Lessons learned from major updates and expansions in a statewide air monitoring program

2022 National Ambient Air Monitoring Conference

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Introduction

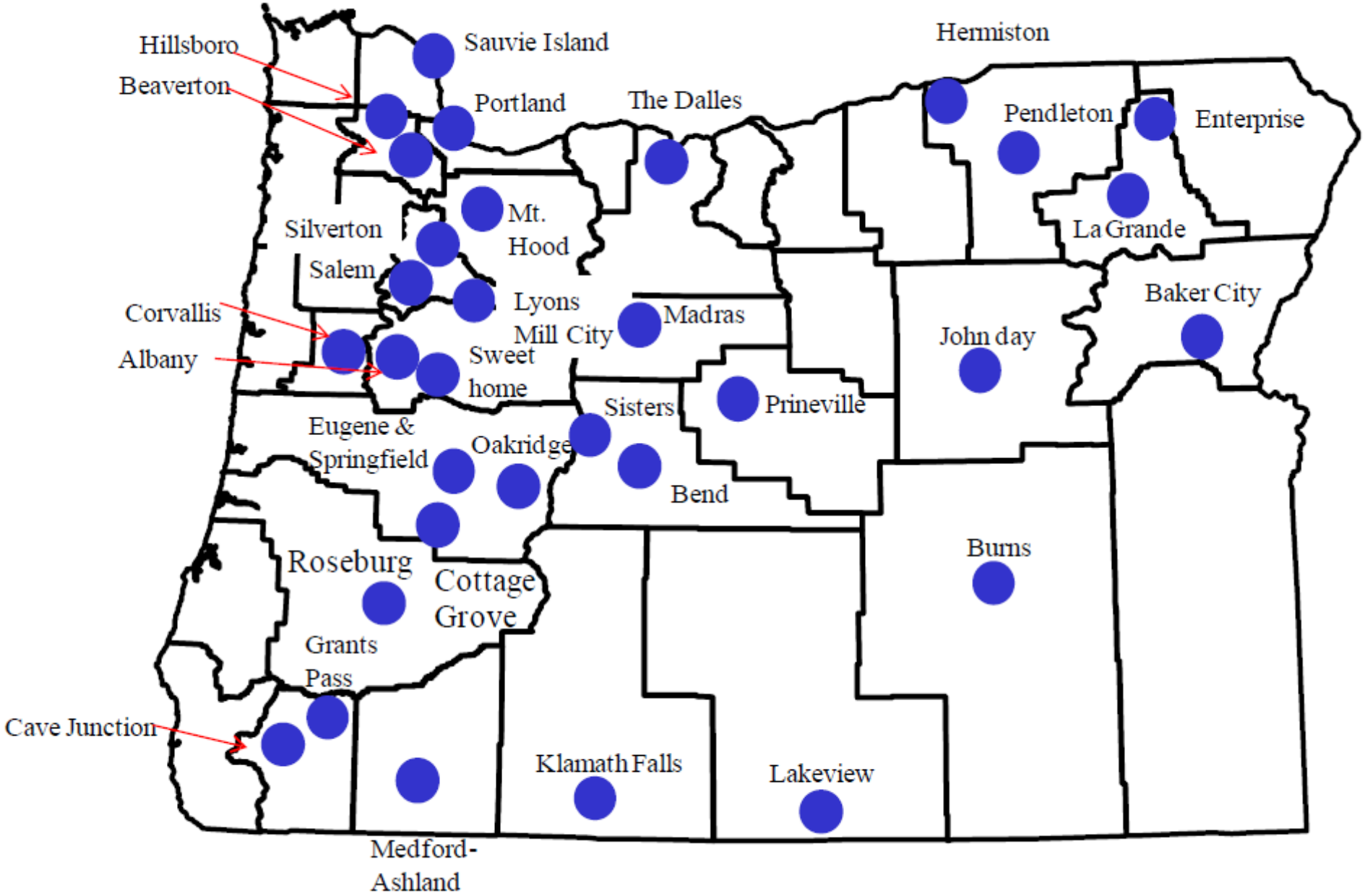
- Every air monitoring program, without exceptions, *must* eventually go through upgrades, transitions and changes
  - Regulatory changes
  - Instrumentation changes or upgrades
  - State/federal/local policy changes or new objectives
  - Staff or management changes
- This is Oregon DEQ Air Quality Monitoring's story from 2016 onwards

Why starting in 2016?

- Many transitions over the years
- 2016 marked the beginning of a period through which DEQ's AQM has been undergoing continuous revision and expansion as a result of...
- Political crisis, staff turnover, and a vastly expanded monitoring mandate
- Ask us about art glass manufacturers!

Oregon DEQ AQM in 2016

- 44 Monitoring Sites, including
  - 11 FRM filter sampling sites
  - 7 seasonal ozone monitoring sites
  - 2 NATTS sites
  - NCORE monitoring site
  - Near-road monitoring site
- At the same time:
  - Up to 16 monitoring sites in Portland on daily sampling (3+ samples/site), 5-6 days/week
- All this with just 13 staff (and 5 remote operators)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Sauvie Island
Portland
The Dalles
Hermiston
Pendleton
Enterprise
La Grande
Mt. Hood
Silverton
Salem
Lyons
Mill City
Madras
Baker City
John day
Corvallis
Albany
Sweet home
Sisters
Prineville
Eugene & Springfield
Oakridge
Bend
Burns
Roseburg
Cottage Grove
Grants Pass
Cave Junction
Klamath Falls
Lakeview
Medford-Ashland

When your work is in the news…repeatedly

- US Forest Service moss sampling revealed the actual location of persistent heavy metals concentrations in Portland
- Follow-up sampling revealed high concentrations of Cd, As, Pb, Cr^{6+} and other heavy metals, primarily emitted from an art glass manufacturer in SE Portland
- Political crisis ensued, high level DEQ personnel retired early, and AQM was now focused on the grind of daily sampling
- The Cleaner Air Oregon regulatory program was formed in response


