

PM_{2.5} Monitoring with the BAM-1020

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Wisconsin DNR



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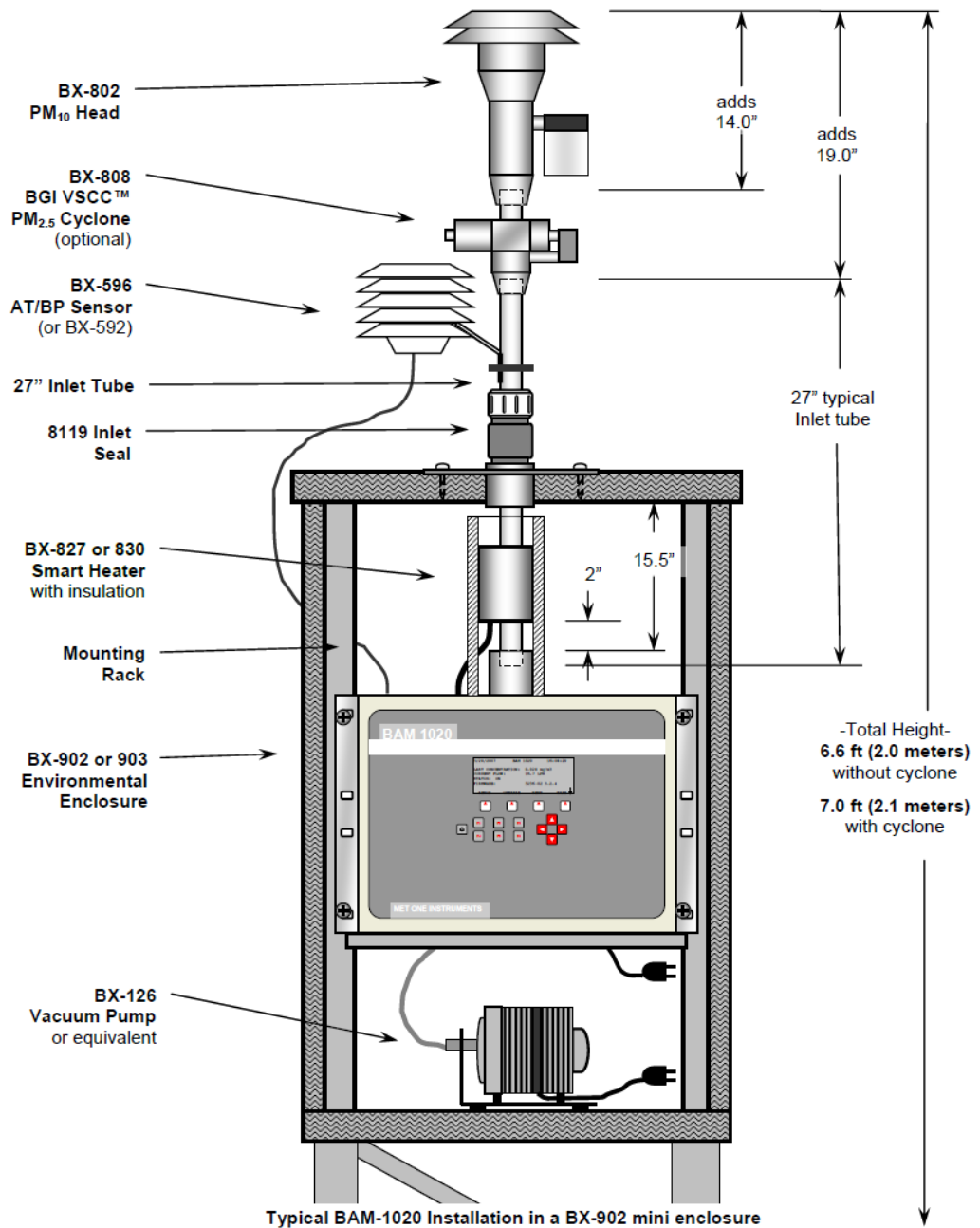


