A National Database of Travel Time, Dispersion and Methodologies for the Protection of River Abstractions

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A National Database of Travel Time, Dispersion and Methodologies for the Protection of River Abstractions

R&D Technical Report P346

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Statement of Use
This report is intended to provide an increased understanding of the fundamental river travel time and dispersion processes. The report describes work undertaken to develop a searchable database for use by EA staff, particularly those involved in contracting out tracer studies or required to give predictions in the event of an incident. The report should also be useful to water quality staff involved in river modelling.

Keywords:
river tracing, pollution, rivers, solutes, advection, dispersion, travel times, database.

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EXECUTIVE SUMMARY

A knowledge of solute travel times within rivers is important for the protection of potable water supplies and in the development and calibration of river and catchment water quality models. This report describes work undertaken to obtain added benefit by incorporating all recent tracer study results into a single searchable database.

Both practical and theoretical approaches for describing advection and dispersion have been described. Results from solute tracer studies, where the raw data were available in electronic form, have been collected from each region of the Agency. These have been plotted in a consistent format. A standard data storage format has been developed and the acceptable data sets have been formatted. This format includes all details of the river traced (region, catchment, area), the contractor that undertook the work, the flow conditions, both at the time of the trace and historical, the tracer used and the reaches studied.

The datastore, containing over one hundred different tracing studies has been analysed to obtain reliable estimates of the mean travel velocity and the longitudinal dispersion. Two techniques have been used for this study, an advection-dispersion and an aggregated dead zone technique. Descriptions of how to calculate advection and dispersion parameters have been included. The optimised results from the analysis of each reach have been appended to the spreadsheet datastore.

A searchable database has been developed and all the results from the data analysis incorporated. This software provides the facility to import additional results and to delete and modify the data. It allows for complex searches of the database using geographical, physical and multiple study criteria.

The database has been used to obtain quantifiable trends relating the solute tracer velocity and dispersion to available parameters, such as discharge and slope. The results exhibit significant scatter, but relationships have been quantified. Recommendations for the maintenance and further development of the database are also included.

For use in future time of travel surveys, the following have been developed:

- minimum methodology for fieldwork
- definition of acceptable data
- requirement of summary data to be collected
- spreadsheet format for holding raw and summary data

Also a survey specification template has been included. This was satisfactory at the time of publication, but may need updating should, for example, Health and Safety requirements change.

1. INTRODUCTION

The protection of potable intakes from pollution is of paramount importance to ultimately maintain the integrity of public health. It is a statutory duty of the Environment Agency to protect private water abstractions. Often there are multiple abstractions on one river and it is the Agency's duty to protect these from pollution incidents.

Over the past 10 years in particular, a great number of dye tracing studies have been completed through the Agency and formerly the National Rivers Authority (NRA). These studies have provided valuable details of travel time-flow relationships and the dispersive characteristics of river reaches. In turn, this data has been successfully used to predict travel times of major pollution spillages, such as the Asulam incident on the river Swale in Yorkshire in 1994.

However, dye tracing is expensive. Usually tracer studies have been designed to provide data for the most critical part of the catchment, e.g. 30 kilometres upstream of the major abstractions. To build a sensible, scientific model to predict the passage of a pollution spillage, a minimum of three independent tracer studies repeated for the same river reach are required. It is therefore impracticable to collect a complete data set for every drinking water catchment in England and Wales. The costs would be prohibitive.

This project was awarded to collate, validate and summarise results, collected from individual river time of travel studies commissioned by separate Regions within the EA. The aim was to realise the potential to significantly increase current understanding of the fundamental river travel time and dispersion processes. A review of recent work related to estimating travel times and dispersion characteristics on untraced rivers is presented in Green *et al* (1994). However, without resorting to complex numerical techniques to estimate uncertainty, it is felt that combining and interpreting results obtained on other similar watercourses, could lead to an improved estimate of the travel time and longitudinal dispersion. This has been performed in the U.S. by Jobson (1997).

The following are reproduced from the original contract.

1.1 Overall Project Objective

To provide each region with a national time of travel and dispersion database, coupled with simple empirical equations for predicting the travel time and spread of pollutant in a river catchment.

1.2 Specific Objectives

- To summarise current thinking, theory and practise within the Agency and externally
- To visit all eight regions to collect copies of existing data
- To analyse all existing data for key travel time and dispersion parameters
- To build a database to hold the raw data, summary data and equations
- To develop new predictive empirical techniques for untraced/ungauged river reaches and associated uncertainty bands or catchment datasets

- To test new predictive techniques against pilot catchment data sets

1.3 Key Tasks for the Project

- Collection of data
- Database design and structure
- Quality control/Validation of data
- Calculation of parameters/coefficients from data
- Derivation of predictive methods (empirical/stochastic) from pilot data
- CD-ROM output incorporating user friendly database and predictive equations.

2. SUMMARY THEORY

Soluble pollutant, instantaneously released into a river may be considered to be subjected to two processes: advection and dispersion. In practise these processes are linked, with several physical mechanisms contributing to the overall observed effects. However, the problem is simplified if it is conceptualised as advection, causing a bodily transport of the pollutant downstream and dispersion, causing a spreading. This spreading leads to an associated reduction in the peak concentration.

Soluble dye tracers have been used for several years to quantify these effects in rivers and an example of good quality data collected from such a study is reproduced in Fig. 2.1 A description of acceptable data is provided in Appendix 10.1. Rutherford (1994) provides an excellent practical guide to river mixing.

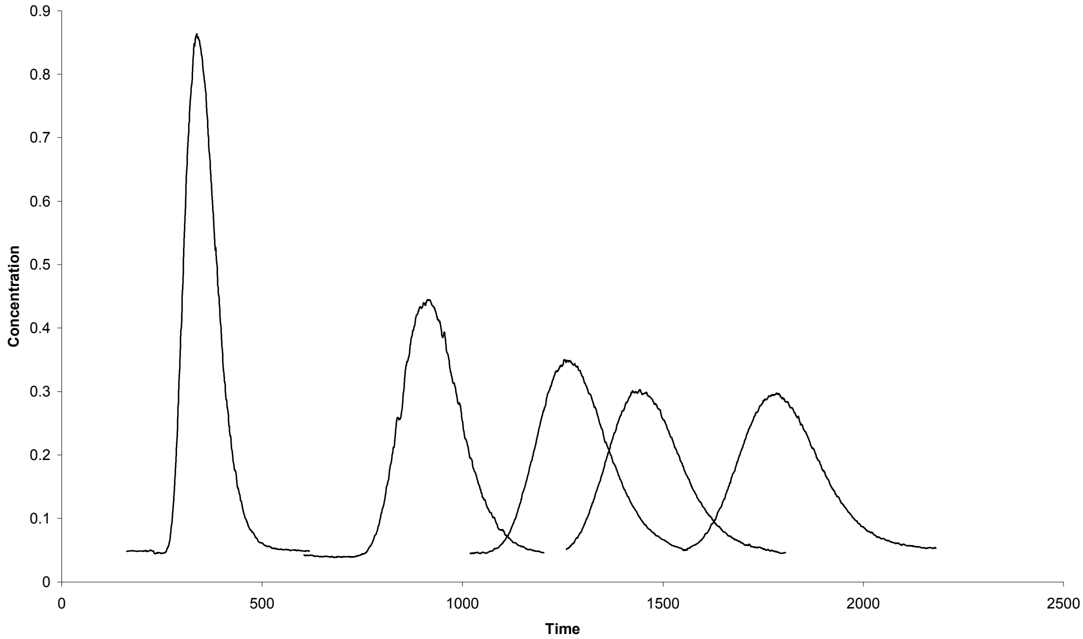


Fig. 2.1 Example of Temporal Concentration Distributions Recorded at Several Sites

Fundamental analysis of shear dispersion was undertaken by Taylor (1954). His work provides a theoretical framework for the analysis and prediction of longitudinal dispersion, although in river studies, compliance with the basic assumptions is rarely achieved. More recently the Aggregated Dead Zone model (Beer and Young, 1984) has been used to quantify and describe the observed features from river tracer studies. Whilst both these techniques may be applied to predict the effect of pollution spillages, they do require the use of modelling tools and a knowledge of the parameters. A brief description of both techniques is provided in the following sections.

On occasions, it may be necessary to provide predictions for a river reach where neither a model nor a knowledge of the required parameters are available. For such situations alternative approaches have been proposed. These range from simply relating the solute velocity (v) to a power (x) of the river discharge (Q), of the form $v \propto Q^x$, to a technique described by Jobson (1997) working for the United States Geological Survey (USGS).

Jobson (1997) described a predictive method based on information which should be available at the time of an incident. It utilises an extensive data set to estimate: the rate of movement of solutes through river reaches, the rate of attenuation of the peak concentration of a conservative solute with time and the length of time required for the solute plume to pass a point in the river. Data is summarised from different rivers representing a wide range of sites, slopes and geomorphic types.

Jobson (1997) collated data from 90 US rivers and obtained a data set where most variables were available for 939 reaches. Four variables were available in sufficient quantities to undertake a regression analysis. These variables were the drainage area, D_a, the reach slope, S, the mean annual discharge, Q_a and the discharge at the time of measurement, Q. To study their relationship with the velocity of the peak concentration, v_p, it was reasoned that the variables could be combined into two dimensionless groups: the dimensionless drainage area, defined as $D'_a = D_a^{1.25}\sqrt{g}/Q_a$, where g is acceleration of gravity and the dimensionless relative discharge, defined as $Q'_a = Q/Q_a$. A linear relationship was assumed between the peak velocity and the product of three terms: the dimensionless drainage area, D'_a raised to a power, x, the dimensionless relative discharge Q'_a raised to a power, y and (Q/D_a). The relationship was optimised to obtain the most accurate fit to the available data by varying four parameters, the intercept and slope of the assumed linear relationship and the powers x and y and produced this an equation with an R^2 of 0.7. Jobson acknowledges that the travel time is the least accurately defined relationship and although the data available to this current Agency study is less comprehensive, similar relationships have been developed and results are illustrated in Section 6.0.

2.1 Advection-Dispersion Model (ADE)

The results of the work by Taylor (1954) predict instantaneous spatial concentration profiles of Gaussian shape. Often in practise a simple routing procedure is used to predict the temporal concentration distribution $c(x_2,t)$ at a downstream site, x_2 knowing the temporal concentration at an upstream site, x_1 (Fischer *et al*, 1979). This is summarised by:

$$c(x_2,t) = \int_{\gamma=-\infty}^{\infty} \frac{c(x_1,\gamma)u}{\sqrt{4\pi D(\bar{t}_2 - \bar{t}_1)}} \exp\left[-\frac{u^2(\bar{t}_2 - \bar{t}_1 - t + \gamma)^2}{4D(\bar{t}_2 - \bar{t}_1)}\right] d\gamma \qquad [2.1]$$

where D = the longitudinal dispersion coefficient, γ = an integration variable, $\bar{t}_i$ = the time of passage of the centroid (centre of mass) of the tracer cloud at site i, given by:

$$\bar{t}_i = \frac{\int_{t=-\infty}^{\infty} t c(x_i,t)dt}{\int_{t=-\infty}^{\infty} c(x_i,t)dt} \qquad [2.2]$$

This method effectively takes each individual upstream element of the temporal concentration distribution, advects it downstream by a fixed amount and spreads it assuming a Gaussian distribution. The individual Gaussian distributions are then summed at each time to obtain the overall downstream temporal concentration distribution. This is illustrated in Fig. 2.2 below.

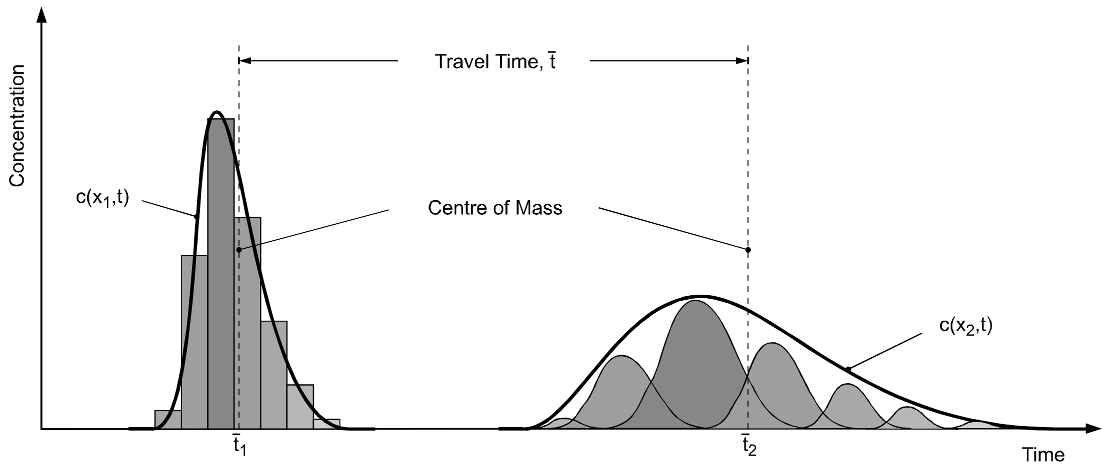


Fig. 2.2 Illustration of ADE Technique

2.2 Aggregated Dead Zone Model (ADZ)

The aggregated dead zone (ADZ) model (Beer & Young, 1984, Wallis *et al,* 1989a) has gained favour by practitioners in the UK wishing to describe the longitudinal dispersion of solutes in small river systems (Young & Wallis, 1986, Barraclough *et al*, 1994). This model assumes that a tracer is advected through an entire reach by plug flow (i.e. advection with no dispersion) after which it passes through a single mixing cell that has the aggregated effect of all the dead zones within the reach (i.e. dispersion with no advection). These processes are illustrated for a single concentration unit and for a complete temporal concentration distribution in Fig. 2.3 and 2.4 respectively.

