River Gauging Station Data Quality Classification (GSDQ)

Software User Guide

R&D Technical Report W6-058/G

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Environment Agency hydrometry/hydrology staff will be required to implement this R&D after receiving training in the use of the Gauging Station Data Classification tool. Guidance will be provided by Policy regarding prioritisation of this work. The tool may be used to set gauging station data targets and to provide data users with information on data quality.

It is anticipated that other agencies responsible for hydrometric networks may also use the classification system as described above.

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FOREWORD

The authors would like to thank the Environment Agency Project Board for their valuable management and technical input throughout this R&D project. We gratefully acknowledge the Environment Agency staff who provided data and carried out software tests and benchmarking of the Gauging Station Data Quality Classification.

We would also like to thank the individuals and organisations listed in the main report who kindly gave their time to respond to consultation during the project.

EXECUTIVE SUMMARY

The Environment Agency commissioned R&D project W6-058 to develop a revised method for representing the quality of gauging station data. A consortium of JBA Consulting – Engineers & Scientists and CEH Wallingford were appointed to carry out the work.

The project comprised the following elements –

- An extensive consultation (both in the UK and overseas) with hydrometrists, data analysts, hydrologists and water managers to determine the requirement for a repeatable, empirical scheme for representing data quality.
- A review of existing approaches, both in the UK and overseas.
- The identification of factors that influence gauging station data quality.
- The development of a Gauging Station Data Quality (GSDQ) classification scheme based on attribute scoring.
- Implementation of the GSDQ classification in a software tool.
- Provision of an R&D technical report, software user guide and training materials.

The Environment Agency requested that the GSDQ software should be a spreadsheet tool. The classification has been implemented as a pair of customised Microsoft Excel applications the **GSDQ Classification Tool**, and the **GSDQ Register**. The Classification Tool is the main application whilst the Register is used to summarise results over a number of gauging stations.

This document is the software user guide for the gauging station data quality classification and aims to provide guidance to users on –

- The basic principles of the GSDQ tools with a brief overview of the classification
- How the spreadsheet applications work
- How to manage the data files created in maintaining the classification
- How to enter the required information into the spreadsheets
- How to interpret the data needed for the classification, especially for 'difficult' stations

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ABBREVIATIONS

Agency	The Environment Agency
ADCP	Acoustic Doppler Current Profiling
BS	British Standard
CEH	Centre for Ecology and Hydrology
MF	Mean (daily) flow
FEH	Flood Estimation Handbook
GSDQ	Gauging Station Data Quality
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
Q95	Flow that is equalled or exceed for 95% of the time
R&D	Research and Development
WISKI	Water Information Management System of the Kisters company

1 INTRODUCTION

1.1 What is GSDQ v1.4?

GSDQ v1.4 is the current version of the Environment Agency's river Gauging Station Data Quality classification, which has been developed through R&D programme W6-058 (Identification of a Method for representing the Quality of Gauging Station Data).

The GSDQ classification uses an attribute scoring method, based on factors such as gauge type, accuracy of measurement, missing data, effects of weed growth, gauge bypass at high flows and so on, to classify the level of data quality typically achieved at a river gauging station between two specified dates. The classification result is expressed both numerically, on a scale between 0 (worst) and 1 (best), and descriptively, as one of three quality classes GOOD, FAIR or CAUTION.

In GSDQ v1.4, the classification procedures are implemented in two software tools that operate as spreadsheets in Microsoft Excel:

- the **Classification Tool** provides a fully automated method for implementing the full (numerical) and abbreviated (descriptive) classification for a selected gauging station. In particular, it includes a user-friendly interface for entering attribute information.

- the **Register**, which enables the user to tabulate and store classification results for groups of gauging stations.

1.2 Using the GSDQ v1.4 Spreadsheet Tools

The tools have been designed for use by a competent hydrologist, but assume no prior knowledge of the GSDQ classification. A basic working knowledge of Microsoft Excel is required. In each case local knowledge of the gauging station is invaluable and users are likely to need to refer to the station file.

This **User Guide** describes how to complete, save and manage gauging station data quality classifications using the GSDQ v1.4 spreadsheet tools. In particular, it provides detailed guidance on the input data required for the classification and includes step-by-step instructions regarding how this data should be entered in the Classification Tool.

Before using the spreadsheet tools those unfamiliar with the GSDQ classification will find it helpful to refer to the brief introduction to the data quality classification presented in Section 2 of this guide. Further detail and other background material can be found in the R&D technical report[1] for the project.

[1] Lamb et al. 2004. Identification Of A Method For Representing The Quality Of Gauging Station Data, R&D Technical Report W6-058/TR

1.3 Software and Hardware Requirements of GSDQ v1.4

The GSDQ v1.4 tools have been developed in Microsoft Excel 97 and also tested in Excel 2000. Visual Basic for Applications (VBA) has been used to automate both tools, which mean that macros (i.e. VBA code modules) are used to implement some parts of the scoring procedure. None of the macros included in GSDQ v1.4 require the user to install or reference non-standard software components such as Dynamic Link Libraries (DLLs), or to make changes to the operating system. However, users may need to enable the use of macros to ensure that the tools function fully and correctly (Excel will normally prompt the user should this action be required).

There are no particular hardware requirements. However, the tools are designed for use on a PC running Microsoft Windows 95, Windows 2000 or XP Professional operating systems, having a minimum screen resolution of 1024 x 768 pixels and a mouse or other pointing device.

1.4 Installation and Data Storage

The GSDQ tools are self-contained spreadsheets and do not require any installation procedure. However, it is recommended that users follow a standard approach to data storage when preparing to use the tools. The suggested directory structure is illustrated in Figure 1-1. Each GSDQ spreadsheet contains all of the code required to run the classification, as well as storing the classification data. All that is required to 'install' the GSDQ tools is to make a copy of each spreadsheet (the Classification Tool and the Register). Copies of existing, completed, spreadsheets can be used, but we would recommend users to create a folder to keep a read-only blank copy of each spreadsheet. In our example we have called this the 'Masters' folder.

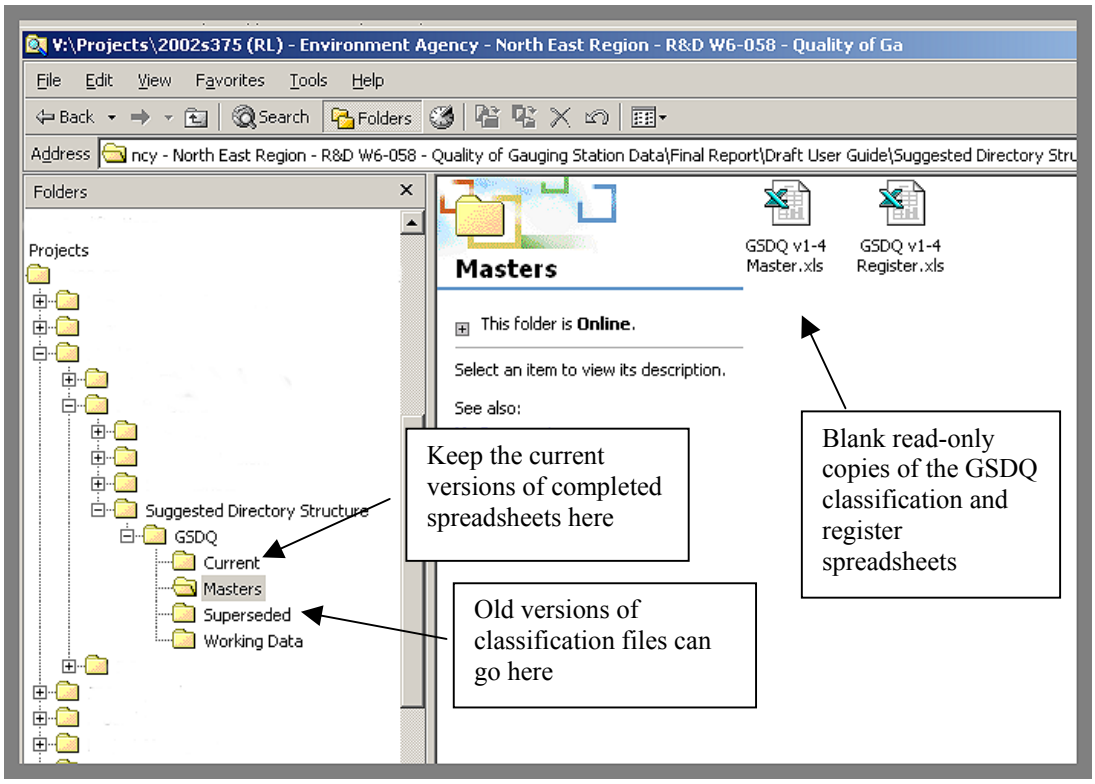


Figure 1-1: Suggested data storage structure for GSDQ classification files

For the register tool to work properly, it must be able to find all of the individual classification spreadsheets in one place on the user's computer system. We therefore recommend keeping all current classifications in one place on your file system.

2 BASIC PRINCIPLES OF THE GSDQ CLASSIFICATION

2.1 Aim and Scope of the Classification

In July 2002 a consortium of JBA Consulting Engineers & Scientists (JBA) and the Centre for Ecology & Hydrology (CEH) Wallingford were commissioned to revise the classification system used within the Environment Agency for representing the quality of gauging station data. The new scheme is intended to supersede previous classifications used at a local or national level, including the 1995 NRA classification[2].

The classification is used to quantify and categorise the level of confidence in continuous flow or level measurements recorded at gauging stations. So that the classification can be relevant to different end-users, the levels of data quality during periods of high flow and during periods of low flow are considered separately, in addition to the overall performance of the gauge over the full flow regime. However, the 'fitness for purpose' of the gauging station data (such as the degree of artificial influence upstream and so on) is not considered. Such issues are beyond the intended scope of the GSDQ classification, but are well documented for many gauging stations in publications by CEH Wallingford, including the national Hydrometric Register and the Flood Estimation Handbook.

The classification is based on the concept of attribute scoring. Attributes represent different properties of the gauging station and flow regime that are considered to have a significant influence on the quality of the data record. The choice of attributes, their theoretical derivation and the procedures employed to combine them into an overall score are discussed in detail in the R&D Technical Report[3]. At the core of the classification, however, is a group of *scoring schemes* that define how attributes are scored and combined to generate a final classification of data quality.

2.2 Scoring Schemes

As different types of gauging station operate in different ways, so different factors influence the quality of the data they record. The GSDQ classification is based around six broad types of station, and different sets of attributes are considered for each gauging station type. These sets of attributes are called scoring schemes. Six scoring schemes are used in the classification, and selection of the most appropriate scoring scheme is one of the key considerations to be made when assessing a particular station. The six schemes are set out in Table 2-1.

In many cases, it will be easy to decide which scheme applies to a particular station. However, there may be stations that do not fall so clearly into one scheme or another. In particular, there are structures that do not comply with the British Standard, due to design, deterioration of the structure or crest, or because they are drowned out over large portions of the flow duration curve. The theoretical weir equations are not applicable at these stations, which are therefore often treated as a rated-section with

[2] National Rivers Authority. 1995. Gauging Station Classification: Guidance on the method and application of river gauging station classification system. Report of the National Hydrometric Group, August 1995. 20pp.

[3] Lamb et al. 2003. Identification Of A Method For Representing The Quality Of Gauging Station Data, R&D Technical Report W6-058/TR.

artificial control. The GSDQ classification provides for a continuum of 'degrees of non-compliance', ranging from structures with no deviations from the standard through structures with significant deviations.

Table 2-1: The six GSDQ scoring schemes

Scoring Scheme	Description
Level-only stations	Sites where a stage recorder is employed, but there is no measurement of discharge
Rated section	An open channel natural or artificial control where the stage-discharge relationship across the cross section (the 'rating') is based on flow gaugings and calculated according to BS 3680. Includes stations where the rating is derived from gaugings made using ADCP or intermittent ultrasonic gauge readings as well as current metering using hand held devices or cableways.
BS Structure	All types of weir or flume (including compound structures) designed and operated according to ISO/British Standard 3680 (Part 4). Includes structures normally operating to BS 3680, where corrective procedures (other than open channel rating) are applied to account for non-modularity effects during periods of high flows.
BS Structures with formal rating at high flows	Structures that are formally rated as open channel during periods of high flow, but operate to the British Standard at other times.
Ultrasonic	Permanent gauging station based on transit-time ultrasonics, installed and operated to BS 3680 (Part 3E).
Electromagnetic	Permanent electromagnetic (EM) gauging station with either a suspended or buried induction coil, installed and operated to BS 3680 (Part 3H).

The classification includes a scheme for the specific case where a station operates as a BS-compliant structure in the modular range, but is formally a rated section at higher flows. However, other combinations of behaviour are possible. In complex cases, some careful thought will be needed to decide how to analyse a station. It may even be necessary to complete several classification spreadsheets for a station, treating it as more than one type, and then to manually copy and paste the final scores as appropriate.

2.3 Attribute Scoring

Users enter data into the GSDQ Classification Tool, which then calculates the values of the attributes for a chosen scoring scheme. Each attribute is first graded independently on a scale of 1 to 5 (with '5' indicating best quality) using look-up tables. These tables

are aligned to current best practice[4], so that grades are both realistic and attainable. Attributes and look-up tables are summarised in the main R&D Technical Report.

Excepting level-only stations, attributes are grouped into three flow categories, as follows

- High flows
- Low flows
- General

For the High flows category, QMED (the median annual maximum flow) is used as an index value against which certain attributes can be defined (for example rating curve confidence intervals). For Low flows, Q95 (flow equalled or exceed for 95 % of the time) plays a similar role. The General grouping includes a mixture of high and low flow attributes as well as overall measures of accuracy, using the mean daily flow (MF) as an index value where appropriate.

Note that the index flows do not need to be defined exactly for the data quality classification to work. The quantities QMED, Q95 and MF have been chosen because they are likely to be available, or easily estimated, for many stations. Whilst great care needs to be taken in calculating these values for floods or water resources studies, all that is needed for the data quality classification is a reasonable indicative estimate. Further details are given in Section 9.11 of this guide.

For each flow range, attribute grades are combined systematically to give an overall picture of the performance of the gauging station on a scale from 0 to 1. A higher score indicates a better level of data quality. The combination is based on the geometric mean of grades, with weighting factors used to reflect the perceived importance of the attributes. The numeric score enables users of the classification to compare the performance of different gauges, or to determine if improvement in quality of gauging station data has occurred over time (for example as a result of implementation of best-practice, following improvements to the gauging structure or any upstream changes).

Depending on this performance the gauging station data quality is then described as ‘good’, ‘fair’ or ‘caution’ for each flow range, as shown in Table 2-2. Thus a station may be classified, for example, as fair overall, fair at low flows and caution at high flows.

[4] Child, S., Woods-Ballard, B., Clare-Dagleish, A. & Sayers, P. 2001. Review of Good Practices for Hydrometry. R&D Technical Report W6-055/TR. 193pp.

