Primer for the ASOS Software Version 3.10 Ice Free Wind Sensor Quality Control Algorithm

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- Bird activity and occasional ice build up on the Ice Free Wind Sensor (IFWS) has generated erroneous wind observations throughout the ASOS Network: unrealistic high gusts/peak winds, bogus variable wind direction reports and inaccurate average wind speed and direction reports.

- Bird activity has resulted in numerous extraneous priority 1 trouble tickets.

- An algorithmic solution has been incorporated into ASOS Version 3.10 software which quality controls wind data from the IFWS.

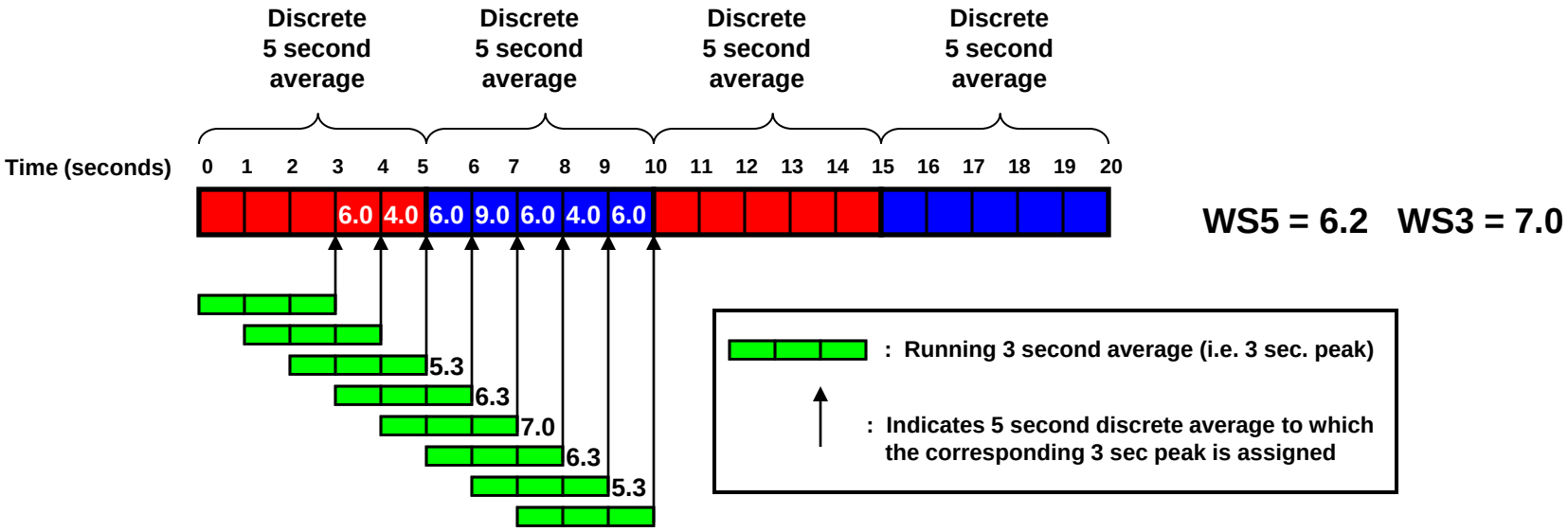
- The algorithm has been implemented in such a way so that a priority 1 trouble ticket is only generated when a hardware problem is detected. This prevents the generation of extraneous priority 1 trouble tickets.

The IFWS QC Algorithm operates on the data received directly from the sensor:

1) Every second, the wind direction and speed are sampled by the IFWS.

2) Every second, a running average of the most recent 3 seconds of data is computed by the IFWS, producing the "3 second peak"

3) Every 5 seconds, the average of the most recent 5 seconds of data is computed by the IFWS, producing the "5 second average". The highest 3 second peak is determined by the IFWS and is stored as the 3 second peak.



WS5 = 6.2 WS3 = 7.0

WS5, WS3 (as determined above) along with diagnostic information is received every 5 seconds from the sensor:

DATE	UTC		P/F	WT5	WT3	WD5	WS5	WD3	WS3	Sig. Qual.
0417	213500	1	P	005	003	199	6.7	196	7.1	99
0417	213505	1	P	005	003	202	6.8	206	6.9	99
0417	213510	1	P	005	003	199	6.3	205	6.7	99
0417	213515	1	P	005	003	206	8.0	205	8.5	99
0417	213520	1	P	005	003	206	5.5	210	6.8	99
0417	213525	1	P	005	003	200	6.5	199	7.0	99
0417	213530	1	P	005	003	197	7.7	204	8.2	99
0417	213535	1	P	005	003	200	7.7	197	8.0	99

QC Algorithm: How it works

- The QC Algorithm evaluates each 5-second sample from the IFWS against 9 criteria. Samples failing to meet any of the 9 criteria are flagged.