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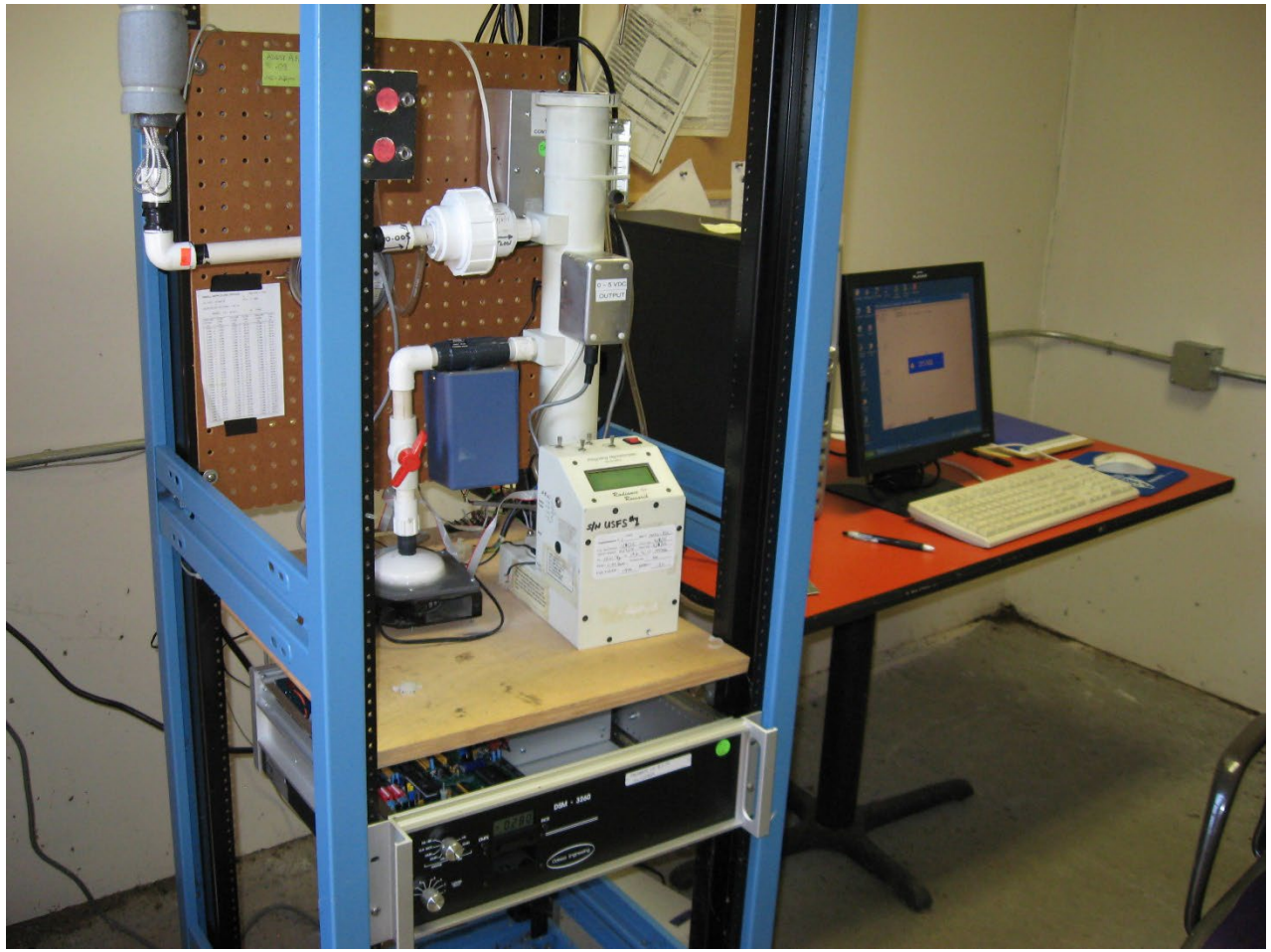
Oregon DEQ AQM in 2016 - Instrumentation

- Still using original Rupprecht & Patashnick 2025 sequential FRM filter samplers
- Continuous PM2.5 via Radiance Research M903 Nephelometers
- Mix of various 70s era Daisibi ozone analyzers, plus various older-generation Thermo, API, and Ecotech FEM gas analyzers (dating from 90s to 2012)
- Computer hardware consisting of hand-me-down Windows PCs running versions of Windows from 98 through XP
- Odessa DSM-360 dataloggers and DataQ USB-analog data interfaces

