Data Validation

REGION 4 QUALITY ASSURANCE TRAINING

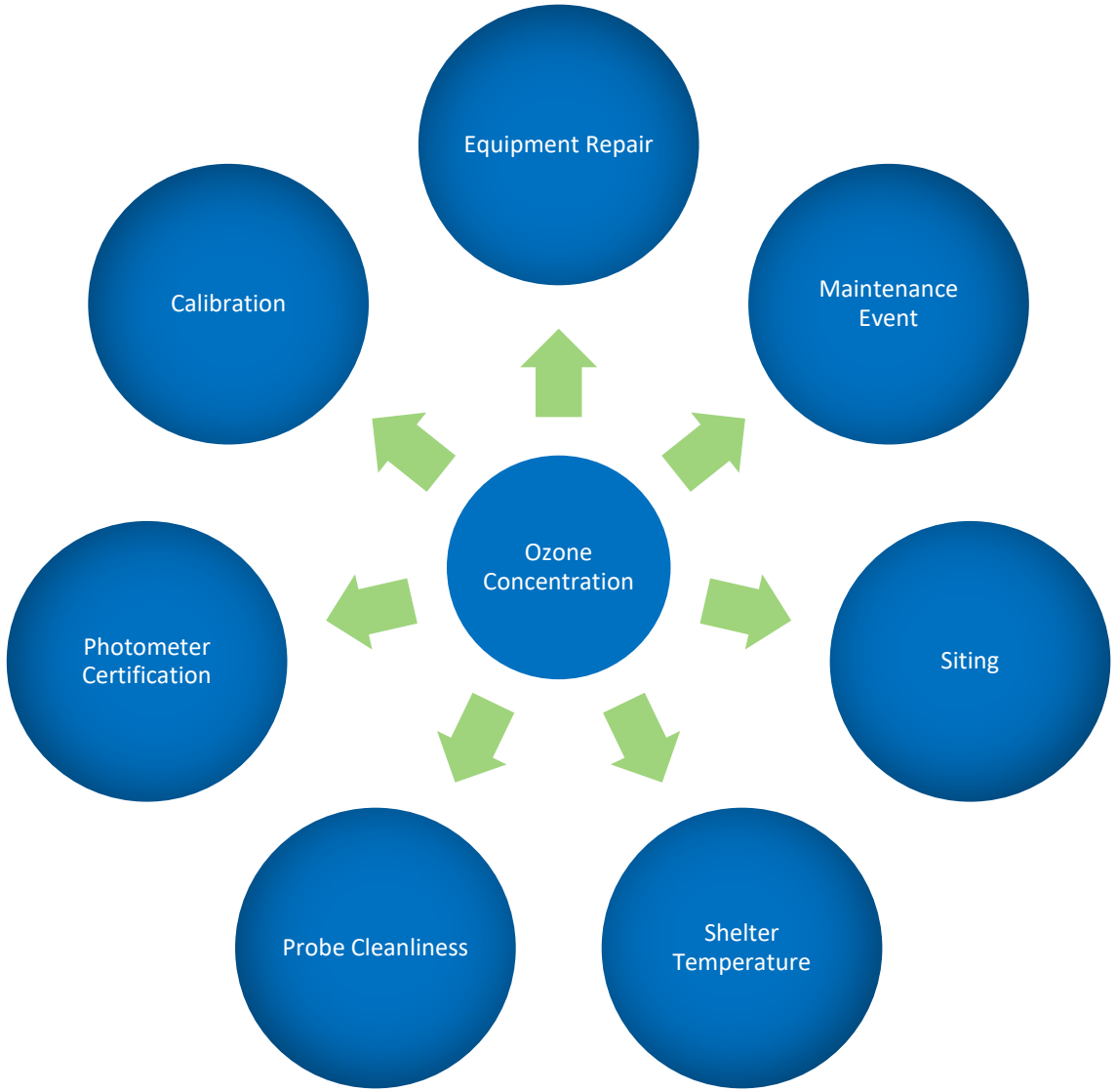
SEPTEMBER 2019

ATHENS, GEORGIA

Agenda

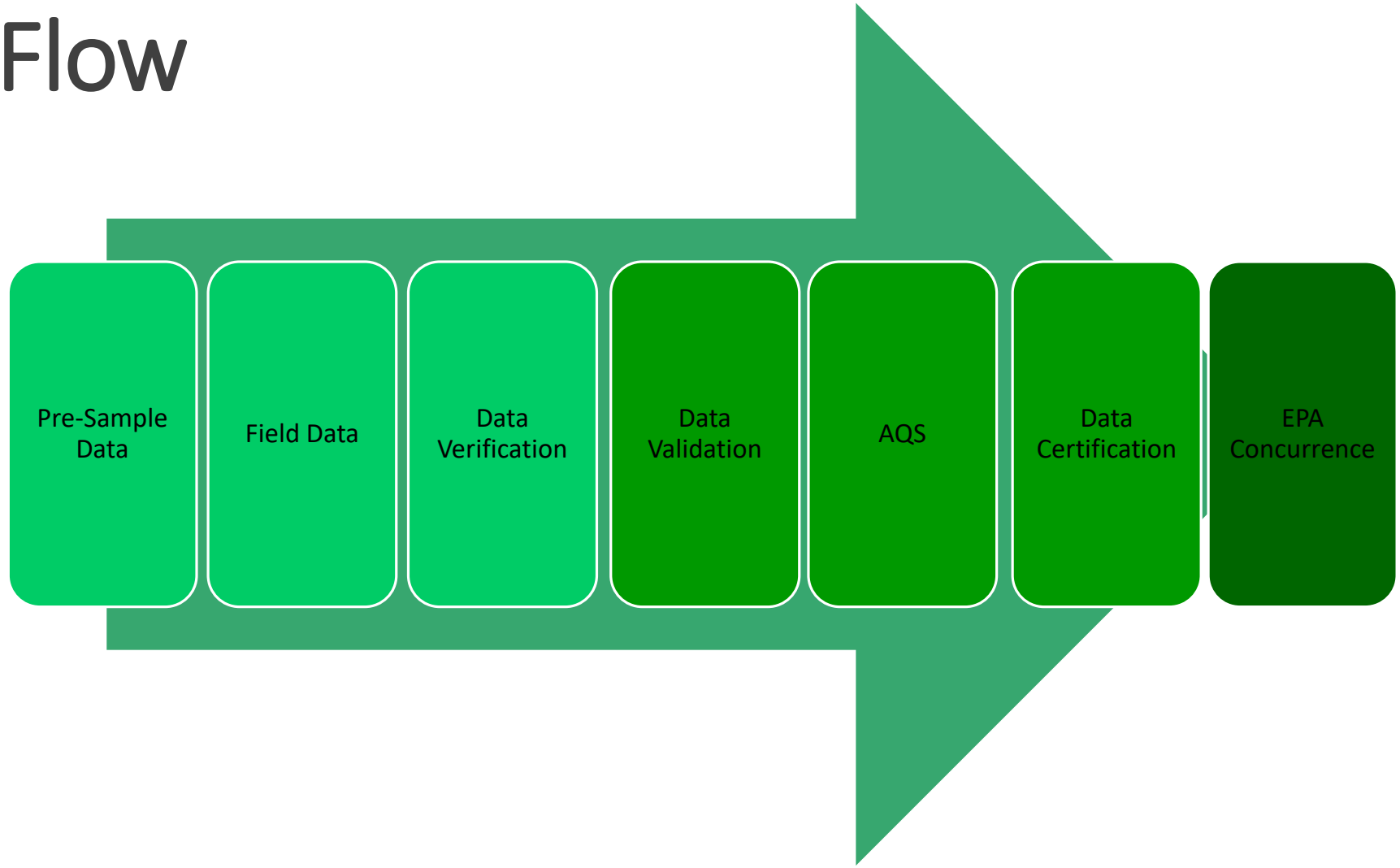
- Validation - What, Why, and Who
- Validation Templates
- Data Review Levels and Supporting Documentation
- AQS Codes and Validation
- Examples and Exercises!!!

Part 1: Introduction to Ambient Air Validation



What influences air monitoring data?

Data Flow



Each data point is influenced by numerous people and processes

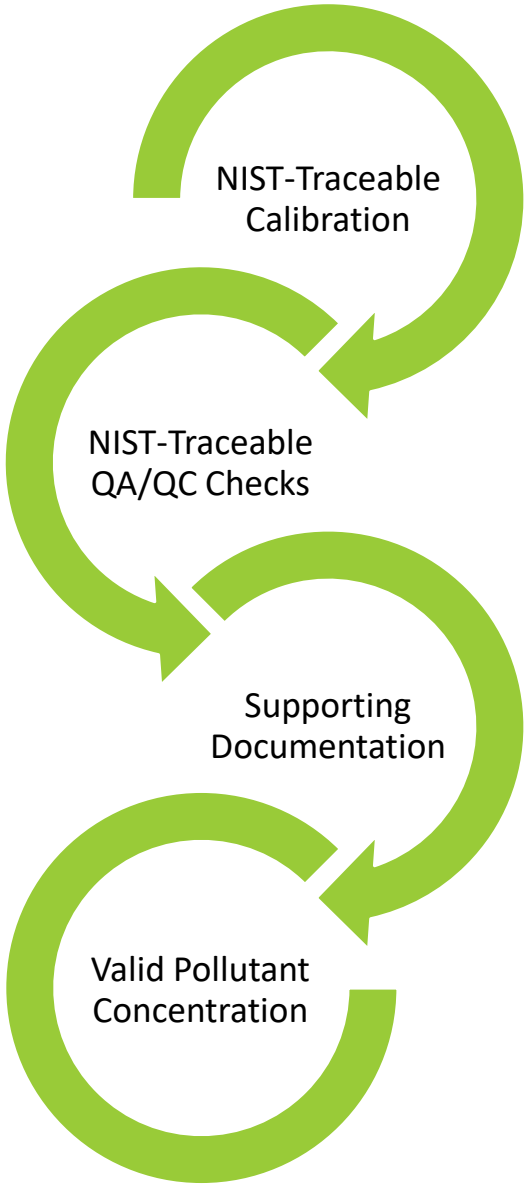
Data of Known Quality

Data are said to be of **known quality** when:

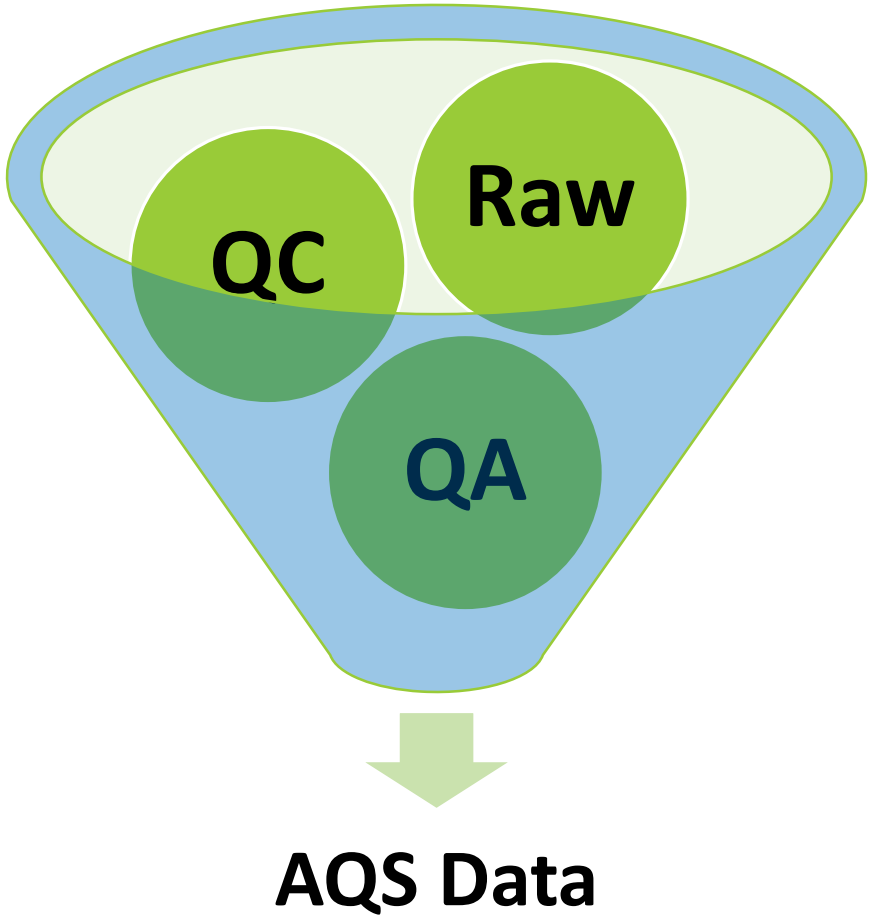
- The quality needs were defined **in advance**
- The data were **verified**
- The data were **validated**
- The data were **assessed**

All other data are of:

UNKNOWN QUALITY



Documentation should be available to track the “life” of all valid sample concentrations, as well as justify concentrations which were flagged or invalidated



Frequent data review is needed at several levels to ensure data integrity

If this does not occur, it is difficult to go back in time and accurately qualify the data

Data Review

Data review is the **in-house examination of data** to ensure it has been recorded, transmitted, and processed correctly

- Data verification and validation **are methods** in the data review process
- Include techniques used to **accept**, **reject**, or **qualify** data in an objective and consistent manner

Definitions

- **Verification:** Evaluation of data for **correctness and completeness**
- **Validation:** Evaluation of data for **compliance** with specified quality control
- **Assessment:** Evaluation of the **aggregated** data set's ability to **meet the intended objectives**
- **Reconciliation:** Evaluation of the **aggregated** data set's and the specified objectives' ability to **meet the users' needs**

Data Verification

- Is the process for evaluating the completeness, correctness, and conformance of data against method, procedural, and/or contractual specifications
- It can be further defined as the confirmation, through provision of objective evidence, that specified requirements have been fulfilled

Data Verification

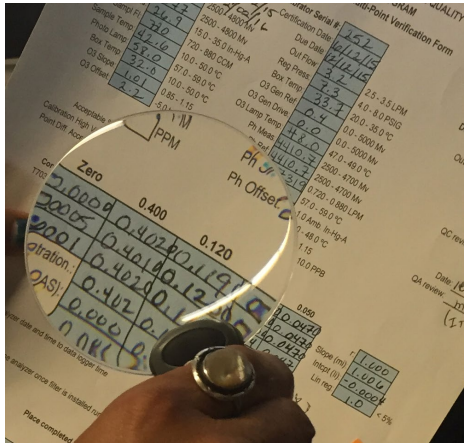
Site Operator

Self-review of **SMALL** data sets

- Data gaps
- Calibration specifications
- QC check specifications
- Datalogger-applied status flags
- Instrument diagnostic / performance specifications
- Concentration values

Data Validation

- Routine process designed to ensure that reported values meet the quality goals of the environmental data operation
- It can be further defined as the confirmation, through provision of objective evidence, that particular requirements for a specified ***intended use*** are fulfilled
- **Intended Use = Monitoring Objective(s)**



Data Validation

Data Reviewer

Verifies the verifier – and more!

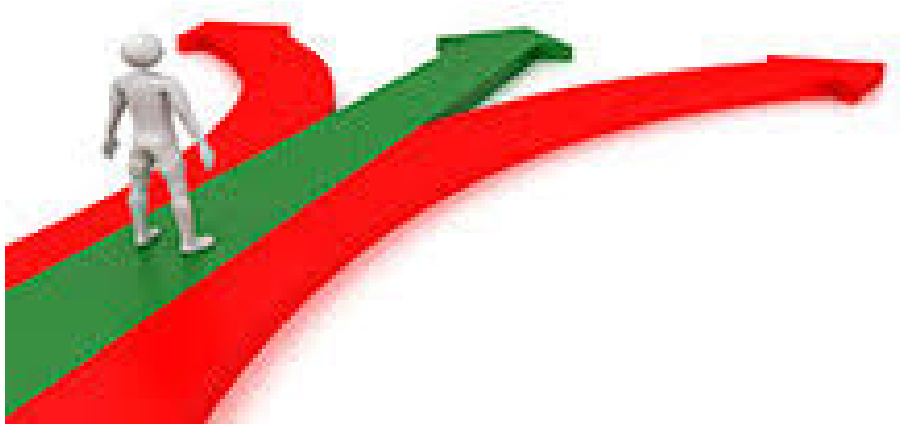
Compares data results to:

- QAPP / SOP Requirements
- CFR and Method Requirements
- Instrument FRM/FEM Designation Specifications
- Measurement Quality Objectives (MQOs)
- Actual Events (documentation)

Data Validation, Continued

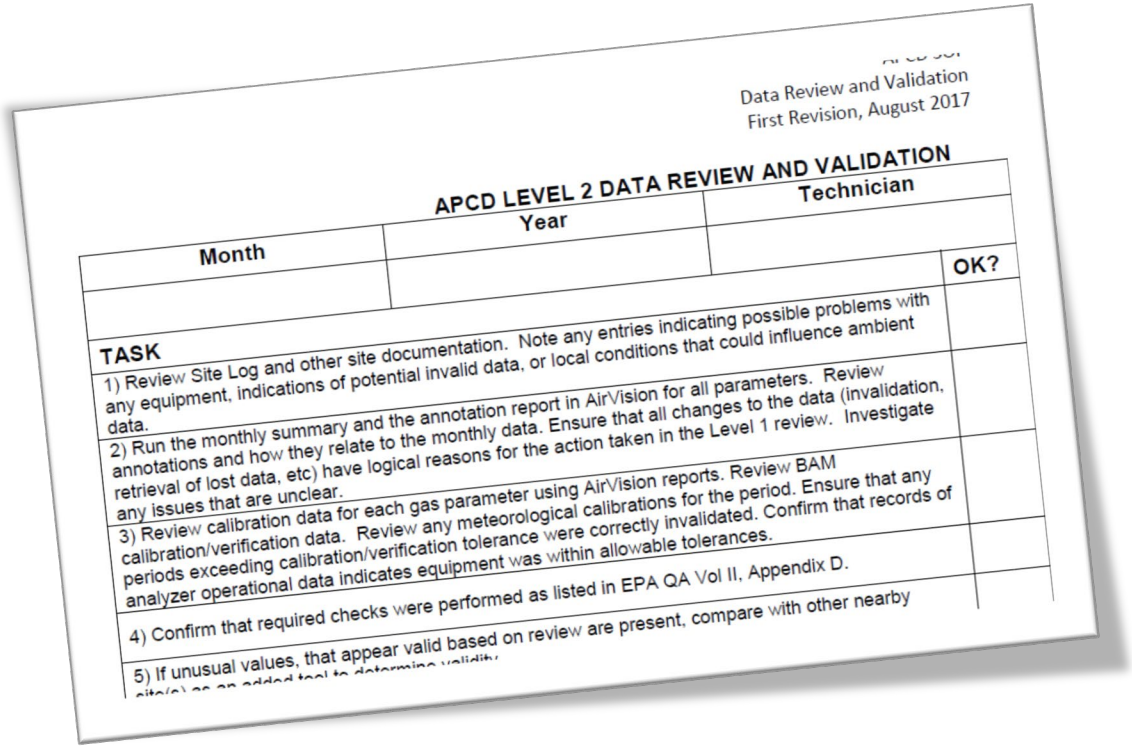
- Looks for trends
- Uses **professional judgment** to make some decisions on validity (usability, defensibility)
- Ensures **consistency** in data review judgment calls
- Ensures consistent AQS data coding, to provide **comparable** data results for the monitoring organization's network

Independence is needed in order to minimize personal bias



The data reviewer must judge the validity of data based upon tangible, objective supporting records and documentation

All staff who review data need to follow the same set of business rules



Data Review and Validation
First Revision, August 2017

APCD LEVEL 2 DATA REVIEW AND VALIDATION

Month	Year	Technician

TASK	OK?
1) Review Site Log and other site documentation. Note any entries indicating possible problems with any equipment, indications of potential invalid data, or local conditions that could influence ambient data.	
2) Run the monthly summary and the annotation report in AirVision for all parameters. Review annotations and how they relate to the monthly data. Ensure that all changes to the data (invalidation, retrieval of lost data, etc) have logical reasons for the action taken in the Level 1 review. Investigate any issues that are unclear.	
3) Review calibration data for each gas parameter using AirVision reports. Review BAM calibration/verification data. Review any meteorological calibrations for the period. Ensure that any periods exceeding calibration/verification tolerance were correctly invalidated. Confirm that records of analyzer operational data indicates equipment was within allowable tolerances.	
4) Confirm that required checks were performed as listed in EPA QA Vol II, Appendix D.	
5) If unusual values, that appear valid based on review are present, compare with other nearby site(s) as an added tool to determine validity	

- Data validation SOPs are needed to ensure a consistent process
- One central/independent figure should be the final decision maker, and should spot check the validation process

Reminder: DQOs vs MQOs

DECISION MAKER

DQOs: Big picture

- Aggregate of all QC checks collected at site and across pollutant network
- CV/bias computation
- Indicator of systemic issues
  - If fails, big picture questions & investigation needed.
  - For example, warning limits may need to be tightened or aged monitors replaced
- **DATA ASSESSMENTS**

DATA COLLECTOR

MQOs: Individual Analyzer

- Single QC checks
- Percent difference (%d) computation
- Assess how well the analyzer compares to the standard against which it was challenged – at that moment in time
  - If fails, investigation needed to determine cause of failure, in order to return the analyzer to an "in control" status
- **DATA VALIDATION**

Part 2: Validation Templates

Templates & Weight of Evidence

40 CFR Part 58, Appendix A, Section 1.2.3

"Each PQAO is required to implement a quality system that provides sufficient information to assess the quality of monitoring data. . . . Accordingly, the EPA and PQAOs shall use a '**weight of evidence**' approach when determining the suitability of data for regulatory decisions…

Templates & Weight of Evidence

40 CFR Part 58, Appendix A, Section 1.2.3 – Continued

…The EPA reserves the authority to use or not use monitoring data submitted by a monitoring organization when making regulatory decisions based on the EPA's assessment of the quality of the data. **Consensus built validation templates** or validation criteria already approved in QAPPs should be used as the basis for the weight of evidence approach."