- The QC Algorithm also assesses the pattern of flagged data to determine if the data stream itself is suspect.

- Flagged samples are recorded by ASOS and bracketed in the high resolution wind data archive and are NOT used in any of the ASOS wind algorithms. Samples are also given a numeric error code corresponding to where the sample did not meet quality control.

5-second samples from IFWS

DATE	UTC		P/F	WT5	WT3	WD5	WS5	WD3	WS3	Sig. Qual.
0417	213500	1	P	005	003	199	6.7	196	7.1	99
0417	213505	1	P	005	003	202	6.8	206	6.9	99
0417	213510	1	P	005	003	199	6.3	205	6.7	99
0417	213515	1	P	005	003	206	8.0	205	8.5	99
0417	213520	1	P	005	003	206	5.5	210	6.8	99
0417	213525	1	P	005	003	200	6.5	199	7.0	99
0417	213530	1	P	005	003	197	7.7	204	8.2	99
0417	213535	1	P	005	003	200	7.7	197	8.0	99

Flag samples when:

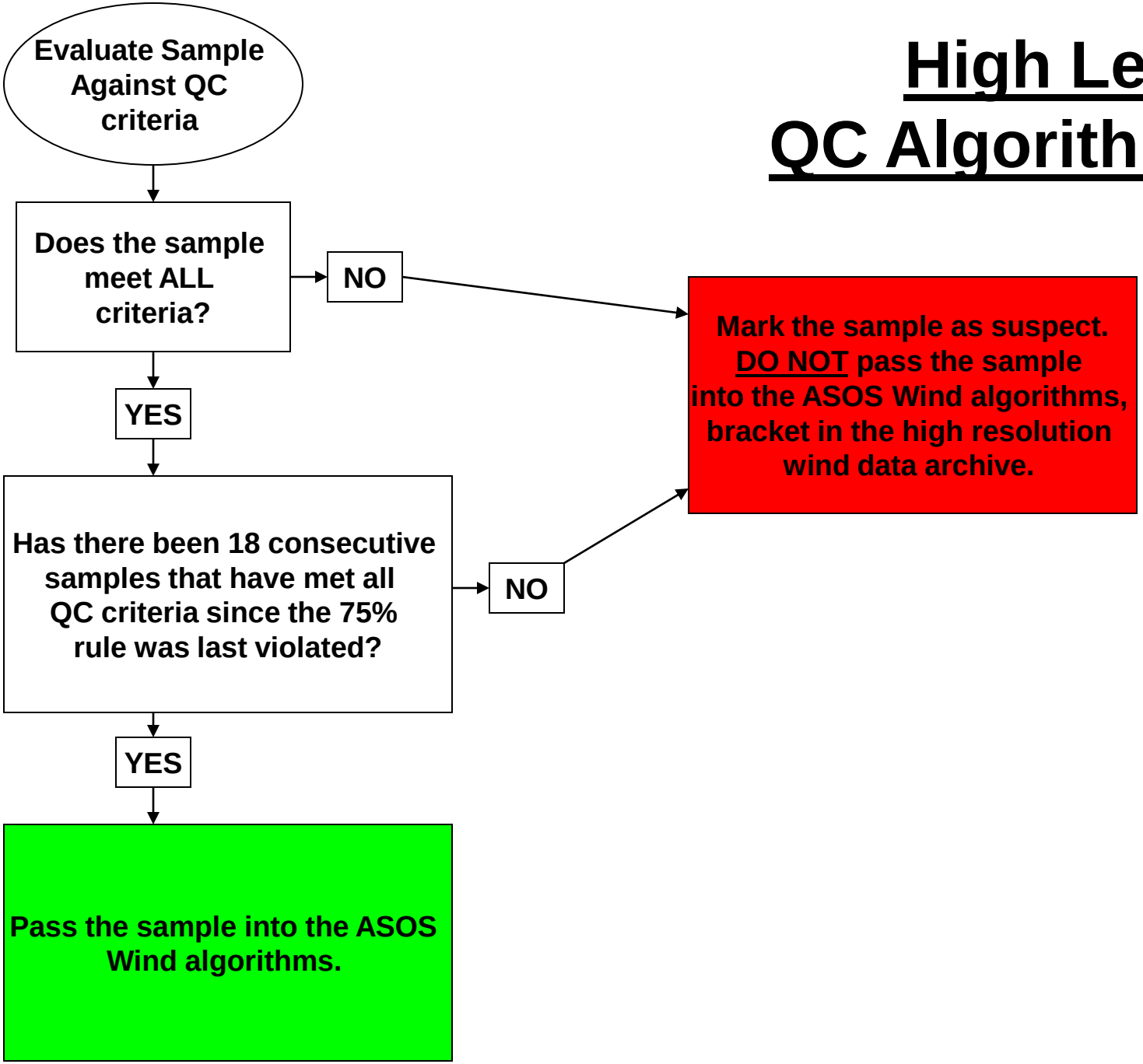
1. P/F flag from the sensor is “F”
2. Signal quality is less than 79
3. $(WS3_{peak} - WS5_{avg}) < -1$
4. $WS5_{avg} >= 12$ **AND** $|(WD5_{avg} - WD3_{peak})| > 30$
5. $WS5_{avg} >= 12$ **AND** $WS3_{peak} > (2.5 * WS2Min)$
6. $WS5_{avg} < 12$ **AND** $WS3_{peak} > 30$
7. $WS2Min <= 6$ **AND** $WS3_{peak} > 6$ **AND** $WS3_{peak} > (2.5 * WS2Min)$
8. $WS5_{avg} > 165$ **OR** $WS3_{peak} > 165$
9. $WT5 \neq 5$ **OR** $WT3 \neq 3$

