



Data Validation & AQS Coding

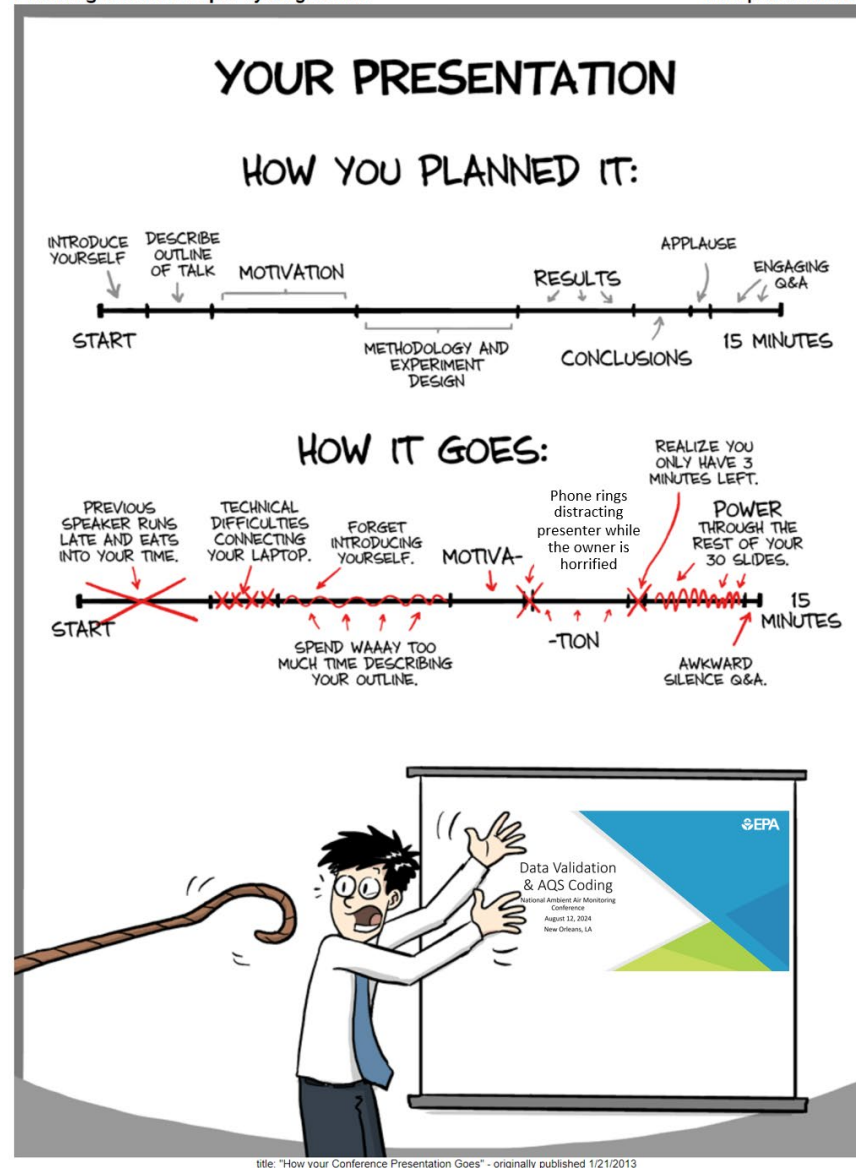
National Ambient Air Monitoring
Conference

August 12, 2024

New Orleans, LA

Welcome!

- Data Validation
 - *Breathe in – Breathe out*
 - *Stand up – sit down*
- AQS Coding
 - 30-minute break after presentation
- Important Resources
 - *This presentation is designed to serve as a desk reference with a lot of links*



Disclaimer

The statements in this presentation, with the exception of referenced requirements, are intended solely as guidance. This presentation is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation with the United States. This presentation serves as guidance to EPA's approach to implementing 40 CFR Parts 50, 53, and 58.

Mention of commercial products or trade names should not be interpreted as endorsement. Some types of instruments currently in use in monitoring networks may be described within this presentation or shown. Sometimes these products are given as a typical and perhaps well-known example of the general class of instruments. Other instruments in the class are available and may be fully acceptable.

Disclaimer's Disclaimer

The thoughts and opinions of the presenter and within this presentation represent those primarily from Region 3's perspective. Be sure to always reach out to your Regional QA Contact for the most current and Region-specific guidance.



Data Validation

Dive into the flow for data validation and tools

Remember to define acronyms 😊



ANNOY GRAMMAR PEDANTS ON ALL SIDES
BY MAKING "DATA" SINGULAR *EXCEPT*
WHEN REFERRING TO THE ANDROID.

<https://xkcd.com/>

Data Validation- A word from our sponsors!

- This presentation, brought to you by:
 - The letter **Q** for:
[Quality Assurance \(QA\) Handbook Volume II](#)



<https://www.giantfreakinrobot.com/wp-content/uploads/2023/04/john-de-lancie-q-star-trek-900x506.jpg>

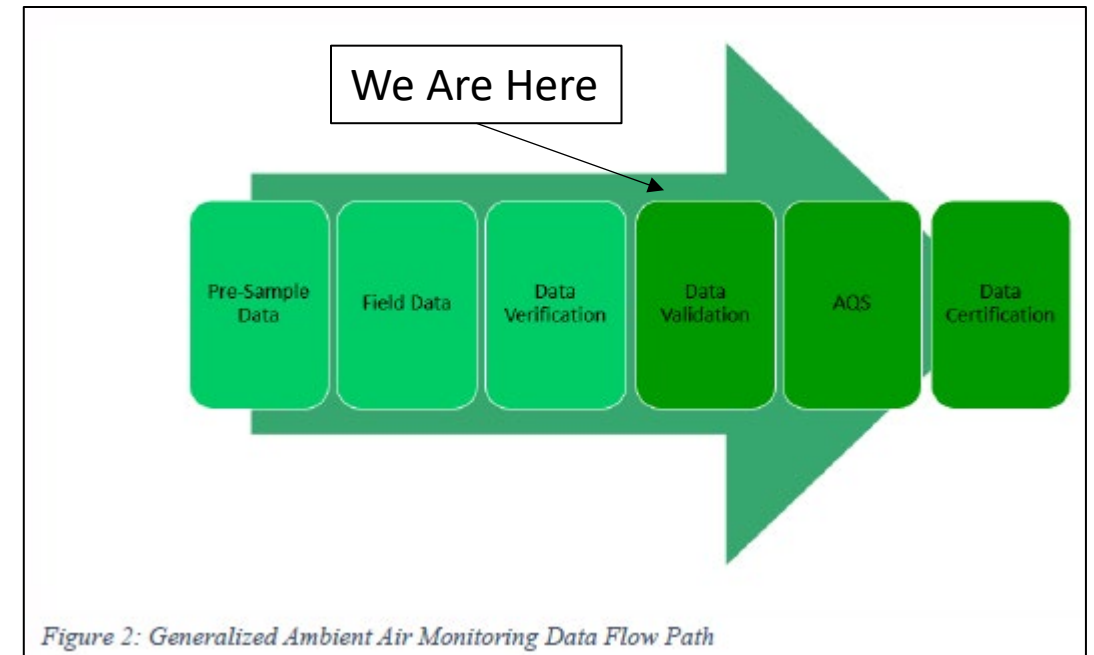
- The [Best Practices for Review and Validation of Air Monitoring Data](#)



- EPA River Delta Cruises
- And viewers like you!

Data Validation – Why?

- Importance of Data validation
 - Regulatory requirements of the Clean Air Act
 - Regulations codified in the Code of Federal Regulation (CFR)
 - Title 40 CFR Chapter I, Subchapter C, Parts 50, 53, and 58 for Air.
- Determines the confidence in the data &
- Produces legally defensible data



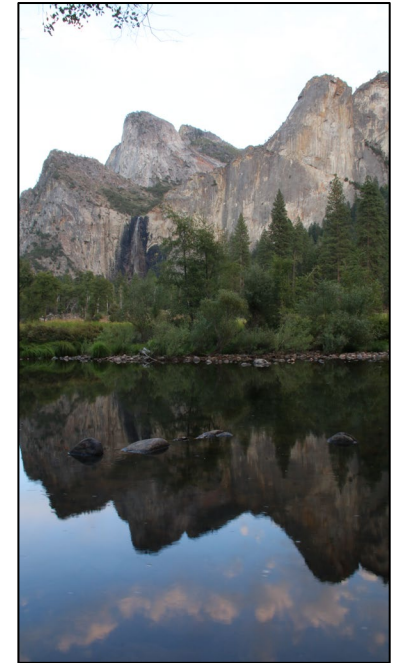
Data Validation – A Reminder

The mission of United States Environmental Protection Agency (US EPA) is to protect human health and the environment...

Insert your organization in place of EPA and it's a safe bet the mission is similar or the same



Members of Region 3 and Philadelphia Air Management Services



Data Validation – Important QAPP Elements

- **Criteria and processes for Data Validation must be detailed in your Quality Assurance Project/Program Plan (QAP/rP)**
- Elements A6 and B4 cover criteria in DQOs, DQIs, and MQOs
- Group D Elements cover the process for Data Verification, **Validation**, Data Quality Assessment, and Data Usability

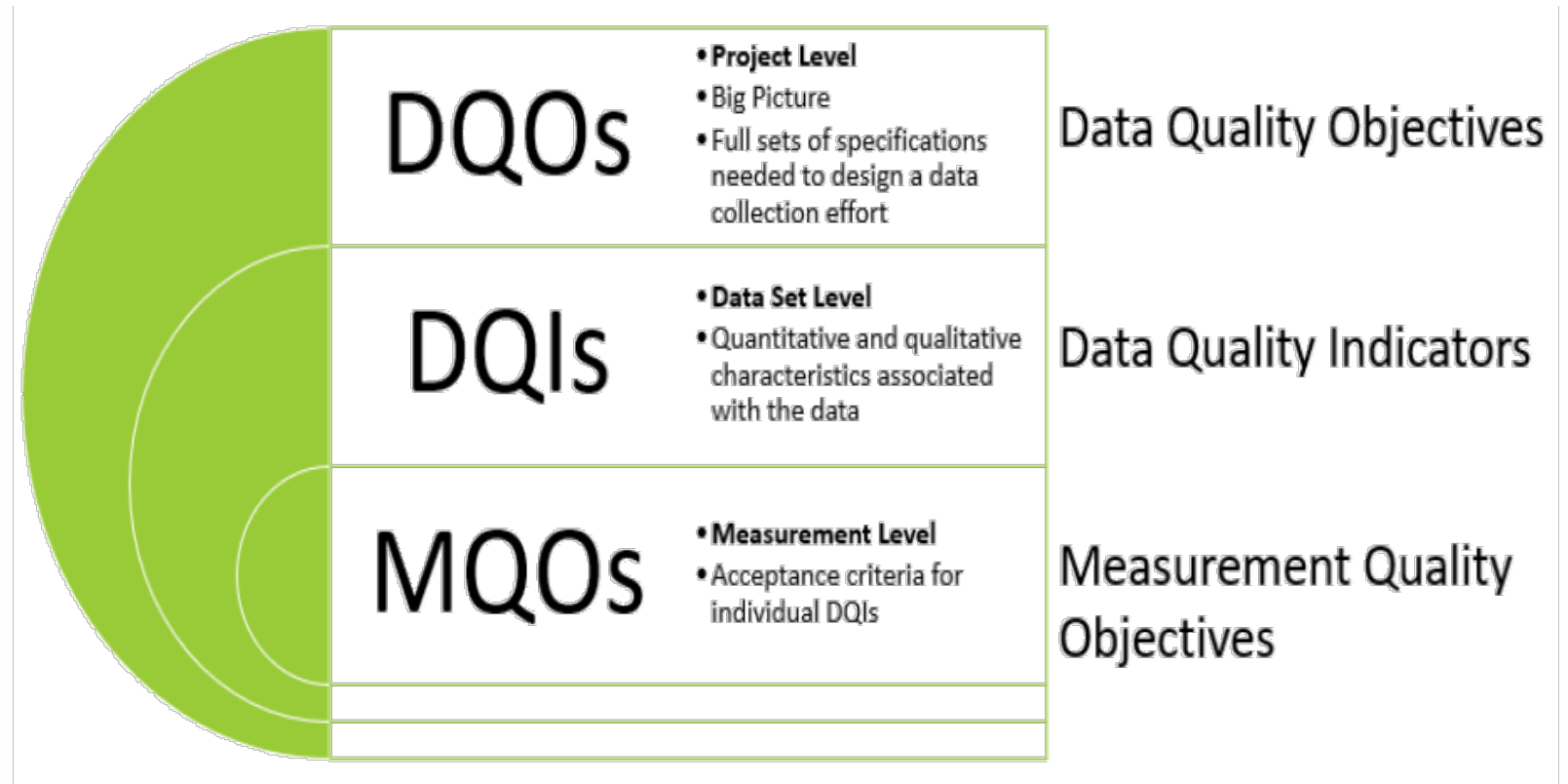


Figure 5: Comparison of DQOs, DQIs, and MQOs

Data Validation - Hierarchy

- Everyone has a role in data validation!
- Independence is key!
- Data validators should not be directly involved in data collection
- **Strongly Recommend a Data Validation Standard Operating Procedure (SOP) for consistency!**

