Quality Coding Water Level under NEMS (June 2013 edition)

Overview:

Under the National Environmental Monitoring Standards (NEMS) the boundaries differ as to what defines 'Good', 'Fair' and 'Poor' Quality data from previous HRC Standards. This has required a modification to the processes we undertake to quality code the data. Below are summarised processing instructions on how to quality code Water Level data along with explanations and examples according to the NEMS June 2013 (version 1) edition.

It is important to note that these guidelines ideally *should* be followed when assigning a Quality code to the Water Level data but there are cases when they may not be applicable.

For example, a Staff Gauge reading used as a Reference value may not be an accurate reading of Water Level at the time due to poor visibility and could cause the lowering of the Quality Code assigned to the data if included, when in fact the Water Level data was performing to a high standard. Therefore it is imperative to investigate *why* there are changes made to the Quality of the data to ensure the right Quality Code is assigned and therefore is a true reflection of the Water Level data.

Error Margins:

Under NEMS for the data to be Quality Coded as 'Good Quality' the **Staff Gauge (ESG) value and error** is within **≤ 3 mm** or **≤ 0.2%** of the effective stage, if it is above 2 metres, of the **recorded Logger value**. The 3 mm represents the error margin of the Logger recorder value, so in order for the data to be Quality Coded as 'Good Quality' the ESG reading and associated reading error needs to overlap *within* the Logger error. This error margin increases to 0.2% of the effective stage once this is above 2 metres. This allows for data to still be of 'Good Quality' with increasing stage height. For example, during a flood event it is difficult to deduce the ESG reading due to factors such as debris reducing visibility and flow dynamics causing a bulge in the channel, yet the sensor may still be within its operational range and could record Good Quality data. As illustrated in Diagram 1, when the effective stage is below 2 metres the error margin is 3 mm for the Logger reading, and increases to 0.2% of the effective stage above 2 metres.

NOTE: If a tower is installed at the site the EPB reading + Error is used as the Check over the ESG reading + Error to verify the Quality of the data*.

**See NEMS (June 2013) Water Level documentation about Electric Plumb Bob accuracy and External Staff Gauge accuracy.*

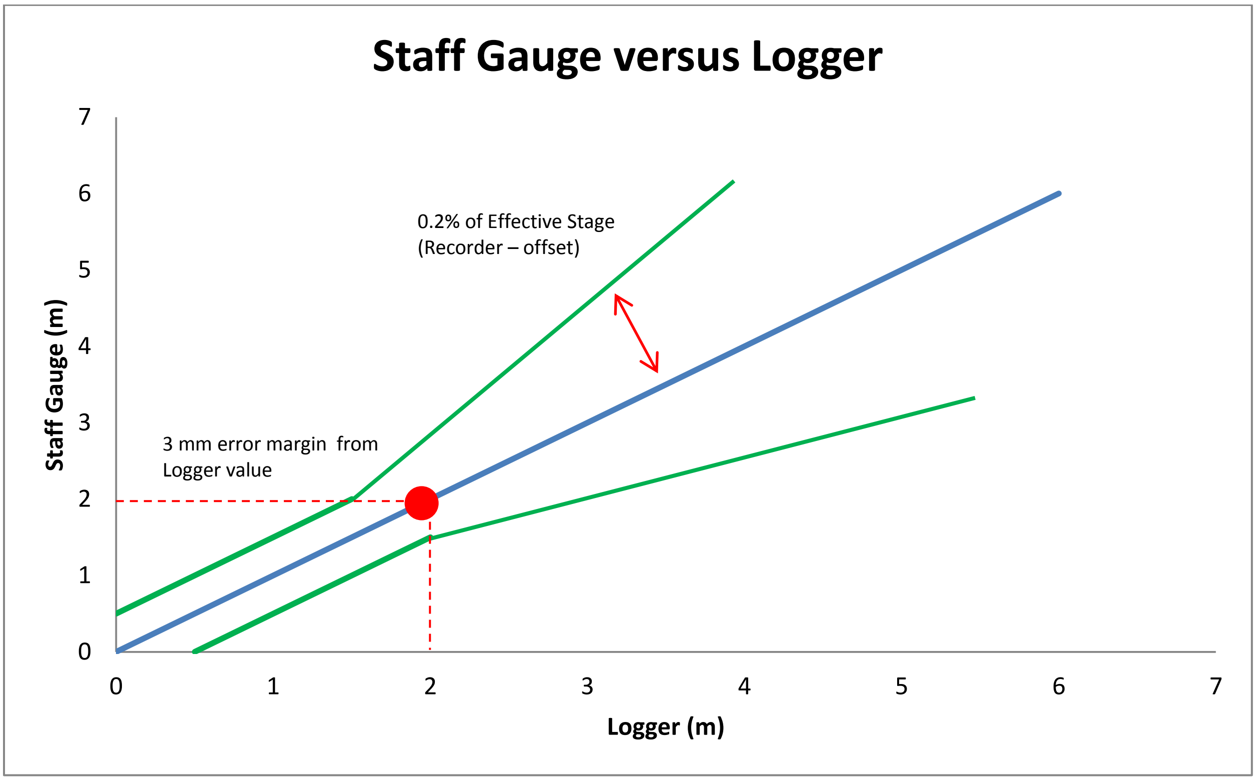


Diagram 1: Staff Gauge against Logger values with Logger ±3 mm and 0.2% of Effective Stage Height error margins (green lines)

