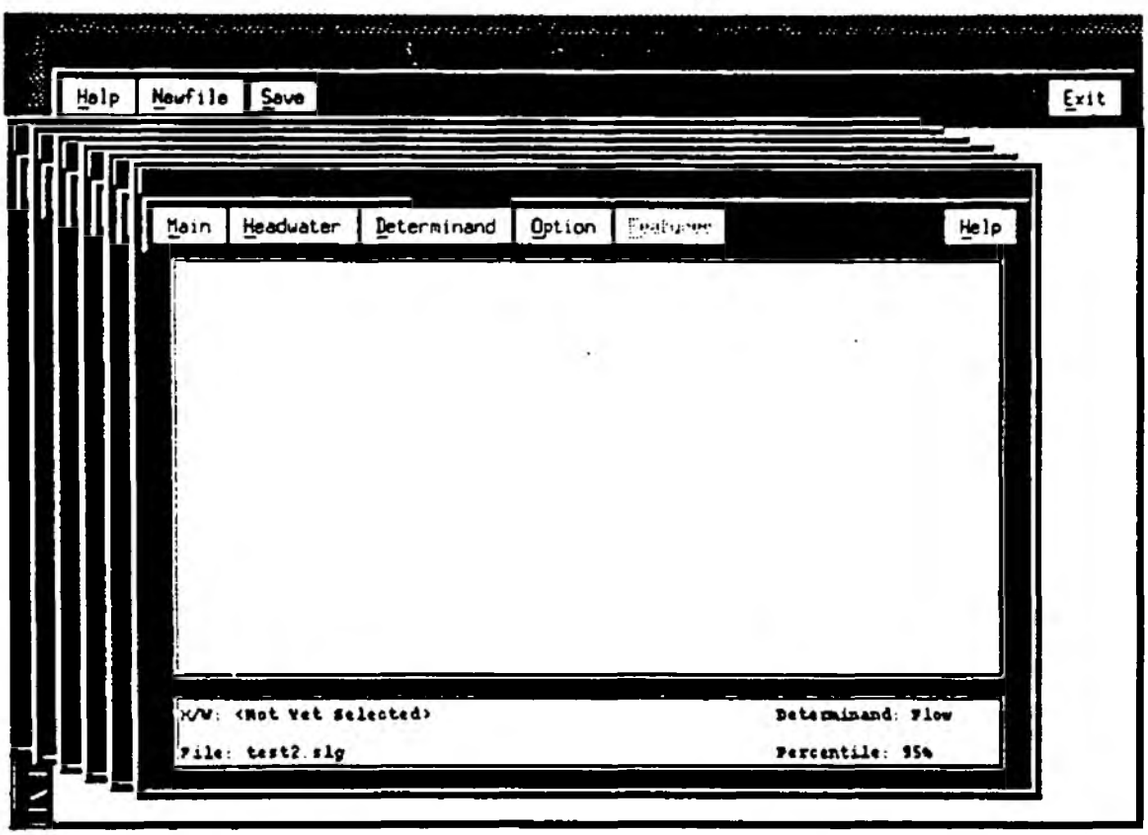


Figure 3.5 Example of Multiple Display Windows

A new display is generated by selecting the *Newfile* option from the program menu bar (see Section 3.2.1). When a new datafile other than the current datafile is selected a new display is generated on top of the current display.

The user can move between displays by clicking the mouses on the required display. This brings this selected display in front of the other displays. The individual displays are offset slightly to enable a corner of each display to be visible at all times.

This multiple graph facility enables the user to move quickly between the results of various SIMCAT simulations. This is particular useful when two alternative proposals or "before-and-after" simulations are being compared and contrasted.

3.3 Examples of graphical displays

This section gives two examples of graphical displays to illustrate the output from CATGRAPH. The SIMCAT datafile used to generate these graphs was the test catchment used in the SIMCAT User Guide. One example of a longitudinal and distribution plot has been given.

3.3.1 Test catchment

A schematic map of the test catchment has been given in Figure 3.6. The river system is split into six reaches and has two tributaries. The graphical output files generated by SIMCAT under run option Ø are given in Appendices A and B.

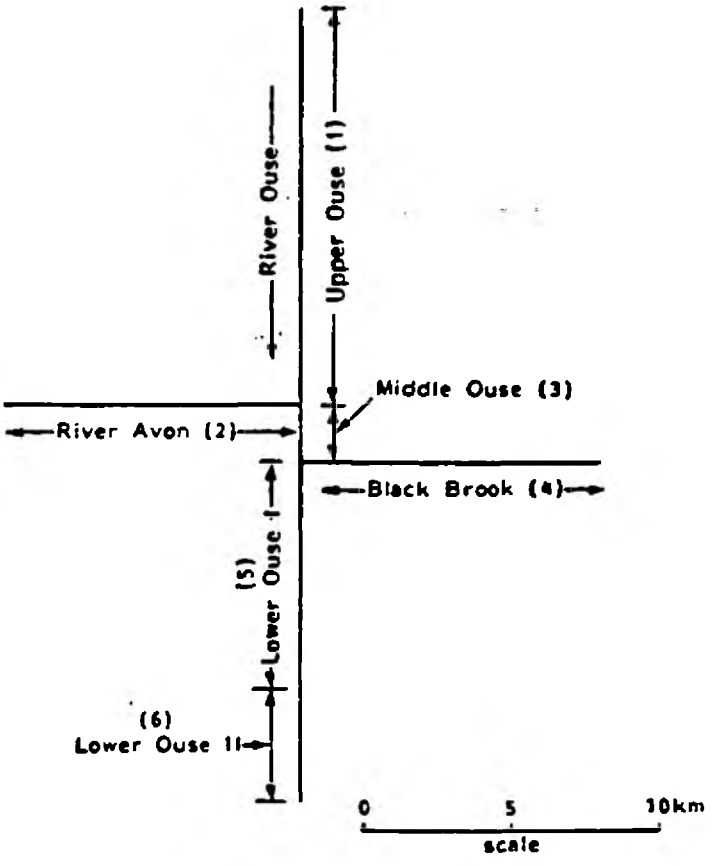


Figure 3.6 Schematic map of test catchment

3.3.2 Example of a longitudinal display

An example longitudinal plot is given in Figure 3.7. This shows a plot of the simulated dissolved oxygen (mg/l) along the River Ouse from its headwater to the defined end of the catchment. The confidence limits around the simulated dissolved oxygen are also plotted. The final feature of the graph is the flow plot which is given in the lower half of the plot. The influence on the dissolved oxygen level by the discharge from Wellington Sewage Treatment Works can be clearly seen.

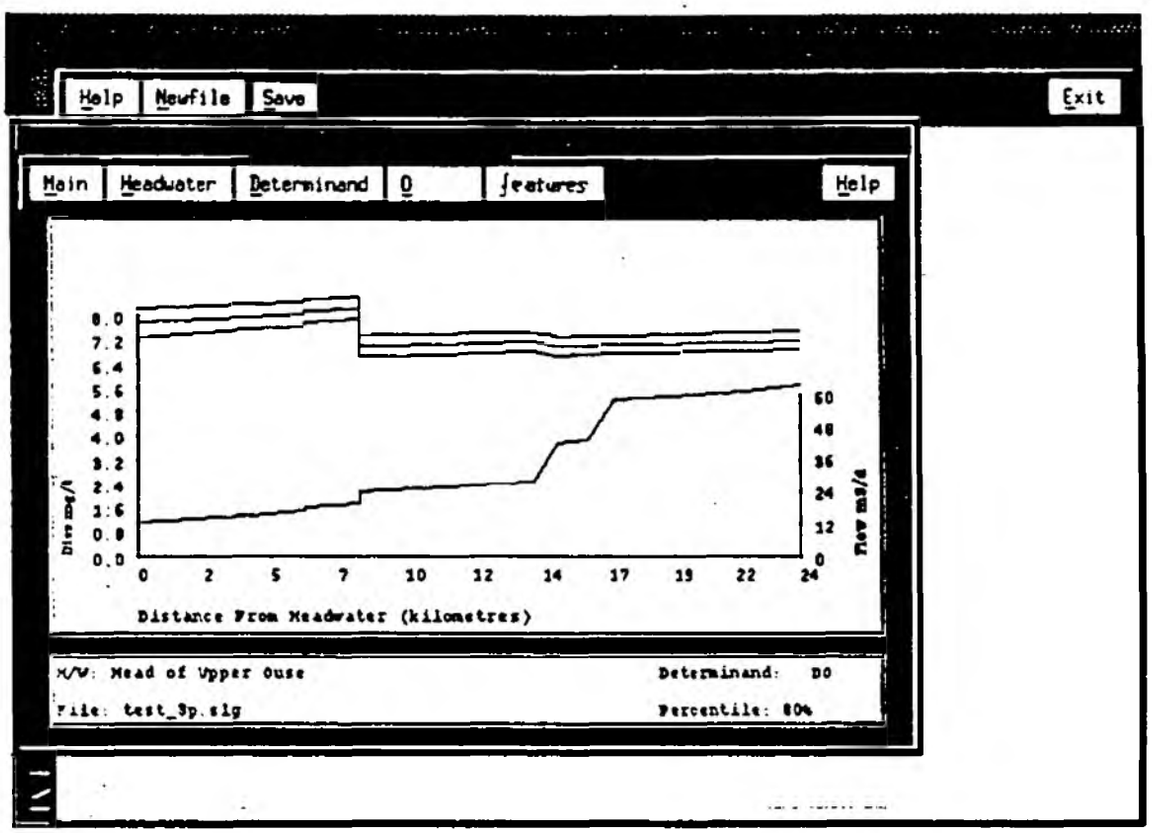


Figure 3.7 Example of longitudinal display from the test catchment

3.3.3 Example of a distributional display

An example of the distributional display is given in Figure 3.8. This shows a plot of the simulated and observed BOD distributions at the Wellington monitoring station. The fit in this case is relatively close.

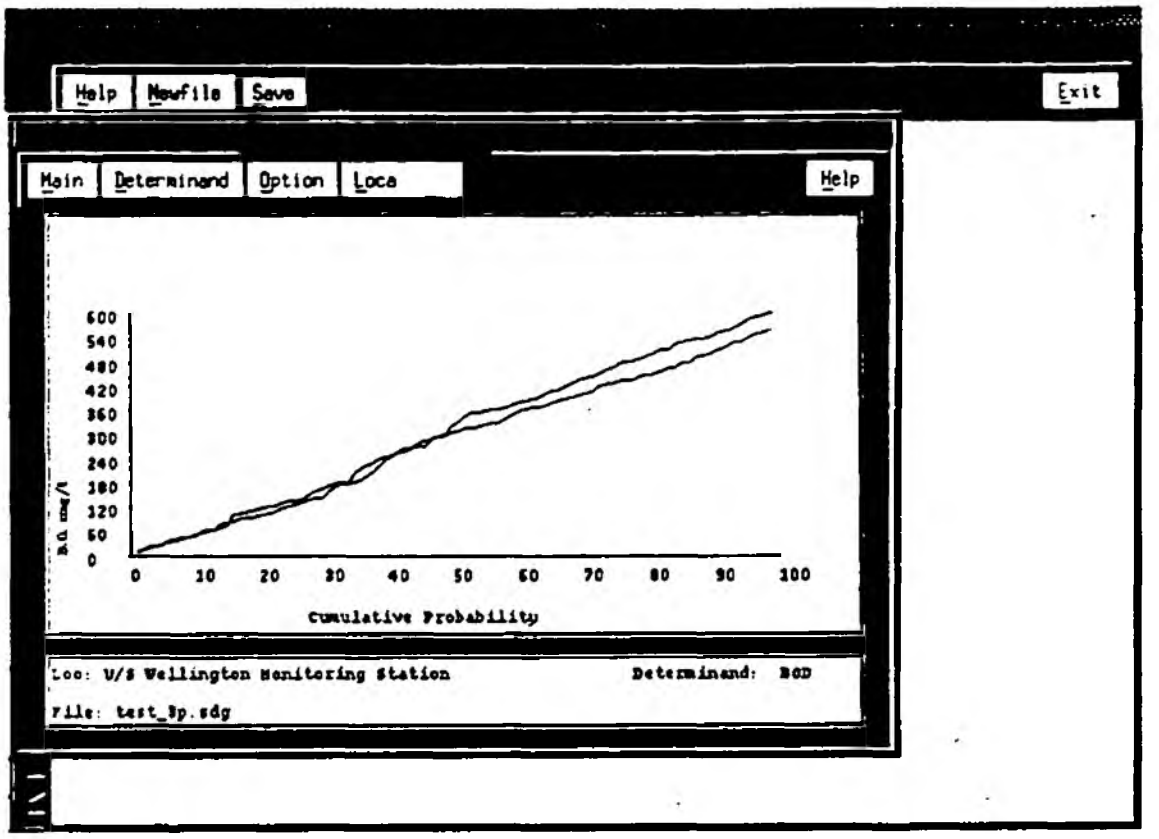


Figure 3.8 Example of distributional display from the test catchment

3.4 Possible enhancements to CATGRAPH

This section outlines a number of enhancements which should be undertaken to improve the functionability of CATGRAPH. These enhancements have been split into three parts, relating to the display windows they will affect. The final section discusses the potential future development of CATGRAPH.

3.4.1 Possible enhancements of the program window

(a) Help messages

None of the help messages have been added to the help windows available at various points in the program. The text for these help windows should be included within the program.

(b) Printer option

The current version of CATGRAPH does not have any printer drivers installed. This makes getting prints of screen displays difficult. Screen displays have to be written to file before they can be printed.

(c) Overlay option

It would be useful to be able to overlay the simulation results from two different design options. The methodology and function of this option would have to be clarified further before it could be incorporated within CATGRAPH.