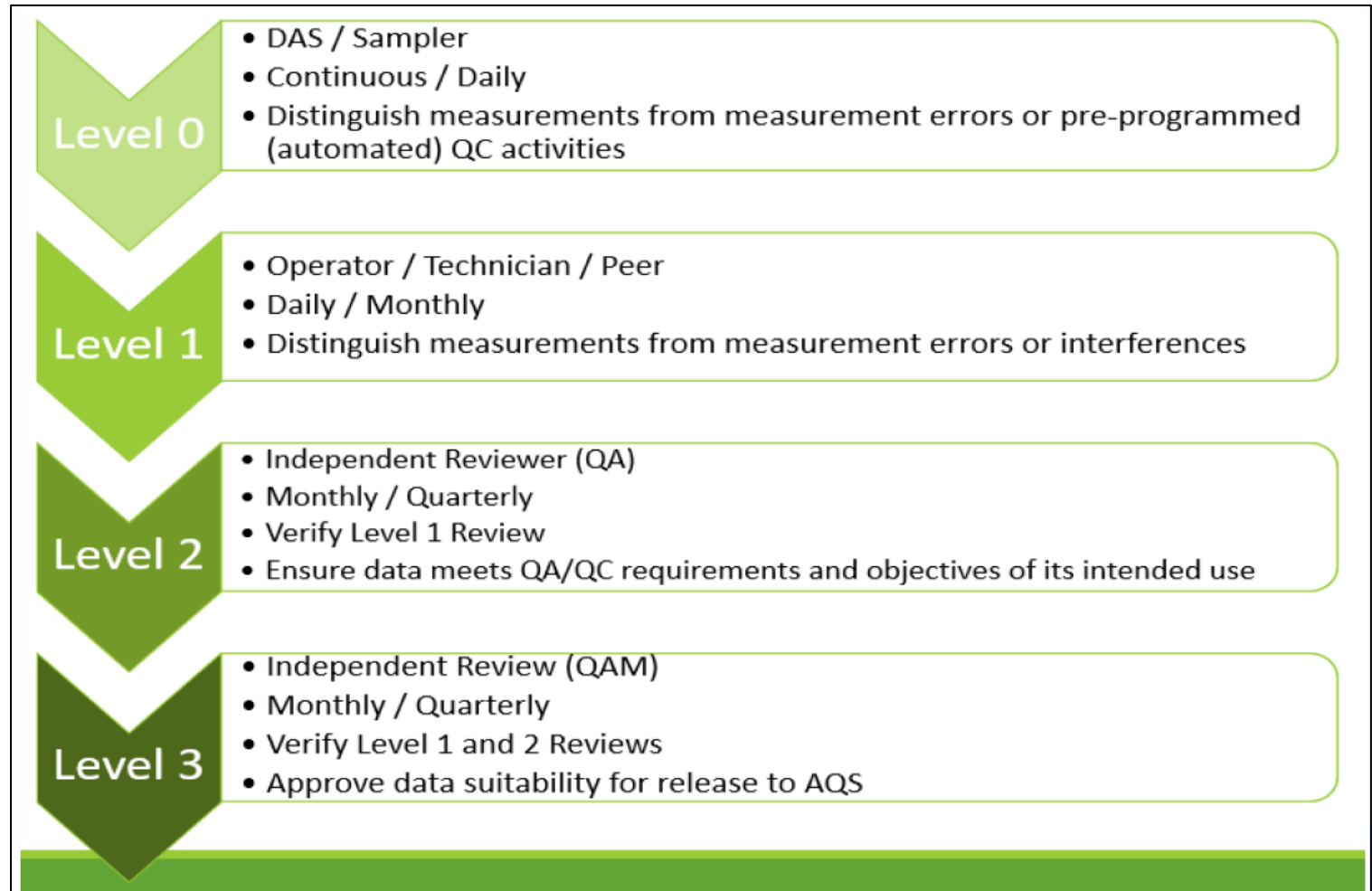


Figure 17: Summary of Levels 0 – 3 Data Review Activities

Data Validation – Hierarchy Part II

	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
Schedule	Hourly	Daily to Weekly	Weekly to Monthly	Monthly to Quarterly	Quarterly to Annually	Annually and Greater
Method	Range Checks QC Verifications	Data Verification QC Evaluation Situational Evaluation Documentation	Document Verification QA/QC Assessment Manual Verification Graphical Analysis	Data Comparisons Statistical Assessment Trend Evaluation Graphical Analysis	Database Verification Statistical Assessment Audits of Data Quality PE Results Evaluation	Data Set Reviews User Needs Evaluation Network Reviews Evaluation of DQOs
Function	Verification		Validation	Assessment	Reconciliation	
Data Flow	Instrument / Logger	Real-time Reporting	System Local Database		Permanent Database	AQS
Reviewers	Instrument / Logger /	Datasytem Technician / Operator / Peers	Forecaster Managers Independent Validator		QA Manager Program Managers /	Planners / EPA

Figure 9: Tiered Data Review Structure for an Ambient Air Monitoring Program

Data Validation – Tools: Data Validation Templates

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Revision 36.1
Date 03/17
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OSHA Validation Template

1) Requirement (a)	2) Frequency	3) Acceptance Criteria	Information/Action
CRITICAL CRITERIA-OZONE			
Monitor	16A	Mean exposure based on PM2.5FEM description	14) CFR Part 10 App D, Sec. 2.1 15) CFR Part 10 App D, Sec. 2.2 16) CFR Part 10 App D, Sec. 2.3 17) CFR Part 10 App D, Sec. 2.4 18) CFR Part 10 App D, Sec. 2.5 19) CFR Part 10 App D, Sec. 2.6 20) CFR Part 10 App D, Sec. 2.7 21) CFR Part 10 App D, Sec. 2.8 22) CFR Part 10 App D, Sec. 2.9 23) CFR Part 10 App D, Sec. 2.10 24) CFR Part 10 App D, Sec. 2.11 25) CFR Part 10 App D, Sec. 2.12 26) CFR Part 10 App D, Sec. 2.13 27) CFR Part 10 App D, Sec. 2.14 28) CFR Part 10 App D, Sec. 2.15 29) CFR Part 10 App D, Sec. 2.16 30) CFR Part 10 App D, Sec. 2.17 31) CFR Part 10 App D, Sec. 2.18 32) CFR Part 10 App D, Sec. 2.19 33) CFR Part 10 App D, Sec. 2.20 34) CFR Part 10 App D, Sec. 2.21 35) CFR Part 10 App D, Sec. 2.22 36) CFR Part 10 App D, Sec. 2.23 37) CFR Part 10 App D, Sec. 2.24 38) CFR Part 10 App D, Sec. 2.25 39) CFR Part 10 App D, Sec. 2.26 40) CFR Part 10 App D, Sec. 2.27 41) CFR Part 10 App D, Sec. 2.28 42) CFR Part 10 App D, Sec. 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App D, Sec. 6.72 486) CFR Part 10 App D, Sec. 6.73 487) CFR Part 10 App D, Sec. 6.74 488) CFR Part 10 App D, Sec. 6.75 489) CFR Part 10 App D, Sec. 6.76 490) CFR Part 10 App D, Sec. 6.77 491) CFR Part 10 App D, Sec. 6.78 492) CFR Part 10 App D, Sec. 6.79 493) CFR Part 10 App D, Sec. 6.80 494) CFR Part 10 App D, Sec. 6.81 495) CFR Part 10 App D, Sec. 6.82 496) CFR Part 10 App D, Sec. 6.83 497) CFR Part 10 App D, Sec. 6.84 498) CFR Part 10 App D, Sec. 6.85 499) CFR Part 10 App D, Sec. 6.86 500) CFR Part 10 App D, Sec. 6.87 501) CFR Part 10 App D, Sec. 6.88 50

- [Appendix D](#)* to the [QA Handbook Volume II](#)
 - Measurement Quality Objectives (MQOs) & Data Quality Indicators (DQIs)
 - Color Coded
 - Pink = Critical Criteria
 - Yellow = Operational Criteria
 - Blue = Systematic Criteria
 - Often adopted in the QAP(r)P
 - **Note:** Particulate Matter (PM) templates will have a field and laboratory component
- *[T640](#) and [x's](#) have Separate Templates

Data Validation Templates – Road Map

1) Requirement (O ₃)	2) Frequency	3) Acceptance Criteria	Information /Action
CRITICAL CRITERIA-OZONE			
<i>Monitor</i>	NA	<i>Meets requirements listed in FRM/FEM designation</i>	1) 40 CFR Part 58 App C Sec. 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
<i>One Point QC Check Single analyzer</i>	<i>Every 14 days</i>	$< \pm 7.1\%$ (percent difference) or $< \pm 1.5$ 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 $< \pm 3.1$ ppb (24 hr) $< \pm 5.1$ ppb (>24 hr-14 day) Span drift $< \pm 7.1\%$	1 and 2) QA Handbook Volume 2 Sec. 12.3 3) Recommendation and related to DQO

- 1) Requirement – Quality Control Check or other criteria
- 2) Frequency – How often the check is performed
- 3) Acceptance Criteria – Watch for multiple criteria and “or”
- Information / Action – Column provides a citation for, 1) Requirement, its 2) Frequency, and its 3) Acceptance Criteria

Data Validation Templates – Critical Criteria

1) Requirement (O ₃)	2) Frequency	3) Acceptance Criteria	Information /Action
CRITICAL CRITERIA-OZONE			
<i>Monitor</i>	NA	<i>Meets requirements listed in FRM/FEM designation</i>	1) 40 CFR Part 58 App C Sec. 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
<i>One Point QC Check Single analyzer</i>	<i>Every 14 days</i>	$< \pm 7.1\%$ (percent difference) or $< \pm 1.5$ 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 $< \pm 3.1$ ppb (24 hr) $< \pm 5.1$ ppb (>24 hr-14 day) Span drift $< \pm 7.1\%$	1 and 2) QA Handbook Volume 2 Sec. 12.3 3) Recommendation and related to DQO

- Critical Criteria have the greatest implications on overall data quality with most related to a regulation per the citation
- Data not meeting each critical criteria should be invalidated*
 - *Using a Weight of Evidence Approach, a limited amount of data may be considered valid but qualified (flagged) if there is sufficient compelling evidence
 - **Presentation on Weight of Evidence Approach after the break**

Data Validation Templates – Operational Criteria

1) Criteria (PM2.5 LC)	2) Frequency	3) Acceptable Range	Information /Action
<i>Pressure Verification/Calibration</i>	on installation, and on one-point verification failure	$< \pm 10.1$ mm Hg	1) 40 CFR Part 50, App. L, Sec. 9.3 2 and 3) Method 2.12 Sec. 6.5 Sampler BP verified against independent standard verified against a lab primary standard that is certified as NIST traceable 1/year
<i>Flow Rate Multi-point Verification/Calibration</i>	<i>Electromechanical maintenance or transport</i> or every 365 days and once a calendar year	$< \pm 2.1\%$ of transfer standard	1) 40 CFR Part 50, App. L, Sec. 9.2. 2) 40 CFR Part 50, App. L, Sec. 9.1.3, Method 2.12 Sec. 6.3 & Table 6-1 3) Recommendation
Other Monitor Calibrations	per manufacturers' op manual	per manufacturers' operating manual	1, 2 and 3) Recommendation
Precision			

- Operational criteria are important for maintaining and evaluating the quality of the data collection system
- Violation(s) of these criteria may be cause for data invalidation, depending on the severity of the violation(s)
- A Weight of Evidence Approach, with documentation of additional QC information (compelling evidence) will be needed to support data validity*
 - *If valid, data should still be qualified (flagged)

Data Validation Templates – Systematic Criteria

Field Activities			
Verification/Calibration Standards Recertifications – All standards should have multi-point certifications against <u>NIST Traceable</u> standards			
<i>Flow Rate Transfer Std.</i>	every 365 days and once a calendar year	$< \pm 2.1\%$ of <u>NIST Traceable Std.</u>	1) 40 CFR Part 50, App. L Sec. 9.1 & 9.2 2) Method 2-12 Sec. 4.2.2 & 6.4.3 3) 40 CFR Part 50, App. L Sec. 9.1 & 9.2
Field Thermometer	every 365 days and once a calendar year	$\pm 0.1^\circ \text{C}$ resolution, $\pm 0.5^\circ \text{C}$ accuracy	1, 2 and 3) Method 2.12 Sec. 4.2.2
Field Barometer	every 365 days and once a calendar year	± 1 mm Hg resolution, ± 5 mm Hg accuracy	1, 2 and 3) Method 2.12 Sec. 4.2.2
Clock/timer Verification	Every 30 days	1 min/mo	1 and 2) Method 2.12 Sec. 4.2.1 3) <u>40 CFR Part 50, App. L Sec. 7.4.12</u>
Laboratory Activities			
<i>Microbalance Readability</i>	At purchase	1 μg	1, 2 and 3) 40 CFR Part 50, App. L Sec. 8.1
Microbalance Repeatability	At purchase	1 μg	1) Method 2.12 Sec. 4.3.6 2) Recommendation 3) Method 2.12 Sec. 4.3.6

- Systemic Criteria are important for correct data interpretation, but violations do not usually impact the validity of the sample(s)
- This section includes information on data handling, completeness rules, reporting units and criteria related to Data Quality Indicators (DQIs)
- In some cases, violation of a systematic criterion may result in data qualification, while invalidation may be recommended under egregious circumstances

Data Validation Templates - Summary



- Violations of Critical Criteria typically result in data invalidation (null codes)
- Violations of Operational or Systematic Criteria typically result in data qualification (flagging)
- **Perform all operational or systematic QA/QC checks that are required in the CFR, if you do not all associated data may be invalidated!**
- The more violations, the assurance of data quality decreases
 - Compelling evidence using the Weight of Evidence Approach are needed to validate violations of Critical Criteria or compounding Operational and/or Systematic Criteria

Data Validation – Process

Ozone Data Verification Checklist										<Document Control ID>	
Organization:		<Agency/Section>				Data Reviewed:		<Month>	<Year>	Revision 0.0	
Monitor(s) Reviewed:		<Site Name(s)/Monitor ID(s)>								Last revised: July 2021	
The following is a checklist designed to provide assistance to the Levels 1 and 2 data reviewers of the associated ozone dataset. The checklist should be used along with professional judgment and experience with the goal of verifying data in a consistent and holistic manner. Generally, Level 1 and 2 data reviewers (e.g., site operators, QA staff) verify data on a daily, monthly, and/or quarterly frequency to distinguish measurements from measurement errors/interferences and to ensure data meets QC/QA requirements and the objectives of the data's intended use. To complete this checklist, the Level 1 data verifier must answer each question with a "X" in the "Yes", "No", or "N/A" column wherever an "L1" is found in the corresponding row. Similarly, the Level 2 data verifier must answer each question that contains "L2" in the corresponding row. After answering each question, please provide comments in the "Comments" field in the column second from the right to detail the next steps to take if any problems are identified while reviewing the dataset. Some problems may highlight bigger issues related to the agency's quality system or personnel training that must be addressed. For example, if an issue in the applicable QAPP or SOP is found, the document(s) should be revised as soon as possible to resolve that particular issue. Hyperlinks to relevant information are provided in the column furthest to the right. Once all questions have been answered, please provide your name, signature or initials, and date of the completion of this data review at the end of the checklist. Please provide a copy of the completed checklist and, if applicable, any associated paperwork (e.g., data worksheets, QC check forms, logbook documentation) to the next level data reviewer (i.e., Level 2 or Level 3). Retain a copy of the completed checklist for your records either in hard-copy or in digital copy that is "locked" to any future edits to preserve the original record.											
Ozone Criteria (Levels 1-2)		L1/2	Yes	No	N/A	Comments		Recommended Response to Criteria Not Met		References	
Critical Criteria	Levels 1 & 2: 1-point QC checks completed according to the SOP and at least every 14 days?	L1					If not completed according to SOP, check should be considered invalid and documented as such. If checks were not completed every 14 days, determine and document reason(s) why and confirm checks that did occur passed acceptance criteria.		40 CFR Part 58, Appendix A, Section 3.1.1		
		L2								QA Handbook Volume II, Appendix D	
	Levels 1 & 2: 1-point QC points within $\pm 7.1\%$ (or ± 1.5 ppb, whichever is greater) of the transfer standard value?	L1					Mark impacted concentration data as void. If other compelling evidence exists to validate the data, document such information.		40 CFR Part 58, Appendix A, Section 2.3.1.2		
		L2								QA Handbook Volume II, Appendix D	
	Level 2: 1-point QC check percent differences calculated correctly? At least 10% and a minimum of 1 (whichever is greater) of 1-point QC checks should be verified.	L1					Review all 1-point QC check calculations. Confirm checks did pass acceptance criteria. If check(s) exceeded acceptance criteria, mark impacted data as void. If other compelling evidence exists to validate the data, document such information. Investigate possible causes/solutions to this issue.		40 CFR Part 58, Appendix A, Section 4.1.1		
		L2									
	Levels 1 & 2: Zero/span checks completed according to the SOP and at least every 14 days?	L1					If not completed according to SOP, check should be considered invalid and documented as such. If checks were not completed every 14 days, determine and document reason(s) why and confirm checks that did occur passed acceptance criteria.		QA Handbook Volume II, Section 12.3 and Appendix D		
		L2									
	Levels 1 & 2: Zero points within ± 3.1 ppb over 24 hours? Zero points within ± 5.1 ppb over >24 hours - 14 days? Only answer "Yes" if the answer to both questions is "yes". Otherwise, answer "No".	L1					Mark impacted concentration data as void. If other compelling evidence exists to validate the data, document such information.		QA Handbook Volume II, Appendix D		
		L2									
Levels 1 & 2: Span points within $\pm 7.1\%$ of the transfer standard value?	L1					Mark impacted concentration data as void. If other compelling evidence exists to validate the data, document such information.		QA Handbook Volume II, Appendix D			
	L2										
Level 2: Zero/span point differences calculated correctly? At least 10% and a minimum of 1 (whichever is greater) each of zero and span checks should be verified.	L1					Review all zero and/or span check calculations. Confirm checks did pass acceptance criteria. If check(s) exceeded acceptance criteria, mark impacted data as void. If other compelling evidence exists to validate the data, document such information. Investigate possible causes/solutions to this issue.		40 CFR Part 58, Appendix A, Section 4.1.1			
	L2										