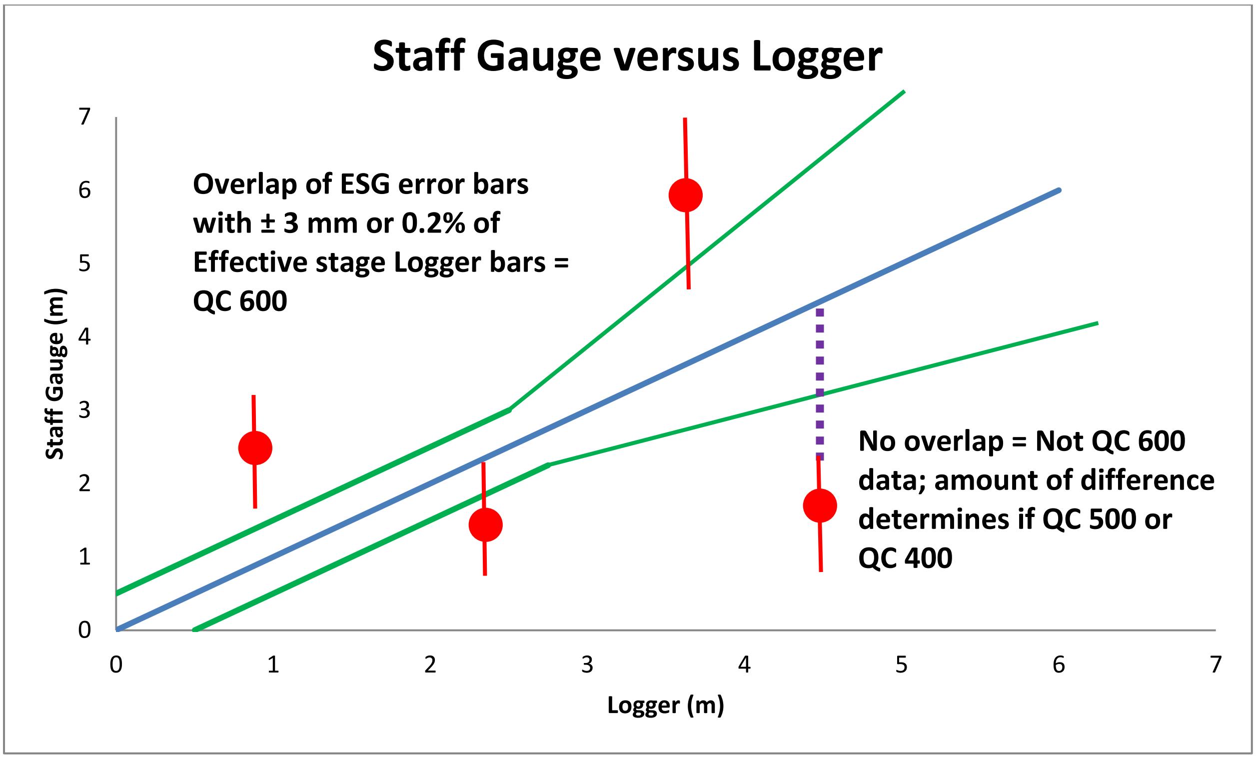


Diagram 2: Visual example of how to calculate the difference between the ESG error and Logger error to deduce the QC of the Water Level data

Diagram 2 illustrates how to determine the difference between the different error margins. Blue line represents the Logger readings, the red circles ESG (Staff Gauge readings), red line the ESG error margin and the green lines the ± 3 mm or 0.2% of Effective Stage Height error margins.

For each Staff Gauge reading there shall be an error margin associated with it (red lines above and below red points on Diagram 2). As a minimum it will be ± 3 mm but this is not always the case; rough conditions, surge around the ESG plates, debris and reading the Staff gauge from the opposite bank can all add error to the reading so increasing the error margin increases the likelihood that is it a fair representation of the Water Level at that time. **However** in medium to low Water Level conditions a high error margin (e.g. ± 10 mm) should be questioned and/or have a relevant reason as to why there is such a high error margin associated with the reading.