Oregon DEQ AQM in 2016 - Instrumentation



Oregon DEQ AQM in 2016 - Instrumentation

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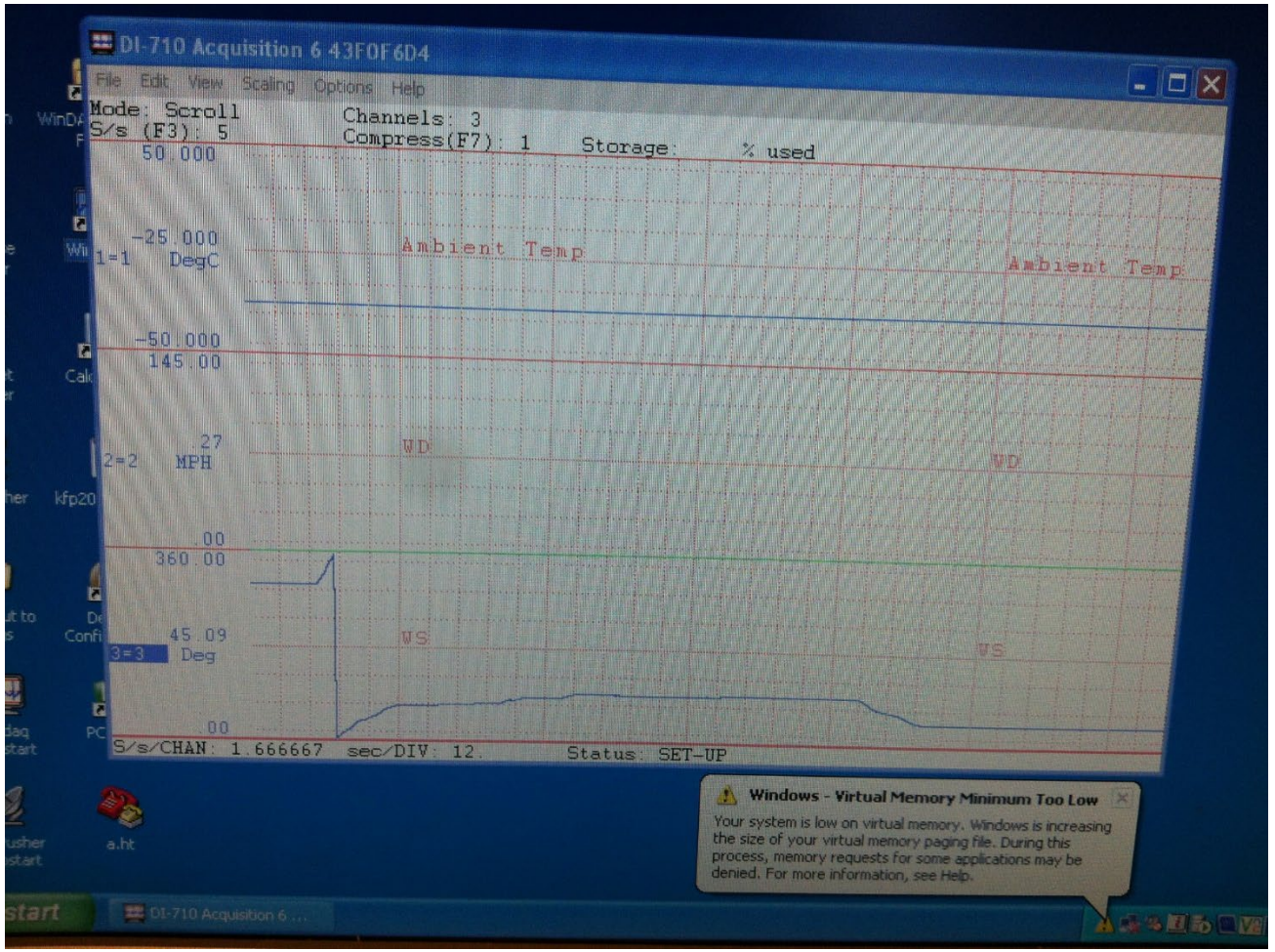


Philosophy of expansion & upgrades

- Ask: “What are we trying to do, and why?” on a regular basis
- Meet requirements, or get ahead to best practices and ideally meet future needs
- Direct improvement activities to serve those answers
  - Typically:
    - Get more data (or metadata) or fill in gaps
    - Improve data quality and/or reliability and response time
    - More remote-controllability!
    - Look to the future

Personalities matter!

- One dedicated employee can change the way the work is done for years, even after they've left
- Operational flexibility gave our staff the ability to push changes through quickly when they were motivated
- Meet the minimum, or look to the future and adopt best practices? Doing more than the minimum (or cheapest option) set us up for success