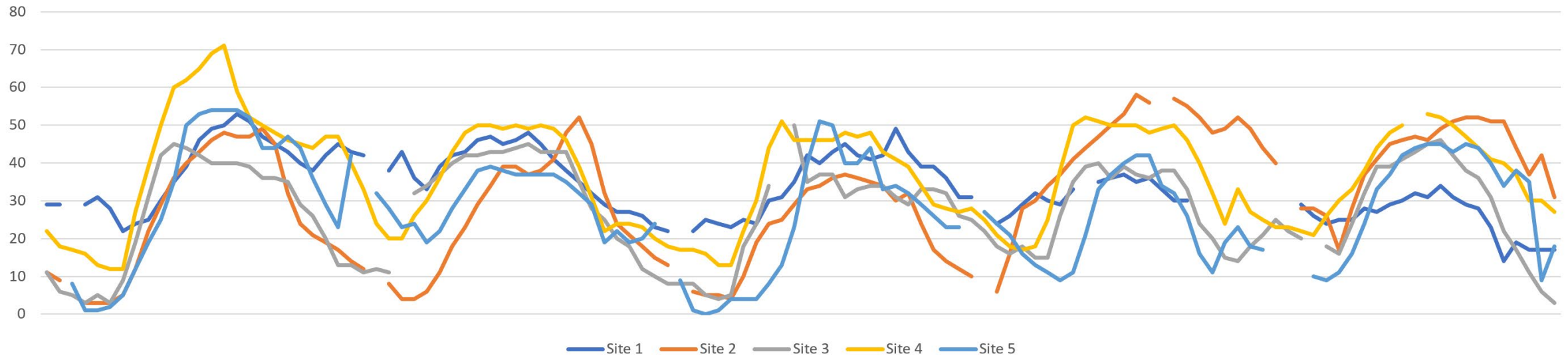
- **Regular review and documentation will make data validation easier!**
- Recommend working in chunks, weeks or months depend on organization staffing
- Use [Appendix A Checklists](#) from the Best Practices for Data Validation as a framework or your memo
- If you have a process in place, review it to make sure all points are covered

Data Validation – Lets walk through it!

- QA Clichés, what are some yours?
- My top three:
 - Know your data.
 - If it wasn't documented, then it didn't happen!
 - Trust but verify.

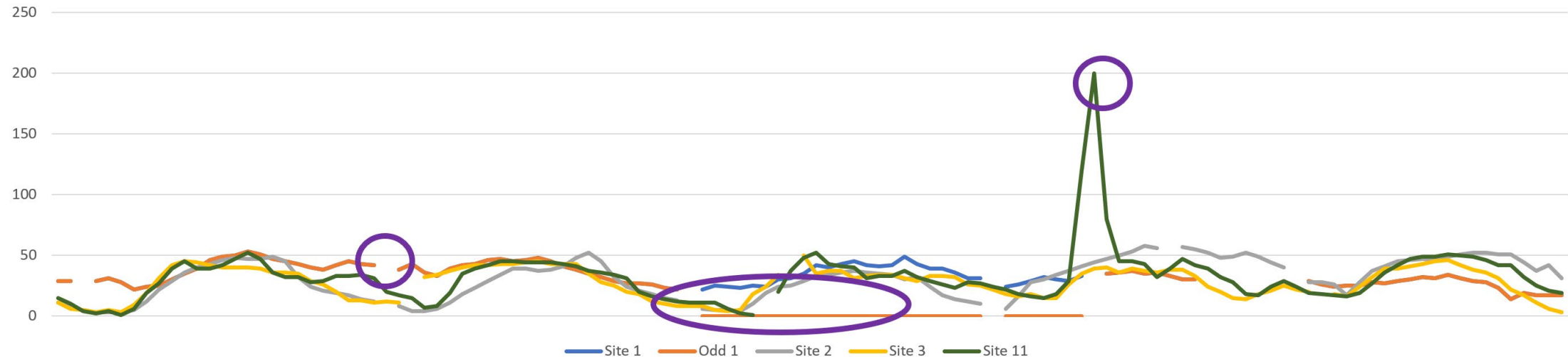


Data Validation – Know your Data! Routine



- Review data every day possible, develop a routine!
- Hourly recommended but periodically review minute data (Trust but verify)
 - Operators should review minute data and document issues
- Review data behind null codes (Trust but verify)
- Review longer time periods and historical data

Data Validation – Know your Data! Routine



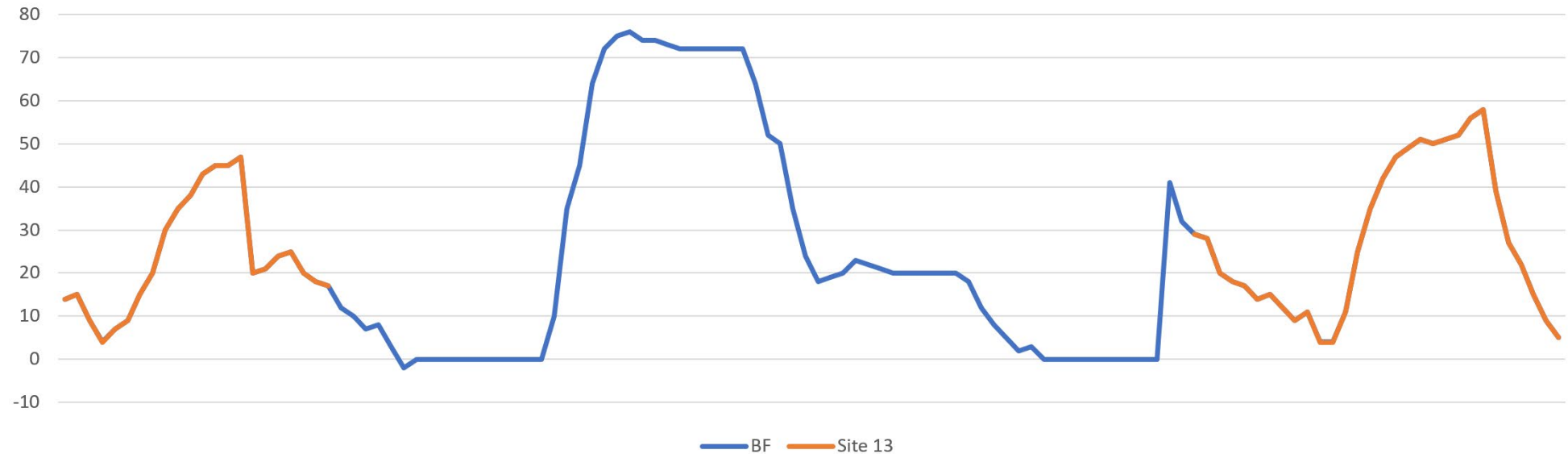
- Document anything unexpected:
 - Gaps (where expected)
 - Flatlines
 - Spikes
 - Buddy sites similar
 - Note exceedances of the National Ambient Air Quality Standards (NAAQS)
 - Historically consistent
- Important to communicate issues to protect data completeness:
 - Monitor failures
 - Maintenance activities
 - Correct use of null codes
 - Network or power outages
 - **Document corrective actions**
 - (If it wasn't documented, then it didn't happen!)

Data Validation – If it wasn't documented....

Parameter	Site	Notes
Station Temp	Site 1	Spike in temperature 90 degrees, due to AC failure
	Site 2	
	Site 3	
	Site 4	
	Site 5	
	Site 6	
	Site 7	
	Site 8	
SO2	Site 1	Temperature exceeded 30 C due to AC failure QC Check failed 8/12
	Site 2	
	Site 3	
	Site 4	
	Site 5	
Ozone	Site 1	Flatlined 8/11 at 0900
	Site 2	
	Site 3	
	Site 4	Calibration 8/1 0700 - 0900
	Site 5	
	Site 6	
	Site 7	
PM2.5	Site 1	Flow check 8/12 1200
	Site 2	
	Site 3	data diverges from buddy site abnormally beginning 8/12 - 8/20, investigate
	Site 4	
	Site 5	

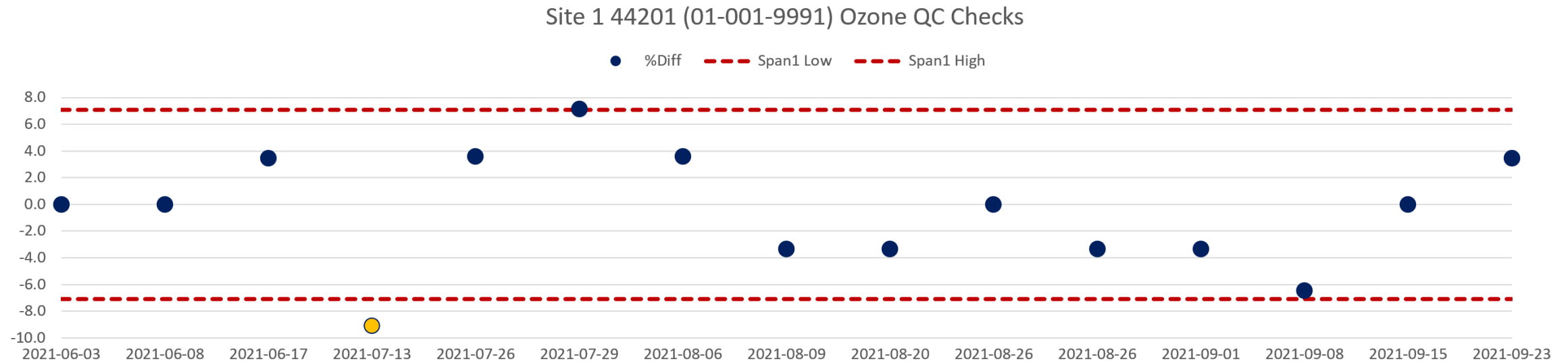
- Develop a consistent process for notes:
 - Electronic recommended
 - Weekly notes
 - Monthly memos
 - Emails
 - Be careful, these can get lost especially attachments and chains
 - Break up in chunks
 - Site
 - Parameter
 - Region
 - Etc.
- Documentation is key!

Data Validation – Know your Data! QC Checks



- Review Quality Control (QC) Checks
 - Coded properly
 - Following SOPs
 - Appropriate levels
 - Allowing for stability
 - Frequency
- Every 14 Days at a minimum
 - QC Check
 - Zero/Span Check
 - May be combined into Zero/Span/Precision (QC) Checks
- Recommend nightly automated checks one or both type
- Be mindful of data completeness rules!

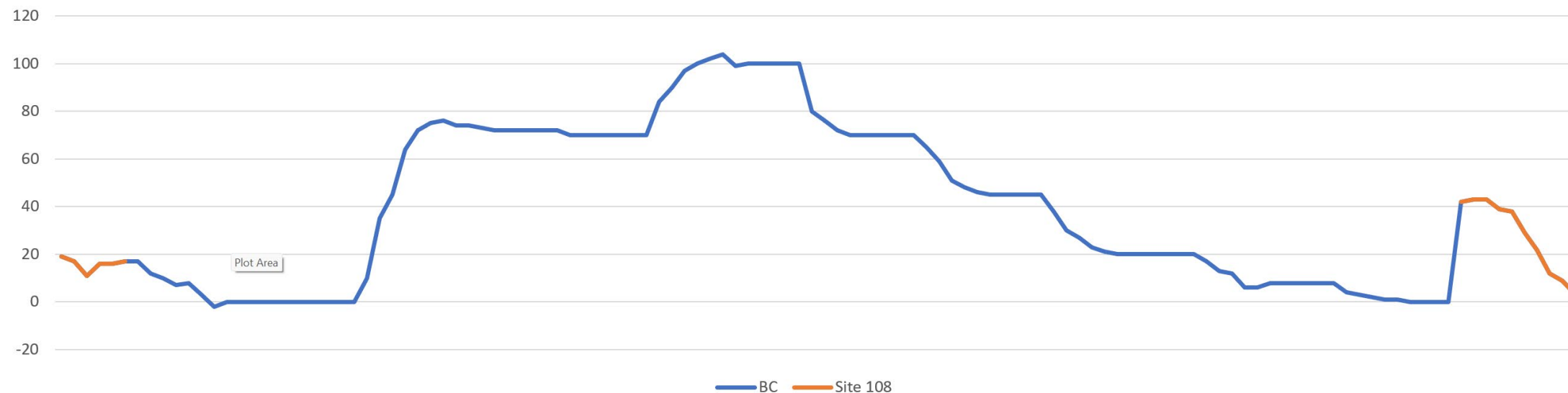
Data Validation – Know your Data! QC Checks



- Control Chart Checks

- Do one each for Zeros, Spans, and Precision (QC) Checks
- Look for trends and shifts
- Watch for zero drift
- Are exceedances documented and data coded appropriately (bracketed)?

Data Validation – Know your Data! QA/QC



- Review Calibration and Performance Evaluation (PE)/Audit Results

- Null coded appropriately
- Following SOP for stability, concentration levels, number of points
- Clear stair steps
- Frequency – Annual at least

- Go deeper

- Traceable standards
 - Expiration dates
- Certified/Verified standards
 - Flow, Zero Air, Dilution Calibrators

Data Validation – Trust but verify – QA/QC



- Do not rely on automation or record review only!
- Spot check at different review levels
- Look behind the null codes

Data Validation – Process – Record Review

- Things to review beyond routine data:
 - QC Checks
 - Logbooks
 - Maintenance records
 - Calibration records
 - PE/Audit Records
 - Certification records
 - Chain of Custody
 - Document control features
 - Edit histories (documents and Data Acquisition System (DAS))
 - Firmware/Software Versions
 - Anything that could affect data quality!



Data Validation – Process – Documentation

- Strongly recommend development of a consistent documentation process:
 - Weekly – L1 & L2
 - Monthly – L1, L2 & L3
 - Quarterly – L2 & L3
 - Annual Report - L3 & others
- Make decisions and document them:
 - Data valid, invalid, or qualified?
 - Apply correct codes as applicable
 - Document compelling evidence
- Track QA/QC frequency
 - Review QA/QC codes
- Track data completeness
- Double check and use peer review as much as possible
- **Track changes in codes or validation decisions, having audit trails are important!**
- Submit only validated data to AQS!