The Quality Control Algorithm also makes the following checks on the data stream:

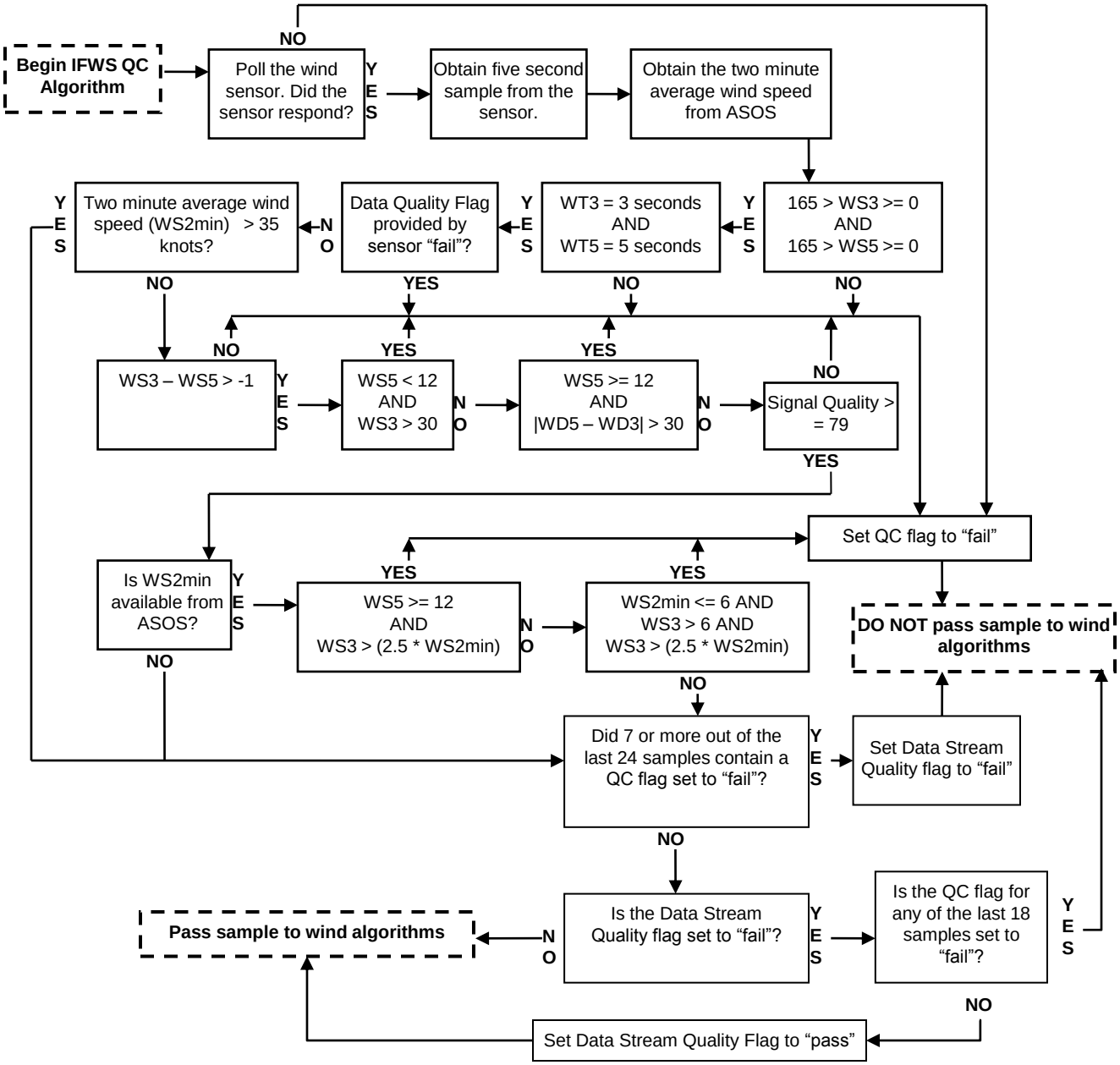
- If 7 or more of the preceding 24 samples have been flagged (75% rule), all subsequent samples will be flagged until there are 18 consecutive samples which meet the QC criteria.

