Agrifood Water Quality Index (AFWQI) Help Manual

Water Resources Management Division
Department of Environment and Conservation

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Table of Contents

1   Introduction

The Agri-Food Water Quality Index (AFWQI) 1.0 was adapted from the National Water Quality Index and developed by the Water Resources Division of the Department of Environment and Conservation, Government of Newfoundland and Labrador. The AFWQI was developed as part of the contribution agreement *Real Time Groundwater Level and Water Quality Monitoring of Farming Areas* under the Canada-Newfoundland and Labrador National Water Supply Expansion Program.

The calculator will be used to summarize water quality information into easy to understand rankings that will rank the quality and suitability of water for use in agricultural (irrigation and livestock watering) applications. The AFWQI and data reports will be accessible to farmers and the general public via a website.

The Agricultural Water Quality Index is a tool which can be used to screen the suitability of groundwater for agricultural operations, and evaluate the impact of various Agricultural Best Practices on groundwater quality.

1.1   Welcome to the AFWQI

Welcome to the world of water quality!

Water quality indexing is a means to convert raw data from the field to results that are meaningful and useful to the user. It will provide you with information on just how good your water is for a broad range of applications.

We have endeavored to bring you all the information you require in order to get the most benefit out of the AFWQI application through this help file. To navigate through the file you can use links contained within the file itself, the table of contents, the index, the keyword search and/or the browser navigation buttons ("Back", "<<" and ">>") of the help file.

For more information regarding the Water Quality Index, see the CCME Homepage or contact Amir Ali Khan at akhan@gov.nl.ca

1.2   Using the AFWQI

The AFWQI program is an interactive calculator which has been designed in Visual Basic for Applications around the platform of Microsoft Excel by the Water Resources Management Division of the Department of Environment and Conservation, Government of Newfoundland and Labrador.

In order to properly use the AFWQI you will need Excel 2000 SR-3 or later. Excel users should note that the security setting should be set to no stricter than Medium.

To change your security setting simply open Excel and select "Tools>Options" from the menu. In the options window select the Security tab and alter the setting as desired.

With a medium security setting you will be prompted by Excel asking if you wish to Enable <u>Macros</u> each time you open a worksheet with contains source code. To use this model you will need to enable macros.

2   AFWQI Excel Components

2.1   Section Overview

Within this chapter you will find specialized information regarding all of the available pages you will see and interact with during your use of the AFWQI Calculator.

Simply select the page you wish to know more about and read on!

Jump to page:
<u>Start Page</u>
<u>Guidelines/Objectives Page</u>
<u>Data Page</u>
<u>Report Page</u>
<u>The Manual</u>
<u>The WQI</u>

2.2   Page Descriptions

2.2.1   Start Page

When you first open the AFWQI this is what you will see:

This page provides you with a method to maneuver to all of the main pages of the application via the buttons located at the top of the page as you can see below. These buttons are present on most of the pages of the AFWQI.
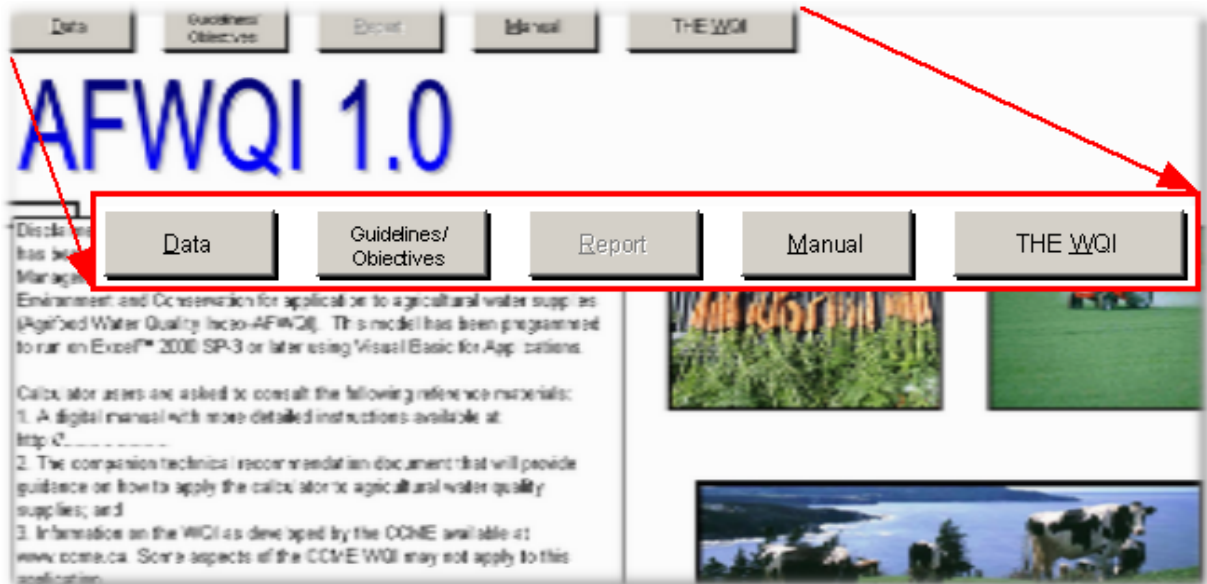
As you can see above, the Report page is not accessible when the program is initially opened. Upon initial opening of the program the calculator has yet to run to generate results and access to the Report page is not available until there are results to report. Once you have computed AFWQI values for data you will be allowed to access the Report page from here as well as the other pages of the application.

2.2.2   Guidelines/Objectives Page

The Guidelines/Objectives page is where you define the guidelines which will be used to evaluate the water quality for the data you supply on the Data page.