('The term dead zone is often misunderstood, although it implies a form of pocket that is separated from the main flow, it should be considered in a wider context as a bulk parameter that not only describes the effect of segregated regions of flow, but also other dispersive catalysts such as eddies, viscose sub layers and velocity profile' (from Wallis, Young & Beven, 1989a))

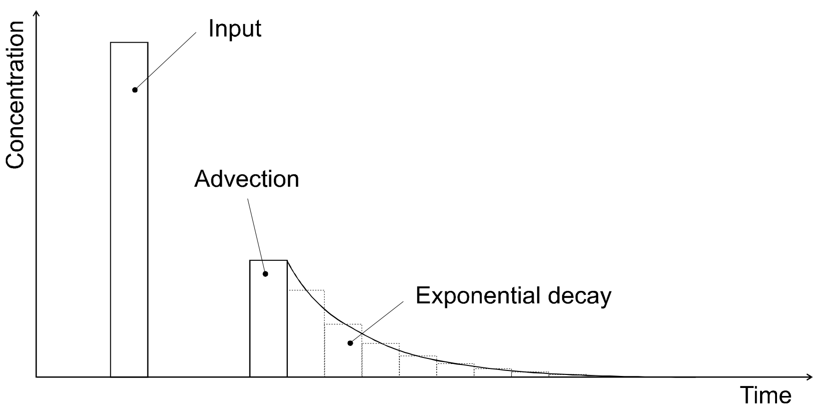


Fig. 2.3 Representation of an ADZ prediction for a single unit.

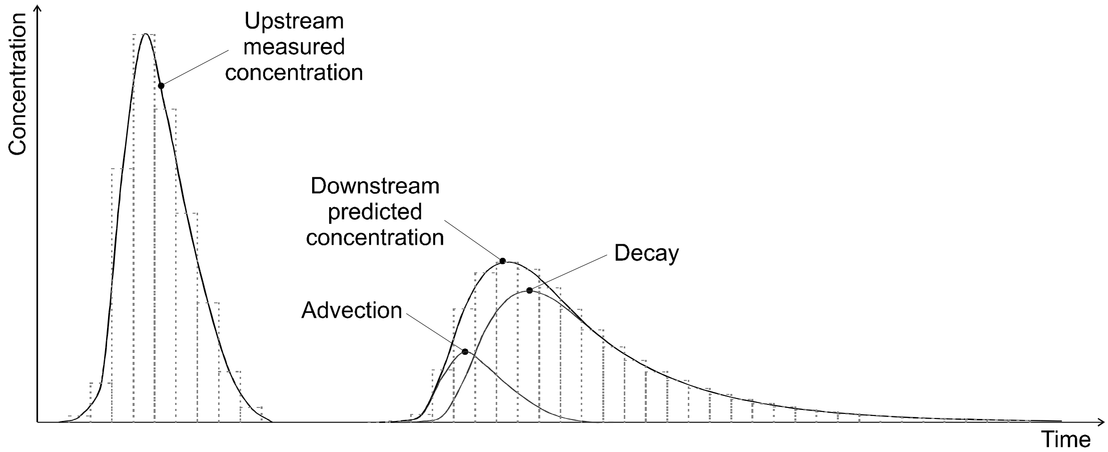


Fig. 2.4 ADZ prediction, showing both the advection and decay elements.

In practice, data is often acquired at discrete sampling times rather than as a continuous time varying fluctuation. Within Fig. 2.5 the dashed line represents the actual concentration / time distribution of a tracer at two locations (up and downstream) within a reach. Superimposed over these temporal concentration distributions are bars that illustrate the discrete time representation of the data set. It is a discretised data set of this form that is used when applying the aggregated dead zone model.

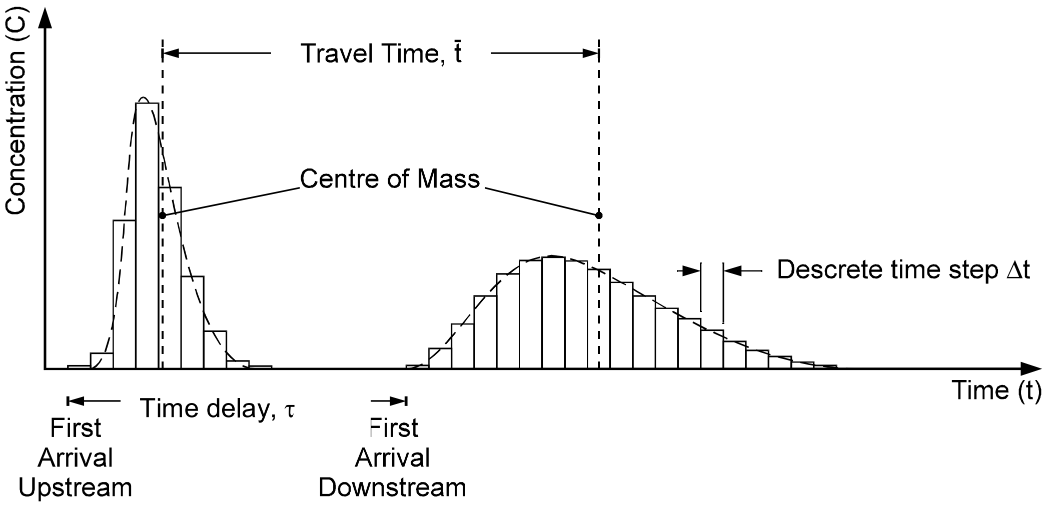


Fig. 2.5 Illustration of ADZ Parameters.

Wallis *et al* (1989b) give a simple discrete-time equation for predicting the temporal concentration distribution at a downstream site for a single cell:

$$c(x_2, t) = -\alpha c(x_2, t-1) + (1+\alpha)c(x_1, t-\delta) \qquad [2.3]$$

where: $c(x_i, t)$ = concentration at longitudinal position, x_i at time t, with i = 1 or 2 representing the upstream and downstream locations respectively,

α = $-e^{\left(\frac{-\Delta t}{T}\right)}$

T = residence time, $\bar{t} - \tau$

$\bar{t}$ = travel time, $\bar{t}_2 - \bar{t}_1$

τ = time delay, $t_2' - t_1'$

	t_i^f	=	first arrival time at location i
	δ	=	the discrete-time equivalent of the time delay, τ that is the nearest integer value of $\tau/\Delta t$
and	Δt	=	the time step or sampling interval,

Young and Wallis (1986) define the dispersive fraction, as:

$$D_f = \frac{T}{\bar{t}} = \frac{\bar{t} - \tau}{\bar{t}} \qquad [2.4]$$

This parameter quantifies the proportion of the river reach that is assumed responsible for the dispersion of the tracer. As such its variation may be considered comparable to the longitudinal dispersion coefficient used in the ADE technique.

3. DATA COLLATION

Several attempts, between the start of the project in November 1997 and April 1999, were made to obtain electronic copies of river travel time data for inclusion in the analysis. Table 3.1 provides summary details by Region. Considerable resources were employed to collate this data and convert it into a consistent format. Once the data had been converted to standard Microsoft Excel format and graphical hard copies produced, these copies were used to make the initial decision whether to include the data for the analysis.

Agency Region	1st Call deadline 12/Nov/98	2nd Call deadline 1/April/99	Final Call Accepted Data Events	Optimised Data included in Database
Anglian	0	0	16	2
Midlands	43	0	13	12
North East	48	35	60	57
North West	0	0	0	0
South West	60	19	27	18
Southern	0	0	0	0
Thames	238*	0	0	0
Welsh	0	0	0	0

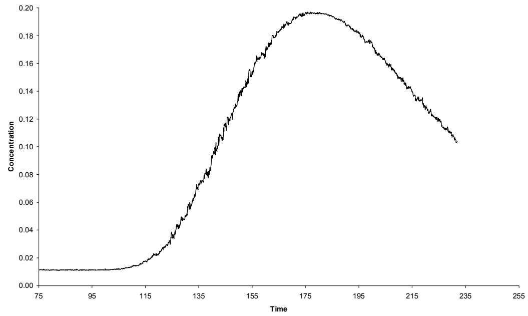
Table 3.1 Details of Data Obtained and Included for Analysis

3.1 Acceptance of Data

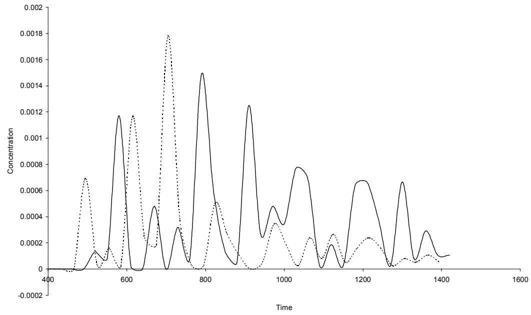
A preliminary, subjective decision whether to include data within the first round of analysis was made, based on the visual inspection of the distributions. It had been agreed that tracing events would only be included if multiple stations were used for measurement. This is due to the problems of uncertainty in injection method if only one downstream measurement station was used. All the tracing data provided by Thames Region* comprised a single measurement station and has therefore not been included within this first round of analysis. The main factors that have been used to decide on inclusion of the data are: the completeness of the distributions (do they exhibit a clearly defined start, peak and reduction of tracer concentration towards background, as defined in section 10.1) and data recording interval (this needs to be constant and equal at both the up and downstream sites on a reach). An example of good data that has been included for analysis is shown in Fig. 2.1, whilst examples of poor quality data, illustrating the main reasons for discarding data, are shown in Fig. 3.1. For example, the noise exhibited in Fig. 3.1b precludes any useful information on either travel times or dispersion.

3.2 Development of Spreadsheet Data Format

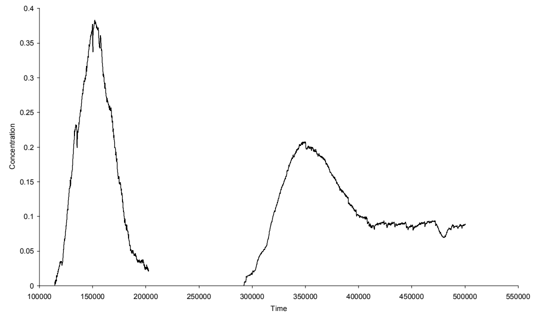
It was agreed that data would be stored in two forms. Firstly, a file (Microsoft Excel) was to be created to contain all background information regarding the actual river tracing exercise, including details of the contractor, hydrological conditions and all the raw data (*minutes of meeting, 24/Feb/98*). Secondly, a database (Microsoft Access) was to be constructed to contain the summary results after analysis of the raw data.



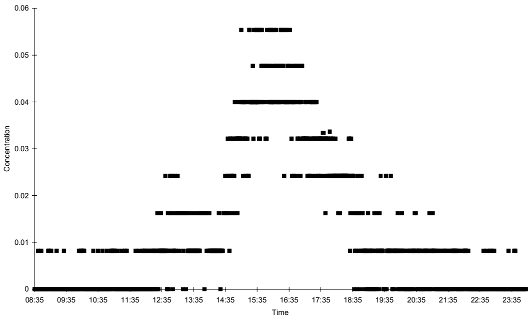
a) Incomplete Trace (recording ceased early)



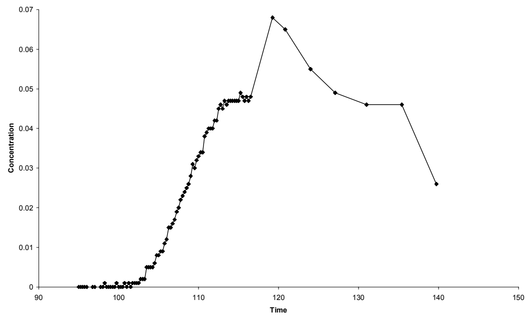
b) Noisy Ill-Defined Distributions



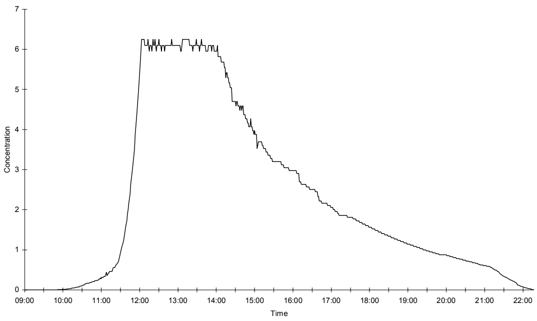
c) Variable Background Values



d) Inadequate Concentration Resolution



e) Variable Sampling Rate



d) Attenuated Distributions

Fig. 3.1 - Examples of Poor Quality Data

After discussions at meetings of the National Project Technical sub-group, a format for storing all necessary raw data was agreed (*minutes of meeting, 6/May/98*). Initially all river tracing data was converted to Excel work book format containing the following sheets:

- Sheet 1 (Summary) - Containing all details of the data set.
- Sheet 2. (Data) - Containing actual data for each measurement station. In paired columns of time/concentration data.
- Sheet 3. (Complot) - Composite time/concentration plot of all the data recorded at each station, and for each of n measurement stations,
- Sheets 3+1 to 3+n. (Station name) - A plot of the individual concentration/time distribution.

