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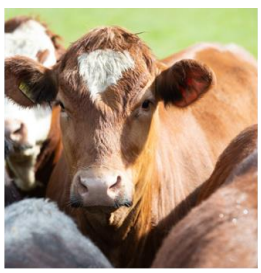
Biotechnology and Biological Sciences Research Council

North Wyke Farm Platform

Quality Control System (Data version 3; released on 01-12-2018)



User Guide

Version 2.0

The North Wyke Farm Platform: Quality Control System (Data version 3; released on 01-12-2018)

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Description: The North Wyke Farm Platform (NWFP) was established in 2010 to study and improve grassland livestock production at the farm-scale. The NWFP uses a combination of environmental sensors, routine field and lab-based measurements, and detailed management records to monitor livestock and crop production, emissions to water, emissions to air, soil health, and biodiversity. The rich NWFP datasets help researchers to evaluate the effectiveness of different grassland (and arable) farming systems, which in turn, contributes to the development of sustainable, resilient and net zero land management strategies. This document serves as a user guide to the quality control (QC) system of the water run-off, water chemistry, soil moisture and meteorological data produced at a 15-minute temporal resolution on the North Wyke Farm Platform (NWFP). The guide gives limits and thresholds for the instrumentation, and the QC flags applied to each data point. Also included are information on the QC process for the latest data version and changes since the previous version. This document is associated with other dedicated user guides that detail the collection of other dataset types produced on the NWFP.

Site: North Wyke, Okehampton, Devon, UK. Geographic location: 50.76944, -3.90138; 50°46’10” N, 3°54’05” W.

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1 Introduction

This document provides a guide to the quality control (QC) system for the latest release on the data portal (https://nwfp.rothamsted.ac.uk/) of the 15-minute temporal resolution data (water, soil moisture, meteorological) that are produced on the North Wyke Farm Platform (NWFP). The tables referred to in the text can be found in the Appendices.

2 Quality Control System

The QC system incorporates aspects of sensor calibrations or harmonisations, details of which are described in the individual user guides for each of the 15-minute datasets. A log of all sensor downtime issues is maintained in an MS Access database where input forms and restricted fields are used to ensure that the correct and required data are recorded. The information includes details on the location, the sensor, the start and end times the sensor was functioning incorrectly, information about the problem and the required QC action (i.e., set recorded data as missing (NA) or add a 'unreliable' flag to the data). Exports from this worksheet are automatically used as part of the QC process. The sensor downtime log also serves as a useful reference when trouble shooting sensor issues.

Different levels of QC of the 15-minute data are possible. Each level of QC consists of a bespoke R (http://www.r-project.org) script on 4 weeks' worth of data at a time. The R script automatically and statistically processes data from the 15 flume labs,15 soil moisture stations, and the single meteorological site. Each 4-weekly set of data produces an outputted log-file (and associated reports) to enable any re-runs and further checks as required. Full details of the QC system, the current QC level, and the associated traffic light flagging system; together with how the QC is expected to evolve over time (via timely data releases) are given below.

2.1 Data Quality Flags

When downloaded from the NWFP data portal, all 15-minute data variables are provided with a data quality flag in Appendix A for each measurement, together with the date that it was last modified. The flags are designed to give the user an indication of reliability, however this is rather subjective. Often, we can only comment on events that have taken place that could potentially affect the data, without knowing the full extent of it.

If during a period the data were affected by multiple data issues, the data in the download file were given only the most severe data quality flag.

2.2 Limits and Thresholds

The limits (or thresholds) that were used to identify **extreme** distributional (lower limit and upper limit) outliers are given in Appendix B, for flow and each water quality variable in turn.

The limits (or thresholds) that were used to identify simple distributional (lower limit and upper limit) outliers are given in Appendix C, for each variable in turn. All such thresholds were simply based on expert judgement of the NWFP's 15-minute data; and were set to identify unusual or interesting low- and high-valued measurements. These thresholds were not statistically set or set according to some known threshold in the literature; and it was not the intention to do so.