Parameters	Symbol	Units	Irrigation (CCME)		Livestock (CCME)		UserDefined2		User
			Lower	Upper	Lower	Upper	Lower	Upper	Lower
1 Aldicarb	Aldicarb	ug/L		54.9		11			
2 Aldrin & Dieldrin	Aldrin & Dieldrin	ug/L							
3 Aluminum	Al	ug/L		5000		5000			
4 Arsenic	As	ug/L		100		25			
5 Atrazine	Atrazine	ug/L		10		5			
6 Azinophos-methyl	Azinophos-methyl	ug/L							
7 Bendiocarb	Bendiocarb	ug/L							
8 Beryllium	Be	ug/L		100		100			
9 Boron	B	ug/L		6000		5000			
10 Bromacil	Bromacil	ug/L		0.2		1100			
11 Bromoxynil	Bromoxynil	ug/L		0.33		11			
12 Cadmium	Cd	ug/L		5.1		80			
13 Calcium	Ca	ug/L				1000000			
14 Captan	Captan	ug/L				13			
15 Carbaryl	Carbaryl	ug/L				1100			
16 Carbofuran	Carbofuran	ug/L				45			
17 Chlorate	Chlorate	ug/L							
18 Chlordane	Chlordane	ug/L							
19 Chloride	Cl⁻	ug/L		700000					

Data Formats

Unlike other WQI calculators, the AFWQI does not give you the option to select between different data formats since the parameters typically measured for agricultural water quality are not included in the common WQMA or Drinking Water data formats. The user may modify the Objectives by simply typing into or deleting from the table.

If your data is not stored in the available format, you can modify the order of your data so that it follows the available predefined format.

Guidelines/Objectives

The guidelines included in the Guidelines/Objectives table are those listed by CCME (2005) for irrigation and livestock watering purposes. All provinces, with the exception of British Columbia, recommend the use of CCME's guidelines for these usages. British Columbia recommends their own provincially developed set of guidelines.

A summary table of guidelines used in Canada is listed below and to the right of the Guidelines/Objectives table. If the user wishes to test data against these guidelines, they may copy and paste them from the summary table into the guidelines/objectives table.

Irrigation and Livestock Water Quality Guidelines by Province

	CCME Guidelines (ug/L)		CCME Guidelines	
	Irrigation (ug/L)	Livestock (ug/L)	Irrigation (mg/L)	
Aldicarb	54.9	11	0.0549	
Aldrin & Dieldrin				
Aluminum	5000	5000	5	
Arsenic	100	25	0.1	
Atrazine	10	5	0.01	
Azinophos-methyl				
Bendiocarb				
Beryllium	100	100	0.1	
Boron	500-6000	5000	6	
Brom	0.2	1100	0.0002	
B.	0.33		0.00033	

It should be noted that the values given for livestock and irrigation water in the guidelines/objectives table are in µg/L, the measurement used by CCME's recommended guidelines. Should the user wish to test data that is in mg/L, the CCME guidelines are converted and listed in the summary table as well. These can then be copied and pasted into the criteria table.

The order of the parameters as listed on this page must match the order of your data if you wish to generate an accurate analysis of water quality (see <u>Entering Data</u>). If you wish, you can select a user defined data format which will allow you to modify your parameter list as you see fit. With this option you can enter each parameter individually by typing it into the table. Up to six sets of user defined guidelines can be entered into the guidelines/objectives table.

Once you have the desired guideline order set for your data you may want to alter the individual acceptable limits or criteria values. CCME uses Maximum Acceptable Concentration (MAC) values for most agricultural water parameters. However, more specific guidelines for particular species' often have a recommended tolerance range. Thus each parameter has an available upper and lower limit to its acceptable range as shown below.

While the irrigation guideline for boron is 6000 µg/L, the specific guideline for red peppers, peas, carrots, radishes, potatoes and cucumbers is 1000-2000 µg/L, as shown below.

Agrifood Water Quality Guidelines/Objectives

Parameters	Symbol	Units	Irrigation (CCME)		Livestock (CCME)	
			Lower	Upper	Lower	Upper
1 Aldicarb	Aldicarb	ug/L		54.9		11
2 Aldrin & Dieldrin	Aldrin & Dieldrin	ug/L				
3 Aluminum	Al	ug/L		5000		5000
4 Arsenic	As	ug/L		100		25
5 Atrazine	Atrazine	ug/L		10		5
6 Azinophos-methyl						
7 Bendiocarb	E					
8 Beryllium				100		100
9 Boron			1000	2000		5000
10 Bromacil	Bromacil	ug/L		0.2		1100
11 Bromoxynil	Bromoxynil	ug/L		0.33		11
12 Cadmium	Cd	ug/L		5.1		80
13 Calcium	Ca	ug/L				1000000

Callout box: Bendiocarb / Beryllium / Boron

Here you can see an example of the possible criteria states for a parameter:

- Boron has a value for both limits (for this species) which indicate a range of acceptable measurements
- Bendiocarb has no guideline given (note that an entry of zero (0) is the same as a blank entry)
- Berylliusm has a value which should not be exceeded by the test data (an upper guideline)

Each parameter which is present in the data file to be tested should have a corresponding entry in the criteria table. This table defines the values that indicate the difference between acceptable and unacceptable measurements (if applicable for that parameter). Also the order of appearance of the parameter list on the criteria table and that of the data file itself must match. For more information see Entering Data.