Table 2-2: The GOOD/FAIR/CAUTION classification

Classification	Numeric Score, S	Interpretation
CAUTION	$S < 0.55$	A classification of CAUTION implies that the user should take a cautionary approach to use of the data, and should acknowledge that there could be a high level of uncertainty associated with it.
FAIR	$0.55 \leq S < 0.7$	A classification of FAIR implies that whilst the gauging station data quality is generally acceptable, there may be some weaknesses with respect to data quality that would warrant further investigation.
GOOD	S $0.7 \leq S < 1.0$	A classification of GOOD implies that the quality of gauging station data quality is generally good, and suitable for most applications

2.4 Input Data Fields

The GSDQ v1.4 spreadsheet tools calculate all attribute values from basic data, so users of the classification are rarely required to carry out any calculations, but may need to access data in a certain format. Typically, the raw data required are readily available from the Agency's Hydrolog or WISKI databases or are routinely recorded in the station files.

Check gaugings (where the discharge across the section is measured independently using either spot current metering, ADCP or portable ultrasonic gauges) are important basic data within the scoring schemes. Whilst is it recognised that the level of random error or 'noise' within a small sample of current meter gaugings is likely to be high it is nonetheless considered useful to know whether gaugings generally support flows measured at the gauging station (i.e. station or archived flows). The consideration given to check gaugings varies between station types. For example, as structures built and operated to British Standard can be regarded as inherently more accurate, gaugings are given less influence in the BS Structures scheme.

2.5 Time Required to Complete a Station Classification

Most of the attribute calculations and scoring procedures within the GSDQ classification tool are carried out using VBA macros and the intermediate processing is therefore hidden from the user. This means that the tool will generally be very simple and quick to use to use. Where the required station information is readily available it takes approximately ten minutes to complete the Classification Tool. Of course, accessing the station data, deciding over which periods to apply the classification, which gaugings to consider, and so on, may take somewhat longer.

3 GETTING STARTED

3.1 Introduction

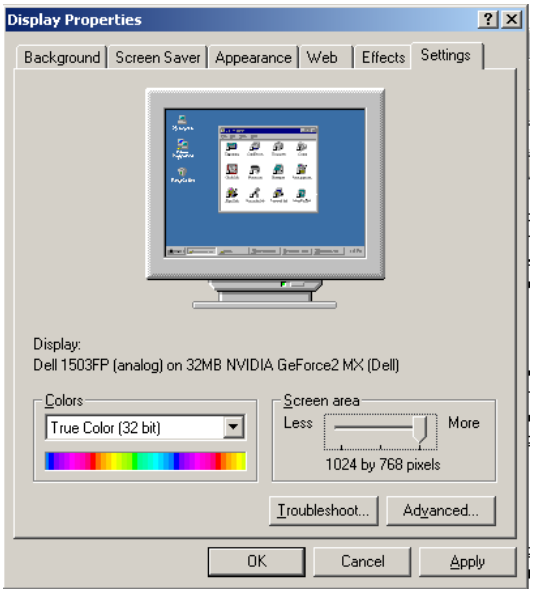
This section is intended as a quick reference guide for completing the classification for a single site. Specifically, it gives instruction on how to operate the Classification Tool. More detailed guidance on particular input fields and issues to be considered for particular gauge types are discussed in Section 4.

3.2 Display Settings

The GSDQ tools have been designed to work best on a monitor displaying 1024 x 768 or more pixels. Although the tools will work on lower-resolution displays, the quality of the screen image may be less clear, and the full spreadsheets might not be visible at all times. We therefore recommend setting your display to a screen area of at least 1024 x 768 before working with the GSDQ tools.

To set your screen area to 1024 x 768 pixels:

- Select 'Settings' from the Windows Start button
- Select Control Panel
- For Windows 2000 or lower, select Display
- For Windows XP select Display from the list of icons, or, if you see a option saying 'Appearances and Themes', click on this, then click on Display
- From the Display dialogue box, select the Settings tab. You should now see something like the dialogue box shown on the right.
- Ensure that Screen area is set to 1024 x 768 or greater and click OK.
- Click [*OK*] to the prompts that follow.



You may also be able to improve the visibility of the GSDQ tool by maximising the Excel window and removing any surplus Excel toolbars (right-click on the toolbars at the top of the screen and de-select toolbars that have a tick next to them).

3.3 Managing the Classification Tool

Opening the Classification Tool

Open the classification tool in the same way as any other Excel file (either double-click on the file **GSDQ Classification Tool v1-4.xls** in Windows Explorer or open Microsoft Excel and select [File] [Open], then navigate to the same file).

You may receive a pop-up warning about Excel macros. The following action should be taken in all cases:

- Select the *[Enable Macros]* option.

The GSDQ classification tool may take a few seconds to open, and the first thing you will see is the 'Input Station Info' worksheet (shown below). No other worksheets will be visible at this stage.

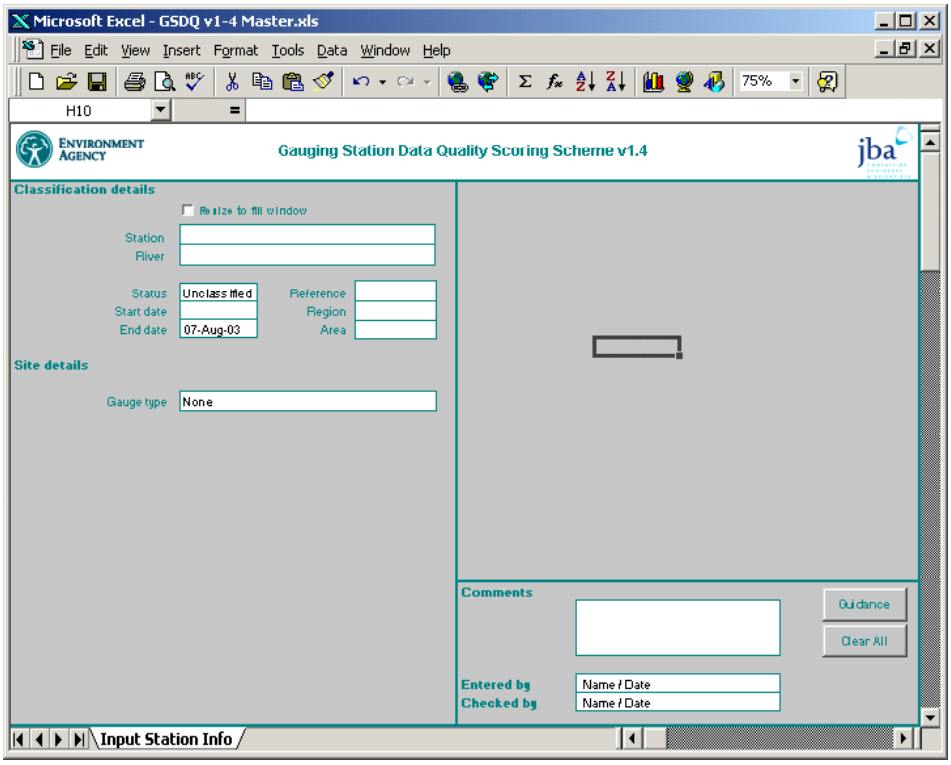
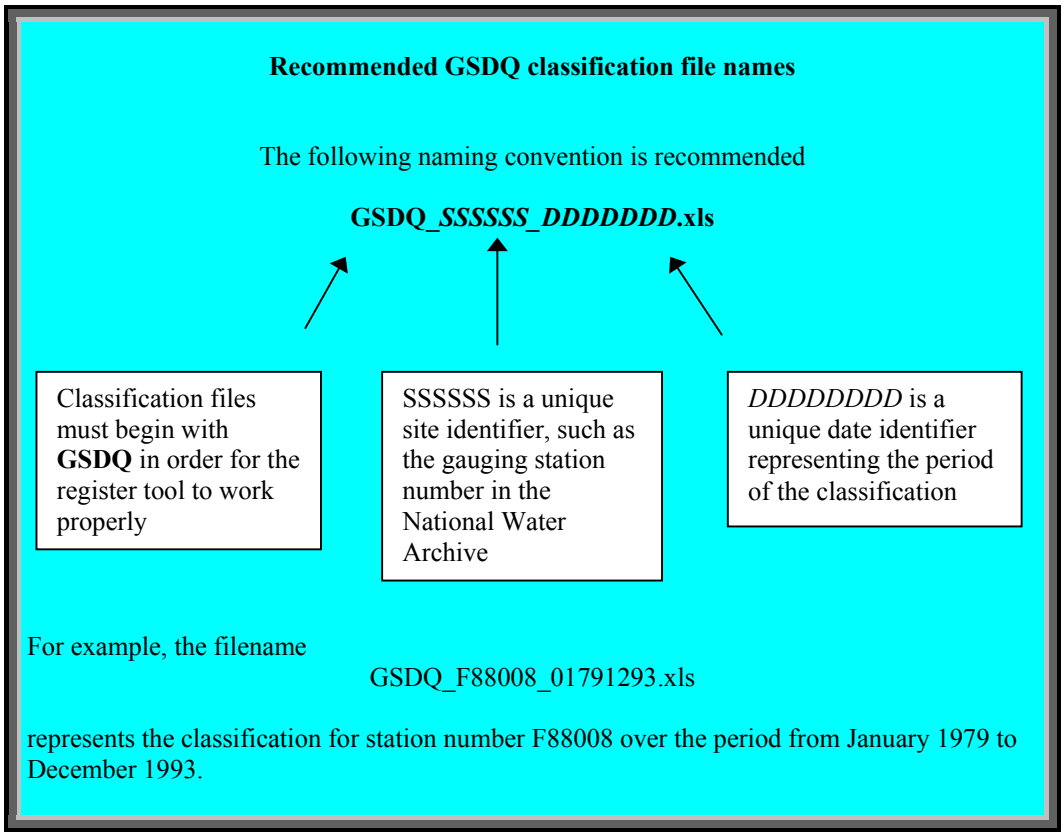


Figure 3-1: The 'Input Station Info' worksheet

Renaming the Classification Tool

If you are creating a new station classification, you should save the GSDQ spreadsheet under a new name in your 'current classifications' folder before proceeding any further. The file may be renamed by selecting [File] [Save As…] from the Excel toolbar.

Provided it begins with **GSDQ…** you can use any name you wish for the new file, but we would suggest adopting a logical naming convention as described in the box below.



Saving the classification results

Data and results will not be retained if the spreadsheet is closed without saving. You should always therefore save the spreadsheet after the classification is completed by choosing [File] [Save As…] from the Excel toolbar and using the suggested naming convention.

Completed copies of the classification spreadsheet may be opened later as for any usual Excel file, and all data, results and worksheets will re-appear as they were when the file was saved. (Note that you may be asked to *Enable Macros* again when re-opening a saved GSDQ file).

Modifying a completed copy of the Master Tool

To create a classification for a station where a spreadsheet already exists for a different period of record, it is possible to open the existing sheet and modify as required. The file should then be saved under a new name using the suggested naming convention.

3.4 Navigating within the Classification Tool

Moving between worksheets

You can move between visible worksheets via the tabs at the bottom of the Excel window. The active worksheet is highlighted in bold on the tab bar.

Moving within worksheets

You can navigate around the worksheets using one of the following methods:

- Use the scroll bars located to the right hand and bottom edges of the window,
- Use the scrolling wheel on your mouse, if it has one
- Use the arrow keys on the keyboard to move between cells.

Changing the magnification (zooming in and out)

The magnification may be changed in a number of ways as follows:

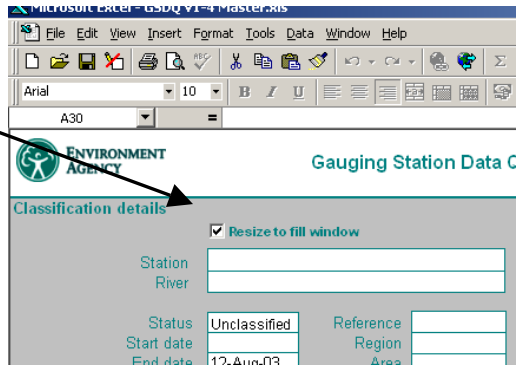
- From the Excel toolbar use the [View] [Zoom] option, and select the appropriate magnification.
- Hold down the CTRL key and use the built-in zoom wheel of your mouse, if installed.

The **Resize to fill window** check-box can be used to automatically resize the sheet so that the panels fills the Excel window. Depending on the size of the Excel window this may either reduce or magnify the sheet (typically it will reduce to a magnification of ~75%, making the text appear smaller). The check box is located in upper panel the Input Station Info Sheet, but applies changes to all visible (open) worksheets.

To use the **Resize to fill window** check box:

- Activate the 'Input Station Info' worksheet.
- Point to the check box labelled **Resize to fill window** (located in the Classification Details panel as shown on the right).
- Click over the check box, so that a tick mark appears.

  The sheet will reset to the new magnification, so that all the panels are visible in the Excel window



To turn off the **Resize to fill window** facility (reset to 100% magnification):

- Activate the 'Input Station Info' worksheet.

- Point to the filled check box labelled **Resize to fill window.**
- Click over the check box, so that the X disappears.

Activating a cell

Either of the following methods can be used to activate (move to) a cell on a worksheet using

- Use the arrow keys to move the cursor to the desired cell.
- Point and click on the cell.

Activating a text box or drop-down list box

Some of the text boxes and drop-down lists cannot be activated using the keyboard arrow keys. It is generally safest to work with the text boxes or drop-down lists by pointing and clicking with the mouse. If the object is a text box a text cursor will appear, otherwise a list of options will drop-down from the box.

Printing a worksheet

By default each worksheet will print on one side of A4 paper in landscape orientation. Page margins are set to 25mm at the top and bottom of the page and 19mm at the left and right of the page. To print, from the Excel toolbar use the [File] [Print…] menu to access Excel's Print dialog box.

3.5 Entering Data

Areas for data entry (e.g. cells and tables) are shown clearly in white. The input field may be a text string, a numeric value or a date, or a selection from a drop-down list box. Data can be entered into input boxes/tables with the standard Copy and Paste facility of Excel – however it is strongly advised to use [Edit] [Paste Special…] [Values] when copying data as this pastes only the text or number itself and does not try to paste any formatting.

Entering text in a cell

Text or numeric values may be entered in a cell as follows:

- Activate the cell
- With reference to the data field tables, determine the data format required.
- Enter the value /text in the required format using the keyboard

Or

- From the Excel toolbar use [Edit] [Paste Special] [Values] to enter a value from the Clipboard

Note that numeric values are automatically rounded up to an appropriate number of decimal places. dialog box giving an error message appears if the user attempts to enter the wrong data type, e.g. if text is entered where a numeric is required.

Entering a date in a cell

Text or numeric values may be entered in a cell as follows:

- Activate the cell
- Enter the date using a DD-MMM-YYYY format, e.g. 01-Jan-2002.

Or

- From the Excel toolbar use [Edit] [Paste Special] [Values] to enter the date from the Clipboard

A dialog box giving an error message appears if the user attempts to enter the date using the wrong format

Making a selection using a drop-down list box

To select an option from a drown-down list box:

- Point and click to activate the list box
- Use the pointer to move down the list stopping when the desired option is highlighted

Or

- Use the arrow keys to move up or down the list stopping when the desired option is highlighted.
- Press the RETURN key or click once to select the option
- Click away from the box to deactivate it

Clearing entered data

To delete all input data, including selections from list boxes:

- Point and click on the **Clear All** button located at the bottom right of the sheet.

Entering data from the Clipboard

The sheets have been designed so that data can be entered into input boxes/tables with the standard Copy and Paste facility of Excel. 'Paste special' should always be used to avoid over-writing the spreadsheet formatting. The 'CTRL-V' shortcut key has therefore been re-programmed to invoke this option, which can also be selected in Excel from the toolbar using [Edit] [Paste Special] [Values].