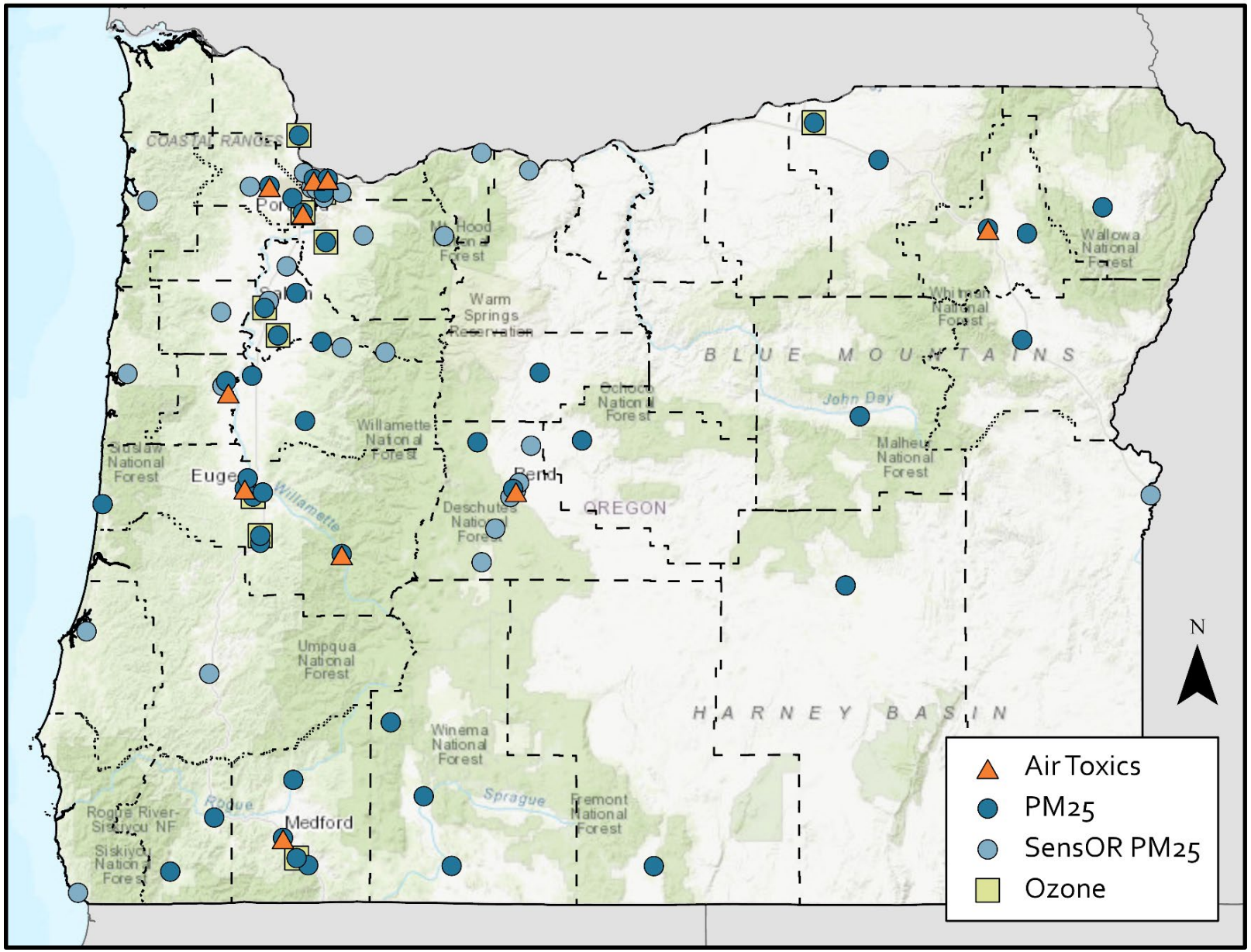
2016-2022 Upgrade/Expansion Summary

- Switched to cellular modems at all sites (away from DSL connections)
- Added 9 air toxics trends sites similar to existing NATTS sites
- Developed, designed, and built SensOR™ low-cost sensor modules
- Added ~35 SensOR™ low-cost sensor modules as standalone monitoring sites
- Completely replaced all computer hardware, software, dataloggers at all existing monitoring sites, overhauled all data acquisition in the process
- Switched to new database/AQI website (including smartphone app)
- Complete replacement and full automation of all continuous gas analyzers
- Switched seasonal PM monitoring sites to year-round monitoring
- Began rollout of continuous FEM PM2.5 monitors to replace all FRM filter samplers

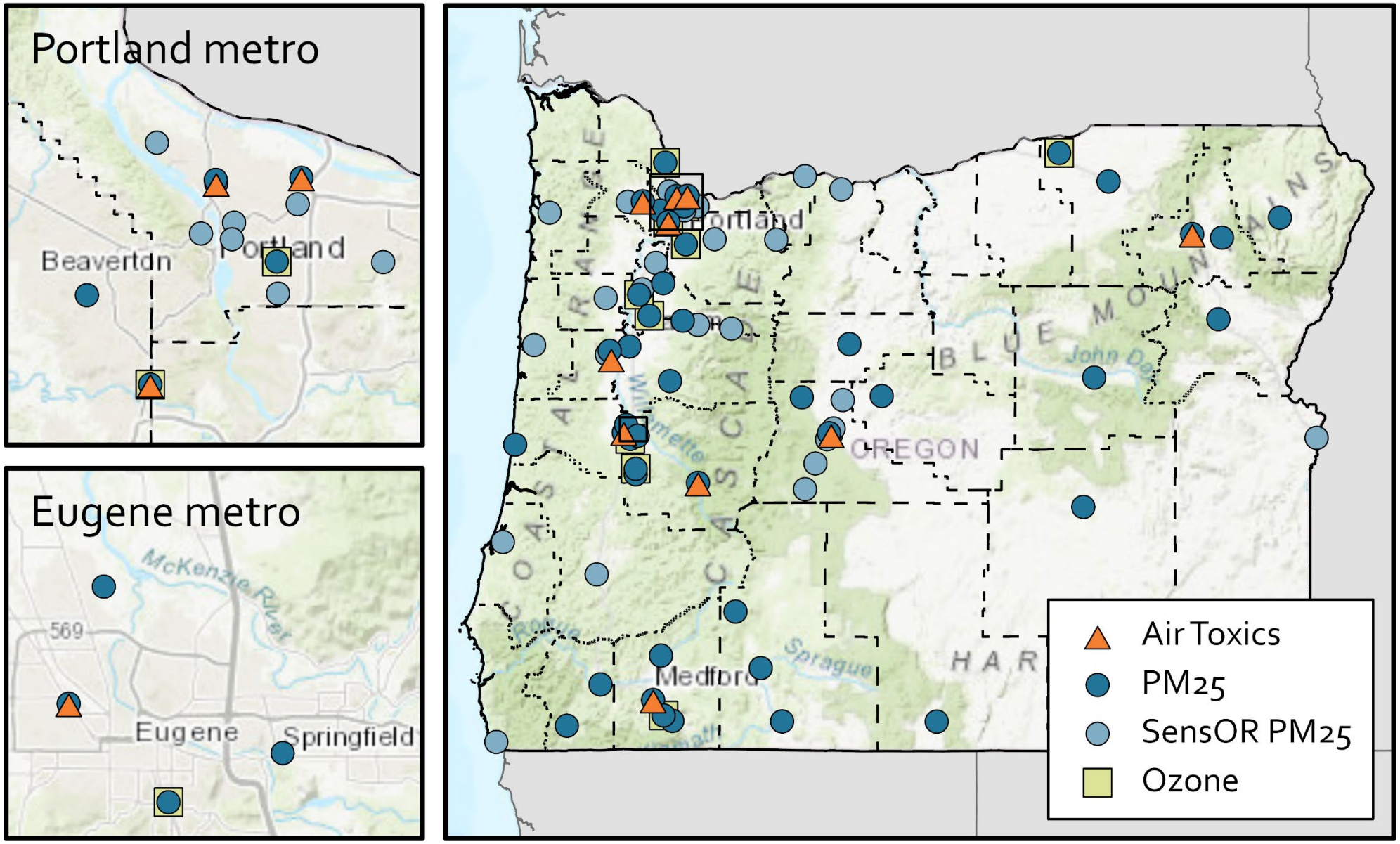
Oregon DEQ AQM in 2022

- 79 Monitoring Sites, including
  - 11 FRM filter sampling sites
  - 34 SensOR™ low-cost particulate monitoring sites
  - 6 seasonal ozone monitoring sites
  - 9 Air Toxics Trends sites
  - 2 NATTS sites
  - NCORE monitoring site
  - Near-road monitoring site
- All this with just 15 staff (and 7 remote operators)
- Around 3,214,800 hours of data collection