Rank

AFWQI scores are grouped into categories or rankings much the same as letter grades in school. Although there is a generally accepted range and number of these categories, you may alter the settings if desired. Below the criteria table you will see a rank table

Ranking Categories Minimum Values

Ranking Categories	Irrigation (CCME)	Livestock (CCME)	UserDefined2	User Defined3	User Defined4	User Defined5	User Defined6	User Defined7
Excellent	95	95	95	95	95	95	95	95
Very Good	89	89	89	89	89	89	89	89
Good	80	80	80	80	80	80	80	80
Fair	65	65	65	65	65	65	65	65
Marginal	45	45	45	45	45	45	45	45
Poor	0	0	0	0	0	0	0	0

For each index of the criteria you can set your desired range for each rank and/or
alter the number of available ranks for the AFWQI to fall into by altering the table as
desired. The value listed for each rank defines the minimum score required (lower
bound) for a result to fall into that category. Note that Poor is fixed as the worst
possible ranking.

2.2.3   Data Page

The Data page is where you initiate all AFWQI calculations. Along the top of the
page you can see that there are more navigation buttons to let us maneuver to other
pages. Here is an example of what you will see when you view the Data page:

Data

On the right side of the screen you will see that there is some sample test data
already entered into the calculator; here it is enlarged:

This is the general format of input data as it should exist in the calculator. The top two rows should be reserved for labels which describe the data. The first column of your data should contain the dates of each sample while the second column is unspecified. This column can be anything you want and it can be used in grouping (see Grouping Subsets) to help split your data into distinct groups such as season or site. These sections of the data which have a generally defined format are shaded grey whereas the data portion of the file is shaded in blue. This shading is done automatically when you enter a data file using the available command button and is done on the first calculation of the AFWQI when data is entered manually (see below).

There are several ways to enter data into the data sheet. You can load in an existing Excel data sheet using the "Open New Data Sheet" button or you can type it in manually using the data option buttons available.
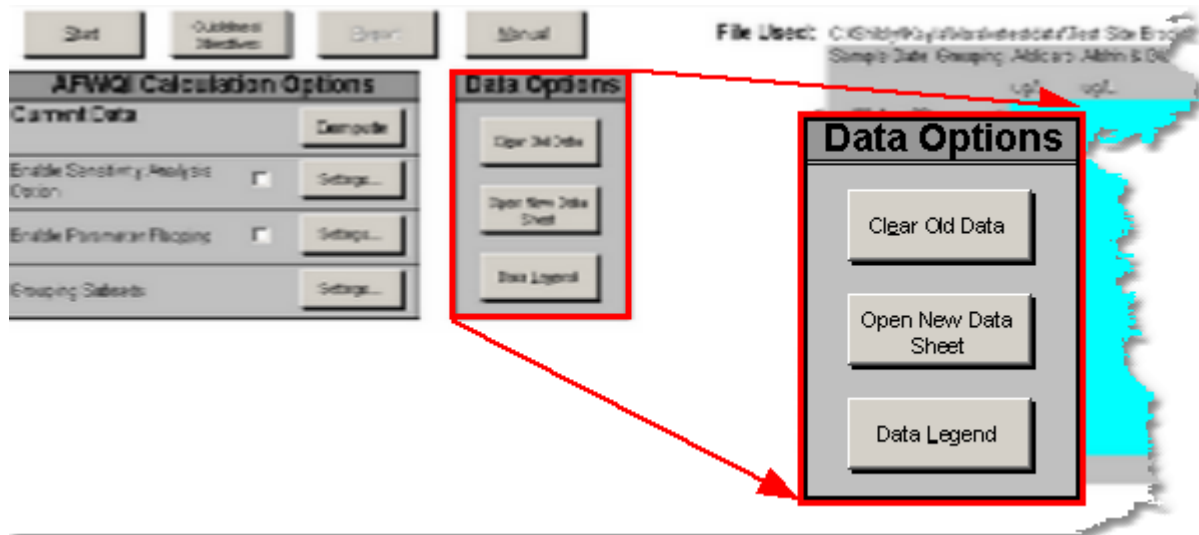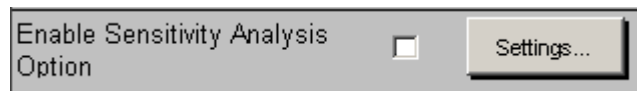
For more information on data entry see Entering Data.

Sensitivity Analysis

Using the sensitivity option allows you to examine how your data would score if it was altered, without having to manually alter your original data.

To enable this option, simply ensure that the check box shown contains a check mark. Below is what you will see when the option is NOT enabled

Clicking on the settings button for this option will display the following window.
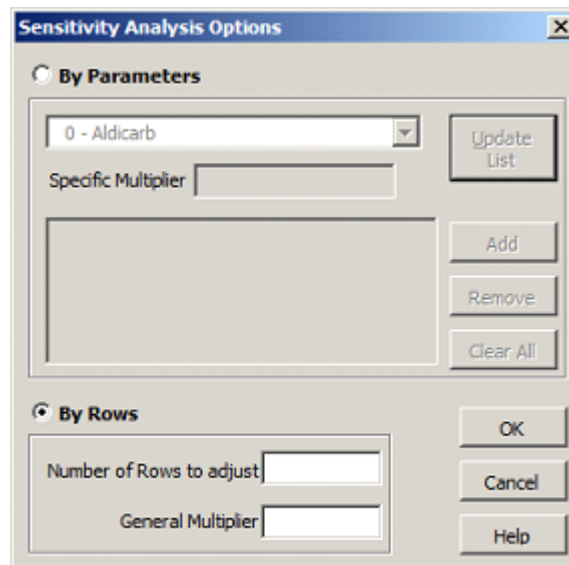
As you can see there are two options available for sensitivity adjustments; by parameter or by row. Above in our example "By Row" is the currently selected option as its "radio button" is selected, click on the "By Parameter" option to enable the feature.

By parameter adjustment allows you to specify a separate multiplier for each parameter. Simply select the parameter you wish to adjust from the pull down menu, enter the desired multiplier and click the "Add" button. Your selections will be visible when added which then will allow you to remove any unwanted entries by using the "Remove" and "Clear All" buttons.