3 Data Release

3.1 Latest version (version 3; released on 01-12-2018)

On 01/12/2018 all existing flume data on the data portal were replaced with the latest QCd version and additional data were added for the soil moisture station (SMS) and meteorological (MET) datasets. Details of this QC data are given in Appendices E to J.

These changes affected the following 15-minute datasets:

- Flume data: 01/10/2012 - 25/08/2018
- Soil Moisture Station (SMS) data: 18/01/2016 - 25/08/2018
- Meteorological (MET) data: 18/01/2016-25/08/2018 (Precipitation only between 31/10/2011 – 29/04/2013)

3.1.1 Quality control system for the latest data release

Only a very basic level of QC was applied to this latest data release. Future data releases will provide at least the same level of QC, but in general, the QC is expected to become more sophisticated. This sophistication can take several forms – from a QC that is more integrated within the database, through to a QC that identifies numerous types of outlying observations (e.g., seasonal outliers, relationship outliers, etc.).

During the latest QC process for this data release, data were flagged unreliable for certain periods based on records in the Sensor Downtime Log (SDL) stating this. This could be from a few hours up to months. Data exceeding extreme upper or lower limits were set to NA. These limits are listed in Appendix B. The number of impossible values set to NA and the number of potential or possible outliers is available in the 4-weekly QC summary reports available on the data portal link below.

https://nwfp.rothamsted.ac.uk/fpdownload/showfiles.aspx\qc_reports\15_minute qc-reports\reports_qc_v3.

In the data portal, the measurements are flagged 'Outlier' if they fall outside the 'outlier' limits. These limits are listed in Appendix C.

In addition, the rudimentary extended Traffic Light Quality Flag (**TLQF**) system for suspicious data is explained in Appendix D and the QC step that each variable was subjected to is indicated in Appendices E to J.

3.1.2 Changes to the existing data since the last version

- **Flume data**

The flume data underwent a revised QC and were flagged using the SDL to identify potentially suspicious data. The previous version of these data on the Data Portal was drift-corrected, but these corrections have since been removed in order to be transparent with the data and to give the user the opportunity to apply drift correction using a methodology of their choice. Details of sensor drift can be found on the link below where all instrument drift data are still recorded.

https://nwfp.rothamsted.ac.uk/fpdownload/QC_Reports/Additional%2015-minute%20QC%20files/

- **SMS 10 cm data harmonised**

To harmonise the data collected from the two different firmware versions of the soil moisture probes, new conversion formulae were generated under experimental conditions and used to recalculate the data. The experiment was conducted as follows. A $1m^3$ soil-block of Hallsworth series soil, as found on the NWFP, was extracted, and moved undercover. The 2 firmware versions of the soil moisture probes were installed in the block. The soil-block was saturated above field capacity and then allowed to dry naturally over a 6-month period. During this time, fortnightly measurements were taken from the probes and simultaneously a soil sample was removed from the block to coincide with the measurement depth(s). The soil sample was oven dried to measure the actual moisture content. The data from the probes and the oven dried samples were plotted against each other and fitted with a linear regression. No clear relationship was found for either the 20 cm or 30 cm depth results and thus these data from the probes were deemed unreliable for this soil series. Consequently, the 20 cm and the 30 cm SMS data have been removed from the Data Portal, and only the SMS 10 cm data remain. Conversion formulae are given in Appendix K.

NB. Soil Moisture for 20 cm and 30 cm have been removed from the Data Portal Download, as they were deemed highly unreliable after calibration checks (see above).

- **MET data - precipitation**

The tipping bucket precipitation data of the original Catchment 4 situated in the met compound have been assigned to the MET dataset, until the installation of the new Pluvio weighing rain gauge (RG) in the SMS compound. As the rainfall collection started 1.5 years before the other MET variables, only rainfall data are available for the period from 31/10/2011 – 29/04/2013.