3.4.2 Possible longitudinal display enhancements

(a) Title bar

The current title bar only displays the SIMCAT datafile simulation title. Given that other programs may wish to use CATGRAPH it would be useful to add a second title bar to display the name of the water quality model used to generate the graphical data. This information is included within the header section of the graphical datafiles.

(b) Observed data plot

It would be useful to display the observed values for the plotted percentile at the locations along a river. This facility is not available in the current version of CATGRAPH. The development of this feature would require adjustments to the longitudinal graphical datafile.

(c) Zoom and scale

It is not possible to zoom into a particular portions of a longitudinal plot or to scale the axes. Both these options would be useful in preparing graphical outputs.

(d) Targets

This option would enable the user to define the quality objectives for the river reach. This target value may vary with river reach. Consequently, a more detailed specification is required before this feature could be incorporated into CATGRAPH.

(e) Features

The facility to add feature names to the longitudinal display would improve its visual effectiveness. The location of these names within the display requires further thought.

3.4.3 Possible Distributional display enhancements

(a) Title bar

As with the longitudinal display the incorporation of a simulations title bar at the top of the display would be a useful feature.

(b) Cumulative/probability

The option to generate a probability plot rather than a cumulative probability would be a useful feature particularly for comparing observed versus simulated values.

(c) Linear/logged data

This option may be useful when comparing observed and simulated distributions when they are log-normal in nature.

3.4.4 Future development of CATGRAPH

The future development of CATGRAPH is linked closely with the proposed development of SIMCAT. The current situation will require SIMCAT to be run in a DOS window under the UNIX operating systems. The generated graphical output files will have to be transferred to the UNIX environment to be utilised by CATGRAPH.

If a UNIX version of SIMCAT is developed then CATGRAPH should be further developed to incorporate the enhancements outlined in Sections 3.4.1, 3.4.2 and 3.4.3. This would enable the results of large simulations, in terms of catchment size and shot numbers, to be plotted graphically with CATGRAPH.

If SIMCAT continues to be developed in DOS then a DOS equivalent of CATGRAPH needs to be developed. This could be undertaken using the WINDOWS3 package. This package was not available when this current project was initiated.

The final option for CATGRAPH is to develop it to meet the requirement of water quality models which have a UNIX version but no graphical interface.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The project has produced an prototype version of a graphical package CATGRAPH. This package runs under a UNIX operating system with pull down menus and a mouse driven user interface. Two main graphical displays are available, a longitudinal river profile and a distributional plot of simulated values of a designated location.

The graphical data is transferred from SIMCAT to the graphical package CATGRAPH via two datafiles. The layout of these datafiles has been documented. The changes in the SIMCAT source code to enable the generation of these datafiles have also been documented. It is anticipated that a number of other water quality models will also be able to generate these datafiles so that they can also make use of the graphical display packages of CATGRAPH.

Not all the options in CATGRAPH have been implemented. The current version does not generate hard copy of graphs particularly easily. Other enhancements have also been identified on Section 3.4. The work involved in implementing the majority of these features and enhancements is relatively small.

The long term future of this package is linked with the proposed development of SIMCAT. A new DOS version of the program has just been released which has up to 500 shots. If SIMCAT continues to be developed for use under the DOS operating system, the use of CATGRAPH by SIMCAT will be limited. However, if other water quality models (e.g. MONTEQUAL - estuarine model) are developed under a UNIX operating environment CATGRAPH may be used for the graphical display. Alternatively, a UNIX version of SIMCAT may be developed.

Another spin-off of this project is the development of a design specification for the graphic display. This could be used to produce a DOS equivalent to CATGRAPH.

4.2 Recommendations

As discussed in Section 3.4.4, the development of CATGRAPH is linked closely with the proposed development of SIMCAT and similar water quality models. The recommendations for future work relate closely to those developments. The various options are given below:

(a) SIMCAT continues to be developed under a DOS operating environment

The UNIX version of CATGRAPH is unlikely to be utilised. Therefore, it is suggested that the design specification for CATGRAPH is used as a basis to develop a DOS equivalent.

(b) UNIX version of SIMCAT is developed

The existing version of CATGRAPH should be enhanced to incorporate the outstanding the features and options

(c) UNIX versions of other similar water quality models are developed.

There is an NRA project to develop a stochastic water quality model for estuaries which is equivalent to the river based SIMCAT. If the development of this model is under a UNIX operating system, it is recommended that the existing version of CATGRAPH is enhanced and adjusted to be utilised by this model.

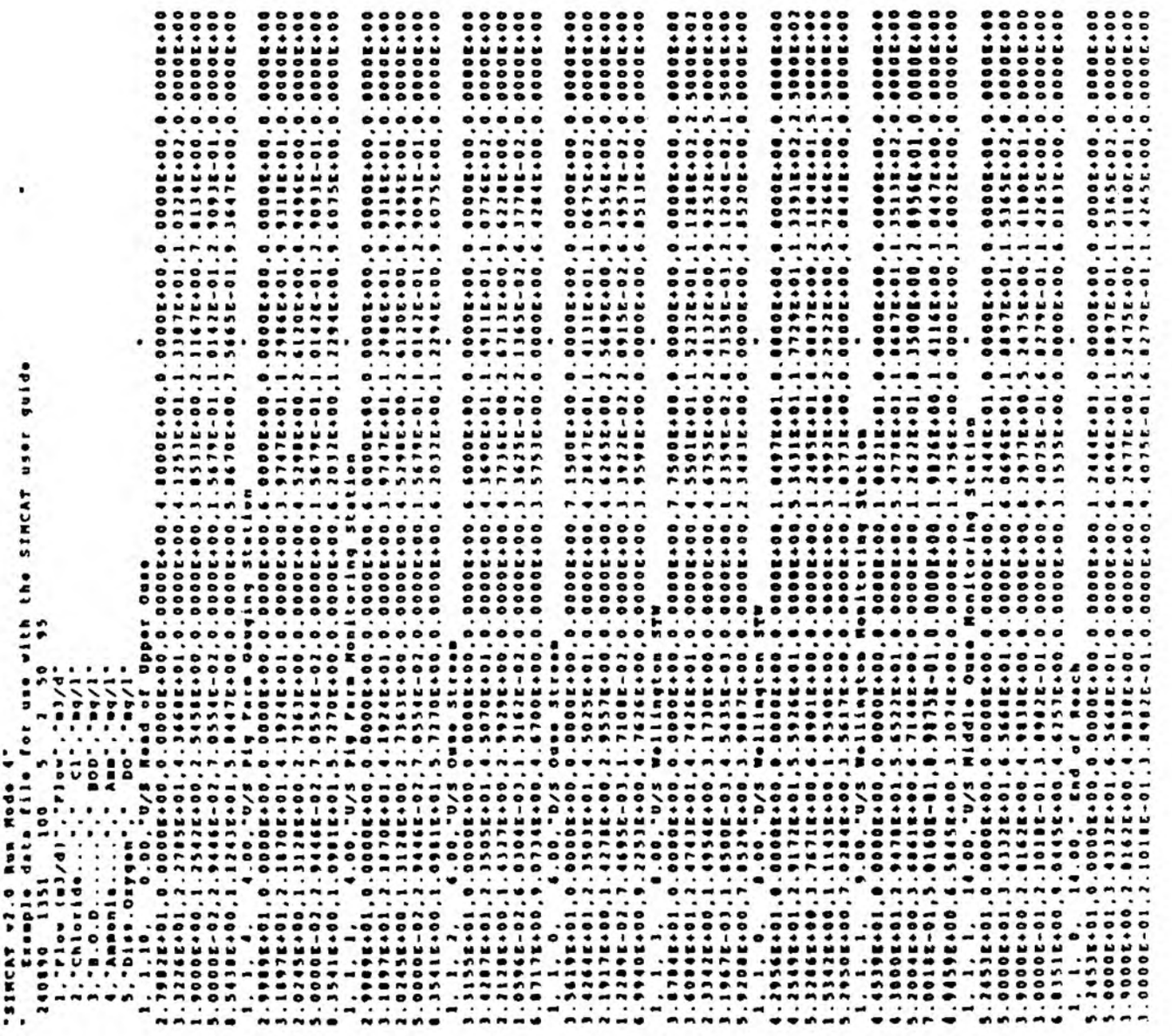
At this stage it is not possible to indicate which option should be checked. This selection depends on the requirements of the NRA and the proposed development of SIMCAT.

REFERENCES

CROCKETT C P and CRABTREE R W (1990). Model for Consent Conditions for Continuous Discharges - Project Report. WRc, PRS 2511-M.

CROCKETT C P, CRABTREE R W and WARN A E (1990). SIMCAT User Guide, WRc, PRS 2386-SW.

APPENDIX A - EXAMPLE OF THE LONGITUDINAL (.SLG) DATAFILE STRUCTURE



```
 4, 1, 3,   1.00,'U/S Appleford STW                                    '
3.9994E+00,0.0000E+00,0.0000E+00,0.0000E+00,4.1000E-01,0.0000E+00,0.0000E+00,0.0000E+00
3.5253E+01,2.4099E+01,4.6407E+01,0.0000E+00,4.7810E+01,1.8019E+01,1.1424E+02,2.5000E+02
2.0632E+00,1.3637E+00,2.7627E+00,0.0000E+00,4.2038E+00,2.3232E+00,8.4090E+00,8.0000E+00
4.0308E-02,2.3678E-02,5.6937E-02,0.0000E+00,1.3045E-01,8.5659E-02,2.3909E-01,3.0000E+00
0.4575E+00,1.1102E+01,5.8128E+00,0.0000E+00,7.0237E+00,2.0165E+00,1.0451E+01,0.0000E+00
 4, 3, 0,   3.00,'D/S Appleford STW                                    '
6.1403E+00,0.0000E+00,0.0000E+00,0.0000E+00,2.2560E+00,0.0000E+00,0.0000E+00,0.0000E+00
6.2393E+01,4.2572E+01,8.2214E+01,0.0000E+00,8.4008E+01,3.1046E+01,2.0229E+02,2.5000E+02
7.8348E+00,5.7704E+00,9.8992E+00,0.0000E+00,1.5709E+01,9.8375E+00,2.6628E+01,8.0000E+00
5.6557E+00,4.2851E+00,7.4263E+00,0.0000E+00,1.3370E+01,8.8578E+00,2.1661E+01,3.0000E+00
5.8369E+00,7.6173E+00,4.0524E+00,0.0000E+00,3.3402E+00,1.2088E-03,5.6661E+00,0.0000E+00
 4, 3, 0,  10.00,' End of Reach                                        '
2.0139E+01,0.0000E+00,0.0000E+00,0.0000E+00,3.2828E+00,0.0000E+00,0.0000E+00,0.0000E+00
4.5264E+01,3.0756E+01,5.9773E+01,0.0000E+00,7.2034E+01,3.3228E+01,1.5693E+02,2.5000E+02
3.9463E+00,2.8724E+00,5.0162E+00,0.0000E+00,8.2753E+00,5.2211E+00,1.3996E+01,8.0000E+00
2.6040E+00,1.8194E+00,3.3885E+00,0.0000E+00,7.5095E+00,5.2572E+00,1.1759E+01,3.0000E+00
7.4756E+00,9.7184E+00,5.2327E+00,0.0000E+00,5.4219E+00,1.2204E+00,8.3486E+00,0.0000E+00
 5, 1, 1,  17.00,'U/S New Mill Monitoring Station                      '
8.3976E+01,0.0000E+00,0.0000E+00,0.0000E+00,1.3000E+01,0.0000E+00,0.0000E+00,0.0000E+00
5.3000E+01,3.6384E+01,6.9616E+01,0.0000E+00,6.4846E+01,2.0513E+01,1.6345E+02,0.0000E+00
4.1002E+00,3.0047E+00,5.1957E+00,0.0000E+00,9.1524E+00,6.0339E+00,1.4970E+01,0.0000E+00
3.0000E-01,2.2064E-01,3.7936E-01,0.0000E+00,7.2394E-01,4.9608E-01,1.1413E+00,0.0000E+00
7.6895E+00,1.0074E+01,5.3046E+00,0.0000E+00,3.4848E+00,0.0000E+00,6.5969E+00,0.0000E+00
 5, 1, 4,  17.00,'U/S New Mill Flow Gauging Station                    '
8.3976E+01,0.0000E+00,0.0000E+00,0.0000E+00,1.3000E+01,0.0000E+00,0.0000E+00,0.0000E+00
5.3000E+01,3.6384E+01,6.9616E+01,0.0000E+00,6.4846E+01,2.0513E+01,1.6345E+02,0.0000E+00
4.1002E+00,3.0047E+00,5.1957E+00,0.0000E+00,9.1524E+00,6.0339E+00,1.4970E+01,0.0000E+00
3.0000E-01,2.2064E-01,3.7936E-01,0.0000E+00,7.2394E-01,4.9608E-01,1.1413E+00,0.0000E+00
7.6695E+00,1.0074E+01,5.3046E+00,0.0000E+00,3.4848E+00,0.0000E+00,6.5969E+00,0.0000E+00
 5, 1, 1,  22.00,'U/S Tomply Monitoring Station                        '
8.0975E+01,0.0000E+00,0.0000E+00,0.0000E+00,1.3367E+01,0.0000E+00,0.0000E+00,0.0000E+00
5.0000E+01,3.6332E+01,6.5668E+01,0.0000E+00,6.0696E+01,1.8897E+01,1.5365E+02,0.0000E+00
3.9000E+00,2.8744E+00,4.9256E+00,0.0000E+00,8.2976E+00,5.3811E+00,1.3719E+01,0.0000E+00
1.0000E-01,7.0036E-02,1.2996E-01,0.0000E+00,3.1358E-01,2.2754E-01,4.7569E-01,0.0000E+00
6.8351E+00,8.9525E+00,4.7178E+00,0.0000E+00,3.1536E+00,0.0000E+00,5.9165E+00,0.0000E+00
 5, 1, 0,  24.00,' End of Reach                                        '
9.2975E+01,0.0000E+00,0.0000E+00,0.0000E+00,1.3660E+01,0.0000E+00,0.0000E+00,0.0000E+00
4.8559E+01,3.3344E+01,6.3774E+01,0.0000E+00,5.8883E+01,1.8293E+01,1.6914E+02,0.0000E+00
3.7991E+00,2.8066E+00,4.7915E+00,0.0000E+00,7.9105E+00,5.0897E+00,1.3146E+01,0.0000E+00
6.6154E-02,4.5502E-02,8.6805E-02,0.0000E+00,2.2292E-01,1.6376E-01,3.3544E-01,0.0000E+00
6.8929E+00,9.0221E+00,4.7636E+00,0.0000E+00,3.2908E+00,0.0000E+00,6.0693E+00,0.0000E+00
 0, 0, 0,   0.00,' End of Simulation                                   '
  5   3
'Upper Ouse       '
'River Avon       '
'Middle Ouse      '
'Black Brook      '
'Lower Ouse I     '
'Head of Upper Ouse           '
'Head of River Avon           '
'Head of Black Brook          '
```