Data Validation - Continuous Monitors, NCore CSN and Toxics Samplers						
Month/Year:	Date Reviewed:		Reviewed by:			
Data Submitted to AQS:			Completeness Check:			
Station	Parameter	QA/QC Checks, Results	Validity, Missing, Comments	Data Capture	Action: Valid, Invalid, Flag?	Response
Site 1	O3					
	NO2					
	WS/WD					
Site 2	SO2					
	O3					
	Temp, RH, WS/WD					
NCore	SO2					
	CO					
	O3					
	NO/NO2/NOx					
	NO/NOy					
	PM2.5 Continuous					
	BC					
	WS/WD					
	Temp/RH					
	PM2.5 spec - carbon				Validated in DART	

Validation and Data Submittal Checklist													
Year													
Date Complete:		Validation Complete	Submitted to AQS										
			Month										
Station	Parameter		1	2	3	4	5	6	7	8	9	10	11
Site1	PM _{2.5} Continuous												
	Metr. Check												
Site 2	Partisol												
	PM _{2.5} Continuous												
	SO ₂												
NCore & PAMS Met.	O ₃												
	Station Check												
	SO ₂												
	CO												
	O ₃												
	NO/NO ₂ /NO _x												
	True NO ₂												
	NO/NO _y												
	PM _{2.5} Continuous												
	PM _{2.5} Continuous CO												
	PM ₁₀ Continuous												
	PM ₁₀ Continuous												
	PM ₁₀ Continuous												
	BC												
	Metr. Check												
	UV/Solar												
	Rain												
PAMS (Jun - Aug)	Ceillometer												
	PM2.5 spec - SASS												
	PM2.5 spec - URG												
	VOC canisters												
	Carbonyls												

Data reviewed but not submitted to AQS

Data reviewed but not submitted to AQS until 2023

Data reviewed but not submitted to AQS

Data reviewed and validated in DART, EPA contractor submits to AQS

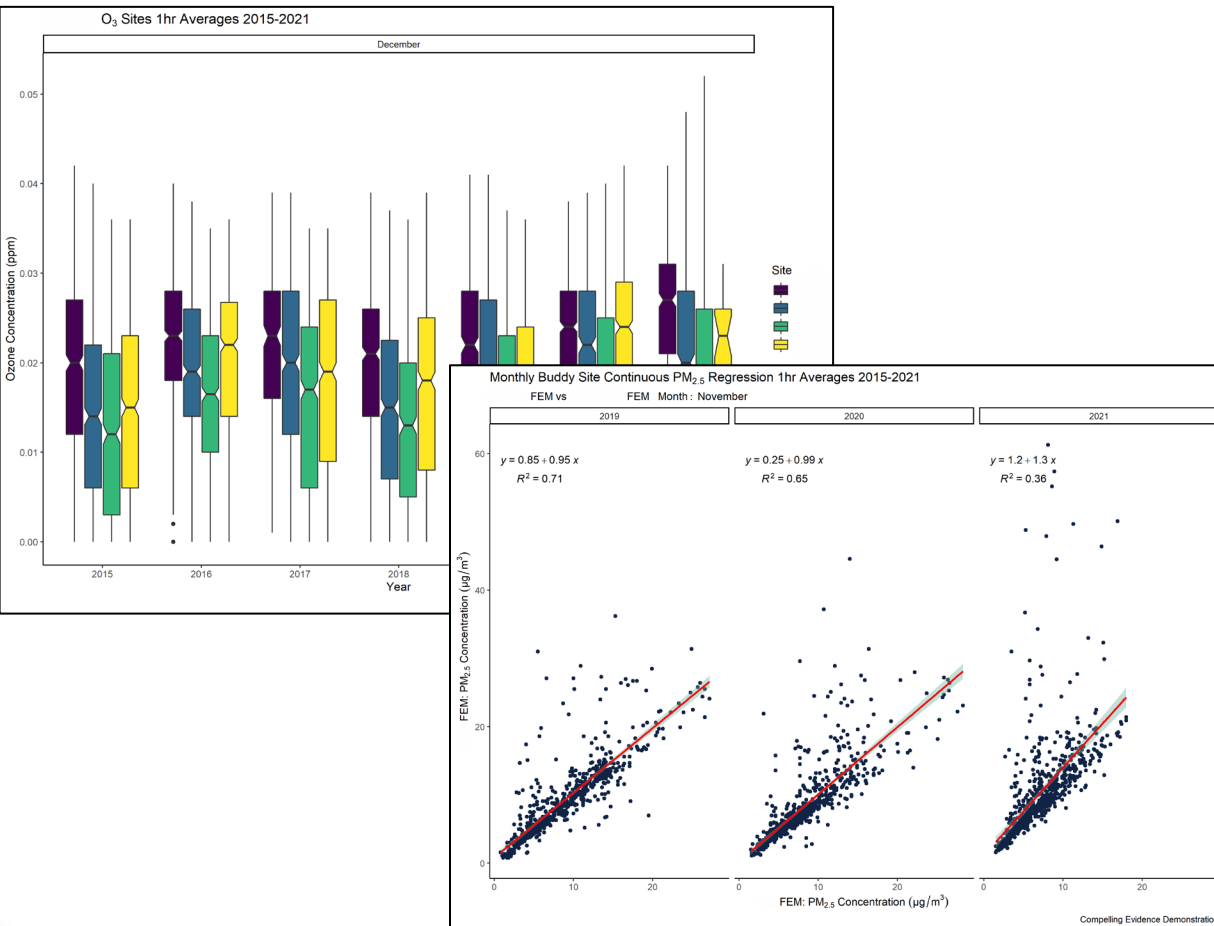
Data reviewed and validated in DART, EPA contractor submits to AQS

Data from contract lab, validated separately and manually submitted to AQS

PAMS Season only, validated separately and manually submitted to AQS

PAMS Season only, validated separately and manually submitted to AQS

Data Validation – Compelling Evidence



- If you need compelling evidence to support validation decisions:
- Box (or Violin) Plots, Linear regressions and other analyses can be used for compelling evidence in various ways:
 - Monthly comparisons
 - Site comparisons
 - Annual comparisons
 - Seasonal comparisons
- **Be sure to stick around for the next presentation on the Weight of Evidence Approach!**

Data Validation – Data Completeness

- Invalid data lowers the percentage of valid data capture, referred to as Data Completeness
- Rules for data completeness vary by pollutant see **Systematic Criteria** section of Validation Templates for each pollutant
- Invalid hours affect days which affect the completeness of a month which affect the completeness of a quarter which affect the completeness of a year
- Design values require 3 valid years of data

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Value	19	17	11	16	16	17	16	18	22	35	46	50	56	54	50	43	41	37	34	32	27	26	25	25	24	23	17	18	16	9	15

Quarter/Year	1	2	3	4	5	6	7	8	9	10	11	12
Percent	98	99	95	75	60	17	88	99	98	97	98	99

3 Year	1	2	3
Percent	85	99	95

Data Validation – Data Completeness

Minute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
Value	19	17	11	16	16	17	16	18	22	35	46	50	56	54	50	43	41	37	34	32	27	26	25	25	24	23	17	18	16	9	15	23	28	31	32	33	33	34	36	37	37	35	34	26	15																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

- An hour is complete if 75% of the minutes are valid
 - Plan checks with data completeness in mind
 - To save hours have checks cross from 15 minutes in one hour to 15 minutes in the next

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Value	19	17	11	16	16	17	16	18	22	35	46	50	56	54	50	43	41	37	34	32	27	26	25	25

- A day/24-hour average is complete if 75% of the hours are valid
 - Plan calibrations and maintenance with data completeness in mind
 - Be mindful of individual pollutant rules, some highlights:
 - Can affect PM 24 or Ozone 8-hour* averages either positively or negatively
 - *6 valid hours out of an 8-hour average count for completeness
 - Ozone season has high data completeness requirements
 - 1 in 3-, 6-, or 12-day sample schedules can miss fewer samples

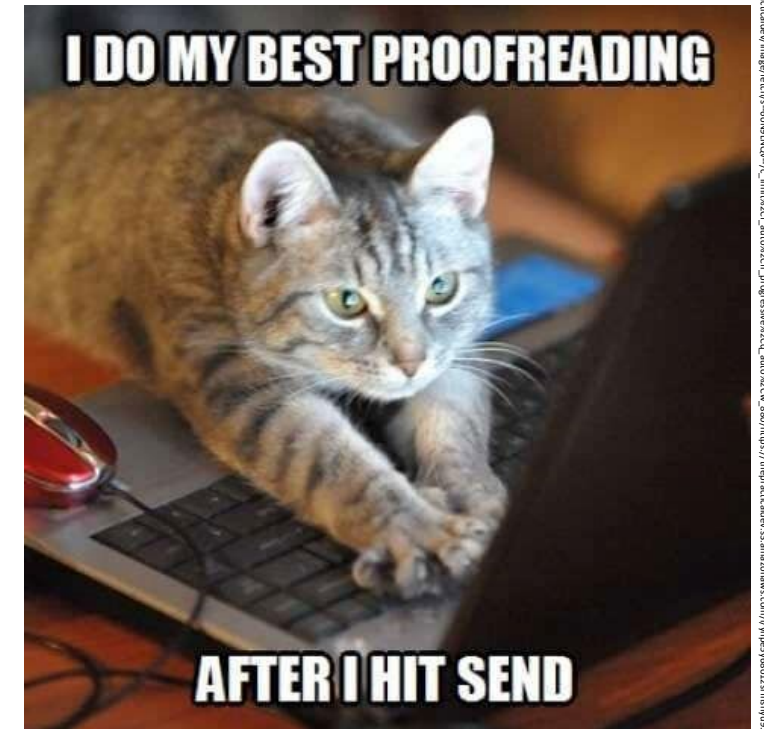
Data Validation – Data Substitutions

Hour/Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Primary Value	19	17	11	16	16	17	16	18	22	35	46	50	56	54	50									
Collocated Value	19	16	13	16	17	18	16	19	23	33	47	51	54	52	49	41	41	37	34	32	27	26	25	25

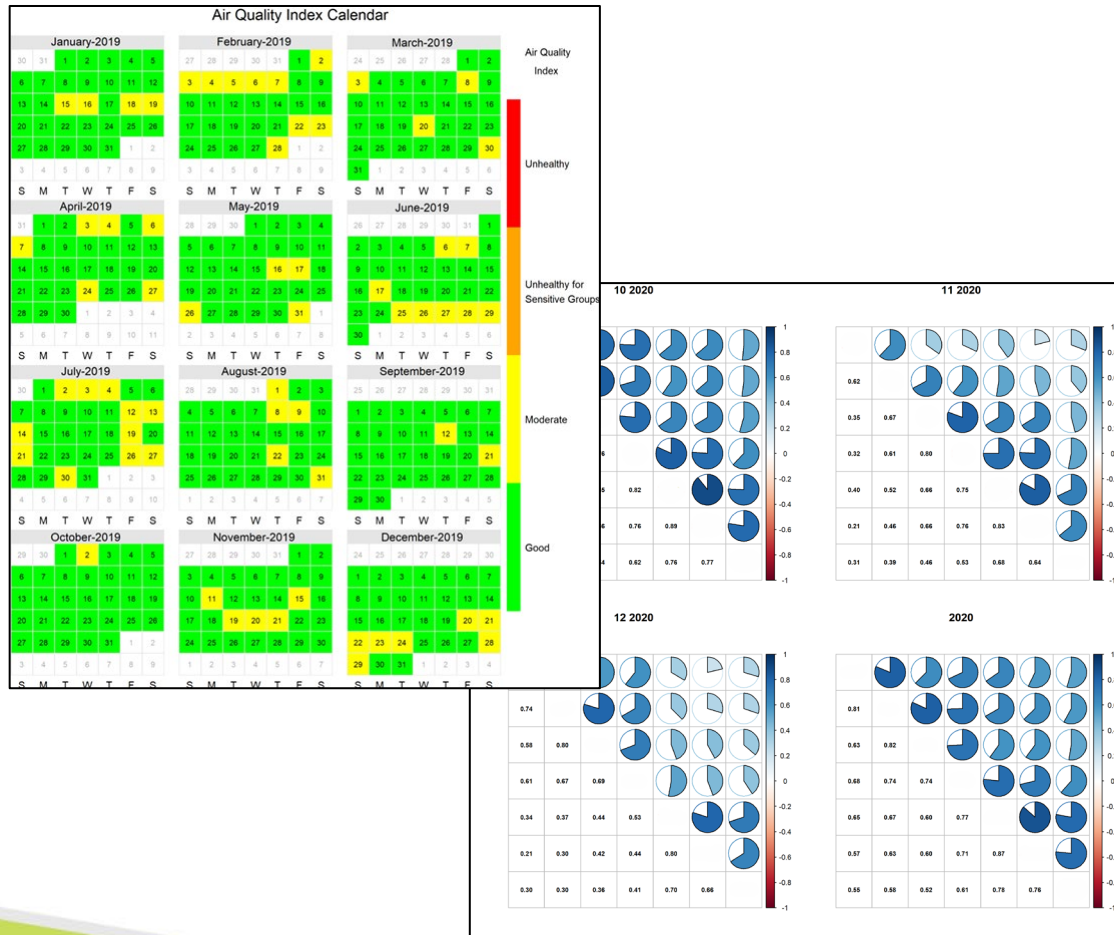
- In specific cases missing data from a primary monitor may be substituted with validated data from a collocated secondary monitor
- Secondary monitor data must be valid and validated with the same procedures the primary monitor
- Some of this occurs automatically in AQS, especially for PM monitors
- 40 CFR Parts 50 & 58 have rules on data substitutions

Data Validation – Data Certification

- Data Certification – end of year review and certification of validated data in AQS to determine if Data Quality Objectives (DQOs) are being met.
 - Helpful AQS Reports:
 - AMP 430 – Data completeness report
 - AMP 350 – Data matrix report, data bracketed correctly, more on this later
 - AMP 600 – Required, shows data completeness, precisions/bias calculations, sufficient audits
 - With a well documented and thorough data validation process there should be no surprises!
 - Recommend documenting any failing criteria or missing data in the cover letter