3.6 Using the Built-in Guidance Facilities

Most of the worksheets used in the Classification Tool have a corresponding guidance note, giving additional guidance and considerations regarding input fields or classification results.

Accessing a guidance note

To access the guidance you should:

- Point and click on the **Guidance** button, located near the bottom right of the sheet.
- Scroll down the Guidance worksheet to the point of interest.

Closing a guidance note

Once opened guidance notes stay on the tab bar, until they are closed. To close a guidance note

- Point and click on the **Close** button, located near the bottom right of the sheet.

4 ENTERING STATION INFORMATION

4.1 The 'Input Station Info' Worksheet

The 'Input Station Info' worksheet appears by default when the Master Tool is opened. This sheet allows information regarding the physical characteristics of the gauging station and statistical characteristics of the flow record to be entered. The sheet is divided into a number of panels, as listed in Table 4-1. Note that only the Classification details and Site details will be visible on opening the Master Tool. The other panels appear as appropriate upon the selection of the **Gauge Type**. Tables shown in Appendix B summarise the fields to be input in each section.

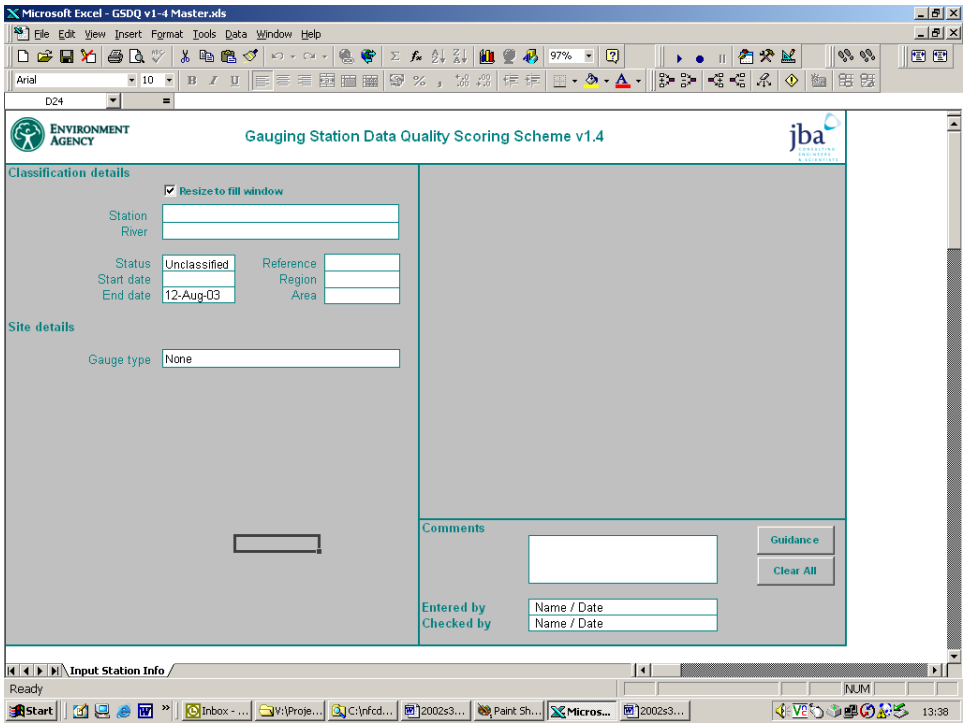


Figure 4-2: The 'Input Station Info' worksheet

The sheet is divided into a number of panels, as listed in Table 4-1. Note that only the Classification details and Site details will be visible on opening the Master Tool. The other panels appear as appropriate upon the selection of the **Gauge Type**. Tables shown in Appendix A summarise the fields to be input in each section.

Table 4-3: Panels in the 'Input Station Info' worksheet

Panel	Description	Reference Table (Appendix A)
Classification details	Details regarding the gauging station, and period of application of the classification	Table A1-1
Site details	Details regarding the typical range of flows observed at the site and any local features that might influence data quality	Table A1-2

Table 4-3: Panels in the 'Input Station Info' worksheet

Missing data	Details regarding the capture and recording of flow measurements	Table A1-3
Effective accuracy of stage measurement	Details relating to stage measurement at gauging stations	Table A1-4
Modularity of structure (for Structures only)	Details relating to modularity of weirs and flumes	Table A1-5
Configuration Parameters (for Ultrasonics only)	Details relating to configuration of a transit time ultrasonic	Table A1-6

4.2 Completing the 'Input Station Info' Worksheet

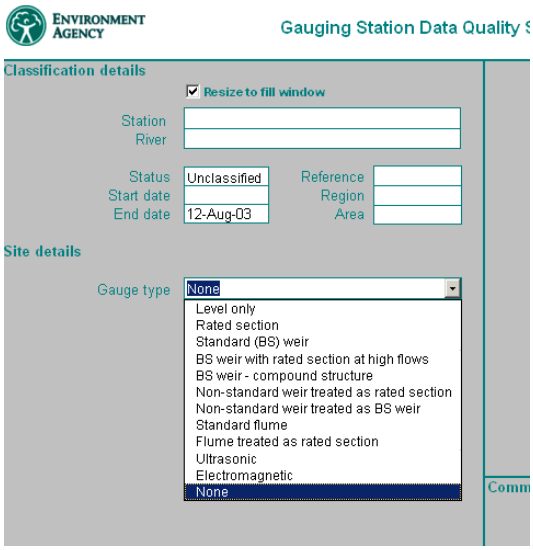
To complete the Input Station Info Worksheet the user should adopted the following procedure referring to earlier guidance on data entry (Section 3.5):

- Complete the Classification details panel with reference to the appropriate table in Appendix A and to further guidance in Section 9 or to built in Guidance Note

- Use the **Gauge type** drop-down box, as shown to the right, to select the gauging station type

  The screen will refresh automatically at this point. You will now see a number of other panels have appeared.

- Complete the other panels with reference to the appropriate tables in Appendix A, to further guidance in Section 9 or to built in Guidance Note



Note that the drop-down list has eleven entries describing the most common types of gauging station. These relate to the six distinct scoring schemes described in Section 2. **It is important to select an appropriate gauge type before proceeding, as changing the gauge type resets the scoring scheme and clears all entered data,** except the station identification entered in the Classification details panel.

You will now see one or more additional worksheets have appeared, depending on which type of gauging station you have selected. Some are for you to enter classification data, whilst others display outputs of the classification.

5 ENTERING A RATING EQUATION

5.1 Completing the 'Input Rating Equation' Worksheet

The 'Input Rating Data' worksheet opens only where a rated-section scoring scheme is applied. It allows the user to input the rating equation. It is assumed the rating equation will take the following general form:

$$Q = c\,(h + a)^b$$

where Q is the discharge through the cross section (m^3s^{-1}), h is the stage (m above datum), and c, a and b are parameters.

In many cases, the station rating will consist of more than one limb, each limb being characterised by the parameters of the same general formula.

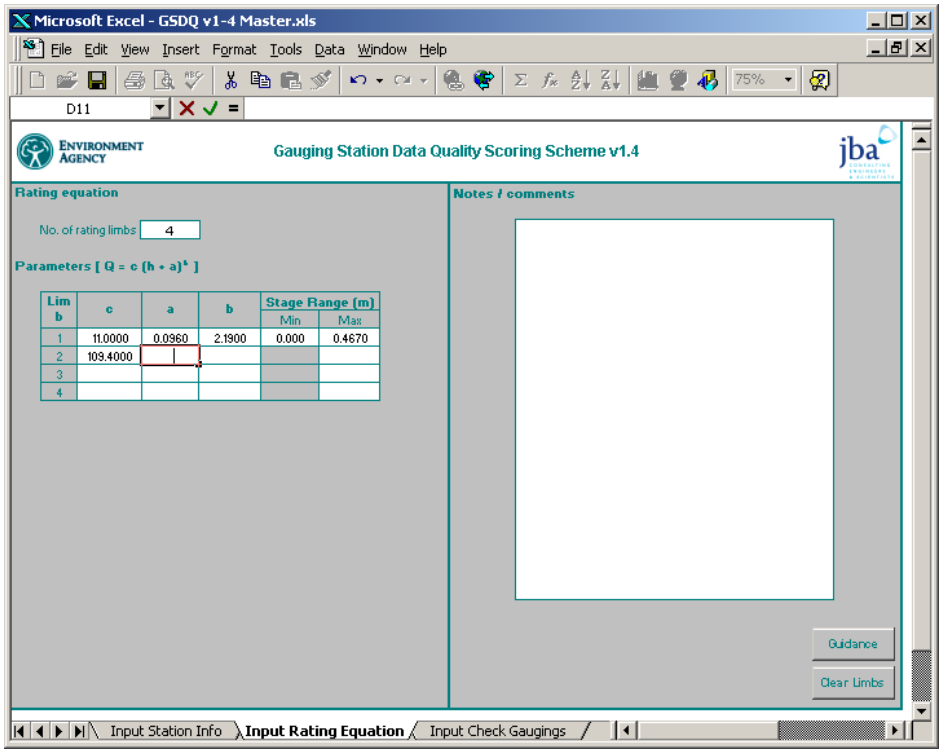
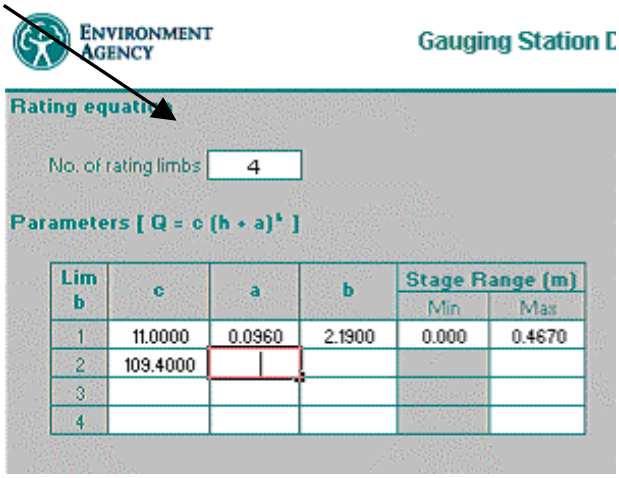


Figure 5-1: The 'Input Rating Equation' worksheet

To complete the 'Input Rating Equation' Worksheet the user should adopt the following procedure referring to earlier guidance on data entry (Section 3.5):

- Activate the 'Input Rating Equation' worksheet
- Use the **Number of rating limbs** drop-down list box, as shown to the right, to select the number of limbs in the rating equation (up to 20 limbs can be considered).

  A table of input cells will now appear as shown (the number of rows in the table depends on the number of limbs selected).



- Enter parameter values (**a, b, c**) for each limb
- Enter the **minimum applicable stage** and **maximum applicable stage** for the first limb.
- Enter the **maximum applicable stage** for the subsequent limbs

The minimum applicable stage for limbs 2 to 20 will be filled automatically. At this stage it is important to ensure that there are no blank cells in the table - for zero values a numeric 0 should be entered rather than a 'Null' or blank – modify the number of limbs if necessary.

Modifying the number of rating limbs

The **Number of rating limbs** drop-down list box may be used to revise the number of limbs. If the number of limbs is increased additional blank rows are added to the end of the table. If the number of limbs is reduced rows are removed from the end of the table until the appropriate number of limbs is reached. Data in deleted rows is lost.

Clearing the table of input cells

To clear entries from the table of input cells you should:

- Highlight the cells to be changed (this should not include any grey cells)
- Use the DELETE key to remove values

Or

- Use the **Clear Limbs** button, located to the bottom right of the sheet, to delete all entries in the table and reset to zero limbs

6 ENTERING FLOW GAUGINGS

6.1 Completing the 'Input Check Gaugings' Worksheet

The 'Input Check Gaugings' worksheet must be completed for the Rated section, Electromagnetic and Structure with Formal Rating for High Flows scoring schemes. However it is optional to enter check gaugings for the BS Structures and Ultrasonic scoring schemes. The scoring procedures will be aborted if gaugings are omitted where required.

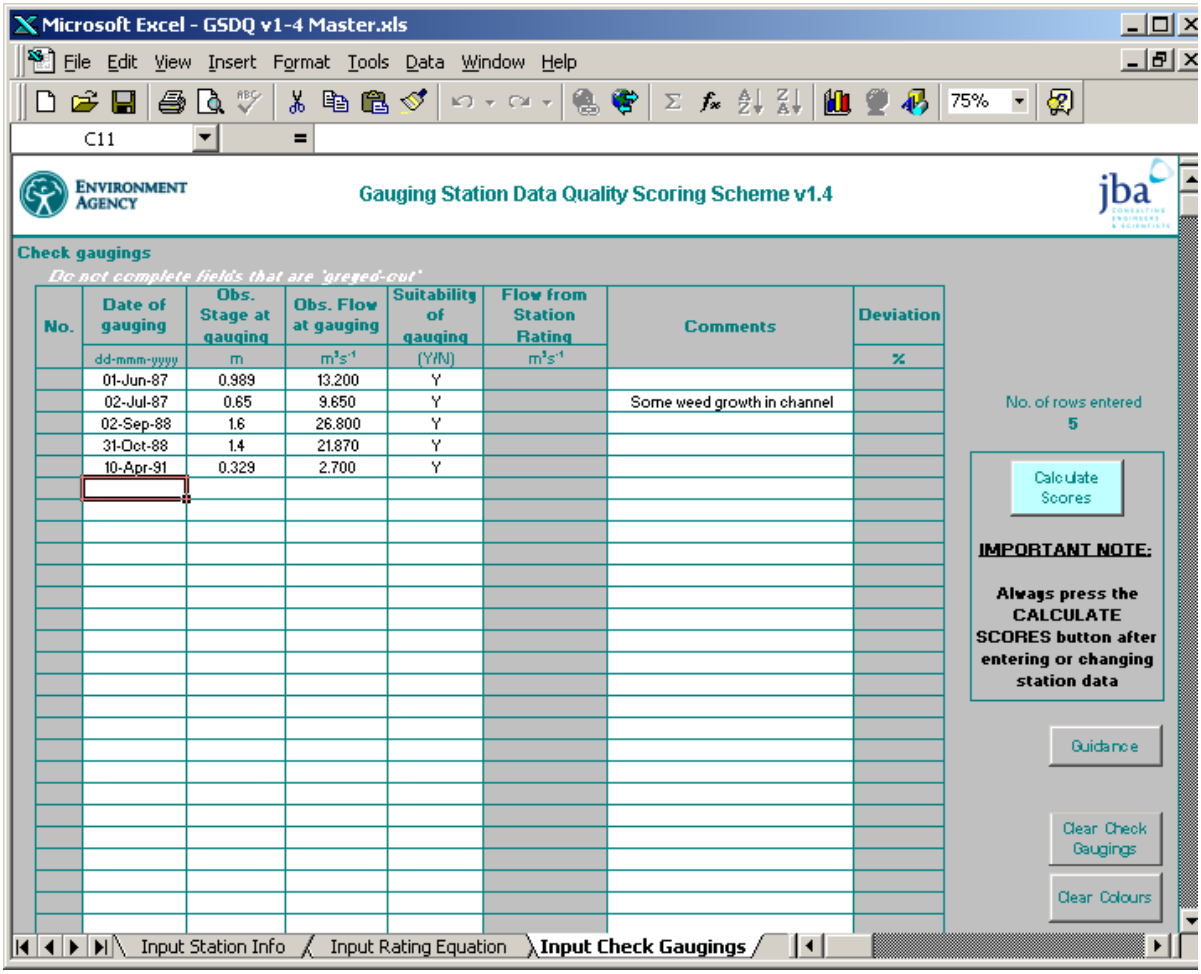


Figure 6-1: Entering check gaugings

Entering check gaugings

To enter check gaugings you should adopt either of the following procedures:

- Activate the 'Input Check Gaugings' worksheet.
- Starting on the first blank row, enter the input data as required, referring to Table 6-2 where necessary.
- Data should not be entered in "greyed" columns.