QA Handbook, Appendix D: Data Validation Templates

Appendix D

Measurement Quality Objectives and Validation Templates

Table of Contents
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Validation Template	Page
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NO_2 , NOx, NO	10
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PM10c for $PM_{10-2.5}$ Low –Volume , Filter-Based Local Conditions	25
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Continuos PM10 STP Conditions	36
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Data Validation Templates

Data Validation templates are the MQO tables for each pollutant

Data validation templates are typically ~2-4 pages per pollutant

Ozone Validation Template

1) Requirement (O_3)	2) Frequency	3) Acceptance Criteria	Information /Action
CRITICAL CRITERIA-OZONE			
Monitor	NA	*Meets requirements listed in FRM/FEM designation*	1) 40 CFR Part 58 App C Sec. 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
One Point QC Check Single analyzer	*Every 14 days*	< ±7.1% (percent difference) or < ±1.5 ppb difference whichever is greater	1 and 2) 40 CFR Part 58 App A Sec. 3.1 3) Recommendation based on DQO in 40 CFR Part 58 App A Sec. 2.3.1.2. QC Check Conc range 0.005 - 0.08 ppm and 05/05/2016 Technical Note on AMTIC
Zero/span check	Every 14 days	Zero drift < ± 3.1 ppb (24 hr) < ± 5.1 ppb (>24hr-14 day) Span drift < ± 7.1 %	1 and 2) QA Handbook Volume 2 Sec. 12.3 3) Recommendation and related to DQO
OPERATIONAL CRITERIA -OZONE			
Shelter Temperature Range	Daily (hourly values)	20.0 to 30.0° C. (Hourly avg) or per manufacturers specifications if designated to a wider temperature range	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2 Generally, the 20-30.0° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance. FRM/FEM list found on AMTIC provides temp. range for given instrument. FRM/FEM monitor testing is required at 20-30° C range per 40 CFR Part 53.32
Shelter Temperature Control	Daily (hourly values)	< 2.1° C SD over 24 hours	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2
Shelter Temperature Device Check	Every 182 days and 2/ calendar year	< ± 2.1° C of standard	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2
Annual Performance Evaluation Single analyzer	*Every site every 365 days and 1/ calendar year within period of monitor operation,*	Percent difference of audit levels 3-10 < ±15.1% Audit levels 1&2 < ± 1.5 ppb difference or < ± 15.1%	1 and 2) 40 CFR Part 58 App A Sec. 3.1.2 3) Recommendation- 3-audit concentrations not including zero. AMTIC guidance 2/17/2011 AMTIC Technical Memo
Federal Audits (NPAP)	*20% of sites audited in calendar year*	Audit levels 1&2 < ± 1.5 ppb difference all other levels percent difference < ± 10.1%	1 and 2) 40 CFR Part 58 App A Sec. 3.1.3 3) NPAP QAPP/SOP
Verification/Calibration	Upon receipt/adjustment/repair/ installation/moving and repair and recalibration of standard of higher level Every 182 day and 2/ calendar year if manual zero/span performed biweekly Every 365 day and 1/ calendar year if continuous zero/span performed daily	All points < ± 2.1 % or ≤ ±1.5 ppb difference of best-fit straight line whichever is greater and Slope 1 ± .05	1) 40 CFR Part 50 App D 2) Recommendation 3) 40 CFR Part 50 App D Sec 4.5.5.6 Multi-point calibration (0 and 4 upscale points) Slope criteria is a recommendation
Zero Air/Zero Air Check	Every 365 days and 1/calendar year	Concentrations below LDL	1) 40 CFR Part 50 App D Sec. 4.1 2 and 3) Recommendation
Ozone Level 2 Standard			

			Information /Action
			1) 40 CFR Part 50 App D Sec. 5.4 2 and 3) Transfer Standard Guidance EPA-454/B-10-001 Level 2 standard (formerly called primary standard) usually transported to EPA Regions SRP for comparison
			1) 40 CFR Part 50 Appendix D Sec. 3.1 2) Recommendation, part of reverification 3) 40 CFR Part 50 Appendix D Sec. 3.1
			1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001
			1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001
			1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001 1
			1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001 recertification test that then gets added to most recent 5 tests. If does not meet acceptability certification fails
			is recommended that monitoring organizations perform the LDL test to mation.
Noise	Every 365 days and 1/ calendar year	*≤ 0.0025 ppm (standard range)* *≤ 0.001 ppm (lower range)*	1) 40 CFR Part 53.23 (b) (definition & procedure) 2) Recommendation- info can be obtained from LDL 3) 40 CFR Part 53.20 Table B-1
Lower detectable limit	Every 365 days and 1/calendar year	*< 0.005 ppm (standard range)* *≤ 0.002 ppm (lower range)*	1) 40 CFR Part 53.23 (b) (definition & procedure) 2) Recommendation 3) 40 CFR Part 53.20 Table B-1
SYSTEMATIC CRITERIA-OZONE			
Standard Reporting Units	*All data*	*ppm (final units in AQS)*	1, 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1
Rounding convention for design value calculation	*All routine concentration data*	*3 places after decimal with digits to right truncated*	1, 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1 The rounding convention is for averaging values for comparison to NAAQS not for reporting individual hourly values.
Completeness (seasonal)	*3-Year Comparison*	*≥ 90% (avg) daily max available in ozone season with min of 75% in any one year.*	1) 40 CFR Part 50 App I 2) 40 CFR Part 50 App I Sec. 2.3 3) 40 CFR Part 50 App I Sec. 2.3 (b)
	8- hour average	*≥75% of hourly averages for the 8-hour (6 of 8 hours)*	1) 40 CFR Part 50 App I 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1
	Valid Daily Max	*≥ 75% of the 24, valid 8 hour averages (18 of 24 8-hour averages*	1) 40 CFR Part 50 App I 2) 40 CFR Part 50 App I Sec. 2.1.2 3) 40 CFR Part 50 App I Sec. 2.1.2 (b)

The data validation templates were developed by a workgroup consisting of OAQPS, the EPA Regions, and State/Local/Tribal air monitoring organizations!

The main focus of **data validation** is determining data quality in terms of accomplishment of **measurement quality objectives (MQOs)**

How to “Read” the Templates

Pink = Critical Criteria

Yellow = Operational Criteria

Blue = Systematic Criteria

Column 1 = Itemized Requirement/Element

Column 2 = Frequency of Requirement

Column 3 = Acceptance Criteria

Column 4 = Additional information, including citations noting where the requirement originated

Use of ***Bold Italics*** identifies requirements codified in the CFR

Critical Criteria

- **Requirement, implementation frequency, and/or acceptance criteria are found in CFR**
- Critical to maintaining the integrity of a sample or group of samples
- **Invalidate** unless there is **compelling evidence** for not doing so
- This compelling evidence is needed in order to **prove** the data is valid

CRITICAL CRITERIA-OZONE			
Monitor	NA	*Meets requirements listed in FRM/FEM designation*	1) 40 CFR Part 58 App C Sec. 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
One Point QC Check *Single analyzer*	*Every 14 days*	< ±7.1% (percent difference) or < ±1.5 ppb difference whichever is greater	1 and 2) 40 CFR Part 58 App A Sec. 3.1 3) Recommendation based on DQO in 40 CFR Part 58 App A Sec. 2.3.1.2. QC Check Conc range 0.005 - 0.08 ppm and 05/05/2016 Technical Note on AMTIC
Zero/span check	Every 14 days	Zero drift < ± 3.1 ppb (24 hr) < ± 5.1 ppb (>24hr-14 day) Span drift < ± 7.1 %	1 and 2) QA Handbook Volume 2 Sec. 12.3 3) Recommendation and related to DQO

Compelling Evidence

- Data that concretely establishes instrument performance or validity of the check
- Includes, but is not limited to, data generated from:
  - Independent audit point(s), multi-point verification, and/or prior zero/span check
- This data establishes whether the analyzer was operating within its acceptance limits
- Indicates whether a QC check itself is considered valid or invalid

Operational Criteria

- Important for maintaining and evaluating the quality of the data collection system
- The sample or group of samples for which one or more of these criteria are not met are suspect unless other quality control information demonstrates otherwise and is documented
- Violation of an operational criterion may result in the application of an AQS QA qualifier flag(s)
- Violation of an operational criterion or a number of operational criteria may also be cause for data invalidation
- The reason for not meeting the criteria **must** be investigated, mitigated or justified

Operational Criteria

OPERATIONAL CRITERIA -OZONE			
Shelter Temperature Range	Daily (hourly values)	20.0 to 30.0° C. (Hourly avg) or per manufacturers specifications if designated to a wider temperature range	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2 Generally, the 20-30.0° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance. FRM/FEM list found on AMTIC provides temp. range for given instrument. FRM/FEM monitor testing is required at 20-30° C range per 40 CFR Part 53.32
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Shelter Temperature Device Check	Every 182 days and 2/ calendar year	<± 2.1° C of standard	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2
Annual Performance Evaluation Single analyzer	*Every site every 365 days and 1/ calendar year within period of monitor operation,*	Percent difference of audit levels 3-10 < ±15.1% Audit levels 1&2 < ± 1.5 ppb difference or <± 15.1%	1 and 2) 40 CFR Part 58 App A Sec. 3.1.2 3) Recommendation- 3-audit concentrations not including zero. AMTIC guidance 2/17/2011 AMTIC Technical Memo
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Zero Air/Zero Air Check	Every 365 days and 1/calendar year	Concentrations below LDL	1) 40 CFR Part 50 App D Sec. 4.1 2 and 3) Recommendation
Ozone Level 2 Standard			

Systematic Criteria

- Criteria which are important for the correct interpretation of the data, but do not usually impact the validity of a sample or group of samples
- Includes such items as reporting units and quarterly data completeness goals
- Includes the DQOs
- If the DQOs are not met, it does not invalidate specific samples; rather, **it may impact the uncertainty associated with the attainment/non-attainment decision**
- In some cases, violation of a systematic criterion may result in the application of AQS QA qualifier flags

Systematic Criteria

SYSTEMATIC CRITERIA-OZONE			
Standard Reporting Units	*All data*	*ppm (final units in AQS)*	1, 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1
Rounding convention for design value calculation	*All routine concentration data*	*3 places after decimal with digits to right truncated*	1, 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1 The rounding convention is for averaging values for comparison to NAAQS not for reporting individual hourly values.
Completeness (seasonal)	*3-Year Comparison*	*> 90% (avg) daily max available in ozone season with min of 75% in any one year.*	1) 40 CFR Part 50 App I 2) 40 CFR Part 50 App I Sec. 2.3 3) 40 CFR Part 50 App I Sec. 2.3 (b)
	8- hour average	*≥75% of hourly averages for the 8-hour (6 of 8 hours)*	1) 40 CFR Part 50 App I 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1
	Valid Daily Max	*> 75% of the 24, valid 8 hour averages (18 of 24 8-hour averages*	1) 40 CFR Part 50 App I 2) 40 CFR Part 50 App I Sec. 2.1.2 3) 40 CFR Part 50 App I Sec. 2.1.2 (b)
Sample Residence Time Verification	Every 365 days and 1/calendar year	*≤ 20 Seconds*	1) 40 CFR Part 58 App E, Sec. 9 (c) 2) Recommendation 3) 40 CFR Part 58 App E, Sec. 9 (c)
Sample Probe, Inlet, Sampling train	*All sites*	*Borosilicate glass (e.g., Pyrex®) or Teflon®*	1) 40 CFR Part 58 App E, Sec. Sec. 9 (a) 2) Recommendation 3) 40 CFR Part 58 App E, Sec. Sec. 9 (a) FEP and PFA have been accepted as an equivalent material to Teflon. Replacement or cleaning is suggested as 1/year and more frequent if pollutant load or contamination dictate
Siting	Every 365 days and 1/calendar year	*Meets siting criteria or waiver documented*	1) 40 CFR Part 58 App E, Sec. 2-6 2) Recommendation 3) 40 CFR Part 58 App E, Sec. 2-6
EPA Standard Ozone Reference Photometer (SRP) Recertification (Level 1)	Every 365 days and 1/calendar year	Regression slope = 1.00 ± 0.01 and intercept < 3 ppb	1, 2 and 3) Transfer Standard Guidance EPA-454/B-10-001 This is usually at a Regional Office and is compared against the traveling SRP
Precision (using 1-point QC checks)	*Calculated annually and as appropriate for design value estimates*	**90% CL CV < 7.1%**	1) 40 CFR Part 58 App A 2.3.1.2 & 3.1.1 2) 40 CFR Part 58 App A Sec. 4 (b) 3) 40 CFR Part 58 App A Sec. 4.1.2
Bias (using 1-point QC checks)	*Calculated annually and as appropriate for design value estimates*	**95% CL < ± 7.1%**	1) 40 CFR Part 58 App A 2.3.1.2 & 3.1.1 2) 40 CFR Part 58 App A Sec. 4 (b) 3) 40 CFR Part 58 App A Sec. 4.1.3

Template Rankings

- Operational or systematic quality control checks need to be performed
- **Not performing an operational or systematic quality control check that is required by regulation can be a basis for invalidation of all associated data**
- Consistently not meeting an operational or systematic criteria requires a corrective action(s) be implemented

Part 3:
Data Review Levels

Tiered Data Review Approach

- **Multi-step review process, conducted by several individuals with different perspectives**
- May not be fully possible in smaller agencies, but efforts should be made to ensure independence
- Ensures data in AQS tells the complete and correct story

Level 0

- Datalogger / Sampler
- Continuous / Daily
- Distinguish measurements from measurement errors or pre-programmed (automated) QC activities

Level 1

- Site Operator
- Daily / Monthly
- Distinguish measurements from measurement errors or interferences

Level 2

- Independent Reviewer (QA)
- Monthly / Quarterly
- Verify Level 1 Review
- Ensure data meets QA/QC requirements and objectives of its intended use

Level 3

- Independent Review (QAM)
- Monthly / Quarterly / Annually
- Verify Level 1 and 2 Reviews
- Approve data suitability for release to AQS

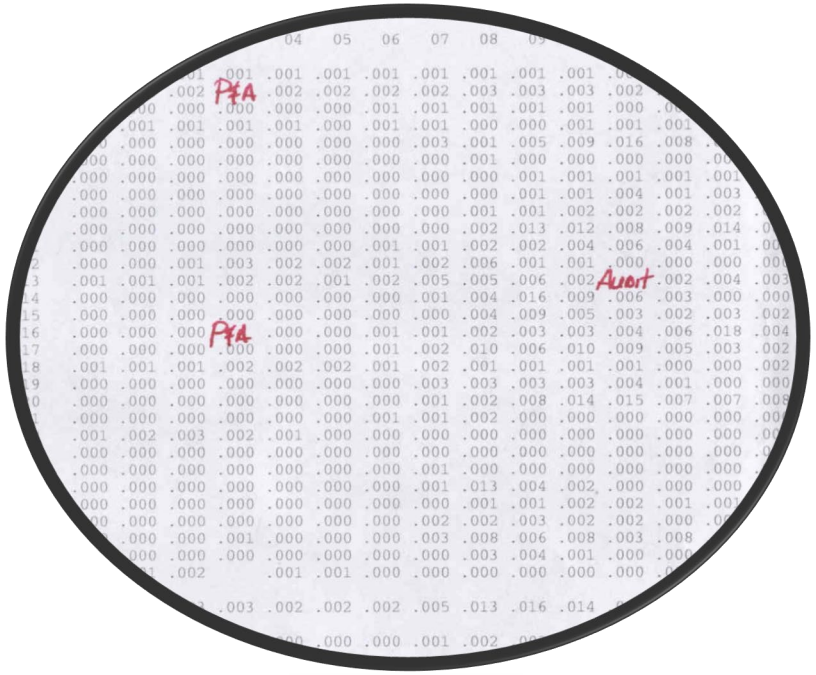
AQS qualifier flags or null value codes can be applied or suggested at any level

Level 0 Review

- Continuous / Real-time
- Data loggers can be pre-programmed to flag data during certain events
- Data loggers and samplers will also apply status flags when certain pre-programmed specifications have been exceeded
- Data sets polled / downloaded will display the flags applied by these instruments

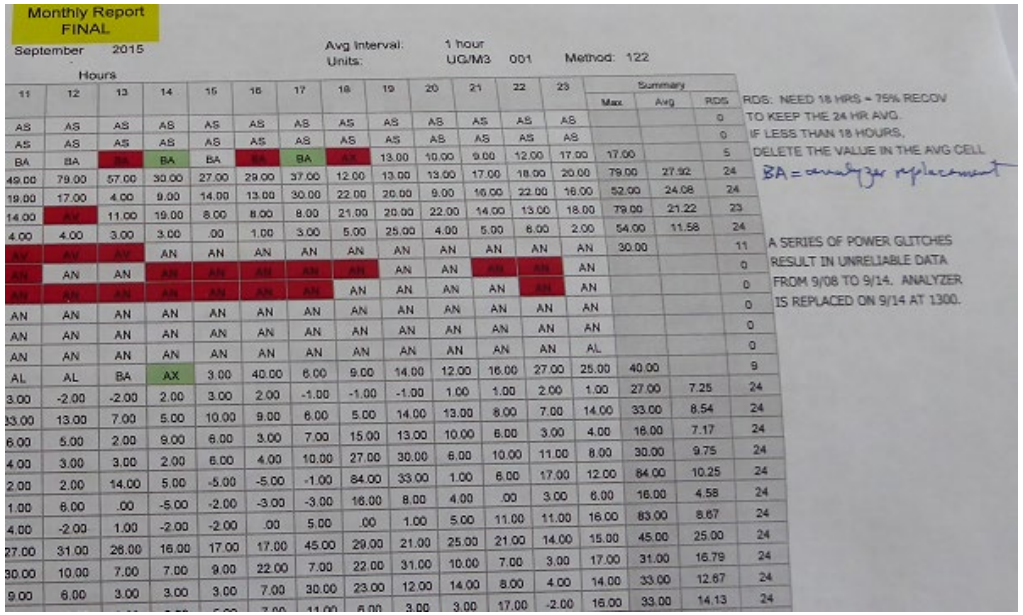
Level 1 Review

- Performed by the operator
- Daily / Weekly / Monthly Process
- Goal is to distinguish measurements from measurement errors or interferences
- Operator is the most knowledgeable about the specific site and specific instrument-performance