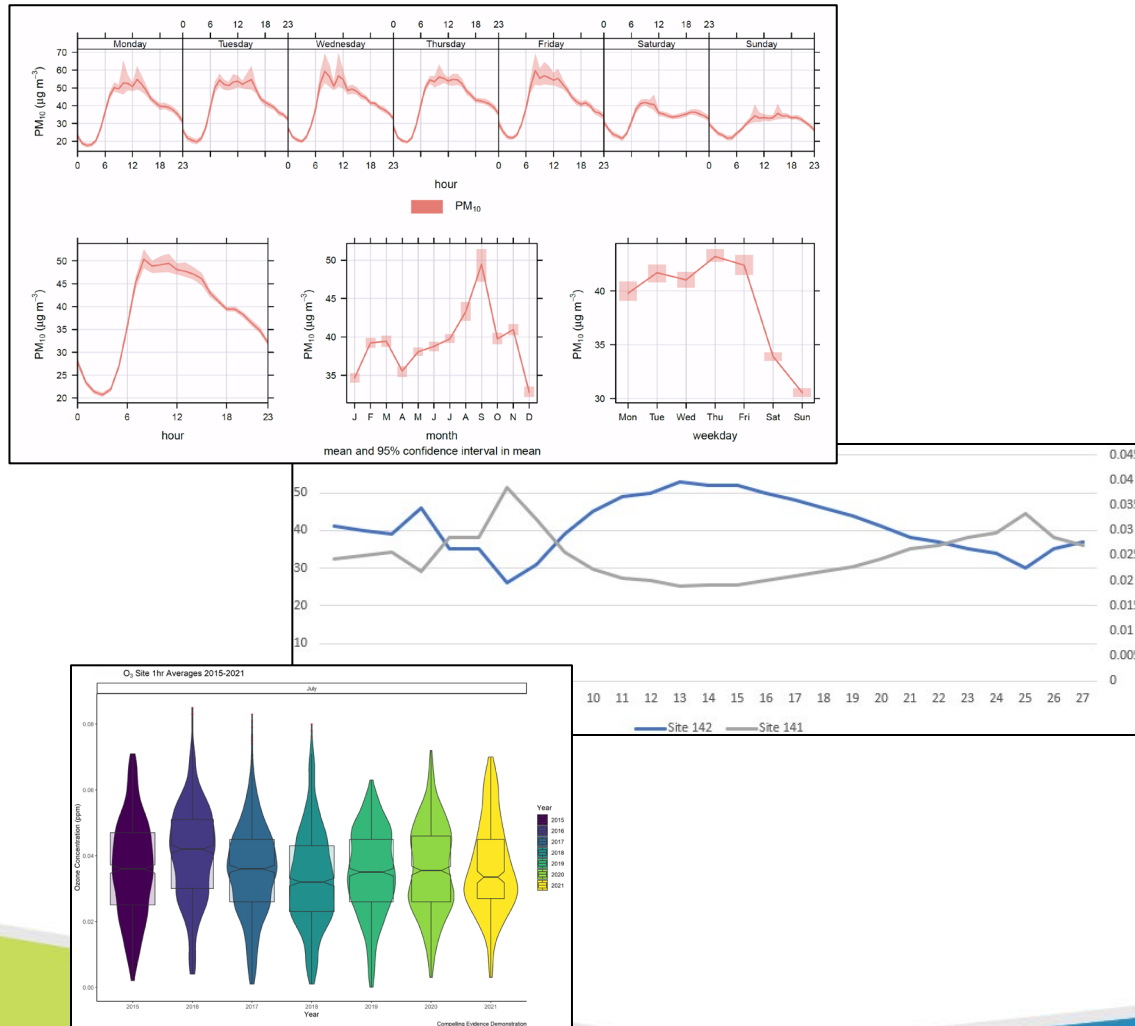


Data Validation – Know your Data! - Historical



- As you review data you will be more comfortable with the variability and be able to anticipate issues as they arise
- If you're new be sure to read your agency's:
 - 5-Year Network Assessment
 - Annual Network Plan
- Review longer periods of data
- Use data visualization tools such as Excel, R, or online resources
- Examples of additional data review:
 - Perform correlation analyses to help determine:
 - “buddy sites” Sites with similar readings and usually nearby
 - Unique sites

Data Validation – Know your Data! – Historical



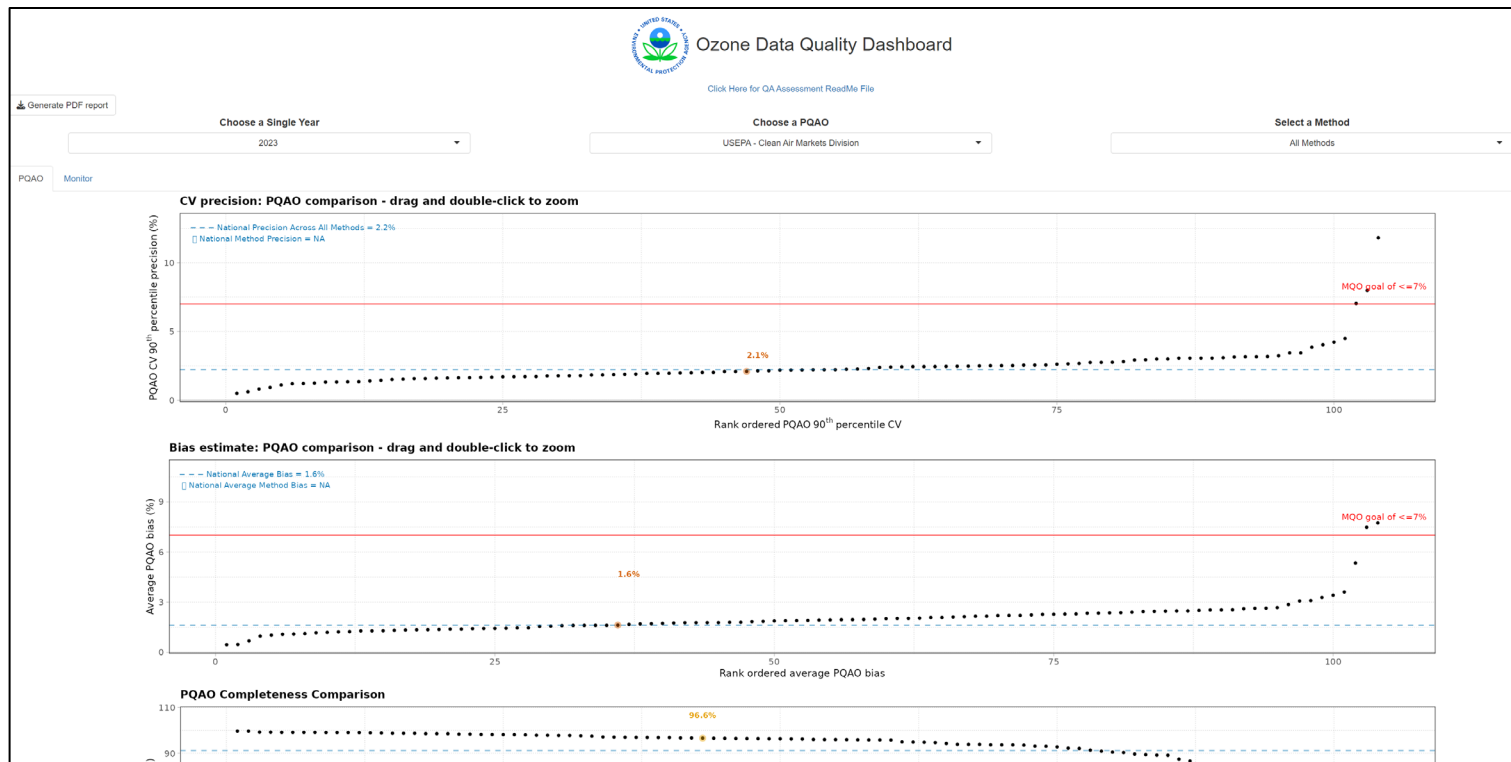
- More example data review:
 - Time series
 - Diurnal patterns
 - Seasonal patterns
 - Compare different pollutants or meteorological data 2Y (NO_x/Ozone or Ozone/Temperature)
 - Box (and whisker) plots:
 - Averages
 - Inner quartile ranges
 - Outer quartile ranges
 - Outliers
 - Violin plots, similar but show data distribution, can be combined with box plots

Data Validation – Tools: Data Quality Dashboards



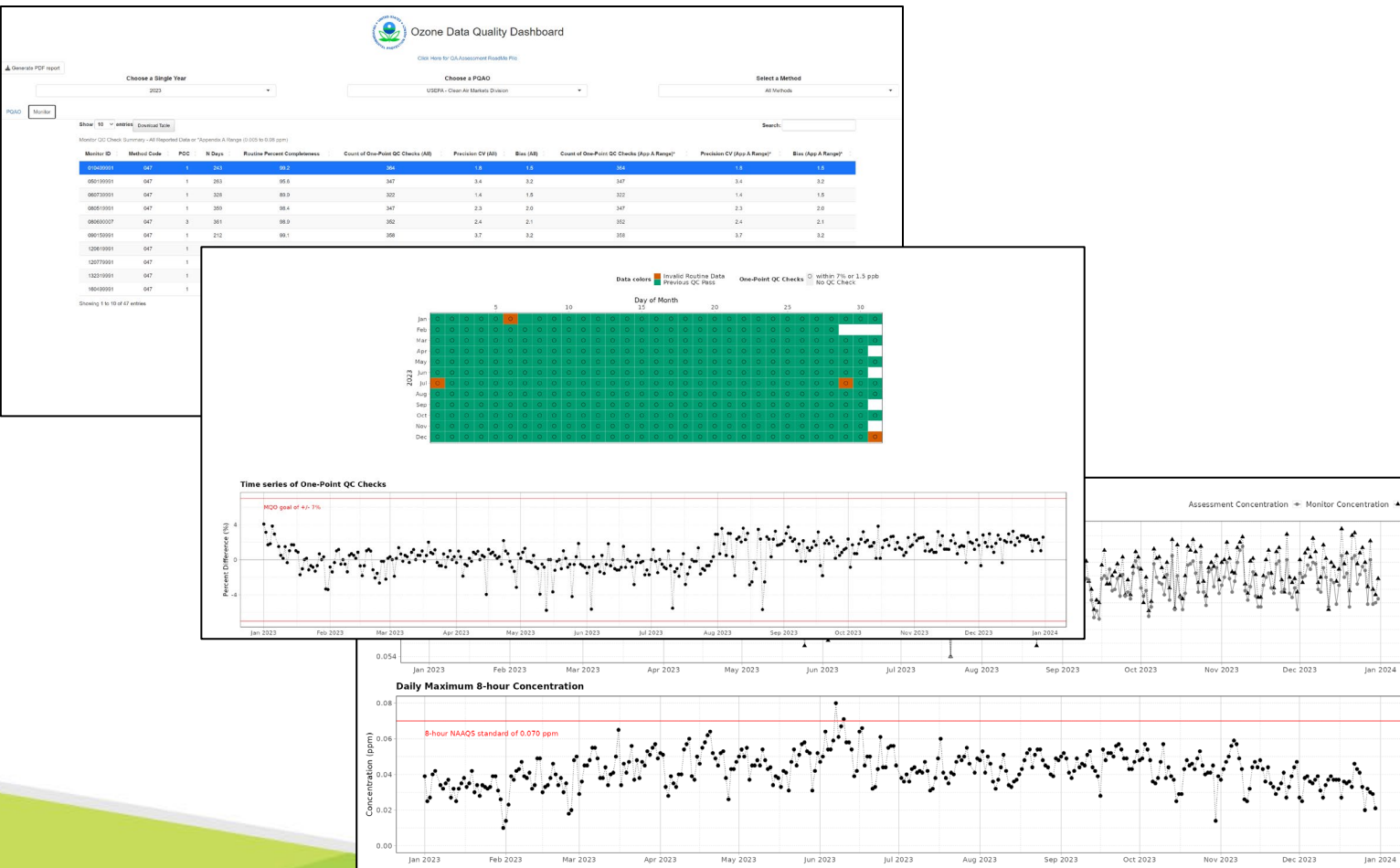
- Let's talk EPA's online dashboards.
 - Links in the Important Resources section
- Limitations:
 - Data must have been submitted to AQS
 - Updated periodically
 - Can only review one year at a time

Data Quality Dashboards – PQAO Page



- Focusing on Gaseous pollutants
 - Select Year
 - Choose your Primary Quality Assurance Organization (PQAO)
 - Optional choose a specific method
 - First tab shows MQO's compared to other PQAOs
 - Can select and see how you compare to other PQAOs

Data Quality Dashboards – Monitor Tab



- Often missed is the Monitor Tab
- Shows all the chosen PQAO's monitors and various MQO's
- Select a monitor ID to explore the data related to that monitor in charts below:
 - Graphical matrix view of checks and validity
 - **QC Check control charts***
 - QC check levels and responses
 - **Data time series***
- *Recommend developing these charts internally

Data Validation – Stats for higher ups...

- Give data validators their flowers!
 - 1 Continuous Parameter
 - Minutes in a day = 1,440
 - Hours in a week = 168
 - Hours in a month = 744 (31 days)
 - Hours in a year = 8,760
 - Now multiply by at least 6 continuous criteria pollutants = 52,560
 - R3 Largest agency ~64 sites, 2022, all parameter Raw Data in AQS = **3,242,379**
 - R3 Smallest agency ~5 sites, 2022, all parameter Raw Data in AQS = **725,419**
- A lot of data is reviewed by people



Breathe in, breathe out

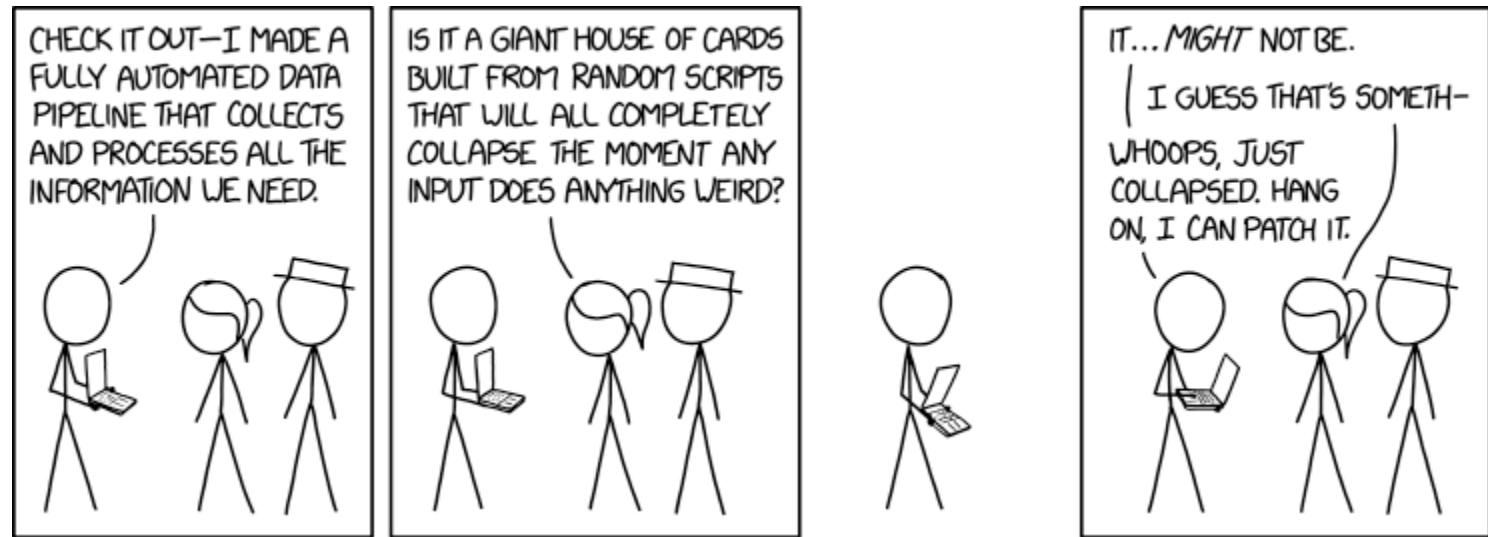
Breathe in, breathe out, breathe in, breathe out, breathe in, scream into the void while breathing out!



Stand up, Sit down



Stretch, grab a drink of water, start a conversation you won't be able to finish 😊



<https://xkcd.com/>

Air Quality System Coding

Guidance and recommendations on coding data.