Monitoring with the BAM-1020

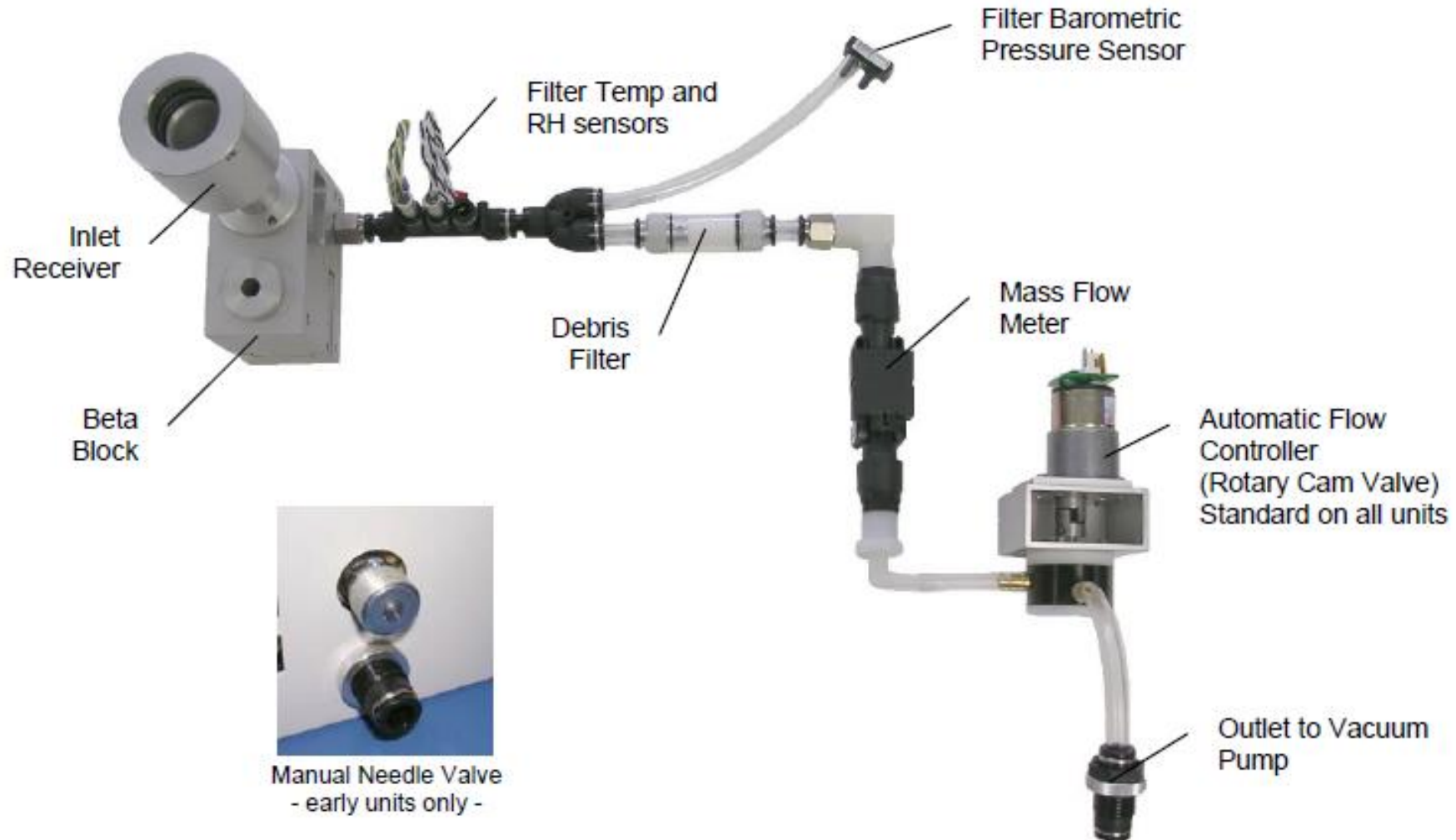
Gabe Ziskin WDNR

- Introduction to the BAM-1020 and PM monitoring
- History of the BAM-1020 in the WDNR network
- Personal experience with the BAM-1020
- BAM 1020 vs. other options
- Experience in Addis Ababa