In the interests of storage, the individual plots were later removed. Examples of the agreed format are provided in the Appendix 10.2. It was also agreed that all future data to be included within the database would only be accepted in this format.

4. ANALYSIS OF DATA

To remove the variability in the prediction of travel time and dispersion parameters due to data quality and accuracy, a method of optimising predictions of a downstream temporal concentration distribution from an upstream distribution was developed. Firstly, it was necessary to mass balance the data. This procedure assumed that the tracer was conservative, the river flow constant and that the entire tracer mass measured upstream was also measured at the downstream site. To achieve a mass balance, the downstream data points were each multiplied by a mass balance factor. This factor was calculated from the upstream tracer mass divided by the downstream tracer mass.

A FORTRAN program was written which could calculate the standard ADE and ADZ coefficients from a given pair of temporal concentration distributions. These are the coefficients used in equations [2.1] and [2.3] for predicting downstream temporal concentration distributions. For each temporal concentration distribution, the time of the first arrival of the tracer was noted and the value for the centroid time (equation 2.2) was determined. From these values, both the mean velocity of the tracer cloud, u_c, given by:

$$u_c = \frac{x_2 - x_1}{\bar{t}_2 - \bar{t}_1} \qquad [4.1]$$

and the temporal variance $\sigma_t^2(x_i)$ at site i given by:

$$\sigma_t^2(x_i) = \frac{\int_{t=-\infty}^{\infty} (t - \bar{t}_i)^2 c(x_i, t)dt}{\int_{t=-\infty}^{\infty} c(x_i, t)dt} \qquad [4.2]$$

were determined. A value for the longitudinal dispersion coefficient, D, was then determined from

$$D = \frac{u_c^2}{2}\left[\frac{\sigma_t^2(x_2) - \sigma_t^2(x_1)}{\bar{t}_2 - \bar{t}_1}\right] \qquad [4.3]$$

These values, for centroid travel time, $\bar{t}$, dispersion coefficient, D and reach time delay, τ, were obtained directly from analysis of the raw data and as such have been termed 'standard coefficients'. They are strongly influenced by the quality of the raw data and decisions on both the start and end times for the temporal concentration distributions. An optimisation procedure was developed to minimise the influences.

The ADE and ADZ equations, [2.1] and [2.3] were then used in combination with these standard coefficients to predict downstream concentration profiles from the upstream data. A measure of the goodness of fit between the profiles and the actual data, R_t^2, (Young, Jakeman & McMurtrie, 1980) was calculated. The determination of R_t^2 is given by equation.

$$R_t^2 = 1 - \left[\frac{\sum_{t=1}^{n} (c_t - p_t)^2}{\sum_{t=1}^{n} c_t^2}\right] \qquad [4.4]$$

where c_t and p_t are the measured and predicted data values at time t. Using this definition, a prediction with an exact fit to the measured downstream data would give a value of unity for

R_t^2, and a value of less than zero would indicate that the prediction fails to describe any part of the measured result.

Having produced an initial prediction using the determined 'standard' parameters in equations [2.1] and [2.3], the values of the parameters were optimised to improve the prediction. For the ADE and ADZ equations the optimisation procedure was very similar. A sequence of refined searches through combinations of parameters, travel time and dispersion coefficient values for the ADE equation and travel time and time delay for the ADZ model, were performed to determine the pair which gave the best fit to the downstream temporal concentration profile. A matrix system was employed which greatly reduced the number of calculations required to reach the best fit solution. The pair of coefficients which gave the prediction with the best fit to the downstream data, represented by the cell with the greatest R_t^2 value assigned to it, were determined. A new matrix was created by the programme which 'zoomed in' towards the best fit coefficients. This procedure is shown diagrammatically in Fig. 4.1. The process of producing a new matrix was repeated until a predetermined final resolution was obtained. The final resolutions used are given in Table 4.1.

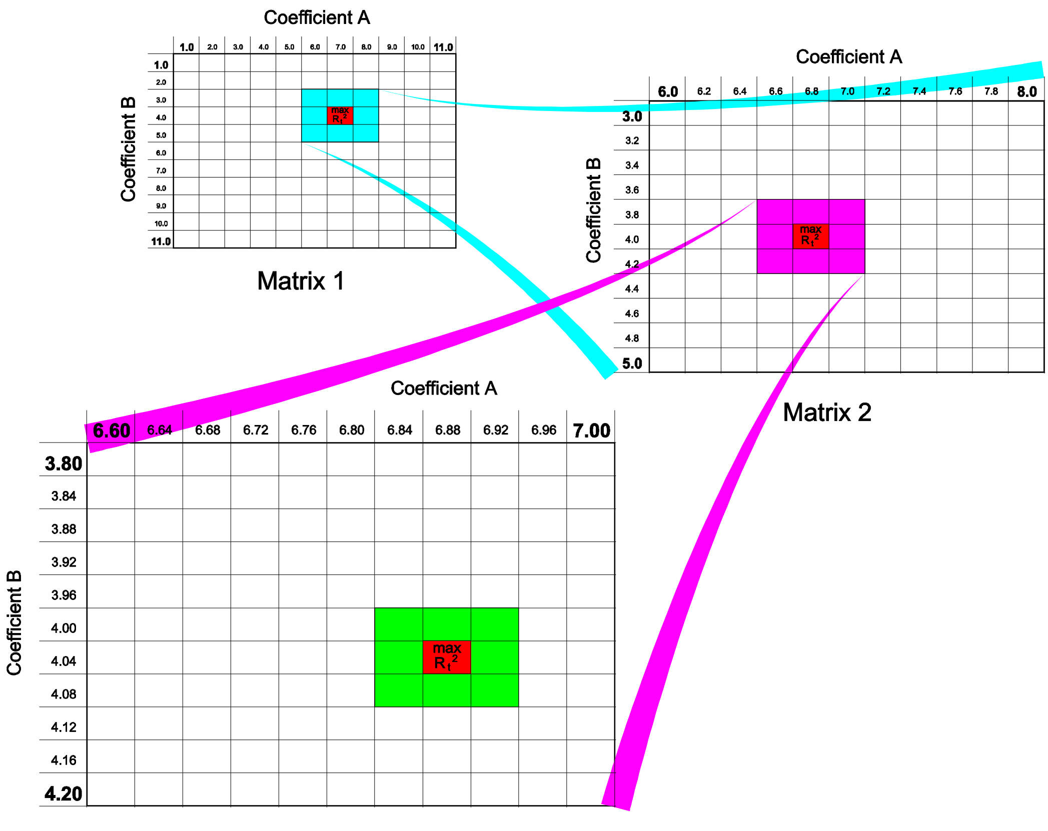


Fig. 4.1 Representation of the Matrix Optimisation Procedure.

For the optimisation technique to be reliable it was essential to verify that there was a unique pair of coefficients which gave the best fit of the prediction to the measured data. This was determined by examining the R_t^2 values over the entire matrix and ensuring that there was only one peak value. Fig. 4.2 displays the results of this procedure for the ADZ model. The base of the chart in the figure is composed of the travel time and time delay values used in the matrix. The three-dimensional surface represents the R_t^2 values for each travel time and time delay combination on the base. Fig. 4.2a shows a very coarse matrix and it is clear that there is a single peak. Fig. 4.2b shows results from a more refined matrix and indicates for this sample data that the prediction is more sensitive to time delay than travel time.

Coefficient	Resolution
Travel time steps	0.1 min
Dispersion coefficient steps	0.001 m^2/s
Time delay steps	data time step (Δt)

Table 4.1 Ultimate matrix resolution values.

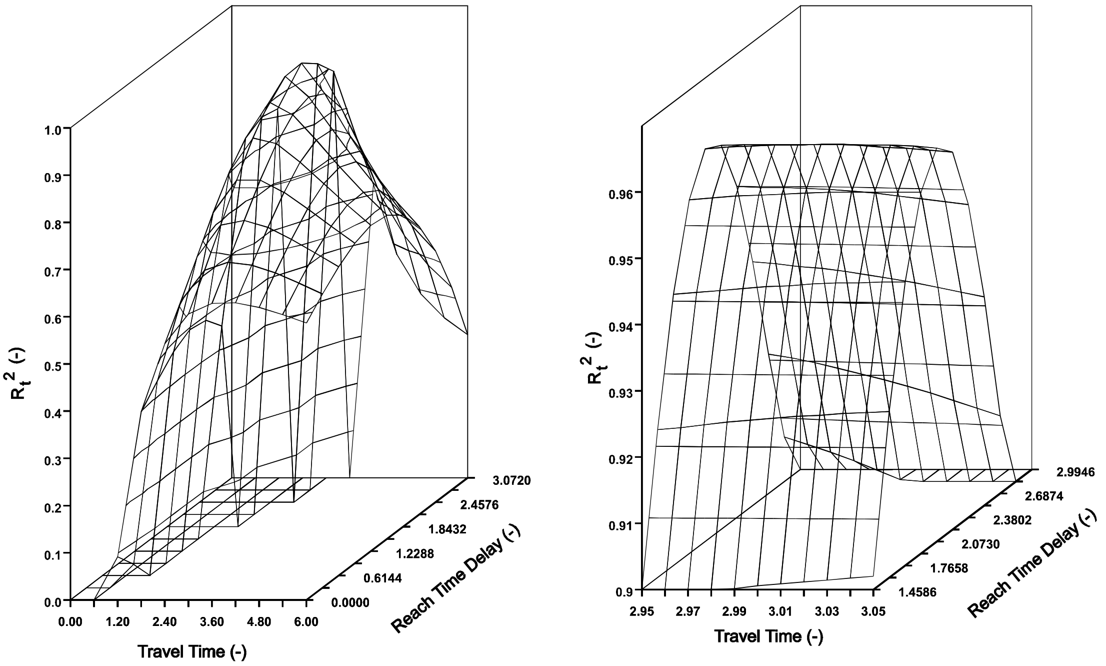


Fig. 4.2a Fig. 4.2b

Fig. 4.2 Surface Representation of Matrix Optimisation Results.

On completion of the optimisation procedure for each reach, all the standard and optimised coefficients were given, along with the R_t^2 values for each case. A hard copy summary sheet was also produced and these have been collated in the Project Record, Appendix 6.0.

5. PRODUCTION OF ACCESS DATABASE

A database has been designed and developed to hold information pertinent to reaches that have been studied and whose data were considered acceptable - see 3.0 Data collation. If a reach has been studied and the data accepted more than once, then there will be multiple entries for that reach.

The database was produced by Mr Tom Tunstill, as part requirement for the MSc in Information Systems, supervised by Dr Ian Guymer. Below is reproduced the abstract from the thesis which is provided in full in the Project Record, Appendix 5.0. A User Manual is reproduced in Appendix 10.3.

> ' ....the development of a database system intended to store data from time of travel studies carried out on rivers throughout the UK. In order to store this data, a relevant relational data structure was created. Several key features also had to be designed to meet the user's requirements. These included:
>
> i) an automatic import facility, which allows the user to import data directly from an excel spreadsheet file.
> ii) a feature to allow the user to search the database using complex criteria.
> iii) the system should be user-friendly.
>
> This was achieved by designing and implementing a graphical user interface. The system has been tested for durability and usability, and relevant changes incorporated before production of a final system.'

6. PREDICTIONS AND TRENDS

Having populated the database with analysed results, the final objective of the work was to develop empirical trends relating to both the travel time and the dispersion of material for untraced/ungauged rivers. In total some 193 reach results were available providing information from 96 different reaches.

Channel slope was only available for a total of 74 reaches. This was provided from OS maps, the accuracy of which is illustrated as 3 of the reaches were reported to have negative (uphill) slopes. The paucity of additional data describing the channel properties, such as slope, channel width, planform curvature or bed material, restricted the degree to which the development of trends could be achieved. However, basic variations of mean travel time and dispersion have been obtained.

6.1 Travel Times

A histogram illustrating the distribution of mean velocities is given in Fig. 6.1.

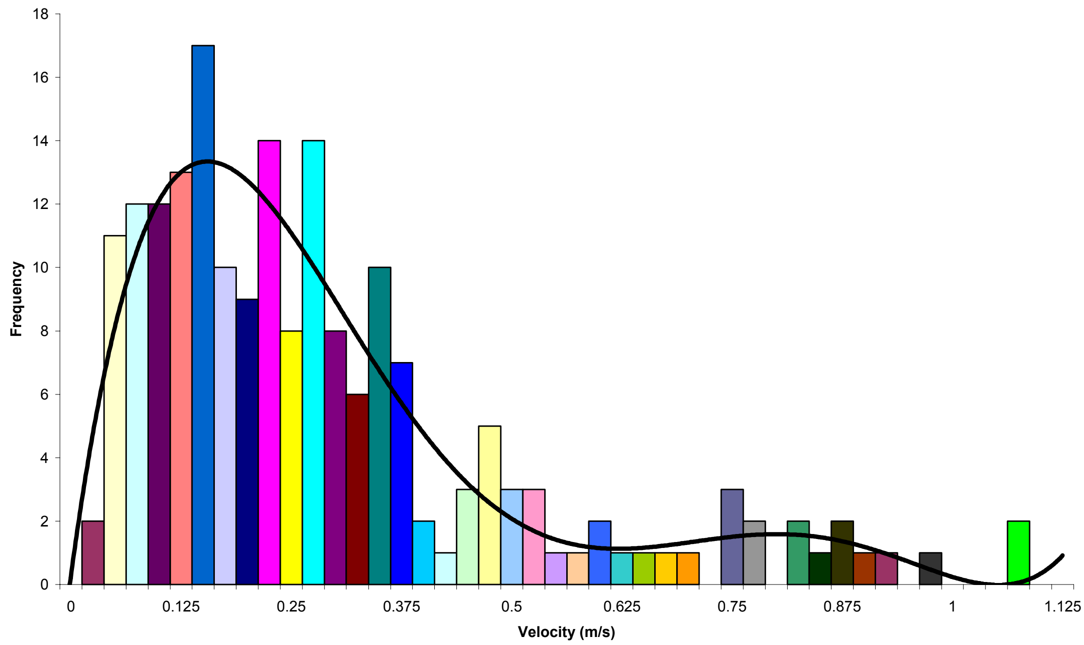


Fig. 6.1 Histogram of Reach Mean Velocities.