AQS Coding - Resources

- Coding Manual
- <https://aqs.epa.gov/aqsweb/documents/codingmanual/html/index.html>
- AQS Code Lists
- <https://www.epa.gov/aqs/aqs-code-list>
- Best Practices for Review and Validation of Ambient Air Monitoring Data – Section 3.1
- <https://www.epa.gov/system/files/documents/2021-10/data-validation-guidance-document-final-august-2021.pdf>

AQS Coding – Null Data Codes

AT - Calibration

BK - Site computer/data logger down

QV - Quality Control Multi-point Verification

AS - Poor Quality Assurance Results

AQ - Collection Error

AB - Technician Unavailable

BA - Maintenance/Routine Repairs

- Data are invalidated
 - Indicates causes for data invalidation or QA/QC & maintenance activities
 - No concentration is shown
 - 1C and 1F may be applied to QA transactions for frequency credit
 - **Affects data completeness**
- Important to use appropriate null code to explain missing data, useful for analyses:
 - Determine frequency and type of QA/QC activities
 - Helps find associated QA Transactions
 - Determine frequency of maintenance or calibrations
- Always code missing data!
 - Recommend limiting use of Miscellaneous Void “AM”, codes should be as specific as possible
 - *NOTE: AQS Codes are periodically updated, usually with some notification, but agencies are encouraged to review the list routinely.*
 - Some more appropriate for laboratory analyses
 - Consult with regional QA staff when in doubt

AQS Coding – Qualifier (flag) Codes

2 - Operational Deviation

QX - Does not meet QC criteria

SX - Does Not Meet Siting Criteria

6 - QAPP Issue

V - Validated Value

QT - Temperature Sensor Questionable

1 - Deviation from a CFR/
Critical Criteria Requirement

- Data qualified (flagged) but not invalidated
 - Indicates there are concerns with data quality
 - Qualifiers cannot be applied to invalidated data
 - Cannot be applied to QA transactions
 - **Does not affect data completeness**
- Maximum of 10 qualifiers
 - Reminder, depending on the number of and type of qualifier, it is important to consider whether data should actually be invalidated
 - Compelling evidence should be thoroughly **documented** in validation notes
- Some more appropriate for laboratory analyses
 - Consult with regional QA staff when in doubt

AQS Coding – Informational & Request Exclusion Codes

IA	African Dust.
IB	Asian Dust.
IC	Chem. Spills & Indust Accidents.
ID	Cleanup After a Major Disaster.
IE	Demolition.
IF	Fire - Canadian.
IG	Fire - Mexico/Central America.
IH	Fireworks.
II	High Pollen Count.
IJ	High Winds.
IK	Infrequent Large Gatherings.
IL	Other.
IM	Prescribed Fire.
IN	Seismic Activity.
IO	Stratospheric Ozone Intrusion.
IP	Structural Fire.
IQ	Terrorist Act.
IR	Unique Traffic Disruption.
IS	Volcanic Eruptions.
IT	Wildfire-U. S.
J	Construction.

RA	African Dust.
RB	Asian Dust.
RC	Chemical Spills & Industrial Accidents.
RD	Cleanup After a Major Disaster.
RE	Demolition.
RF	Fire - Canadian.
RG	Fire - Mexico/Central America.
RH	Fireworks.
RI	High Pollen Count.
RJ	High Winds.
RK	Infrequent Large Gatherings.
RL	Other.
RM	Prescribed Fire.
RN	Seismic Activity.
RO	Stratospheric Ozone Intrusion.
RP	Structural Fire.
RQ	Terrorist Act.
RR	Unique Traffic Disruption.
RS	Volcanic Eruptions.
RT	Wildfire-U. S.

- Similar to Qualifier codes
 - **Does not affect data completeness**
- Used to provide additional information that may be impacting data, or
- First step in an exclusion request
 - Exceptional Events, work with your Region, will require additional documentation and information in AQS

AQS Coding – Confusing Terminology

- All codes contribute to “Qualified Data”
- Some are Null Data codes
- Codes that aren’t null code are referred to as “Qualifier” codes or as “Flags” and “Flagged” data
- Some may use the term “Informational” in place of “Qualifier” or “Flag”, this can also refer to specific type of Qualifier Code as noted previously

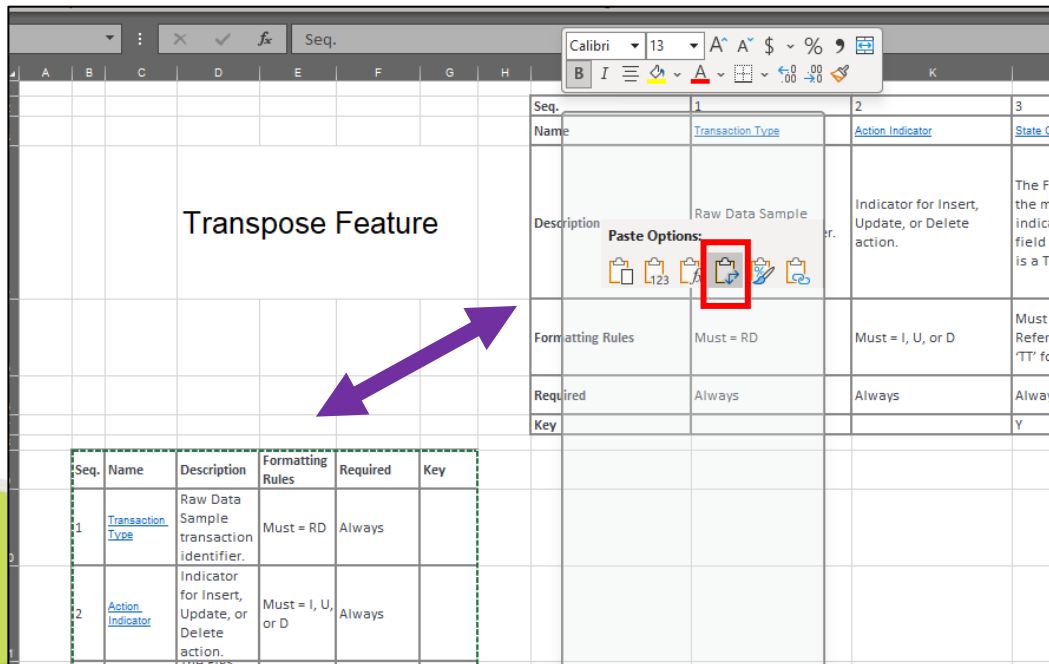
AQS Coding – Data Strings

Raw Data

RD|I|00|001|9991|44201|1|1|007|047|20240812|00:00|0.020|||1V|||||||

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Name	Transaction Type	Action Indicator	State Code / Tribal Indicator	County Code / Tribal Code	Site Number	Parameter Code	POC	Sample Duration Code	Reported Unit Code	Method Code	Sample Date	Sample Begin Time	Reported Sample Value	Null Data Code	Collection Frequency Code	Monitor Protocol ID	Qualifier Code - 1	Qualifier Code - 2	Qualifier Code - 3	Qualifier Code - 4	Qualifier Code - 5	Qualifier Code - 6	Qualifier Code - 7	Qualifier Code - 8	Qualifier Code - 9	Qualifier Code - 10	Alternate Method Detection Limit	Measurement Uncertainty
Example	RD	I	00	001	9991	44201	1	1	007	047	20240812	00:00	0.020				1V											

Transpose Feature



Seq.	Name	Description	Formatting Rules	Required	Key
1	Transaction Type	Raw Data Sample transaction identifier.	Must = RD	Always	
2	Action Indicator	Indicator for Insert, Update, or Delete action.	Must = I, U, or D	Always	

- Pro-Tip! Copy table and Right Click > Paste Options: “Transpose” is handy for going from vertical to horizontal tables and vice versa!

AQS Coding – Null Data Code Considerations

- Quality Control (QC) Activities
 - Use the appropriate code for the activity
 - Should be corresponding QA transaction for QC Checks to meet the minimum CFR criteria (some agencies submit all)
 - AX – 1 Point, QC/Precision Check only, no zero or span
 - AY – 2 Points, Zero/Span only, no QC check (if submitting zero/span checks)
 - BF – 3 Points, Zero/Span/and QC/Precision
- Calibrations
 - AT – Calibration: Recommend used for continuous PM monitor calibrations
 - BC – Multi-point Calibration: Recommend used for multi-point Gas calibrations
 - QV – QC Multi-point Verification: May be used for un-adjusted gas linearity checks

AQS Coding – Null Data Code Considerations

- Quality Assurance (QA) Activities
 - Performance Evaluations/Audits
 - Strongly recommend differentiating between agency audits and NPAP or other third-party audits, R3 Recommends:
 - AZ – QC Audit: Agency audits
 - BL – QA Audit: Third-party audits
 - *Note: Use codes consistently!*
 - Dates with these codes should have corresponding audit transactions, differentiating helps search for either Performance Evaluations or NPAP Results



AQS Coding – Bracketing Data

- Bracketing Data
 - Null and qualifier codes should be informative, providing a “narrative” of the data quality
 - For QA/QC Null codes there should be corresponding QA Transaction records as applicable
 - **There must be supporting documentation for all codes!**

NOTE: For the next examples, the Qualifier column either indicates the meaning of the null code or a qualifier is applied

Date Time	Ozone ppb	Qualifier
8/12/2024 0:00	25	-
8/12/2024 1:00	AX	Precision Check
8/12/2024 2:00	17	-
8/12/2024 3:00	17	-
8/12/2024 4:00	15	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
8/12/2024 7:00	BF	Z/S/P Check
8/12/2024 8:00	45	-
8/12/2024 9:00	70	-
8/12/2024 10:00	80	-
8/12/2024 11:00	74	-
8/12/2024 12:00	73	-
8/12/2024 13:00	67	-
8/12/2024 14:00	77	-
8/12/2024 15:00	80	-
8/12/2024 16:00	67	-
8/12/2024 17:00	59	-
8/12/2024 18:00	50	-
8/12/2024 19:00	49	-
8/12/2024 20:00	54	-
8/12/2024 21:00	42	-
8/12/2024 22:00	36	-
8/12/2024 23:00	32	-
8/13/2024 0:00	32	-
8/13/2024 1:00	27	-
8/13/2024 2:00	21	-
8/13/2024 3:00	16	-
8/13/2024 4:00	14	-
8/13/2024 5:00	14	-
8/13/2024 6:00	BF	Z/S/P Check
8/13/2024 7:00	24	-
8/13/2024 8:00	35	-
8/13/2024 9:00	46	-

AQS Coding – Bracketing Data

- Bracketing Data – Example 1
 - “AX” Code likely an automatic Precision (QC) Check
 - “BF” codes indicating zero/span/precision checks (QC point)
 - One on 8/12 and on 8/13
 - Data between “BF” and “AX” are not qualified indicating checks passed criteria.
 - As applicable there should be a corresponding QA Transaction for those dates.
 - *NOTE: not all agencies may report all automatic QC checks or Zero/Span checks.*

DateTime	Ozone ppb	Qualifier
8/12/2024 0:00	25	-
8/12/2024 1:00	AX	Precision Check
8/12/2024 2:00	17	-
8/12/2024 3:00	17	-
8/12/2024 4:00	15	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
8/12/2024 7:00	BF	Z/S/P Check
8/12/2024 8:00	45	-
8/12/2024 9:00	70	-
8/12/2024 10:00	80	-
8/12/2024 11:00	74	-
8/12/2024 12:00	73	-
8/12/2024 13:00	67	-
8/12/2024 14:00	77	-
8/12/2024 15:00	80	-
8/12/2024 16:00	67	-
8/12/2024 17:00	59	-
8/12/2024 18:00	50	-
8/12/2024 19:00	49	-
8/12/2024 20:00	54	-
8/12/2024 21:00	42	-
8/12/2024 22:00	36	-
8/12/2024 23:00	32	-
8/13/2024 0:00	32	-
8/13/2024 1:00	27	-
8/13/2024 2:00	21	-
8/13/2024 3:00	16	-
8/13/2024 4:00	14	-
8/13/2024 5:00	14	-
8/13/2024 6:00	BF	Z/S/P Check
8/13/2024 7:00	24	-
8/13/2024 8:00	35	-
8/13/2024 9:00	46	-

AQS Coding – Bracketing Data

- Bracketing Data – Example 2a
 - “AX” code again indicating an automatic Precision (QC) Check
 - “BF” codes again indicating zero/span/precision checks (QC point)
 - Data between “BF” codes are null coded as “AS” (Poor QA) and then “BA” (Maintenance) right before the second check
 - This indicates the first “BF” check likely failed and data were null coded to indicate poor QA results followed by maintenance and a repeated check
 - *NOTE: “EC” for exceeds criteria may also be used here, internal consistency is key*
 - Data afterward are not qualified indicating the check passed and the problem was resolved
 - **Reminder, this is all conjecture without documentation!**

DateTime	Ozone ppb	Qualifier
8/12/2024 0:00	25	-
8/12/2024 1:00	AX	Precision Check
8/12/2024 2:00	17	-
8/12/2024 3:00	17	-
8/12/2024 4:00	15	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
8/12/2024 7:00	BF	Z/S/P Check
8/12/2024 8:00	AS	Poor QA Result
8/12/2024 9:00	AS	Poor QA Result
8/12/2024 10:00	AS	Poor QA Result
8/12/2024 11:00	AS	Poor QA Result
8/12/2024 12:00	AS	Poor QA Result
8/12/2024 13:00	AS	Poor QA Result
8/12/2024 14:00	AS	Poor QA Result
8/12/2024 15:00	AS	Poor QA Result
8/12/2024 16:00	AS	Poor QA Result
8/12/2024 17:00	AS	Poor QA Result
8/12/2024 18:00	AS	Poor QA Result
8/12/2024 19:00	AS	Poor QA Result
8/12/2024 20:00	AS	Poor QA Result
8/12/2024 21:00	AS	Poor QA Result
8/12/2024 22:00	AS	Poor QA Result
8/12/2024 23:00	AS	Poor QA Result
8/13/2024 0:00	AS	Poor QA Result
8/13/2024 1:00	AS	Poor QA Result
8/13/2024 2:00	AS	Poor QA Result
8/13/2024 3:00	AS	Poor QA Result
8/13/2024 4:00	BA	Maintenance
8/13/2024 5:00	BA	Maintenance
8/13/2024 6:00	BF	Z/S/P Check
8/13/2024 7:00	24	-
8/13/2024 8:00	35	-
8/13/2024 9:00	46	-

AQS Coding – Bracketing Data

- Bracketing Data – Example 2b
 - Is anything wrong with this coding?