Oregon Air Quality Monitoring Sites in 2022



Oregon Air Quality Monitoring Sites in 2022



2016-2017 activities

- ~50 **daily** samples for metals/PM at 12-15 sites across Portland (drastically reduced, then discontinued end of 2017)
- Continued to maintain network and perform regular work
- Began work of replacing computer hardware, software and dataloggers across all monitoring sites – necessitating total rewiring and programming at every location where code and configuration could not be reused, and new software configurations

2018 activities

- Began building, deploying, operating new air toxics trends sites
- Switched away from old (70s era) Daisibi ozone analyzers to newer (but still obsolete) ozone analyzers with full digital communications (while awaiting analyzers contract completion).
- Moved from paper, *mailed* operator logs to digital sheets
- Implemented new contract to purchase FEM analyzers
- Completed switch to modern dataloggers
- Completed switch to newer data acquisition software database, AQI website, and smartphone app (Oregon Air)

2019 activities

- Replaced entire continuous gas analyzer network with newer, more sensitive instruments friendlier to automation
- Began implementing automated gas analyzer spans across entire network
- Began configuring monitoring network's DAS to email alerts
- Completed switch to newer PC workstations better designed for monitoring
- Started bringing in-house developed SensOR™ network of low-cost PM sensors online at new monitoring locations.

2020 activities

- Managed to operate through COVID shutdowns with minimal data loss and kept up operations (3-4 dedicated staff filled in a lot of gaps)
- Completed remaining gas analyzer automation (for spans, linearity checks and calibration verifications
- Switched particulate seasonal monitoring to year-round monitoring

2021 activities

- Managed to continue operating through COVID-imposed difficulties
- Implemented instant (rather than last-hour) PM exceedance notifications and alerts to other agency staff and Oregon Department of Forestry & Wildlife to better manage prescribed burns
- Began training a new cohort of staff
- Started testing FEM BAM-1022 as candidate for FRM filter monitoring network replacement
- Applied for, and later won ARP funding for replacing FRM filter samplers with continuous PM monitors

2022 activities

- Began replacing all FRM filter samplers with FEM BAM-1022 continuous PM analyzers
- Planning next revision of SensOR™ hardware
- Planning next deployment of 20+ SensOR™ sites
- Prepare for replacement of legacy nephelometers with low cost sensors as nephelometers fail out and cannot be repaired
- Beginning project to switch from high-volume to low-volume air toxics sampling
- Replace NCORE shelter and begin implementing PAMS (hopefully)
- Switch data acquisition server (and SensOR™ management node) over to cloud services

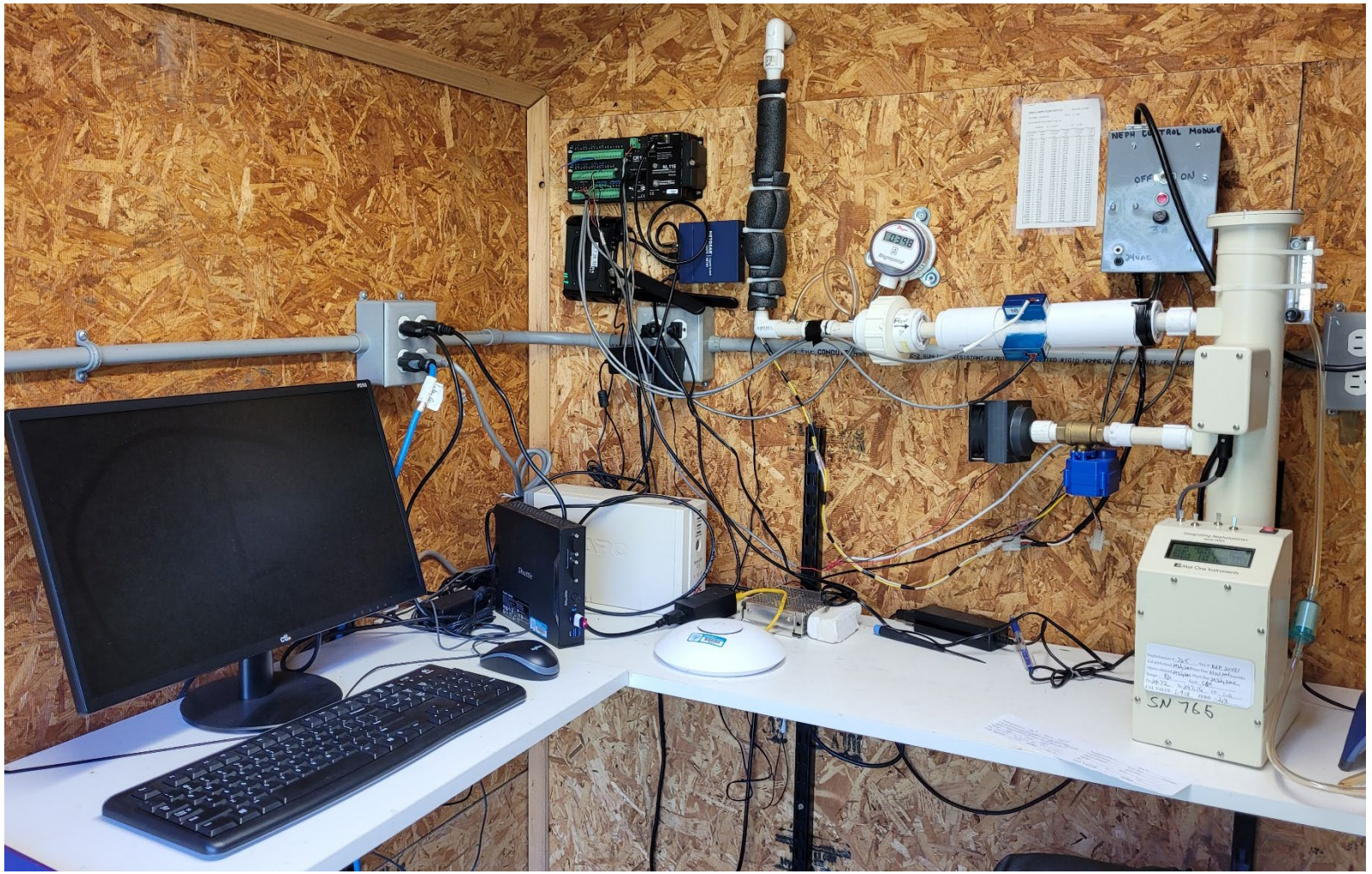
During each of these years:

- Continued to maintain and operate network
- Began planning for, and started phases of PAMS site implementation (more contracts!)
- Hired new staff or saw staff leave every single year. Estimated training requirements at 150 hours *minimum* to get our generalist/operator staff training to operate all instruments and samplers - 300 hours preferred
- Improved calibration, QA, and audit procedures
- Added new contracts with more vendors

Oregon DEQ AQM in 2022 - Instrumentation

- Full remote control of most analyzers (and some samplers)
- Consistent configuration across all sites
- Smarter metadata collection and notification system
- Data backed up locally in triplicate across DAS, datalogger, and instruments
- 5x the number of air toxics monitoring sites, 35 more continuous AQM sites than in 2016

Oregon DEQ AQM in 2022 - Instrumentation



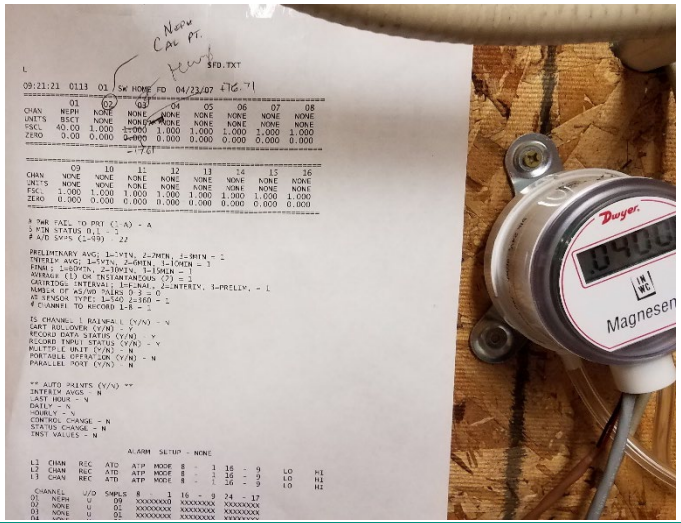
New Air Toxics Trends Sites

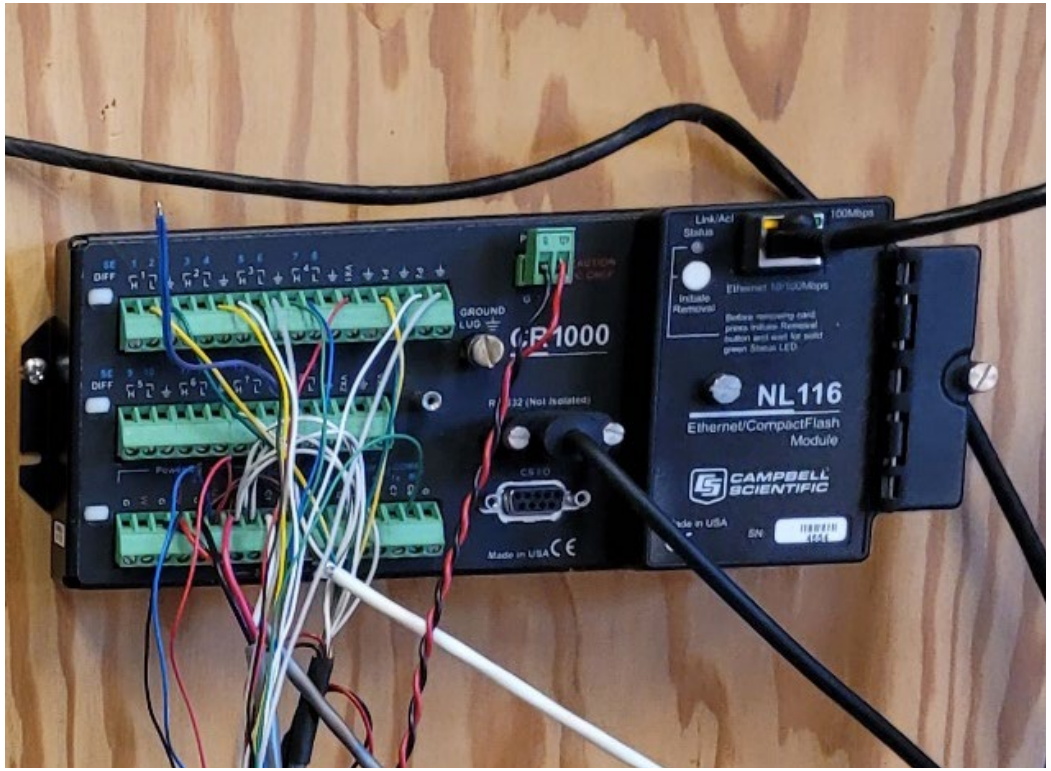
- Run the same as NATTS sites with the addition of CR6+ sampling and black carbon monitoring with Aethalometer
- Worked with vendor (ARA Instruments) to build us new carbonyl samplers (previous instruments homemade)
- Program includes permanent trends sites and rotating temporary sites