Level 2 Review

- Independent Reviewer (QA)
- Monthly / Quarterly Process
- Goals include:
  - Verifying the Level 1 Review and supporting documentation
  - Ensure data meets the QA/QC requirements and objectives of its intended use (validation)



Monthly Report FINAL

September 2015 — Avg Interval: 1 hour — Units: UG/M3 — 001 — Method: 122

Hours 11	12	13	14	15	16	17	18	19	20	21	22	23	Summary Max	Avg	RDS
AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS			0
AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS			0
BA	BA	BA	BA	BA	BA	BA	AS	13.00	10.00	9.00	12.00	17.00	17.00		5
49.00	79.00	57.00	30.00	27.00	29.00	37.00	12.00	13.00	13.00	17.00	18.00	20.00	79.00	27.92	24
19.00	17.00	4.00	9.00	14.00	13.00	30.00	22.00	20.00	9.00	16.00	22.00	16.00	52.00	24.08	24
14.00	AX	11.00	19.00	8.00	8.00	8.00	21.00	20.00	22.00	14.00	13.00	18.00	79.00	21.22	23
4.00	4.00	3.00	3.00	.00	1.00	3.00	5.00	25.00	4.00	5.00	6.00	2.00	54.00	11.58	24
AV	AV	AV	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	30.00		11
AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN			0
AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN			0
AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN			0
AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN			0
AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AL			0
AL	AL	BA	AX	3.00	40.00	6.00	9.00	14.00	12.00	16.00	27.00	25.00	40.00		9
3.00	-2.00	-2.00	2.00	3.00	2.00	-1.00	-1.00	-1.00	1.00	1.00	2.00	1.00	27.00	7.25	24
33.00	13.00	7.00	5.00	10.00	9.00	6.00	5.00	14.00	13.00	8.00	7.00	14.00	33.00	8.54	24
6.00	5.00	2.00	9.00	6.00	3.00	7.00	15.00	13.00	10.00	6.00	3.00	4.00	16.00	7.17	24
4.00	3.00	3.00	2.00	6.00	4.00	10.00	27.00	30.00	6.00	10.00	11.00	8.00	30.00	9.75	24
2.00	2.00	14.00	5.00	-5.00	-5.00	-1.00	84.00	33.00	1.00	6.00	17.00	12.00	84.00	10.25	24
1.00	6.00	.00	-5.00	-2.00	-3.00	-3.00	16.00	8.00	4.00	.00	3.00	6.00	16.00	4.58	24
4.00	-2.00	1.00	-2.00	-2.00	.00	5.00	.00	1.00	5.00	11.00	11.00	16.00	83.00	8.67	24
27.00	31.00	26.00	16.00	17.00	17.00	45.00	29.00	21.00	25.00	21.00	14.00	15.00	45.00	25.00	24
30.00	10.00	7.00	7.00	9.00	22.00	7.00	22.00	31.00	10.00	7.00	3.00	17.00	31.00	16.79	24
9.00	6.00	3.00	3.00	3.00	7.00	30.00	23.00	12.00	14.00	8.00	4.00	14.00	33.00	12.67	24
						11.00	6.00	3.00	3.00	17.00	-2.00	16.00	33.00	14.13	24

RDS: NEED 18 HRS = 75% RECOV TO KEEP THE 24 HR AVG. IF LESS THAN 18 HOURS, DELETE THE VALUE IN THE AVG CELL

BA = analyzer replacement

A SERIES OF POWER GLITCHES RESULT IN UNRELIABLE DATA FROM 9/08 TO 9/14. ANALYZER IS REPLACED ON 9/14 AT 1300.

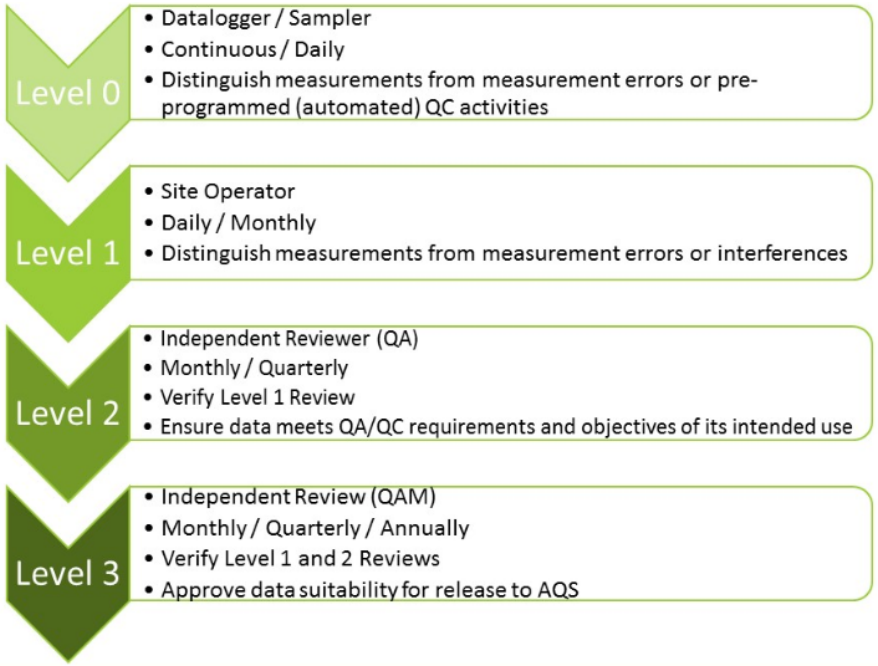
Level 3 Review

- Additional Independent Reviewer (QA Manager or equivalent)
- Monthly / Quarterly / Annual Process
- Verifies the Levels 1 and 2 Reviews
- **Ensures data is accurate, complete, comparable, representative, and defensible, given the supporting documentation**
- Includes data quality assessment (DQA)
- Approves data suitability for release to AQS

AQS Reporting – 40 CFR 58.16(b)

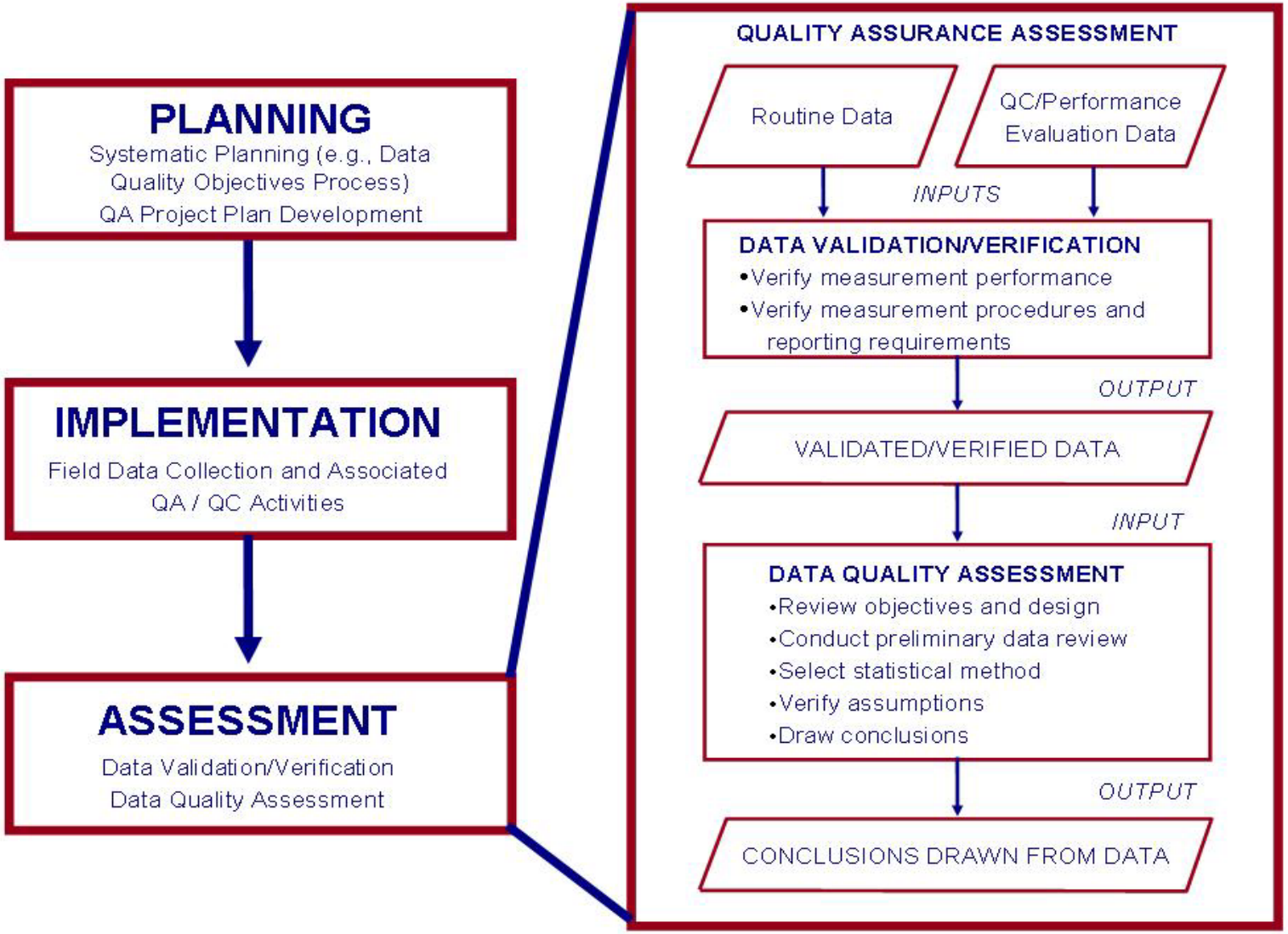
- Specific quarterly reporting periods
- Report all data and information gathered during the reporting period to AQS **within 90 days** after the end of the quarterly reporting period
- For example, the data for the reporting period January 1-March 31 are due **on or before** June 30 of that year

Validation Timeline



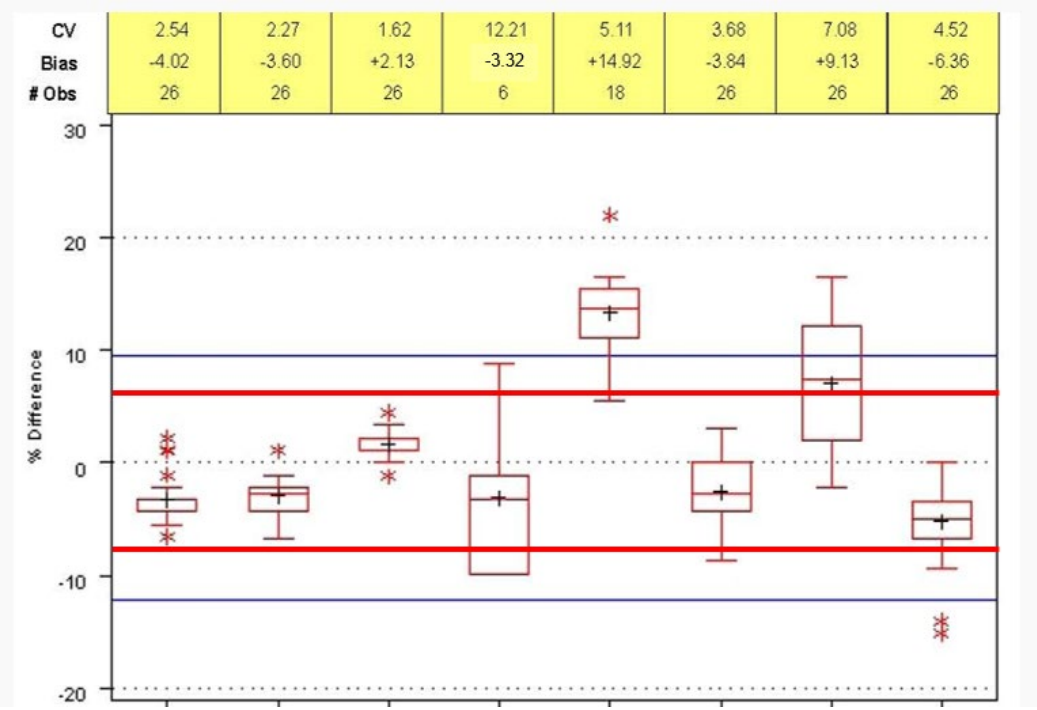
- 40 CFR Part 58.16 establishes the timeline by which data must be edited, validated, and reported to AQS
- The reporting schedule allows **approximately 90-180 days** for Levels 0 – 3 data review activities to occur
- Data modifications can occur at any time after data has been reported to AQS
- Data certification is due May 1 annually

Reminder:Data Quality Assessment (DQA)



The process of evaluating data against the Data Quality Objectives (DQOs) – **after** validation has been completed!

Data Quality Assessments



Annual Box & Whisker Plots – PQAO Level

- Monitor-level and network-level (PQAO)
- Annual data assessments should be completed by QAM (or other designated staff)
  - Annual data certification is an assessment
  - Other AQS reports can be run, such as the AMP 256
- 3-year assessments are also helpful when assessing criteria pollutant data
- Longer-term assessments (e.g., 6-year or 10-year) may happen in some programs, like toxics

Continuous Analyzer Data Review

The following slides describe **general procedures** to review data

Data Verification Levels 0-1

Level 0
- Datalogger / Sampler
- Continuous / Daily
- Distinguish measurements from measurement errors or pre-programmed (automated) QC activities

Level 1
- Site Operator
- Daily / Monthly
- Distinguish measurements from measurement errors or interferences

Level 2
- Independent Reviewer (QA)
- Monthly / Quarterly
- Verify Level 1 Review
- Ensure data meets QA/QC requirements and objectives of its intended use

Level 3
- Independent Review (QAM)
- Monthly / Quarterly / Annually
- Verify Level 1 and 2 Reviews
- Approve data suitability for release to AQS

Param :	PM25H	24/HR	SO2	NO	NO2	OZONE	TTEMP	FLOAD	NOX	SO25MIN
Units :	UG/M3	UG/M3	PPB	PPB	PPB	PPM	DEGC	%	PPB	PPB
Hour										
00	3	9	0C	0	1	.042C	25.5	34	0	0
01	4	8	1	0C	2C	.041C	25.7	34	0C	1
02	5	8	0	C	C	.039	25.7	34	C	0
03	5	8	1	0	2	.036	26.0	34	0	1
04	6	7	1	0	3	.035	26.0	35	0	1
05	5	7	0	0	3	.036	25.7	35	0	0
06	6	7	0	0	5	.033	25.3	35	1	0
07	8	7	0	0	10	.027	24.9	35	7	1
08	7	7	0	0	9	.028	25.0	34	8	1
09	9	7	1	0	6	.032	24.8	34	4	2
10	11	7	1	0	4	.036	24.1	34	1	2
11	8	7	2	0	4	.038	23.9	34	1	3
12	3	7	1	0	3	.041	24.1	34	1	1
13	3D	7D	1	1	5	.041	24.4	34D	5	2
14	53D	8D	1	0	5	.043	24.5	33D	3	2
15	5	9	0	0	4	.045	24.4	33	1	1
16	4	9	0	0	6	.044	24.4	33	3	0
17	4	9	0	0	6	.043	24.6	33	3	0
18	5	9	0	0	11	.037	25.0	34	8	0
19	6	8	0	3	31	.015	25.5	34	33	1
20	11	8	2	51	47	.002	25.7	35	98	3
21	17	9	2	96	46	.002	26.2	35	142	3
22	18	9	2	92	45	.001	26.2	35	136	3
23	9	9	1C	21	35	.011	26.0	35	53	2
Max :	53	9	2	96	47	.045	26.2	35	142	3
Min :	3	7	0	0	1	.001	23.9	33	0	0
Mean :	8	7	0	11	12	.031	25.1	34	22	1
Hours :	24	24	24	23	23	24	24	24	23	24

Data Flags :
'<' - Less than ##% Data, 'P' - Power Fail, 'D' - Disabled, 'T' - Out-of-Control, 'F' - Boiler Off-Line,
'B' - Bad Status, 'C' - Calibration, 'M' - Maintenance, 'O' - Analog Overrange, 'U' - Analog Underrange,
'A' - Arithmetic Error, '+' - Maximum, '-' - Minimum, 'R' - Rate of Change, 'H' - High-High Alarm,
'L' - Low-Low Alarm, 'h' - High Alarm, 'l' - Low Alarm, 'J' - High Rate of Change, 'j' - Low Rate of Change,
'V' - DIS #1 Obs, 'W' - DIS #2 Obs, 'X' - DIS #3 Obs, 'Y' - DIS #4 Obs, 'Z' - DIS #5 Obs,
'f' - Floor Exceeded, 'c' - Ceiling Exc.

Level 0 is performed **automatically** by the site datalogger or the sampler

In some organizations, the status flags applied during Level 0 verification are programmed to translate into AQS null codes by the data acquisition software

Types of flags available for this example application

- Level 1 = Site operator
- **Daily** data review **(target = 100%)**
  - Proactive approach to preventive data loss
  - Scrutinize the previous 24 hours of data
- **Monthly** data review also recommended to look for **trends**
- **Goal**: To distinguish measurements from measurement errors or interferences
- Operator will have information and evidence to illustrate whether data anomalies resulted from analyzer issues and/or localized events near the site (e.g., nearby prescribed fire)

Level 1 Verification should include, but is not limited to, the following:

- Look for missing data (**gaps**)
  - If identified, determine root cause and document it
  - Re-poll datalogger or instrument, if possible
- Review all **status flags** applied by the datalogger/sampler
  - Determine if those flags are expected (i.e., correct)
  - If unexpected, investigate the data points further to determine root cause(s) and document it

Param :	PM25H	24/HR	SO2	NO	NO2	OZONE	TTEMP	FLOAD
Units :	UG/M3	UG/M3	PPB	PPB	PPB	PPM	DEGC	%
Hour								
00	3	9	0C	0	1	.042C	25.5	34
01	4	8	1	0C	2C	.041C	25.7	34
02	5	8	0	C	C	.039	25.7	34
03	5	8	1	0	2	.036	26.0	34
04	6	7	1	0	3	.035	26.0	35
05	5	7	0	0	3	.036	25.7	35
06	6	7	0	0	5	.033	25.3	35
07	8	7	0	0	10	.027	24.9	35
08	7	7	0	0	9	.028	25.0	34
09	9	7	1	0	6	.032	24.8	34
10	11	7	1	0	4	.036	24.1	34
11	8	7	2	0	4	.038	23.9	34
12	3	7	1	0	3	.041	24.1	34
13	3D	7D	1	1	5	.041	24.4	34D
14	53D	8D	1	0	5	.043	24.5	33D
15	5	9	0	0	4	.045	24.4	33
16	4	9	0	0	6	.044	24.4	33
17	4	9	0	0	6	.043	24.6	33
18	5	9	0	0	11	.037	25.0	34
19	6	8	0	3	31	.015	25.5	34
20	11	8	2	51	47	.002	25.7	35
21	17	9	2	96	46	.002	26.2	35
22	18	9	2	92	45	.001	26.2	35
23	9	9	1C	21	35	.011	26.0	35
Max :	53	9	2	96	47	.045	26.2	35
Min :	3	7	0	0	1	.001	23.9	33
Mean :	8	7	0	11	12	.031	25.1	34
Hours :	24	24	24	23	23	24	24	24