An equation is used to calculate the difference between the Staff Gauge error and the Logger error. This is available in the Excel spreadsheet under the 'Register' tab to enable quick calculations and therefore determination of the underlying Quality Code for the data (excluding edits made to the data).

To calculate the error margins for the Logger when the Effective Stage is above 2 metres, the **sensor offset is subtracted from the recorded Logger value** (see Sensor Offset section).

Example 1: Below Effective Stage of 2 metres

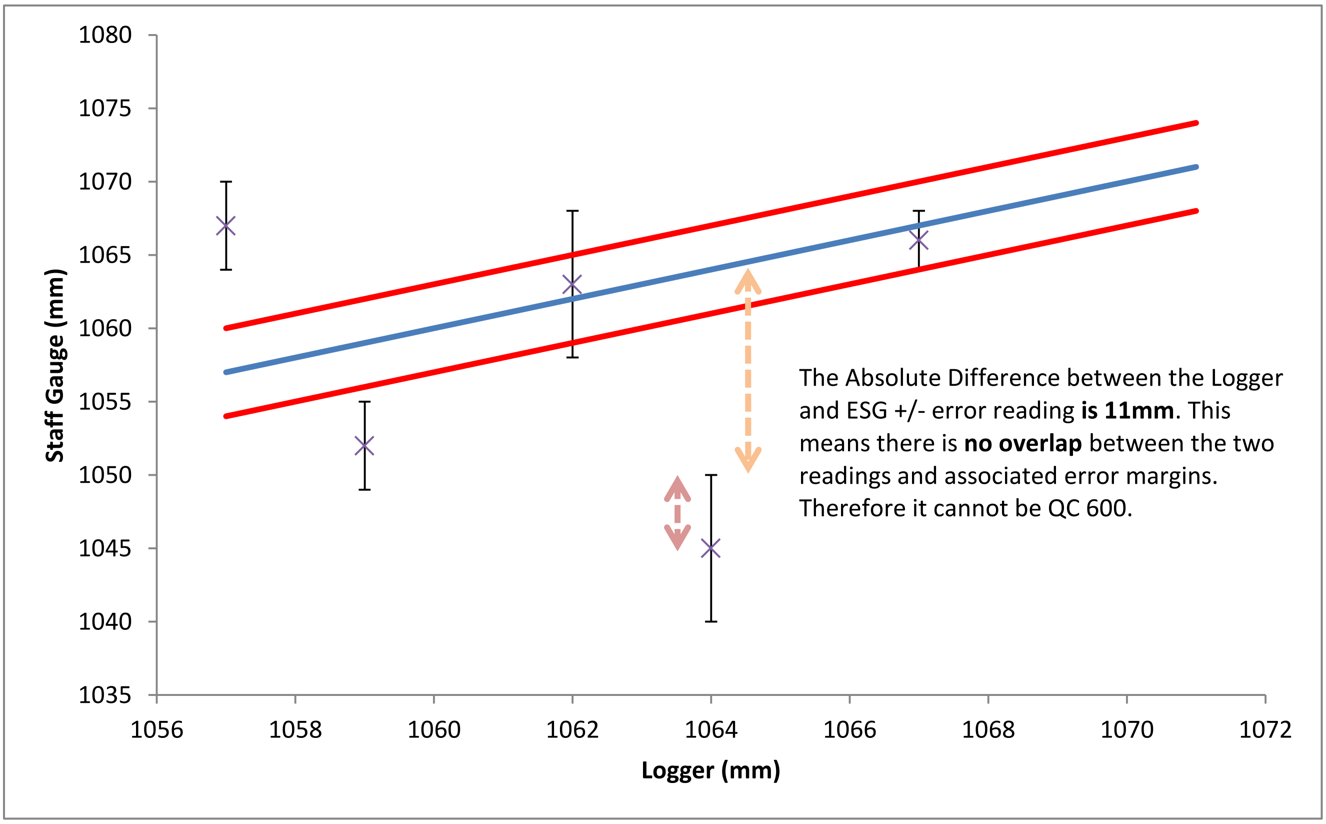


Diagram 3: Staff Gauge against Logger values with Logger error margins and ESG Reference Readings and error margins to demonstrate differences

Diagram 3 demonstrates visually how the Staff Gauge readings and subsequent error compare against the associated Logger reading and ±3 mm error margin. The red lines represent the ± 3 mm error margin of the Logger value that the Staff Gauge and error bars need to fall into in order for the data to be Quality Coded as 'Good Quality' i.e. QC 600.

If there is no overlap between the <u>ESG + error</u> and the <u>Logger + error</u> then the data cannot be Quality Code 600.

5 mm error of ESG reading

In the above example three of the five ESG readings have no overlap between the ESG values ± error and the Logger value ± 3mm, meaning they cannot be Quality Coded as QC 600.