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6.8351E+00,9.0445E+00,4.6257E+00,0.0000E+00,3.1535E+00,0.0000E+00,6.0183E+00,0.0000E+00
  2, 2,10,    0.00,'U/S Head of River Avon
3.9967E+00,0.0000E+00,0.0000E+00,0.0000E+00,1.2000E+00,0.0000E+00,0.0000E+00,0.0000E+00
3.5000E+01,2.4011E+01,4.5989E+01,0.0000E+00,4.3694E+01,1.4170E+01,1.0894E+02,0.0000E+00
1.8000E+00,1.1830E+00,2.4170E+00,0.0000E+00,3.6751E+00,2.0152E+00,7.4703E+00,0.0000E+00
1.0000E-01,5.8893E-02,1.4111E-01,0.0000E+00,3.1358E-01,2.0283E-01,5.4186E-01,0.0000E+00
8.5438E+00,1.1243E+01,5.8447E+00,0.0000E+00,5.8670E+00,7.5665E-01,9.3647E+00,0.0000E+00
  2, 2, 3,    3.00,'U/S Brichton STW
6.6506E+00,0.0000E+00,0.0000E+00,0.0000E+00,1.5891E+00,0.0000E+00,0.0000E+00,0.0000E+00
3.2845E+01,2.2523E+01,4.3166E+01,0.0000E+00,4.2133E+01,1.4586E+01,1.0345E+02,2.5000E+02
1.2787E+00,6.6251E-01,1.8948E+00,0.0000E+00,2.1165E+00,1.0017E+00,4.6247E+00,5.0000E+00
2.5148E-02,1.4993E-02,3.5303E-02,0.0000E+00,7.7494E-02,5.0111E-02,1.4345E-01,1.5000E+00
7.7280E+00,1.0174E+01,5.2816E+00,0.0000E+00,4.9584E+00,3.2657E-01,8.1285E+00,0.0000E+00
  2, 2, 0,    3.00,'D/S Brichton STW
9.6798E+00,0.0000E+00,0.0000E+00,0.0000E+00,4.1625E+00,0.0000E+00,0.0000E+00,0.0000E+00
5.4738E+01,3.7496E+01,7.1981E+01,0.0000E+00,7.0015E+01,2.3984E+01,1.7254E+02,2.5000E+02
1.0536E+01,7.6160E+00,1.3455E+01,0.0000E+00,2.3500E+01,1.5125E+01,3.9075E+01,5.0000E+00
4.5300E+00,3.3454E+00,5.7146E+00,0.0000E+00,9.5024E+00,6.1028E+00,1.5714E+01,1.5000E+00
5.3459E+00,7.0388E+00,3.6530E+00,0.0000E+00,2.7786E+00,0.0000E+00,4.9793E+00,0.0000E+00
  2, 2, 4,    9.00,'U/S Valley Bottom Gauging Station
1.4988E+01,0.0000E+00,0.0000E+00,0.0000E+00,5.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
6.6701E+01,3.1913E+01,8.1489E+01,0.0000E+00,6.3904E+01,2.4403E+01,1.5203E+02,0.0000E+00
3.9023E+00,2.8953E+00,4.9092E+00,0.0000E+00,8.5212E+00,5.6414E+00,1.3791E+01,0.0000E+00
5.0018E-01,3.5032E-01,6.5003E-01,0.0000E+00,1.5088E+00,1.1381E+00,2.3791E+00,0.0000E+00
5.6103E+00,7.4318E+00,3.7888E+00,0.0000E+00,1.7878E+00,0.0000E+00,4.1557E+00,0.0000E+00
  2, 2, 1,    9.00,'U/S Valley Bottom Monitoring Station
1.4988E+01,0.0000E+00,0.0000E+00,0.0000E+00,5.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
6.6701E+01,3.1913E+01,8.1489E+01,0.0000E+00,6.3904E+01,2.4403E+01,1.5203E+02,0.0000E+00
3.9023E+00,2.8953E+00,4.9092E+00,0.0000E+00,8.5212E+00,5.6414E+00,1.3791E+01,0.0000E+00
5.0018E-01,3.5032E-01,6.5003E-01,0.0000E+00,1.5684E+00,1.1381E+00,2.3791E+00,0.0000E+00
5.6103E+00,7.4318E+00,3.7888E+00,0.0000E+00,1.7878E+00,0.0000E+00,4.1557E+00,0.0000E+00
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6.5306E+01,3.0943E+01,5.9668E+01,0.0000E+00,6.2763E+01,2.4394E+01,1.4839E+02,0.0000E+00
3.4387E+00,2.5632E+00,4.3062E+00,0.0000E+00,7.2824E+00,4.7930E+00,1.1821E+01,0.0000E+00
3.4389E-01,2.3750E-01,4.4948E-01,0.0000E+00,1.1492E+00,8.4536E-01,1.7256E+00,0.0000E+00
5.7601E+00,7.6192E+00,3.9011E+00,0.0000E+00,2.0205E+00,0.0000E+00,4.4371E+00,0.0000E+00
  3, 1, 3,   15.00,'U/S Allied Industries
7.0561E+01,0.0000E+00,0.0000E+00,0.0000E+00,1.7730E+01,0.0000E+00,0.0000E+00,0.0000E+00
4.8682E+01,3.3402E+01,6.3963E+01,0.0000E+00,6.2251E+01,2.1477E+01,1.5297E+02,2.5000E+02
3.7614E+00,2.8046E+00,4.7182E+00,0.0000E+00,8.2148E+00,5.4012E+00,1.3201E+01,5.0000E+00
3.0907E-01,2.1639E-01,6.0175E-01,0.0000E+00,9.8795E-01,7.2183E-01,1.4894E+00,1.5000E+00
6.5626E+00,8.6508E+00,4.4784E+00,0.0000E+00,3.5046E+00,0.0000E+00,6.2192E+00,0.0000E+00
  3, 1, 0,   15.00,'D/S Allied Industries
7.0637E+01,0.0000E+00,0.0000E+00,0.0000E+00,1.7762E+01,0.0000E+00,0.0000E+00,0.0000E+00
4.9124E+01,3.3642E+01,6.4607E+01,0.0000E+00,6.2620E+01,2.1348E+01,1.5478E+02,2.5000E+02
3.6475E+00,2.8551E+00,4.0400E+00,0.0000E+00,8.4643E+00,5.6350E+00,1.3660E+01,5.0000E+00
3.0856E-01,2.1606E-01,6.0105E-01,0.0000E+00,9.8614E-01,7.2055E-01,1.4866E+00,1.5000E+00
6.5546E+00,8.6404E+00,4.4607E+00,0.0000E+00,3.4984E+00,0.0000E+00,6.2099E+00,0.0000E+00
  3, 1, 0,   16.00,' End of Reach
7.2637E+01,0.0000E+00,0.0000E+00,0.0000E+00,1.7909E+01,0.0000E+00,0.0000E+00,0.0000E+00
4.8763E+01,3.3390E+01,6.0130E+01,0.0000E+00,6.2410E+01,2.1426E+01,1.5394E+02,2.5060E+02
3.8090E+00,2.8276E+00,4.7903E+00,0.0000E+00,8.3752E+00,5.5777E+00,1.3519E+01,5.0000E+00
3.0323E-01,2.1209E-01,3.9436E-01,0.0000E+00,9.7006E-01,7.1640E-01,1.8714E+00,1.5000E+00
6.5872E+00,8.6804E+00,4.4941E+00,0.0000E+00,3.5794E+00,0.0000E+00,6.3004E+00,0.0000E+00
  4, 3,10,    0.00,'U/S Head of Black Brook
9.9960E-01,0.0000E+00,0.0000E+00,0.0000E+00,2.0000E-01,0.0000E+00,0.0000E+00,0.0000E+00
4.0100E+01,2.7534E+01,5.2666E+01,0.0000E+00,4.8734E+01,1.5269E+01,1.2329E+02,0.0000E+00
1.9000E+00,1.2431E+00,2.5569E+00,0.0000E+00,3.9209E+00,2.1525E+00,7.0751E+00,0.0000E+00
4.0000E-02,2.3557E-02,5.6443E-02,0.0000E+00,1.2543E-01,8.1132E-02,2.3275E-01,0.0000E+00
9.0000E+00,1.1819E+01,6.1807E+00,0.0000E+00,7.3355E+00,1.9976E+00,1.0989E+01,0.0000E+00
  4, 3, 1,    2.00,'U/S Black Brook Monitoring Station
2.9995E+00,0.0000E+00,0.0000E+00,0.0000E+00,3.4000E-01,0.0000E+00,0.0000E+00,0.0000E+00
3.5900E+01,2.4560E+01,4.7240E+01,0.0000E+00,4.8012E+01,1.7729E+01,1.1552E+02,0.0000E+00
2.0178E+00,1.3257E+00,2.7000E+00,0.0000E+00,4.0835E+00,2.2353E+06,8.3036E+00,0.0000E+00
4.0003E-02,2.3560E-02,5.6446E-02,0.0000E+00,1.2541E-01,8.1133E-02,2.3274E-01,0.0000E+00
8.3539E+00,1.0973E+01,5.7345E+00,0.0000E+00,6.5556E+00,1.5963E+00,9.9499E+00,0.0000E+00
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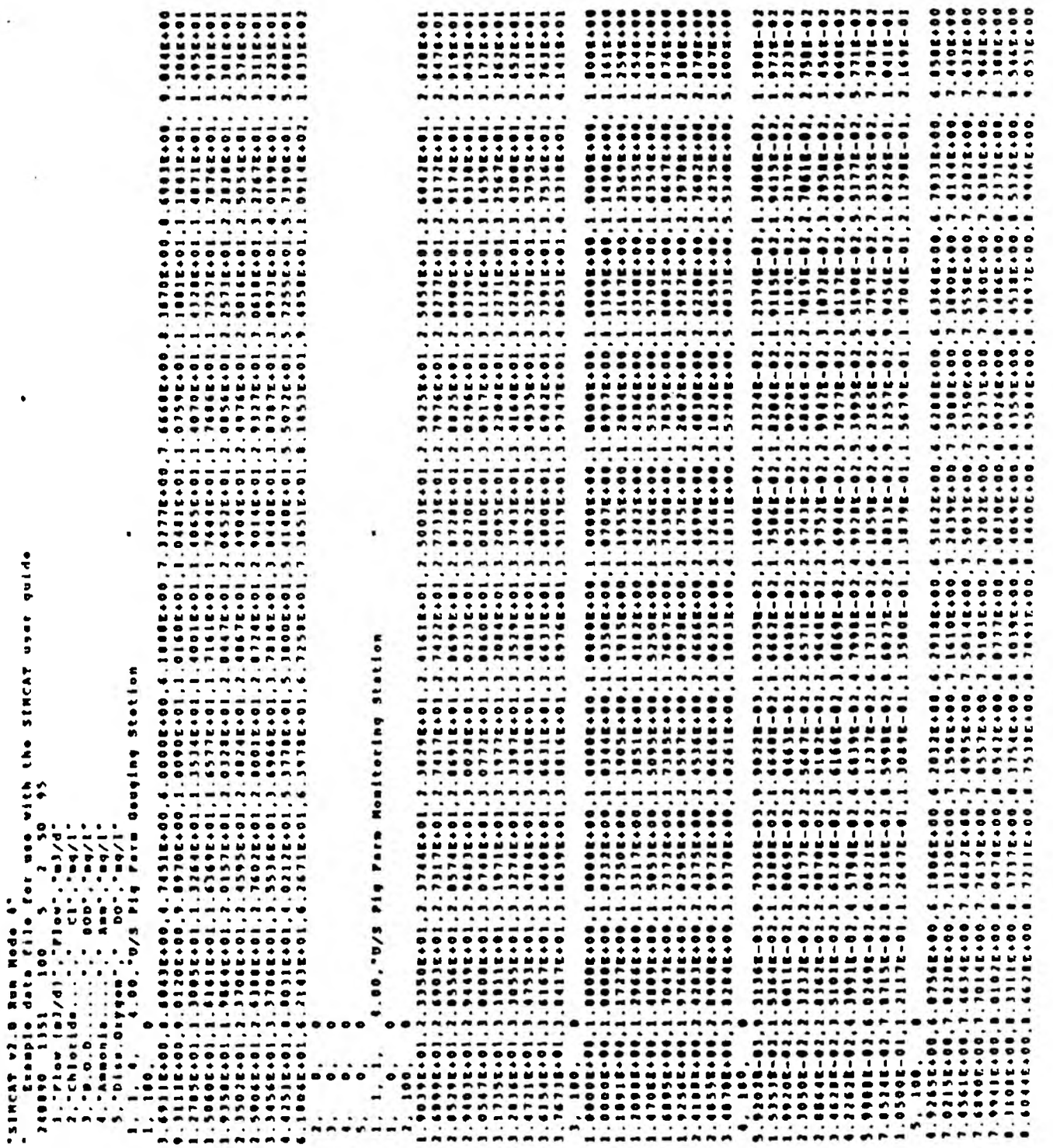
APPENDIX B - EXAMPLE OF THE DISTRIBUTIONAL (.SDG) DATAFILE STRUCTURE