The velocities used to compile this distribution have been quantified in Table 6.1 below. A total of four velocities have been obtained for both the ADE and ADZ method of analysis, providing the mean travel velocity, together with the velocity for the peak concentration and the start and end 10% concentrations. In addition, the velocities obtained from analysis of the raw data have also been presented. For each method the maximum and minimum values are tabulated to illustrate the range of values obtained, together with the value of the mean, the variance and number of results used in the analysis.

Parameter	Velocity (m/s) Mean	$C_{-10\%}$	C_{max}	$C_{+10\%}$
	ADE			
Minimum	0.01	0.02	0.01	0.01
Maximum	1.06	1.19	1.05	1.01
Mean	0.28	0.33	0.27	0.26
Variance	0.05	0.07	0.04	0.04
Number of Values.	194	193	194	188
	ADZ			
Minimum	0.01	0.02	0.02	0.01
Maximum	1.04	1.11	1.07	0.98
Mean	0.27	0.30	0.28	0.24
Variance	0.04	0.06	0.05	0.04
Number of Values.	194	194	194	188
	Raw Data			
Minimum		0.02	0.02	0.02
Maximum		1.15	1.05	1.00
Mean		0.31	0.28	0.25
Variance		0.06	0.05	0.04
Number of Values.		194	194	174

Table 6.1 Summary of Reach Mean Velocities

It is encouraging to note that there is little difference between the mean velocities obtained from both ADE and ADZ analyses and with the peak concentration velocities (c_{max}). The velocities obtained for the first arrival of the 10% concentration value ($c_{-10\%}$) are of the order of 10% greater than the mean velocities, whilst the velocity from the tail 10% concentration value ($c_{+10\%}$) are also around 10% less. Predictions of the velocity for $c_{+10\%}$ using the ADE analysis exhibit less change compared with the mean. This would be expected from a technique that has a limited ability for describing skewed distributions.

Variations of mean velocity with discharge and reach slope are presented in Fig. 6.2 and 6.3 respectively. A general trend of increasing velocity with discharge is evident in Fig. 6.2, however the individual reach results obtained during a single injection appear to mask any significant trend. It is also suggested that to allow for the different scales of rivers tested a parameter describing discharge, perhaps non-dimensionalised with the long term mean discharge may provide a better insight.

Variation of mean velocity with channel slope, Fig. 6.3, suggests an increasing velocity with increasing slope, again with much scatter. It is clear that in it's current form this data is of limited use, partially due to the method of obtaining slope information, but also due to a lack of additional information describing the channel type and boundary material.

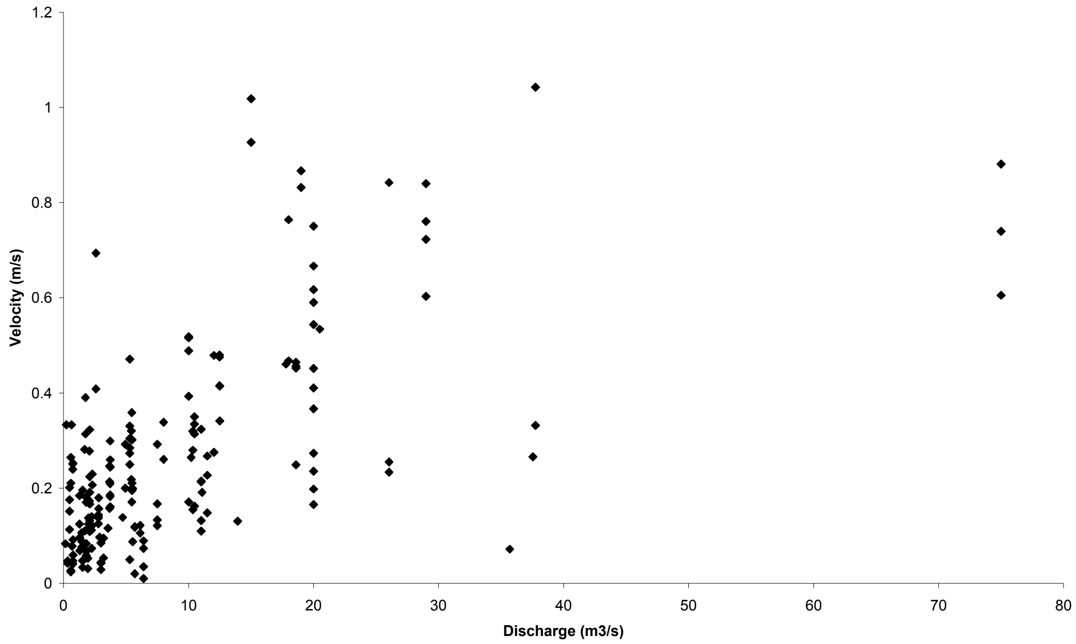


Fig. 6.2 Variation of Mean Velocity with Discharge

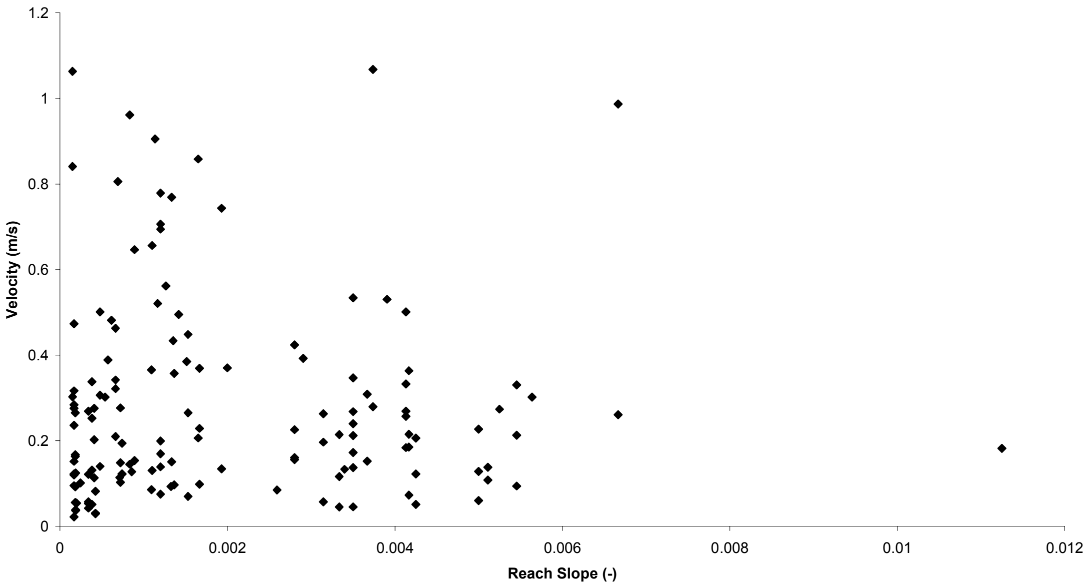


Fig. 6.3 Variation of Mean Velocity with Reach Slope

An analysis similar to that performed by Jobson (1997) has been undertaken using the data available in the EA database. The resulting optimised relationship has been used to compare predicted peak velocities with measured peak velocities. This is shown in Fig. 6.4 and produces an R^2 value of 0.76, indicating a slightly better fit than that derived by Jobson (1997) for the US data. This clearly shows the potential benefit of the analysis, however determining the working limits of such a relationship requires further investigation, especially as the relationships derived for the US and EA data are not similar.

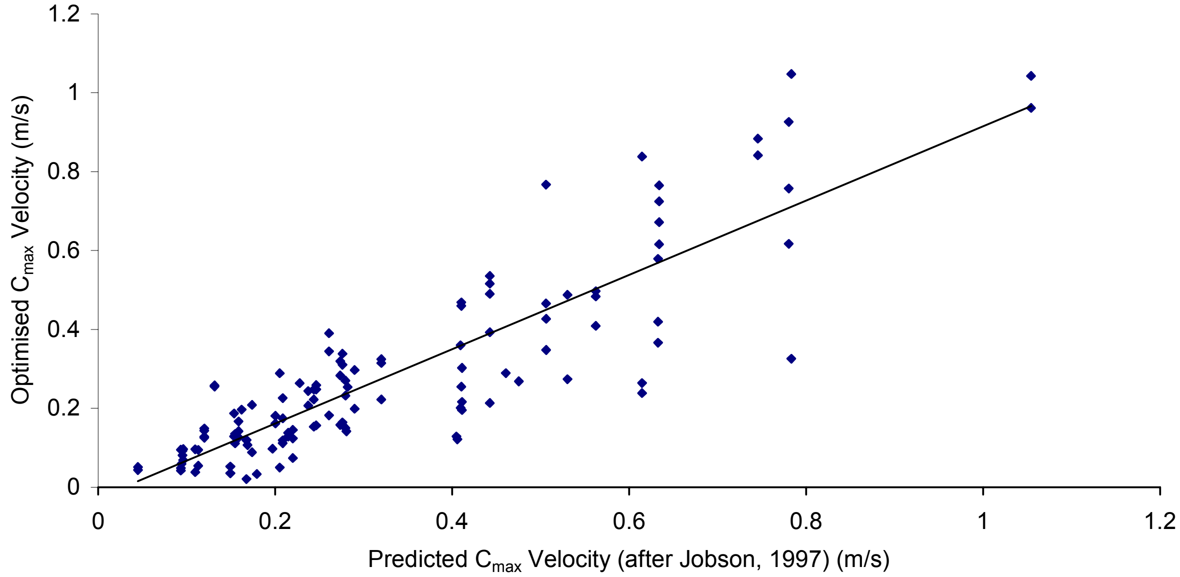


Fig. 6.4 Comparison of Predicted Peak Velocities Using Jobson (1997) Technique

6.2 Velocity/Discharge Trends

In reviewing current practise within the Agency (Scoping Report, Project Record Appendix 4.0) it was found that predicting the effect of discharge changes on the travel time was undertaken using equations of the form $v = kQ^x$, where v is the mean velocity, Q the discharge, k a constant and x the power. In collating the results from this study, values of k and x have been obtained for reaches where more than three travel time studies have been performed. These are shown in Fig. 6.5 and 6.6 for reaches with five and four results respectively. However, the reaches that have five repeat traces performed have two repeat tests undertaken at similar discharges and are of little additional benefit than those with four traces. Values for the fitted parameters are presented in Table 6.2.

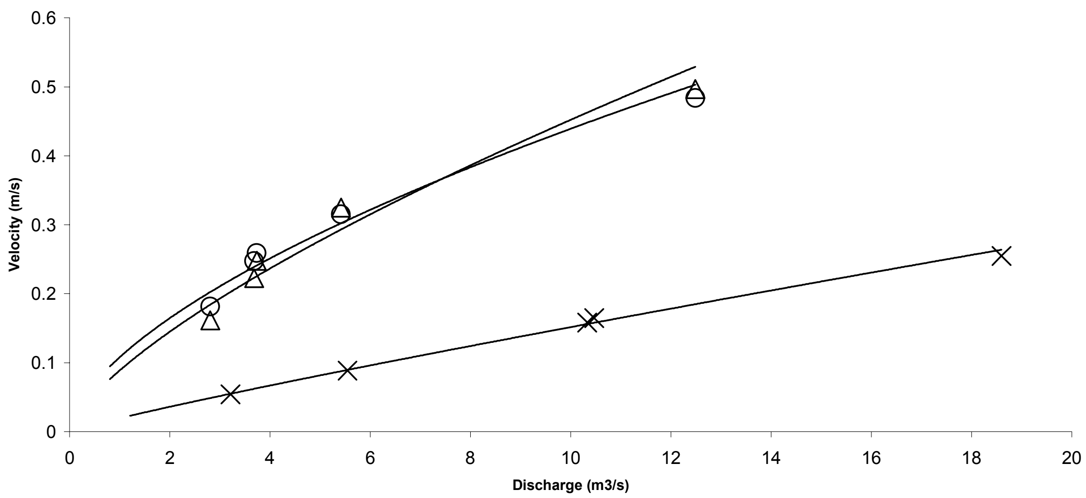


Fig. 6.5 Results for Reaches with Five Traces Undertaken.