Or

- Determine which input parameters are required according to the gauge type (refer to Table 6-2)
- In a separate blank Excel workbook organise gauging information in the correct order and format.
- Highlight the gauging information, and from the Excel toolbar use the [Edit] [Copy] option to copy the data to the clipboard.
- Activate the 'Input Check Gaugings' worksheet.
- From the Excel toolbar use the [Edit] [Paste Special] [Values] option or the CTRL-V key to paste the data into worksheet.

Table 6-2 gives details of the information required for each gauging. A maximum of 1000 gaugings may be entered. These do not need to be entered in chronological order, and blank rows are allowed. Typically at least the set of gaugings that were used to calibrate the rating curve will be input; further guidance on selection of check gaugings is given in Section 9.

Table 6-2: Input parameters for Gaugings

Field Name	Description	Rated-section	BS structure	Structure (rating at high flows)	EM	Ultrasonic
Date	Date of spot gauging (in DD-MMM-YYYY format)	√	√	√	√	√
Obs. Stage at gauging (m)	The observed stage (in m above datum) when the spot gauging was made.	√	√	√	√	√
Obs. Flow at gauging (m^3s^{-1})	The observed flow (in (m^3s^{-1}) calculated using the spot gauging data.	√	√	√	√	√
Suitability of gauging	The suitability of the gauging for inclusion in the scoring scheme (indicated by a Y/N)	√	√	√	√	√
Flow from rating (m^3s^{-1})	The flow (in m^3s^{-1}) calculated using the rating equation based on the Obs. Stage	√	X	√	X	X
Station or Archive Flow (m^3s^{-1}) (or Ultrasonic flow)	The flow in (m^3s^{-1}) measured using gauging station over the period when the spot gauging was made. The 15-minute or hourly flow should be entered in preference to the daily mean flow.	X	√	√	√	√

Notes: √ indicates required data, *X* indicates data not required. Grey cells indicate fields calculated by the Tool.

The total number of gaugings entered is shown on the upper left of the sheet. This number is updated automatically as rows are entered (for example, five gaugings are shown on Figure 6-1). This counts the number of date values entered. Gaugings for which no date is entered will be ignored during the scoring procedures.

The suitability field allows gaugings that have been entered on the sheet to be disregarded when implementing the scoring scheme procedure (by assigning a N). This feature is useful if there are doubts about the reliability of particular gaugings and the user wishes to investigate the influence if they are used or not.

The scoring procedure cannot be implemented unless all of the required fields have been entered. If any these fields cannot be filled the suitability field should be set to 'N', or the gauging deleted from the list.

Deleting check gaugings

To clear one or more check gaugings the user should either:

- Highlight the cells to be cleared (do not highlight greyed cells)
- Use the DELETE key to clear the cells
- Leave the cleared cells blank

Or

- Enter N in the suitability column for that gauging
- Note why the gauging has been disregarded in the comments column

To clear all check gauging data the user should:

- Point and click on the Clear Check Gaugings button located to the right of the screen.

7 COMPLETING THE GSDQ CLASSIFICATION

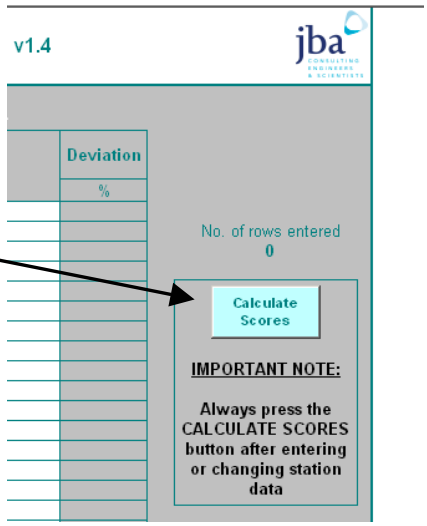
7.1 Running the Classification

The scoring procedures should be initiated only when all input worksheets have been completed.

Initiating the scoring procedures

To start the scoring procedure the user should:

- Verify that all input fields have been completed
- Save the GSDQ spreadsheet using the naming convention GSDQ_*site reference_date range*.xls
- Point and click the blue '**Calculate scores**' button (this appears on either the 'Input Station Info' worksheet (level-only scheme) or the 'Input Check Gaugings' (for all other gauge types), as shown to the right.



Calculation procedure

The GSDQ tool will now perform the following actions:

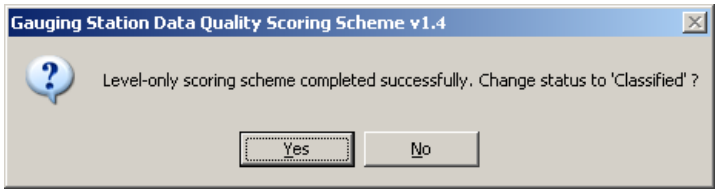
1. Read and check all user-input data
2. Read and check rating equation parameters and ranges (if applicable)
3. Process flow gaugings as follows –
    - Arrange gaugings in chronological order
    - Reject gaugings with missing fields (suitability will be changed automatically to 'N')
    - Gaugings that fall within the high flows range (above 0.5 x QMED) will be shaded in blue, whilst those in the low flow range (flows below Q95) will be shaded in yellow.
    - If a rating equation has been entered it will be used to calculate theoretical flows for gaugings based on gauging stage values
4. Calculate all attribute values automatically
5. Write attribute values to the final results tables.
6. Assign grades to each attribute using look-up tables defined as part of the research project
7. Write attribute descriptions and grades to the results table
8. Calculate numerical scores
9. Classify the score as GOOD, FAIR or CAUTION

10. Notify the user that the scheme has completed successfully or alert user to any errors.

Successful completion

If the scheme is completed successfully then a dialog box similar to the one shown here will appear. At the prompt the user should:

- Set the **Status** field to **Classified** by selecting *[Yes]*
- Save the workbook using the naming convention discussed previously.



This will open the Scoring Scheme worksheet, Further details worksheet and the Rating Curve Worksheet (if applicable).

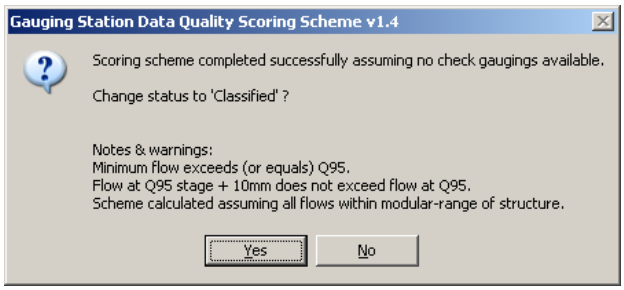
If you do not choose to set the Status field to **Classified**, the scoring procedures will still be completed, but the status will remain as Unclassified.

Successful completion with notes or warnings

In some cases warnings may be given on completion of the scheme. These are used to either alert you to inconsistencies in the data entered, or to notify you of procedures implemented by the software. Notes and warnings are shown on the dialog box when the scheme is completed (as shown below) and also on the 'Further Details worksheet'. The 'Further Details' worksheet also gives details of some of the parameters derived during attribute calculation procedures. A list of warnings that may appear in the dialog boxes is given in Appendix B.

If the user wishes to investigate any of the warnings, prior to accepting the results of the classification, at the prompt they should:

- Select *[No]* in order to set the status to unclassified.
- Save the workbook using the naming convention discussed previously.



You should always act upon warnings where appropriate (e.g. by revising input data and repeating the classification procedure). However if, after investigating the warnings, you wish to proceed with the classification without changes, the status may be changed

manually by selecting Classified from the Status drop-down box appearing on the 'Input Station Info' worksheet.

7.2 Dealing with Errors

In some cases the dialog box will indicating that the scheme has not been completed successfully. Errors that may occur during the calculation procedure are documented in Appendix B.

Dealing with errors caused by blank input fields

If the scheme is not completed successfully due to one or more incomplete input fields, a dialog box similar to the one shown below will appear.

You should then proceed as follows:

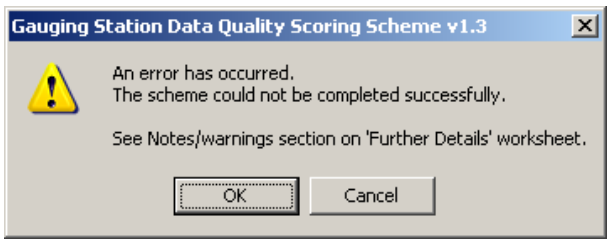
- At the prompt, select [*OK*] making a note of any errors reported.
- Re-complete the input worksheets, making sure that the correct gauge type is selected, that all entered data is correct and that there are no missing fields (missing data will be highlighted in red).

Software errors

The GSDQ Excel tool has been tested on a wide range of sites, and is designed to fail 'gracefully' in most situations where an error could occur. However, it is possible that some circumstances may still exist that could lead to a software error, in which case the you will see a dialog box similar to that shown below. The most likely cause of thus problem is input data being inappropriate, for example check gaugings that do not match with the rating equation and so on.

You should then continue as follows:

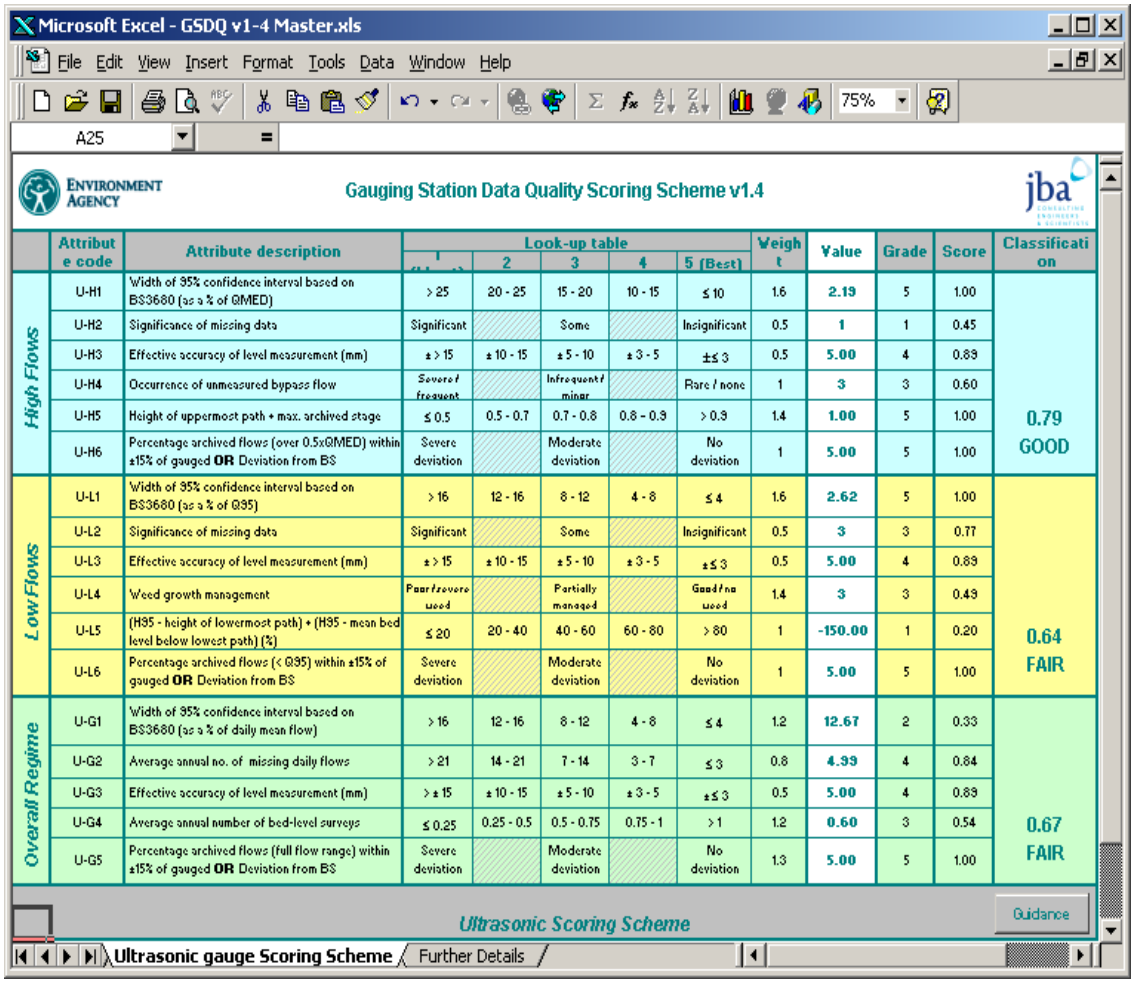
- At the prompt, select [*OK*] making a note of any errors reported.
- Re-complete the input worksheets, ensuring that sufficient gaugings have been entered, checking for any errors in input values, and that all data refer to the same gauging station.



7.3 Reviewing the Classification Results

Viewing the classification results

The final classification results are detailed on the Scoring Scheme worksheet. Classification results are shown in tabular format, as illustrated in Figure 7-1. Attributes are listed in the second column, and are colour coded according to category (blue for High Flows, yellow for Low Flows, green for the General category). The main R&D technical report lists and describes individual attributes. The look-up tables and weights for each attribute are shown in the Classification Tool itself for information.