NOTE: When the 2-minute average wind speed exceeds 35 knots, only checks 1, 8 and 9 are made.

High Level QC Algorithm Logic



Detailed QC Algorithm Logic



QC Algorithm: Impact on ASOS Maintenance

- The maintenance flag ($) and the corresponding priority 1 AOMC trouble ticket can only be set when a hardware problem is detected (sensor, communications, etc.).

- The maintenance flag ($) will NOT be set solely due to a wind data quality error, as purely environmental factors (such as roosting birds) are not issues that are correctable by the electronics staff.

- Extraneous IFWS-related maintenance flags ($) and priority 1 trouble tickets are eliminated with software V3.10.

QC Algorithm: Impact on ASOS Observations

- The IFWS QC Algorithm results in a median loss of 0.33% of the good 5-second wind data.

- The IFWS QC Algorithm results in the removal of 97% of corrupted 5-second wind data.

QC Algorithm: Impact of Missing Data on ASOS Observations

• When the QC Algorithm removes six or less 5-second samples in a 2 minute period, the removal of those samples will be transparent to the end user: a QC'ed wind report is available.

• When the QC Algorithm removes more than six 5-second samples, the wind report will go missing and will take a minimum of 4 ½ minutes to return.

• In order to remove 97% of the corrupted 5-second samples, the IFWS QC Algorithm must remove some good data as well.

• The median amount of good data removed by the algorithm is 0.33%, which will be representative of the vast majority of the ASOS Network.

• There will be some sites that will experience good data loss of 1% or more, and other sites where good data loss will be near 0. Sites with unorthodox siting constraints, sites in mountain passes and in dessert areas tend to have above median good data rejection rates.

• The majority of good data rejected are "ordinary" samples. However, the algorithm can wrongfully reject a piece of good data that is of operational significance. Case in point: the highest peak wind observed during a severe thunderstorm in Topeka, KS on April 11, 2008 would have been rejected by the algorithm.

• NOTE: Data rejected by the algorithm is not lost, it is retained for 14 hours in the high resolution archived.

QC Algorithm: Impact of Bogus Data Removal on ASOS Observations

• Corrupt samples result in erroneous peak winds and gusts that can exceed 100 knots on a calm day.

• Corrupt samples result in erroneous variable wind reports, squall reports and wind shift reports.

• Corrupt samples result in unrepresentative wind speed and direction reports which can negatively affect surface analyses, forecaster awareness, forecast verification, the climate record and airport operations.

• Corrupt wind samples are NOT meteorological in nature, but are a by-product of how the sensor interprets the interplay between the acoustical waves it uses to measure wind velocity and an entity in the sample volume (birds, ice, insects, etc.).

• The IFWS QC Algorithm removes 97% of the corrupted 5-second samples, nearly eliminating bogus wind reports from the ASOS Network.

QC Algorithm: Cost vs. Benefit

Cost:

- The QC Algorithm causes 0.33% of the good wind data to be rejected from the ASOS wind algorithms.

- This can result in a missing wind report or the under reporting of a peak wind on rare occasions.

Benefit:

- 97% reduction in bogus peak wind reports, bogus gusts, false variable wind reports, unrepresentative wind observations and false SQ reports

- Elimination of extraneous priority 1 AOMC trouble tickets

The tradeoff:

- 0.33% of ASOS 5-second wind data is not processed through the wind algorithms in exchange for a 97% reduction in bogus wind observations and the elimination of environmentally induced wind-related extraneous priority 1 trouble tickets.

Anonymous Quote: *"Show me a perfect algorithm, and I will show you an algorithm that does nothing."*