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9.4888E+00,9.4922E+00,9.5705E+00,9.4160E+00,9.6165E+00,9.6810E+00,9.6989E+00,9.8186E+00,9.8572E+00, 9.861E+00
9.8838E+00,1.0092E+01,1.0151E+01,1.0198E+01,1.0241E+01,1.0279E+01,1.0447E+01,1.0686E+01,1.0865E+01, 1.089E+01
 1, 1, 3,    8.00,"U/S Wellington STW                                    '
 1, 100,    0
4.1708E+00,5.4614E+00,5.6961E+00,7.7500E+00,8.0536E+00,1.0113E+01,1.0659E+01,1.1270E+01,1.1779E+01, 1.231E+01
1.2712E+01,1.3466E+01,1.3594E+01,1.3880E+01,1.3965E+01,1.4461E+01,1.4871E+01,1.5344E+01,1.6507E+01, 1.674E+01
1.7796E+01,1.6107E+01,1.6472E+01,1.6850E+01,1.9500E+01,1.9588E+01,1.9595E+01,1.9952E+01,2.0696E+01, 2.061E+01
2.0955E+01,2.2438E+01,2.2715E+01,2.2992E+01,2.3762E+01,2.4419E+01,2.4449E+01,2.4541E+01,2.4695E+01, 2.637E+01
2.6595E+01,2.7233E+01,2.7600E+01,2.7813E+01,2.7962E+01,2.8216E+01,2.8488E+01,3.0560E+01,3.0866E+01, 3.104E+01
3.1669E+01,3.1909E+01,3.2951E+01,3.3218E+01,3.3268E+01,3.3311E+01,3.3394E+01,3.3440E+01,3.3464E+01, 3.429E+01
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4.2581E+01,4.2915E+01,4.4656E+01,4.6044E+01,4.6856E+01,4.7444E+01,4.7760E+01,4.7941E+01,4.9071E+01, 5.115E+01
5.3710E+01,5.8564E+01,5.9797E+01,6.6083E+01,6.6032E+01,6.6476E+01,6.7688E+01,7.0537E+01,7.8713E+01, 7.397E+01
7.6506E+01,7.6952E+01,7.7644E+01,7.9372E+01,8.3715E+01,9.2232E+01,1.0273E+02,1.2099E+02,1.4076E+02, 2.476E+02
 2, 100,    0
2.3888E+01,2.7769E+01,2.8134E+01,2.9025E+01,2.9192E+01,2.9507E+01,2.9668E+01,3.0079E+01,3.0202E+01, 3.066E+01
3.0692E+01,3.0784E+01,3.0790E+01,3.0869E+01,3.1077E+01,3.1710E+01,2.1810E+01,3.1632E+01,3.1649E+01, 3.190E+01
3.1942E+01,3.1964E+01,3.1977E+01,3.2122E+01,3.2216E+01,3.2240E+01,3.2315E+01,3.2668E+01,3.2497E+01, 3.300E+01
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4.0600E+01,4.1648E+01,4.1859E+01,4.1899E+01,4.1940E+01,4.2068E+01,4.2332E+01,4.2742E+01,4.2975E+01, 4.303E+01
4.3367E+01,4.4002E+01,4.4312E+01,4.4554E+01,4.5209E+01,4.5291E+01,4.5501E+01,4.6013E+01,4.7350E+01, 4.830E+01
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1.6474E+00,1.6636E+00,1.6706E+00,1.6824E+00,1.7210E+00,1.7843E+00,1.8206E+00,1.8294E+00,1.8377E+00, 1.923E+00
1.9500E+00,1.9571E+00,1.9595E+00,1.9617E+00,2.0443E+00,2.0604E+00,2.1056E+00,2.1563E+00,2.2053E+00, 2.244E+00
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3.7055E+00,3.8225E+00,3.9094E+00,4.1931E+00,4.2813E+00,4.2839E+00,4.2970E+00,4.3439E+00,4.4425E+00, 4.448E+00
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5.4208E+00,5.4215E+00,5.5276E+00,5.6839E+00,5.6999E+00,5.7216E+00,5.7570E+00,5.7825E+00,5.8013E+00, 5.806E+00
5.8333E+00,5.8535E+00,5.9343E+00,5.9696E+00,6.0190E+00,6.1151E+00,6.1297E+00,6.1774E+00,6.2022E+00, 6.337E+00
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7.7790E+00,7.8760E+00,7.9501E+00,7.9843E+00,8.0317E+00,8.0354E+00,8.0696E+00,8.1313E+00,8.1506E+00, 8.209E+00
8.4150E+00,8.4526E+00,8.5865E+00,8.7076E+00,8.8833E+00,8.9361E+00,8.4931E+00,9.6362E+00,9.6825E+00, 9.958E+00
 1, 1, 0,    8.00,"D/S Wellington STW                                    '
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1.5161E+01,1.5639E+01,1.5994E+01,1.6371E+01,1.6919E+01,1.7218E+01,1.7888E+01,1.8675E+01,1.9218E+01, 2.057E+01
2.0820E+01,2.0949E+01,2.0976E+01,2.2236E+01,2.2953E+01,2.3325E+01,2.3461E+01,2.3594E+01,2.3845E+01, 2.462E+01
2.4747E+01,2.5085E+01,2.6614E+01,2.6701E+01,2.6712E+01,2.6795E+01,2.7414E+01,2.7458E+01,2.7970E+01, 2.945E+01
3.0207E+01,3.0932E+01,3.1607E+01,3.1662E+01,3.2280E+01,3.2311E+01,3.3337E+01,3.3531E+01,3.4636E+01, 3.521E+01
3.5778E+01,3.6583E+01,3.6730E+01,3.6844E+01,3.6885E+01,3.7180E+01,3.7803E+01,3.8305E+01,3.8613E+01, 3.928E+01
```

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4.6626E+01,4.8528E+01,4.9023E+01,4.9412E+01,4.9843E+01,5.0644E+01,5.1298E+01,5.2600E+01,5.3328E+01, 5.563E+01
6.0445E+01,6.3232E+01,6.6041E+01,7.2156E+01,7.2689E+01,7.2693E+01,7.2084E+01,7.0269E+01,7.9529E+01, 7.063E+01
8.0047E+01,8.0998E+01,8.5403E+01,8.6171E+01,9.0242E+01,9.9583E+01,1.0859E+02,1.2799E+02,1.4690E+02, 2.548E+02
 2, 100,    0
2.7802E+01,3.1671E+01,3.2190E+01,3.2420E+01,3.2836E+01,3.3699E+01,3.4182E+01,3.4403E+01,3.4964E+01, 3.522E+01
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4.9920E+00,5.1117E+00,5.3188E+00,5.3867E+00,5.4797E+00,5.6222E+00,5.9011E+00,6.0014E+00,6.0104E+00, 6.069E+00
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7.6638E+00,7.6805E+00,7.8100E+00,8.1997E+00,8.2203E+00,8.2943E+00,8.5384E+00,9.0778E+00,9.2894E+00, 9.346E+00
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1.0903E+00,1.1176E+00,1.1720E+00,1.1876E+00,1.1876E+00,1.2231E+00,1.2422E+00,1.2434E+00,1.2742E+00, 1.300E+00
1.3016E+00,1.3419E+00,1.3455E+00,1.3527E+00,1.3541E+00,1.3548E+00,1.3652E+00,1.3687E+00,1.3937E+00, 1.425E+00
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2.2030E+00,2.2066E+00,2.2152E+00,2.2800E+00,2.3016E+00,2.3043E+00,2.3110E+00,2.3179E+00,2.3905E+00, 3.492E+00
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7.6473E+00,7.9278E+00,8.0827E+00,8.1101E+00,8.1802E+00,8.2675E+00,8.5362E+00,8.0359E+00,9.0815E+00, 9.277E+00
 1, 1, 1,    9.00,'U/S Wellington Monitoring Station                '
 1,   0,    0
 2, 100,    0
2.0428E+01,3.2489E+01,3.2891E+01,3.2978E+01,3.3322E+01,3.4212E+01,3.4660E+01,3.4699E+01,3.5347E+01, 3.562E+01
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5.0006E-01,1.2705E+00,1.4394E+00,1.4756E+00,1.6181E+00,1.9793E+00,2.1605E+00,2.1727E+00,2.4249E+00, 2.529E+00
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6.7615E+00,6.7670E+00,6.8929E+00,6.9663E+00,6.9670E+00,7.0366E+00,7.0996E+00,7.2924E+00,7.3545E+00, 7.393E+00
7.6133E+00,7.7325E+00,7.8276E+00,7.9037E+00,7.9723E+00,8.0334E+00,8.3031E+00,8.6919E+00,8.9773E+00, 9.017E+00
 1, 1, 1,  14.00,"U/S Middle Ouse Monitoring Station          "
 1,   0,    0
 2, 100,    0
3.5989E+01,4.0054E+01,4.0450E+01,4.0536E+01,4.0874E+01,4.1744E+01,4.2188E+01,4.2218E+01,4.2847E+01, 4.311E+01
4.3778E+01,4.3783E+01,4.4741E+01,4.4352E+01,4.4358E+01,4.4706E+01,4.4981E+01,4.5324E+01,4.5433E+01, 4.554E+01
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4.7999E+01,4.8072E+01,4.8244E+01,4.8273E+01,4.8381E+01,4.8406E+01,4.8450E+01,4.8708E+01,4.9120E+01, 4.945E+01
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9.6809E-01,2.9351E+00,3.1147E+00,3.1535E+00,3.3050E+00,3.6892E+00,3.8820E+00,3.8949E+00,4.1636E+00, 4.274E+00
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6.7611E+00,6.7957E+00,6.8686E+00,6.8716E+00,6.9204E+00,6.9255E+00,6.9752E+00,7.0058E+00,7.1408E+00, 7.163E+00
7.2636E+00,7.3636E+00,7.4634E+00,7.5194E+00,7.5798E+00,7.6771E+00,7.8696E+00,7.9232E+00,7.9315E+00, 8.032E+00
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 2, 2, 3,   3.00,"U/S Brickton STW                                "
 1, 100,    0
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8.7662E+00,8.8206E+00,8.8986E+00,8.9210E+00,9.0835E+00,9.3104E+00,9.3367E+00,9.3673E+00,9.3925E+00, 9.593E+00
9.6090E+00,9.6138E+00,9.6213E+00,9.7339E+00,9.9567E+00,1.0123E+01,1.0541E+01,1.0702E+01,1.1116E+01, 1.115E+01
 2, 2, 0,   3.00,"D/S Brickton STW                                "
 1, 100,    0
3.2622E+00,3.5219E+00,3.6385E+00,4.1625E+00,4.3348E+00,4.3477E+00,4.4817E+00,4.8395E+00,4.9979E+00, 5.022E+00
5.1133E+00,5.1170E+00,5.1659E+00,5.1864E+00,5.4020E+00,5.5026E+00,5.5949E+00,5.7913E+00,5.7940E+00, 5.810E+00
6.0452E+00,6.1562E+00,6.2961E+00,6.3491E+00,6.3546E+00,6.4734E+00,6.5326E+00,6.5548E+00,6.7802E+00, 6.784E+00
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4.5064E+00,4.5064E+00,4.5767E+00,4.6182E+00,4.6638E+00,4.7537E+00,4.7641E+00,4.7854E+00,4.8321E+00, 4.877E+00
4.9741E+00,5.0656E+00,5.0857E+00,5.0985E+00,5.1224E+00,5.1275E+00,5.1827E+00,5.2059E+00,5.2294E+00, 5.264E+00
5.2775E+00,5.3853E+00,5.3120E+00,5.3378E+00,5.3417E+00,5.3544E+00,5.4089E+00,5.4098E+00,5.4480E+00, 5.509E+00
5.5811E+00,5.6961E+00,5.7116E+00,5.7163E+00,5.7291E+00,6.0008E+00,6.0496E+00,6.0621E+00,6.0732E+00, 6.098E+00
6.1239E+00,6.1687E+00,6.2228E+00,6.2458E+00,6.3215E+00,6.3288E+00,6.4900E+00,6.5990E+00,6.6364E+00, 6.647E+00
6.6947E+00,6.7504E+00,6.7760E+00,6.7999E+00,6.8140E+00,7.8230E+00,7.8972E+00,7.1062E+00,7.1172E+00, 7.256E+00
7.3165E+00,7.3956E+00,7.7310E+00,7.7408E+00,7.9531E+00,8.2362E+00,8.3262E+00,8.4072E+00,8.5163E+00, 9.421E+00
 2, 2, 4,   9.00,'U/S Valley Bottom Gauging Station
 1, 100,   0
3.5216E+00,4.1305E+00,4.2213E+00,5.0000E+00,5.1131E+00,5.4200E+00,5.6087E+00,6.3064E+00,6.4856E+00, 6.671E+00
6.8121E+00,7.0745E+00,7.1191E+00,7.2183E+00,7.2545E+00,7.4192E+00,7.5607E+00,7.7235E+00,8.1226E+00, 8.209E+00
8.5630E+00,8.6691E+00,8.7935E+00,8.9220E+00,9.1431E+00,9.1733E+00,9.1754E+00,9.2968E+00,9.5494E+00, 9.587E+00
9.6372E+00,1.0140E+01,1.0234E+01,1.0328E+01,1.0569E+01,1.0812E+01,1.0822E+01,1.0853E+01,1.0906E+01, 1.148E+01
1.1551E+01,1.1768E+01,1.1893E+01,1.1965E+01,1.2016E+01,1.2103E+01,1.2189E+01,1.2905E+01,1.3010E+01, 1.308E+01
1.3286E+01,1.3369E+01,1.3729E+01,1.3821E+01,1.3838E+01,1.3853E+01,1.3882E+01,1.3898E+01,1.3913E+01, 1.419E+01
1.4253E+01,1.4444E+01,1.4920E+01,1.5076E+01,1.5355E+01,1.5467E+01,1.5587E+01,1.6155E+01,1.6700E+01, 1.701E+01
1.7141E+01,1.7263E+01,1.7904E+01,1.8421E+01,1.8725E+01,1.8948E+01,1.9071E+01,1.9137E+01,1.9569E+01, 2.028E+01