	Attribute code	Attribute description	Look-up table 1	2	3	4	5 (Best)	Weight	Value	Grade	Score	Classification
High Flows	U-H1	Width of 95% confidence interval based on BS3680 (as a % of QMED)	> 25	20 - 25	15 - 20	10 - 15	≤ 10	1.6	2.19	5	1.00	
	U-H2	Significance of missing data	Significant		Some		Insignificant	0.5	1	1	0.45	
	U-H3	Effective accuracy of level measurement (mm)	± > 15	± 10 - 15	± 5 - 10	± 3 - 5	±≤ 3	0.5	5.00	4	0.89	
	U-H4	Occurrence of unmeasured bypass flow	Severe / frequent		Infrequent / minor		Rare / none	1	3	3	0.60	
	U-H5	Height of uppermost path + max. archived stage	≤ 0.5	0.5 - 0.7	0.7 - 0.8	0.8 - 0.9	> 0.9	1.4	1.00	5	1.00	0.79 GOOD
	U-H6	Percentage archived flows (over 0.5xQMED) within ±15% of gauged **OR** Deviation from BS	Severe deviation		Moderate deviation		No deviation	1	5.00	5	1.00	
Low Flows	U-L1	Width of 95% confidence interval based on BS3680 (as a % of Q95)	> 16	12 - 16	8 - 12	4 - 8	≤ 4	1.6	2.62	5	1.00	
	U-L2	Significance of missing data	Significant		Some		Insignificant	0.5	3	3	0.77	
	U-L3	Effective accuracy of level measurement (mm)	± > 15	± 10 - 15	± 5 - 10	± 3 - 5	±≤ 3	0.5	5.00	4	0.89	
	U-L4	Weed growth management	Poor / severe weed		Partially managed		Good / no weed	1.4	3	3	0.49	
	U-L5	(H95 - height of lowermost path) + (H95 - mean bed level below lowest path) (%)	≤ 20	20 - 40	40 - 60	60 - 80	> 80	1	-150.00	1	0.20	0.64 FAIR
	U-L6	Percentage archived flows (< Q95) within ±15% of gauged **OR** Deviation from BS	Severe deviation		Moderate deviation		No deviation	1	5.00	5	1.00	
Overall Regime	U-G1	Width of 95% confidence interval based on BS3680 (as a % of daily mean flow)	> 16	12 - 16	8 - 12	4 - 8	≤ 4	1.2	12.67	2	0.33	
	U-G2	Average annual no. of missing daily flows	> 21	14 - 21	7 - 14	3 - 7	≤ 3	0.8	4.99	4	0.84	
	U-G3	Effective accuracy of level measurement (mm)	> ± 15	± 10 - 15	± 5 - 10	± 3 - 5	±≤ 3	0.5	5.00	4	0.89	
	U-G4	Average annual number of bed-level surveys	≤ 0.25	0.25 - 0.5	0.5 - 0.75	0.75 - 1	> 1	1.2	0.60	3	0.54	0.67 FAIR
	U-G5	Percentage archived flows (full flow range) within ±15% of gauged **OR** Deviation from BS	Severe deviation		Moderate deviation		No deviation	1.3	5.00	5	1.00	

Figure 7-2: Typical arrangement of results

Attribute values, grades and scores are also shown for each attribute. The combined scores for each category are shown in the boxes to the right of the sheet. Both numeric and classification (GOOD/FAIR/CAUTION) results are shown. The table is password-protected and cannot be overwritten. However the details may be copied to the Windows clipboard in the normal way.

7.4 Supporting Results

The Scoring Scheme results table is the key output of the classification, however there are further worksheets containing supporting results that may help in judging whether the GSDQ classification is appropriate, and in providing further information to data users.

The 'Rating Curve' worksheet is generated as part of the scoring scheme for rated sections. It provides a quick visual summary of the agreement (or otherwise) between the rating curve and gaugings, which may highlight any significant data errors.

The 'Further Details' worksheet is generated for all schemes (except the Level-only Scoring Scheme) and reports various statistics relating to the classification, some of which are intermediate steps in the calculation of attribute values.

Notes and Warnings are also shown on the 'Further Details' worksheet. The user should always try to resolve any warnings issued.

8 THE GSDQ REGISTER TOOL

8.1 What the Register Tool Does

The Register Tool is essentially a table showing details of completed classifications. It is operated using the **Populate Register** button. The tool automatically searches a user-defined network folder for GSDQ classification files, interrogates the completed classifications and reads the basic station information (including the gauging station type) and the scores for each of the three flow categories. These data are then saved in tabular format.

The only input field required is the path name of the directory in which the scoring sheets are located. The register reads all files named **GSDQ*.xls** in this directory. Up to 1000 files may be accessed by a single register. The running time depends on the number of files from which data must be retrieved. Typically about 30 seconds are required to access 10 files.

The Register spreadsheet should be updated regularly to ensure that the tabulated summary of classification scores is kept up-to-date. In particular the Register tool should be used after new classification spreadsheets are completed or after any change to classification spreadsheets.

8.2 Setting up the Register Tool

The Register Tool Excel workbook may be opened from Windows Explorer by double-clicking on the file named "**GSDQ v1.4 Register.xls**" or from the [File] [Open…] menu in Excel. You may receive a pop-up warning about Excel macros and should select the *[Enable Macros]* option. On opening the Register, the 'GSDQ' worksheet is activated as default (Figure 8-2). No other worksheets are used.

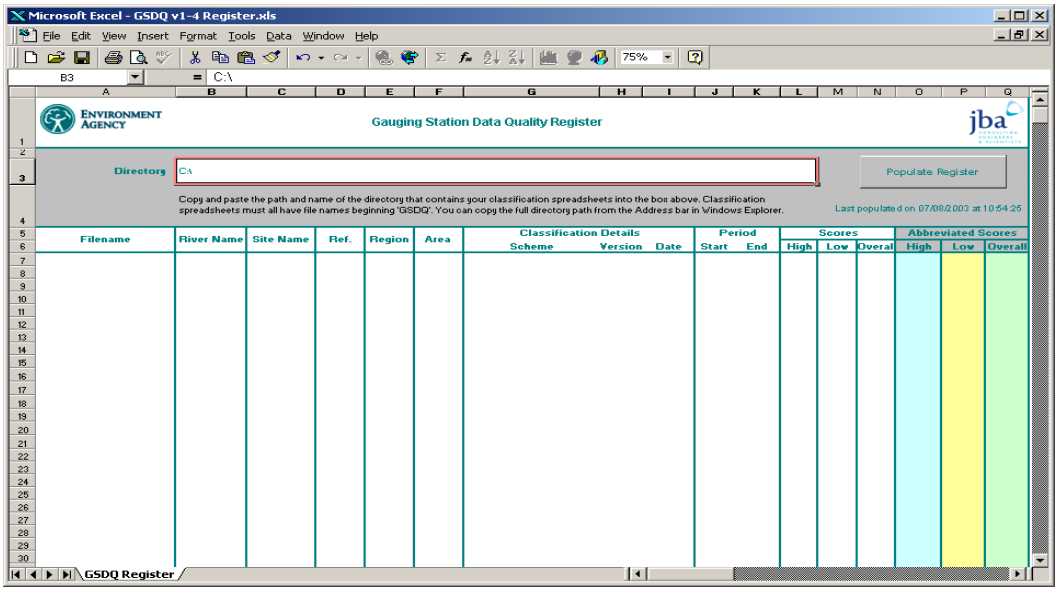


Figure 8-3: Register Tool

We recommend saving the Register spreadsheet using a naming convention similar to the one suggested for the station classifications. The name chosen does not matter **except that it must begin with 'GSDQ_Register…'**.

Suggested GSDQ register file names

The following naming convention is recommended

GSDQ_Register_*XXXXXX*_*DDMMMYY*.xls

Filename must begin with **GSDQ Register** in order for the register tool to work properly

XX a unique site identifier, such as the Environment Agency region and area

DDMMMYY is a date stamp for the last time the register was updated

For example, the filename

GSDQ_Register_NERidings_23Jul03.xls

represents the Register saved on 23rd July for Ridings area, North East region.

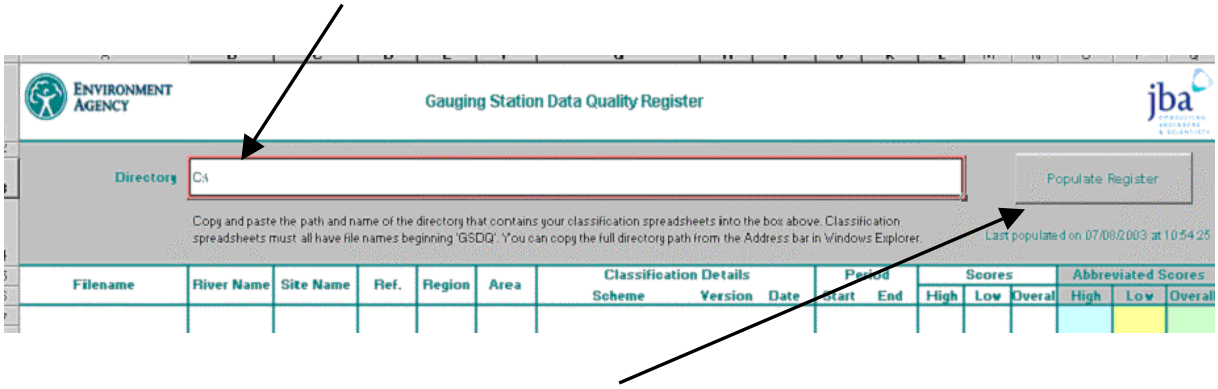
8.3 Running the Register Tool

The Register Tool reads all GSDQ files in a single directory. To select the appropriate directory:

- Type the path and name of the directory that contains the classification spreadsheets into the box labelled **Directory**.

Or

- Copy the full directory path from the Address bar in Windows Explorer and use the [Edit] [Paste] option from the Excel toolbar to insert this into the box labelled **Directory**.



- Point and click on the **Populate Register** button.

The Register Tool will now be automatically updated. This procedure will take between a few seconds and several minutes depending on the number of GSDQ files to be accessed. On completion, the Register Tool should be saved using the naming convention described above. It is possible for the user to modify entries on the Register worksheet, except those shown in shaded columns (these are automatically set by the Tool and cannot be changed). This should not be done to over-ride the classification results based on a 'hunch', but will be necessary if scores from a number of different schemes have to be combined for a particularly complex station.

9 GUIDANCE ON INPUT FIELDS

9.1 General Considerations

Selecting the classification period

The choice of classification period should be linked to changes in gauging station disposition that will in turn cause discrete changes in some or all of the station quality attributes. It will sometimes be a matter of judgment as to what constitutes a 'discrete change' in data quality attributes. Some likely situations are listed below:

- Change of station type (e.g. replacement of rated section with ultrasonic)
- Significant revision of the rating curve
- Re-engineering of the station (e.g. widening to reduce flow by-passing)
- Change in weed growth management practices
- Change of the approach taken to correct for drowned flow
- Change in management of siltation
- Replacement of instruments of different tolerances or reliability
- Change in hydraulic control no accounted for by shift procedures

In some of these situations, much of the existing quality attribute data may be carried over straightforwardly between classification periods. The specific issue of choice of check gaugings is discussed later in this section of the user guide.

It may be that there are some cases where a change at a station does not impact equally on the quality classification at low and high flows. In such cases, it may be necessary to create a new classification spreadsheet, but to change only the attribute data corresponding to one of the flow ranges. An example might be a station where weed growth management changes (to improve low flow measurement) but high flow measurement is not affected.

Updating the classification

Initial retrospective application of the data quality classification may require some care in making suitable judgments about the sub-division of records into separate classification periods, if appropriate. However, once established, the classification should require little maintenance. If any significant changes are made to the operation or fabric of the station, including changes in ratings, then the classification should be updated accordingly. Otherwise, it is suggested that a routine annual check should be carried out to update classification spreadsheets, adding any new check gaugings, if appropriate.

It is not recommended to adjust indicator flow and stage values (which might change as more data are added to the record at a station) unless the changes are substantial, say greater than 15%. If indicator flow estimates are adjusted for a particular station, then the adjustment should also be carried out retrospectively to classification spreadsheets for earlier periods or record, if any exist.

After any change to classification spreadsheets, the Register spreadsheet should be updated to ensure that the tabulated summary of classification scores is kept up-to-date.

Where input data is not available.

The user may have to make a best judgement when completing input fields for which no or little information is available, probably in discussion with colleagues. If there is a complete lack of hard information for a particular input field, especially for drop-down lists, users should resist the temptation to select the middle option in an attempt to enter a 'neutral' value. Selecting the middle option does not generally imply a neutral selection, and it is better to make an informed estimate (perhaps based on other similar stations), or better still, to arrange to collect the missing information.

9.2 Classification Date Ranges

Start date

The **Start date** field refers to the first day included in the classification. The date should be input as DD-MMM-YYYY format.

End date

The **End date** field refers to the last day included in the classification. As a default the end date field is set at today's date, but this should be overwritten (in DD-MMM-YYYY format) if appropriate.

Pre-1901 dates

Dates are prior to 1901 are not recognised by Microsoft Excel. For stations where the period of record predates 1901, a work-around is to add a fixed amount, say 100 years, to all date entries including those associated with flow gaugings. This work-around should be recorded in the comments box on the 'Input Station Info' or 'Further Details' worksheets.

Status

The **Status** of the gauge refers to whether the classification has been completed and found acceptable. The default status is Unclassified, although it will automatically change to Classified when the scoring is completed. The user should not generally need to alter the Status field unless it is felt that the scores achieved are unacceptable, in which case it may be appropriate to set Status to Unclassified until the problems are resolved.

9.3 Gauge Type

This is the type of gauging station. The appropriate option should be selected from the drop-down list box according to the following guidance:

Rated - section

Select the **Rated section** option if the gauging station is an open channel section (with either a natural or artificial control) where discharge is routinely derived using a stage-discharge relationship of the form

$$Q = c\,(h + a)^b$$

where Q is the discharge through the cross section (m^3s^{-1}), h is the stage (m above datum), and c, a and b are constants.

It is assumed that the relationship is derived via least squares regression through a set of discharge-stage pairs. It is also assumed that all historic gaugings, particularly those used to derive the rating equation, are readily available and may be used in the classification.

Standard Structures

The **Standard (BS) Weir** option should be selected if the gauging station is a weir that is designed and operated to British Standard BS 3680 (Part 4). It is therefore appropriate for the following types of structures:

- Thin plate weirs
- Broad-crested weirs
- Triangular profile weirs

The **BS Weir – Compound Structure** option should be selected if the gauging station is a compound weir that is designed and operated to British Standard BS 3680. It is therefore appropriate for the following types of structures:

- Compound broad-crested weir. The compounding may include a mixture of types such as rectangular profiles, flat-v's, with or without divide walls.
- Compound crump weir
- Essex weir (modified crump)

The **Standard (BS) Flume** option should be selected if flows are measured using any type of flume provided that this is designed and operated to BS 3680. It is therefore appropriate for the following types of flume:

- Critical depth flume (e.g. Parshall flume, Cut-throat flume, H-flume)
- Long throated flume

Non standard structures

For structures that have a non-standard design or that have suffered severe deterioration over time the theoretical weir equations no longer apply, and it is not strictly appropriate to treat these stations in the same way as BS structures.

If a non-standard structure is formally treated as a rated-section (the structure providing an artificial control at which a stage-discharge relationship of the form $Q = c\,(h + a)^b$ is

applied) then select either the **Non-standard weir treated as rated-section** or **Flume treated as rated-section** option as the Gauge Type.

If a non-standard weir is nonetheless operated solely using theoretical weir equations then select the **Non-standard weir treated as BS Weir** option.

Hybrid gauges

Some structures are managed as hybrid gauges with a formal rating curve applied over parts of the flow range, but treated as a standard structure at other times. This approach is used in particular where the modular limit of the structure is reached at a relatively low point on the flow duration curve resulting in uncertain measurement of discharge during periods of high flow.

For the purposes of the classification weirs managed in this way can be treated as either a BS structure by selecting the **Standard (BS) Weir** option or as a structure with formal rating at High Flows by selecting the **BS Weir with rating at high flows** option. The latter is not appropriate if either the rating is applied to flows lower than 0.5 x QMED, or if the specific set of gaugings used to derive the high flow rating is not available.

If other types of hybrid gauges are to be considered, a more 'hands-on' approach is required. The user should run the classification separately for each gauge type and then copy the classification scores as appropriate into the Register spreadsheet.

Ultrasonic Gauge

The **Ultrasonic** option should be selected if a transit-time ultrasonic gauge is operated at the site. This option is not currently appropriate for other acoustic methods such as side-looking Doppler ultrasonics.