Air Toxics trends monitoring site in Medford, OR

Complete replacement of gas analyzers

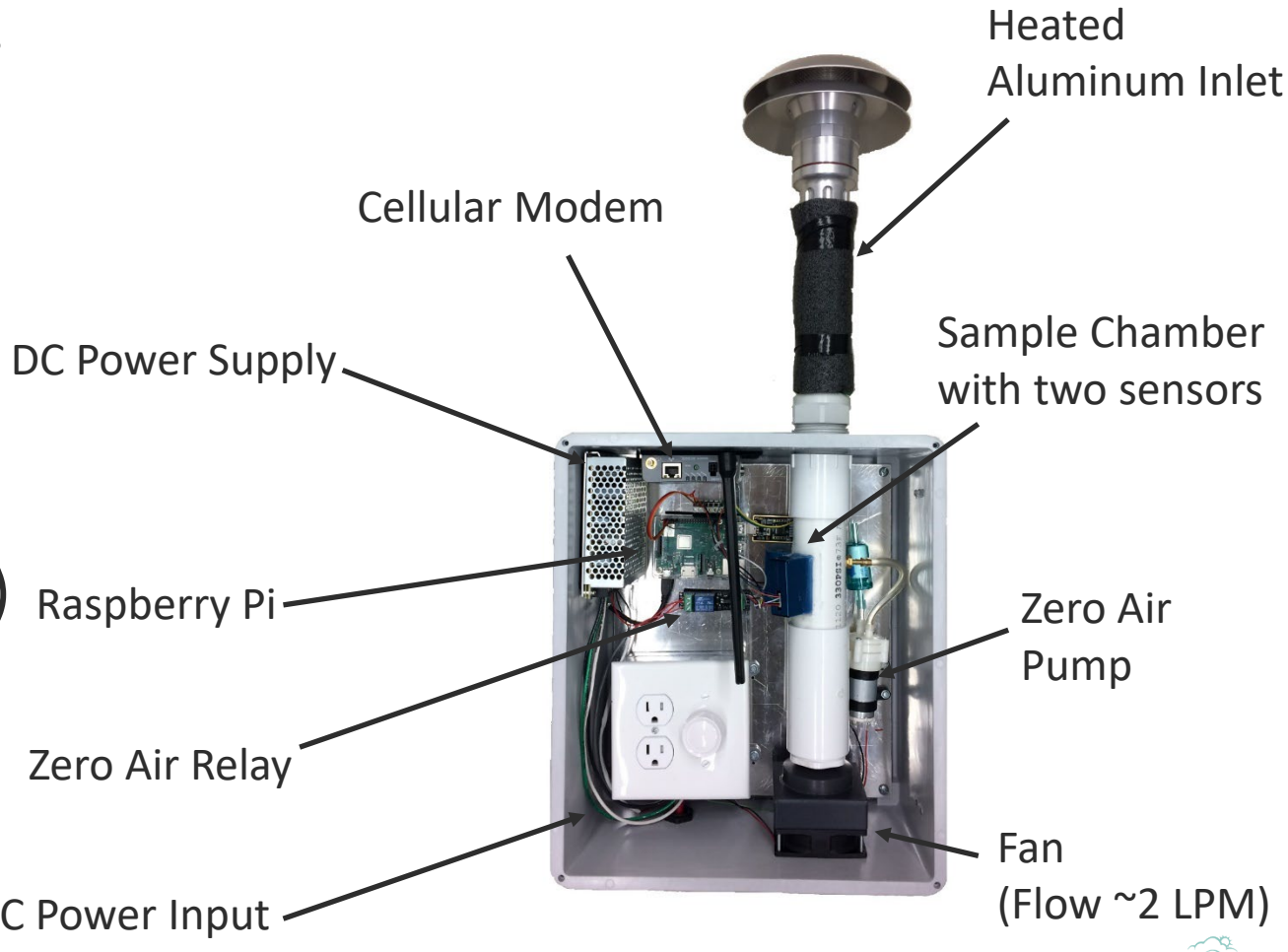
Changing to modern dataloggers





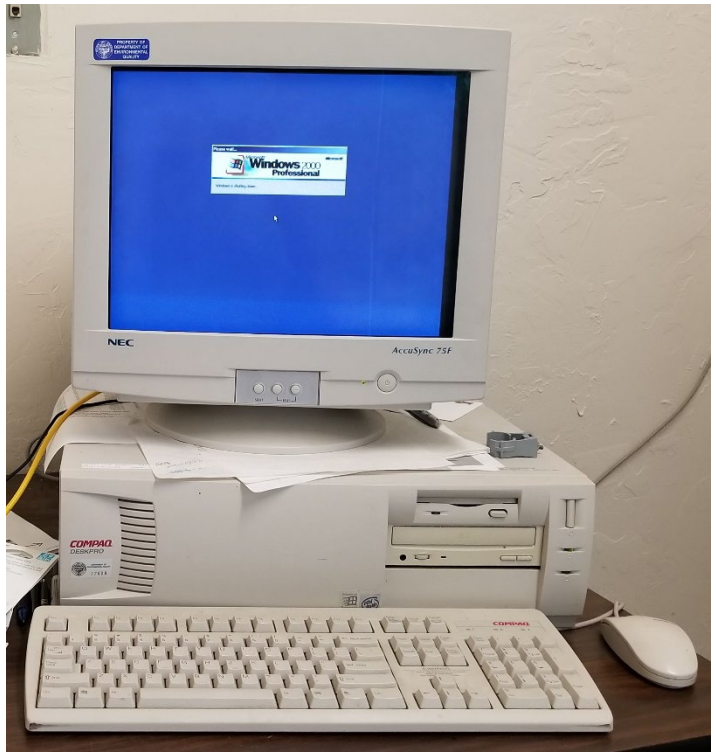
DEQ-built SensOR™: Version 1.0

- Pair of Plantower PMS5003ST sensors
- Active airflow
- Heated to remove humidity
- Auto-zero functionality
- Control/logged by Raspberry Pi
- Cell modem
- Modbus output directly to Data Acquisition Software (DrDas/EnviDAS)
- Integration into AQI and AirNow
- 35 sites deployed