By row adjustment lets you specify one multiplier which will be used for every parameter for the number of rows you specify. For example, enter a value of 10 to have the multiplier applied to the first 10 rows of data. If the number of rows entered is larger than the number of rows in your data file the application will simply apply the multiplier to all rows of data.

Parameter Flagging

This option allows you to have a secondary check for data parameters which exceed the acceptable value. It can be helpful to alert you to a potential problem with the water supply which should be investigated or monitored.

To enable this option, simply ensure that the check box shown contains a check mark. Below is what you will see when the option is NOT enabled.
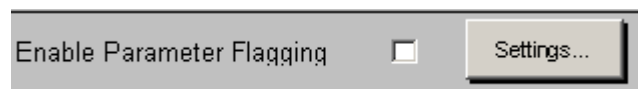
Clicking on the settings button for this option will display the following window.
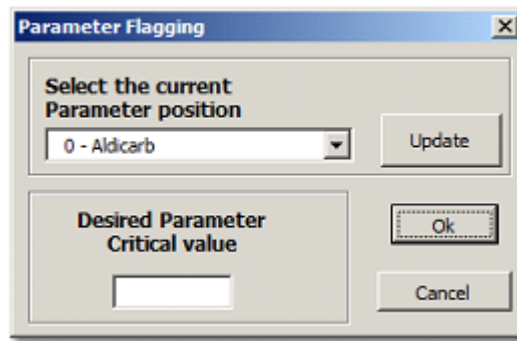
To use this option, you must select from the pull down control the parameter you want to monitor in order to point the application to the parameter's values, then give the desired critical value which you do not wish levels to exceed without producing a warning. To ensure that the pull down control contains the most up to date version of your current data format you can click on the "Update" button.

Grouping Subsets

Grouping is a way for you to break your data up into smaller pieces in order to analyze small sections or to compare different groups of data within the same data file.

Clicking on the settings button for this option will display the following window.
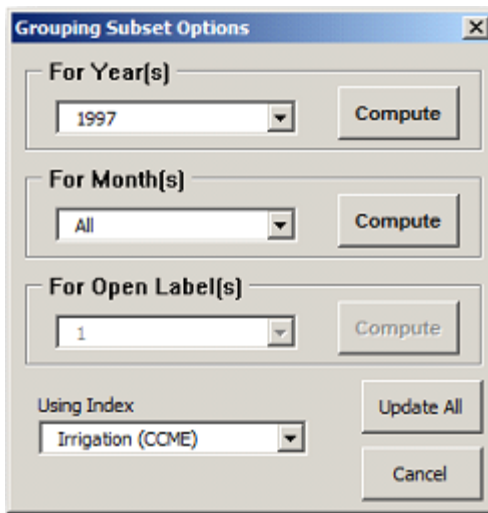
Clicking on the "Update All" button will read in all of the current information about your data and criteria settings.

To compute AFWQI values for a subset or multiple subsets of your data simply select the desired group from the options shown and click on the corresponding "Compute" button. If you wish to test on multiple subsets, as is shown in the months section above, select the "All" item and click on compute. You can also select a

single subset of your data as can be seen above in the year section. If there is only one group present for a category of data, as can been seen in the above example for open labels, the options will be disabled as computing for this group would be the same as simply computing from the main data page so the option to group or subset your data is not valid.

If you are computing for multiple subsets ("All" selected) you will also want to specify which index you wish to use for testing. Performing calculations for multiple subsets of data is more complex therefore it will limit the generation of report options (see Grouping Reports). When you click on compute for this operation, you will be prompted to confirm your choices prior to any AFWQI calculations.

2.2.4   Report Page

The report page is where you will be automatically directed whenever you compute the AFWQI. Below is a sample of what you will see.

As you can see, there is a lot of information available here which summarizes the results of your calculations. However, we have designed the report with the goal of allowing the user to easily extract as much or as little detail as they desire. Below is a summary of all of the information you will see.

AFWQI Values

The first line in the report table simply gives the AFWQI value (both the numeric value and its corresponding rank) of each index tested, as sampled below.

Data Summary	Irrigation (CCME)	Livestock (CCME)	
AFWQI	87	100	
Categorization	Good	Excellent	
F1 (Scope)	15	0	

In this example you can see that our data scored a AFWQI value of 87 or Good for the Irrigation index and 100 or Excellent in Livestock.
For more information regarding the AFWQI values, their ranking and interpretation, please refer to The WQI page of the AFWQI application or to the CCME Homepage.

AFWQI Factor Scores

The value which is assigned to represent the AFWQI is composed of three separate components or "Factors". Below is the result of a sample test for the index Irrigation.

F1 (Scope)	15	
F2 (Frequency)	9	0
F3 (Amplitude)	14	0

Although these values can relate much about strengths and weaknesses of the data tested, the derivation of the individual factors of the AFWQI is beyond the scope of this help file. For more information regarding AFWQI, its derivation and composition please refer to The WQI page of the AFWQI application or to the CCME Homepage.

Minimal Datasets

In order for our results to be meaningful, there is a condition enforced upon the calculations which demands that the input data contain at least 4 separate variables and 4 tests of each variable.

In our test for the Livestock index failed to test at least four separate parameters, therefore we should realize that even though our results show this sample as scoring perfectly for Livestock water, our testing was limited thus our result could have a high margin of error.

Computation Options Summary

As can be reviewed in the Data Page section, there is another option which is available for AFWQI calculations. The state of this option is reported in a separate table shown below.

This review is provided so that, at a glance, you can see what options were used to

generate your results and also so that printing this page will capture not only the results but also the state of the calculator which produced these results.