NB. minor changes to the data are denoted by sub-version numbering, i.e., 3.1, and these are listed on the on the data portal link below.

https://nwfp.rothamsted.ac.uk/fpdownload/db_updates/Data_changes4Users.htm

3.2 Summary Statistics

Summary statistics (daily and 4-weekly) for each 15-minute variable were determined as part of the QC. These data summaries can be downloaded from the "Farm Platform File Store" and not from the Data Portal. Please be aware that the summary statistics are calculated in a specific manner and as such, should be used carefully. They should not be considered as a substitute to a thorough investigation of the fine-resolution data from which they stem from. **Of note, is that all daily summaries run from 00:15:00 one day until 00:00:00 the next day. Similarly, all 4-weekly summaries run from 00:15:00 the first day until 00:00:00, 29 days later.**

For the SMS / MET data this includes the following daily and 4-weekly summaries: means, medians, standard deviations, inter-quartile ranges, coefficient of variations, minimums, maximums, number missing, percentage missing, number of lower limit outliers, number of upper limit outliers, number of zero rainfall values, percentage zero rainfall values and rainfall sums.

For the flume water data, this includes the following daily and 4-weekly summaries: means, medians, standard deviations, inter-quartile ranges, coefficient of variations, minimums, maximums, number missing, percentage missing, number of lower limit outliers, number of upper limit outliers, number of zero flow values, percentage zero flow values and flow sums.

It is important to stress that the validity of any summary statistic is dependent on the number values it is calculated from. Thus the 'number missing' and the 'percentage missing' are key outputs, in this respect. Here the user should define their own '*reliability thresholds'*. For example, a user may decide to only use daily means for pH that have been calculated from at least 90% of the 96 15-minute values for any given day (i.e., if the 'percentage missing' is greater than 10%, then corresponding daily pH means are not considered reliable).

For rainfall and flow totals, it may be safer to only use those found from 0% ‘percentage missing’. An alternative and very important approach to these issues would be to return the 15-minute time series data and infill missing data (see guidelines given here: https://rpubs.com/North_Wyke_Farm_Platform).

4 Citing the Data

If you choose to use any of datasets provided by the NWFP in a publication, please cite:

- *Orr, R. J., Murray, P. J., Eyles, C. J., Blackwell, M. S. A., Cardenas, L. M., Collins, A. L., Dungait, J. A. J., Goulding, K. W. T., Griffith, B. A., Gurr, S. J., Harris, P., Hawkins, J. M. B., Misselbrook, T. H., Rawlings, C., Shepherd, A., Sint, H., Takahashi, T., Tozer, K. N., Whitmore, A. P., Wu, L. and Lee, M. R. F. (2016). The North Wyke Farm Platform: effect of temperate grassland farming systems on soil moisture contents, runoff and associated water quality dynamics. European Journal of Soil Science, 67, 4, 374-385. (doi:10.1111/ejss.12350).*

In addition, if using data from the baseline period please cite:

- *Takahashi, T., Harris, P., Blackwell, M. S. A., Cardenas, L. M., Collins, A. L., Dungait, J. A. J., Hawkins, J. M. B., Misselbrook, T. H., McAuliffe, G. A., McFadzean, J. N., Murray, P. J., Orr, R. J., Rivero, M. J., Wu, L. and Lee, M. R. F. (2018). Roles of instrumented farm-scale trials in trade-off assessments of pasture-based ruminant production systems. Animal, 12, 8, 1766-1776. (doi:10.1017/S1751731118000502).*

- *Orr, R. J., Griffith, B. A., Rivero, M. J. and Lee, M. R. F. (2019). Livestock Performance for Sheep and Cattle Grazing Lowland Permanent Pasture: Benchmarking Potential of Forage-Based Systems. 9, 2, 101-118. (doi:10.3390/agronomy9020101).*

For the datasets used, please cite the latest version of the relevant User Guide PDF document(s), listed in the table below, that describe the establishment and development of the NWFP, and the various datasets produced in detail. The link to these can be downloaded from the NWFP website. Note that the User Guide entitled 'NWFP_UG_Design_Develop.pdf' should be cited irrespective of the dataset used.