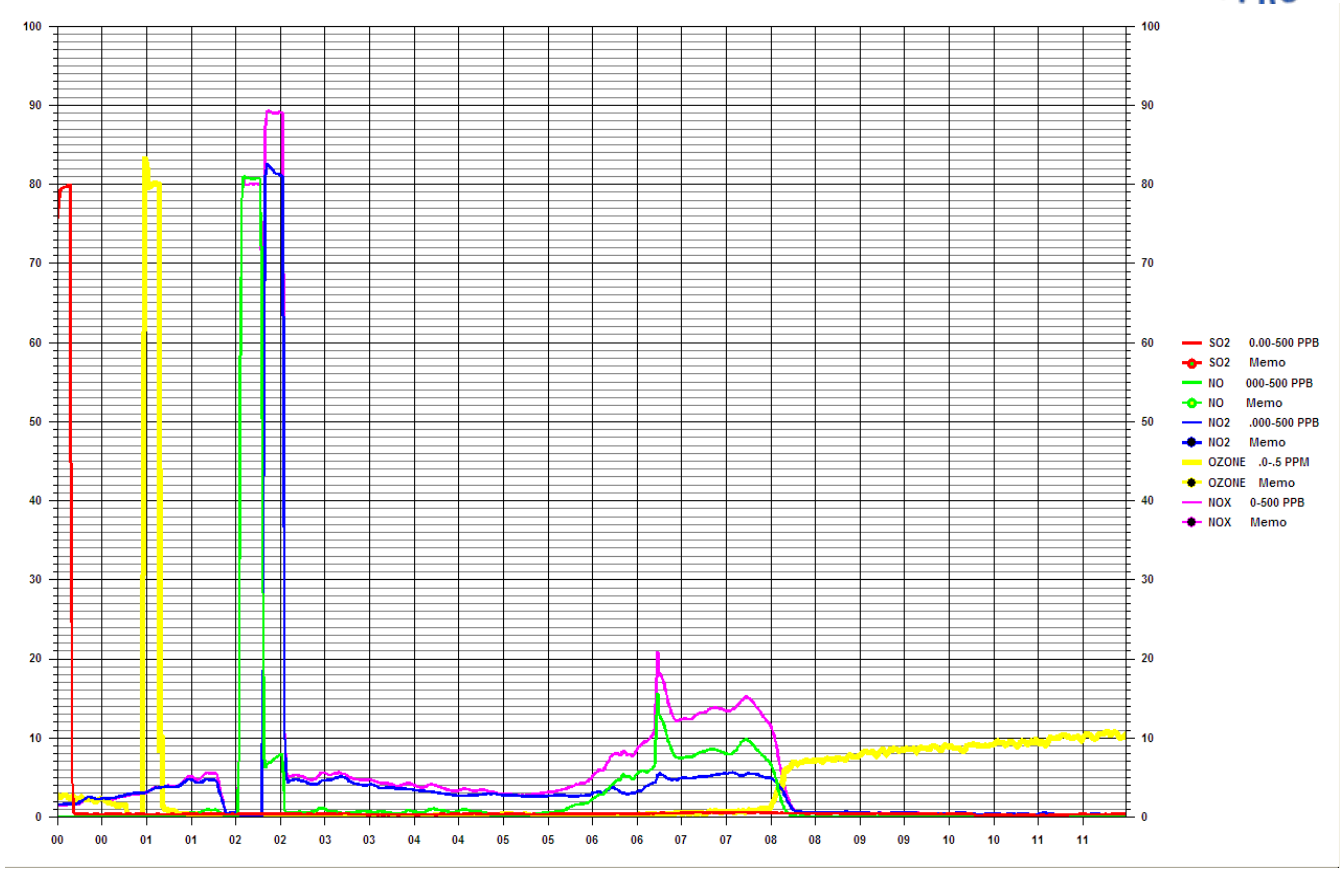
Data Flags : '<' - Less than ##% Data, 'P' - Power Fail, 'D' - Disabled, 'T' - Out-of-Control,
'B' - Bad Status, 'C' - Calibration, 'M' - Maintenance, 'O' - Analog Overrange,
'A' - Arithmetic Error, '+' - Maximum, '-' - Minimum, 'R' - Rate of Change,

Level 1 Verification, Continued:

- Verify data against FRM/FEM specifications. Document any excursions.
- Verify data against other instrument specifications. Document any excursions.
- Review the **maximum and minimum concentrations**
  - Do the values make sense?
  - Are the values real or the results of an automated QC procedure?
  - If errors are found, document them, along with the reasons explaining their cause.

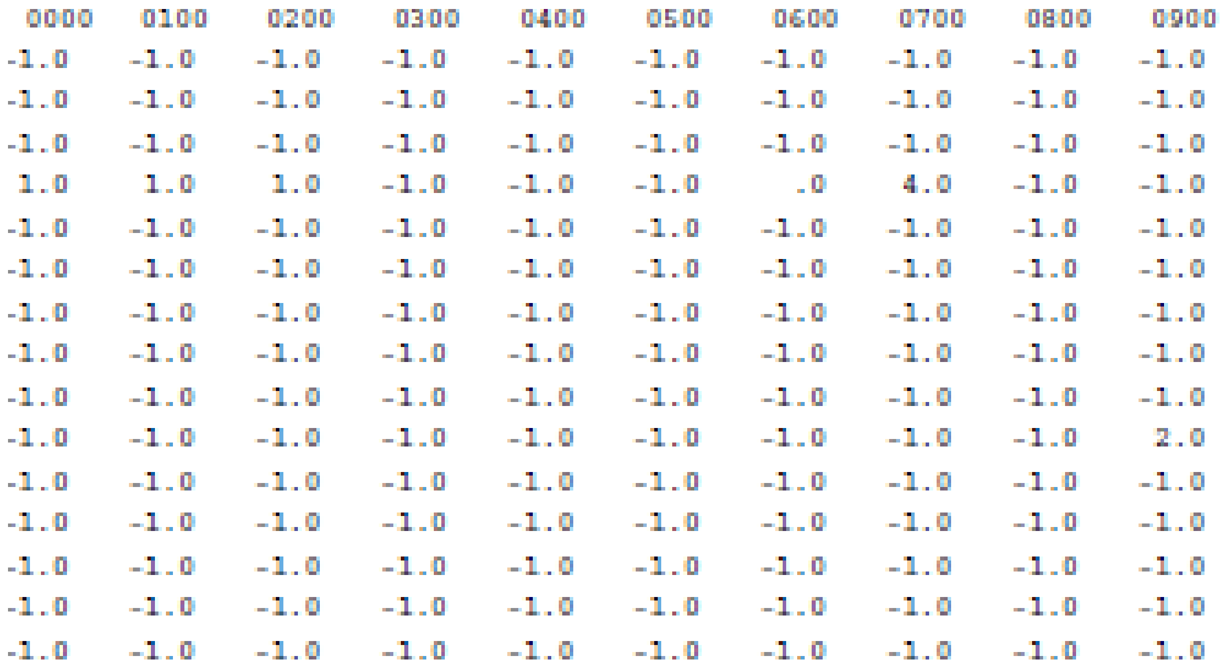
Level 1 Verification, Continued:

- Look for **outliers.** If identified, investigate to determine root cause. Document findings.
- Compare pollutant concentrations to the analyzer's **strip chart** (analog or digital) to check for DAS accuracy.



Monthly Data Verification Procedures

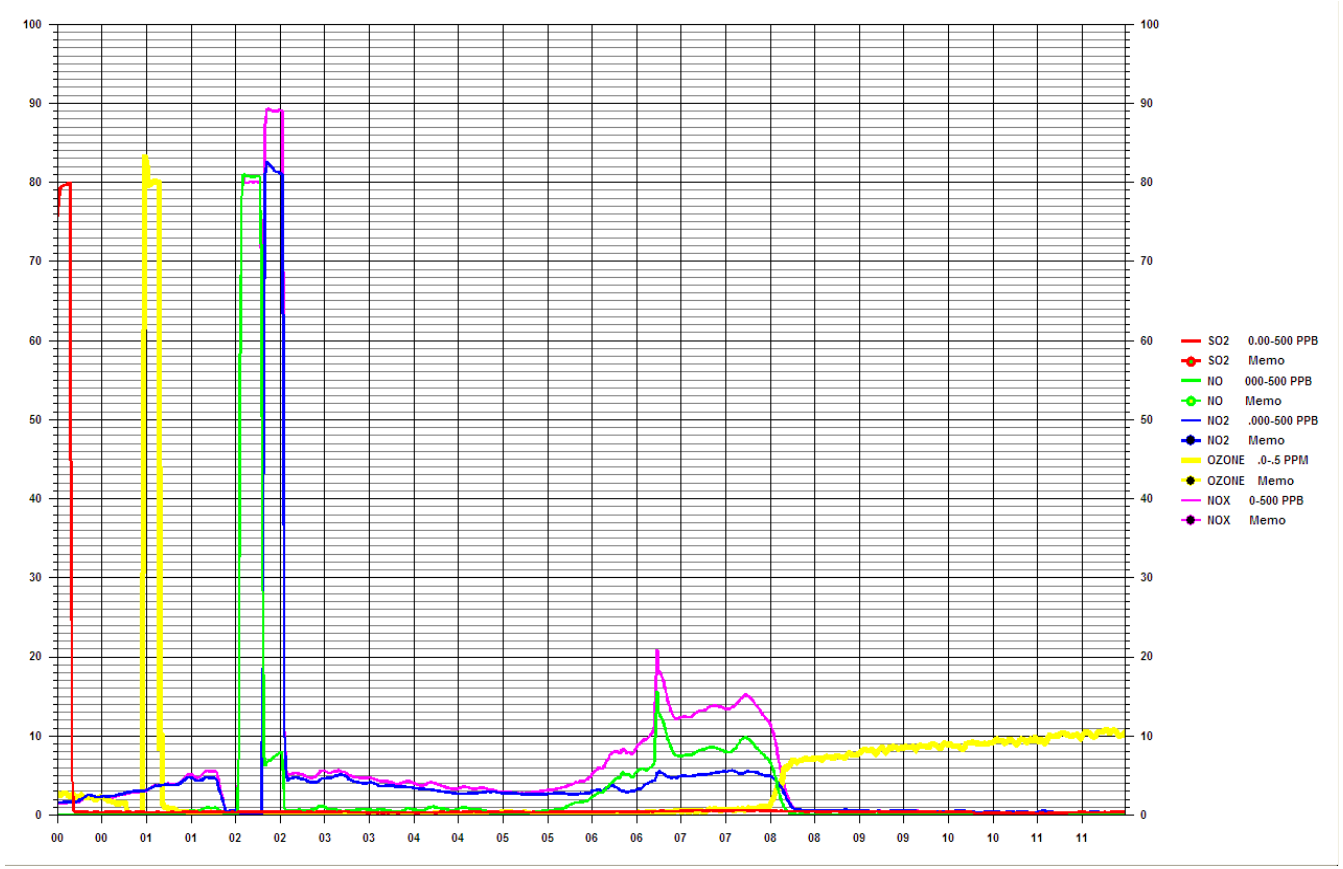
- Still Level 1 Review – but a larger data set (i.e. one month, instead of 24 hours)
- Use same criteria as previously described for daily review to look for oversights



0000	0100	0200	0300	0400	0500	0600	0700	0800	0900
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1.0	1.0	1.0	-1.0	-1.0	-1.0	.0	4.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	2.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

Trends become more apparent through a monthly review!

Data Verification Best Practice: Review Minute Data

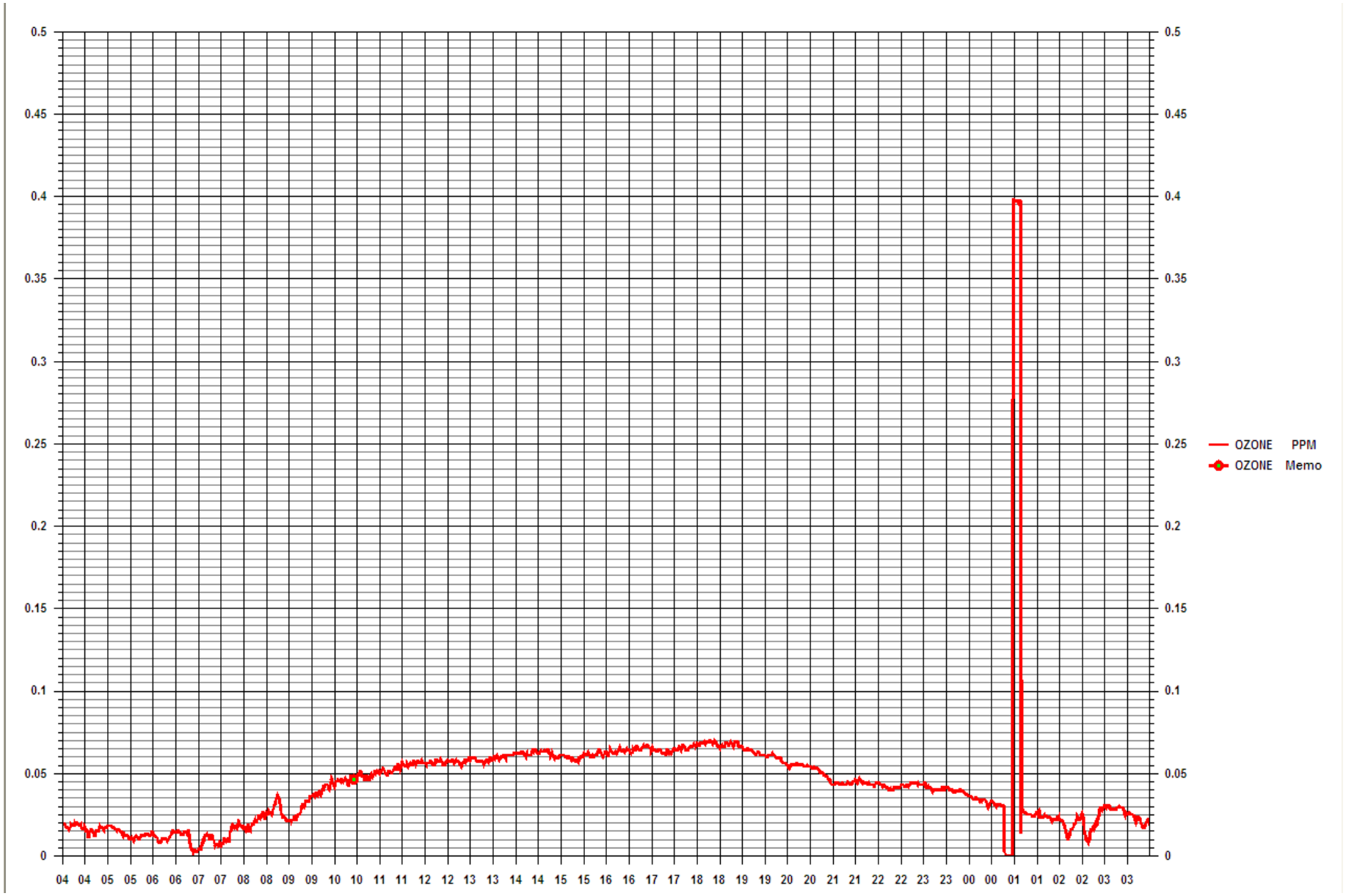


Look for patterns in the minute data

Verify data spikes and anomalies to determine root causes

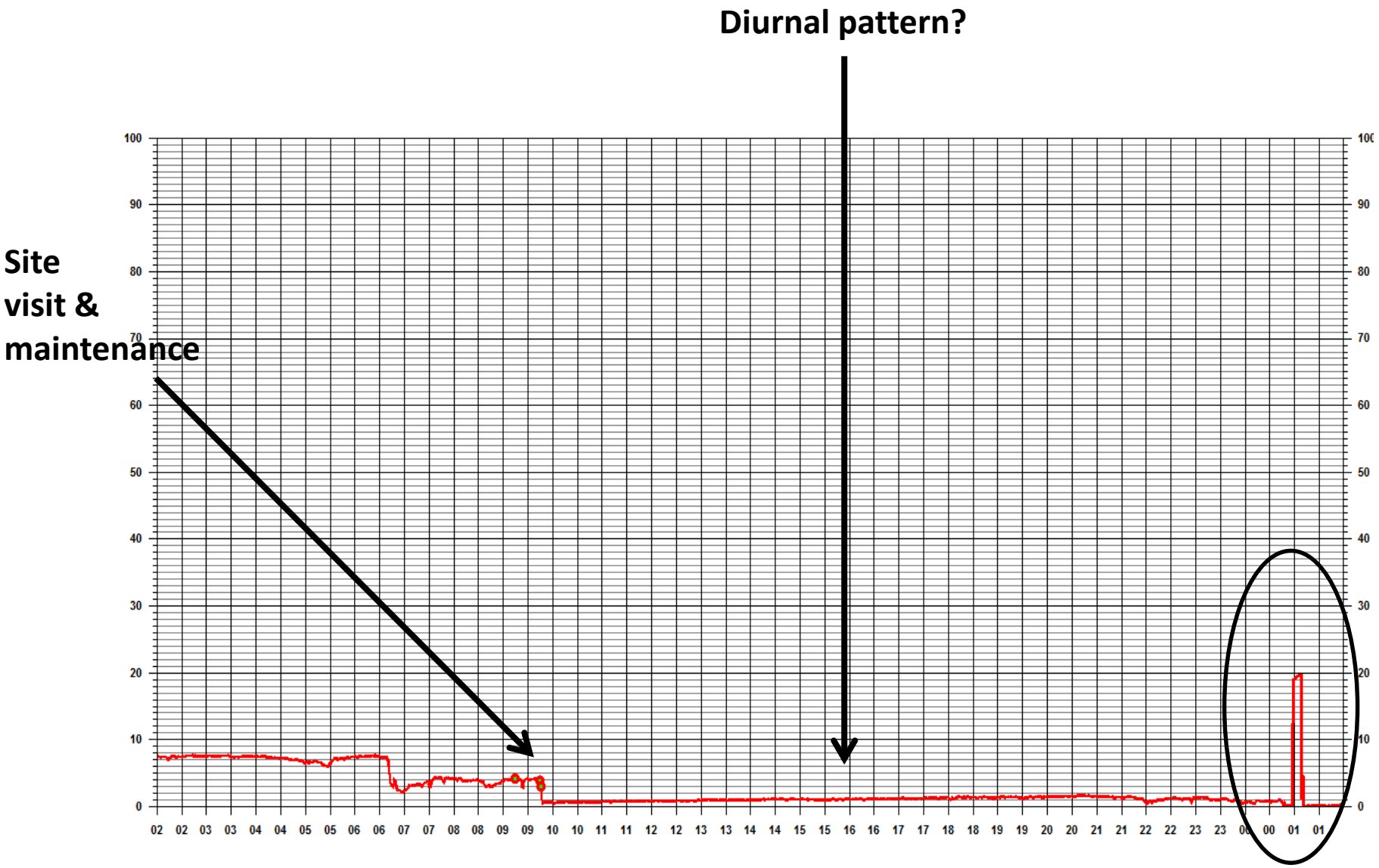
Benefits of Minute Data Review

- Graphical display of data can illuminate problems that might be harder to catch if only viewing numerical reports
- Can identify faulty or degrading equipment prior to a major malfunction, which minimizes data loss
- Identifies problems with instrument set-up or datalogger programming, which can expedite corrective action & minimize data loss
- More easily identifies trends & patterns in the data set; anticipated behavior of pollutants can be more easily seen and verified
- Provides a higher level of confidence in the quality of data collected & reported to AQS