Electromagnetic Gauge

The **Electromagnetic** option should be selected if a permanent electromagnetic coil is operated at the site. This option is not appropriate for other electromagnetic methods, including Doppler radar.

Weir type

For the purposes of the classification only eight types of weir structure are considered, as follows:

- Triangular profile (Crump) 1:2, 1:5
- Triangular profile (Crump) 1:2, 1:2
- Triangular profile flat-vee
- Rectangular thin plate (sharp-crested)
- Triangular thin plate ('V-notch')
- Round-nose broad-crested
- Triangular broad-crested
- Broad-crested rectangular profile weir

For unusual structures the most similar category should be selected (if the weir is a non-standard type refer to section 9.2 for further guidance). For compound weirs, up to two component weir types may be specified.

Flume type

All types of flume are considered under one generic category.

Level Recorder

The **Level only** option should be selected if the station measures stage only.

Instrument type

This refers to the device used to measure stage at a level-only site. One of eight instrument types should be selected using the drop-down list box. It is assumed that the instrument is used in conjunction with a stilling well (except for the stage board).

The options are:

- Stage board
- Chart recorder
- Punched tape recorder (PTR)
- Shaft encoder
- Up-looking ultrasonic water level gauge
- Down-looking ultrasonic water level gauge
- Pressure transducer with diaphragm sensor
- Pressure transducer with pneumatic sensor

9.4 Siltation

The Siltation field is considered only in the level-only scheme. It addresses the severity and management of any siltation that might occur around the level gauge, but refers to silt affecting the stilling well or access/feeder pipes rather than the main channel. The user is required to make some judgement as to the balance between the severity of the problem and the effectiveness of any management practices that are adopted in selecting one of three options using the drop-down list box:

- Severe, or not managed (worst case, grade = 1)
- Minor, or partially managed (intermediate case, grade = 3)
- None, or well-managed (best case, grade = 5)

In the absence of any information regarding siltation, use best judgement based on local experience or anecdotal evidence.

9.5 By-pass Flow

Bypass flow is here defined as that part of the flow conveyed past a gauging station that is not actually captured by a flow measurement. It is therefore intended to encompass situations such as out-of-bank flow on the floodplain around a gauging station or unmeasured flow in a secondary channel during periods of high flow.

Strictly speaking unmeasured flow through sediments on the river bed or leakage under the gauging structure also represent unmeasured bypass flow, but are unlikely to have much significance during the periods of high flow, and can be essentially ignored for the purposes of the classification. However these issues can be addressed by modifying the 'effective accuracy of level measurement – Low Flows' input field according to the amount of head loss that is thought to occur.

It is therefore not intended that bypass flow be used to describe the degree to which a gauging station provides a complete closure of catchment water balance. For example, in some permeable catchments there may be a significant proportion of the water balance that is exported as groundwater flow and therefore, in a sense, 'by-passes' any gauging. This water would not be counted as 'un-measured bypass flow' for the gauging station quality classification.

By definition, 'unmeasured bypass flow' can only ever be estimated. A qualitative assessment of the impact of by-passing at the station is therefore used in the classification, with one of the following three categories being selected as appropriate:

- Frequent or significant bypass flow (grade = 1)
  Unmeasured bypass flow occurs frequently during the classification period, or if occurs less frequently, represents a significant proportion of flow at the site.

- Infrequent or insignificant bypass flow (grade = 3)
  Unmeasured bypass flow occurs infrequently during the classification period or, if occurs more frequently represents a small proportion of the flow at the site.

- No or negligible bypass flow (grade = 5)
  There is no record of bypass flow at the site, or bypass flow has occurred rarely during the classification period.

Some judgement will therefore be required to provide a realistic assessment of bypassing that is appropriate for the classification period. Although this approach is subjective, it avoids the need to produce a numeric estimate of bypass flow. Ask the following questions:

- Are there many truncated peaks within the flow record?
- How do peak flows compare with to those at upstream/downstream gauging stations?
- Is there other evidence regarding the peak stage during flood events, e.g. observations by Agency staff, members of the public, photographs, wrack marks?

9.6 Weed Management

The weed management drop-down list box addresses both the severity of weed growth at the site and any management practices that are used to reduce it.

Weed growth can severely affect the quality of flow data at a site. It usually has greatest impact during periods of low flow, when the stage is low and waters are slow moving, particularly as the lowest flows are often occur during the summer months when vegetation grows most vigorously. For open-channel rated-sections the presence of vegetation changes stage for a given flow whilst weed and algal growth can also affect the performance of structures, especially if along the weir crest. Although velocity-area stations are in principle less affected, growth along the banks at ultrasonic stations can inhibit signal receipt.

A number of different management practices are employed to minimise the impact of weed growth. These include clearance of weed and the use of 'shift procedures' where the rating-curve is continually adjusted by the use of check gaugings to account for changes in stage. The user is therefore required to make some judgement as to the balance between the severity of the problem and the success of any management practices that are adopted. One of the following three options should be selected from the drop-down box:

- Not managed (worst case, grade = 1)
    - Weed growth is a problem but has not been managed.

- Partially managed (intermediate case, grade = 3)
    - Some action has been taken to manage weed growth, but this may fall short of the ideal level of management
    - This might encompass situations such as control of weed growth on an infrequent basis.

- No weed / well managed (best case, grade = 5)
    - No significant weed growth, or significant weed growth would occur, but is managed such that it has negligible impact on flows.
    - This may encompass situations where weed growth is controlled on a frequent basis, relative to the vigour of the growth.

For rated sections a fourth option is available from the weed management list box:

- Shift procedures applied (grade = 1)

This option is only appropriate where rating curve shift procedures are applied at a rated-section gauging station. The use of shift procedures implies that there will be many time-dependent rating curves, rather then a single unique rating equation. The shifting control implies that uncertainty associated with the flow estimates will be larger than for a stable control. If shift procedures have been applied then

- Only those check gaugings taken outside the period in which shift procedures are operating should be input on the 'Input Check Gaugings' worksheet.
- Only the rating equation describing the winter base curve should be input to the 'Input Rating Equation' worksheet.

Prompts will be given by the GSDQ software, where appropriate.

9.7 Stability of Section

The Stability of section field refers to the channel stability for a rated-section gauge. The user is required to make some judgement regarding the channel stability; as a general guide a concrete or artificial channel may be considered to have good stability, whilst a mobile gravel bed can be considered to have poor stability. One of three options should be selected from the drop-down list box as follows:

- Poor stability (worst case, grade = 1)
- Fair stability (intermediate case, grade = 3)
- Good stability (worst case, grade = 5).

9.8 Deviation from British Standard

This input field appears only for BS structures and ultrasonic scoring schemes. It refers to the compliance of the station with the relevant BS/ISO standard and provides an opportunity to enter local knowledge about the condition and performance of the station (whether or not this has been quantified by detailed review of the structure or represents a general perception). Note that deviations from the British Standard can be either in the design, operation or maintenance of the station.

One of three options should be selected from the drop-down list box as follow. Use best judgement, based on local experience or anecdotal evidence, in the absence of firm information.

- 'Strong deviation from BS' (worst case, grade = 1)
    - The stage-discharge relationship is known to deviate strongly from the theoretical or other features of the gauge deviate severely from BS specification.
    - Structures may strongly deviate from BS specification if there are defects such as geometry of the weir not to specification, incorrect or over-design of structure, strong influence of upstream/downstream conditions or turbulence in channel.

- 'Little deviation from BS' (intermediate case, grade = 3)
    - The stage-discharge relationship is known to deviate moderately from the theoretical or other features of the gauge deviate moderately from BS specification.
    - Minor deviation includes corrosion / poor maintenance of structure, wrongly positioned level device, grit/gravel deposition,

re-circulating flows, poor condition of weir crest, bowing of flume cheeks and so on.

- 'No deviation from BS' (best case, grade = 5)
    - The stage-discharge relationship does not deviate from the theoretical and/or the structure is built and maintained to BS specification.

9.9 Membrane Condition

The membrane condition field refers to the condition of the protective membrane that insulates the coil of an electromagnetic (EM) gauge. The coil may be located above or below the bed. Some degree of judgement may be needed to assess the membrane condition, especially if it has not been inspected physically for some time. As a general guide the condition will be poor if the membrane is ripped, leaks or shows general deterioration.

One of three options must be selected from the drop-down list box:

- Poor Condition (worst case, grade = 1)
- Condition of membrane unknown (intermediate case, grade = 3 to allow for uncertainty)
- Good Condition (best case, grade = 5)

9.10 Configuration

The configuration field refers to the number and arrangement of flight paths used in an ultrasonic gauge, and is considered only in the ultrasonic scoring scheme. Where two or more flight paths (at different heights in the water column) are used, the gauging station is said to have a multi-path configuration. Where two symmetrical flight paths are used to measure the velocity at a particular height in the water column, a cross-configuration is in use. The user should therefore select appropriately from the following options:

- Single - path
- Multi - path
- Multi-path, cross configuration

9.11 Setting Indicator Flows and Indicator Stage Values

General concepts

The gauging station data quality classification refers to several 'fixed' points in the flow range when calculating quality attributes. These are:

- Median annual maximum flood (QMED), and its corresponding stage
    - QMED and 0.5 x QMED are used to define the 'High' flow range in the classification

- 95th percentile of flow duration curve (Q95), and its corresponding stage

- Q95 is used to define the 'Low' flow range in the classification

- Minimum and maximum recorded flows or stage
  - Used to calculate attributes to indicate the degree to which the full range of flows can be adequately measured

- Mean Daily flow (MF)
  - Used to scale standard error statistics for the 'General' flow category

The values entered for these fields should be indicative. In other words, it is not expected, or necessary, that they should be exact. All that is needed are reasonable estimates. The indicator flows have been chosen because they are familiar quantities, and, in the case of Q95 and QMED, generalised calculation methods exist to derive them. Corresponding stage values should be determined from the formal stage/discharge relationship at the site or derived from observed data; further guidance is given below.

The indicator flow values should be estimated for the entire period of record at the station, rather than the individual sub-periods over which classification is calculated. This avoids introducing any inconsistencies in the classification as a result of any differences in the length of classification periods.

QMED

The Indicative QMED field refers to the median annual maximum flow, also called the median annual flood. It should not be confused with the Q50 flow (i.e. the 50^{th} percentile on the flow duration curve). A numeric value in units of m^3s^{-1} should be entered.

QMED will typically be estimated using the procedures described in the Flood Estimation Handbook (FEH)[5]. In many cases this has already been done; Appendix B of Volume 3 of the FEH shows QMED for 1000 gauging stations in the UK. For stations not included in this table, the FEH recommends calculating QMED directly from the series of annual maximum flows if the period of record is 14 years or longer. The calculation is described in FEH Volume 3 (Section 12.2.1, pages 78-79). For shorter records, Peaks Over Threshold (POT) data can be used to improve the estimate, although the calculation is somewhat more involved. However, if no previous estimate of QMED exists at a station, then, even for a record shorter then 14 years, the more straightforward annual maxima procedure is probably good enough for the purposes of the GSDQ classification. It should not, however, be passed on for use in flood studies.

Q95

The Indicative Q95 field refers to the flow equalled or exceeded 95% of the time (i.e. the 95^{th} percentile on the flow duration curve). A numeric value in units of m^3s^{-1} should be entered.

[5] Institute of Hydrology. 1999. Flood Estimation Handbook (in five volumes)

Q95 can easily be calculated from the flow record, and is available for many gauging stations from the Hydrometric Register and Statistics 1996-2000, published by CEH Wallingford, or from the web site http://www.nwl.ac.uk/ih/nrfa/station_summaries/crg.html . Alternatively, generalised estimation methods exist, such as those described in by Gustard et al[6] (these are implemented in the 'Micro LOWFLOWS' and 'Low Flows 2000' software packages used by the Agency). The value entered should be indicative, but as accurate as possible. For sites where the Q95 is zero, a small nominal value of 0.01 m^3s^{-1} should be entered instead.

Maximum flow

The maximum flow represents the maximum flow recorded at the site during the entire period of record (not just during the classification period). A numeric value in units of m^3s^{-1} is required. If the record period is very short this may affect the classification, and it is worth considering whether an estimate of the likely maximum flow can be made by transferring a value from a nearby station with a longer history. One simple way to do this is to scale the true value from the 'donor' station by catchment area.

For example, consider a situation where a new station 'A' has been operating for one year on a catchment of 100 km^2 and has gauged a maximum flow in that time of 40 m^3s^{-1}. Imagine that the worst floods on record happened ten years ago, with flows of 180 m^3s^{-1} being recorded at an older station 'B' situated downstream of 'A' and draining 200 km^2. A very basic estimate of maximum flow for station 'A' would then be (180/200)x100 = 90 m^3s^{-1}. Comparison of the flows gauged at both stations for the period of overlapping records would help in deciding whether the revised maximum flow estimate was a reasonable one.

Minimum flow

The minimum flow represents the minimum flow recorded at the site during the entire period of record (not just during the classification period). A numeric value in units of m^3s^{-1} is required. For stations with a very short record, a data transfer (using the same principles as for the maximum flow) might be worth considering if records at other nearby stations show that flows were unusually high for that period.

Mean Daily Flow (MF)

The mean daily flow represents the approximate mean value of the daily flows on archive for the gauge during the entire period of record (not just during the classification period). A numeric value in units of m^3s^{-1} is required. The mean is more robust than the extremes, and so data transfers would not be needed even for a station with a very short record.

Stage at QMED

The stage at QMED field represents the stage value corresponding to the QMED flow. A numeric value in metres above datum should be entered.

[6] Gustard, A., Bullock, A. & Dixon, J. 1992. Low flow estimation in the United Kingdom. Institute of Hydrology Report No 108.

The QMED stage will usually be determined from the rating curve for rated-sections, the rating table for BS structures or from calibration ratings for EM and US gauges based on the QMED flow. For sites where the stage-discharge relationship shows hysteresis (e.g. looping due to backwater effects) the largest of the stage values at QMED should be entered. In some cases it will be more convenient to enter the median annual maximum stage calculated from the stage record for the site, for which the same calculation method can be used as for deriving QMED from annual maximum flow data.

Stage at Q95

The stage at Q95 field represents the stage value corresponding to the Q95 flow. It is represented using the abbreviation H95. A numeric value in metres above datum should be entered.

It will usually be determined from the rating table for BS structures or from calibration ratings for EM and US gauges, based on the Q95 flow. For sites without a unique stage-discharge relationship, the smallest of the stage values at Q95 should be entered. If the stage/discharge relationship is too variable to interpret than it may be better to use the stage equalled or exceeded for 95% of the stage record.

Maximum stage

The maximum stage represents the maximum stage recorded at the site during the entire period of record (not just during the classification period), or if the record period is very short an estimate of the maximum stage may be entered. A numeric value in units of metres above datum is required. If a value for maximum flow has been transferred from a nearby station (see above) then the maximum stage should ideally correspond to that estimated flow.

Flow at H95 + 10mm

This is the flow that will occur when the stage value is 10mm higher than the stage associated with the Q95 flow. It applies specifically for BS Structures, where it is used to calculated the sensitivity of measurement at low flows. It should be determined from the rating table for the weir/flume, based on the value used for stage at Q95 flow.

Mean bed level

The mean bed level represents the typical or average elevation of the river or stream bed. Where the bed surface is very irregular the minimum bed level should be used. Elevation should be given in metres above datum. For ultrasonic stations, mean bed level should be the average level of the cross section *below the lowest ultrasonic path*.