Summary Details Buttons

At the bottom of the Report page you will notice that there are several buttons available as seen below.
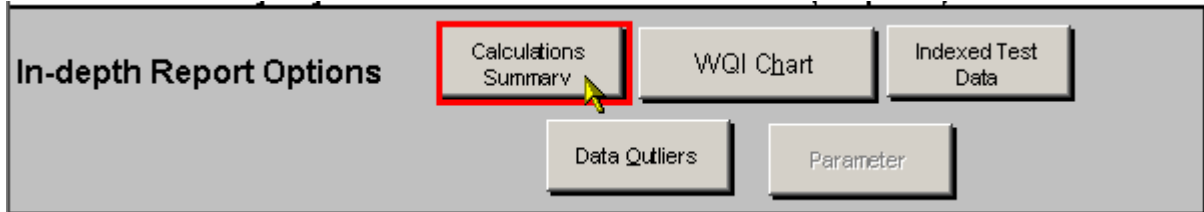
These buttons provide navigation to more detailed results based on your calculations. As you can see, not all navigation options are available to us as access to these pages is dynamic in nature. You can see that we do not have access to Parameter In-Depth Report (its corresponding button is greyed out), this is because we did not invoke the Parameter Flagging option for our sample run, as you can see in the computation options summary.

For descriptions of these extra reports, please refer to the In-Depth Reports section.

2.2.5   The Manual

This page of the AFWQI application provides you with much of the same information which you will find in this help file. It can provide a quick reference to those who are unsure about a procedure without having to refer to this file. The Manual however does not provide any internal features, search query or pictorial guides.

2.2.6   The WQI

The WQI page of the application is a subset reference to facts about the AFWQI which are available form the CCME Homepage.

3 Advanced Topic

3.1 Entering Data

The correct format of data entry is very important to the proper functioning of the AFWQI application. Although much effort has been put into ensuring that the program is as forgiving as possible to the user, incorrectly entered data will cause the AFWQI to generate invalid results.
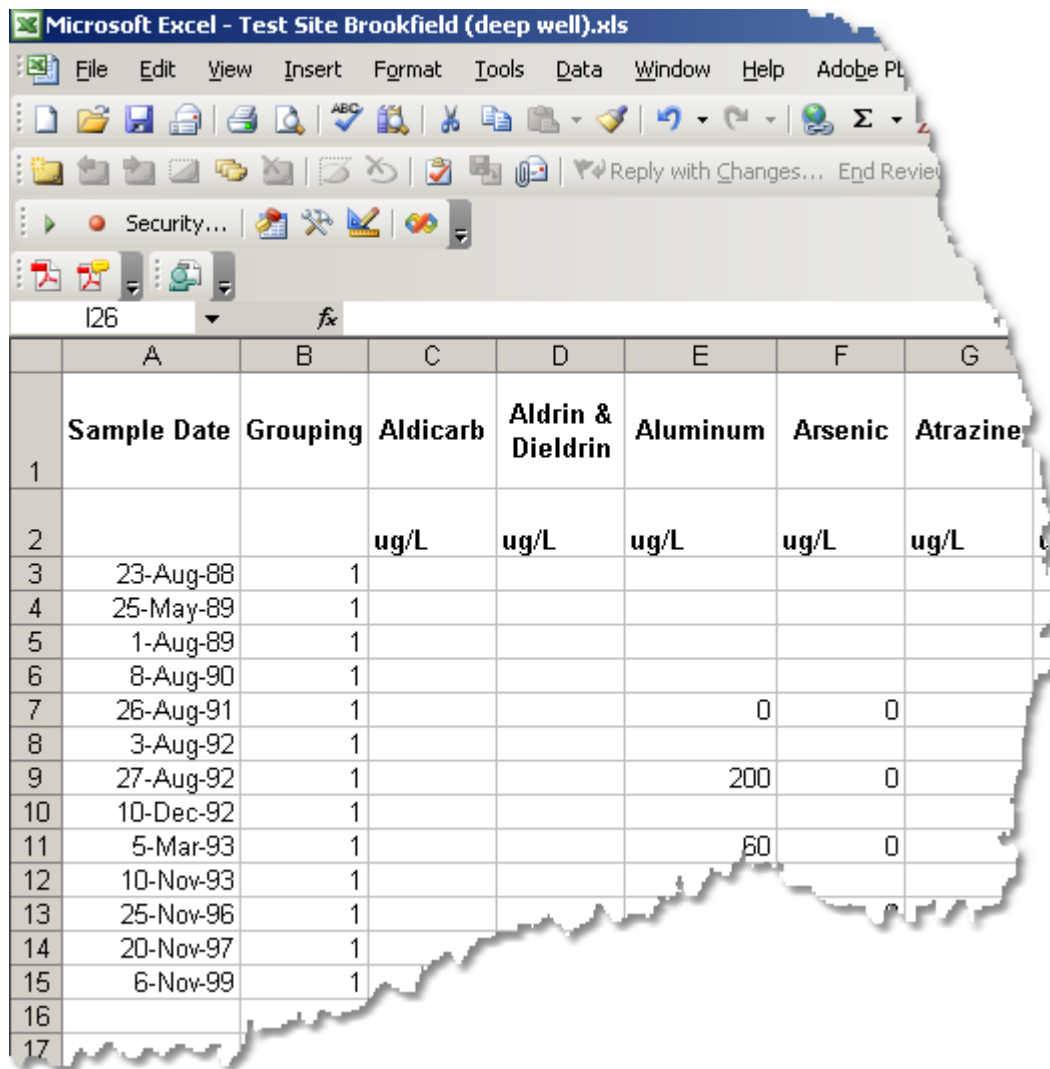
When you run the AFWQI application for the first time you will notice that there is a sample set of data present in the Data page. This sample displays the general format which must exist for any dataset which is to be used for AFWQI calculations. For a snapshot of what this data looks like see the Data section of the Data Page.