2.0973E+01,2.2251E+01,2.2311E+01,2.4141E+01,2.4148E+01,2.4258E+01,2.4559E+01,2.5258E+01,2.5301E+01, 2.609E+01
2.6691E+01,2.6795E+01,2.6960E+01,2.7364E+01,2.8369E+01,3.0290E+01,3.2572E+01,3.6357E+01,4.0229E+01, 5.848E+01
 2,   0,   0
 3,   0,   0
 4,   0,   0
 5,   0,   0
```

```
 2, 2, 1,   9.00,'U/S Valley Bottom Monitoring Station
 1,   0,   0
 2, 100,   0
2.7184E+01,3.2274E+01,3.2791E+01,3.2904E+01,3.3350E+01,3.4510E+01,3.5084E+01,3.5143E+01,3.5999E+01, 3.636E+01
3.7288E+01,3.7295E+01,3.7934E+01,3.8060E+01,3.8098E+01,3.8598E+01,3.8976E+01,3.9468E+01,3.9619E+01, 3.978E+01
3.9892E+01,3.9920E+01,3.9950E+01,4.0144E+01,4.0156E+01,4.0205E+01,4.0365E+01,4.0491E+01,4.0953E+01, 4.098E+01
4.1342E+01,4.1424E+01,4.1826E+01,4.2427E+01,4.2790E+01,4.2856E+01,4.2903E+01,4.2962E+01,4.2978E+01, 4.317E+01
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4.5571E+01,4.5697E+01,4.6003E+01,4.6015E+01,4.6222E+01,4.6287E+01,4.6454E+01,4.6585E+01,4.7165E+01, 4.726E+01
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5.1631E+01,5.1700E+01,5.1768E+01,5.1886E+01,5.1980E+01,5.2004E+01,5.2099E+01,5.3083E+01,5.4026E+01, 5.475E+01
5.4852E+01,5.6882E+01,5.5568E+01,5.5972E+01,5.5976E+01,5.6374E+01,5.6714E+01,5.7805E+01,5.8162E+01, 5.839E+01
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1.9890E+00,1.9897E+00,2.0768E+00,2.0983E+00,2.0992E+00,2.1686E+00,2.2248E+00,2.2967E+00,2.3195E+00, 2.343E+00
2.3507E+00,2.3656E+00,2.3699E+00,2.4001E+00,2.4016E+00,2.4092E+00,2.4347E+00,2.4537E+00,2.5272E+00, 2.5316+00
2.5906E+00,2.6041E+00,2.6705E+00,2.7723E+00,2.8353E+00,2.8469E+00,2.8555E+00,2.8655E+00,2.8684E+00, 2.903E+00
2.9352E+00,2.9547E+00,3.0008E+00,3.0094E+00,3.0388E+00,3.0457E+00,3.0582E+00,3.1299E+00,3.1472E+00, 3.345E+00
3.3494E+00,3.3776E+00,3.4391E+00,3.4415E+00,3.4836E+00,3.8679E+00,3.5309E+00,3.5584E+00,3.6791E+00, 3.700E+00
3.7932E+00,3.8877E+00,3.9872E+00,4.0427E+00,4.1038E+00,4.2053E+00,4.4141E+00,4.4741E+00,4.4836E+00, 4.600E+00
4.7071E+00,4.7245E+00,4.7422E+00,4.7728E+00,4.7967E+00,4.8027E+00,4.8226E+00,5.0809E+00,5.3347E+00, 5.536E+00
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6.6552E+00,7.2711E+00,7.4657E+00,7.6268E+00,7.7686E+00,7.9023E+00,8.5212E+00,9.5098E+00,1.0299E+01, 1.042E+01
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5.9988E-01,6.0316E-01,6.0666E-01,6.1284E-01,6.1778E-01,6.1907E-01,6.2419E-01,6.7839E-01,7.3396E-01, 7.791E-01
7.8570E-01,7.8759E-01,8.3277E-01,8.6036E-01,8.6068E-01,8.8852E-01,9.1295E-01,9.9497E-01,1.0230E+00, 1.041E+00
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3.2378E+00,3.2402E+00,3.4358E+00,3.4827E+00,3.4853E+00,3.6324E+00,3.7473E+00,3.8898E+00,3.9348E+00, 3.988E+00
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4.4218E+00,4.4438E+00,4.5546E+00,4.7174E+00,4.8143E+00,4.8318E+00,4.8443E+00,4.8598E+00,4.8648E+00, 4.916E+00
4.9629E+00,4.9914E+00,5.0578E+00,5.0692E+00,5.1109E+00,5.1202E+00,5.1374E+00,5.2366E+00,5.3936E+00, 5.519E+00
5.5244E+00,5.5551E+00,5.6357E+00,5.6387E+00,5.6840E+00,5.6946E+00,5.7460E+00,5.7732E+00,5.9143E+00, 5.935E+00
6.0453E+00,6.1477E+00,6.2518E+00,6.3110E+00,6.3778E+00,6.4740E+00,6.6725E+00,6.7280E+00,6.7366E+00, 6.841E+00
6.9354E+00,6.9502E+00,6.9694E+00,6.9917E+00,7.0064E+00,7.0133E+00,7.0351E+00,7.2501E+00,7.4433E+00, 7.592E+00
7.6118E+00,7.6189E+00,7.7547E+00,7.8328E+00,7.8385E+00,7.9182E+00,7.9853E+00,8.1975E+00,8.2660E+00, 8.309E+00
8.3309E+00,8.6822E+00,8.7871E+00,8.8709E+00,8.9465E+00,9.0139E+00,9.3109E+00,9.7390E+00,1.0053E+01, 1.010E+01
 3, 1, 3,  15.00,'U/S Allied Industries
 1, 100,   0
1.1236E+01,1.1532E+01,1.2113E+01,1.7730E+01,1.8081E+01,2.2079E+01,2.2253E+01,2.4552E+01,2.4570E+01, 2.620E+01
2.6323E+01,2.7655E+01,2.8101E+01,2.8925E+01,2.9270E+01,2.9498E+01,3.1168E+01,3.1895E+01,3.3559E+01, 3.582E+01
3.6141E+01,3.6301E+01,3.6414E+01,3.8370E+01,3.9996E+01,4.0029E+01,4.0269E+01,4.0859E+01,4.0915E+01, 4.167E+01
4.2406E+01,4.3910E+01,4.5710E+01,4.6230E+01,4.6272E+01,4.6347E+01,4.7512E+01,4.7628E+01,4.8151E+01, 5.107E+01
5.1893E+01,5.3021E+01,5.3362E+01,5.4082E+01,5.4500E+01,5.4685E+01,5.5003E+01,5.7452E+01,5.8754E+01, 5.970E+01
6.0616E+01,6.1132E+01,6.1615E+01,6.2271E+01,6.2321E+01,6.2639E+01,6.3461E+01,6.3705E+01,6.3745E+01, 6.519E+01
6.6627E+01,6.8120E+01,6.8227E+01,6.8414E+01,6.9282E+01,6.9767E+01,7.0615E+01,7.2935E+01,7.5403E+01, 7.580E+01
7.6257E+01,7.8773E+01,7.8966E+01,8.0249E+01,8.0910E+01,8.2044E+01,8.2727E+01,8.4331E+01,8.4784E+01, 8.815E+01
9.0565E+01,1.0042E+02,1.0320E+02,1.1408E+02,1.1445E+02,1.1456E+02,1.1579E+02,1.2294E+02,1.2469E+02, 1.263E+02
1.2802E+02,1.2968E+02,1.3461E+02,1.3640E+02,1.4326E+02,1.5813E+02,1.7505E+02,2.0571E+02,2.3822E+02, 4.248E+02
 2, 100,   0
3.5071E+01,3.6841E+01,3.7847E+01,3.7986E+01,3.9130E+01,3.9487E+01,3.9553E+01,4.0036E+01,4.0318E+01, 4.096E+01
4.1656E+01,4.1763E+01,4.2047E+01,4.2541E+01,4.2828E+01,4.3000E+01,4.3126E+01,4.3478E+01,4.3498E+01, 4.368E+01
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4.5065E+01,4.5123E+01,4.5150E+01,4.5248E+01,4.5316E+01,4.5670E+01,4.5757E+01,4.6270E+01,4.6272E+01, 4.634E+01
4.6344E+01,4.6525E+01,4.6617E+01,4.6666E+01,4.6843E+01,4.7240E+01,4.7681E+01,4.7787E+01,4.7965E+01, 4.818E+01
4.8198E+01,4.9163E+01,4.9214E+01,4.9474E+01,4.9501E+01,4.9568E+01,4.9575E+01,4.9819E+01,4.9916E+01, 5.006E+01
5.0192E+01,5.0216E+01,5.0298E+01,5.0587E+01,5.0621E+01,5.0677E+01,5.1114E+01,5.1169E+01,5.1525E+01, 5.156E+01
5.1901E+01,5.2036E+01,5.2157E+01,5.2417E+01,5.2663E+01,5.2917E+01,5.3104E+01,5.3286E+01,5.3656E+01, 5.372E+01
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3.6174E+00,3.7122E+00,3.7581E+00,3.8827E+00,4.0926E+00,4.1241E+00,4.1315E+00,4.1607E+00,4.1756E+00, 4.236E+00
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5.3033E+00,5.4343E+00,5.4574E+00,5.4850E+00,5.7533E+00,5.8005E+00,5.9140E+00,6.0149E+00,6.2578E+00, 6.294E+00
6.5288E+00,6.5515E+00,6.6429E+00,6.7441E+00,7.1172E+00,7.4445E+00,8.2146E+00,8.5003E+00,8.8524E+00, 9.508E+00
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3.6082E-01,3.6911E-01,3.8661E-01,3.9178E-01,4.0978E-01,4.1755E-01,4.1916E-01,4.4241E-01,4.5079E-01, 4.649E-01
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1.6443E+00,2.1688E+00,2.6940E+00,3.5046E+00,3.5959E+00,1.6920E+00,3.8208E+00,3.0550E+00,3.9136E+00, 4.057E+00
4.1705E+00,4.2062E+00,4.2937E+00,4.3506E+00,4.3702E+00,4.6553E+00,4.7540E+00,4.8533E+00,4.8674E+00, 4.875E+00
4.9302E+00,4.9363E+00,4.9635E+00,5.0183E+00,5.0816E+00,5.1459E+00,5.2378E+00,5.4024E+00,5.4716E+00, 5.471E+00
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6.4181E+00,6.4822E+00,6.4850E+00,6.5751E+00,6.6246E+00,6.6737E+00,6.7507E+00,6.7766E+00,6.8057E+00, 6.845E+00
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8.4826E+00,8.6315E+00,8.7557E+00,8.7683E+00,8.8255E+00,8.8282E+00,8.9480E+00,0.9666E+00,9.0045E+00, 9.042E+00
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4.4105E+00,4.5770E+00,4.6327E+00,4.7100E+00,4.8280E+00,4.8691E+00,4.8818E+00,5.0326E+00,5.2716E+00, 5.355E+00
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8.5631E+00,8.6120E+00,8.6607E+00,8.6880E+00,8.7176E+00,8.7451E+00,8.8591E+00,8.8853E+80,8.8891E+00, 8.939E+00
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9.3026E+00,9.3054E+00,9.3708E+00,9.4089E+00,9.4093E+00,9.4465E+00,9.4782E+00,9.5783E+00,9.6106E+00, 9.631E+00
9.6411E+00,9.8068E+00,9.8563E+00,9.8958E+00,9.9314E+00,9.9632E+00,1.0103E+01,1.0305E+01,1.0453E+01, 1.047E+01
 4, 3, 3,    3.00,'U/S Appleford STW                                    '
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 6, 3, 6,    3.00,'D/S Appleford STW                                    '
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1.9035E+00,1.9529E+00,2.0391E+00,2.2560E+00,2.3676E+00,2.3756E+00,2.4267E+00,2.5118E+00,2.5590E+00, 2.579E+00
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 2, 100,   0
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 5, 100,   0
3.1058E+00,3.4718E+00,3.1171E+00,3.3402E+00,3.3959E+00,3.4023E+00,3.4371E+00,3.6165E+00,3.6574E+00, 3.665E+00
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7.4817E+00,7.5115E+00,7.5653E+00,7.5764E+00,7.6166E+00,7.6752E+00,7.7619E+00,8.2662E+00,8.3405E+00, 9.119E+00
 5, 1, 1,  17.00,"U/S Raw Mill Monitoring Station
 1,   0,   0
 2, 100,   0
3.7625E+01,4.2059E+01,4.2491E+01,4.2585E+01,4.2955E+01,4.3907E+01,4.4393E+01,4.4426E+01,4.5115E+01, 4.540E+01
4.6136E+01,4.6141E+01,4.6644E+01,4.6766E+01,4.6773E+01,4.7155E+01,4.7457E+01,4.7834E+01,4.7953E+01, 4.807E+01
4.8151E+01,4.8185E+01,4.8208E+01,4.8357E+01,4.8366E+01,4.8404E+01,4.8526E+01,4.8623E+01,4.8974E+01, 4.899E+01
4.9269E+01,4.9330E+01,4.9635E+01,5.0087E+01,5.0358E+01,5.0408E+01,5.0443E+01,5.0487E+01,5.0499E+01, 5.064E+01
5.0777E+01,5.0858E+01,5.1048E+01,5.1080E+01,5.1199E+01,5.1226E+01,5.1275E+01,5.1559E+01,5.2014E+01, 5.230E+01
5.2395E+01,5.2500E+01,5.2723E+01,5.2731E+01,5.2881E+01,5.2896E+01,5.3049E+01,5.3143E+01,5.3561E+01, 5.363E+01
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5.6708E+01,5.6757E+01,5.6894E+01,5.6885E+01,5.6950E+01,5.6967E+01,5.7709E+01,5.8352E+01,5.8848E+01, 5.881E+01
5.8912E+01,5.8933E+01,5.9395E+01,5.9666E+01,5.9669E+01,5.9935E+01,6.0163E+01,6.0888E+01,6.1124E+01, 6.127E+01