Using the NEMS Quality Code system, if the difference between the ESG ± error and the Logger value is <u>> 3 mm but ≤ 10 mm</u> then the data is Quality Coded as QC 500. If the difference between the ESG ± error and the Logger value is <u>> 10 mm</u> the data is Quality Coded as QC 400.

<u>Remember the ≤±3 mm error is in regards to the error margin associated with the Logger value i.e. the red lines on the graph</u>

Raw Readings			Adjusted Readings			Uncertainty Calculations				
Reference Reading (mm)	Check Error (mm)	Raw Logger Reading (mm)	Adjusted Logger Reading (mm)	Absolute Difference (mm)	Below 2m Head?	Absolute Error Logger (mm)	Logger Error +	Logger Error -	ESG Error +	ESG Error -
1067	3	1057	1057	10	YES	3	1060	1054	1070	1064
1052	3	1059	1059	7	YES	3	1062	1056	1055	1049
1063	5	1062	1062	1	YES	3	1065	1059	1068	1058
1045	5	1064	1064	19	YES	3	1067	1061	1050	1040
1066	2	1067	1067	1	YES	3	1070	1064	1068	1064

Table 1: Example of Excel Spread sheet (edited to show areas of interest) used to deduce Differences between error margins of ESG and Logger readings to calculate the Quality Code.

Table 1 is an example of a completed spread sheet (with the values used in the graph previously) using the equations described to deduce the Quality Code of the data based on the differences between ESG error margins and Logger readings. If the ESG + Error and Logger + Logger error do **not** overlap the Quality Code cannot by QC 600 but either QC 500 or QC 400 depending on the value of difference, as described previously. The highlighted columns show the margins associated with each value. The blue highlighted squares show where the ESG +/- error and Logger +/- error values overlap, meaning the data falls within the QC 500 boundaries. The yellow highlighted squares show where none of the values cross over, resulting in a lower assigned QC of the data.