One of the options available to you to enable entry of your own data is the "Clear Old Data" button of the data sheet. If you click this button you will see that the application will present you with a template for your own data entry as illustrated below:
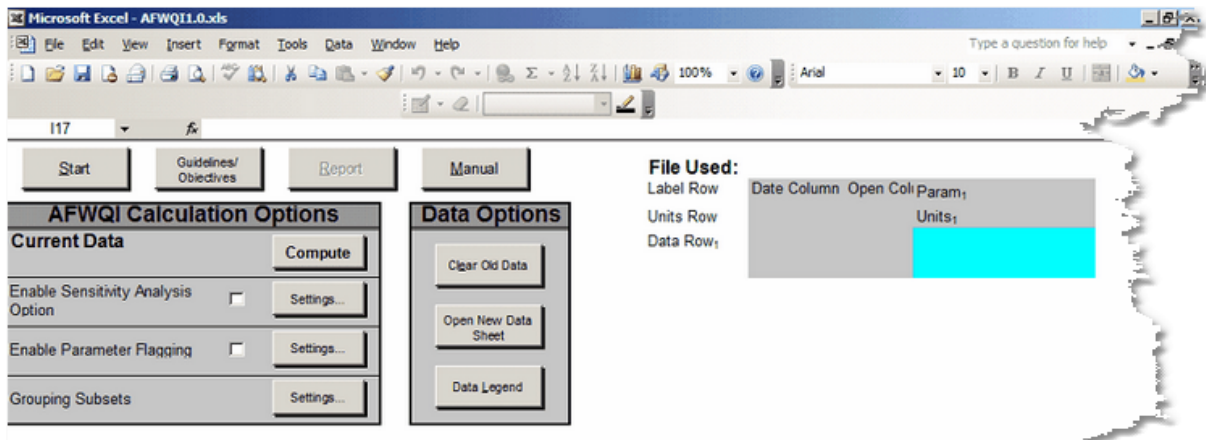
If you wish to enter your data into the application manually this should be your starting point. In the illustration above all of your entered information should be contained within either the grey or blue highlighted cells. The data itself belongs in the blue section while the grey section is reserved for column and row header values such as parameter name, parameter unit and sample date. The column labeled above as "Open Column" is unreserved and can be used for any label you wish, see the Data section of the Data Page for more information on this column.

If you wish to enter data from an existing MS Excel data sheet it must also follow this general format in order for the AFWQI to be allowed to function properly. If you wish to enter data using this option then your source data sheet should follow the format shown below:

Having your test data available in this general format allows you to easily enter your data into the calculator by simply using the "Open New Data" button on the Data page. Following this process, the sample data file shown above in Excel is entered into the calculator to produce the following snapshot:

As can be seen, collecting your data into MS Excel spreadsheet(s) in the proper format prior to using the AFWQI is the easiest way to produce fast and accurate results, especially if you have a lot of data to analyze.

The last step in ensuring you get accurate results from the AFWQI is to ensure your data format order matches the order of the criteria you supply to the application on the Criteria page. Parameters are tested in the order they appear, from one to the next; there is no searching for matching parameters performed. When you compute your data to generate AFWQI results the program will perform a simple analysis of the data versus the criteria list supplied. If the program finds any cases where it cannot resolve if the data parameter heading matches the criteria listing, it will prompt you to determine if there is a match or not. Here is a sample of that prompt:
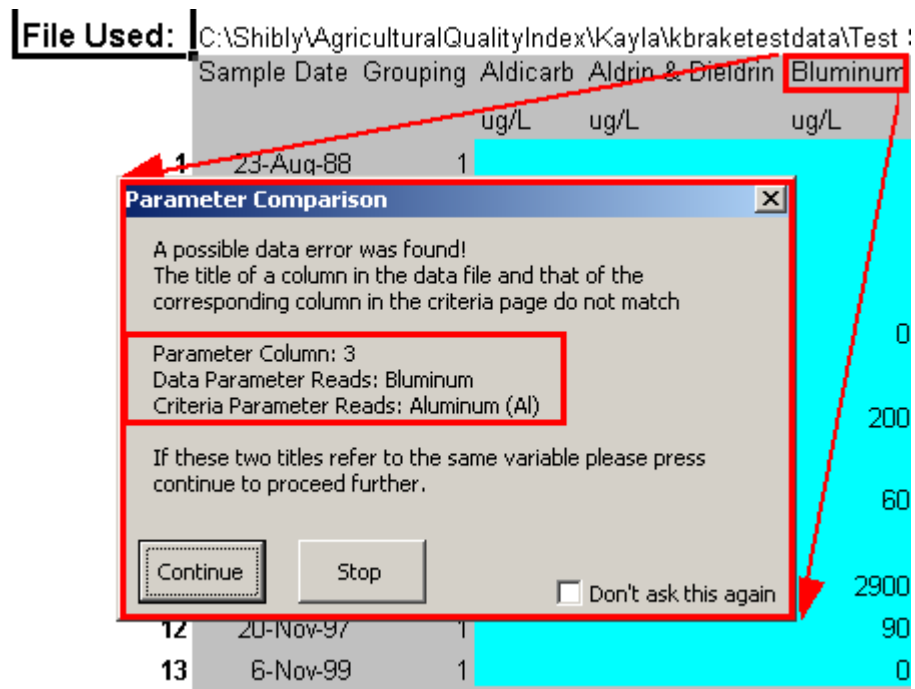
Here you see that the Data page parameter was listed as "Bluminum" (incorrect spelling) whereas the Criteria page parameter was listed as "Aluminum" (correct spelling) for the third parameter. As the program cannot decipher whether or not these two items represent the same data, it will prompt the user for verification of either a data entry error or a valid match. If the two listed items are the same, you can click on the "Continue" button. If they represent two distinctly different parameters, you should click on "Stop", which will halt the current AFWQI calculation process. If you are sure that your data matches other than some textual difference(s), click on the check box on the bottom right corner of the window.
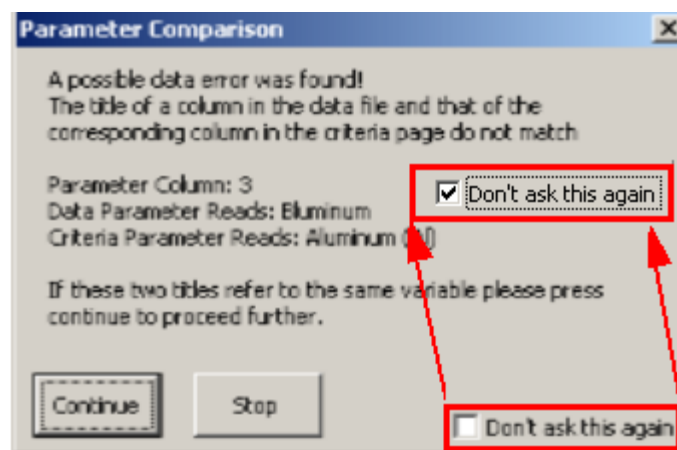
Checking this box will cause the application to stay all checks for dissimilar entries during the life of that particular instance of the program (closing and reopening the program will again enable the function), therefore it is best not to check this box unless you are certain that your data and your criteria match.