Data used	Main title of User Guide PDF document	DOI
All datasets	NWFP_UG_Design_Develop.pdf	https://doi.org/10.23637/rothamsted.98y1x
All datasets	NWFP_UG_Data_Guide.pdf	https://doi.org/10.23637/rothamsted.99440
15-minute time-series datasets (water, soil moisture, meteorology)	NWFP_UG_Hydrology&WaterQuality_Data.pdf	https://doi.org/10.23637/rothamsted.98y34
	NWFP_UG_SMS_Data.pdf	https://doi.org/10.23637/rothamsted.98y4x
	NWFP_UG_MET_Data.pdf	https://doi.org/10.23637/rothamsted.98y4w
Greenhouse gases	NWFP_UG_GHG_Data.pdf	https://doi.org/10.23637/rothamsted.98y52
	NWFP_UG_GreenFeed_Data.pdf	https://doi.org/10.23637/rothamsted.98y53
Field surveys	NWFP_UG_FieldSurvey_Data.pdf	https://doi.org/10.23637/rothamsted.98y51
Livestock	NWFP_UG_Livestock_Data.pdf	https://doi.org/10.23637/rothamsted.98y50
Field events	NWFP_UG_FieldEvents_Data.pdf	https://doi.org/10.23637/rothamsted.98y4z
Forage quantity and quality	NWFP_UG_Forage_Quantity&Quality_Data.pdf	https://doi.org/10.23637/rothamsted.992wy
Biodiversity	NWFP_UG_Biodiversity_Data.pdf	https://doi.org/10.23637/rothamsted.993x2

Also, please include the following sentences in the acknowledgments section:

"The North Wyke Farm Platform is a UK National Capability supported by the Biotechnology and Biological Sciences Research Council (BBS/E/RH/23NB0008)."

"We acknowledge the interests of the Ecological Continuity Trust (ECT), whose national network of LTEs includes the experiment on which this research was conducted."

5 Appendices

Appendix A. Data quality flags – description, severity, and details.

Description	Severity Order	Details
Not set	0	No information on quality available
Good	2	Data were checked and deemed good
Acceptable	4	Data were checked and no issues were found
Suspicious	25	Data were checked and might have been affected by an event
Highly Suspicious	95	Data were checked and have definitely been affected by an event
Reject	100	Data were rejected
High Sensor Drift	39	Instrument calibration values were high over the time period. As calibration takes place monthly, it is impossible to know if or how much the instrument drifted at the measurement timestamp (as this is not a linear relationship
Missing Sensor Drift	40	Missing instrument calibration information, this level of instrument drift during period is unknown
Outlier	20	The value falls outside ‘regular’ limits but within the extreme limits, therefore could still be fine
Level Reset	14	Level pressure sensors were reset, indicating this could result in a step in flow
Calibration	15	Calibration Datetime of the instrument
Wiper Issue	16	An issue was detected with the instrument wiper blade. This could have affected the data.

Appendix B. Extreme lower and upper threshold limits used to identify simple distributional outliers.