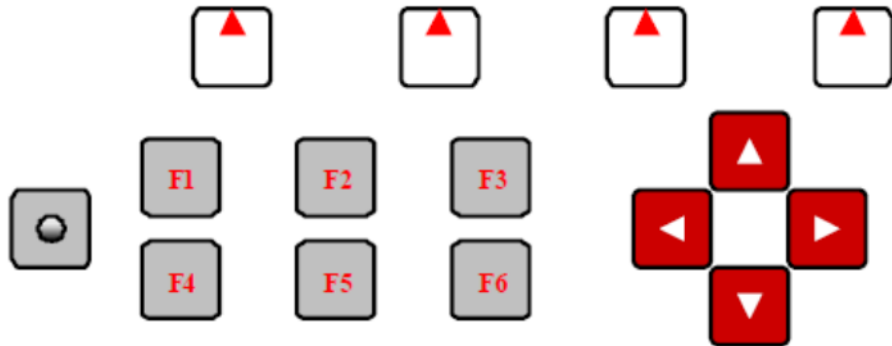


Complete BAM-1020 Flow Control System

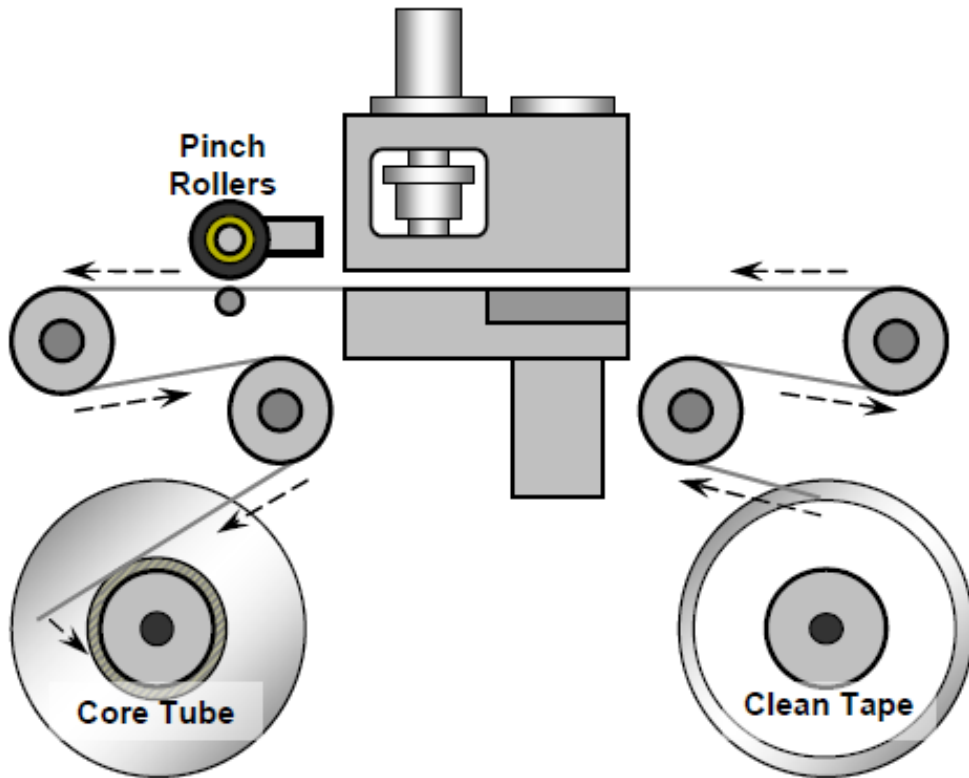


Standard User Interface & Keypad

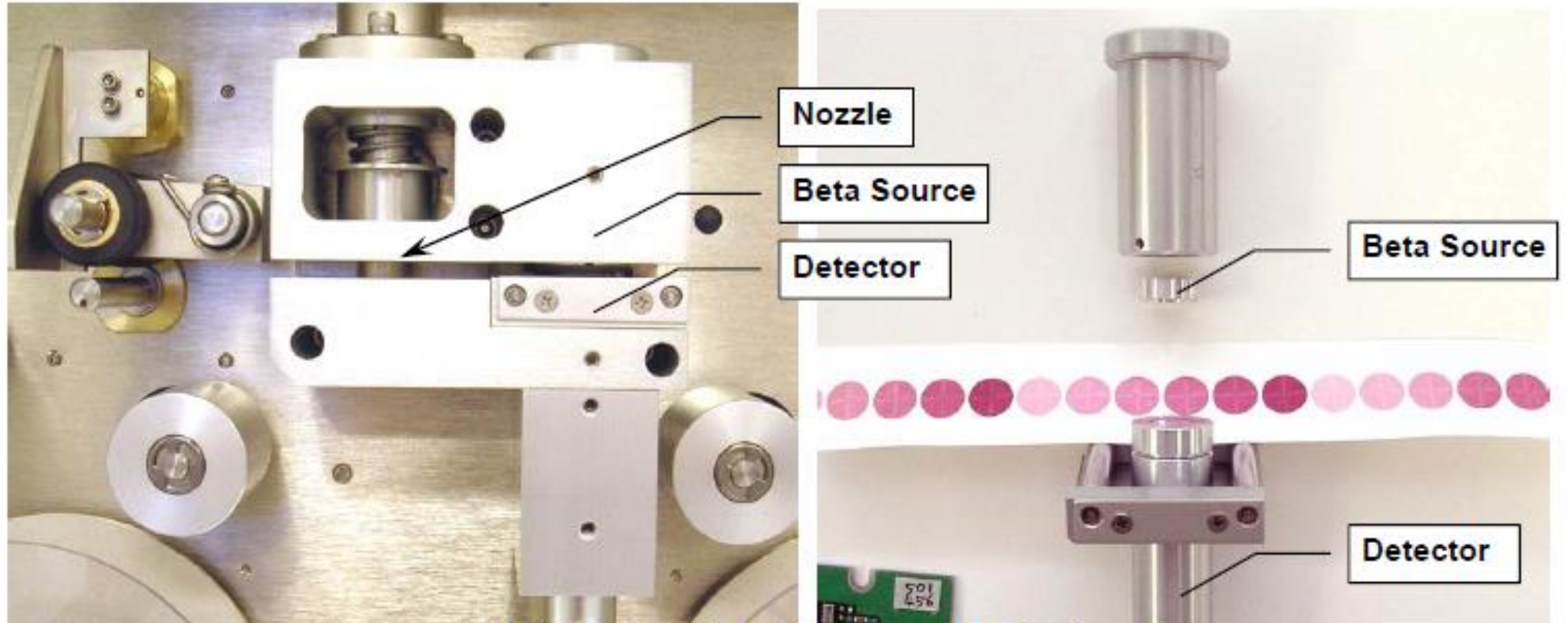
```
3/28/2010 BAM 1020 PM2.5 FEM 16:08:29
LAST CONCENTRATION: 0.028 mg/m3
CURRENT FLOW: 16.7 LPM
STATUS: ON
FIRMWARE: 3236-05 3.6.3
SETUP OPERATE TEST TAPE ↓
```



Filter Tape Assembly



Sample & Measurement Stations



Measurement Cycle

- One-hour cycles
 - **Beginning of hour:** Tape advances clean spot between beta source and detector and counts beta particles for 8 minutes.
 - **Minute 8:** Sampling period begins.
 - **Minute 50:** Sampled spot is moved back between beta source and detector and counts beta particles for 8 minutes.
 - **Minute 58:** Calculates mass of particulates and sits idle.
 - **Minute 60:** Records and reports concentration
- Span checks occur throughout cycle



Safety

- Lifting hazard: Instrument weigh 54 lbs. (25 kg)
- Electrical hazard: Unplug as appropriate
- Site conditions
- Radioactivity: Do not attempt to access or remove beta source
 - Should never need to be replaced
 - Service of detector or source should be performed by factory technicians
 - Instruments are returned to Met One for disposal