6.1348E+01,6.2578E+01,6.2951E+01,6.3250E+01,6.3521E+01,6.3764E+01,6.4846E+01,6.6439E+01,6.7635E+01, 6.780E+01
 3, 100,   0
1.0000E+00,1.0275E+00,1.0824E+00,1.4946E+00,1.5436E+00,1.6778E+00,1.7509E+00,1.7560E+00,1.8651E+00, 1.912E+00
2.0395E+00,2.0404E+00,2.1319E+00,2.1547E+00,2.1559E+00,2.2289E+00,2.2882E+00,2.3641E+00,2.3884E+00, 2.414E+00
2.4299E+00,2.4372E+00,2.4420E+00,2.4736E+00,2.4756E+00,2.4837E+00,2.5101E+00,2.5309E+00,2.6018E+00, 2.613E+00
2.6758E+00,2.6896E+00,2.7609E+00,2.8695E+00,2.9366E+00,2.9489E+00,2.9577E+00,2.9687E+00,2.9717E+00, 3.009E+00
3.0429E+00,3.0639E+00,3.1132E+00,3.1218E+00,3.1533E+00,3.1605E+00,3.1735E+00,3.2505E+00,3.3748E+00, 3.482E+00
```

```
3.4862E+00,3.5168E+00,3.5825E+00,3.5851E+00,3.6299E+00,3.6346E+00,3.6808E+00,3.7097E+00,3.8399E+00, 3.862E+00
3.9626E+00,4.0658E+00,4.1718E+00,4.2325E+00,4.2993E+00,4.4091E+00,4.8355E+00,4.7008E+00,4.7109E+00, 4.837E+00
4.9537E+00,4.9727E+00,4.9912E+00,5.0135E+00,5.0494E+00,5.0561E+00,5.0824E+00,5.3606E+00,5.6370E+00, 5.856E+00
5.8872E+00,5.8964E+00,6.1102E+00,6.2386E+00,6.2399E+00,6.3681E+00,6.4793E+00,6.8448E+00,6.9672E+00, 7.045E+00
7.0855E+00,7.7635E+00,7.9789E+00,8.1956E+00,8.3183E+00,8.4665E+00,9.1524E+00,1.0245E+01,1.1133E+01, 1.126E+01
 4, 100,   0
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1.8321E-01,1.8426E-01,1.8968E-01,1.9798E-01,2.0311E-01,2.0406E-01,2.0474E-01,2.0550E-01,2.0581E-01, 2.087E-01
2.1129E-01,2.1291E-01,2.1673E-01,2.1739E-01,2.1903E-01,2.2039E-01,2.2138E-01,2.2140E-01,2.2724E-01, 2.455E-01
2.4581E-01,2.4822E-01,2.5338E-01,2.5359E-01,2.5713E-01,2.5750E-01,2.6116E-01,2.6344E-01,2.7376E-01, 2.755E-01
2.8355E-01,2.9181E-01,3.0032E-01,3.0520E-01,3.1058E-01,3.1946E-01,3.1785E-01,3.4318E-01,3.4401E-01, 3.543E-01
3.6389E-01,3.6546E-01,3.6698E-01,3.6964E-01,3.7177E-01,3.7232E-01,3.7449E-01,3.9751E-01,4.2852E-01, 4.308E-01
4.4149E-01,4.4224E-01,4.6025E-01,4.7110E-01,4.7122E-01,4.8207E-01,4.9151E-01,5.2260E-01,5.3318E-01, 5.398E-01
5.4333E-01,6.0194E-01,6.2069E-01,6.3612E-01,6.5038E-01,6.6338E-01,7.2394E-01,8.2151E-01,8.0173E-01, 9.136E-01
 5, 100,   0
9.8870E-01,3.2352E+00,3.4404E+00,3.4840E+00,3.6578E+00,4.0965E+00,4.3167E+00,4.3315E+00,4.6383E+00, 4.764E+00
5.0845E+00,5.0868E+00,5.3024E+00,5.3545E+00,5.3573E+00,5.5192E+00,5.6461E+00,5.8029E+00,5.8526E+00, 5.902E+00
5.9339E+00,5.9484E+00,5.9576E+00,6.0188E+00,6.0227E+00,6.0381E+00,6.0883E+00,6.1275E+00,6.2704E+00, 6.278E+00
6.3895E+00,6.4136E+00,6.5358E+00,6.7152E+00,6.8220E+00,6.8414E+00,6.8552E+00,6.8723E+00,6.8770E+00, 6.934E+00
6.9858E+00,7.0174E+00,7.0907E+00,7.1032E+00,7.1493E+00,7.1596E+00,7.1784E+00,7.2078E+00,7.4609E+00, 7.600E+00
7.6050E+00,7.6445E+00,7.7278E+00,7.7312E+00,7.7878E+00,7.7924E+00,7.8495E+00,7.8845E+00,8.0387E+00, 8.064E+00
8.1789E+00,8.2931E+00,8.4071E+00,8.4710E+00,8.5400E+00,8.6512E+00,8.9323E+00,8.9417E+00,8.9417E+00, 9.057E+00
9.1610E+00,9.1777E+00,9.1939E+00,9.2219E+00,9.2443E+00,9.2500E+00,9.2726E+00,9.5037E+00,9.7210E+00, 9.885E+00
9.9079E+00,9.9146E+00,1.0068E+01,1.0157E+01,1.0158E+01,1.0245E+01,1.0319E+01,1.0553E+01,1.0628E+01, 1.068E+01
1.0700E+01,1.1087E+01,1.1203E+01,1.1295E+01,1.1378E+01,1.1453E+01,1.1780E+01,1.2252E+01,1.2599E+01, 1.265E+01
 5, 1, 4,  17.00,'U/S New Mill Flow Gauging Station                '
 1, 100,   0
7.5053E+00,9.6365E+00,9.9705E+00,1.3000E+01,1.3464E+01,1.6390E+01,1.7248E+01,1.9041E+01,1.9896E+01, 2.079E+01
2.1488E+01,2.2800E+01,2.3026E+01,2.3530E+01,2.3715E+01,2.4564E+01,2.5302E+01,2.6162E+01,2.8311E+01, 2.879E+01
3.0754E+01,3.1353E+01,3.2061E+01,3.2799E+01,3.4082E+01,3.4258E+01,3.4271E+01,3.4984E+01,3.6404E+01, 3.671E+01
3.7011E+01,4.0083E+01,4.0667E+01,4.1252E+01,4.2900E+01,4.4323E+01,4.4388E+01,4.4589E+01,4.4925E+01, 4.866E+01
4.9162E+01,5.0616E+01,5.1462E+01,5.1954E+01,5.2299E+01,5.2892E+01,5.3484E+01,5.8488E+01,5.9235E+01, 5.977E+01
6.1216E+01,6.1817E+01,6.4445E+01,6.5126E+01,6.5253E+01,6.5364E+01,6.5577E+01,6.5695E+01,6.5807E+01, 6.790E+01
6.8344E+01,6.9784E+01,7.3423E+01,7.4626E+01,7.6808E+01,7.7685E+01,7.8635E+01,8.3169E+01,8.7604E+01, 9.018E+01
9.1261E+01,9.2280E+01,9.7703E+01,1.0216E+02,1.0482E+02,1.0678E+02,1.0787E+02,1.0845E+02,1.1232E+02, 1.188E+02
1.2520E+02,1.3736E+02,1.3795E+02,1.5689E+02,1.5616E+02,1.5728E+02,1.6034E+02,1.6755E+02,1.6799E+02, 1.762E+02
1.8268E+02,1.8381E+02,1.8558E+02,1.8996E+02,2.0101E+02,2.2274E+02,2.4960E+02,2.9653E+02,3.4750E+02, 6.245E+02
 2,   0,   0
 3,   0,   0
 4,   0,   0
 5,   0,   0
 5, 1, 1,  22.00,'U/S Temply Monitoring Station                '
 1,   0,   0
 2, 100,   0
3.5988E+01,4.0054E+01,4.0450E+01,4.0536E+01,4.0874E+01,4.1744E+01,4.2188E+01,4.2218E+01,4.2847E+01, 4.311E+01
4.3778E+01,4.3783E+01,4.4241E+01,4.4352E+01,4.4358E+01,4.4706E+01,4.4981E+01,4.5324E+01,4.5433E+01, 4.554E+01
4.5612E+01,4.5644E+01,4.5664E+01,4.5808E+01,4.5808E+01,4.5843E+01,4.5954E+01,4.6041E+01,4.6361E+01, 4.638E+01
4.6629E+01,4.6684E+01,4.6962E+01,4.7372E+01,4.7619E+01,4.7663E+01,4.7695E+01,4.7735E+01,4.7746E+01, 4.788E+01
4.7999E+01,4.8072E+01,4.8244E+01,4.8273E+01,4.8381E+01,4.8406E+01,4.8450E+01,4.8768E+01,4.9128E+01, 4.945E+01
4.9466E+01,4.9561E+01,4.9763E+01,4.9771E+01,4.9906E+01,4.9920E+01,5.0058E+01,5.0144E+01,5.0522E+01, 5.059E+01
5.0869E+01,5.1153E+01,5.1438E+01,5.1599E+01,5.1773E+01,5.2055E+01,5.2617E+01,5.2775E+01,5.2799E+01, 5.310E+01
5.3368E+01,5.3412E+01,5.3454E+01,5.3528E+01,5.3586E+01,5.3601E+01,5.3661E+01,5.4272E+01,5.4852E+01, 5.530E+01
5.5357E+01,5.5375E+01,5.5792E+01,5.6037E+01,5.6039E+01,5.6279E+01,5.6484E+01,5.7137E+01,5.7349E+01, 5.748E+01
5.7552E+01,5.8659E+01,5.8993E+01,5.9262E+01,5.9506E+01,5.9724E+01,6.0696E+01,6.2126E+01,6.3198E+01, 6.335E+01
 3, 100,   0
1.0156E+00,1.4617E+00,1.5153E+00,1.5271E+00,1.5748E+00,1.7044E+00,1.7746E+00,1.7794E+00,1.8837E+00, 1.929E+00
2.0492E+00,2.0501E+00,2.1364E+00,2.1579E+00,2.1591E+00,2.2277E+00,2.2833E+00,2.3542E+00,2.3773E+00, 2.400E+00
2.4155E+00,2.4224E+00,2.4268E+00,2.4563E+00,2.4582E+00,2.4656E+00,2.4902E+00,2.5096E+00,2.5817E+00, 2.585E+00
2.6437E+00,2.6565E+00,2.7223E+00,2.8223E+00,2.8838E+00,2.8952E+00,2.9032E+00,2.9133E+00,2.9161E+00, 2.950E+00
2.9812E+00,3.0004E+00,3.0455E+00,3.0533E+00,3.0821E+00,3.0886E+00,3.1005E+00,3.1707E+00,3.2854E+00, 3.381E+00
3.3845E+00,3.4122E+00,3.4715E+00,3.4739E+00,3.5143E+00,3.5186E+00,3.5602E+00,3.5862E+00,3.7032E+00, 3.723E+00
3.8133E+00,3.9057E+00,4.0004E+00,4.0545E+00,4.1139E+00,4.2116E+00,4.4123E+00,4.4701E+00,4.4791E+00, 4.590E+00
4.6932E+00,4.7099E+00,4.7262E+00,4.7544E+00,4.7774E+00,4.7833E+00,4.8064E+00,5.0504E+00,5.2919E+00, 5.482E+00
5.5096E+00,5.5176E+00,5.7031E+00,5.8144E+00,5.8155E+00,5.9263E+00,6.0223E+00,6.3370E+00,6.4422E+00, 6.509E+00
6.5436E+00,7.1227E+00,7.3059E+00,7.4558E+00,7.5937E+00,7.7192E+00,8.2976E+00,9.2126E+00,9.9508E+00, 1.006E+01
```

```
 4, 100,    0
1.1840E-02,1.8627E-02,1.9507E-02,1.9804E-02,2.0690E-02,2.3213E-02,2.4648E-02,2.4768E-02,2.6972E-02, 2.796E-02
3.0707E-02,3.0729E-02,3.2776E-02,3.3296E-02,3.3323E-02,3.5011E-02,3.6407E-02,3.8230E-02,3.8830E-02, 3.944E-02
3.9840E-02,4.0021E-02,4.0140E-02,4.0925E-02,4.0975E-02,4.1177E-02,4.1840E-02,4.2367E-02,4.4358E-02, 4.446E-02
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5.6127E-02,5.6725E-02,5.8139E-02,5.8384E-02,5.9298E-02,5.9505E-02,5.9882E-02,6.2142E-02,6.5917E-02, 6.913E-02
6.9256E-02,7.0202E-02,7.2248E-02,7.2331E-02,7.3739E-02,7.3888E-02,7.5356E-02,7.6275E-02,8.0480E-02, 8.121E-02
8.4523E-02,8.7983E-02,9.1589E-02,9.3677E-02,9.5995E-02,9.9856E-02,1.0799E-01,1.1038E-01,1.1076E-01, 1.154E-01
1.1981E-01,1.2054E-01,1.2124E-01,1.2247E-01,1.2346E-01,1.2371E-01,1.2473E-01,1.3559E-01,1.4671E-01, 1.557E-01
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2.0999E-01,2.4233E-01,2.5295E-01,2.6178E-01,2.7001E-01,2.7757E-01,3.1358E-01,3.7408E-01,4.2596E-01, 4.338E-01
 5, 100,    0
9.6809E-01,2.9351E+00,3.1148E+00,3.1536E+00,3.3051E+00,3.6892E+00,3.8819E+00,3.8949E+00,4.1636E+00, 4.274E+00
4.5542E+00,4.5563E+00,4.7451E+00,4.7906E+00,4.7931E+00,4.9348E+00,5.0459E+00,5.1032E+00,5.2267E+00, 5.270E+00
5.2979E+00,5.3106E+00,5.3187E+00,5.3723E+00,5.3757E+00,5.3892E+00,5.4331E+00,5.4674E+00,5.5926E+00, 5.599E+00
5.6968E+00,5.7179E+00,5.8249E+00,5.9820E+00,6.0756E+00,6.0926E+00,6.1046E+00,6.1196E+00,6.1237E+00, 6.174E+00
6.2190E+00,6.2466E+00,6.3108E+00,6.3217E+00,6.3621E+00,6.3712E+00,6.3876E+00,6.4834E+00,6.6349E+00, 6.756E+00
6.7612E+00,6.7957E+00,6.8686E+00,6.8716E+00,6.9204E+00,6.9255E+00,6.9752E+00,7.0058E+00,7.1408E+00, 7.163E+00
7.2636E+00,7.3636E+00,7.4634E+00,7.5193E+00,7.5798E+00,7.6771E+00,7.8696E+00,7.9232E+00,7.9315E+00, 8.032E+00
8.1235E+00,8.1381E+00,8.1523E+00,8.1768E+00,8.1964E+00,8.2014E+00,8.2212E+00,8.4236E+00,8.6138E+00, 8.757E+00
8.7775E+00,8.7833E+00,8.9172E+00,8.9953E+00,8.9961E+00,9.0723E+00,9.1370E+00,9.3420E+00,9.4081E+00, 9.449E+00
9.4707E+00,9.8099E+00,9.9132E+00,9.9920E+00,1.0065E+01,1.0130E+01,1.0417E+01,1.0830E+01,1.1134E+01, 1.118E+01
 0, 0, 0,    0.00," End of Simulation                    "
  5    3
"Upper Ouse          "
"River Avon          "
"Middle Ouse         "
"Black Brook         "
"Lower Ouse I        "
"Head of Upper Ouse                "
"Head of River Avon                "
"Head of Black Brook               "
--------------------------------------------------------------------------------
```