Parameter	Threshold for the detection of extreme low-valued outliers†	Threshold for the detection of extreme high-valued outliers‡
Rainfall (mm)	0	60
Soil Temperature (ºC)	-30	40
Soil Moisture 10/20/30 (%)	1	100
Flow (l s^{-1})	0	500
Water Temperature Flume (ºC)	-10	30
PLC Switch (0/1)	0	1
Nitrite & Nitrate (mg/l)	0	48.9
Ammonia (mg/l)	0	20
Ammonium (mg/l)	0	200
Specific Conductivity (uS/cm)	10	3000
Dissolved Oxygen (%)	5	500
pH	1	14
Water Temperature Flow-cell (ºC)	-10	30
Turbidity (FNU)	0	5000
Fluorescent Dissolved Organic Matter (µg/l QSU)	0	500
Total Phosphorus (mg/l)	0	5
Ortho-Phosphorus (mg/l)	0	2
Air Temperature (ºC)	-30	40
Relative Humidity (% RH)	25	100
Wind speed (km/h)	0	200
Wind direction (degrees)	0	360
Solar radiation (W/m^2)	0	1500

† *data below these values set to NA*

‡ *data above these values set to NA*

Appendix C. Lower and upper threshold limits used to identify simple distributional outliers.

Parameter	Threshold for the detection of low-valued outliers†	Threshold for the detection of high-valued outliers‡
Rainfall (mm)	0	5
Soil Temperature (ºC)	0	20
Soil Moisture 10/20/30 (%)	10	55
Flow (l s^{-1})	0	100
Water Temperature Flume (ºC)	0	25
PLC Switch (0/1)	0	1
Nitrite & Nitrate (mg/l)	0	20
Ammonia (mg/l)	0	20
Ammonium (mg/l)	0	50
Specific Conductivity (uS/cm)	30	1600
Dissolved Oxygen (%)	60	105
pH	3.5	8.5
Water Temperature Flow-cell (ºC)	0	25
Turbidity (FNU)	0	2000
Fluorescent Dissolved Organic Matter (µg/l QSU)	0	400
Total Phosphorus (mg/l)	0	1
Ortho-Phosphorus (mg/l)	0	0.25
Air Temperature (ºC)	-10	30
Relative Humidity (% RH)	40	100
Wind speed (km/h)	0	75
Wind direction (degrees)	0	360
Solar radiation (W/m^2)	0	1250

† *data below these values flagged as outlier*

‡ *data above these values flagged as outlier*

Appendix D. Reasons for Traffic Light Quality Flag (TLQF) assignment.

Flag	Reason
A	No obvious issues in the data and no reason to suspect any. Level of QC not sufficient however to be given a “Good” assignment.
B	Soil Moisture data are now complete as new sensor readings have been harmonised to old sensor readings. All 20 cm and 30 cm sensor readings currently set as ‘NA’, as the data were deemed unreliable after calibrations.
C	The data seem acceptable, however, for some limited periods the Nitrate/Nitrite data appeared highly erratic. So, proceed with caution.
D	Ammonia is a derived variable from Ammonium and as such should be treated with caution. Where Ammonium data are absent, Ammonia values should be ignored. In general, on the NWFP, Ammonia values can be regarded as 0.
E	For Ammonium, the drift often appears severe, but no evidence has yet been found that these data are incorrect, apart from periods when the data have known issues.
F	For the Phosphax sensors, there are on-going issues with irregular time intervals. Here the data are not always sampled exactly every 15 minutes but always reported as this (refer to the user guide for the water data for details). Data comparison, however, has found the data from the Phosphax sensors to be reliable and the decision was made to no longer flag the data as Suspicious, but as Acceptable.
G	The MET/SMS rainfall data has been deemed Acceptable as data from the tipping buckets are reliable. The only issue found is that rain gauge (RG) checks show a slight underestimation of rainfall (see relevant section in the met and soil moisture station user guides for information on the RG checks), however, the data were deemed acceptable.

Appendix E. QC: Data from rain gauges and soil moisture stations (31/10/2011 to 25/08/2018).