Siting

- **Height:**
 - 2-15m above ground level for neighborhood scale monitoring
 - 2-7m above ground level for micro or medium scale monitoring
- **Spacing:**
 - 90% of monitoring path should be unrestricted
 - >10m from sources of particulates
 - 2m from obstructions
 - >10m from drip line of trees
 - Away from roadways
 - Away from unpaved areas (in general)
- **40 CFR, Part 58, Appendix D and E**



FRM/FEM Designation

- Federal Reference Method (FRM): EPA designation based on a combination of design and performance-based criteria.
 - 24-hour integrated filter samples for gravimetric analysis.
- Federal Equivalent Method (FEM): EPA designation for methods that do not meet requirements for FRM designation but meet other applicable requirements.
 - Provide comparable measurements to the FRM
- BAM-1020 designated as FEM $PM_{2.5}$ method as of March 12, 2008
- BAM-1020 designated as FEM PM_{10} method as of August 3, 1998
- BAM-1020 designated as FEM PM_{course} method as of June 15, 2009



FRM/FEM Designation

- Very Sharp Cut Cyclone (BX-808)
- Standard EPA PM₁₀ size-selective inlet head (BX-802)
- Hourly average measurements
- Firmware revision 3.2.4 or later
- Operated in accordance to operation manual revision F or later
- Ambient temperature and barometric pressure sensor BX-596
- Flow controller BX-961 in volumetric (actual) flow control
- Smart inlet heater BX-827 or BX-830 set to 35% and Delta-T control disabled
- Standard glass fiber filter tape
- COUNT time set to 8 minutes and SAMPLE time set to 42 minutes
- BX-302 zero filter calibration kit
- Equipped with 8470-1 revision D or later tape control transport assembly (standard since March 2007)