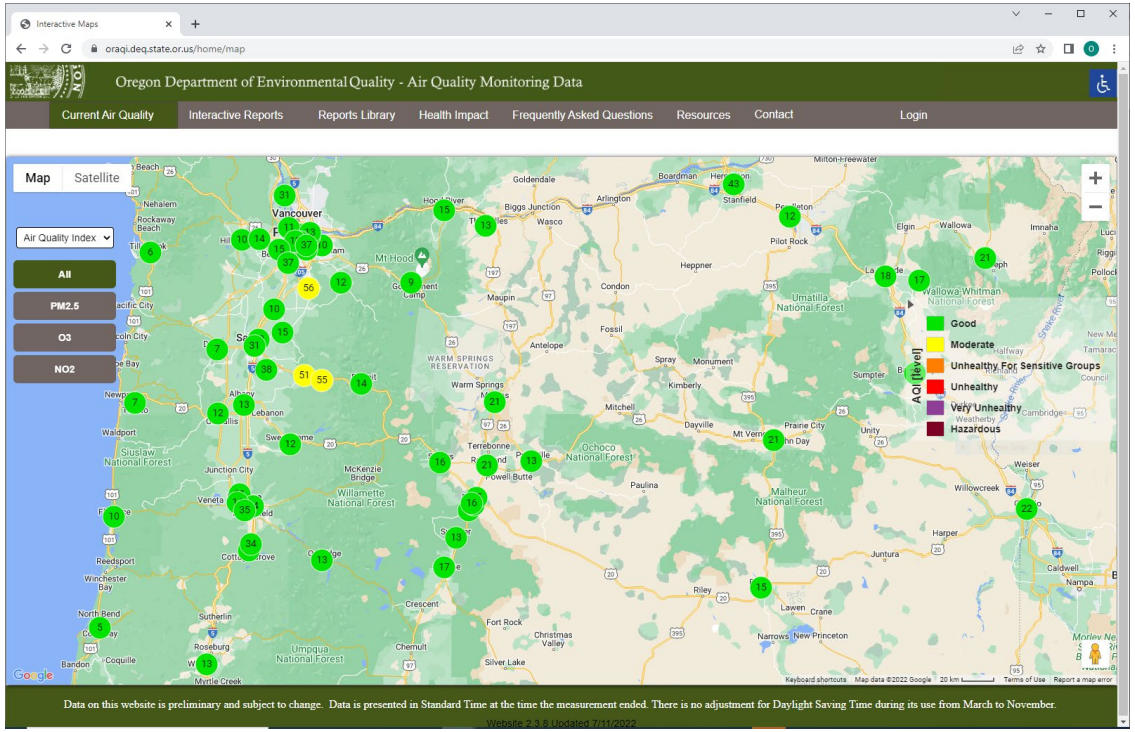
Reliable computing hardware

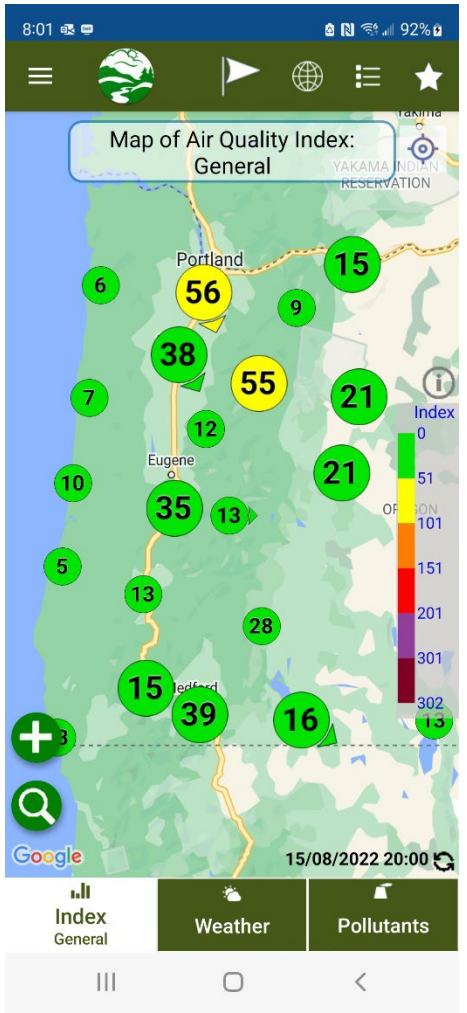
- Used purpose selected fanless mini PCs designed for a similar purpose rather than series of hand-me-downs



New DAS database, AQI Website, App

- Newer, more modernized database for Envista
- New AQI website – shown off at 2018 conference
- Oregon Air mobile app – popular with public





(Obvious) Lessons Learned

- **Double or triple** the time you **expect** to spend in procurement (the horror!)
- Document exhaustively – in particular, people making changes who don't want to document them. Take photos!
- Assume everything – even simple things – will be harder, and take longer than you expect
- Talk to everybody you can find in other air quality monitoring organizations who may have gone through something similar; it saved us time and effort. Try before you buy!
- Any kind of remote access or control that saves hours of driving: a lot of value in money and resources saved

(Non-Obvious) Lessons Learned

- Document your changes and what's working and what isn't **before you finish**
- Spending a lot of money and time to upgrade your systems may pay off in ways you can't possibly predict
- Smarter metadata and alerts are worth a lot – you can catch mistakes you and your operators make much sooner
- Don't assume that staff availability will always be adequate, even if it was historically
- No such thing as too much cross-training
- Be ready for air quality emergencies
- Balancing efficiency of upgrades (on existing field trips), speed of upgrades, and workload is very, very difficult

Acknowledgements

- Everybody at Oregon DEQ who helped get us to this point
- Lance Giles (LRAPA)
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- The rest of our colleagues in region 10 (including ID and AK)

Questions? Comments?

- Always feel free to reach out to me if you'd like to know more:
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