	QC Step	Rainfall	Soil Temperature	Soil Moisture 10cm	Soil Moisture 20cm	Soil Moisture 30cm
1	Data dimension check	Yes	Yes	Yes	NA	NA
2	Headings check	Yes	Yes	Yes	NA	NA
3	Time and time interval check	Yes	Yes	Yes	NA	NA
4	Data format check	Yes	Yes	Yes	NA	NA
5	Sensor downtime check (values set as 'NA')	Yes	Yes	Yes	NA	NA
6	Impossible values – via set upper/lower limits (values set as 'NA')	Yes	Yes	Yes	NA	NA
7	Data correction (according to sensor calibration - including sensor drift)	No	No	No	NA	NA
8	Relational check with all other same sensor readings	Yes	No	No	NA	NA
9	Check against alternative QC	Yes	Yes	Yes	NA	NA
10	Daily summary statistics output	Yes	Yes	Yes	NA	NA
11	4-weekly summary statistics output	Yes	Yes	Yes	NA	NA
12	Traffic Light Quality Flag (TLQF) assignment^	Acceptable	Acceptable	Acceptable	Not Set	Not Set
13	Reason for TLQF assignment (see below)	A	A	B	B	B

^ 7 levels: Not Set, Good, Acceptable, Outlier, Suspicious, Highly Suspicious, Reject.

Appendix F. QC: Data from water flumes – flow, plc switch, nitrate/nitrite (01/10/2012 to 25/08/2018).

	QC Step	Flow	PLC Switch	Nitrate & Nitrite
1	Data dimension check	Yes	Yes	Yes
2	Headings check	Yes	Yes	Yes
3	Time and time interval check	Yes	Yes	Yes
4	Data format check	Yes	Yes	Yes
5	Sensor downtime check (values set as 'NA')	Yes	Yes	Yes
6	Impossible values – via set upper/lower limits (values set as 'NA')	Yes	Yes	Yes
7	Data correction (according to sensor calibration - including sensor drift)	No	No	No
8	Relational check with all other same sensor readings	No	No	No
9	Check against alternative QC	Yes	Yes	Yes
10	Daily summary statistics output	Yes	Yes	Yes
11	4-weekly summary statistics output	Yes	Yes	Yes
12	Traffic Light Quality Flag (TLQF) assignment^	Acceptable	Acceptable	Acceptable
13	Reason for TLQF assignment (see below)	A	A	C

^ 9 levels: Not Set, Good, Acceptable, Outlier, Suspicious, High Sensor Drift, Missing Sensor Drift, Highly Suspicious, Reject.

Appendix G. QC: Data from water flumes – ammonia, ammonium, specific conductivity, dissolved oxygen (01/10/2012 to 25/08/2018).

	QC Step	Ammonia	Ammonium	Specific Conductivity	Dissolved Oxygen
1	Data dimension check	Yes	Yes	Yes	Yes
2	Headings check	Yes	Yes	Yes	Yes
3	Time and time interval check	Yes	Yes	Yes	Yes
4	Data format check	Yes	Yes	Yes	Yes
5	Sensor downtime check (values set as 'NA')	Yes	Yes	Yes	Yes
6	Impossible values – via set upper/lower limits (values set as 'NA')	Yes	Yes	Yes	Yes
7	Data correction (according to sensor calibration - including sensor drift)	No	No	No	No
8	Relational check with all other same sensor readings	No	No	No	No
9	Check against alternative QC	Yes	Yes	Yes	Yes
10	Daily summary statistics output	Yes	Yes	Yes	Yes
11	4-weekly summary statistics output	Yes	Yes	Yes	Yes
12	Traffic Light Quality Flag (TLQF) assignment^	Acceptable	Acceptable	Acceptable	Acceptable
13	Reason for TLQF assignment (see below)	D	E	A	A

^9 levels: Not Set, Good, Acceptable, Outlier, Suspicious, High Sensor Drift, Missing Sensor Drift, Highly Suspicious, Reject.

Appendix H. QC: Data from water flumes -pH, sonde temperature, turbidity, fDOM (01/10/2012 to 25/08/2018).