To illustrate what is meant by matching the order of your data and the criteria, consider the following picture:

Here you can see that we have a data set and a criteria list which are in agreement with the exception of Aluminum. Cutouts from the Data page and the Criteria page show that we need to have the same order of parameters in both sources of information, illustrated by the blue arrows. In order for the application to be able to produce valid results, it is crucial that this matching order exists throughout your data. If the given example were run there would be no prompt for parameter comparison confirmation, so that application does exercise some intelligence when it comes to this comparison.

3.2   In-Depth Analysis

In-Depth Reports of your results are available through buttons located at the bottom of the Report page. They provide you with more detail about your data than can be viewed from the Report page itself.

Calculation Summary

This page is designed to provide much more detail about the AFWQI calculation results and to give a source for spotting the strengths and weaknesses of your data.

Here are two partial views of what you will see:

Back

AFWQI 1.0
C:\Shibly\AgriculturalQualityIndex\Kayla\kbraketestdata\Test Site Brookfield (deep well).xls
Summary of Results

	Irrigation (CCME)	Livestock (CCME)	Use
Number of parameters tested	13	14	
Number of parameters that failed	2	0	
Parameters with most failed tests	Manganese	None	None
Parameters with highest nse	Manganese	None	Non
Total Number of Tests	116	126	
Total Number of Failed Tests	11	0	
Total of NSE	18.9120	0.0000	0

Variables that Failed the objectives	Aldicarb	Aldrin & Dieldrin	Al
Irrigation (CCME)	No Failures	N/A	No F
Livestock (CCME)	No Failures	N/A	No
UserDefined2	N/A	N/A	
User Defined3		N/A	

Number of Tests (Number of Failures)	Aldicarb	Aldrin & Dieldrin	Al
Irrigation (CCME)	No Data	N/A	6 (0)
Livestock (CCME)	No Data	N/A	6 (0)
UserDefined2	N/A	N/A	N/A
User Defined3	N/A	N/A	N/A
User Defined4	N/A	N/A	N/A
User Defined5	N/A	N/A	N/A
User Defined6	N/A	N/A	N/A
User Defined7	N/A	N/A	N/A

Tables entries above with less than 4 tests are highlighted in **red**

Statistical Summary of Data	Aldicarb	Aldrin & Dieldrin	Al
Minimum			0.0000
Maximum			2900.0000
Mean			541.6667
Median			75.0000
Standard Deviation			1056.8257

The tables provided within this page are as follows:

- **Summary of results**
  This table presents the following information:
    1. Number of parameters (variables) tested for each index - how many individual parameters where used in calculations to determine the AFWQI),
    2. Number of parameters that failed for each index - how many

individual parameters had at least one piece of data fail,
3. Parameter(s) with the most failed tests for each index - which
parameter's data had failed the most total times,
4. Parameter(s) with the highest NSE (normalized sum of excursions)
for each index - which parameter's data had failed by the largest
normalized total amount.

- **Parameters that failed the objectives** - displays which parameters for each
  index had at least one failure.
- **Number of tests (number of failures)** - displays the number of tests performed
  and the number of failures
   encountered for each parameter for each index.
- **Statistical summary of data** - displays the minimum, maximum, mean, median
  and standard deviation for each parameter of the test data.