DateTime	Ozone ppb	Qualifier
8/12/2024 0:00	25	-
8/12/2024 1:00	AX	Precision Check
8/12/2024 2:00	17	-
8/12/2024 3:00	17	-
8/12/2024 4:00	15	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
8/12/2024 7:00	BF	Z/S/P Check
8/12/2024 8:00	AS	Poor QA Result
8/12/2024 9:00	AS	Poor QA Result
8/12/2024 10:00	AS	Poor QA Result
8/12/2024 11:00	AS	Poor QA Result
8/12/2024 12:00	AS	Poor QA Result
8/12/2024 13:00	AS	Poor QA Result
8/12/2024 14:00	AS	Poor QA Result
8/12/2024 15:00	AS	Poor QA Result
8/12/2024 16:00	AS	Poor QA Result
8/12/2024 17:00	AS	Poor QA Result
8/12/2024 18:00	AS	Poor QA Result
8/12/2024 19:00	AS	Poor QA Result
8/12/2024 20:00	AS	Poor QA Result
8/12/2024 21:00	AS	Poor QA Result
8/12/2024 22:00	AS	Poor QA Result
8/12/2024 23:00	AS	Poor QA Result
8/13/2024 0:00	AS	Poor QA Result
8/13/2024 1:00	AS	Poor QA Result
8/13/2024 2:00	AS	Poor QA Result
8/13/2024 3:00	AS	Poor QA Result
8/13/2024 4:00	BA	Maintenance
8/13/2024 5:00	BA	Maintenance
8/13/2024 6:00	BF	Z/S/P Check
8/13/2024 7:00	24	-
8/13/2024 8:00	35	-
8/13/2024 9:00	46	-

AQS Coding – Bracketing Data

- Bracketing Data – Example 2c
 - Data must be invalidated forward **AND** back to the last passing QC check
 - Assuming the corresponding “BF” check itself was valid there should still be a QA Transaction using the 1F code to indicate result failed
 - *See policy memo for more details: [Steps to Qualify or Validate Data after an Exceedance of Critical Criteria Checks](#)*
 - This example now shows clear corrective actions being taken; the validation records should include the details of why data were coded in this manner

DateTime	Ozone ppb	Qualifier
8/12/2024 0:00	25	-
8/12/2024 1:00	AX	Precision Check
8/12/2024 2:00	AS	Poor QA Result
8/12/2024 3:00	AS	Poor QA Result
8/12/2024 4:00	AS	Poor QA Result
8/12/2024 5:00	AS	Poor QA Result
8/12/2024 6:00	AS	Poor QA Result
8/12/2024 7:00	1F	QC Check Failed Criteria
8/12/2024 8:00	AS	Poor QA Result
8/12/2024 9:00	AS	Poor QA Result
8/12/2024 10:00	AS	Poor QA Result
8/12/2024 11:00	AS	Poor QA Result
8/12/2024 12:00	AS	Poor QA Result
8/12/2024 13:00	AS	Poor QA Result
8/12/2024 14:00	AS	Poor QA Result
8/12/2024 15:00	AS	Poor QA Result
8/12/2024 16:00	AS	Poor QA Result
8/12/2024 17:00	AS	Poor QA Result
8/12/2024 18:00	AS	Poor QA Result
8/12/2024 19:00	AS	Poor QA Result
8/12/2024 20:00	AS	Poor QA Result
8/12/2024 21:00	AS	Poor QA Result
8/12/2024 22:00	AS	Poor QA Result
8/12/2024 23:00	AS	Poor QA Result
8/13/2024 0:00	AS	Poor QA Result
8/13/2024 1:00	AS	Poor QA Result
8/13/2024 2:00	AS	Poor QA Result
8/13/2024 3:00	AS	Poor QA Result
8/13/2024 4:00	BA	Maintenance
8/13/2024 5:00	BA	Maintenance
8/13/2024 6:00	BF	Z/S/P Check
8/13/2024 7:00	24	-
8/13/2024 8:00	35	-
8/13/2024 9:00	46	-

AQS Coding – Bracketing Data

- Bracketing Data – Example 3a
 - “BF” code indicating zero/span/precision check (QC point)
 - This time data after the “BF” is qualified with “1V” indicating a CFR Criteria was exceeded but data were reviewed and validated

DateTime	SO ₂ ppb	Qualifier
8/12/2024 0:00	2	-
8/12/2024 1:00	2	-
8/12/2024 2:00	3	-
8/12/2024 3:00	3	-
8/12/2024 4:00	2	-
8/12/2024 5:00	1	-
8/12/2024 6:00	1	-
8/12/2024 7:00	BF	Z/S/P Check
8/12/2024 8:00	2	1V
8/12/2024 9:00	0	1V
8/12/2024 10:00	0	1V
8/12/2024 11:00	4	1V
8/12/2024 12:00	3	1V
8/12/2024 13:00	4	1V
8/12/2024 14:00	4	1V
8/12/2024 15:00	2	1V
8/12/2024 16:00	1	1V
8/12/2024 17:00	1	1V
8/12/2024 18:00	0	1V
8/12/2024 19:00	1	1V
8/12/2024 20:00	2	1V
8/12/2024 21:00	3	1V
8/12/2024 22:00	4	1V
8/12/2024 23:00	2	1V
8/13/2024 0:00	2	1V
8/13/2024 1:00	3	1V
8/13/2024 2:00	1	1V
8/13/2024 3:00	2	1V
8/13/2024 4:00	1	1V
8/13/2024 5:00	1	1V
8/13/2024 6:00	0	1V
8/13/2024 7:00	2	1V
8/13/2024 8:00	3	1V
8/13/2024 9:00	4	1V

AQS Coding – Bracketing Data

- Bracketing Data – Example 3b
 - While this example contains limited data for visibility's sake, often this code will be used when the span between checks exceeds the 14-day criteria, but the agency has reviewed the data and has compelling evidence that data are valid
 - Compelling evidence must be recorded in the validation notes associated with the data
 - **Reminder to stick around for Weight of Evidence Presentation**
 - Data would be qualified from one passing check to the next passing check
 - ***NOTE: 1V code should be used sparingly and corrective actions must be taken to meet criteria!***

DateTime	SO ₂ ppb	Qualifier
8/12/2024 0:00	2	-
8/12/2024 1:00	2	-
8/12/2024 2:00	3	-
8/12/2024 3:00	3	-
8/12/2024 4:00	2	-
8/12/2024 5:00	1	-
8/12/2024 6:00	1	-
8/12/2024 7:00	BF	Z/S/P Check
8/12/2024 8:00	2	1V
8/12/2024 9:00	0	1V
8/12/2024 10:00	0	1V
8/12/2024 11:00	4	1V
8/12/2024 12:00	3	1V
8/12/2024 13:00	4	1V
8/12/2024 14:00	4	1V
8/12/2024 15:00	2	1V
8/12/2024 16:00	1	1V
8/12/2024 17:00	1	1V
8/12/2024 18:00	0	1V
8/12/2024 19:00	1	1V
8/12/2024 20:00	2	1V
8/12/2024 21:00	3	1V
8/12/2024 22:00	4	1V
8/12/2024 23:00	2	1V
8/13/2024 0:00	2	1V
8/13/2024 1:00	3	1V
8/13/2024 2:00	1	1V
8/13/2024 3:00	2	1V
8/13/2024 4:00	1	1V
8/13/2024 5:00	1	1V
8/13/2024 6:00	0	1V
8/13/2024 7:00	2	1V
8/13/2024 8:00	3	1V
8/13/2024 9:00	4	1V

AQS Coding – Bracketing Data

- Bracketing Data – Example 4a
 - Using a continuous PM_{2.5} monitor example, a flow check “AX” (Precision) is performed prior to a calibration “AT”
 - Data are not qualified before the flow check or after the calibration indicating successful QC activities
- *NOTE: It is a recommended best practice to perform an “as found” QC check before routine calibrations as well as an “as left” QC check although the final QC check may not be coded.*

DateTime	PM _{2.5} µg/m ³	Qualifier
8/12/2024 0:00	10	-
8/12/2024 1:00	12	-
8/12/2024 2:00	13	-
8/12/2024 3:00	13	-
8/12/2024 4:00	12	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
8/12/2024 7:00	AX	Precision (Flow) Check
8/12/2024 8:00	AT	Calibration
8/12/2024 9:00	AT	Calibration
8/12/2024 10:00	30	-
8/12/2024 11:00	34	-
8/12/2024 12:00	33	-
8/12/2024 13:00	34	-
8/12/2024 14:00	34	-
8/12/2024 15:00	36	-
8/12/2024 16:00	37	-
8/12/2024 17:00	37	-
8/12/2024 18:00	40	-
8/12/2024 19:00	41	-
8/12/2024 20:00	42	-
8/12/2024 21:00	43	-
8/12/2024 22:00	0	-
8/12/2024 23:00	0	-
8/13/2024 0:00	0	-
8/13/2024 1:00	0	-
8/13/2024 2:00	0	-
8/13/2024 3:00	0	-
8/13/2024 4:00	0	-
8/13/2024 5:00	0	-
8/13/2024 6:00	0	-
8/13/2024 7:00	0	-
8/13/2024 8:00	0	-
8/13/2024 9:00	0	-

AQS Coding – Bracketing Data

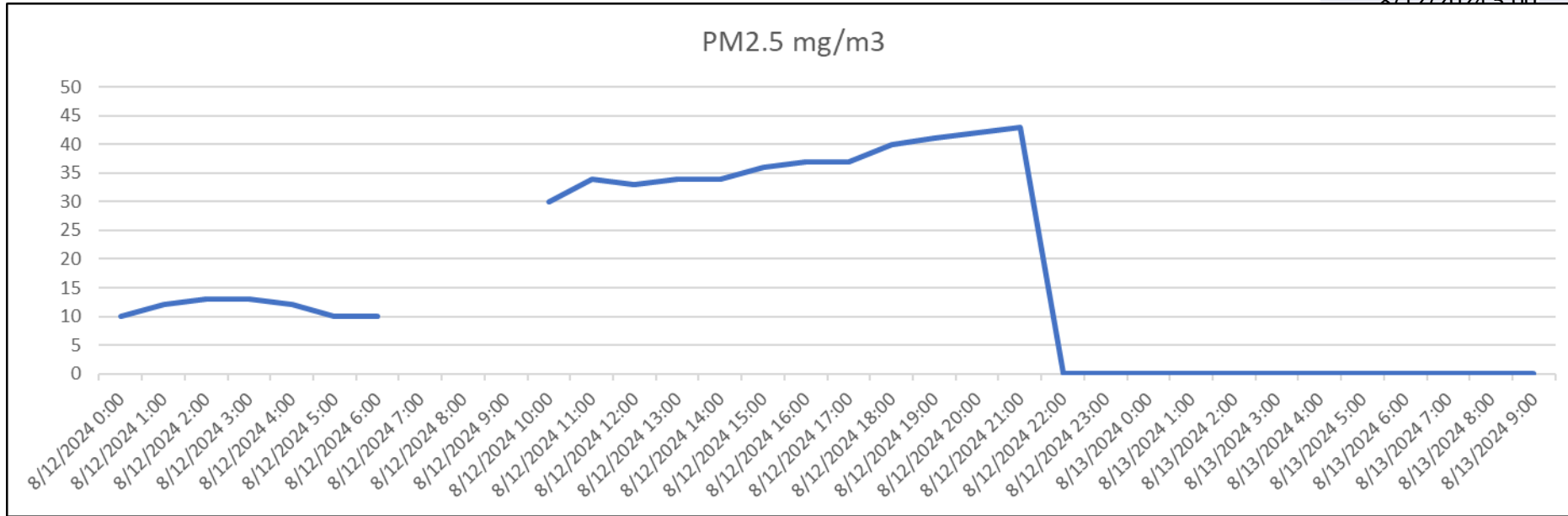
- Bracketing Data – Example 4b
 - **Wait! Does this look right?**



- Let's graph it!

DateTime	PM _{2.5} µg/m ³	Qualifier
8/12/2024 0:00	10	-
8/12/2024 1:00	12	-
8/12/2024 2:00	13	-
8/12/2024 3:00	13	-
8/12/2024 4:00	12	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
8/12/2024 7:00	AX	Precision (Flow) Check
8/12/2024 8:00	AT	Calibration
8/12/2024 9:00	AT	Calibration
8/12/2024 10:00	30	-
8/12/2024 11:00	34	-
8/12/2024 12:00	33	-
8/12/2024 13:00	34	-
8/12/2024 14:00	34	-
8/12/2024 15:00	36	-
8/12/2024 16:00	37	-
8/12/2024 17:00	37	-
8/12/2024 18:00	40	-
8/12/2024 19:00	41	-
8/12/2024 20:00	42	-
8/12/2024 21:00	43	-
8/12/2024 22:00	0	-
8/12/2024 23:00	0	-
8/13/2024 0:00	0	-
8/13/2024 1:00	0	-
8/13/2024 2:00	0	-
8/13/2024 3:00	0	-
8/13/2024 4:00	0	-
8/13/2024 5:00	0	-
8/13/2024 6:00	0	-
8/13/2024 7:00	0	-
8/13/2024 8:00	0	-
8/13/2024 9:00	0	-

AQS Coding – Bracketing Data



- For this example, we'll say the operator performing the QC activity forgot to put the sharp cut cyclone back on and then the filter overloaded and the sampler flatlined.
- How should we code this?

DateTime	PM _{2.5} µg/m ³	Qualifier
8/12/2024 0:00	10	-
8/12/2024 1:00	12	-
8/12/2024 2:00	13	-
8/12/2024 3:00	13	-
8/12/2024 4:00	12	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
AX		Precision (Flow) Check
AT		Calibration
AT		Calibration
30		-
34		-
33		-
34		-
34		-
36		-
37		-
37		-
40		-
41		-
42		-
43		-
0		-
8/12/2024 22:00	0	-
8/12/2024 23:00	0	-
8/13/2024 0:00	0	-
8/13/2024 1:00	0	-
8/13/2024 2:00	0	-
8/13/2024 3:00	0	-
8/13/2024 4:00	0	-
8/13/2024 5:00	0	-
8/13/2024 6:00	0	-
8/13/2024 7:00	0	-
8/13/2024 8:00	0	-
8/13/2024 9:00	0	-

AQS Coding – Bracketing Data

- Bracketing Data – Example 4c
 - The most logical code is operator error “BJ” although others may be acceptable
 - Data are coded from the time of the error until the operator went back out and corrected their error as indicated by the maintenance code “BA”
 - Then they performed a flow check to verify operation as indicated by “AX”.
 - After the passing flow check data were considered valid
 - **Documentation in validation notes is essential!**
 - If a flow check was not recorded or coded the validity of the data can be challenged
 - Auditors internal and external should be on the look out for these types of issues

DateTime	PM _{2.5} µg/m ³	Qualifier
8/12/2024 0:00	10	-
8/12/2024 1:00	12	-
8/12/2024 2:00	13	-
8/12/2024 3:00	13	-
8/12/2024 4:00	12	-
8/12/2024 5:00	10	-
8/12/2024 6:00	10	-
8/12/2024 7:00	AX	Precision (Flow) Check
8/12/2024 8:00	AT	Calibration
8/12/2024 9:00	AT	Calibration
8/12/2024 10:00	BJ	Operator Error
8/12/2024 11:00	BJ	Operator Error
8/12/2024 12:00	BJ	Operator Error
8/12/2024 13:00	BJ	Operator Error
8/12/2024 14:00	BJ	Operator Error
8/12/2024 15:00	BJ	Operator Error
8/12/2024 16:00	BJ	Operator Error
8/12/2024 17:00	BJ	Operator Error
8/12/2024 18:00	BJ	Operator Error
8/12/2024 19:00	BJ	Operator Error
8/12/2024 20:00	BJ	Operator Error
8/12/2024 21:00	BJ	Operator Error
8/12/2024 22:00	BJ	Operator Error
8/12/2024 23:00	BJ	Operator Error
8/13/2024 0:00	BJ	Operator Error
8/13/2024 1:00	BJ	Operator Error
8/13/2024 2:00	BJ	Operator Error
8/13/2024 3:00	BJ	Operator Error
8/13/2024 4:00	BJ	Operator Error
8/20/2024 7:00	BJ	Operator Error
8/20/2024 8:00	BA	Maintenance
8/20/2024 9:00	AX	Precision (Flow) Check
8/20/2024 10:00	10	-
8/20/2024 11:00	10	-

AQS Coding – Best Practices

- Apply null codes for scheduled, but missed, manual samples, e.g. PM_{2.5} FRM or TSP Pb samples
- Limit the use of the CFR Criteria exceeded “1” QA qualifier flag. This code is not intended for widespread use and should only be applied under specific circumstances. Most importantly, the “1” flag is not intended to “save” weeks of data that should be otherwise invalidated. When the “1” flag is applied, EPA will expect to see compelling evidence and documentation to justify the validity of the data.
- **Apply null codes and QA qualifiers consistently! Include practices in your Data Validation SOP.**

AQS Coding – Useful Reports

- AMP360 Raw Data Qualifier Report
 - Shows all data qualifiers and null codes used based on applied filters
 - Recommend using the work file and either importing into Excel and using pivot table to explore or some coding language
- AMP350 Raw Matrix Report
 - Shows data as a matrix with day by hour or day by month for manual samples based on applied filters
 - Shows concentrations, null codes, or concentration plus first 2 qualifier characters (may be one or two codes depending on code characters)
 - Useful for evaluating if data are bracketed appropriately

Questions!