If the channel bed is not stable and is known to vary during the classification period, use your best judgment as to an appropriate value to represent mean bed level. However, if changes in bed profile are significant and systematic then consider implementing a new classification period as discussed in Section 9.1.

9.12 Reliability of Stage Measurements

Five input fields relating to reliability of stage measurement appear for Level Only stations. The 'truncation' attribute reflects the fact that a level station may continue to record data even in situations such as a shaft recorder jamming, but that plateau or truncations of the level series are likely to be regarded rather as missing data. The truncation fields should be completed as follows:

Truncation of stage – high flows

The **Truncation of stage – high flows** field combines the frequency and degree to which stage measurements are truncated during periods of high flow. In each case one of the following options should be selected from the drop down box.

- Frequent (worst case, grade = 1)
    - Stage is frequently truncated during periods of high flow so that peak stage values are consistently missed

- Occasional (intermediate case, grade = 3)
    - Stage is occasionally truncated, or the truncation threshold is fairly high so that peak stage values are close to observed

- Rare (best case, grade = 5)
    - Stage is rarely truncation and measurement accuracy is close to instrument accuracy.

Truncation of stage – low flows

The **Truncation of stage – low flows** field combines the frequency at and degree to which stage measurements are truncated during periods of low flow. In each case one of the following options should be selected from the drop down box.

- Frequent (worst case, grade = 1)
    - Stage drops below the recording range of the instrument by the Q95 flow, or stage is measured imprecisely throughout the low flows range.

- Occasional (intermediate case, grade = 3)
    - Stage is measured imprecisely as flows drop below Q95, and are truncated as flows approach zero

- Rare (best case, grade = 5)
    - Stage is measured even as flows approach zero

Frequency of stage measurement

The frequency of stage measurement field represents the frequency at which stage is recorded, assuming stage is continuously logged. A numeric value in units of hours is required. For example if stage was measured at 15 minute intervals the frequency would be 0.25 hours, if recorded daily a frequency of 24 hours should be entered.

Number of missing stage measurements

The number of missing stage measurements field refers to the number of stage measurements (during the classification period) that are recorded as null or zero values between the start and end dates of the classification period. For example if frequency of measurement was 0.25 hours, and the gauge was out of operation for one hour, four measurements would be missing.

Number of manual checks on level

The number of manual checks on level field refers to the number of confirmatory manual measurements of stage taken during the classification period. This value can be an estimate, for example if level is generally checked weekly, and the classification period is two years and six months, the number of checks will be approximately 130.

9.13 Reliability of Flow Measurements

There are three fields relating to reliability of flow measurement. These should be completed for all gauging station types as follows:

Missing data - high flows range

The missing data - high flows range represents the significance and importance of missing data during periods of high flow For example if flood peaks are consistently missed this would be counted as 'significant'.

- Significant missing data
- Some missing data
- Insignificant or no missing data

Missing data - low flows range

The missing data - low flows range represents the significance or importance of missing data during periods of low flow. For example if the measurement device requires a minimum operating flow, and this is reached frequently in an average summer, this would be counted as 'significant'.

- Significant missing data
- Some missing data
- Insignificant or no missing data

Number of missing daily flow values

This field represents the total number of days during the classification period that that have null or zero values on the daily mean flow archive. It gives a measure of the overall reliability of the gauging station. If a definitive value is not known then an estimate can be entered.

9.14 Accuracy of Stage Measurement

General concepts

There are two distinct interpretations of the accuracy of stage measurement within the gauging station data quality classification. One is pure instrument accuracy – this is really the absolute precision of a correctly installed and well maintained instrument and is often quoted by the manufacturer. Typically the range quoted for level measurement is of the order of a few millimetres. Pure instrument accuracy is needed for the Level Only station type.

In other cases, what is needed for the GSDQ classification is instead an *effective accuracy* of stage measurement. The concept of effective accuracy recognises that the stage used to calculate flows, especially at structures, is really an idealised hydraulic variable and that the water level recorded by a sensor and then on an archive may not quite correspond to the desired hydraulic variable.

Instrument precision

Where there is no available information regarding instrument precision at a particular site, Table 9-3 may be used to estimate typical value for a variety of instrument types. Where one or more types of level recorder are used at a gauging station, the attribute should be scored on the most accurate.

Effective accuracy of stage measurement

The *effective accuracy of stage measurement* is defined as the resultant accuracy of a measurement taking into account the effects of the combination of instrument and sensor accuracy and resolution, site effects and any other impacts such as analogue to digital signal conversion resolution. Site effects that might introduce an additional error to a stage measurement include:

- incorrect installation or calibration of instrument
- instrument drift
- instrument reliability
- instrument datum being inconsistent with that of flow gauge
- inappropriate range of instrument (e.g. stage board poorly located, wrong choice of pressure sensor)
- draw-down effects
- superelevation
- siltation within stilling well,
- channel turbulence, especially during periods of high flow

Note that effects caused by weed growth are not included because weed growth is a separate quality attribute.

Four fields relating to effective accuracy of stage measurement at the gauging station are included. The effective accuracy of level measurement should be entered as a

numeric value in units of mm. For example if a value of 6mm is input, the level measurement can be assumed to be correct to within ± 6mm.

The figures in Table 9-3 provide some guidance as to typical values that might be expected for effective accuracy of stage. Read across the table from left to right to determine a suitable value.

Table 9-3: Effective accuracy of stage measurement

Sensor Type	**Recording medium**	**Effective Accuracy in mm** Good conditions		**Effective Accuracy in mm** Poor conditions	
Shaft encoder	Chart	In stilling well, steady conditions, high resolution chart	**±2**	Rapidly changing stage, difficult to read gauge board, poor chart resolution.	**±20**
Shaft encoder	Logger / Outstation	In stilling well, steady conditions. At least 12 bit A/D conversion, use of internal well dip.	**±1**	Rapidly changing stage, difficult to read gauge board.	**±10**
Pressure transducer	Logger / Outstation	Level range small, sensor calibrated to range, high quality transducer.	**±2**	Large level range, sensor not calibrated to range, poor quality transducer.	**±25**
Upward looking ultrasonic	Logger / Outstation	Steady conditions, small range.	**±3**	Choppy surface or rapidly changing stage. Moderate stage range.	**±10**
Downward looking ultrasonic	Logger / Outstation	Steady conditions, small range.	**±3**	Choppy surface or rapidly changing stage. Moderate stage range.	**±10**

Table 9-3 provides a guide for a range of conditions from good to poor. It is possible that effective accuracy may lie outside the above limits where better or worse conditions apply. For example, using a logger or outstation with only an 8-bit A/D conversion attached to a pressure transducer could provide a resolution of 25mm. The effective accuracy under these conditions would therefore be no better than ±12.5mm. Another example is a site that incurs, say, 50mm draw-down of stilling well level during flood flows, and no compensation for this is allowed. This site will have at best an effective accuracy of ±50mm at high flows.

Typical value for full range

This represents the effective accuracy to which stage may be measured, in general, throughout the entire flow range, or specifically the effective accuracy of a measurement of daily mean flow. A numeric value in mm is required.

Typical value at high flows

This field represents the effective accuracy to which stage may be measured during periods of high flows (flows between 0.5 x QMED and QMED). A numeric value in mm is required.

Typical value at low flows

This field represents the effective accuracy to which stage may be measured during periods of low flows (flows at or below Q95 flow).

Tailwater

This field represents the typical effective accuracy of the tailwater level gauge, if operated at the site. It applies specifically to the BS structures where tailwater stage may be used to correct for non-modular conditions.

9.15 Modularity of Structures

General concepts

Structures are designed to provide a hydraulic control that ensures a unique relationship between stage and flow. In most cases the relationship can be expressed as a mathematical function (a weir equation). The unique relationship can break down as the structure becomes submerged and downstream conditions begin to affect upstream levels. This is called *non-modularity*. For the majority of structures non-modularity becomes an issue in the high flow range. The *modular limit* is the point when flow just begins to be affected by the downstream level, although it is not always known precisely.

During non-modular conditions the structure is said to be *drowned*. Typically the highest 10-30% of flows will occur in the non-modular range, although this depends on the type of structure and the flow regime at the site. Occasionally non-modularity becomes an issue for low flows, for instance where the flow/stage is insufficient to maintain an adequately aerated nappe over the weir crest or downstream weed growth affects the flow.

The calculation of effect of non-modularity in GSDQ is somewhat more complicated than other attributes, which is a reflection of the complexity of the issue and the many possible responses to it at different sites. A full description of the treatment of non-modularity is given in the project R&D technical report. In the GSDQ software, three input fields are used to enter information regarding the effects of non-modularity. These should be completed according to the following guidance.

Modular Range

The modular range field attempts to represent the location of the modular limit in relation to the QMED. Select the most appropriate option from the drop-down box. The possible options are

- Always within modular range
    - The structure is always modular and the theoretical rating is applicable across the full range of measured flows
- 1.5 x QMED < Modular limit

    - The operating range of the structure is such that the theoretical rating is applicable up to flows equivalent to 1.5 x QMED flow or higher.
- QMED < Modular limit < 1.5 x QMED
    - The operating range of the structure is such that the theoretical rating is applicable up or over the QMED flow, but the structure is thought to become non-modular before the 1.5 x QMED flow is reached
- 0.5 x QMED < Modular limit < QMED
    - The operating range of the structure is such that the theoretical rating breaks down before the QMED flow is reached, but is still applicable when the flow is equal to 0.5 x QMED.
- Non-modular at lower flows
    - Non-modularity also occurs during periods of lower flows, that is the modular limit is below 0.5 x QMED.

Number of daily flows in the non-modular range

The number of daily flows in non-modular range represents the number of days during the classification period for which the structure is known or thought to have been operating outside its modular range. If the modular limit is sometimes not known with certainty then an approximate value will be appropriate. A numeric value in days should be entered.

Type of correction

The type of correction field records procedures routinely used for computing flows in the non-modular range of structures. The user should select the most appropriate option based on the guidance below:

- No correction applied
    - This option should be selected if the structure is rated entirely according to the theoretical weir equations despite being thought or known to behave in a non-modular manner.
- Rating over non-modular range
    - This option should be selected if a rating is used to adjust flows over the non-modular range, the theoretical weir equations being used otherwise.
    - Selection of this option does not imply that check gaugings have to be entered (these are still optional).
- Tailwater stage measurement
    - This option should be selected if the correction procedure is based on the use of tailwater (downstream) stage measurements to determine the head drop across the weir.
- Crest tapping
    - Correction based on tapping of the weir crest to provide information on the pressure/head drop across the weir .
- Always within modular range

- This option should be selected if the structure is always modular and the theoretical rating is applicable across the full range of measured flows.
- It should always be selected if [Always within modular range] is selected from the Modular Range drop-down list box.

9.16 Configuration Parameters for Ultrasonic Stations

A number of input fields relating to the configuration of the gauge must be entered for ultrasonic gauging stations, as follows:

Highest flight path

The height of the uppermost flight path at an ultrasonic gauging station. Elevation should be given in metres above datum. If the gauge is a single-path type, the lowest and highest path fields will be equal.

Lowest flight path

The height of the lowermost flight path operated at an ultrasonic gauging station. If the gauge is a single-path type, the lowest and highest path fields will be equal. Elevation should be given in metres above datum.

Path angle

The angle (in degrees) between the direction of the flight path and the direction of flow in the channel at an ultrasonic gauging station. For a multi-path system the mean or typical path angle should be entered. The path angle should be between 30^{o} and 60^{o}. A value of 45^{o} is typical.

Path length

The length of the flight path (i.e. distance between transmitter and receiver) for an ultrasonic gauging station. For a multi-path system the mean or typical path length should be entered. A numeric value in metres is required.

Number of bed surveys

The typical number of surveys of the channel bed (cross-section) carried out per year. Good practice guidelines state that the bed profile should be surveyed annually.

9.17 Selection of Check Gaugings

In the simplest case, a station could have a single rating curve or calibration, and a single set of flow gaugings that would be used to calculate uncertainty statistics. In reality, multiple rating curves or calibration curves and gaugings often exist, relating to different periods of time. It will be necessary to judge which gaugings to use in the spreadsheet tool, and this is perhaps best left open to the knowledge and expertise of hydrometry staff using the classification. The suitability flag field allows the user to

enter all gaugings in one go and then to experiment with different selections of gaugings.

Flow gaugings used to assess data quality for a given period of the record should be accurate independent measurements of flow, relevant to the hydraulic control or measurement instruments operating during that period for the flow/stage range.

For example, if reliable gaugings have been carried out at a new rated section for 5 years and the rating equation is then updated, but the control at the station is not thought to have changed, then we would suggest that early gaugings should continue to be used to calculate uncertainty about the new rating. If, however, the rating has been changed because it is thought that the control has in fact changed, then the old ratings are no longer a 'fair' independent check on the new rating and should not be used. Judgement may be needed to decide, if it is thought that the control has shifted slowly, whether to allow some of the older gaugings to be included notwithstanding.

APPENDIX A

Details of Input Fields

Table A-1: Fields in the Classification details section

Field name	Method of input	Description	Example
Station	Enter as text	The name of the gauging station	Armley
River	Enter as text	The name of the watercourse	River Aire
Reference	Enter as text	The reference number (which is either a local Agency reference number or the CEH station number)	F1707
Region	Drop down box	Agency Region in which gauging station is located. Changing the Region Box updates the Areas listed in the Area box.	[North East]
Area	Drop down box	Agency area in which gauging station is located.	[Ridings]
Status	Drop down box	The level of completion of the scheme, either 'Classified' or 'Unclassified'	[Unclassified]
Start Date	Enter as date	These refer to the start and end of the period to which the classification is to apply, and not the period of record of the gauge. The start date field should precede the end date. The end date field defaults to today's date, although any appropriate date may be entered here (it can be post-dated by up to one year).	01-Jan-1989
End Date	Enter as date		14-Jul-2003

Table A-2: Fields in the Classification details section

Field-name	Scoring scheme	Method of input	Description	Example
Instrument type	L	Drop down box	The type of stage recorder used at the site	[Pressure transducer]]
Siltation (of instrument)	L	Drop down box	The degree of siltation within the stilling well & management thereof.	[Severe or not managed]
Bypass flow	L, R, S, SR, U, E	Drop down box	Occurs when the capacity of the gauge is exceeded, e.g. when flows are out-of-bank. Bypass flow is, by definition, unmeasured.	[No or neglible bypass flow]
Weed management	L, R, S, SR, U, E	Drop down box	Encompasses the amount and management of weed growth.	[Weed growth not Managed]
Maximum stage	L, U	Enter as numeric	Maximum stage in m recorded at the site during the entire POR (not just during POC)	2.45
Stability of Section	R	Drop down box	The stability of the cross-section at the control point.	[Fair stability]
Indicative QMED	R, S, SR, U, E	Enter as numeric	The approximate value of QMED (the median annual maximum flood), in m^3s^{-1}	100
Indicative Q95	R, S, SR, U, E	Enter as numeric	The approximate value of Q95 (the 95th percentile on the flow duration curve) in m^3s^{-1}	4.6
Maximum flow	R, S, SR, U, E	Enter as numeric	The maximum flow in m^3s^{-1}recorded at the site during the entire POR (not just during POC)	137.14
Minimum flow	R, S, SR, U, E	Enter as numeric	The minimum flow in m^3s^{-1} recorded at the site during the entire POR (not just during POC)	2.23
Mean daily flow	R, S, SR, U, E	Enter as numeric	The daily mean flow in m^3s^{-1} determined from the entire POR at the site	52.7
Weir type	S, SR	Drop down box	The type of weir or flume	[Triangular]
Flume type	S	Drop down box	The type of flume (at present all flumes are considered under one category)	[All flume types]
Deviation from BS	S, U	Drop down box	The level of deviation from standard conditions for example due to damage of weir crest, or channel effects	[Severe deviation]
Stage at Q95 (H95)	S, SR, U	Enter as numeric	The stage (in m) when the Q95 flow occurs, or median annual stage if backwater effects occur.	1.34
Flow at H95 + 10mm	S, SR	Enter as numeric	The flow in m^3s^{-1} corresponding to a stage 10mm higher than the stage at Q95 flow.	4.7
Stage at QMED	S, U	Enter as numeric	The stage (in m) when the QMED flow occurs, or median annual stage if backwater effects occur.	3.7
Configuration	U	Drop down box	The path configuration of the ultrasonic gauge	[Multi-Path]