Expected Ozone Diurnal Pattern

24-hr view of data

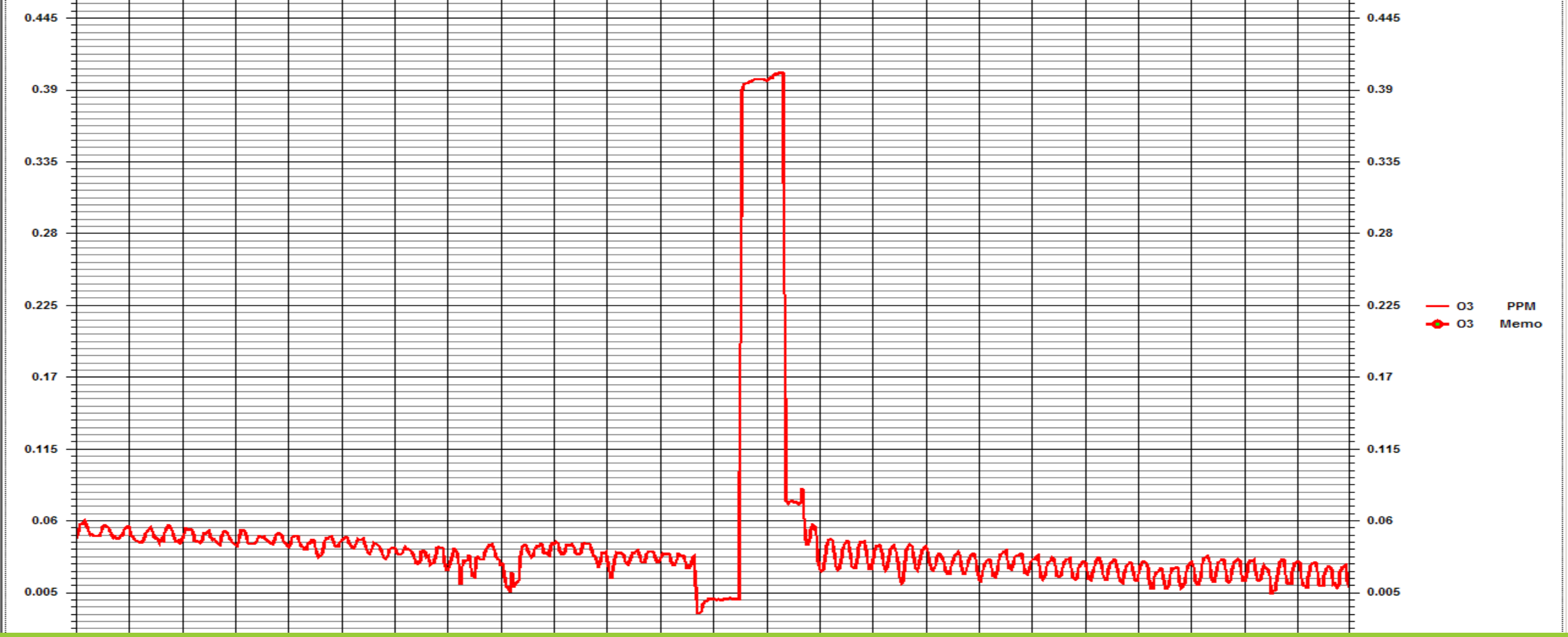


24-hr view of ozone data

Analyzer leak following internal filter change

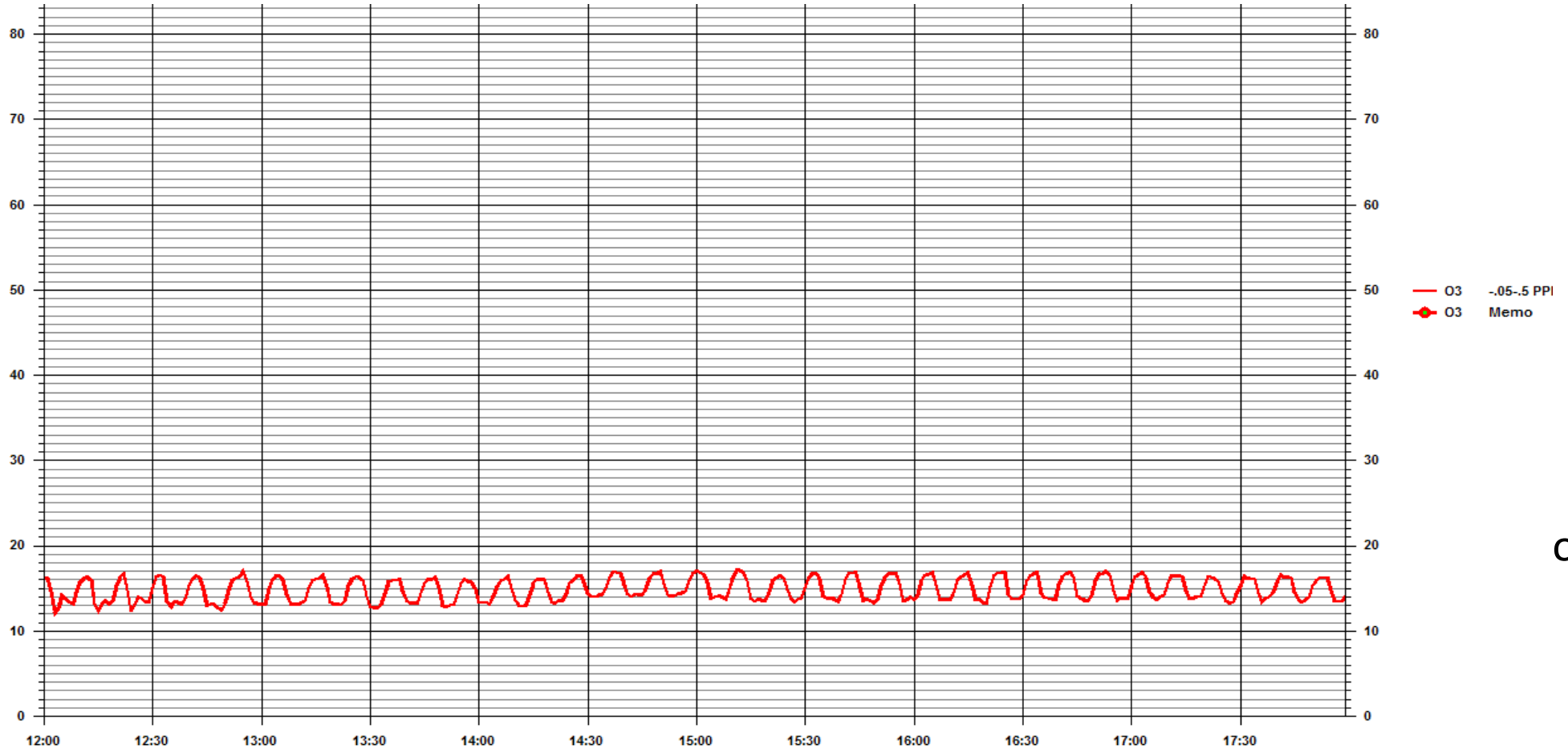
Minute data illustrates lack of diurnal pattern during heat of day

Failed span check follows



Solenoid and/or Detector Malfunction

The QC data for this day looked normal, as did the hourly averages. However, you can see from the graph that there is actually a malfunction occurring.



6-hour view of ozone data

Water in the Sample Lines

The QC data for this day looked normal, but the operator can see from the graph that there is something wrong.

Parameter:O3 Units:ppb

July 2016

Day/Hour		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Obs	Min	Max	Avg
Fri	1	35	36	33	37	31	21	28	38	42	42	41	40	45	53	53	53	48	43	40	37	35	34	34	BF	23	21	53	39
Sat	2	36	38	34	31	26	23	36	46	42	43	48	42	46	42	44	45	43	42	35	30	35	32	32	BF	23	23	48	38
Day/Hour		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Obs	Min	Max	Avg
Sun	3	40	43	46	46	40	33	40	44	45	44	42	42	49	47	54	61	60	60	59	58	55	50	50	BF	23	33	61	48
Mon	4	50	46	42	40	39	35	BF	BF	30	32	30	35	34	38	45	44	45	47	47	50	47	45	39	BF	21	30	50	41
Tue	5	20	20	19	18	16	15	18	BF	23	26	26	27	27	27	28	28	26	27	28	25	25	25	26	BF	22	15	28	24
Wed	6	25	23	21	18	18	19	21	22	26	28	29	25	26	34	26	25	24	20	19	20	18	19	19	BF	23	18	34	23
Thu	7	14	13	9	10	9	6	14	21	23	23	25	26	24	22	22	22	21	22	20	19	15	13	11	BF	23	6	26	18
Fri	8	15	12	10	10	7	5	9	17	20	29	30	28	34	29	27	26	23	21	19	16	14	14	14	BF	23	5	34	19
Sat	9	17	18	17	17	14	14	19	23	26	31	36	43	43	44	42	40	34	28	19	15	19	16	14	BF	23	14	44	26
Day/Hour		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Obs	Min	Max	Avg
Sun	10	9	7	5	5	3	5	15	24	35	41	47	40	38	34	34	38	35	38	33	22	15	14	9	BF	23	3	47	24
Mon	11	4	4	5	3	5	6	12	21	23	28	20	22	24	28	29	27	21	18	15	13	11	9	7	BF	23	3	29	15
Tue	12	5	3	5	6	6	9	11	18	22	18	24	26	26	23	22	22	22	30	24	17	19	17	17	BF	23	3	30	17
Wed	13	11	15	15	5	4	5	11	21	27	23	23	30	26	26	22	20	16	16	8	8	9	5	4	BF	23	4	30	15
Thu	14	5	2	1	1	2	2	10	21	30	32	34	44	48	44	35	36	33	26	23	23	16	8	14	BF	23	1	48	21
Fri	15	16	12	8	6	4	6	9	23	34	40	46	50	55	57	53	35	45	39	36	31	27	20	18	BF	23	4	57	30
Sat	16	13	8	9	7	12	14	19	29	35	37	39	40	42	38	37	37	33	29	27	26	22	12	14	BF	23	7	42	25
Day/Hour		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Obs	Min	Max	Avg
Sun	17	9	7	9	20	13	13	18	24	34	36	38	34	35	40	50	51	50	49	45	40	35	34	30	BF	23	7	51	31
Mon	18	27	25	13	7	6	-1	AY	35	55	-2	48	BA	35	24	34	26	30	14	15	19	19	19	15	BF	21	-2	35	22
Tue	19	10	7	7	8	9	3	8	-2	0	1	3	3	12	19	14	4	5	7	9	7	6	3	2	BF	23	-2	19	6
Wed	20	10	13	12	13	9	5	8	7	2	-4	-1	3	2	1	0	2	-2	4	8	7	2	5	4	-3	24	-4	13	4
Thu	21	-2	1	0	1	-1	2	3	3	2	1	5	6	2	7	9	7	8	4	3	1	-1	0	4	1	24	-2	9	3
Fri	22	1	2	3	5	7	3	3	2	7	5	3	2	5	7	8	4	5	3	2	1	1	1	-1	-1	24	-1	8	3
Sat	23	1	1	2	3	4	1	5	5	7	5	2	3	1	-1	1	-1	-2	-1	1	1	2	2	4	0	24	-2	7	2
Day/Hour		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Obs	Min	Max	Avg
Sun	24	2	2	1	1	-1	-1	-2	-2	-3	-3	-4	-4	-4	-4	-5	-4	-4	-5	-5	-5	-5	-5	-5	-5	24	-5	2	-3
Mon	25	-5	-5	-4	-5	-4	-4	-5	-5	-4	-4	-4	-5	-5	-4	-4	-4	-3	-4	-5	-5	-5	-5	-5	-5	24	-5	0	-4
Tue	26	-5	-5	-5	-5	-4	-4	-5	BA	BA	BA	BA	BC	BC	BC	39	36	35	33	31	27	26	24	23	20	17	-5	39	15
Wed	27	15	19	22	25	27	25	25	33	40	50	54	55	58	61	60	60	59	58	58	55	53	50	50	45	24	15	61	44
Thu	28	45	35	28	38	42	42	48	45	46	52	55	54	53	52	55	53	59	57	55	56	45	43	39	38	24	28	59	47
Fri	29	35	25	28	26	24	30	34	35	34	35	27	28	34	31	27	26	23	25	17	10	10	6	4	4	24	4	35	24
Sat	30	2	3	10	11	13	10	17	27	34	38	36	38	35	40	46	45	43	39	30	26	24	24	24	20	24	2	46	26
Day/Hour		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Obs	Min	Max	Avg
Sun	31	20	19	13	8	5	11	19	31	41	41	43	42	35	44	46	39	36	37	35	34	35	30	25	22	24	5	46	30

Significantly low concentrations of ozone in July?

Monthly Data Verification Procedures

- Re-review minute data (strip charts) to watch for trends or shifts **over time**
- Review logbook notations for issues not previously observed

Monthly Data Verification Procedures

- Verify documentation on all spreadsheets, forms, and/or supporting data reports
  - Is documentation complete and accurate?
  - Does it convey everything the data validator needs to know?

Form No. DEP 06-13-B

Thermo 49i Preventative Maintenance Schedule

Identification Block							
Site Name:	Acme Island	Site AQS:	A033-0004	Data Logger Model:	8832	Data Lo	
Calendar Year:	2016	49i Serial Number:	738506	Data Logger Serial No.:	A28475		

Task	Frequency	Date Perf	Op. Init.	QA Init.	Due Date	Date Perf	Op. Init.	QA Init.	Due Date	Date Perf	Op. Init.	QA Init.	Due D
Sample Line Filter Change	Monthly	1/21/16	JM		2/20/16	2/22/16	JM		3/23/16	3/15/16	JM		4/14
Sample Line Filter Change	Monthly	5/27/16	JM		6/26/16	6/24/16	JM		7/24/16	7/17/16	JM		8/16
Sample Line Filter Change	Monthly												
Clean Instrument Interior	Quarterly	2/26/16	JM		5/26/16								
Sample Line Integrity Check	Quarterly	2/19/16	JM		5/19/16								
Multipoint Calibration	Annually	2/29/16	JM		2/28/17	5/2/16	JM		5/2/17	6/24/16	JM		6/24
Replace Sample Line	Annually	2/26/16	JM		2/25/17								
Clean Absorption Cells	Annually	2/22/16	JM		2/21/17								
Pressure Sensor Calibration	Annually	2/22/16	JM		2/21/17								
Temperature Calibration	Annually	2/22/16	JM		2/21/17								
[illegible] Performance Audit	Annually	[illegible]			3/24/17								

Operator Comments

Water observed in the sample line and in the instrument on July 17.

QA Review Comments

- **Document** Level 1 Reviews
  - Daily: Notations on an electronic log, printed Daily Summary Report
  - Monthly summary report
  - Agency-specific written report
- Sign and date the data review report/summary
- Submit report and any required supporting documentation to the designated next-level reviewer

Data Validation Levels 2-3

Level 0
- Datalogger / Sampler
- Continuous / Daily
- Distinguish measurements from measurement errors or pre-programmed (automated) QC activities

Level 1
- Site Operator
- Daily / Monthly
- Distinguish measurements from measurement errors or interferences

Level 2
- Independent Reviewer (QA)
- Monthly / Quarterly
- Verify Level 1 Review
- Ensure data meets QA/QC requirements and objectives of its intended use

Level 3
- Independent Review (QAM)
- Monthly / Quarterly / Annually
- Verify Level 1 and 2 Reviews
- Approve data suitability for release to AQS

- Level 2 = **Independent** data reviewer/validator
- **Monthly** data review (percentage)
- **Quarterly** data review to look for trends or oversights
- Goals:
  - 1) Verify Level 1 Review
  - 2) Ensure data meets QA/QC requirements and intended use
- Use supporting documentation and objective evidence to make data validity judgment calls
- Do <u>not</u> make assumptions

Level 2 Goal #1: Verify the Level 1 Review

Should include, but is not limited to, the following:

- Look for any missing data (**gaps**) not identified by the operator
  - If found, investigate cause and determine method to handle data gap
- Check suggested null codes against supporting documentation
- Review the daily **maximum and minimum concentrations** for accuracy
- Look for constantly **repeating values** and/or **outliers**
- If errors are found, the data validator should scrutinize a larger percentage of the data and/or return the data package to the Level 1 Reviewer for a second review

Level 2 Goal #2: Ensure data meets QA/QC requirements and the objectives of its intended use

What does this generally include?

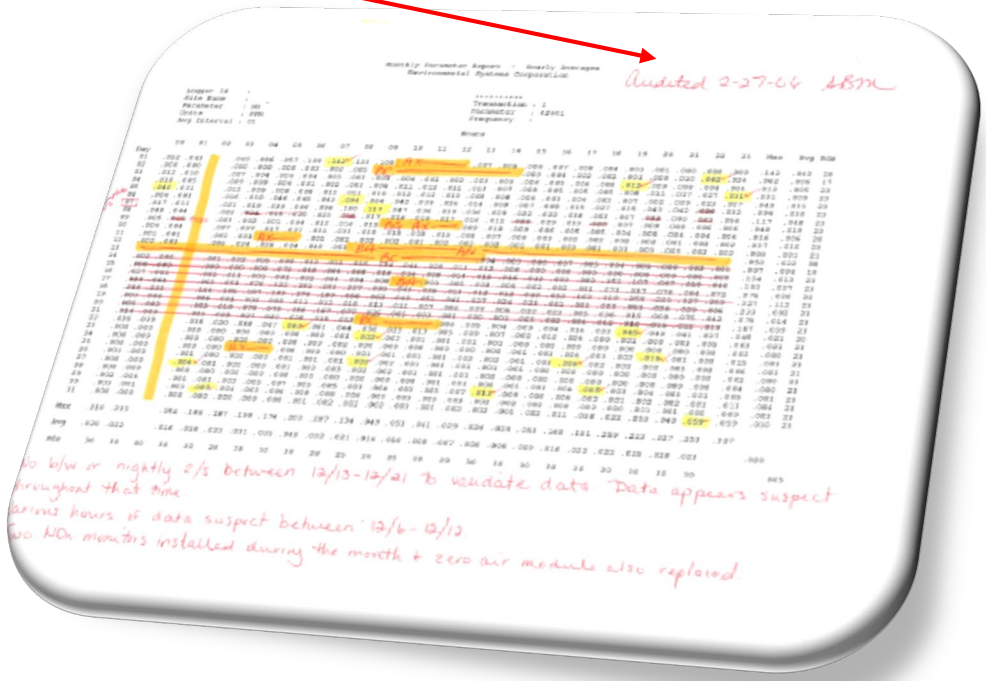
- Compare data to pollutant's MQO table
- Verify QA/QC checks were completed & performed in accordance with QAPP/SOPs (**strip chart!!**)
- Compare data to other QAPP/SOP requirements
- Investigate any areas of concern noted by the site operator
- Compare concentrations to neighboring sites
- Bracket data using QA/QC check results and/or other objective, documented evidence