APPENDIX C - CHANGES TO SIMCAT CODE

The changes to the FORTRAN code of SIMCAT undertaken to generate the new graphical output files were discussed in Section 2.4. This appendix lists the changes to the existing code. The changes in code are listed below within section relating to the various source code files which make up SIMCAT. The new FORTRAN code is contained within a new souce code file GRAHEAD which is listed in appendix D.

C.1 Changes to ATTACH.FOR

The changes in this subroutine were to rename the two graphical data file output channels. The additional code is shown below.

```
cpg...change name of graphical data files


      OPEN(UNIT=20, FILE=F1(1:F1Len)//'.SLG',
      .IOSTAT=iWRC ,STATUS= 'UNKNOWN')
      OPEN(UNIT=21, FILE=F1(1:F1Len)//'.SDG',
      .IOSTAT=iWRC ,STATUS= 'UNKNOWN' )
```

C.2 Changes to COM.FOR

The changes in COM.FOR as shown below. A new data structure had to be globally defined. This stored the names of the various headwaters and the associated headwater information

```
       character*40 chw

cpg....headwater data

      common/hdwn/ihwb(kr),ihw,nhw,chw(nr)

cpg..ihwb - backup headwater number
cpg..ihw  - current headwater number
cpg..nhw  - total number ofg headwaters
cpg..chw  - headwater names
cpg..define headwater name
```

C.3 Changes to CONTROL.FOR

The changes in CONTROL.FOR relate to replacing the old graphic output statments with calls to new subroutines which controlled the output of the new graphic output data files. This occurred at various points through this subroutine as indicated by the different portion seperated by dotted lines

i)

```
cpg...write out end of simulation event data

      call gradt1(20,4,0.0,0,ju)
      call gradt2(21,4,0.0,0,ju)
```

```
      call graend (20)
      call graend (21)
```

---

ii)

```
cpg...Remove old graph output
c
c       DO 5211 J=1,NDET
c       IF(QTYPE(J).EQ.4)GOTO 5211
c       CALL CPERX(J,CL(1,J),CL(2,J),CL(3,J),CL(4,J))
c 5211 CONTINUE
c       IF(NOPROF(IREACH).EQ.1)WRITE(21,6993,ERR=99996)JT(JU),DIS,
c      .FLOW(1),FLOW(2),(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),
c      .CL(4,J),J=1,NDET),UNAME(JU),RNAME(IREACH)
c       IF(NOPROF(IREACH).EQ.0)WRITE(20,6993,ERR=99996)JT(JU),DIS,
c      .FLOW(1),FLOW(2),(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),
c      .CL(4,J),J=1,NDET),UNAME(JU),RNAME(IREACH)
c 6993 FORMAT(I4,' ',27(1PE10.4,','),' " U/S ',A40,A16,'"')

cpg...Insert new graph output

       call gradt1 (20,1,adist(ireach)+dist(ju),jt(ju),ju)
       call gradt2 (21,1,adist(ireach)+dist(ju),jt(ju),ju)
```

---

iii)

```
cpg...store headwater number

      ihwb(istor)=ihw

      DO 6944 IS=1,NS
      FD(ISTOR,IS)=FMS(IS)
      DO 6944 J=1,NDET
 6944 QD(ISTOR,J,IS)=CMS(J,IS)

C     Store quality statistics for graph plotting...
C     ----------------------------------------------

 2099 DIS=RLENGTH(IREACH)+ADIST(IREACH)
      CALL STATC

cpg...Remove old graphical output

c       DO 5214 J=1,NDET
c       IF(QTYPE(J).EQ.4)GOTO 5214
c       CALL CPERX(J,CL(1,J),CL(2,J),CL(3,J),CL(4,J))
c 5214 CONTINUE
c       IF(NOPROF(IREACH).EQ.1)WRITE(21,5995,ERR=99996)DIS,FLOW(1),
c
.FLOW(2),(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),CL(4,J),J=1,NDET),
c      &RNAME(IREACH)
c       IF(NOPROF(IREACH).EQ.0)WRITE(20,5995,ERR=99996)DIS,FLOW(1),
c
.FLOW(2),(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),CL(4,J),J=1,NDET),
c      &RNAME(IREACH)
```

```
c 5995 FORMAT('    0 ',27(1PE10.4,','),' " END of
Reach',32X,A16,'"')

cpg...Insert new graphical output

       call gradt1 (20,3,dis,0,ju)
       call gradt2 (21,3,dis,0,ju)
```

---

iv)

```
cpg...get primary headwater out of store

      ihw=ihwb(istor2)
```

C.4 Changes to FEATURE.FOR

i) changes to SUBROUTINE BOUND

At a channel boundary (ie confluence) it is necessary to store the headwater name.

```
cpg...update headwater number and name

      nhw=nhw+1
      ihw=nhw
      chw(nhw)=uname(ku)
```

ii) changes to SUBROUTINE BIFURC

This ensures that the distance from the headwater for both bifurcated channels is correct.

```
cpg....correct distance of reach from headwater

      adist(ireach)=adist(i)+rlength(i)
```

iii) changes to SUBROUTINE PLOT

A call to SUBROUTINE PLOT is used to generate graphical output information at many points within SIMCAT. The code was adjusted to call the new graphical output subroutines.

```
      SUBROUTINE PLOT

$     INCLUDE:'COM.FOR'

cpg      DIMENSION CL(4,MP)

$     INCLUDE:'ERROR.FOR'

      CALL STATF

C     Distance for plotting profiles...
```

```
c     ------------------------------------------------------

      CALL STATC

cpg...Remove old graphics output

c       DO 1 J=1,NDET
c       IF(QTYPE(J).EQ.4)GOTO 1
c       CALL CPERX(J,CL(1,J),CL(2,J),CL(3,J),CL(4,J))
c     1 CONTINUE
c
IF(NOPROF(IREACH).EQ.1)WRITE(21,2,ERR=99996)DIS,FLOW(1),FLOW(2),
c      &(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),CL(4,J),J=1,NDET),
c      &UNAME(KFEAT),RNAME(JREACH(KFEAT))
c
IF(NOPROF(IREACH).EQ.0)WRITE(20,2,ERR=99996)DIS,FLOW(1),FLOW(2),
c      &(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),CL(4,J),J=1,NDET),
c      &UNAME(KFEAT),RNAME(JREACH(KFEAT))
c     2 FORMAT('    0 ',27(1PE10.4,','),' " D/S ',A40,A16,'"')

cpg....new graphical data file

          call gradt1 (20,2,dis,0,kfeat)
          call gradt2 (21,2,dis,0,kfeat)

      RETURN
      END
```

C.5 Changes to MAIN

i) changes to SUBROUTINE MAIN

This addition ensured the date and time were written to the header section of the two graphical output files

```
cpg... write header section to graphical data files

       it1=iday*10000+imon*100+iyr
       it2=ihr*100+imin
       call grahead(20,it1,it2,title)
       call grahead(21,it1,it2,title)
```

ii) changes to SUBROUTINE WriteH

This ensured that ICAL was not written to the graphical output files

```
cpg          WRITE( 20,6692,ERR=99896)ICAL
cpg          WRITE( 21,6692,ERR=99896)ICAL
```

C.6 Changes to TRANS.FOR

SUBROUTINE NPLOT is used in SIMCAT to output data at a interpolated location in the river system. The update ensured that only the

longitudinal datafile was updated at this location.

```
      SUBROUTINE NPLOT(DISX)

$     INCLUDE:'COM.FOR'

cpg      DIMENSION CL(4,MP)
$     INCLUDE:'ERROR.FOR'

      CALL STATF

C     Distance for plotting profiles...
C     ---------------------------------

      CALL STATC

cpg...remove old graphical file

c      DO 1 J=1,NDET
c      IF(QTYPE(J).EQ.4)GOTO 1
c      CALL CPERX(J,CL(1,J),CL(2,J),CL(3,J),CL(4,J))
c    1 CONTINUE
c
IF(NOPROF(IREACH).EQ.1)WRITE(21,2,ERR=99996)DISX,FLOW(1),FLOW(2),
c     &(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),CL(4,J),J=1,NDET),
c     &UNAME(KFEAT),RNAME(JREACH(KFEAT))
c
IF(NOPROF(IREACH).EQ.0)WRITE(20,2,ERR=99996)DISX,FLOW(1),FLOW(2),
c     &(C(J,1),CL(1,J),CL(2,J),C(J,3),CL(3,J),CL(4,J),J=1,NDET),
c     &UNAME(KFEAT),RNAME(JREACH(KFEAT))
c    2 FORMAT('    0 ',27(1PE10.4,','),' " D/S ',A40,A16,'"')

cpg...new graphical data file

      call gradt1 (20,2,disx,0,kfeat)

      RETURN
      END
```