For PM₁₀ FEM monitoring, remove VSCC and set CONC TYPE to STD

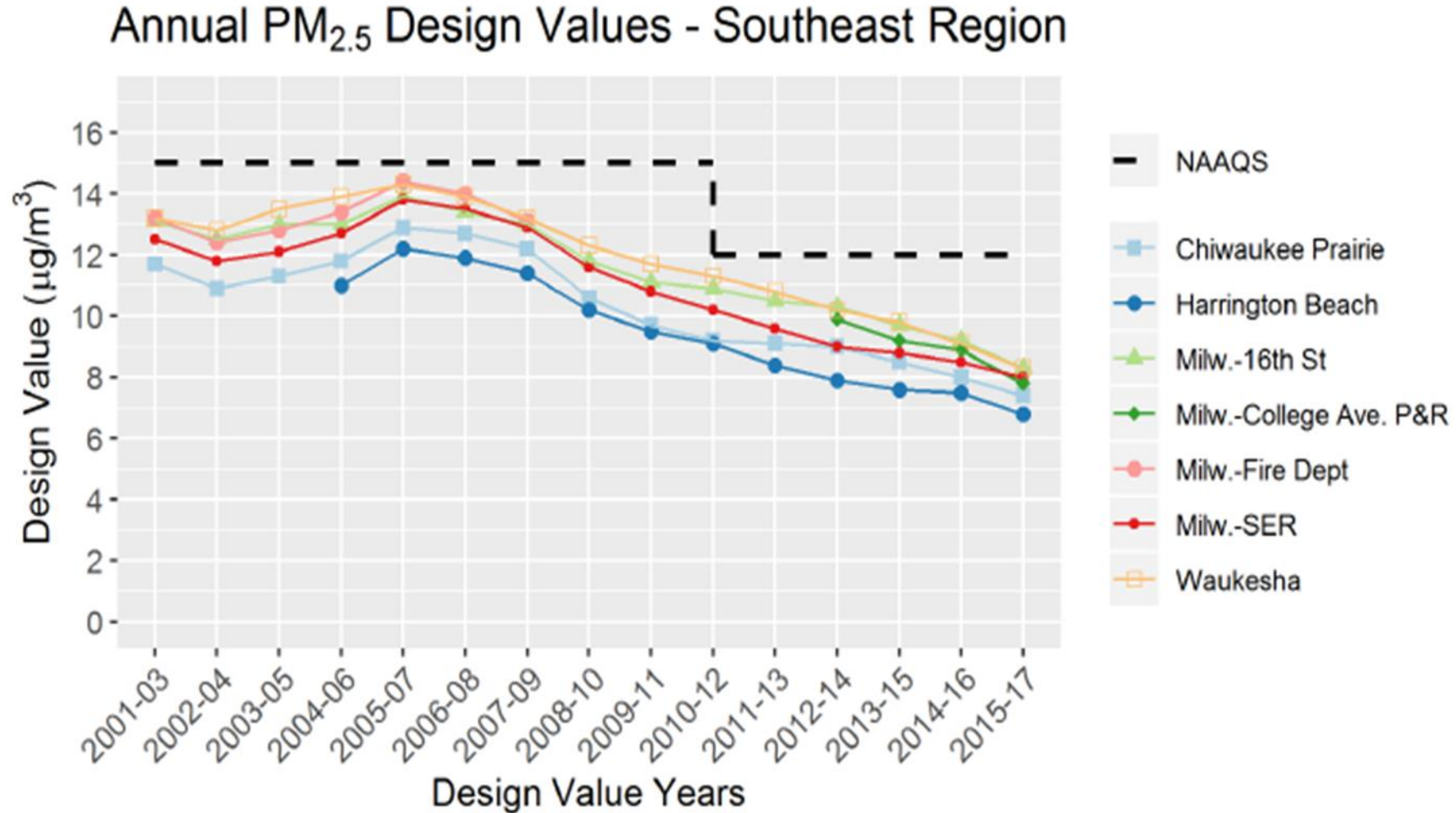


Regulatory History

- **1970:** Clean Air Act
- **1971:** First National Ambient Air Quality Standard (NAAQS) for PM established
 - 24-hour and annual standards for Total Suspended Particulate ($260 \mu\text{g}/\text{m}^3$ and $75 \mu\text{g}/\text{m}^3$)
- **1987:** NAAQS for TSP discontinued and established 24-hour and annual standards for PM_{10} ($150 \mu\text{g}/\text{m}^3$ and $50 \mu\text{g}/\text{m}^3$)
- **1997:** established 24-hour and annual standards for $\text{PM}_{2.5}$ ($65 \mu\text{g}/\text{m}^3$ and $15 \mu\text{g}/\text{m}^3$)
- **2006:** annual PM_{10} standard discontinued and 24-hour $\text{PM}_{2.5}$ standard reduced ($35 \mu\text{g}/\text{m}^3$)
- **2012:** annual $\text{PM}_{2.5}$ standard reduced ($12 \mu\text{g}/\text{m}^3$)