Ozone Validation Template

1) Requirement (O_3)	2) Frequency	3) Acceptance Criteria	Information /Action
CRITICAL CRITERIA-OZONE			
Monitor	NA	*Meets requirements listed in FRM/FEM designation*	1) 40 CFR Part 58 App C Sec. 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
One Point QC Check Single analyzer	*Every 14 days*	< ±7.1% (percent difference) or < ±1.5 ppb difference whichever is greater	1 and 2) 40 CFR Part 58 App A Sec. 3.1 3) Recommendation based on DQO in 40 CFR Part 58 App A Sec. 2.3.1.2. QC Check Conc range 0.005 - 0.08 ppm and 05/05/2016 Technical Note on AMTIC
Zero/span check	Every 14 days	Zero drift < ± 3.1 ppb (24 hr) < ± 5.1 ppb (>24hr-14 day) Span drift < ± 7.1 %	1 and 2) QA Handbook Volume 2 Sec. 12.3 3) Recommendation and related to DQO
OPERATIONAL CRITERIA -OZONE			
Shelter Temperature Range	Daily (hourly values)	20.0 to 30.0° C. (Hourly avg) or per manufacturers specifications if designated to a wider temperature range	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2 Generally, the 20-30.0° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance. FRM/FEM list found on AMTIC provides temp. range for given instrument. FRM/FEM monitor testing is required at 20-30° C range per 40 CFR Part 53.32
Shelter Temperature Control	Daily (hourly values)	< 2.1° C SD over 24 hours	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2
Shelter Temperature Device Check	Every 182 days and 2/ calendar year	< ± 2.1° C of standard	1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2
Annual Performance Evaluation Single analyzer	*Every site every 365 days and 1/ calendar year within period of monitor operation,*	Percent difference of audit levels 3-10 < ±15.1% Audit levels 1&2 < ± 1.5 ppb difference or < ± 15.1%	1 and 2) 40 CFR Part 58 App A Sec. 3.1.2 3) Recommendation- 3-audit concentrations not including zero. AMTIC guidance 2/17/2011 AMTIC Technical Memo
Federal Audits (NPAP)	*20% of sites audited in calendar*	Audit levels 1&2 < ± 1.5 ppb difference all other levels percent difference < ± 10.1%	1 and 2) 40 CFR Part 58 App A Sec. 3.1.3 3) NPAP QAPP/SOP
Certification/recertification to Standard Reference Photometer (Level 1)	Every 365 days and 1/calendar year	single point difference < ± 3.1%	1) 40 CFR Part 50 App D Sec. 5.4 2 and 3) Transfer Standard Guidance EPA-454/B-10-001 Level 2 standard (formerly called primary standard) usually transported to EPA Regions SRP for comparison
Level 2 and Greater Transfer Standard Precision	Every 365 days and 1/calendar year	***Standard Deviation less than 0.005 ppm or 3.0% whichever is greater***	1) 40 CFR Part 50 Appendix D Sec. 3.1 2) Recommendation, part of reverification 3) 40 CFR Part 50 Appendix D Sec. 3.1
(if recertified via a transfer standard)	Every 365 days and 1/calendar year	Regression slopes = 1.00 ± 0.03 and two intercepts are 0 ± 3 ppb	1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001
Ozone Transfer standard (Level 3 and greater)			
Qualification	Upon receipt of transfer standard	< ±4.1% or < ±4 ppb (whichever greater)	1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001
Certification	After qualification and upon receipt/adjustment/repair	RSD of six slopes ≤ 3.7% Std. Dev. of 6 intercepts ≤ 1.5	1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001 1
Recertification to higher level standard	Beginning and end of O3 season or every 182 days and 2/calendar year whichever less	New slope = ± 0.05 of previous and RSD of six slopes ≤3.7% Std. Dev. of 6 intercepts ≤ 1.5	1, 2 and 3) Transfer Standard Guidance EPA-545/B-10-001 recertification test that then gets added to most recent 5 tests. If does not meet acceptability certification fails
Detection (FEM/FRMs) Noise and Lower Detectable Limits (LDL) are part of the FEM/FRM requirements. It is recommended that monitoring organizations perform the LDL test to minimally confirm and establish the LDL of their monitor. Performing the LDL test will provide the noise information.			
Noise	Every 365 days and 1/ calendar year	***≤ 0.0025 ppm (standard range)*** ***≤ 0.001 ppm (lower range)***	1) 40 CFR Part 53.23 (b) (definition & procedure) 2) Recommendation- info can be obtained from LDL 3) 40 CFR Part 53.20 Table B-1
Lower detectable limit	Every 365 days and 1/calendar year	***< 0.005 ppm (standard range)*** ***≤ 0.002 ppm (lower range)***	1) 40 CFR Part 53.23 (b) (definition & procedure) 2) Recommendation 3) 40 CFR Part 53.20 Table B-1
SYSTEMATIC CRITERIA-OZONE			
Standard Reporting Units	***All data***	***ppm (final units in AQS)***	1, 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1
Rounding convention for design value calculation	***All routine concentration data***	***3 places after decimal with digits to right truncated***	1, 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1 The rounding convention is for averaging values for comparison to NAAQS not for reporting individual hourly values.
Completeness (seasonal)	***3-Year Comparison***	***≥ 90% (avg) daily max available in ozone season with min of 75% in any one year.***	1) 40 CFR Part 50 App I 2) 40 CFR Part 50 App I Sec. 2.3 3) 40 CFR Part 50 App I Sec. 2.3 (b)
	8- hour average	***≥75% of hourly averages for the 8-hour (6 of 8 hours)***	1) 40 CFR Part 50 App I 2 and 3) 40 CFR Part 50 App I Sec. 2.1.1
	Valid Daily Max	***≥ 75% of the 24, valid 8 hour averages (18 of 24 8-hour averages***	1) 40 CFR Part 50 App I 2) 40 CFR Part 50 App I Sec. 2.1.2 3) 40 CFR Part 50 App I Sec. 2.1.2 (b)

Sign and date the data review report/summary to document the completed Level 2 review

Submit report/summary and any required supporting documentation to the **designated next-level reviewer**



- Level 3 = Another **independent** data reviewer (QAM)
- Goals:
  - 1) Verify Levels 1 & 2 Reviews
  - 2) Ensure data meets objectives of its intended use
  - 3) Approve data suitability for upload to AQS
- Similar to Level 2 review, except that a **smaller percentage** of data is examined
- Verify that in-house records and documentation support the data validation decisions
- **If issues are found, the QAM should review a larger percentage of the data and/or return the package to the Level 2 reviewer for second review**

Intermittent Sampler Data Review

Monitoring Organization

- Level 0 = Sampler
- Level 1 = Site Operator
- Level 2 = Data Reviewer
- Level 3 = QAM

Laboratory

- Level 1 = Lab Analyst
- Level 2 = Lab Supervisor
- Level 3 = Lab QAM

Final Review & Approval by Monitoring Org QAM → AQS

Example Particulate Data Validation Template

Field Criteria

$PM_{2.5}$ Filter Based Local Conditions Validation Template

1) Criteria (PM2.5 LC)	2) Frequency	3) Acceptable Range	Information /Action
CRITICAL CRITERIA- $PM_{2.5}$ Filter Based Local Conditions			
Field Activities			
Sampler/Monitor	NA	*Meets requirements listed in FRM/FEM/ARM designation*	1) 40 CFR Part 58 App C Sec. 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
Filter Holding Times *Pre-sampling*	*all filters*	*≤ 30 days before sampling*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.3.5
Sample Recovery	*all filters*	*≤ 7 days 9 hours from sample end date*	1, 2 and 3) 40 CFR Part 50, App. L 10.10
Sampling Period (including multiple power failures)	*all filters*	*1380-1500 minutes, or if value < 1380 and exceedance of NAAQS 1/ midnight to midnight local standard time*	1, 2 and 3) 40 CFR Part 50 App L Sec. 3.3 and 40 CFR Part 50 App N Sec. 1 for the midnight to midnight local standard time requirement See details if less than 1380 min sampled
Sampling Instrument			
Average Flow Rate	*every 24 hours of op*	*average within 5% of 16.67 liters/minute*	1, 2 and 3) Part 50 App L Sec. 7.4.3.1
Variability in Flow Rate	*every 24 hours of op*	*CV ≤ 2%*	1, 2 and 3) 40 CFR Part 50, App L Sec. 7.4.3.2
One-point Flow Rate Verification	*every 30 days each seperated by 14 days*	*< ± 4.1% of transfer standard* *< ± 5.1% of flow rate design value*	1, 2 and 3) 40 CFR Part 50, App L, Sec. 9.2.5 and 7.4.3.1 and 40 CFR Part 58, Appendix A Sec. 3.2.1
Design Flow Rate Adjustment	*After multi-point calibration or verification*	*< ± 2.1% of design flow rate*	1, 2 and 3) 40 CFR Part 50, App. L, Sec. 9.2.6
Individual Flow Rates	*every 24 hours of op*	*no flow rate excursions > ±5% for > 5 min. 1/*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 7.4.3.1
Filter Temp Sensor	*every 24 hours of op*	*no excursions of > 5° C lasting longer than 30 min 1/*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 7.4.11.4
External Leak Check	*Before each flow rate verification/calibration* and before and after $PM_{2.5}$ separator maintenance	*< 80.1 mL/min* (see comment #1)	1) 40 CFR Part 50 App L, Sec. 7.4.6.1 2) 40 CFR Part 50 App L Sec. 9.2.3 and Method 2-12 Sec. 7.4.3 3) 40 CFR Part 50, App. L, Sec. 7.4.6.1
Internal Leak Check	If failure of external leak check	*< 80.1 mL/min*	1) 40 CFR Part 50, App. L, Sec. 7.4.6.2 2) Method 2-12, Sec. 7.4.4 3) 40 CFR Part 50, App. L, Sec. 7.4.6.2

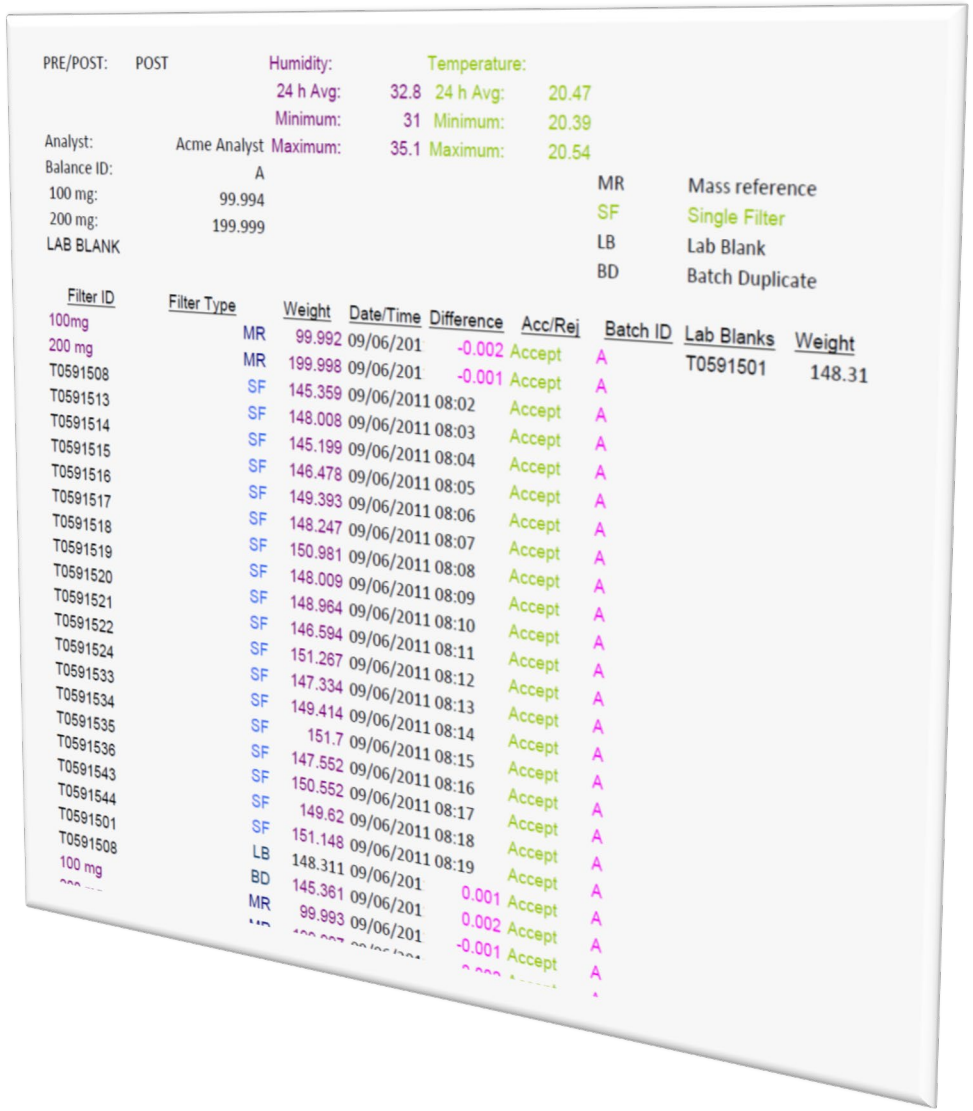
Laboratory Criteria

Laboratory Activities			
1) Criteria (PM2.5 LC)	**2) Frequency**	**3) Acceptable Range**	**Information /Action**
Post-sampling Weighing	*all filters*	*Protected from exposure to temperatures above 25C from sample retrieval to conditioning* *≤10 days from sample end date if shipped at ambient temp, or* *< 30 days if shipped below avg ambient (or 4° C or below for avg sampling temps < 4° C) from sample end date*	1, 2 and 3) 40 CFR Part 50 App L Sec. 8.3.6 and L Sec. 10.13. See technical note on holding time requirements at : https://www3.epa.gov/ttn/amtic/pmpolgud.html
Filter Visual Defect Check (unexposed)	*all filters*	*Correct type & size and for pinholes, particles or imperfections*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 10.2
Filter Conditioning Environment			
Equilibration	*all filters*	*24 hours minimum*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.2.5
Temp. Range	*all filters*	*24-hr mean 20.0-23.0° C*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.2.1
Temp. Control	*all filters*	*< 2.1° C SD* over 24 hr.*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.2.2 SD use is a recommendation
Humidity Range	*all filters*	*24-hr mean 30.0% - 40.0% RH or Within ±5.0 % sampling RH but ≥ 20.0%RH*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.2.3
Humidity Control	*all filters*	*< 5.1 % SD* over 24 hr.*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.2.4 SD use is recommendation
Pre/post Sampling RH	*all filters*	*difference in 24-hr means < ± 5.1% RH*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.3.3
Balance	*all filters*	*located in filter conditioning environment*	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.3.2
Microbalance Auto-Calibration	*Prior to each weighing session*	Manufacturer's specification	1) 40 CFR Part 50, App. L, Sec. 8.1 2) 40 CFR Part 50, App. L, Sec. 8.1 and Method 2.12 Sec. 10.6 3) NA

The monitoring organization is responsible for final validation of data, including data obtained from contract laboratories

In The Lab

- Each method will have different QA/QC requirements that will need to be reviewed.
- Analyst will be responsible for verifying laboratory batch session results
- Lab supervisor will ensure the acceptability of the analyses, QC checks, and the completeness of the data
- Final review and release to client by laboratory QAM



PRE/POST: POST

		Humidity:		Temperature:	
		24 h Avg:	32.8	24 h Avg:	20.47
		Minimum:	31	Minimum:	20.39
Analyst:	Acme Analyst	Maximum:	35.1	Maximum:	20.54
Balance ID:	A				
100 mg:	99.994				
200 mg:	199.999				
LAB BLANK					

MR	Mass reference
SF	Single Filter
LB	Lab Blank
BD	Batch Duplicate

Filter ID	Filter Type	Weight	Date/Time	Difference	Acc/Rej	Batch ID	Lab Blanks	Weight
100mg	MR	99.992	09/06/201	-0.002	Accept	A	T0591501	148.31
200 mg	MR	199.998	09/06/201	-0.001	Accept	A		
T0591508	SF	145.359	09/06/2011 08:02		Accept	A		
T0591513	SF	148.008	09/06/2011 08:03		Accept	A		
T0591514	SF	145.199	09/06/2011 08:04		Accept	A		
T0591515	SF	146.478	09/06/2011 08:05		Accept	A		
T0591516	SF	149.393	09/06/2011 08:06		Accept	A		
T0591517	SF	148.247	09/06/2011 08:07		Accept	A		
T0591518	SF	150.981	09/06/2011 08:08		Accept	A		
T0591519	SF	148.009	09/06/2011 08:09		Accept	A		
T0591520	SF	148.964	09/06/2011 08:10		Accept	A		
T0591521	SF	146.594	09/06/2011 08:11		Accept	A		
T0591522	SF	151.267	09/06/2011 08:12		Accept	A		
T0591524	SF	147.334	09/06/2011 08:13		Accept	A		
T0591533	SF	149.414	09/06/2011 08:14		Accept	A		
T0591534	SF	151.7	09/06/2011 08:15		Accept	A		
T0591535	SF	147.552	09/06/2011 08:16		Accept	A		
T0591536	SF	150.552	09/06/2011 08:17		Accept	A		
T0591543	SF	149.62	09/06/2011 08:18		Accept	A		
T0591544	SF	151.148	09/06/2011 08:19		Accept	A		
T0591501	LB	148.311	09/06/201		Accept	A		
T0591508	BD	145.361	09/06/201	0.001	Accept	A		
100 mg	MR	99.993	09/06/201	0.002	Accept	A		
				-0.001	Accept	A		

Example PM2.5 Weigh Session Data Sheet

In The Field – Monitoring Organization

LEVEL 0 DATA REVIEW

- Some models of PM samplers contain data loggers that are pre-programmed to identify exceedances of critical performance specifications or other outliers
  - Examples: Flow rate and temperature excursions
- Some samplers will also throw status flags in the event of certain mechanical failures
- Capabilities are model-specific.
- Less sophisticated PM samplers do not have these capabilities.

LEVEL 1 DATA REVIEW

Site operators are responsible for pre- and post-sample collection activities, including verifying specific instrument and atmospheric conditions

Visual inspection of sample media

Visual inspection of sampler and station conditions

Download and review of all data collected by the sampler to look for errors

Documentation of all activities and observations which impact sample integrity

Can recommend sample be “void” based on data review or known issues (e.g., damaged sample)

Level 2 Data Review (Field)

Should include, but is not limited to:

- **Verification of all flow rate verifications**
  - Completed on time?
  - Within acceptance criteria (transfer standard and design flow rate)?
- **Verification of performance audit results**
  - Completed on time?
  - NIST-traceable, Independent equipment?
  - Within specification (transfer standard and design flow rate)?
- **Results of field blanks**
  - Within acceptance limits?
  - Any trends? Control charts recommended
- **Sampler Maintenance**
  - Perform when required?
  - Sampler performance specifications checked before & after maintenance?
- **Field Equipment Repairs Noted? If so, determine:**
  - What was the issue?
  - Were sensors recalibrated?
  - QC check prior to field use?
- **Exceptional Events**
  - Unusually high concentrations?
  - Regional review of data results
  - Supporting documentation?

- Levels 2 and 3 review at the monitoring organization should include a review of the **lab data package** to ensure all method requirements and pollutant-specific critical criteria elements were met
- Monitoring Organization should establish agreement with the laboratory to provide specific QC data from the analytical batches in data packages, in addition to sample results (e.g., masses or µg/filter concentrations)
- Copies of all chain-of-custody forms should also be maintained by the monitoring organization

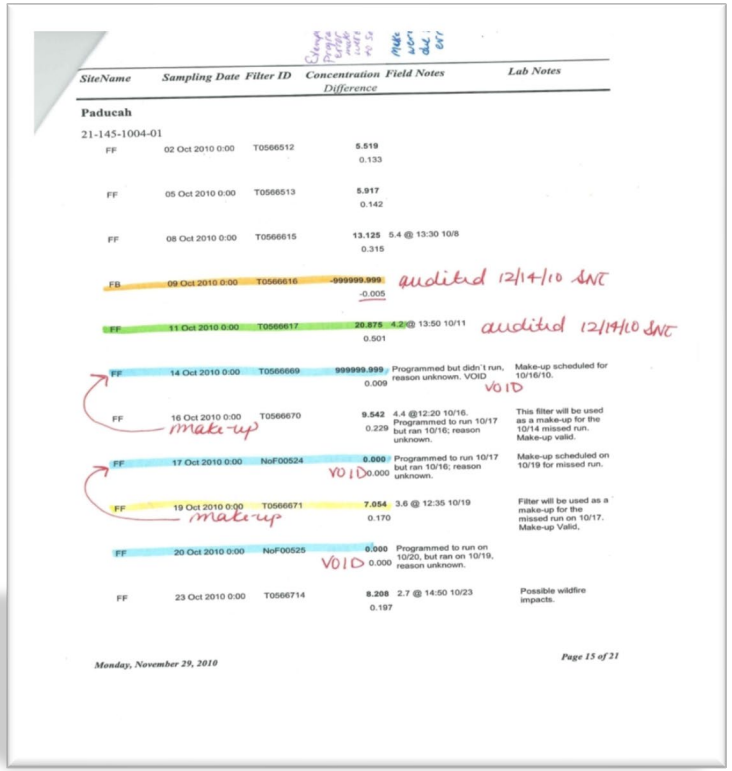
Example Level 2 Data Review Procedure for $PM_{2.5}$

Scenario:

PQAO-operated Gravimetric Laboratory, with a Concentration Query Generated by Lab Analyst from in-house database for QA Review

Query provides site ID, filter type (e.g., sample filter, field blank, trip blank), sample date, concentration, mass difference, and pertinent comments by the site operator and lab analyst

Query contains results from all sites for one calendar month



SiteName	Sampling Date	Filter ID	Concentration / Difference	Field Notes	Lab Notes
Paducah					
21-145-1004-01					
FF	02 Oct 2010 0:00	T0566512	5.519 / 0.133		
FF	05 Oct 2010 0:00	T0566513	5.917 / 0.142		
FF	08 Oct 2010 0:00	T0566615	13.125 / 0.315	5.4 @ 13:30 10/8	
FB	09 Oct 2010 0:00	T0566616	-999999.999 / -0.005	audited 12/14/10 SNT	
FF	11 Oct 2010 0:00	T0566617	20.875 / 0.501	4.2 @ 13:50 10/11	audited 12/14/10 SNT
FF	14 Oct 2010 0:00	T0566669	999999.999 / 0.009	Programmed but didn't run, reason unknown. VOID	Make-up scheduled for 10/16/10. VOID
FF	16 Oct 2010 0:00	T0566670	9.542 / 0.229	4.4 @12:20 10/16. Programmed to run 10/17 but ran 10/16; reason unknown.	This filter will be used as a make-up for the 10/14 missed run. Make-up valid.
FF	17 Oct 2010 0:00	NoF00524	0.000 / 0.000	Programmed to run 10/17 but ran 10/16; reason unknown.	Make-up scheduled on 10/19 for missed run.
FF	19 Oct 2010 0:00	T0566671	7.054 / 0.170	3.6 @ 12:35 10/19	Filter will be used as a make-up for the missed run on 10/17. Make-up Valid.
FF	20 Oct 2010 0:00	NoF00525	0.000 / 0.000	Programmed to run on 10/20, but ran on 10/19, reason unknown.	
FF	23 Oct 2010 0:00	T0566714	8.208 / 0.197	2.7 @ 14:50 10/23	Possible wildfire impacts.