Example 2: Effective Stage above 2 metres

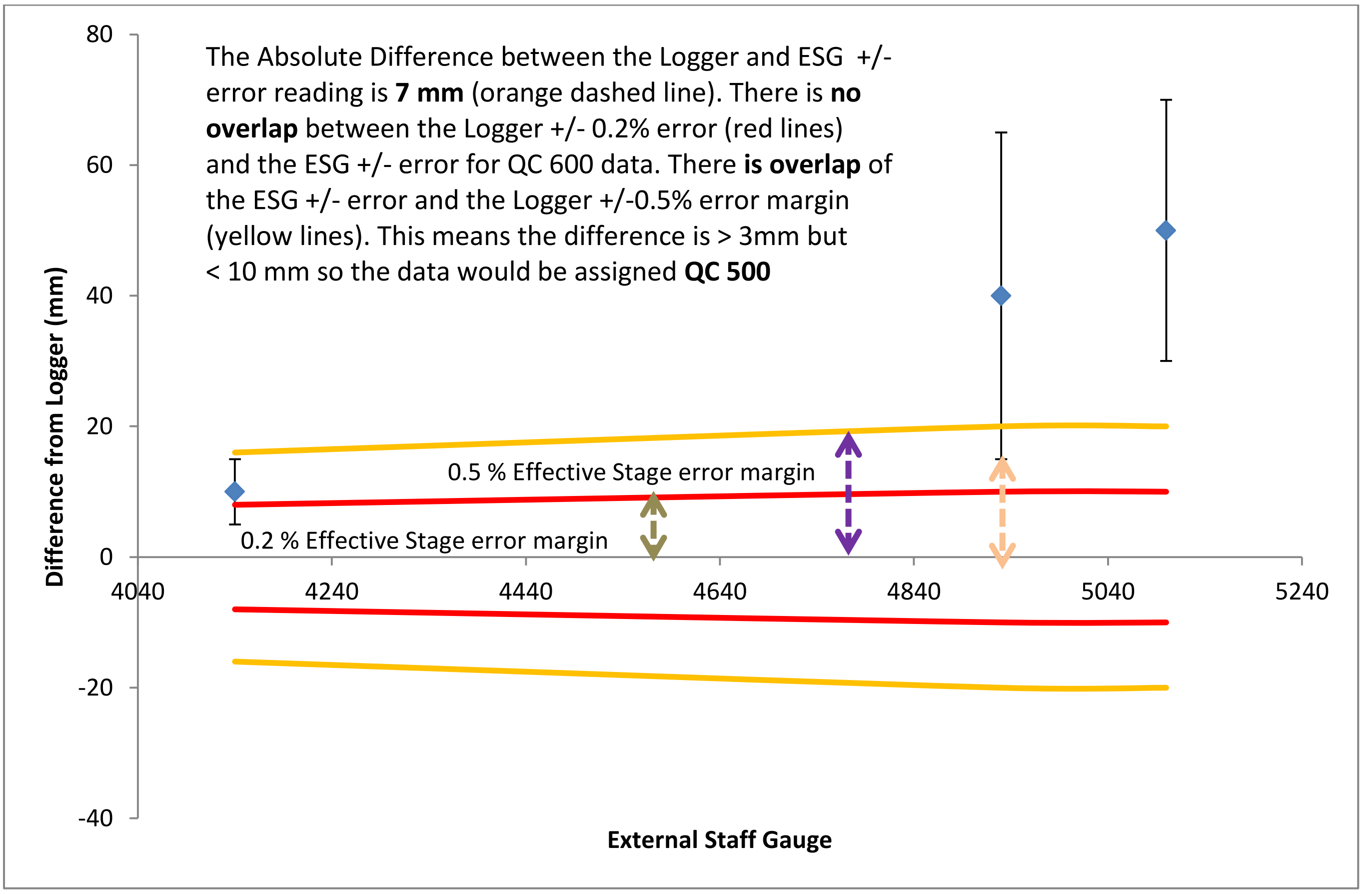


Diagram 4: Staff Gauge plotted against Logger Difference including 0.2% and 0.5% Effective Stage error margins

	ESG Reading (mm)	Check Error (mm)	Raw Logger Reading (mm)	Abs Difference (mm)	Adjusted Logger Reading (mm)	Absolute Difference (mm)	Below 2m Head?	Absolute Error Logger (mm)	ESG Error +	ESG Error -	Effective Stage Height +	Effective Stage Height -
872	4140	5	4150	10	4150	10	NO	3	4145	4135	4157	4143
872	4930	25	4890	40	4890	40	NO	3	4955	4905	4898	4882
872	5100	20	5150	50	5150	50	NO	3	5120	5080	5159	5141

Table 2:: Example of Excel Spread sheet (edited to show areas of interest) used to deduce differences between error margins of ESG and Logger readings to calculate the Quality Code for Water Level where the Effective Stage Height is greater than 2 metres.

In this example as shown on Diagram 4 and in Table 2, the Staff Gauge (ESG) reading with associated error margins has been plotted against the *difference* of the Logger reading with accompanying Logger error margins calculated from **0.2% and 0.5% of the Effective Stage Height** (red lines are 0.2% and the orange lines the 0.5% of Effective Stage Height) as the Effective Stage Height is **greater than 2 metres** (refer back to Diagram 1). The red lines represents the top and bottom error margins by multiplying 0.002 (0.2% = 0.002 in decimal form) by the Effective Stage with the orange lines similarly calculated by multiplying 0.005 (0.5% = 0.005 in decimal form) for the Logger values at the **time of the Staff Gauge reading**.

For example, a site recorded a Logger Water Level value of 4150 mm, which has an Effective Stage of 3278 by removing the sensor offset of 872 mm*. 0.2% of this Effective Stage is 0.002 x 3278 = 7 mm (6.556 mm but rounded to whole number), giving a top end error margin value of 4157 mm and a bottom end error margin of 4143 i.e. an error margin **of ±7 mm** (for 0.2% of the Effective Stage) for that Logger reading. If an ESG reading was taken at the same time of 4140 mm ±5 then between the error margins there **is overlap**, resulting in a Quality Code of 600. However, another Logger reading recorded later may be 4000 mm, which has an Effective Stage of 3128 mm, giving an error margin of **±6 mm** (for 0.2% of the Effective Stage) for that Logger reading. In summary, the **higher the Effective Stage the greater the Logger error margin may be**.

* To find out the sensor offset see section 'Sensor Offset' as this is site and/or sensor specific.

Method of Quality Code to use:

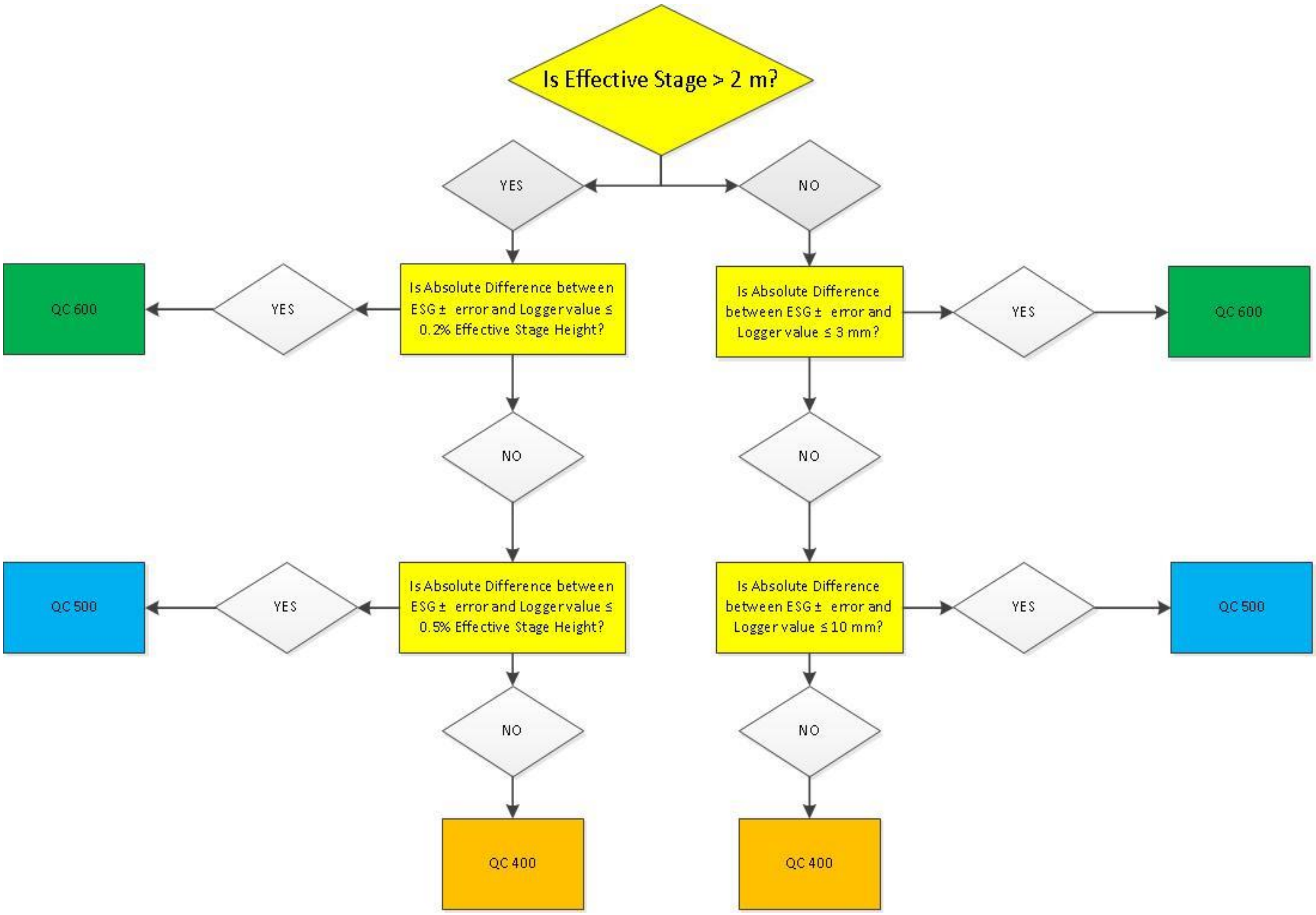
Flowchart 1 summarises how to Quality Code the data based on what method was used to create the Logger error margins.

In the Excel spreadsheet Register both sections (± 3 mm and 0.2% Effective Stage) are calculated regardless of which method is used, though it automatically decides which one will produce the final QC for the data set. The 0.5% Effective Stage is not displayed but is still calculated when determining the QC for Water Level data that has an Effective Stage greater than 2 metres.

Quality Coding Water Level under NEMS (June 2013 edition)

In Table 3 (edited from the Excel spread sheet) shows the two Quality Codes calculated for both methods but chooses the Final Quality Code to be assigned to the data based on the Effective Stage Height (Logger Reading minus Site Offset). From the table it is clear that the first three readings have an Effective Stage above 2 metres so the Final Quality Code assigned is the ‘ > 2 metres Effective Stage QC’ rather than the ‘ <2 metres Effective Stage QC’

Flowchart 1: Decision Tree Matrix for determing Final Qulaity Code for Water Level Data



Sensor Offset	Final Readings				NEMS Error			Quality Data
	ESG Reading (mm)	Check Error (mm)	Final Logger Reading (mm)	Abs Difference (mm)	< 2 metres Effective Stage QC	> 2 metres Effective Stage QC	WARNING >10 mm	Final Data Quality
872	4140	5	4150	10	500	600	-	600
872	4930	25	4890	40	400	500	YES	500
872	5100	20	5150	50	400	400	YES	400
872	1067	3	1057	10	500	400	-	500
872	1052	3	1059	7	500	400	-	500
872	1063	5	1062	1	600	600	-	600
872	1045	5	1064	19	400	400	YES	400
872	1066	2	1067	1	600	600	-	600

Table 3: Calculations used in Excel Spread sheet (edited to show columns of interest) to determine the Final Quality Code for the Water Level Data

Sensor Offset:

To establish the sensor offset involves several steps as outlined below. Once this has been done the information (i.e. the offset number) should be entered in the Logsheet loader alongside the batch it was used for, so this process will not have to be repeated each time a new batch for the same site and data source is picked up for processing unless a programme change due to alteration at the site has resulted in a change of offset.