Table A-2: Fields in the Classification details section

Mean bed level	U	Enter as numeric	the mean bed level (in m) of the section, or the lowest bed level or datum	0.2
Membrane condition	E	Drop down box	The condition of the protective membrane that insulates the EM coil	[Good condition]

Notes: POR = period of record, POC = Period of Classification

Table A-3: Fields in the Missing data section

Field-name	Scoring Scheme	Method of input	Description	Example
Truncation of stage - high flows	L	Drop down box	The significance and/or frequency of truncation of stage measurements at flows equal or greater than 0.5 x QMED	[Frequent]
Truncation of stage - low flows	L	Drop down box	The significance and/or frequency of truncation of stage measurements at flows less than Q95	[Rare]
No. missing stage measurements	L	Enter as numeric	The number of stage measurements, during the POC, that are recorded as null or zero values.	200
Frequency of stage measurement	L	Enter as numeric	The frequency (hour) at which stage is recorded, assuming stage is continuously logged.	0.25 hours
Number of manual checks on level	L	Enter as numeric	The number of confirmatory manual measurements of stage taken during the POC	30
Missing data - high flows range	R	Drop down box	The significance / importance of missing data. For example if flood peaks are consistently missed this would be 'significant'.	[Significant]
Missing data - low flows range	R	Drop down box	The significance / importance of missing data during periods of low flow	[Insignificant]
Number of missing daily mean flows	R	Enter as numeric	The total number of days during the classification period that are classed as missing on the daily mean flow archive during the POC.	50

Notes POR = period of record, POC = Period of Classification

Table A-4: Fields in the Effective Accuracy section

Field name	Scoring Scheme	Method of input	Description	Example
Accuracy of stage measurement	L	Enter as numeric	The accuracy (in mm) of the level recorder under typical operating conditions.	3
Typical value for full flow range	R,S,SR, U,E	Drop down box	Effective accuracy of stage measurement at daily mean flow	5
Typical value at high flows	R,S,SR, U,E	Enter as numeric	Effective accuracy of stage measurement during periods of high flows (typically for flows greater than 0.5 x QMED)	15
Typical value at low flows	R,S,SR, U,E	Enter as numeric	Effective accuracy of stage measurement during periods of low flow (flows equal or lower to Q95)	10
Tailwater	S,SR	Enter as numeric	Typical effective accuracy of tailwater level gauge if operated at the site	10

Table A-5: Fields in the Modularity of Structures section

Field-name	Scoring Scheme	Method of input	Description	Example
No. daily flows in non-modular range	S, SR	Enter as numeric	The number of days during the classification period for which the weir/structure is known/thought to have been operating outside its modular range.	25
Modular range	S, SR	Drop down box	The relation of the modular limit of the weir/structure to the QMED flow.	[Always within modular range]
Type of correction	S, SR	Drop down box	The procedure applied to correct flow measurements during periods of non-modular flow.	[Crest –tapping]

Table A-6: Fields in the Configuration Parameters section

Field-name	Scoring Scheme	Method of input	Description	Example
Highest flight path	U	Enter as numeric	The height of the uppermost flight path operated at an Ultrasonic gauging station. Set highest and lowest path to be equal if a single-path configuration is used.	2.3
Lowest flight path	U	Enter as numeric	The height of the lowestmost flight path operated at an Ultrasonic gauging station.	0.6
Path angle	U	Enter as numeric	The angle between the direction of the flight path and the direction of flow in the channel. For a multi-path system the mean or typical path angle should be entered	45
Path length	U	Enter as numeric	The length of the flight path (i.e. distance between transmitter and receiver). For a multi-path system the mean / typical path length should be entered.	25
Number of bed surveys per year	U	Enter as numeric	The number of surveys of the channel bed (cross-section) during a typical year.	1

APPENDIX B

Errors and Warnings

Table B-1: Notes issued on successful completion of scoring procedures

Note	Explanation	Action Required
Scoring scheme completed successfully assuming no check gaugings available.	Where optional, the user did not enter any gaugings on the 'Input Check Gaugings' worksheet. The classification was completed accordingly.	None
For *n* gauging(s) the observed stage was outside the stated range of the rating equation.	The user input 'n' gaugings having stage values outside the range of applicability of the rating equation (as input in Input Rating Equation worksheet). The software will ignore such gaugings.	The user should consider whether stage values have been entered correctly, or if these gaugings are appropriate for use, repeating the classification if necessary.
Rated flow calculated for 25 gauging(s) of which 1 has suitability of 'No'	The rating equation has been used to calculate the 'Station flow' for 25 gaugings entered on the 'Input Check Gaugings' worksheet. For one of these the suitability field was 'N' (set either by the software, or by the user).	None
Scheme calculated assuming all flows within modular range of structure.	This note is given when the 'Always within modular range' option is selected from the Modular Range drop-down box.	None

Table B-2: Errors issued when scoring procedures are not completed successfully

Note	Explanation	Action Required
To continue please complete all required fields on the 'Input Station Info' worksheet. Incomplete fields are highlighted in red.	The user has omitted input data required in the 'Input Station Info' worksheet. Omitted fields will be shown in red colour.	The user should complete any blank fields, and use the calculate scores button to repeat the classification procedures.
To continue please complete all required fields on the 'Input Check Gaugings' worksheet. Incomplete fields are highlighted in red. Alternatively set the suitability of problem gaugings to 'N'.	The user has omitted some input data required on the 'Input Check Gaugings' worksheet.	The user should either complete blank fields or set the suitability of the gauging to 'N', in which case the gauging will be ignored. The calculate scores button should then be used to repeat the classification procedures.
To continue please complete all required fields on the 'Input Rating Equation' worksheet. Incomplete fields are highlighted in red.	The user has failed to complete required fields on the 'Input Check Gaugings' worksheet.	The user should complete any blank fields, and use the calculate scores button to repeat the classification procedures.
Gauging error: Could not take natural log of gauging. Problem associated with n^{th} suitable gauging.	The value entered for the n^{th} gauging with suitability of 'Y' has caused an error to occur during the scoring procedure.	The user should identify and validate the fields for the n^{th} gauging, making amendments as appropriate. Alternatively the user should set the suitability of the gauging to 'N'. The calculate scores button should then be used to repeat the classification procedures.
Gauging error: cannot calculate SED for EM gauge, problem associated with the ith suitable gauging.	The value entered for the n^{th} gauging with suitability of 'Y' has caused an error to occur during the scoring procedure.	The user should identify and validate the fields for the n^{th} gauging, making amendments as appropriate. Alternatively the user should set the suitability of the gauging to 'N'. The calculate scores button should then be used to repeat the classification procedures.
Gaugings error: Could not calculate SEE.	One of the check gaugings has caused an error to occur during the scoring procedure.	The user should attempt to identify the problem gauging, making amendments as appropriate, or setting the suitability of the gauging to 'N'. The calculate scores button should then be used to repeat the classification procedures.
Calculation error: ultrasonic gauge. Problem associated with path type, path angle or elevation of highest/lowest path	The values entered for either of /all of path type, path angle or elevation of highest / lowest flight path are inappropriate.	The user should revise the values as appropriate (note the acceptable range for path angle is between 30^{o} and 60^{o}). The calculate scores button should then be used to repeat the classification procedures.
An error has occurred. The scheme could not be completed successfully. See notes/warning sections on 'Further Details' worksheet.	This is a catch-all error message. It implies that the source of the error cannot be identified.	The user should follow guidance for any warnings issued. If the problem cannot be resolved, the user should start again with a blank copy of the Master Tool.

Notes: The status field is automatically set to 'Unclassified' if any of the above errors occur.

Table B-3: Warnings issued when scoring procedures are completed successfully

Note	Explanation	Action Required
Indicative Q95 exceeds (or equals) indicative QMED.	The value entered for Q95 is larger than the value entered for QMED.	The user should not accept the classification results & is recommended to revise the values entered, as appropriate.
Flow at Q95 stage + 10mm does not exceed flow at Q95.	The value entered for the flow at 'Q95 stage + 10mm) is smaller than the flow entered for Q95.	The user should not accept the classification results & is recommended to revise the values entered, as appropriate.
Minimum flow exceeds (or equals) daily mean and maximum flow.	The value entered for the minimum flow is larger than values entered for both the daily mean flow and maximum flow fields.	The user should not accept the classification results & is recommended to revise the values entered, as appropriate.
Minimum flow exceeds (or equals) daily mean flow.	The value entered for the minimum flow is larger than value entered for the daily mean flow.	The user should not accept the classification results & is recommended to revise the values entered, as appropriate.
Daily mean flow exceeds (or equals) maximum flow.	The value entered for the daily mean flow is larger than the value entered for maximum flow.	The user should not accept the classification results & is recommended to revise the values entered, as appropriate.
Minimum flow exceeds (or equals) Q95.	The value entered for minimum flow is larger than the value entered for the Q95 flow.	The user should not accept the classification results & is recommended to revise the values entered, as appropriate.
Number of non-modular days exceeds length of classification period.	An incorrect value has been input for 'number of non-modular days'.	The user should not accept the results of the classification & is recommended to revise the value entered as appropriate.
Number of missing daily mean flows exceeds classification length.	An incorrect value has been input in the 'number of missing daily mean flows' field	The user should not accept the results of the classification & is recommended to revise the value entered as appropriate.
Mean bed level is above stage at Q95 flow.	The value entered for mean bed level is larger than the stage corresponding to the Q95 flow.	The user may accept the results of the classification but is recommended to revise the value entered as appropriate.
Mean bed level is above height of lowest flight path.	The value entered for mean bed level is larger than the stage corresponding to the lower most ultrasonic flight path used.	The user may accept the results of the classification & is recommended to revise the value entered as appropriate.
Mean bed level is above maximum stage.	The value entered for mean bed level is larger than the maximum stage or stage corresponding to the maximum flow.	The user should not accept the results of the classification & is recommended to revise the value entered as appropriate.
Lowermost flight path has been set higher than upper most flight path.	The stage of the lower most ultrasonic flight path has been set at the same value as that of the uppermost ultrasonic flight path.	The user may accept the results of the classification but is recommended to revise the value entered as appropriate.
Path angle is greater than 90 degrees	The path angle value exceeds the acceptable range. The path angle should not exceed 90^{o}, and should ideally be between 30^{o} and 60^{o}.	The user should not accept the results of the classification & is recommended to revise the value entered as appropriate.
Error associated with check	Some check gauging data was not	The user may accept the results

Table B-3: Warnings issued when scoring procedures are completed successfully

gauging entries	entered in the required format. These gaugings are ignored during the scoring procedures.	of the classification, but should consider revising the check gaugings entered.
Some check gaugings exceed maximum flow.	Some of the observed flow values for check gaugings entered are larger than the value entered for maximum flow.	The user should not accept the classification results & should evaluate whether the check gaugings are appropriate for use and/ or should consider revising the value entered for the maximum flow.
No low flow gaugings entered.	None of the gaugings entered were taken during periods when the flow was lower than value input in the Q95 field.	The user may accept the results of the classification. However, ideally 3 or more low flow check gaugings should be entered.
No high flow gaugings entered.	None of the gaugings entered were taken during periods when the flow was higher than 0.5 X QMED	The user may accept the results of the classification. However, ideally 3 or more high flow check gaugings should be entered.
No low flow and no high flow gaugings entered.	None of the gaugings entered were taken either during periods where the flow was lower than Q95 or during periods where the flow was higher than 0.5 x QMED.	The user may accept the results of the classification. However, ideally a more representative sample of check gaugings should be entered.
There was a software error when drawing confidence intervals on the rating curve plot.	The rating curve plot has not been plotted correctly. This does not affect the scoring results.	The user may accept the results of the classification, but should not use the rating curve plot.

Notes: The user should ALWAYS use the CALCULATE SCORES button to repeat the scoring procedures after making ANY changes to the input fields in the 'Input Station Info', 'Input Rating Equation' or 'Input Check Gaugings' worksheets.

GLOSSARY OF TERMS

(Check) Gauging	A 'spot' measurement of discharge across the section, used to check or calibrate flows measured at the station.
(Scoring) Scheme	A particular arrangement of attributes and weights, thought to be most relevant for a particular gauging station type.
Abbreviated Score	A label applied to the category score, depending on the result as follows: 0 to 0.4: CAUTION 0.4 to 0.7: FAIR 0.7 to 1.0: GOOD
Attribute	A factor having a strong influence (either negative or positive) on gauging station quality, generally one of the following: • A physical feature of the gauging station / recorder • A statistical / numerical property the flow or stage record • A statistic relating to check gaugings made at the site.
Attribute Value	The magnitude or, where the attribute cannot be described numerically, status of the attribute.
Classification	The assessment of quality of gauging data observed between two discrete points in time based on applying the appropriate scheme given the type of gauging station used.
Data quality	The level of data quality refers to the amount of confidence in the recorded flow measurements. It should not be confused with water quality, which refers to the purity of the water in the channel.
Flow Range	The attributes used in each scheme are arranged in three 'flow' categories, "High Flows Range", "Low Flows Range" and "General".
Grade	An integer between 1 and 5 representing the 'quality' of each attribute. A grade of 1 indicates that the attribute has a very detrimental effect on quality, a grade of 5 indicates that the attribute has a positive or neutral effect on quality.
Score	The grade expressed as a fraction of the maximum grade (i.e. out of 5).
High Flows Range	The part of the flow duration curve above the flow percentile equivalent to 0.5 x the median annual flood (QMED). Index flow event is the median annual flood (QMED) in m^3s^{-1}.
Look-up table	A table from which the grade associated with a particular attribute value (or description) is determined.
Low Flows Range	The part of the flow duration curve below the 5^{th} flow percentile (Q95). Index flow event is the Q95 flow in m^3s^{-1}.
General Category	The whole of the flow duration curve (including flows described as high or low), but specifically describing flows around the Q50 flow percentile. Index flow event is the average daily flow (ADF) m^3s^{-1}.
Combined Score	The weighted geometric mean of the attribute grades for each category. Presented as a fraction (out of 1).
Station flow or Archive flow	The flow measured at the gauging station, in the conventional manner. Specifically, the archived flow represents the accepted flow, after any correction procedures applied.
Weight	A weighting factor used to adjust attribute grades, where the attribute is thought to have greater/lesser influence on data quality for a particular type of gauging station.