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Example: Monthly $PM_{2.5}$ Data Review

- ✓ Highlight the maximum concentration and one random concentration from each site
  - ✓ Manually calculate concentrations using lab and field data to ensure computations are correct
  - ✓ Review all field/lab critical criteria and supporting documentation to ensure samples are valid and meets method requirements
- ✓ Highlight all field blanks results
  - ✓ Verify concentrations on a percentage of blanks & note if any exceed 30 µg
- ✓ Review results between all collocated data pairs
  - ✓ If pair exceeds acceptance limits, investigate why
- ✓ Highlight any sample concentrations less than 2 $\mu g/m^3$
  - ✓ If observed, review operator notes & compare concentrations from site to site

Example: $PM_{2.5}$ Data Review, Continued

Supporting documentation to review to inform this process:

- ✓ Documentation from lab analyst that may cause samples to be questionable or void
- ✓ Documentation by site operator for pertinent notes/commentary that may cause samples questionable or void. Includes, but is not limited to:
  - ✓ Chain-of-custody forms
  - ✓ Logbook documentation
  - ✓ QC check, calibration, and/or maintenance forms
- ✓ Spot-check a percentage of sampler filter and interval data files for anomalies, in order to confirm Level 1 review
- ✓ Bracket data using results of QA/QC checks!

V	W	X	Y	Z	AA	AB	AC	
Sample Date	Sample Retrieval Date	Sample Date & Sample Retrieval Difference (hrs)	Tare Mass (mg)	Exposed Mass (mg)	Net Mass (mg)	Sampler Runtime (min)	Sampler CV	C
07/02/2019	07/03/2019 09:35	9.58	378.7491	379.0030	0.2539	1440	0.60	
07/08/2019	07/11/2019 11:00	59.00	377.2786	377.6087	0.3301	1434	0.60	
07/14/2019	07/19/2019 12:15	108.25	372.3888	372.6070	0.2182	1440	0.50	
07/20/2019	07/25/2019 11:30	107.50	373.6867	373.8096	0.1229	1440	0.20	
07/26/2019	08/02/2019 11:15	155.25	377.4632	377.7493	0.2861	1440	0.40	
07/21/2019	07/25/2019 11:30		374.6224	374.6293	0.0069			
07/19/2019			372.2163	372.2177	0.0014			
07/02/2019			364.2075	364.5390	0.3315	1440	0.40	
07/05/2019	07/10/2019 10:12	106.20	372.2730	372.8705	0.5975	1440	0.40	
07/08/2019	07/10/2019 10:12	34.20	374.5390	374.8099	0.2709	1440	0.20	
07/11/2019	07/16/2019 10:40	106.67	373.9615	374.1595	0.1980	1440	0.40	
07/14/2019	07/16/2019 10:40	34.67	376.8520	377.0150	0.1630	1440	0.30	
07/17/2019	07/19/2019 09:35	33.58	375.1158	375.4079	0.2921	1440	0.40	
07/20/2019	07/25/2019 09:15	105.25	372.6438	372.7577	0.1139	1440	0.30	
07/23/2019	07/25/2019 09:15	33.25	374.4757	374.6081	0.1324	1440	0.50	
07/26/2019	07/31/2019 10:42	106.70	375.1719	375.4295	0.2576	1440	0.20	
07/29/2019	07/31/2019 10:42	34.70	372.7959	372.9854	0.1895	1440	0.40	
07/24/2019	07/25/2019 09:15		377.0433	377.0435	0.0002			
07/19/2019			374.6209	374.6249	0.0040			
			369.8881	369.8846	-0.0035			

ExposedLabConditions

Date	Filter ID	Concentration (µg/m3) LTP	Sample Period (hr:min)	Sample Volume (m3)	Mass Tare (mg)	Mass Gross (mg)	Mass Net (mg)	Flag	Comments
04/03/19	T8519312	**10.2**	24:00	24.0	374.6194	374.8656	0.2462		
04/09/19	T8519316	**3.5**	24:00	24.0	366.4344	366.5200	0.0856		
04/15/19	T8519325	**6.4**	24:00	24.0	374.3427	374.4986	0.1559		
04/21/19	T8519326	**5.3**	24:00	24.0	363.4693	363.5969	0.1276		
04/27/19	T8519321	**7.2**	24:00	24.0	375.1395	375.3128	0.1733	XT	
05/03/19	T8519330	**7.2**	23:49	23.9	368.1036	368.2772	0.1736	PI	
05/09/19	T8519340	**7.2**	24:00	24.0	370.8835	371.0576	0.1741		
05/15/19	T8519341	**10.8**	24:00	24.0	370.1730	370.4328	0.2598		
05/21/19	T8519342	**7.9**	23:59	24.0	365.7386	365.9289	0.1903		
05/27/19	T8519351	**11.0**	24:00	24.0	373.4761	373.7415	0.2654		
06/02/19	T8519353	**14.8**	24:00	24.0	364.2672	364.6246	0.3574		
06/08/19	T8519360	**5.9**	24:00	24.0	370.1430	370.2869	0.1439		
06/14/19	T8519361	**8.5**	24:00	24.0	370.3265	370.5323	0.2058		
06/20/19	T8519371	**10.7**	24:00	24.0	370.0958	370.3527	0.2569		

Part 4: Data Handling Qualification Concepts

Data Usability

- QAPP/SOPs will not be able to cover every unique situation or circumstance data reviewers may encounter, but should be detailed enough to guide the data reviewer's decision-making process
- Data Validation SOP should contain specific procedures and criteria to judge data against, as well as rules on coding and flagging

R4 QA Training September 2019

AQS Data Reporting

Null Data Codes

- **Invalidate** data
- Impact data completeness

Qualifier Codes

- Data does not meet a particular criterion, but has been determined to be valid
- Does not impact completeness

Informational Flags ("I" series)

- Related to external environmental conditions

Request for Exclusion Flags ("r" series)

- Formal request for data exclusion under the Exceptional Events Rule

Applying AQS Null Codes & Flags

Critical Criteria

- Invalidate with AQS null code
- Or apply AQS QA Qualifier Flag “1”, or “1V” if compelling evidence exists

Operational Criteria

- Apply “2” QA Qualifier Flag

Systematic Criteria

- Apply “3” or other more representative QA Qualifier

Data Flagging

- ✓ Qualifier flags **caution** data users, but do **not** invalidate data
- ✓ Increases transparency, when needed
- ✓ AQS allows up to 10 qualifier codes per data point
  - ✓ *Warning: If a data point requires **multiple** flags because of **multiple** deviations, a **null value code** may be needed!*
- ✓ Allows for more data to be used to calculate a design value
- ✓ Helps ensure data is legally defensible
- ✓ Supports exceptional events demonstrations and modeling

CAUTION!

Are these samples *really* valid?

```
105|145|20150121|00:00|7.250|||2|LB|NS|4||
105|145|20150124|00:00|13.541||||2|LB|NS|4||
105|145|20150127|00:00|12.625||||2|LB|NS|4||
105|145|20150130|00:00|6.333||||2|LB|NS|4||
105|145|20150202|00:00|5.291||||2|NS|LB|4||
105|145|20150205|00:00|10.583||||1|2|4|6|||
105|145|20150208|00:00|10.541||||1|2|3|6|||
105|145|20150211|00:00|14.500||||1|2|3|6|||
105|145|20150214|00:00|10.958||||1|2|4|6|||
105|145|20150217|00:00|19.625||||2|4|LB|1||
105|145|20150301|00:00|21.625||||2|6|4|||||
105|145|20150304|00:00|9.541||||2|6|4||||||
105|145|20150307|00:00|9.416||||2|6|4||||||
105|145|20150310|00:00|9.333||||2|6|4||||||
105|145|20150313|00:00|6.916||||2|6|4||||||
105|145|20150316|00:00|6.333||||2|6|4||||||
```

Templates are meant to be applied to
small data sets
(single values or a few weeks of information)

AQS QA qualifier flag of “1” is **not** intended for widespread, common use

Data Bracketing

When QC checks exceed acceptance limits, data should be invalidated **back** to the last passing QC check

Similarly, data should be invalidated **forward** until the next passing QC check or calibration

The AQS AMP 350 Report Tells a Story

Code change?

What malfunctioned?
Where is maintenance & recalibration?

HOUR DAY	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	OBS	MAXIMUM
1	5.5	1.8	3.2	2.9	3.2	2.1	2.3	3.4	7.1	5.6	2.9	2.7	2.1	3.2	5.7	8.1	11.0	2.7	2.7	2.[illegible]	2.2	1.8	2.4	3.0	24	11.0
2	4.7	4.1	4.1	5.5	5.2	2.6	1.3	2.0	2.9	2.2	1.9	1.0	.9	.7	.7	.7	.8	.6	.6	.6	.5	.6	.8	1.0	24	5.5
3	1.5	.9	.7	.7	[illegible]	.6	.6	1.0	1.0	.7	.7	1.3	1.1	1.5	1.9	.9	.5	.5	.5	.4	.5	.5	.4	.5	24	1.9
4	1.5	.7	.5	.4	.4	.4	.4	.4	.8	2.5	3.6	4.9	8.6	1.5	[illegible]	.8	.7	.7	.7	.8	.5	.4	.5	.4	24	8.6
5	2.6	1.0	.7	.6	.6	.6	.7	.7	.9	1.1	1.9	2.7	BF	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	12	2.7
6	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	BL	AN	AN	AN	AN	AN	AN	0	
7	AN	AN	AN	AN	AN	AN	AN	AN	AN	BA	BA	BA	AN	BC	BC	BL	AN	AN	AN	AN	AN	AN	AN	AN	0	
8	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	BA	BC	BC	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	0	
9	AN	AN	AN	AN	AN	AN	AN	AN	AN	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	0	
10	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	0	
11	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	0	
12	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	0	
13	AS	AS	AS	AS	AS	AS	AS	AS	AS	AY	AS	AY	AY	1.0	.7	.3	.2	.1	.4	.3	.2	.3	.5	.4	11	1.0
14	4.3	1.6	1.0	1.2	1.5	1.3	1.3	1.2	1.4	1.9	2.3	2.4	2.1	2.4	2.0	1.8	1.6	1.4	1.5	2.4	4.3	3.5	2.3	1.4	24	4.3
15	4.4	1.7	1.5	1.2	1.2	.5	.5	.6	2.3	4.3	4.4	4.7	8.5	13.2	12.9	10.1	8.1	8.3	5.7	2.1	.8	.5	.4	.4	24	13.2
16	4.6	1.4	.7	.5	.5	.4	.6	.5	.4	1.0	4.9	8.5	8.8	6.2	5.3	4.9	17.6	21.7	6.7	2.6	1.6	1.7	2.0	2.2	24	21.7
17	4.0	1.5	.9	.8	.8	.7	.6	.5	.5	2.8	4.7	4.1	3.7	3.3	3.1	2.8	2.4	1.9	1.5	1.4	1.2	1.1	1.1	1.0	24	4.7
18	3.6	1.9	1.5	1.1	.6	.9	.9	.9	.8	2.1	3.9	6.3	12.9	8.9	6.7	5.7	6.5	5.5	3.1	1.8	1.1	.5	.4	.3	24	12.9
19	3.7	1.1	.7	.7	.7	.6	.6	.5	.7	1.8	3.4	7.0	BF	10.0	6.7	4.0	3.3	3.0	2.9	2.8	2.3	2.1	1.7	1.6	23	10.0
20	3.8	2.5	1.8	1.6	1.7	1.0	.7	.6	1.2	3.0	3.7	6.5	9.2	8.7	7.3	8.0	6.1	5.0	5.4	6.0	5.8	4.9	4.6	3.1	24	9.2
21	3.8	1.9	1.4	.9	.8	1.3	1.0	.9	1.4	1.6	2.4	4.7	7.8	10.7	6.6	5.1	4.2	2.5	1.9	1.7	1.2	.7	.5	.5	24	10.7
22	3.1	1.2	.8	.7	.8	.4	.5	.5	.7	.6	1.0	7.4	28.6	18.1	9.2	4.3	2.5	1.5	1.3	1.3	1.5	3.2	4.0	2.9	24	28.6
23	4.1	4.7	12.5	13.1	8.0	2.5	2.0	1.0	.3	.3	.2	.1	.2	.1	.1	.9	.1	.0	.0	.0	.0	.1	.1	.0	24	13.1
24	1.5	.5	.3	.1	.0	.0	.2	.1	.3	.6	.4	.3	.4	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	24	1.5

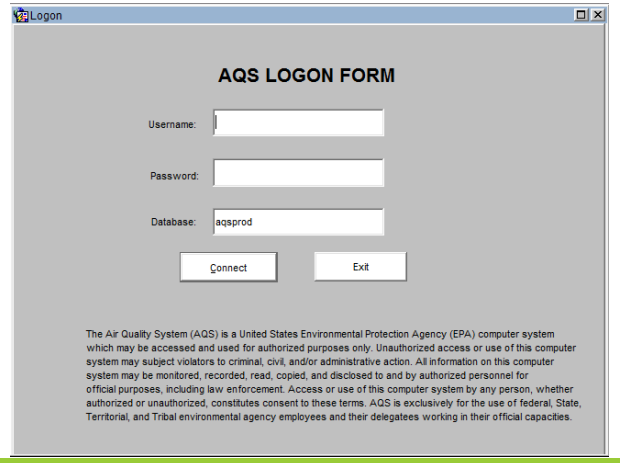
Data should be coded in a manner that most accurately represents what happened

After AQS Upload – Next Steps

As a best practice, AQS Reports should be generated after AQS upload in order to spot-check that data entry was successful and complete

AMP 350 – Raw Data Report

AMP 251 – QA Raw Assessment Report



Manually generated data (such as QA/QC data) should be peer-reviewed for typographical errors or any oversights

Data quality issues can span AQS reporting schedules. Data modifications can occur after data has been uploaded to AQS.

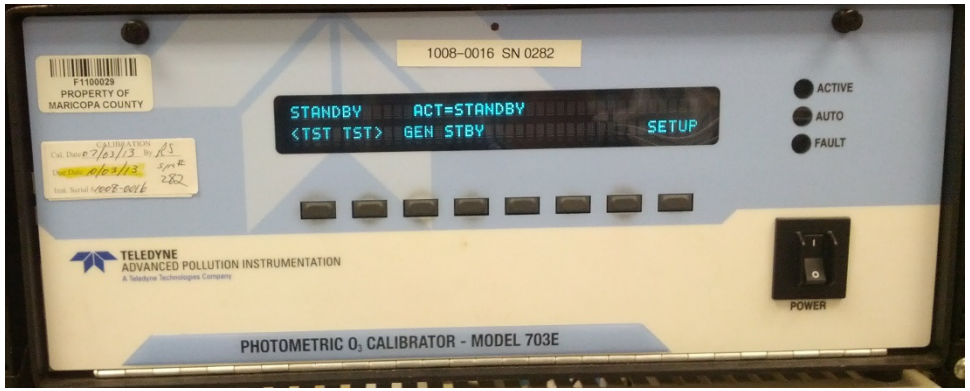
Data assessments can be performed by AQS, through generating various reports. Results of assessments may also reveal issues that require investigation and potential modification of data in AQS.

Part 5: Examples and Exercises

AQS DATA CODING EXERCISE

DESCRIPTION:

Site technician takes an ozone analyzer off-line and performs a one-point QC check



POSSIBLE CODE/FLAGS:

BD:
Auto Calibration

AY:
QC Control Points (zero/span)

BF:
Precision/Zero/Span

AC:
QC Audit

AX:
Precision Check

AQS DATA FLAGGING EXERCISE

DESCRIPTION:

Audit team performs a semi-annual flow check on a $PM_{2.5}$ FEM BAM1020

POSSIBLE CODE/FLAGS:

BC:
Multi-Point Calibration

AT:
Calibration

BL:
QA Audit

BM:
Accuracy Check

AM:
Miscellaneous Void

AQS DATA CODING EXERCISE

DESCRIPTION:

During a filter weighing session, the lab technician discovers that there is a fingerprint on the filter.

POSSIBLE CODE/FLAGS:

AJ:
Filter Damage

AQ:
Collection Error

AR:
Lab Error

BJ:
Operator Error

FI:
Filter Inspection Flag

AQS DATA CODING EXERCISE

DESCRIPTION:

A PM_{10} BAM-1020 measures an hourly concentration of 985 µg/m^3 for 2 hours.
The preceding and following hourly averages were 675 and 700 µg/m^3, respectively.

POSSIBLE CODE/FLAGS:

DA:
Aberrant Data

DL:
Detection Limit Analysis

AV:
Power Failure

EH:
Exceeds Upper Limit

5:
Outlier

AQS DATA CODING EXERCISE

DESCRIPTION:

A data reviewer observes a concentration of 0.168 ppm during the *0700* hour for the NCore ozone monitor. The logbook contains a notation of “site visit, rainy”, with no additional information. The minute data for the monitor shows the ozone trace with level stair-steps at zero and two span concentrations.

POSSIBLE CODE/FLAGS:

AB:
Technician
Unavailable

BD:
Auto Calibration

BF:
Precision, Zero, Span

6:
QAPP Issue

No codes / flags –
Valid concentration

AQS DATA CODING EXERCISE

DESCRIPTION:

An ozone probe is within 10 meters of a tree dripline.

POSSIBLE CODE/FLAGS:

3:
Field Issue

SX:
Does Not Meet Siting Criteria

QX:
Does Not Meet QC Criteria

SC:
Sampler Contamination

AM:
Miscellaneous void

AQS DATA CODING EXERCISE

DESCRIPTION:

Internal auditor determined that the agency's QAPP had not been revised in 6 years since its last EPA-approval. Contents within the QAPP did not meet current regulatory requirements or accurately reflect the agency's processes.

POSSIBLE CODE/FLAGS:

1:
Deviation from CFR/Critical Criteria Requirement

2:
Operational Deviation

AM:
Miscellaneous void

6:
QAPP Issue

No codes or flags:
Valid data

AQS DATA CODING EXERCISE

DESCRIPTION:

SOP calls for a quarterly ozone calibrations. Site operator performs the multi-point verification and all points pass, so no adjustment is needed.

POSSIBLE CODE/FLAGS:

BC:
Multi-point Calibration

BD:
Auto-Calibration

QV:
Quality Control Multi-Point Verification

BL:
QA Audit

AZ:
QC Audit

AQS DATA CODING EXERCISE

DESCRIPTION:

Agency begins monitoring for source-oriented lead (Pb). A QAPP is developed, but the agency does not write an SOP for operating the Pb sampler.