1) Open \\ares\hydrology\Hydrology Sites\<Site_name>\Logger Software
   → e.g. Kiwitea at Haynes Line

2) Right-click on a file type that is **.CR8** or **.CSI** (for older sites not updated/upgraded yet)
   →Open this in Notepad

3) Scroll through the information; this is the Software that is loaded onto the Logger and enables data to be read. Look for 'site offset' or something of that description. Example: Below is the Software file for Kiwitea at Haynes Line. The Offset is 438.

10: SDI-12 Recorder (P105) ; Wiring: C2 for signal, 12v and G for power
1: 0 SDI-12 Address
2: 0 Start Measurement (aM!)
3: 2 Port
4: 1 Loc [Stage]
5: 10 Multiplier ; Multiplier is 100 for Handar, 10 for Sutron
6: 438 Offset

4) Enter this number in the 'Sensor Offset' section of the Register in the Excel Spreadsheet. This value will automatically be used in the equations to generate the Logger error margins of 0.2% of the Effective Stage and used for the Final Quality Code of the Data if the Effective Stage is above 2 metres.

Raw Readings						
ESG Reading (mm)	EPB Reading (mm)	Check Error (mm)	Raw Logger Reading (mm)	ESG Difference (mm)	EPB Difference (mm)	Sensor Offset
4140		5	4150	10		438
4930		25	4890	-40		438
5100		20	5150	50		438
1069		3	1057	-12		438
1045		3	1059	14		438
1063		5	1062	-1		438
1045		5	1064	19		438

Changes in the offset can also be tracked in the **Logsheet Loader** when extracting all 'Instrumentation' inspections; however not all offset changes are noted on Field Chits (and therefore not entered manually into the Logsheet Loader) so this should only be used as a **guide**. Open the programme file described above to verify any offset changes and/or current offsets applied to the Water Level data source.

Extras: To be considered after Station Setup and Survey NEMS is published

Datum Consistency Considerations:

*When processing Water Level data, survey information is very important to verify that the Datum used has not shifted or been altered in any way as a change in datum height and/or position impacts the recorded Water Level data. Therefore it is imperative that all survey information is collated **before** processing Water Level Data and subsequently assigning a Quality Code to the data, as changes to the datum can result in corrections applied to the Logger and/or Reference ESG data. Furthermore a record should be maintained of changes to Datums at the site and any adjustments made to the References (i.e. benchmarks, Staff Gauge locations etc.).*

Below is a consideration when processing and assigning Quality Coding Water Level Data and should be kept in mind, though at present the QC 575 is **not** applicable to the data (refer to WL_Register_v3.2):

At present, there is no NEMS documentation taking into account the survey error and how it impacts the recorded Water Level data. This is important to consider as there is a ± 3 mm error in instrumentation height (more specifically for orifice heights for sites that have a gas purge Water Level recording system in operation).

To include the survey error when assigning Quality Codes but to also abide by the NEMS Quality Codes, within the excel spread sheet the equations have taken into account the survey error margin (see WL_Register_v.3.2). It will assign a Child Quality Code of QC 575 to Water Level data that has a difference between the ESG reading ± error and Logger reading ± error of ≤ 3mm i.e. there is overlap between the ESG error + Survey error + Logger error.

As shown in the example graph above, the ESG reference value of 1052 mm has an error margin of ± 3 mm, with the associated Logger reading of 1059 ± 3 mm. Ignoring the survey error, there is no overlap between the ESG error and Logger error, with a difference of 1 mm. When the survey error of ± 3 mm is included there is overlap as the previous difference of 1 mm is ≤ 3 mm. This data is therefore Quality Coded as QC 575 to represent that the data is not currently within the NEMS definition of 'Good Quality' data of QC 600 but is not lowered to 'Fair Quality' data of QC 500.

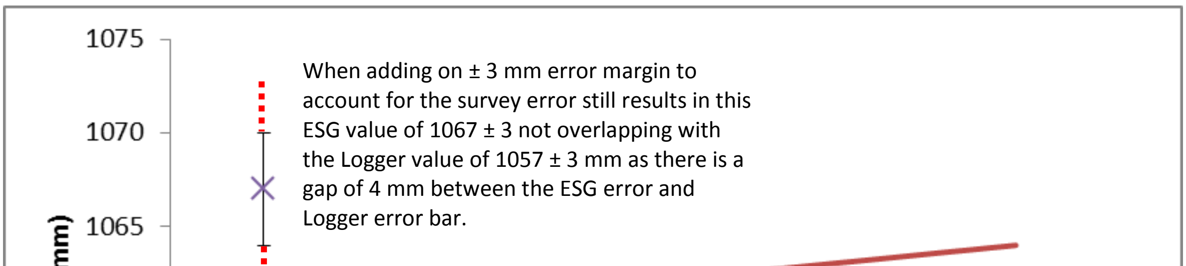


Diagram 5: Graph illustrating Survey error taken into account when assigning Quality Codes

Appendices:

Below is the layout for the spread sheet which was used for the examples presented in this document along with the equations used for each cell.