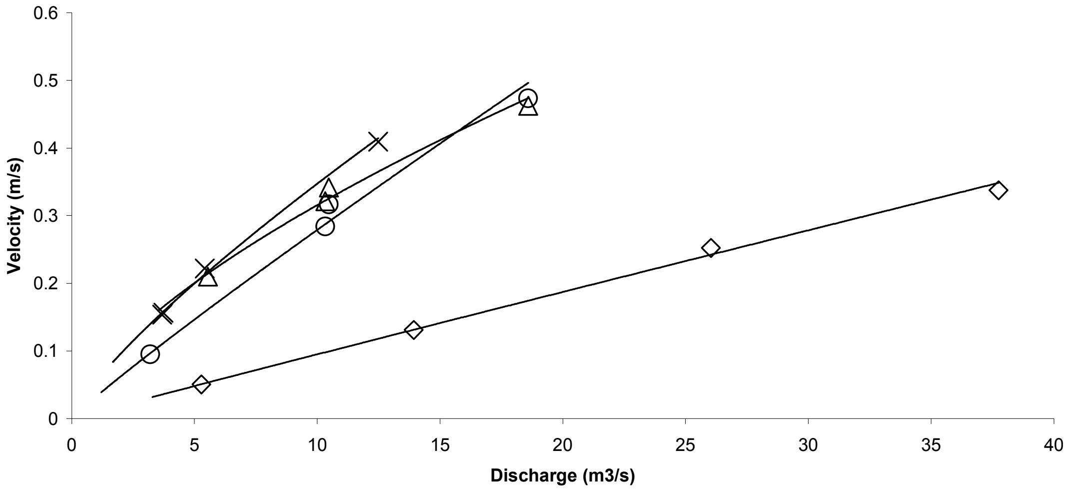


Fig. 6.6 Results for Reaches with Four Traces Undertaken.

It is difficult from such a small data set, to obtain clear trends with any degree of confidence. Values of the power range from 0.6100 to 0.9777, with the constant ranging between 0.01 and 0.1078. It appears that the power increases with decreasing river slope, however further results would be required over a wider range of slopes, with more discharges, to provide any definite relationship.

	k	X	R^2	Slope, S_o
Five Traces				
1	0.0887	0.7073	0.9427	0.0035
2	0.1078	0.6100	0.9583	0.0041
3	0.0194	0.8936	0.9977	0.0002
Four Traces				
1	0.0554	0.7972	0.9962	0.0028
2	0.0329	0.9287	0.9930	0.0002
3	0.0699	0.6546	0.9890	0.0007
4	0.0100	0.9777	0.9988	0.0004

Table 6.2 Parameters Derived from Fitting $v = kQ^x$ Trends

6.3 Longitudinal Dispersion Trends

Quality and completeness of temporal concentration distributions have a greater influence on the prediction of dispersion parameters than on the prediction of mean velocities. Optimisation of both ADE and ADZ predictions have been made for the available data sets and the results are summarised below. No attempt has been made at present to filter or remove any values as this becomes subjective and requires detailed consideration of all the predictions. The variation of the longitudinal coefficient (ADE) and the dispersive fraction (ADZ) with discharge have been produced in Fig. 6.7 and 6.8 respectively.

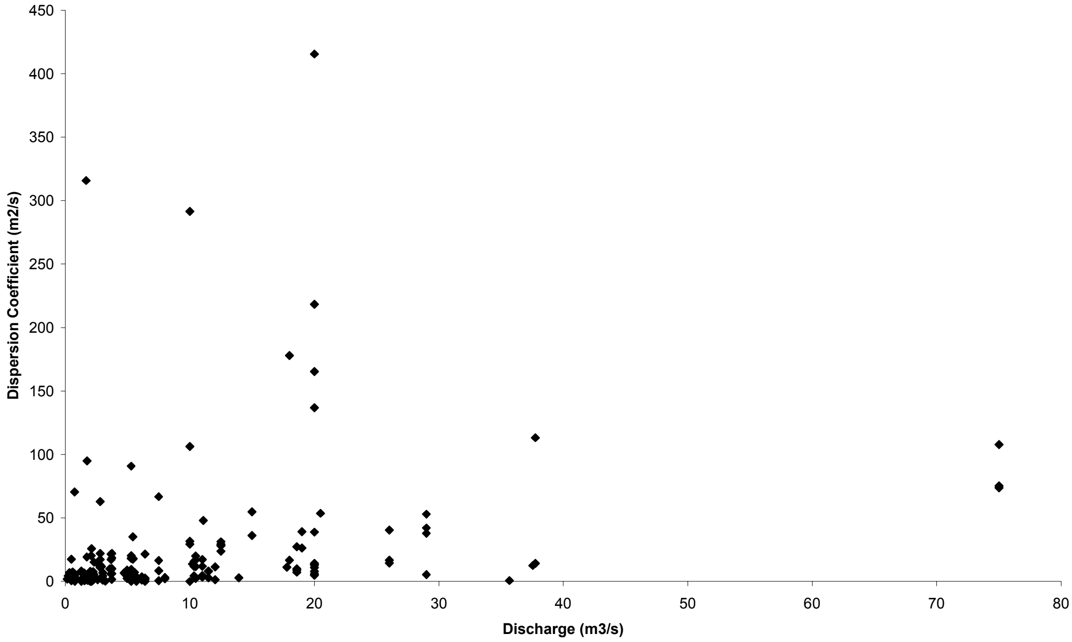


Fig. 6.7 Variation of Dispersion Coefficient with Discharge

As with the travel time results, on first inspection there are no clear trends, and further interpretation of the data set is required. It is however, encouraging to note that Fig. 6.9 shows a positive correlation between the longitudinal dispersion coefficient and the dispersive fraction.

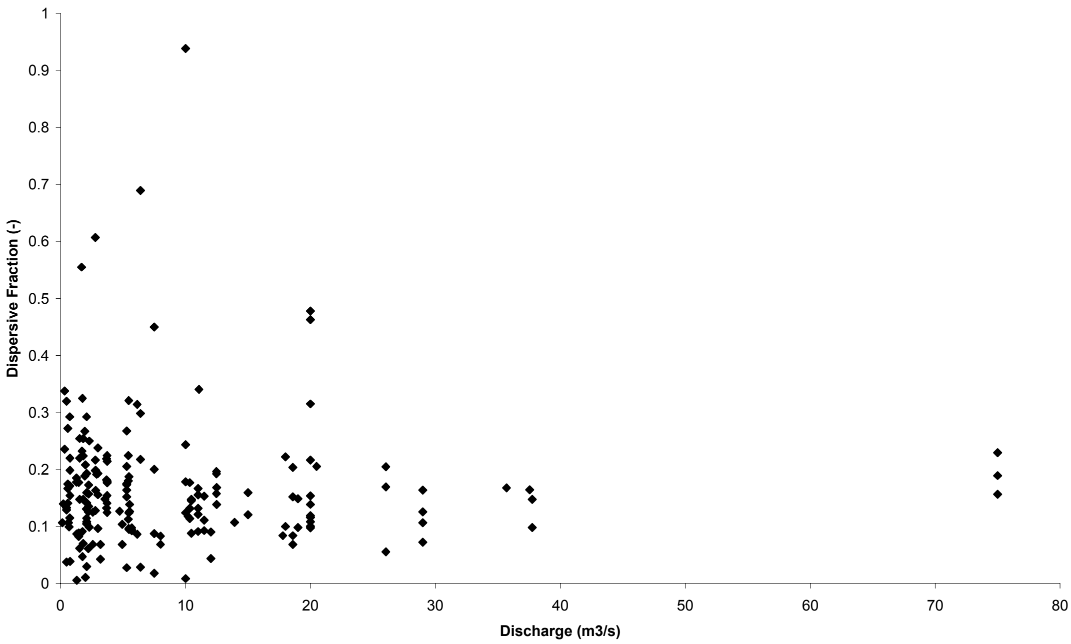


Fig. 6.8 Variation of Dispersive Fraction with Discharge.

The magnitude of the dispersive fraction appears to vary less with discharge than the longitudinal dispersion coefficient and as a result it may introduce less variations if this technique were adopted for predictions. However, with the quality and quantity of data available to date, use of different mean velocities for first arrival ($c_{-10\%}$) and end of the trace ($c_{+10\%}$), would provide a robust method to predict the spread of soluble material.

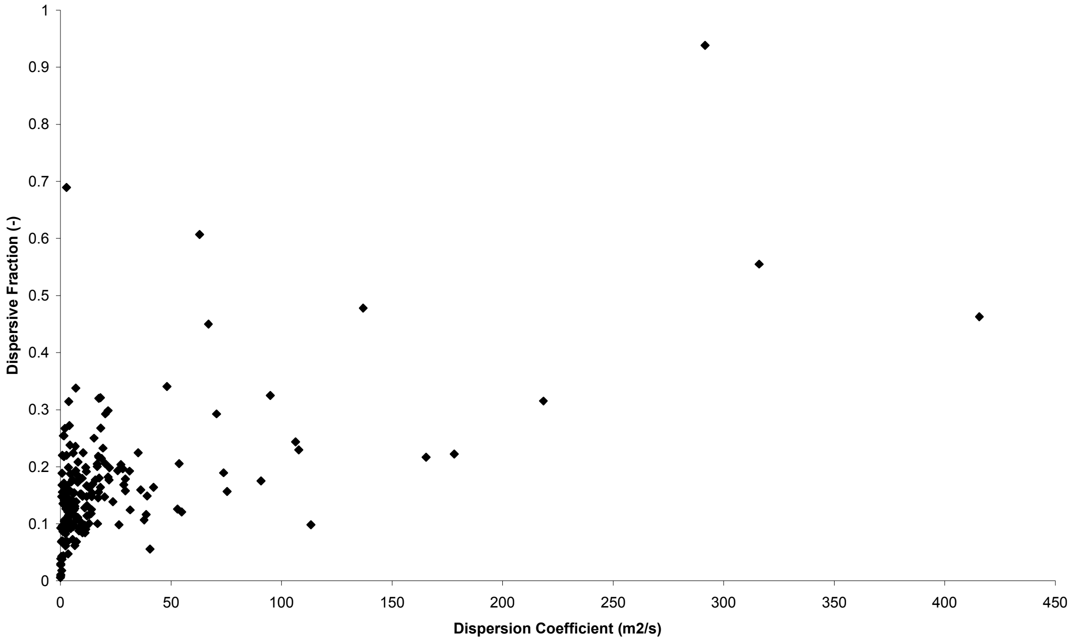


Fig. 6.9 Variation of Dispersion Coefficient with Dispersive Fraction.

7. CONCLUSIONS

All available temporal concentration distributions obtained from recent river tracing studies have been collected and an initial quality assurance check undertaken. The acceptable data have been stored in an agreed MS Excel format, containing summary details of the tracing exercise, together with a plot and listing of the raw data. These data have been analysed for advection and dispersion characteristics and the results for each reach appended to the Excel files.

A MS Access database has been developed that allows complex search criteria to be adopted. This database has been used to define the variation of solute velocity within the reaches studied and also to develop trends relating the travel velocity to the discharge. To a lesser extent, relationships with river bed slope have also been obtained. This has produced useful results, but is limited by the quality and quantity of available data.

Descriptions of current theories and approaches for describing and predicting advection and dispersion have been summarised. Guidelines have been developed to assist with collecting appropriate and accurate information in future time of travel studies.

8. RECOMMENDATIONS

Considerable resources have been employed both within and external to the Agency to produce this database and it is essential that ownership is taken and it is maintained thoroughly. It has the capacity to be extended to include new surveys and it's usefulness will then be enhanced. The database has been structured to allow for the inclusion of historical data, without the need to undertake optimisation analysis. Although the confidence level associated with this data may be reduced, significant additional information may be obtained by expanding the database in this way. This is strongly recommended.

The paucity of available data has severely limited the level of analysis and applicability of predictions. Improved accuracy of reach lengths alone would improve accuracy of velocity and dispersion parameters. Inclusion of bed levels at all monitoring sites would allow the determination of reach slopes for all the available data. This would significantly expand the available data set.

It has not been possible to test the predictive techniques against catchment data sets. At this stage it is suggested that further development of the database is undertaken. More specifically, it is possible that greater confidence can be gained by looking at the goodness of fit of the analysed results. This should be followed by an attempt to obtain additional information regarding the river reaches that have already been traced. Information such as an accurate measurement of bed slope, channel size and cross-sectional shape, if possible as a function of longitudinal distance. Planform curvature is also a channel property that will significantly influence longitudinal dispersion and one that may be readily obtainable from GIS systems. This should reduce some of the scatter observed on the relationships and increase the confidence of predictions. This would allow the working envelope of the Jobson (1997) analysis to be determined.

Further, it may be that additional useful information is available within the Environment Agency River Habitat Survey database and a merger of the information may make a significant contribution to predicting travel times and dispersion within catchment modelling processes.

REFERENCES

Barraclough, A., Freestone, R., Guymer, I. and O'Brien, R.T., (1994) 'Evaluation of the Aggregated Dead Zone (ADZ) method as a River Catchment Management Tool applied to the rivers Aire and Derwent in Yorkshire'. 2nd Int. Conf. on Hyd. Modelling, Stratford-upon-Avon, U.K., 14-16 June, 439-449.

Beer, T. & Young, P.C. (1984) 'Longitudinal Dispersion in Natural Streams', Proc. A.S.C.E., J. Env. Eng. Div., 109, 1049-1067.

Fischer, H.B., List, E.J., Koh, R.C.Y., Imberger, J. and Brooks, N.H. (1979) 'Mixing in Inland and Coastal Waters', *Academic Press, New York.*

Green, H. M., Beven, K. J., Buckley, K. & Young, P. C. (1994). 'Pollution Incident Prediction with Uncertainty.' Mixing and Transport in the Environment, K.J. Beven, P.C. Chatwin, & J.H. Millbank, eds., John Wiley & Sons, 113-137.

Jobson, H.E. (1997) 'Predicting Travel time and Dispersion in Rivers and Streams', Journal of Hydraulic Engineering, Vol. 123, No. 11, Nov., 971-978.