WQI Chart

This page provides you with a graphical representation of your results. Here is an
example of the WQI chart.
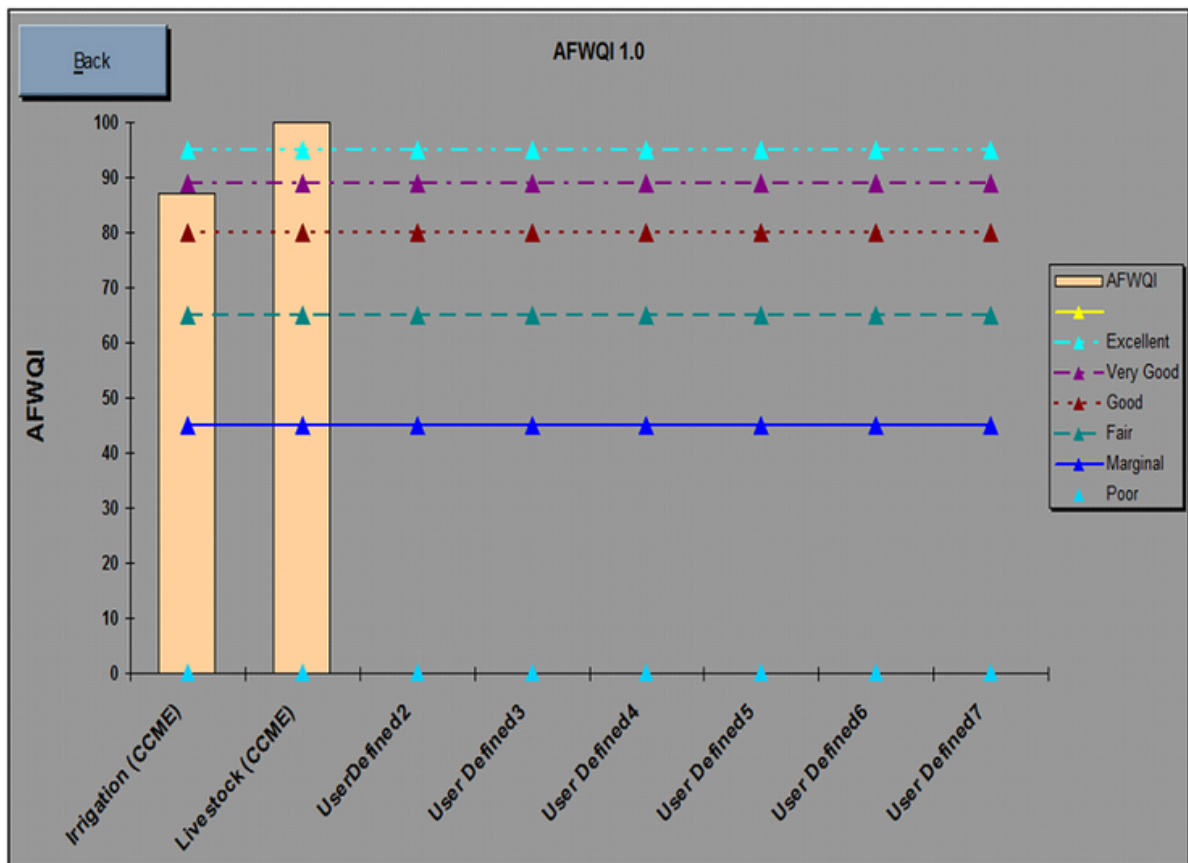
As you can see the AFWQI score of each index is displayed on an overlay of the
given ranks.

Indexed Test Data

This page provides you with a copy of the input data which is highlighted showing each pass and fail of the data supplied for each index.

These displays can help you see if there are any patterns to the strength and weakness of your data.

Data Outliers

This page highlights for you data which is outside the "norm" using several different methods.

Back   Legend

Normal Range: Mean Plus and/or Minus Two Standard Deviation

C:\Shibly\AgriculturalQualityIndex\Kayla\kbraketestdata\Test Site Brookfield (deep well).x

	Sample Date	Grouping	Aldicarb ug/L	Aldrin & Dieldrin ug/L	Bluminum ug/L	Arsenic ug/L	Atrazine ug/L	Azinophos- ug/L
1	23-Aug-88	1						
2	25-May-89	1						
3	1-Aug-89	1						
4	8-Aug-90	1						
5	26-Aug-91	1			0	0		
6	3-Aug-92	1						
7	27-Aug-92	1			200	0		
8	10-Dec-92	1						
9	5-Mar-93	1			60	0		
10	10-Nov-93	1						
11	25-Nov-96	1			2900	0		
12	20-Nov-97	1			90	0		
13	6-Nov-99	1			0	0		

Normal Range: 90th Percentile Data

C:\Shibly\AgriculturalQualityIndex\Kayla\kbrak

	Sample Date	Grouping	Aldicarb ug/l	Ald
1	23-Aug-88			

These tables are helpful in finding anomalies within your data without having to study each measurement.

Parameter Flagging

This page will summarize the results of a Parameter Flagging test.

Data which passed and failed the parameter flagging tests specified by the user will be highlighted within this table, letting you find failures at a glance. in the above example the calculator was run with the parameter flagging option turned on and a value of 1000 set as the critical value. For more information please refer to the Parameter Flagging Option section of the Data page.

3.3   Grouping Reports

Using the Grouping option can produce a different set of reports than normal. If you are familiar wilth the general form of AFWQI reports, none of the results presented through grouping will be new to you. For more information on using groups see the Grouping Subsets section of the Data Page.

Unless you wish to compare multiple sets of your data, the reports generated will be the same as those presented without invoking the grouping options (see Report Page). If however you wish to compare multiple subsets of your data at the same time, your report will look like the illustration below.

Start	Data	Guidelines/ Objectives	Manual	THE WQI

AFWQI 1.0

AFWQI for Irrigation (CCME)

C:\Shibly\Kayla\kbraketestdata\Test Site Brookfield (deep well).xls

Year	WQI	Category	F1(Scope)	F2(Frequency)	F3(Amplitude)
1988	100	Excellent	0	0	0
1989	79	Fair	17	17	29
1990	100	Excellent	0	0	0
1991	89	Very Good	9	9	14
1992	86	Good	9	13	18
1993	92	Very Good	9	6	9
1996	90	Very Good	8	8	13
1997	90	Very Good	8	8	13
1999	86	Good	15	15	11

Please Note: In order to provide meaningful results the AFWQI should be applied on data sets that contain at least 4 variables and at least 4 tests of each variable. However, users can exercise professional judgement based on knowledge of the data and site specific conditions.

As you can see there is much less resultant data available. This is due to the fact that the presentation of a full set of results, as you would get normally without grouping, would be too confusing to effectively display and analyze.