Quality Coding Water Level under NEMS (June 2013 edition)

Water Level Corrections

		Raw Readings							Fouling Corrections					
									Sensor cleaning		Field Reading			
Date/Time	Party	ESG Reading (mm)	EPB Reading (mm)	Check Error (mm)	Raw Logger Reading (mm)	ESG Difference (mm)	EPB Difference (mm)	Sensor Offset	Before (M_b)	After (M_a)	Before (F_b)	After (F_a)	Fouling Correction (E_f)	Offset Correction (mm)
8/06/2014 15:25	Andrew Swanney, Darren Bentley-Hewitt	4140		5	4150	10		872					(Ma - Mb) -	-3
18/01/2015 9:55	Andrew Swanney	4930		25	4890	-40		872						-3
1/11/2014 17:00	Andrew Swanney	5100		20	5150	50		872						-3
2/02/2014 12:00	Darren Bentley-Hewitt	1067		3	1057	-10		872						-3
21/07/2014 8:10	David Brown	1045		3	1059	14		872						-3
30/08/2014 14:45	Darren Bentley-Hewitt	1063		5	1062	-1		872						-3
7/03/2015 14:35	Andrew Swanney, Darren Bentley-Hewitt	1045		5	1064	19		872						-3

	Adjusted Readings			Uncertainty Calculations							NEMS Error			Quality Data		
Date/Time	Adjusted Logger Reading (mm)	Abs Difference (mm)	Below 2 m Head?	Absolute Error Logger (mm)	Logger Error +	Logger Error -	ESG Error +	ESG Error -	Effective Stage Height X	Effective Stage Height Y	< 2 metres Effective Stage QC	> 2 metres Effective Stage QC	WARNING >10 mm	Final Data Quality	Processing Comments	Inspection Comments
8/06/2014 15:25	4147	7	NO	3	4150	4144	4145	4135	4153.55	4140.45	600	600	-	600		± 5, No gauging - too much weed in river.
18/01/2015 9:55	4887	-43	NO	3	4890	4884	4955	4905	4895.03	4878.97	400	500	YES	500		± 25
1/11/2014 17:00	5147	47	NO	3	5150	5144	5120	5080	5155.55	5138.45	400	500	YES	500		± 20
2/02/2014 12:00	1054	-13	YES	3	1057	1051	1070	1064	1054.364	1053.636	400	400	YES	400		± 3
21/07/2014 8:10	1056	11	YES	3	1059	1053	1048	1042	1056.368	1055.632	500	400	YES	500		± 3
30/08/2014 14:45	1059	-4	YES	3	1062	1056	1068	1058	1059.374	1058.626	600	600	-	600		± 5
7/03/2015 14:35	1061	16	YES	3	1064	1058	1050	1040	1061.378	1060.622	400	400	YES	400		± 5

Quality Coding Water Level under NEMS (June 2013 edition)

Abs Difference	Adjusted Logger Reading	ESG Difference (mm)	Below 2 m Head?	Absolute Error Logger	Logger Error +	Logger Error -	ESG Error +	ESG Error -	Effective Stage Height +	Effective Stage Height –	< 2 metres Effective Stage QC	> 2 metres Effective Stage QC	WARNING > 10 mm	Final Data Quality
=ABS(P5-C5)	=F5+O5	=F5-C5	=IF((F5-I5)<2000,"YES","NO")	3	=P5+S5	=P5-S5	=C5+E5	=C5-E5	=P5+((P5-I5)*0.002)	=P5-((P5-I5)*0.002)	=(IF(AND(W5-T5<=0,U5-V5<=0),"600",(IF(AND(W5-T5<=7,U5-V5<=7),"500",(IF(OR(W5-T5>7,U5-V5>7),"400","???"))))))	=(IF(AND(W5-X5<=((F5-I5)*0.002),Y5-V5<=((F5-I5)*0.002)),"600",(IF(AND(W5-X5<=((F5-I5)*0.005),Y5-V5<=((F5-I5)*0.005)),"500","400"))))	=IF(OR(Q5>10,Q5<-10),"YES","-")	=IF(F5-I5<2000,Z5,AA5)

Sensor Offset, Reference Reading (the Staff Gauge reading), Error (Staff Gauge error), Raw Logger and Adjusted Logger values are obtained from Field Chits, Hilltop files and program files (for Sensor Offset; see Sensor Offset section on how to find)