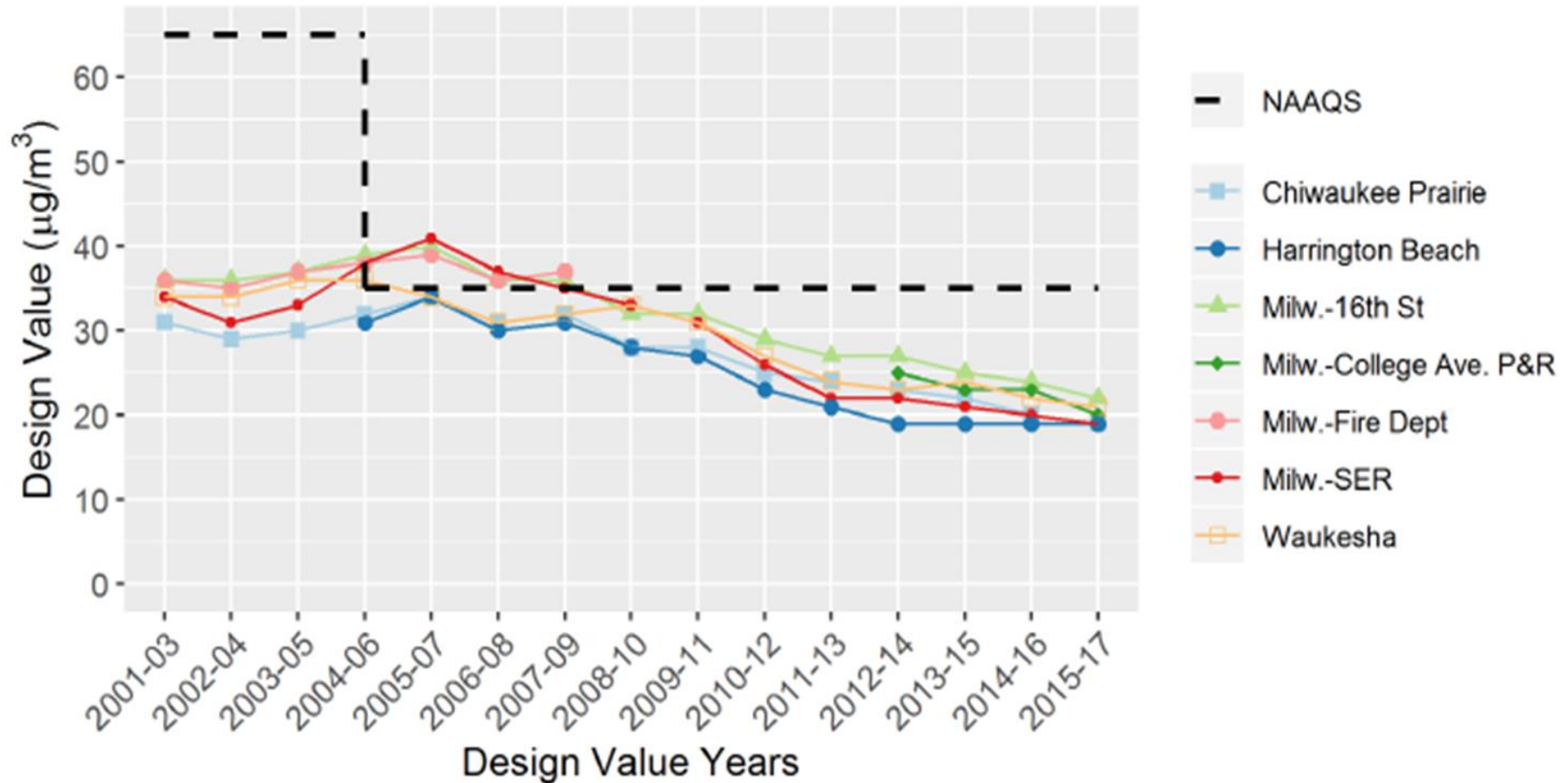


Regulatory History



Regulatory History

24-Hour PM_{2.5} Design Values - Southeast Region



PM_{2.5}

- Fine particles, primarily formed in atmosphere when pollutants (sulfur and nitrogen oxides) react with ammonia and other gases.
 - Small amount from emissions (power plants, industry, vehicles and other forms of combustions)
- Behaves like gases.
 - Days to weeks in atmosphere
 - Travel long distances
 - Uniformly distributed
 - Strongly influenced by weather and topography
- Health risks:
 - Penetrate respiratory tract and bloodstream
 - Heart and lung disease and aggravation of respiratory conditions
 - Compromised individuals, older adults and children



PM₁₀

- Inhalable particles, primarily formed during mechanical processes and combustion.
- Health risks:
 - Penetrate respiratory tract
 - Heart disease and aggravation of respiratory conditions
 - Compromised individuals, older adults and children
 - PM_{2.5} considered a greater risk



History of PM monitoring

- **PM₁₀:** FRM models have changed but technology stays the same.
 - Filter-based, high volume sampler with impactor assembly for 24-hour samples
 - BAM-1020 and T640x added as FEM
- **PM_{2.5}:** Combination of filter-based and continuous methods
 - Prior to my arrival: Thermo Fisher Scientific 2020 and 2025 (FRM) and TEOM with FDMS (FEM)
 - 2012: Transitioned from 2020/2025 to 2025i