	QC Step	pH	Sonde Temperature	Turbidity	fDOM
1	Data dimension check	Yes	Yes	Yes	Yes
2	Headings check	Yes	Yes	Yes	Yes
3	Time and time interval check	Yes	Yes	Yes	Yes
4	Data format check	Yes	Yes	Yes	Yes
5	Sensor downtime check (values set as 'NA')	Yes	Yes	Yes	Yes
6	Impossible values – via set upper/lower limits (values set as 'NA')	Yes	Yes	Yes	Yes
7	Data correction (according to sensor calibration - including sensor drift)	No	No	No	No
8	Relational check with all other same sensor readings	No	No	No	No
9	Check against alternative QC	Yes	Yes	Yes	Yes
10	Daily summary statistics output	Yes	Yes	Yes	Yes
11	4-weekly summary statistics output	Yes	Yes	Yes	Yes
12	Traffic Light Quality Flag (TLQF) assignment^	Acceptable	Acceptable	Acceptable	Acceptable
13	Reason for TLQF assignment (see below)	A	A	A	A

^6 levels: Not Set, Good, Acceptable, Suspicious, Highly Suspicious, Reject

Appendix I. QC: Data from water flumes – total phosphorus, ortho-phosphorus (01/10/2012 to 25/08/2018).

	QC Step	Total Phosphorus	Ortho-Phosphorus
1	Data dimension check	Yes	Yes
2	Headings check	Yes	Yes
3	Time and time interval check	Yes	Yes
4	Data format check	Yes	Yes
5	Sensor downtime check (values set as 'NA')	Yes	Yes
6	Impossible values – via set upper/lower limits (values set as 'NA')	Yes	Yes
7	Data correction (according to sensor calibration - including sensor drift)	No	No
8	Relational check with all other same sensor readings	No	No
9	Check against alternative QC	Yes	Yes
10	Daily summary statistics output	Yes	Yes
11	4-weekly summary statistics output	Yes	Yes
12	Traffic Light Quality Flag (TLQF) assignment^	Acceptable	Acceptable
13	Reason for TLQF assignment (see below)	F	F

^6 levels: Not Set, Good, Acceptable, Suspicious, Highly Suspicious, Reject

Appendix J. QC: Data from met station (31/10/2011 to 18/01/2016; Rainfall only between 31/10/2011 – 29/04/2013).

	QC Step	Rainfall	Air temperature	Relative humidity	Wind speed	Wind direction	Solar radiation
1	Data dimension check	Yes	Yes	Yes	Yes	Yes	Yes
2	Headings check	Yes	Yes	Yes	Yes	Yes	Yes
3	Time and time interval check	Yes	Yes	Yes	Yes	Yes	Yes
4	Data format check	Yes	Yes	Yes	Yes	Yes	Yes
5	Sensor downtime check (values set as 'NA')	Yes	Yes	Yes	Yes	Yes	Yes
6	Impossible values – via set upper/lower limits (values set as 'NA')	Yes	Yes	Yes	Yes	Yes	Yes
7	Data correction (according to sensor calibration - including sensor drift)	No	No	No	No	No	No
8	Relational check with all other same sensor readings	Yes	No	No	No	No	No
9	Check against alternative QC	Yes	Yes	Yes	Yes	Yes	Yes
10	Daily summary statistics output	Yes	Yes	Yes	Yes	Yes	Yes
11	4-weekly summary statistics output	Yes	Yes	Yes	Yes	Yes	Yes
12	Traffic Light Quality Flag (TLQF) assignment^	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
13	Reason for TLQF assignment (see below)	G	A	A	A	A	A

^6 levels: Not Set, Good, Acceptable, Suspicious, Highly Suspicious, Reject.

Appendix K. Formulae for conversion from scaled frequency unit (SFU) to soil moisture.

Soil Moisture Sensor	Formulae
SM1 A51730, F/W 6.0	% soil moisture = SFU -18.8) / 1.808
SM1 A51730, F/W 6.2	% soil moisture = SFU+ 12.87) / 1.808