Complaints, gripes, groans,
or pleas for mercy also accepted.
No, it's not time for lunch!





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And Zoe for being a very good doggo





Important Resources

Links to important resources take these and bookmark them, keep them handy!

Data Validation – Resources: 40 CFR...

- <https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C>
- 40 Code of Federal Regulations (CFR) Parts 50, 53, and 58 specifically
 - **Part 50 National Ambient Air Quality Standards (NAAQS)**
 - Part 53 Reference and Equivalent Methods for Ambient Air Monitoring
 - **Part 58 Ambient Air Monitoring Quality Assurance**
- Useful online features
 - Ctrl + F (Find) is your friend if you click on the “text”, the “Part” takes to >
 - Table of Contents (TOC) for that Part and can be helpful if you know where you want to go
 - Links & Citations can be created for most major sections

Data Validation – Resources: Quality Assurance

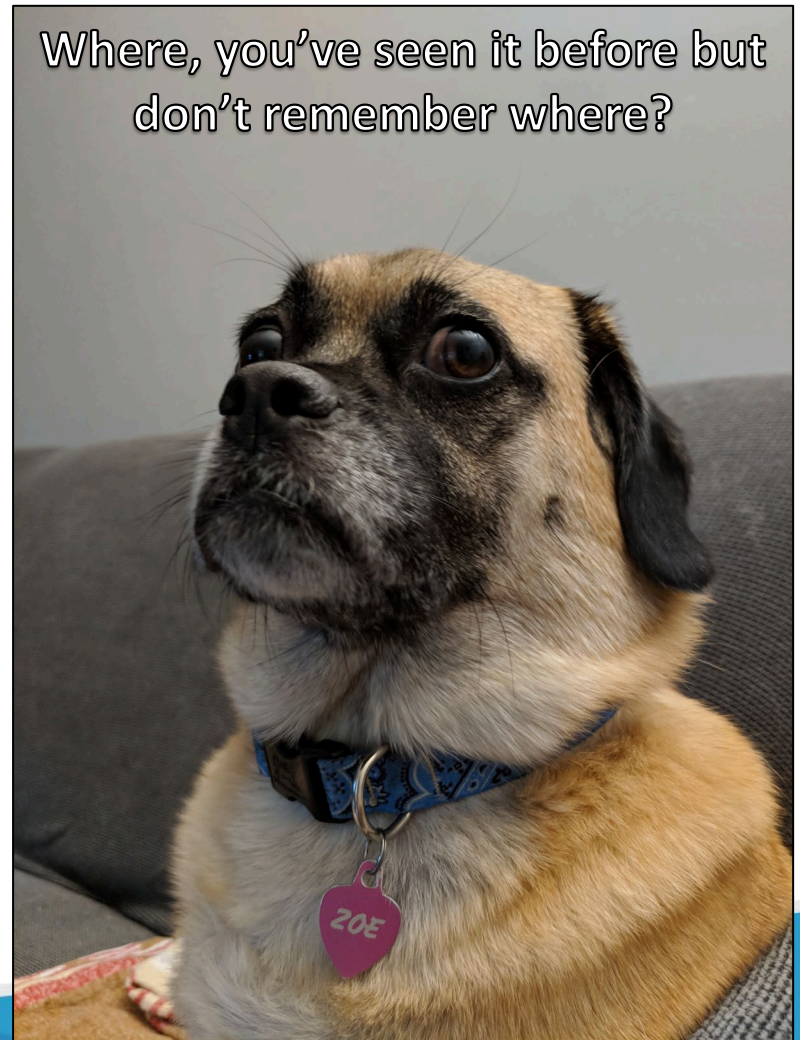
- EPA's Quality Program (Agency wide QA)
- <https://www.epa.gov/quality>
- Environmental Information Policy and Procedures
- <https://www.epa.gov/irmpoli8/environmental-information-policy-procedures-and-standards>
 - Quality Management Plan (QMP) Standard – New standard implemented in 2023
 - Quality Assurance Project Plan (QAPP) Standard – New standard implemented in 2023

Data Validation – Resources: NAAQS

- <https://www.epa.gov/criteria-air-pollutants/naaqs-table>
- Current National Ambient Air Quality Standards Table
 - Learn it, cite it, keep it handy!
- Useful features:
 - Clicking on the pollutant takes you to a sub table that shows a history of the standard and Federal Register Citation if available
 - Further in the sidebar there are links to learn more about the NAAQS process and specific pollutants.

Data Validation – Resources: AMTIC

- <https://www.epa.gov/amtic>
- Ambient Monitoring Technology Information (AMTIC)
- Hub for Air Monitoring Information:
 - Quality Assurance
 - Air Monitoring Methods
 - Air Monitoring Programs
 - Policy Memos and Guidance
 - Past conference information (where this presentation will live)
 - And more!



Data Validation – Resources: AMTIC Part I

- <https://www.epa.gov/amtic/amtic-ambient-air-monitoring-networks>
- Air Monitoring Network Information
 - NCore and SLAMS and PAMS oh my!
 - Information about specific network/site types and programs
- <https://www.epa.gov/amtic/air-monitoring-methods>
- Air Monitoring Methods
 - **Federal Reference and Equivalent Method List**
 - These are the only monitors to be used for official NAAQS Determination
 - Air Toxics, inorganic (PM, metals, etc.) and organic (VOCs, etc.) methods

Data Validation – Resources: AMTIC Part II

- <https://www.epa.gov/amtic/ambient-air-monitoring-quality-assurance>
- Quality Assurance Resources
 - One stop shop for Air Monitoring Specific QA information
 - Highlights:
 - Most of the QA Documents referenced in this presentation can be found here
 - [QA Handbook Volume II](#)
 - [Appendix D Validation Templates, T640](#), and [T640x](#)
 - [Best Practices for Review and Validation of Air Monitoring Data](#)
 - [Appendix A Checklists](#)
 - Tools to assist with calculations
 - Newsletters (QA Eye), index of topics and then links to old newsletters, note that some information may not be applicable to current requirements
 - QA Handbooks for Meteorological data
 - Links to Air Toxics, Chemical Speciation Network, and PAMS sites with QA

Data Validation – Resources: AMTIC Part III

- <https://www.epa.gov/amtic/amtic-ambient-air-monitoring-assessments>
- Air Monitoring Assessment Dashboards
 - R-Shiny Application QA Information
 - Bonus: PAMS Dashboard: https://rstudio-connect.sonomatechdata.com/pams_dashboard/
- Highlights:
 - PM2.5 FRM to FEM and collocation comparisons
 - Pollutant specific QA statistics, both compared to other agencies and by agency and monitor.

Data Validation – Resources: Training

- Air Knowledge
- <https://airknowledge.gov/>
- **AMBM208-SI: Quality Assurance for Air Pollution Measurement Systems (formerly APTI/SI-470)**
- <https://airknowledge.gov/SI/AMBM208-SI.html>
- EPA Conferences and Training on AMTIC
- <https://www.epa.gov/amtic/conferences-and-training>

Data Validation – Resources: AQS

- <https://www.epa.gov/aqs>
- Main page with further links to documentation, training, etc.
- Coding Manual
- <https://aqs.epa.gov/aqsweb/documents/codingmanual/html/index.html>
- AQS Code Lists
- <https://www.epa.gov/aqs/aqs-code-list>

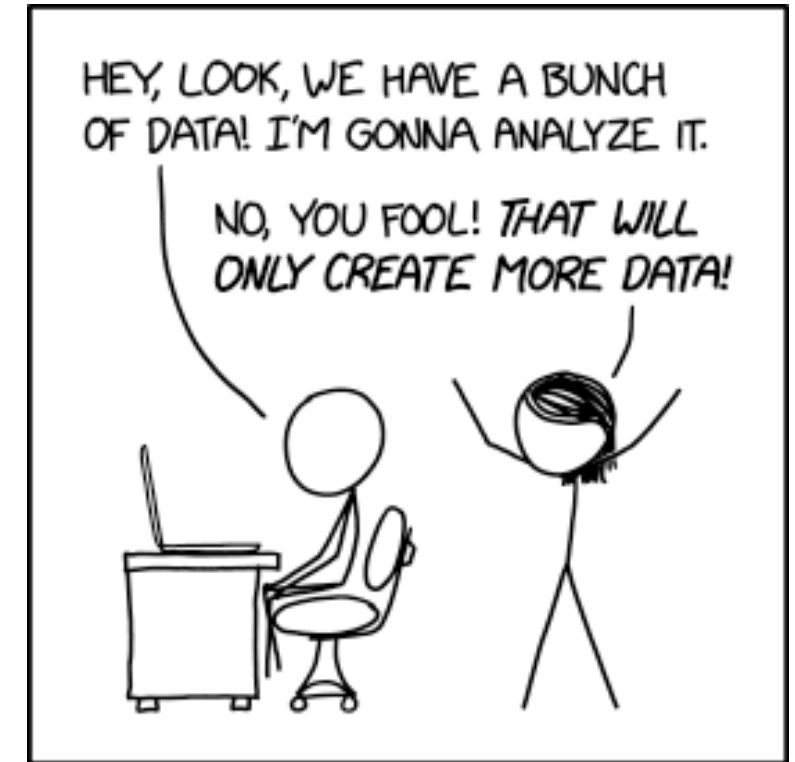
Data Validation – Resources: AirNow, Etc.

- Ambient Air Data

- <https://www.epa.gov/aqs>
- <https://www.epa.gov/outdoor-air-quality-data>
- <https://www.airnow.gov/>
- <https://fire.airnow.gov/>
- <https://www.airnowtech.org/>

- Meteorological and Climate Data

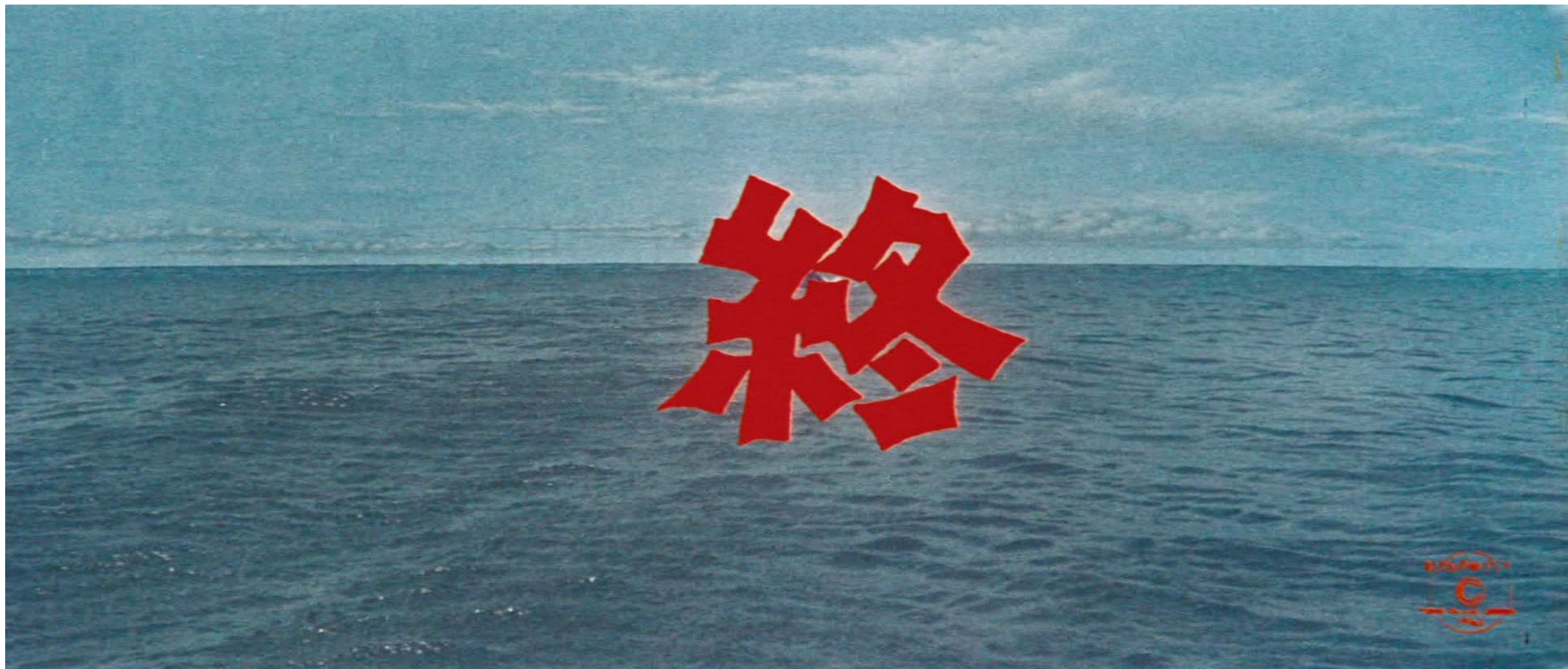
- <https://www.ncdc.noaa.gov/cdo-web/datatools>
- <https://mesonet.agron.iastate.edu/>
- <https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/>



<https://xkcd.com/>

Data Validation – Resources: R

- Data Visualization with R
 - Openair - <https://davidcarslaw.github.io/openair/>
 - Ggplot2 - <https://ggplot2.tidyverse.org/>
 - Plotly - <https://plotly.com/r/>
 - R For Excel Users - <https://rforexcelusers.com/blog/>
 - R Graph Gallery - <https://r-graph-gallery.com/>
 - Data to Viz - <https://www.data-to-viz.com/>
- Other Resources
 - CARB - <https://ww2.arb.ca.gov/capp-resource-center/data-portal/visualization-and-data-analysis-tools>



https://wikizilla.org/w/images/4/4a/King_Kong_vs._Godzilla_Japanese_Title_End_Title.png