Rutherford, J.C. (1994) "River Mixing", *J. Wiley & Sons, Chichester, England.*

Taylor, G.I. (1954) "The Dispersion of Matter in Turbulent Flow Through a Pipe", Proc. R. Soc. London Ser. A, 223, 446-468.

Wallis, S.G., Guymer, I. and Bilgi, A. (1989b) 'A Practical Engineering Approach to Modelling Longitudinal Dispersion', Proc. of Int. Conf. on Hydraulic and Environmental Modelling of Coastal, Estuarine and River Waters, Bradford, England. 19-21 Sept., 291-300.

Wallis, S.G., Young, P.C. and Beven. K.J. (1989a) 'Experimental Investigations of the Aggregated Dead Zone Model for Longitudinal Solute Transport in Stream Channels' Proc. Inst. Civil Eng., Part 2, 87, 1-22.

Young, P., Jakeman, A. & McMurtrie, R. (1980). 'An Instrument Variable Method for Model Order Identification.' Automatica, Vol. 16, 281-294.

Young, P.C. and Wallis, S.G. (1986) 'The aggregated dead zone (ADZ) model for dispersion in rivers', Int. Conf. on Wat. Qual. Modelling in the Inland Nat. Env., Bournemouth, Eng., L1, 421-433.

APPENDICES

10.1 DEFINITION OF ACCEPTABLE DATA, METHODOLOGY AND SPECIMEN TENDER DOCUMENT

The following points define the minimum standard of data required to fulfil the objectives of this project.

1. The minimum concentration resolution should be $1/40^{th}$ of the measured peak concentration (after background removal). Any perceived difficulties in achieving this standard should be resolved with the Project Manager prior to commencing the survey. Much greater resolutions are, however, preferred.
2. Tracer arrival and peak should be clearly defined.
3. The tail should recede at least to 10% of the peak concentration. It is expected that unless there are strong reasons for ending the monitoring early, the tail should recede to 5% of the peak and ideally to background.
4. The temporal resolution of the data should be constant at all stations and should provide a minimum of 40 points to define the distribution.
5. If the EA concludes that the data is not acceptable, the contractor will redo the whole trace at their expense.
6. The information indicated on the EXCEL template should be provided for each survey.

METHODOLOGY

- The minimum quantity of tracer should be injected consistent with the following two requirements:
  - The maximum concentration at the Tees Intake must be no more than 0.1ug/l above background. This is an absolute requirement of each study. (Note, in the Greta studies, there is considerable dilution between the most downstream monitoring point and the intake.)
  - There should be clear resolution of the concentration curve at each monitoring point, as described in the document 'DEFINITION OF ACCEPTABLE DATA'.
- The only acceptable tracer is Rhodamine WT.
- Immediate contact should be made with the water undertaker if these values are likely to be exceeded at the point of abstraction.
- The total length of river specified must be traced at one time for any flow condition. However, more than one injection may be used if agreed beforehand with the Project Manager.
- Monitoring should be at a suitably fine temporal resolution to give an accurate definition of the passage of the Rhodamine plume through a site.
- All tracer injections must be of a gulp nature.
- Where not already defined, the location of the first sampling point must be sufficiently downstream to achieve initial mixing.
- All reasonable efforts should be made to ensure the plume will not be visible during daylight hours.
- The EA Public Relations Department and Water Company operations must be notified of impending survey work. All press releases concerning this project should be handled by the EA. The contractor must therefore specify injection times and dates for any surveys at least 24 hours in advance.
- Water samples should be taken from the mainstream section of the channel, avoiding any dead zones. The same sites identified in the specification should be used in each survey.
- Tenders will be favoured that can demonstrate the use of three fluorometers in series operating at the same time if this is likely to be required given the spacing of the monitoring sites. A backup fluorometer should be on hand at all times to ensure:
  - Continued sampling;
  - Full protection of water company intakes
- Tenders will be favoured that can demonstrate the ability to meet the resolution requirements described in 'DEFINITION OF ACCEPTABLE DATA'.
- A reliable source of power should be demonstrated with an acceptable noise level and heavy duty batteries. It should be assumed that mains power will not be available.
- Communication should be established between the contractor and EA for the duration of the surveys. Results should be made immediately available to identify any immediate risk to intakes.
- As far as it is possible to pre-plan, tracing studies should not be undertaken in adverse weather conditions. Tracing studies should be undertaken at constant discharge for the duration. (It is accepted that this may not be possible to strictly adhere to for high flows.)
- The EA will provide one liaison person for each experiment.
- All EA Health & Safety requirements as described in the Specification should be fully adhered to.

Time of Travel & Dispersion Studies

River Tees Risk Assessment

1.0 Project Outline

Aim: To collect and validate time of travel data for the River Greta and to produce pollution incident tables.

Objectives:

1) To collect time of travel and solute dispersion data across three flow bands for the river Greta.
2) To validate this data and derive pollution incident tables appropriate for use by field staff.

2.0 Background

It is the intention of the North East Region of the Environment Agency (EA) that each of its riverine potable abstractions should be protected from pollution incidents. This will be achieved by the collection of appropriate field data, which will be used to develop predictive techniques describing the advection and dispersion of pollutants. These measures will in many cases be supported by catchment-based Risk Assessment Studies, which will locate, categorise and where possible minimise the quantities of pollutants in a catchment and develop strategies for dealing with pollution incidents.

One such Risk Assessment Study is ongoing in the Tees catchment. A significant risk already identified is that of road tanker accidents on the A66(T). This project aims to provide the necessary data and capability to effectively manage such accidents which result in pollution of the River Greta and which pose a threat to the Tees Intake.

3.0 Tracer Surveys

Surveys to be undertaken

River	Approximate length to be traced Km	Number of surveys at flow bands: Low	Medium	High
Greta	25	1	1	1

The flow bands are defined as follows:

Low	< 20%ile
Medium	20 – 55%ile
High	> 55%ile

Survey sites

Site	Name	NGR
Injection	Railway Bridge	NY 900 119
Monitor 1	Bowes Bridge	NY 995 133
Monitor 2	Rutherford Bridge (GS)	NZ 034 122
Monitor 3	Rokeby Park Footbridge or	NZ 087 139
	Dairy Bridge	NZ 084 144

Note: A decision on which of the two site should be selected for Monitor 3 must be agreed with the EA. At Rokeby Park Footbridge, permission will have to be obtained from the owners of the estate.

The above flow bands are preferred. It is required, however, that the project is completed this financial year (1998/99). All three studies should therefore be completed, data validated and outputs delivered by 12th February 1999. It will therefore be acceptable if the three surveys are not all in different flow bands.

Details of individual surveys should be agreed with the project leader in advance. The EA can provide assistance and on line river flow information during the working day. Each survey should be undertaken in accordance with the acceptable data document, (appended).
The survey methodology appended should be adhered to strictly, in order to maintain healthy & wholesome public water supplies.

4.0 Project Outputs

4.1 Data

Raw data, validated data (corrected to background concentration, spurious data removed etc.) a data summary and a study summary should be provided in EXCEL format. A template is provided (only mandatory fields need be completed).
Ownership of the data is the sole right of the EA and can be provided by the EA to third parties at its discretion.
The data collected for the purpose of this project must not be sold by the contractor, used for any other projects or distributed without the consent of the EA.
Provision should be made by the contractor to provide the data or information about the data at any time throughout the contract in order to fulfil operational requirements e.g. pollution incidents.

4.2 Reports

One final report should be provided at the end of the project. This should include a comprehensive discussion of the data, its value in incident prediction, flow conditions of surveys (including relevant hydrographs provided by the EA) and recommendations.

5.0 Review

The EA reserves the right to redesign the tracer surveys within the overall cost boundaries of the contract.

6.0 Health & Safety

The EA will undertake assessments of study sites to enable it to highlight health and safety risk over which it has control. The EA will then provide appropriate details to the successful contractor to enable them to carry out their own health and safety risk assessments effectively. The successful contractor will be required to work in accordance with the Codes of Practice and Safe Systems of Work sections of the EA Health and Safety Manual where appropriate. The successful contractor will, however, need to demonstrate their awareness of and competency to manage risks associated with any equipment and procedures that may be used in the surveys.

10.2 Format of Excel Data Store

The Excel data store comprises a summary sheet, a chart showing the data and a worksheet containing all the original raw data as provided by the contractor. After analysis additional worksheets will be created to contain the results for each reach.

Summary Sheet Information

	Cell Location	Meaning
General Information		
Version 1 Last Update: (dd/mm/yyyy)	D1	
File Name:	B2	Excel file name
Region:	B3	EA Region
Area:	B4	within Region
Catchment Name:	B5	
Flow Excedence / Category: Q'n' (where 'n' is excedence)	B6	
Reach Name: (if applicable)	B7	
Contractor Details		
Project Reference:	J2	
Contracting Company:	J3	
Company Contact:	J4	
Telephone Number:	J5	
Address:	J6 &J7	
Injection Information		
River/trib/watercourse name:	B11	
Dye Injected: Time (hh:mm)	B12	
Date (dd/mm/yyyy)	D12	
at (Location)	B13	
Bed level (m A.O.D.)	B14	
Tracer:	B15	Type of tracer used
Dosing Volume: (Litres)	B16	
Dosing Concentration: (mg/l)	B17	
Catchment Area:	B18	upstream of injection point
Grid Reference:	B19	
Theoretical mean flow: (m3/s)	B20	
Theoretical Q95 Flow: (m3/s)	B21	
Hydrological reference:	B22	
Flow Data		
Ref. Gauging Station	J13	
Grid Ref.	K13	
Hydrological Reference	L13	
EA Number	M13	
Catchment area for Gauging station (m3/s)	J14	
Discharge @ Time of Injection (m3/s)	J15	

Daily Mean Flow (m3/s)	J16	During test
Average Daily Flow (m3/s)	J17	Over long period
Q95 Flow @ Gauging station (m3/s)	J18	
No. of Spot Gauges	J19	If undertaken
Comments	J20 & J21	

Summary of Spot Gauges:- (rows 28 to 31)

Number	G28
Grid Ref.	H28
Time (hh:mm)	I28
Discharge (m3/s)	J28
Theoretical Mean Flow (m3/s)	K28
Theoretical Q95 Flow (m3/s)	L28
Hydrological reference	M28

List of Monitoring Points: (rows 43 upwards)

Number	A43
Names	B43
Grid Ref.	C43
Elevation (m A.O.D.)	D43
River/Trib./Watercourse Name	E43
Catchment Area (km2)	F43
Hydrological Reference	G43
River Distance from Injection Point (km)	H43
Theoretical Mean Flow (m3/s)	I43
Theoretical Q95 Flow (m3/s)	J43
Logging Started Time (hh:mm)	K43
Date (dd/mm/yyyy)	L43
Time Since Injection (minutes)	M43

Additional Comments	G35 & G36

Chart Format

Dye Conc. (Y-Axis) Unit: (PPB, ug/l, etc)	B26
Time-Plot (X-Axis) Unit: (Days, Hours, Minutes or Seconds)	B27
Data Logging Method: -	B28
Data Logging Interval: (Seconds)	B29
Date Logging Started: (dd/mm/yyyy) & (hh:mm)	B30 & D30
Date Logging Ended: (dd/mm/yyyy) & (hh:mm)	B31 & D31

Raw Data Sheet

For each monitoring station the name is stored in cell B6 and the data listed below in columns A and B, from rows 11 onwards. Subsequent data is stored in the same format translated 4 columns to the right (i.e. for the monitoring station name, columns E, H, K etc. - see attached example print out)

General Information

Version 1 Last Update: *13/09/99* *(dd/mm/yyyy)*

File Name:	*AN_12*	
Region:	*Anglian*	
Area:	*Eastern*	
Catchment Name:	*Waveney*	
Flow Excedence / Category:	-	*Q'n' (where 'n' is excedence)*
Reach Name: (if applicable)	-	

For 'MANDATORY' Fields:-
Enter input data within red shaded cells
Notes displayed in blue font

For 'OPTIONAL' Fields:-
Enter input data within grey shaded cells
Notes displayed in green font

Contractor Details

Project Reference:	-
Contracting Company:	-
Company Contact:	-
Telephone Number:	-
Address:	-

Injection Information

River/trib/watercourse name:	*Waveney*			
Dye Injected:	*21:37*	*(Time hh:mm)*	*29/01/98*	*(Date dd/mm/yyyy)*
at	*Denmark Bridge*	*(Location)*		
Bed level		*(m A.O.D.)*		
Tracer:	*RWT*			
Dosing Volume:	-	*(Litres)*		
Dosing Concentration:	-	*(mg/l)*		
Catchment Area:	-	*(km2)*		
Grid Reference:	*TM 111 794*			
Theoretical mean flow:	-	*(m3/s)*		
Theoretical Q95 Flow:	-	*(m3/s)*		
Hydrological reference:	-			

Flow Data

		Grid Ref.	Hydrological Reference	EA Number
Ref. Gauging Station	*Billingford*	*TM 168 782*	*34010*	*34010*
Catchment area for Gauging station (km2)	149.4			
Discharge @ Time of Injection (m3/s)	0.684			
Daily Mean Flow (m3/s)	0.527			
Average Daily Flow (m3/s)				
Q95 Flow @ Gauging station (m3/s)	0.074			
No. of Spot Gauges	*0*			
Comments	-			
	-			