APPENDIX D - NEW GRAPHICAL CODE - GRAHEAD.FOR

The function of the various subroutines in GRAHEAD have been summarised in section 2.4. The full listing of this new FORTRANcode is given below

```
CPC-----------------------------------------------------------------
CPC
CPC Write out header section for graphical display program data file
CPC
CPC
CPC-----------------------------------------------------------------

   SUBROUTINE GRAHEAD (ICHL,IT1,IT2,TITLE)

         CHARACTER*70 TITLE

$        INCLUDE:'COM.FOR'

cpg...if ical=1 set np=0

         NPP=1
         DO 10 J=1,NP
          IF(QTYPE(J).NE.4) NPP=NPP+1
 10      CONTINUE

         WRITE(ICHL,999) ICAL
         WRITE(ICHL,998) TITLE
         WRITE(ICHL,997) IT1,IT2,NS,NPP,2,50,95
         WRITE(ICHL,995) 1,FUNIT

         IF (NPP.GT.1) THEN
          DO 20 I=1,NP
           IF(QTYPE(I).NE.4) WRITE(ICHL,996)I+1,DNAME(I),DNA(I),UNITS(I)
 20       CONTINUE
         END IF

         RETURN

 999     FORMAT(' "','SIMCAT v2.0 Run Mode ',I1,'"')
 998     FORMAT(1X,'"',A70,'"')
 997     FORMAT(2X,I6,2(2X,I4),4(2X,I2))
 996     FORMAT(2X,I2,',"',A11,'","',A4,'","',A4,'"')
 995     FORMAT(2X,I2,',"Flow.......",','"Flow","',A4,'"')
         END

CPC-----------------------------------------------------------------
CPC
CPC Write out end data section for graphical display program data file
CPC
CPC
CPC-----------------------------------------------------------------

   SUBROUTINE GRAEND (ICHL)

         CHARACTER CHH*40
```

```
$       INCLUDE:'COM.FOR'

CPC... Write out number of reach names and headwaters

        WRITE(ICHL,999) NREACH,NHW

CPC... Write out reach names

        DO 20 I=1,NREACH
          WRITE(ICHL,998) RNAME(I)
 20     CONTINUE

CPC... Write out headwater names

        DO 30 I=1,NHW
          CHH=CHW(I)
          WRITE(ICHL,997) CHH(1:30)
 30     CONTINUE

CPC... Write out end of file indicator

        WRITE(ICHL,996)

        RETURN

 999    FORMAT(2(2X,I2))
 998    FORMAT(1X,'"',A16,'"')
 997    FORMAT(1X,'"',A30,'"')
 996    FORMAT(1X,87('='))

        END
CPC-----------------------------------------------------------------
CPC
   SUBROUTINE GRADT1 (ICHL,ITYP,DDX,IFTN,JU)
CPC
CPC Write out data section for graphical display program data file
CPC
CPC-----------------------------------------------------------------
CPC
CPC  ICHL - Channel number
CPC  DDX  - Distance from headwater
CPC  ITYP - Location type  0 - normal          2 - downstream
CPC                        1 - upstream        3 - end of reach
CPC                                            4 - end of simulation
CPC  IFTN - Feature type number
CPC  JU   - Feature simulation number
CPC
CPC-----------------------------------------------------------------

$       INCLUDE:'COM.FOR'

        CHARACTER*40 CNAME,CN1
        DIMENSION CL(4)

CPC...End of simulation output

        IF (ITYP.EQ.4) THEN
            CNAME=' End of Simulation
```

```
            WRITE(ICHL,999) 0,0,IFTN,DDX,CNAME
            RETURN
          END IF

CPC..adjust name of site as required

          CN1=UNAME(JU)
          IF(ITYP.EQ.0) THEN
              CNAME=CN1
            ELSE IF(ITYP.EQ.1) THEN
              CNAME='U/S '//CN1(1:36)
            ELSE IF (ITYP.EQ.2) THEN
              CNAME='D/S '//CN1(1:36)
            ELSE IF (ITYP.EQ.3) THEN
              CNAME=' End of Reach
          END IF
CPC...write out location data

     WRITE(ICHL,999) IREACH,IHW,IFTN,DDX,CNAME

CPC...write out flow details

          WRITE(ICHL,998) FLOW(1),0.0,0.0,0.0,FLOW(2),0.0,0.0,0.0

CPC...write out quality data

          DO 10 J=1,NDET
            IF(QTYPE(J).NE.4) THEN
              TAR1=0.0
              TAR2=0.0
              IRQ=IFRQS(JU)

              IF(IRQ.GT.0) THEN
                IF(RQS(IRQ,J).GT.0.0) THEN
                  IF(MORQ.EQ.0) THEN
                      TAR2=RQS(IRQ,J)
                    ELSE IF (MORQ.EQ.1) THEN
                      TAR1=RQS(IRQ,J)
                  END IF
                END IF
              END IF

              CALL CPERX (J,CL(1),CL(2),CL(3),CL(4))
              WRITE(ICHL,998) C(J,1),CL(1),CL(2),TAR1,C(J,3),CL(3),
     +                        CL(4),TAR2
            END IF
 10       CONTINUE

          RETURN

 999      FORMAT(1X,3(I2,','),F7.2,',"',A40,'"')
 998      FORMAT(1X,7(1PE10.4,','),1PE10.4)
          END
CPC-----------------------------------------------------------------
CPC
     SUBROUTINE GRADT2 (ICHL,ITYP,DDX,IFTN,JU)
CPC
CPC Write out data section for graphical display program data file
CPC
```

```
CPC-----------------------------------------------------------------
CPC
CPC  ICHL - Channel number
CPC  DDX  - Distance from headwater
CPC  ITYP - Location type  0 - normal          2 - downstream
CPC                        1 - upstream        3 - end of reach
CPC                                            4 - end of simulation
CPC  IFTN - Feature type number
CPC  JU   - Feature simulation number
CPC
CPC-----------------------------------------------------------------

$       INCLUDE:'COM.FOR'

        CHARACTER*40 CNAME,CN1
        DIMENSION OBS(MS),SIM(MS)

CPC...End of simulation output

        IF (ITYP.EQ.4) THEN
            CNAME=' End of Simulation
            WRITE(ICHL,999) 0,0,IFTN,DDX,CNAME
            RETURN
        END IF

CPC..Check if data to be outputted (ie is there any calibration data
CPC..sets or target values at this feature

        IF=IABS(JFCAL(JU))
        IQ=IABS(JQCAL(JU))
        IRQ=IFRQS(JU)

        IF(ITYP.EQ.3) RETURN
        IF(IF.NE.0.OR.IQ.NE.0.OR.IRQ.GT.0) GOTO 5
        RETURN

 5      CONTINUE

CPC..adjust name of site as required

        CN1=UNAME(JU)
        IF(ITYP.EQ.0) THEN
            CNAME=CN1
          ELSE IF(ITYP.EQ.1) THEN
            CNAME='U/S '//CN1(1:36)
          ELSE IF (ITYP.EQ.2) THEN
            CNAME='D/S '//CN1(1:36)
          ELSE IF (ITYP.EQ.3) THEN
            CNAME=' End of Reach
        END IF
CPC...write out location data

   WRITE(ICHL,999) IREACH,IHW,IFTN,DDX,CNAME

CPC...find what observed data is to be outputed (ie if flow or
CPC...quality has been calibrated do not output observed values)

        IFOUT=1
        IQOUT=1
```

```
      IF(ICAL.GT.0) IFOUT=0
      IF(ICAL.GT.2) IQOUT=0

CPC...collate flow data

      NOBS=0
           NSIM=NS
           IF(IF.EQ.0.AND.IRQ.EQ.0) NSIM=0
           IF(ICAL.EQ.1) NSIM=0
           IF(NSIM.GT.0) THEN

CPC...backup current flow in river

             DO 10 IS=1,NSIM
               SIM(IS)=FMS(IS)
               OBS(IS)=0.0
 10          CONTINUE

CPC...generate observed data if required

             IF(IF.GT.0.AND.F(IF,1).GE.0.0.AND.IFOUT.EQ.1) THEN
               NOBS=NSIM
               FMM=F(IF,1)
               FPP=F(IF,2)
               CALL GENERF

CPC...place observed data in array and return simulated river flows

               DO 20 IS=1,NSIM
                 OBS(IS)=FMS(IS)
                 IF(OBS(IS).LT.1.0E-8) OBS(IS)=1.0E-8
                 FMS(IS)=SIM(IS)
 20            CONTINUE

CPC...recalculate flow summary statistics

               CALL STATF
             END IF
           END IF

CPC...output flow data

           CALL DISOUT(ICHL,1,SIM,NSIM,OBS,NOBS)

CPC...collate quality data

           NSIM=NS
           IF(IQ.EQ.0.AND.IRQ.EQ.0) NSIM=0
           IF(ICAL.EQ.3) NSIM=0

           DO 50 JDET=1,NDET
             NOBS=0
             IF(QTYPE(JDET).NE.4) THEN
               IF(NSIM.GT.0) THEN

CPC...backup current river quality

                 DO 30 IS=1,NSIM
                   SIM(IS)=CMS(JDET,IS)
```

```
                OBS(IS)=0.0
 30             CONTINUE

CPC...if observed data to be calculated

                IF(IQ.GT.0.AND.QMAT(IQ,JDET,1).GE.0.0.
     +                                    AND.IQOUT.EQ.1) THEN
                  NOBS=NSIM
                  CALL CPERQ (JDET,DCM,DCS,DCP)
                  JP=JDET
                  CALL GENERQ

CPC...place generated observed data in array and return simulated

                  DO 40 IS=1,NSIM
                    OBS(IS)=CMS(JDET,IS)
                    IF(OBS(IS).LT.QBASE(JP)) OBS(IS)=QBASE(JP)
                    CMS(JDET,IS)=SIM(IS)
 40               CONTINUE

CPC...regenerate simulated summary statistics

                  CALL STATC

                END IF

CPC...output data

              END IF
              CALL DISOUT (ICHL,JDET+1,SIM,NSIM,OBS,NOBS)
            END IF
 50       CONTINUE

          RETURN
 999      FORMAT(1X,3(I2,','),F7.2,',"',A40,'"')
          END
CPC-----------------------------------------------------------------
CPC
     SUBROUTINE DISOUT (ICHL,NNN,SIM,NSIM,OBS,NOBS)
CPC
CPC Write out data section for graphical display program data file
CPC                        (distributional data)
CPC-----------------------------------------------------------------
CPC
CPC   ICHL - Channel number
CPC   NNN  - Determinand number
CPC   SIM  - Simulated data
CPC   NSIM - Number of simulated data values
CPC   OBS  - Observed data
CPC   NOBS - Number of observed data values
CPC
CPC-----------------------------------------------------------------

$         INCLUDE:'COM.FOR'
          DIMENSION OBS(MS),SIM(MS),IVAL(MS)

          WRITE(ICHL,999) NNN,NSIM,NOBS

CPC...Rank and output simulated data
```

```
        IF(NSIM.GT.0) THEN
c          CALL RANK2 (SIM,IVAL,NSIM)
          DO 10 I=1,NSIM,10
            WRITE(ICHL,998) (SIM(K),K=I,I+9)
 10       CONTINUE
        END IF
CPC...Rank and output observed data (if any)

        IF(NOBS.GT.0) THEN
c          CALL RANK2(OBS,IVAL,NOBS)
          DO 20 I=1,NOBS,10
             WRITE(ICHL,998) (OBS(K),K=I,I+9)
 20       CONTINUE
        END IF

        RETURN

 999    FORMAT(1X,I2,2(',',I4))
 998    FORMAT(1X,9(1PE10.4,','),1PE10.3)
        END
```

APPENDIX E - PROJECT INVESTMENT APPRAISAL

1.	R and D Commission A	- Water quality
	Topic A12	- Mathematical modelling
	Project title	- Development of SIMCAT
	Project number	- A12.4
	Classification	- Applied research with strategic and specific aims
2.	Project Leader	- Tony Warn Assistant Chief Scientist (Planning) NRA Anglian Region Kingfisher House Goldhay Way Orton Goldhay Peterborough PE2 0ZR Tel: 0733 371811 Fax: 0733 231840
3.	Research Contractor	- WRc plc Henley Road Medmenham PO Box 16 Marlow Buckinghamshire SL7 2HD Tel: 0491 571531 Fax: 0491 579094
	Contract signatory	Dr Keith Whitelaw
	Project Manager	Dr Keith Whitelaw
4.	Contract Details	
	Start date	01 May 1990
	End date	30 March 1990
	Type	STA (specialist organisation)

5. Objectives

Overall Project Objectives

To provide tools for calculating the action needed to meet Water Quality Objectives for rivers

Specific Objectives

To test SIMCAT and make it easier to use. To provide graphics.

6. Background

Two prime duties of the NRA are:

- to achieve Water Quality Objectives; and

- to determine consents for discharges

Our planning objectives include:

- a national strategy for the maintenance and improvement of water quality, based on regional plans;

- to establish and implement a common policy of consent determination

The achievement of these obligations depends on our ability to quantify the effects of sources of pollution. Then, to ensure proper action is taken, we must be able to make a case which will stand up to scrutiny. Models help by speeding up the testing of options and by increasing confidence in the decisions which are recommended.

Context

The construction of efficient models for rivers is attractive because the finished products can be applied cheaply and directly to nearly all rivers.

The research will also be applicable to other models, including those for estuaries.

7. Strategy

The work will be done by an external Contractor supervised by the Project Leader and monitored by the Modelling Group. The project relies heavily on Dr Bob Crabtree and Dr Paul Crockett who are particularly knowledgeable about river catchment modelling and our requirements in this field.

Method

SIMCAT produces a number of datafiles as output for a graphics package. A graphics package will be developed using the UNIX/X-windows/MOTIF system.

8. Targets and timescales

Work item	Date completed	(Month)
Demonstrate basic functionality	August 1990	5
Agree remaining details	August 1990	5
Main elements of system complete	December 1990	9
User testing	February 1990	11
Software finished	March 1990	12

9. Outputs

Progress Report	August 1990
Progress Report	December 1990
Final Report and User Manual	March 1991 (50 copies)
Computer Code	March 1991

10. Costs (£)

	NRA		
Item	External	Internal	Others (shared)
Staff	25 500	-	-
Travel and Subsistence	1 500	-	-
Capital Items	-	-	-
Consumables	3 000	-	-
Final Report	-	-	-
Other costs (specify)	-	-	-
Total	30 000	-	-

R and D Budget provision

Budget	1990/1991	1991/1992
NRA	30 000	-
Others	-	-

11. Benefits

Quick and authoritative decisions on the measures needed to meet Water Quality Objectives. Improved consistency within the NRA. Reduced numbers of disputes with dischargers. Cost effective decisions on improvements to discharges.

12. Assumptions and Risks

There are no major uncertainties in the work programme or the cost. Success depends strongly on the skills of the Contractor.

13. Overall Appraisal

A project which will facilitate directly the main duty of the NRA. There is a strong probability of success. The payback will be improved efficiency of decision-taking, better decisions with less hassle from dischargers.