POSSIBLE CODE/FLAGS:

1:
Deviation for CFR/Critical Requirement

3:
Field Issue

6:
QAPP Issue

AS:
Poor Quality Assurance Results

No codes/flags:
Valid Data

AQS DATA CODING EXERCISE

DESCRIPTION:

Agency's SOP requires PM2.5 filter-based samples to be retrieved within 96 hours of sample end-time. EPA's data validation templates allow for 177 hours. Documentation on a sample's chain-of-custody shows the site operator picked the sample up ~148 hours after sample end-time.

POSSIBLE CODE/FLAGS:

1:
Deviation for CFR/Critical Requirement

HT:
Sample pick-up hold time exceeded

6:
QAPP Issue

TS:
Holding Time

No codes/flags:
Valid Data

AQS DATA CODING EXERCISE

DESCRIPTION:

Agency's QAPP requires PM2.5 filter-based samples to be retrieved within 177 hours of sample end-time. Documentation on a sample's chain-of-custody shows the site operator picked the sample up ~180 hours after sample end-time.

POSSIBLE CODE/FLAGS:

1:
Deviation for CFR/Critical Requirement

HT:
Sample pick-up hold time exceeded

6:
QAPP Issue

TS:
Holding Time

No codes/flags:
Valid Data

AQS DATA CODING EXERCISE

DESCRIPTION:

A site operator performs maintenance/repair on an analyzer prior to a calibration. The maintenance/repair took ~40 minutes of the hour, with the calibration procedure starting immediately thereafter. The hour should be coded:

POSSIBLE CODE/FLAGS:

BA:
Maintenance /
Routine Repairs

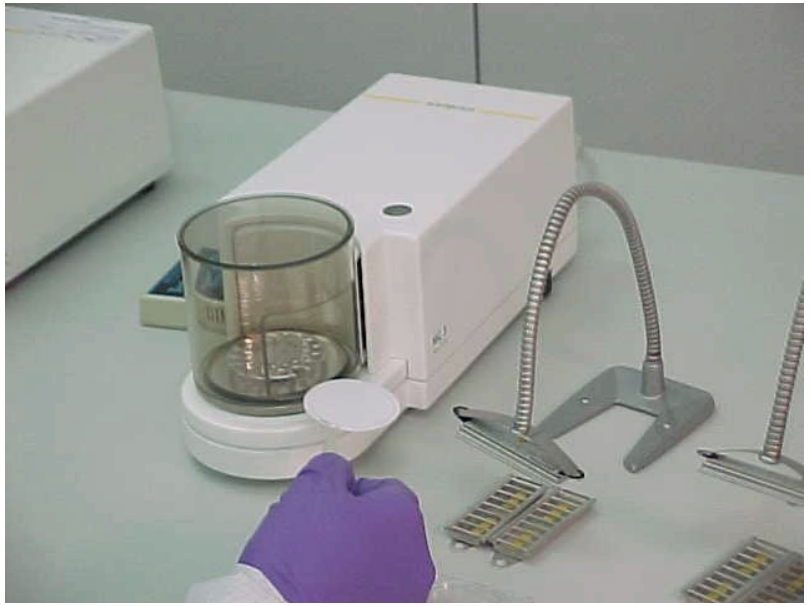
BC:
Multi-point
calibration

AT:
Calibration

AM:
Miscellaneous Void

AL:
Voided by Operator

AQS DATA CODING EXERCISE



DESCRIPTION:

A PM2.5 FRM sampler collects 720 minutes of data. The lab analyst weighed the filter from this sample run. The concentration was 52 ug/m^3.

POSSIBLE CODE/FLAGS:

AG:
Sample Time Out of Limits

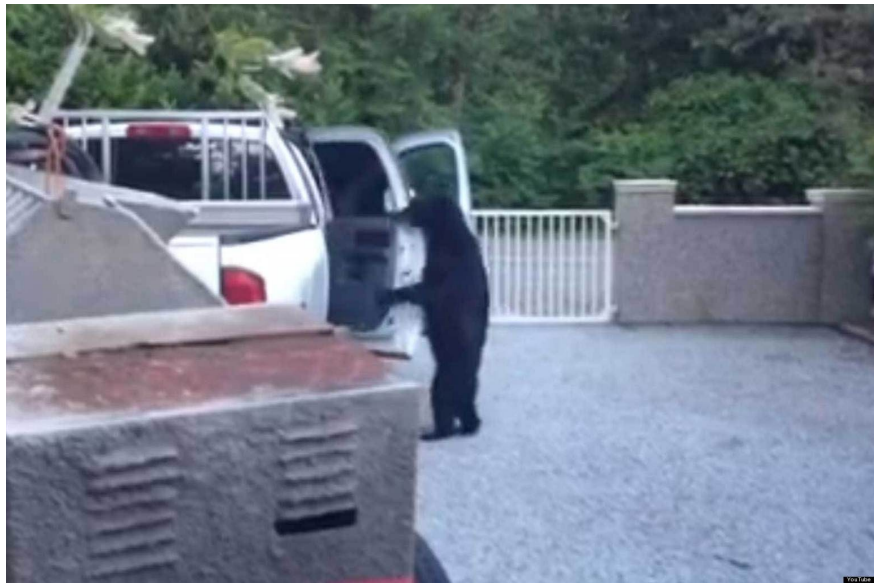
AH:
Sample Flow Rate Out of Limits

AI:
Insufficient Data, Cannot Calculate

1:
Critical Criterion Not Met

AM:
Miscellaneous void

AQS DATA CODING EXERCISE



DESCRIPTION:

Site operator does not lock the door to the monitoring site and leaves a sandwich on top of an ozone analyzer. A bear enters the site and destroys everything.

POSSIBLE CODE/FLAGS:

AW:
Wildlife Damage

AP:
Vandalism

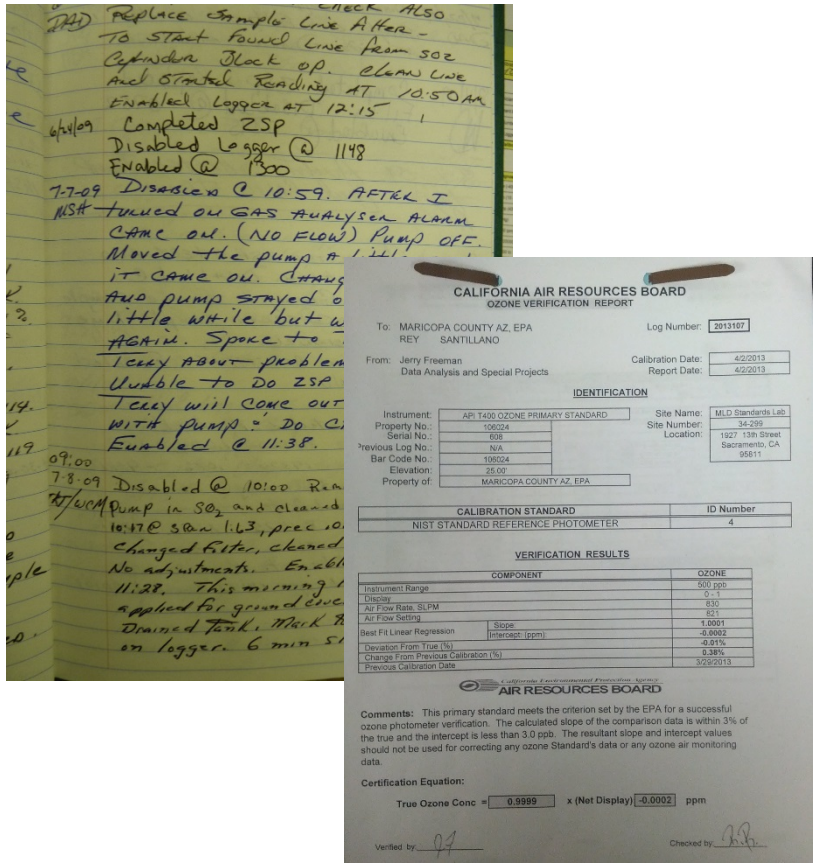
BJ:
Operator Error

BK:
Site Computer/Data Logger Down

6:
QAPP Issue

Code / Flag Recommendations

- Always code missing data
- Apply null codes for scheduled, but missed, filter-based samples
- Use **descriptive** qualifier codes or informational flags that best fit the scenario
- Limit use of Miscellaneous Void (AM) null data code – or, define specific applications of the code in your Data Validation SOP
- Apply codes / flags CONSISTENTLY
- Rationale for data code/flags should be supported by the appropriate DOCUMENTATION



Compelling Evidence - Example

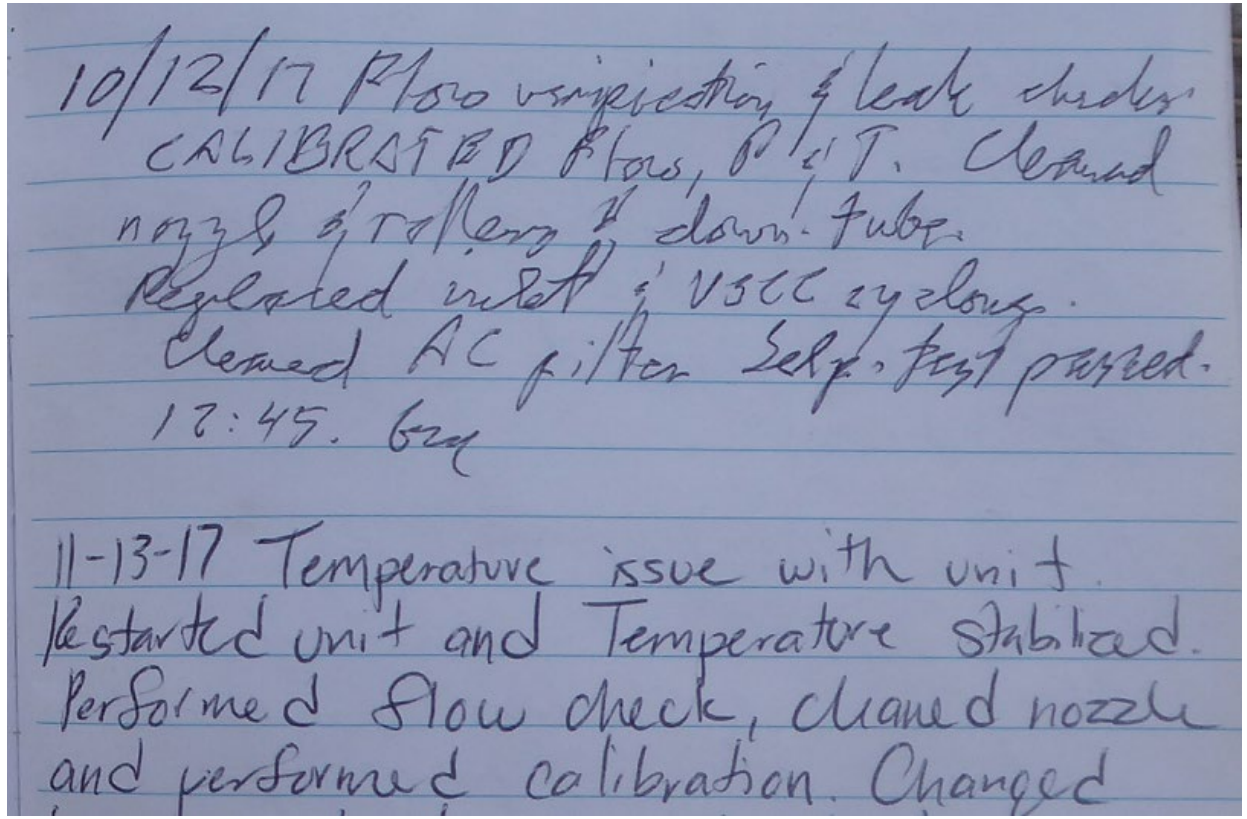
REPORT FOR: NOVEMBER 2017

HOUR DAY	0000	0100	0200	0300	0400	0500	0600	0700	0800	0
1	18.0 1	6.0 1	18.0 1	8.0 1	7.0 1	8.0 1	9.0 1	45.0 1	16.0 1	6
2	12.0 1	9.0 1	11.0 1	9.0 1	6.0 1	5.0 1	15.0 1	15.0 1	9.0 1	8
3	9.0 1	5.0 1	2.0 1	2.0 1	5.0 1	5.0 1	6.0 1	32.0 1	25.0 1	8
4	8.0 1	10.0 1	7.0 1	7.0 1	4.0 1	1.0 1	6.0 1	12.0 1	16.0 1	21
5	8.0 1	6.0 1	10.0 1	6.0 1	5.0 1	7.0 1	6.0 1	8.0 1	6.0 1	4
6	3.0 1	6.0 1	5.0 1	4.0 1	6.0 1	4.0 1	3.0 1	2.0 1	1.0 1	2
7	2.0 1	1.0 1	1.0 1	3.0 1	3.0 1	5.0 1	6.0 1	7.0 1	4.0 1	
8	3.0 1	3.0 1	2.0 1	3.0 1	5.0 1	3.0 1	2.0 1	2.0 1	2.0 1	2.0 1
9	5.0 1	1.0 1	1.0 1	1.0 1	.0 1	2.0 1	2.0 1	4.0 1	4.0 1	1.0 1
10	.0 1	3.0 1	4.0 1	2.0 1	.0 1	1.0 1	1.0 1	1.0 1	.0 1	-1.0 1
11	5.0 1	5.0 1	7.0 1	4.0 1	3.0 1	4.0 1	3.0 1	2.0 1	3.0 1	3.0 1
12	16.0 1	10.0 1	10.0 1	6.0 1	3.0 1	4.0 1	3.0 1	2.0 1	1.0 1	1.0 1
13	5.0 1	3.0 1	5.0 1	2.0 1	-1.0 1	.0 1	1.0 1	12.0 1	6.0 1	AX
14	BA	BA	BA	BA	BA	BA	BA	BA	BA	BA
15	BA	BA	BA	BA	BA	BA	BA	BA	BA	BA
16	BA	BA	BA	BA	BA	BA	BA	BA	BA	BA
17	7.0	7.0	7.0	4.0	3.0	5.0	8.0	14.0	21.0	22.0
18	6.0	4.0	2.0	3.0	3.0	2.0	10.0	7.0	4.0	4.0

		1020													
2	2.0 1	2.0 1	2.0 1	1.0 1	1.0 1	3.0 1
9	2.0 1	2.0 1	2.0 1	2.0 1	2.0 1	.0 1
10	8.0 1	6.0 1	1.0 1	.0 1	2.0 1
11	10.0 1	5.0 1	2.0 1	4.0 1	4.0 1
12	1.0 1	.0 1	1.0 1	4.0 1	6.0 1
13	AT	BA	BA	BA	BA
14	BA	BA	BA	BA	BA
15	BA	BA	BA	BA	BA
16	BA	BA	AX	AX	3.0
17	8.0	6.0	2.0	1.0	3.0
18	4.0	1.0	0	1.0	1.0

Met One BAM- 1020 Mass M		Beta Attenuation	
Assess Date	Assess Flow	Monitor Flow	% Diff
2017- 09- 07	16.39	16.7	1.9
2017- 10- 12	16.94	16.7	- 1.4
2017- 11- 13	15.63	16.7	6.8
2017- 11- 16	16.72	16.7	- 0.1
2017- 12- 11	16.74	16.7	- 0.2

Compelling Evidence - Example


10/12/17 Flow verification & leak checks
CALIBRATED flow, P & T. Cleaned
nozzle & rollers & down tube.
Replaced inlet & VSCC cyclone.
Cleaned AC filter Self-test passed.
12:45. Gzq

11-13-17 Temperature issue with unit.
Restarted unit and Temperature stabilized.
Performed flow check, cleaned nozzle
and performed calibration. Changed

1. Flow check failed 11/13/17 at 6.8%
2. Instrument installed June 17, 2017
3. Flow audit passed August 13, 2017
4. Flow checks passed June – October
5. Intermittent temperature issue found during failed flow check

How should the data be qualified?

Compelling Evidence - Example

More Information:

1. Intermittent temperature issue apparent in the meta data since instrument installation
2. Temperature inaccuracy variable but could be up to 10°C, when malfunctioning
3. Multiple malfunctions in most hours

Does the Meta Data Change the Validation Decision?

Weight of Evidence – Example 1

- Auditor reviews certification record for agency's local primary flow standard
  - Vendor certificate show's low flow cell arrived "out of tolerance" at -7% difference
  - This cell is used to calibrate the dilution mass flow controllers (MFCs) in agency's gas dilution calibrators
  - The agency had not performed any pre/post checks prior to shipment to the vendor
- A review of in-house certification records shows a dilution MFC in a **site calibrator** was biased -7%
- Records review also shows an SO_2 analyzer was calibrated (adjusted) using this calibrator with the negative bias
- An NPAP audit of this SO_2 analyzer fails

Weight of Evidence – Example 1A

- Auditor reviews certification record for agency's local primary flow standard
  - Vendor certificate show's low flow cell arrived "out of tolerance" at -7% difference
  - This cell is used to calibrate the dilution mass flow controllers (MFCs) in agency's gas dilution calibrators
  - The agency had not performed any pre/post checks prior to shipment to the vendor
- A review of in-house verification records during this time period shows the dilution MFC in an **audit calibrator** was biased -7%

Weight of Evidence – Example 2

- Agency brings its Level 2 bench standard to EPA for annual certification at the **end** of the ozone season
  - The standard was not adjusted or modified in any manner prior to arrival at the EPA lab
  - The agency's Level 2 is used to certify both field and audit standards
- The Level 2 standard does not pass its certification against the SRP
  - The standard is ~6% off
- Recent NPAP ozone audits at several of the agency's ozone sites have yielded poor to failing audits

Weight of Evidence – Example 2A

- Agency brings its Level 2 bench standard to EPA for annual certification at the **beginning** of ozone season
  - The standard was not adjusted or modified in any manner prior to arrival at the EPA lab
  - The agency's Level 2 is used to certify both field and audit standards
- The Level 2 standard does not pass its certification against the SRP
  - The standard is ~6% off

Weight of Evidence – Example 3

- Internal auditor observes a PM2.5 flow check reported to AQS on November 18 at 4.5% difference (d)
- Site operator uses no QA/QC forms in the field, but records all data in a ledger logbook by hand
- Site operator's manual calculation of the flow check results was 2%d
- Flow rate verifications checks are performed once per month
  - Previous passing check was October 23 at 3.7%d
  - Next passing check is December 30 at 1.6%d
- Semi-annual flow audit performed on December 21 with results of 3.9%
- Logbook shows a flow rate calibration following the December 21 audit

Weight of Evidence – Example 4

- Critical, operational, and systematic criteria met for organization's $PM_{2.5}$ samples for all field parameters
- TSA conducted on organization's recently relocated in-house PM2.5 gravimetric laboratory
- Audit occurs within 2 months of start-up, in order to ensure the new set-up is in good order
- TSA finds multiple non-conformances, all of which are considered "operational criteria"
- Findings include:
  - Aged microbalance has no known calibration or certification (traceability) documentation
  - Balance is found to not be properly grounded
  - Laboratory blanks (QC samples) are out of specification (acceptance criterion = 15µg; blank results range from 98µg to -477 µg)
  - Field blanks (QC samples) are also significantly out of specification
  - Newly purchased RH/temperature datalogger doesn't meet accuracy specifications

Weight of Evidence – Example 5

For toxics, NATTS, and upcoming PAMS….

Audit conducted identified the following issues:

- The laboratory was operating without a QAPP
- Each lab analyst was implementing a different version of a draft SOP
- Laboratory calibration standards were expired
- Laboratory calibration procedures did not adhere to the requirements of TO-15
- Analytical data did not undergo independent review before release to the client
- There no documentation to verify completion of required QA/QC checks of the toxics field sampling equipment

Summary

Site operators and QA staff are both intimately involved in the data review process

- Good documentation is vital!

Data handling should involve multiple levels of review

There is a significant difference between data verification and validation procedures

Know your QAPP and SOP requirements!

Utilize the Data Validation Templates in the QA Handbook

Questions?