Chart Format

Dye Conc. (Y-Axis) Unit:	*ug/l*	*(PPB, ug/l, etc)*		
Time-Plot (X-Axis) Unit:	*Hours*	*(Days, Hours, Minutes or Seconds)*		
Data Logging Method:	-			
Data Logging Interval:	-	*(Minutes)*		
Data Logging Started:	*Date*	*(dd/mm/yyyy)*	*Time*	*(hh:mm)*
Data Logging Ended:	*Date*	*(dd/mm/yyyy)*	*Time*	*(hh:mm)*

Summary of Spot Gauges:-

(Number)	Grid Ref.	Time (hh:mm)	Discharge (m3/s)	Theoretical mean flow (m3/s)	Theoretical Q95 flow (m3/s)	Hydrological Reference
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

Monitoring Stations

No. of Monitoring Stations: *4*

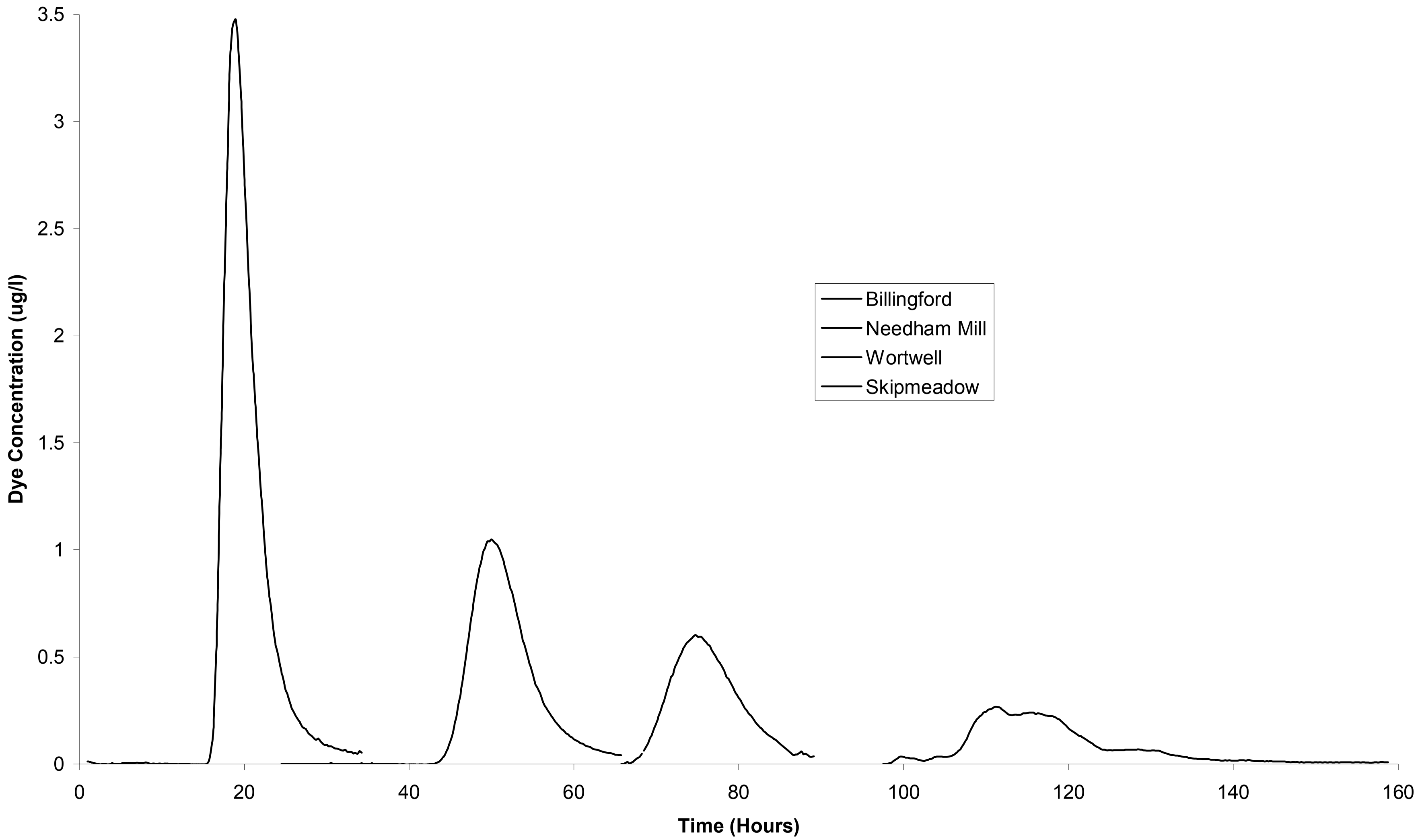
Additional Comments

station 3 has variable time steps

-

List of Monitoring Points:

Number	Names	Grid Ref.	Elevation (m A.O.D.)	River/Trib./ Watercourse Name	Catchment Area (km2)	Hydrological Reference	River distance from injection point (km)	Theoretical Mean Flow (m3/s)	Theoretical Q95 Flow (m3/s)	*(Logging Started:)* (Time) (hh:mm)	(Date) (dd/mm/yyyy)	Time since Injection *(Minutes)*
1	*Billingford*	*TM 168 782*	*20.3*	*Waveney*	*149.4*	*34010*	*6*	*0.76*	*0.074*			
2	*Needham*	*TM 229 811*	*16.5*	*Waveney*	*370*	*34006*	*15*	*1.76*	*0.311*			
3	*Wortwell*	*TM 285 846*	-	-	-	-	*23.3*	-	-			
4	*Shipmeadow*	*TM 385 907*	-	-	-	-	*50.15*	-	-			



Billingford
Needham Mill
Wortwell
Skipmeadow
Dye Concentration (ug/l)
Time (Hours)

Raw Data Sheet

Monitoring Station:- Billingford		Monitoring Station:- Needham Mill		Monitoring Station:- Wortwell		Monitoring Station:- Skipmeadow	
Time since injection (Hours)	Dye Concentration (ug/l)	Time since injection (Hours)	Dye Concentration (ug/l)	Time since injection (Hours)	Dye Concentration (ug/l)	Time since injection (Hours)	Dye Concentration (ug/l)
1	0.012576	24.5	-0.000276	65.75	-0.00044	97.5	0
1.25	0.010658	24.75	0.000683	66	0.000573	97.75	0.000298
1.5	0.006822	25	0.000683	66.25	0.004625	98	0.001257
1.75	0.004904	25.25	0.000683	66.5	0.008677	98.25	0.003175
2	0.002027	25.5	0.001642	66.75	0.002314	98.5	0.006052
2.25	0.001068	25.75	0.001642	67	0.00615	98.75	0.013724
2.5	-0.00085	26	0.000683	67.25	0.013822	99	0.020437
2.75	0.000109	26.25	0.000683	67.5	0.021494	99.25	0.026191
3	0.000109	26.5	0.000683	67.75	0.029166	99.5	0.032904
3.25	0.000109	26.75	-0.000276	68	0.03492	99.75	0.034822
3.5	-0.00085	27	-0.000276	68.25	0.047387	100	0.033863
3.75	0.000109	27.25	-0.000276	68.35		100.25	0.030027
4	0.004904	27.5	-0.000276	68.5	0.061772	100.5	0.030027
4.25	0.000109	27.75	-0.000276	68.75	0.079034	100.75	0.02715
4.5	0.000109	28	-0.000276	69	0.096296	101	0.02715
4.75	0.000109	28.25	0.000683	69.25	0.12123	101.25	0.026191
5	0.000109	28.5	-0.000276	69.5	0.141369	101.5	0.023314
5.25	0.003945	28.75	0.000683	69.75	0.168221	101.75	0.020437
5.5	0.003945	29	-0.000276	70	0.190278	102	0.01756
5.75	0.004904	29.25	-0.000276	70.25	0.220966	102.25	0.015642
6	0.004904	29.5	-0.000276	70.5	0.2459	102.5	0.013724
6.25	0.004904	29.75	0.001642	70.75	0.276588	102.75	0.01756
6.5	0.003945	30	0.000683	71	0.30344	103	0.020437
6.75	0.004904	30.25	-0.000276	71.25	0.337005	103.25	0.023314

10.3 Access database user manual

N.T.Tunstill 1999

Before running the database

This database requires Microsoft Access '97 or later.
Running the database directly from the disc it is supplied on is not recommended.

Before running the database it is recommended that you copy the database file (named TOT.mde) onto your hard disc (in Win95 or NT4, Windows Explorer can be used to do this).

Running the database

The database can be run by either of the two following methods

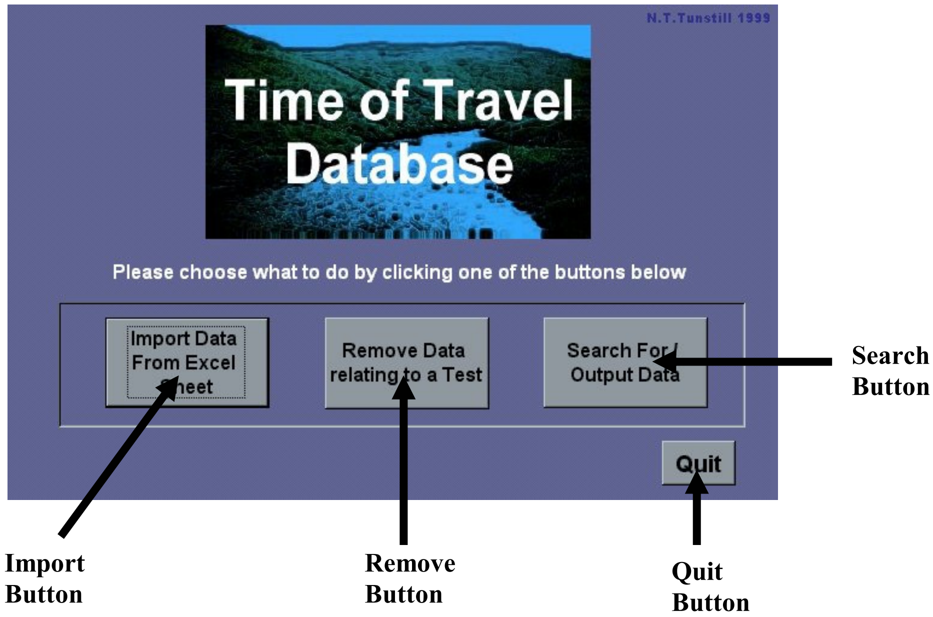
A) starting Access '97 and loading the file (TOT.mde)
B) double clicking on the file's icon (in either Windows Explorer or My Computer for Win '95 or NT4).

The location of the file (TOT.mde) will depend on whereabouts you have copied it to on your hard disc.
You may wish to create a shortcut to the database to place on your desktop. Win '95 users can do this by clicking the right mouse button over an empty area of desktop and selecting 'New' and then 'Shortcut'. The 'Browse' facility will allow you to locate and select the 'TOT.mde' file.

The Main Menu

Once the database has loaded successfully, the main menu will be shown. Depending on your display setup, this will look similar to 'Figure 1' below.

Figure 1. – The Main Menu



Depending on what you wish to do, you may click one of the three main buttons or the ‘Quit’ button.

Exiting the Database:

If you wish to leave the database, you should click the ‘Quit’ button on the main menu (Figure 1).

Adding Data to the Database:

There is only one method provided to add data to the database. This is to import data from an Excel file. The Excel file must be in the standard format (paying particular attention to the cell locations). Included with this database should be a set of Excel files from which data has already been imported. If you are unsure of what the standard format is, please refer to these.

To import data from an Excel file, use the following steps:

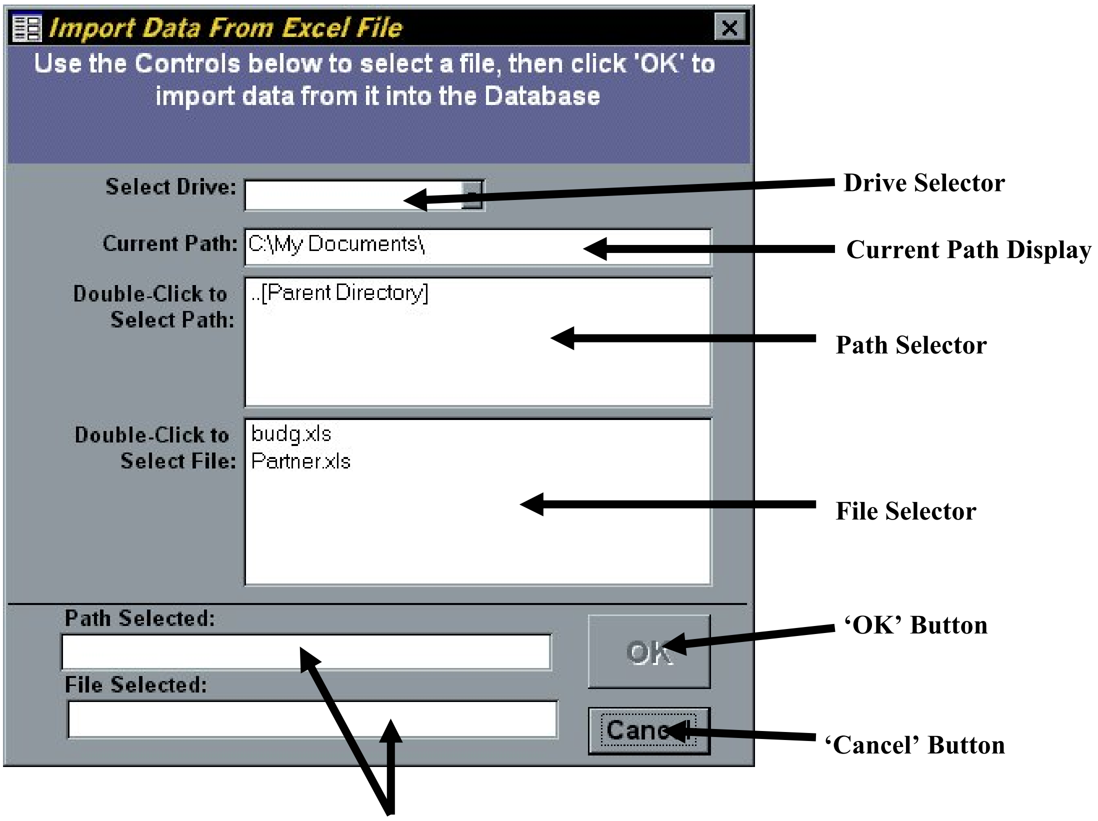
1. Click the button labelled ‘Import Data from Excel Sheet’ on the main menu (Figure 1). After a short pause, another window should appear. This is the ‘Import Menu’. It should look something like Figure 2.
2. First select the drive from which to import the file using the ‘Drive Selector’ (see Figure 2.).
3. You then need to select the path where the file to be imported is stored. The current path is shown in the ‘Current Path Display (Figure 2). You can use the ‘Path Selector’ to navigate to the path you require by double clicking on a path’s name to set it as the current path. Once you are satisfied that you have selected the correct path, you are ready to select the file.
4. You may select the file you wish to import data from using the ‘File Selector’ (Figure 2). If you have selected the path correctly in the previous step, the filename you require will be shown as one of the list in ‘File Selector’. To select it, double click on it. The selected path and file will be shown in the ‘Selected path and file displays’ (Figure 2).
5. Ensure that Excel is not running.
6. To begin importing data from the file, click the ‘OK’ button (Figure 2). If the button is not enabled, you have not selected a file correctly, please check the previous steps.
7. At any time during the previous steps, you may click the ‘Cancel’ button (Figure 2) to return to the main menu.

Once the import is started (step 5 above), a message will be shown. This message will keep you informed as to what the system is doing.

The system will first check that the data in the Excel file is valid for input. If it is not, then a list of problems will be displayed.

If the import is successful, the message ‘Finished importing data’ will be displayed. You may now click ‘OK’ to return to the main menu.

Figure 2. – The Import Menu



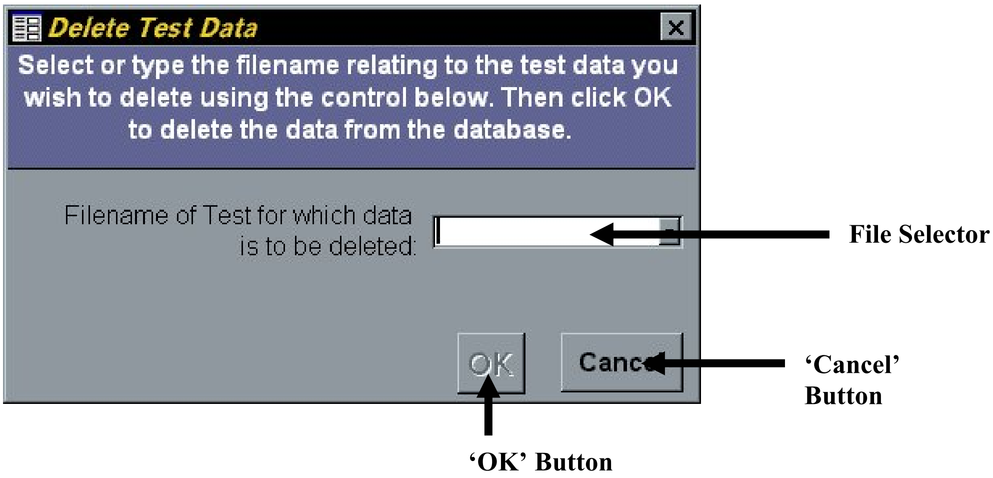
Removing Data from the Database:

Occasionally, you may wish to remove data from the database (e.g. to replace it with updated data). The database provides a facility for this.
To remove data, you will need to know the Excel file name(s) from which it was imported. The delete facility will remove data related to the test described in this file. If part of this data is shared with other tests still in the database, this part will not be removed.

To remove data from the database, use the following steps:

1. Click the button labelled 'Remove Data Relating to a Test' on the main menu (Figure 1). After a short pause, another window should appear. This is the 'Delete Menu'. It should look something like Figure 3.
2. Using the 'File Selector' (Figure 3), select or type the filename for the test which you wish to remove from the database.
3. Click the 'OK' button to begin removing data. If the 'OK' button is not enabled, please check that you have selected a filename correctly
4. A message will be displayed showing that you are deleting data
5. When the removal process has finished, a message will be displayed stating this. You may now click the 'OK' button to return to the main menu.

6. Figure 3. – The Delete Menu



Searching for data and producing output:

The database can be searched using search criteria. These may be geographical criteria (e.g. a specific river name or injection point), physical criteria (e.g. reach length or slope) or Analysed results criteria (e.g. Rt^2 values, ADE Velocities etc.), or any combination of these. The database can also be searched for reaches or rivers which have had specific numbers of tests performed on them.

Setting Criteria:

To begin setting criteria click the button labelled 'Search for / Output data' on the main menu (Figure 1). After a short pause, another window should appear. This is the 'Search Menu'. It should look something like Figure 4.

The best way of explaining the criteria setting process is to give an example.

Criteria Setting Example:

Say that you wanted to search for test data for the Midland region, where the Rt^2 value for the ADE analysis was greater than 0.95. You would need to set the following criteria:

1. Region is Midland
2. ADE Rt2 is greater than 0.95

To set the first of these the following steps would be taken

1. Using the 'criteria type setter' (Figure 4), choose 'Geographical' from the list, since this is a geographical criteria.
2. Using the 'attribute setter' (Figure 4), choose 'Region' from the list
3. Using the 'operator setter', choose 'is' from the list
4. Type 'Midland' into the 'Specified value box' (Figure 4)

5. Add this criteria by clicking the ‘Add / Update’ button (Figure 4)
6. The criteria will be displayed in the ‘Criteria List’ (Figure 4)

Similar steps would be taken to add the second criteria, only this time, the criteria type would be ‘Analysed Results’, the operator would be ‘is greater than’ and the specified value would be ‘0.95’

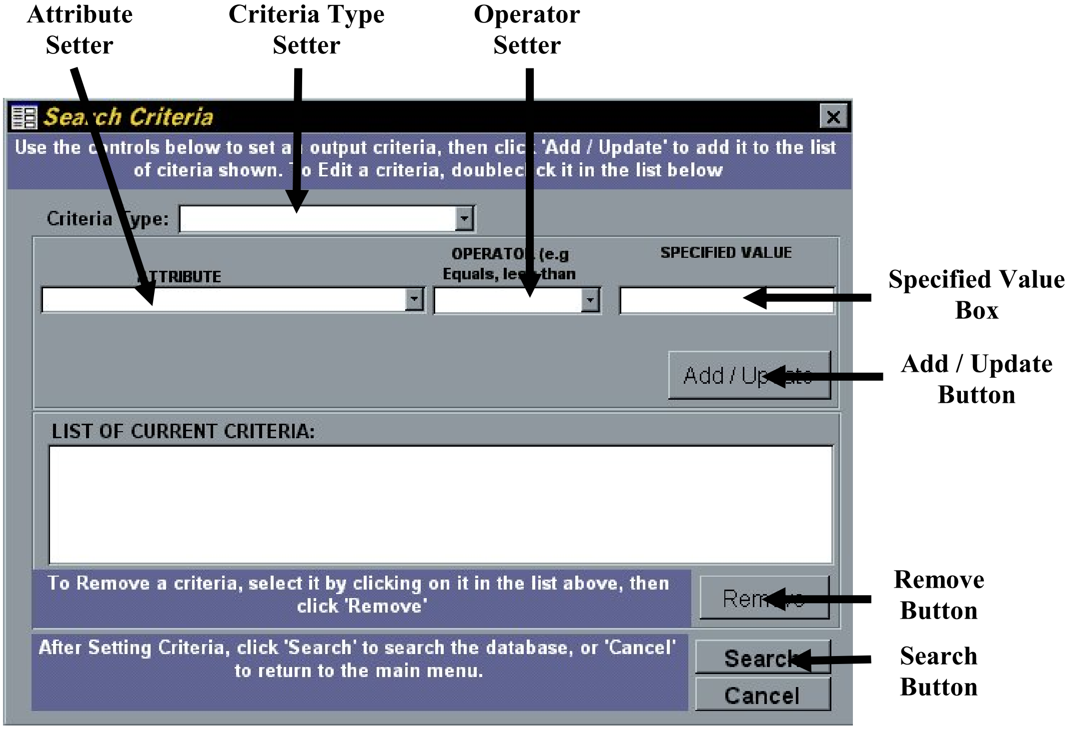
Removing Criteria:

After setting criteria, you may wish to remove one. To do this, select the criteria you wish to remove from the ‘criteria list’ (Figure 4) by clicking on it. The selected criteria will be highlighted. To remove it, click the ‘Remove’ button (Figure 4).

Editing Criteria:

After setting criteria, you may wish to edit it. To do this, double click on it in the ‘Criteria List’ (Figure 4). The values you set for it will appear in the ‘Attribute Setter’, ‘Operator setter’, and ‘Specified Value box’. You can the edit these. After editing, you can update the criteria by clicking the ‘Add / Update’ button (Figure 4). The updated criteria will be shown in the ‘Criteria List’.

Figure 4 – Search Menu



Searching the Database:

After you have set your search criteria, you may now use them to search the database. If you have set no criteria, all data in the database will be given as output. To search, click the 'Search' button on the 'Search Menu' (Figure 4).

After a short pause, another window should appear. This is the 'Initial Results Menu'. It should look something like Figure 5.

Shown in this window is the 'Initial Results List' (Figure 5). This is a summary of which tests contain data that matches the criteria set for the search, and is intended to give some idea of the number of results found.

Initial Results:

At this stage, you can return to setting or editing criteria by clicking the 'Cancel' button.

If however, you want to produce output from the search, you may choose one of two alternatives. These are described below.

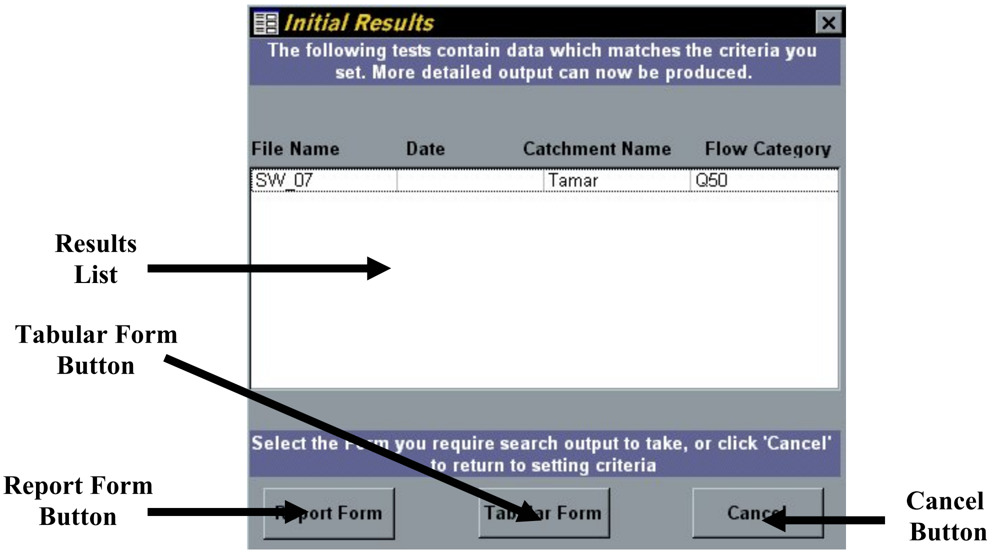
Report Form:

Produces output intended for printing out as hard copy. This output is arranged in a similar way to the standard Excel file. The sections to be shown on the report can be chosen. This is useful to check what data is stored in the database.
To produce 'Report Form' Output click the 'Report Form' Button (Figure 5)

Tabular Form:

Produces a table of results. The data that is included in the columns can be chosen. This is particularly useful when examining possible relationships between pieces of numerical data.
To produce 'Tabular Form' Output click the 'Tabular Form' Button (Figure 5)

Figure 5. – Initial Results Menu



Producing Output:

From the initial results window, you can choose to produce tabular or report form output.

Report Form Output:

If report form output is chosen, a window appears giving the choices for report form output. Using the checkboxes, you may select which sections to include in your report. Using the 'Report Title' box, you may enter a title for your report.

After selecting the required sections and setting a title, you can produce the report by clicking the 'OK' button. The report will open in 'Print Preview' mode. Using the buttons at the top of the screen, you may choose to print the report.

Tabular Form Output:

If tabular form output is chosen, a window appears giving the choices for tabular form output. Using the checkboxes, you may select which information to include on your table. These checkboxes relate to groups of columns, for example checking the 'River Details' box will add three columns to the table (River Name, Area and Region).

After selecting the required columns, you can produce the table by clicking the 'OK' button. The table will then be shown. You may now print the table, or copy and paste information from it into other applications (e.g. MS Excel).