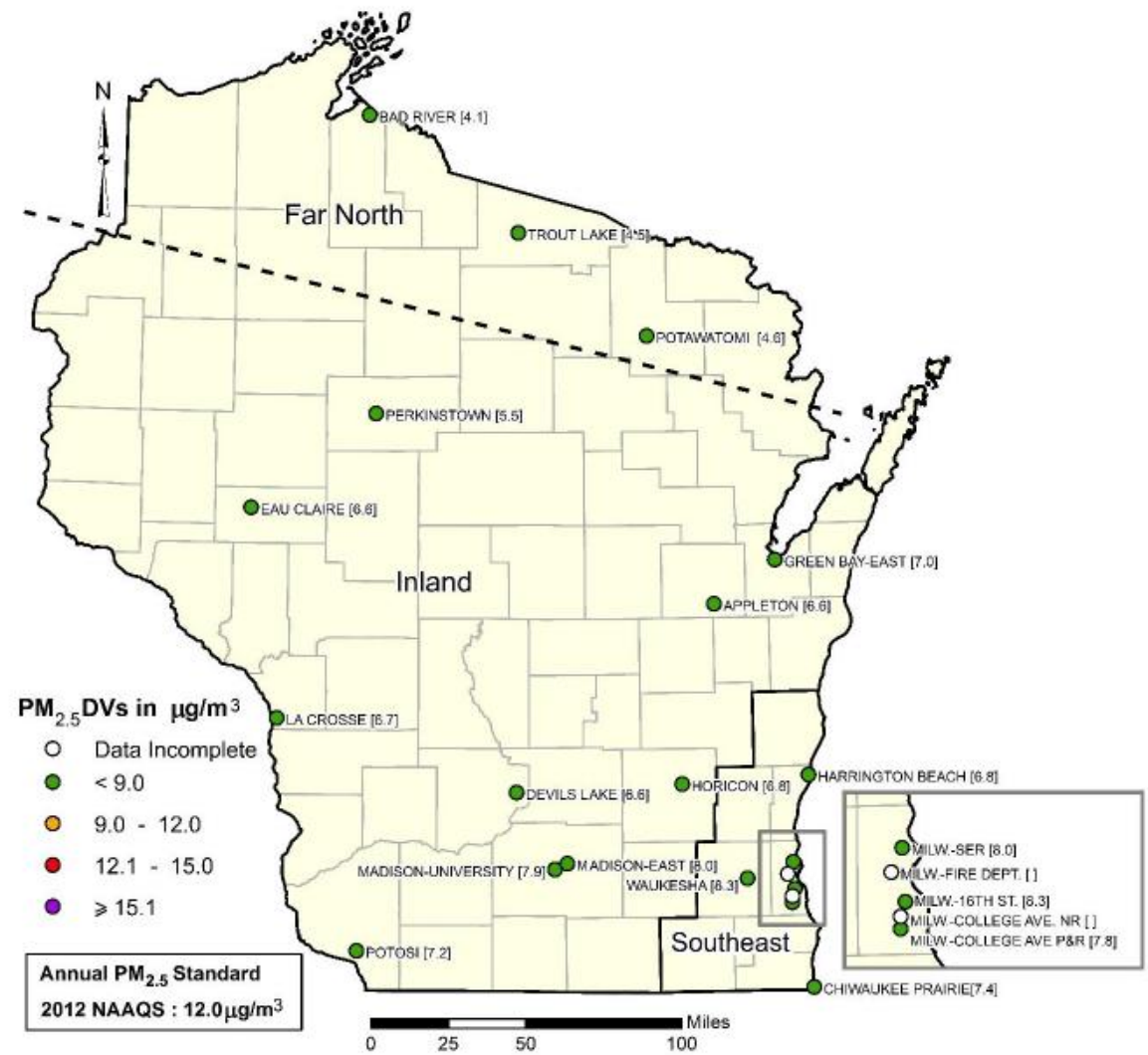
History of PM monitoring

- **2002:** Field test of BAM-1020
 - Issues with water vapor acting as interferent. Decided against incorporating into network.
- **2009:** Field tested BAM-1020 at two sites
- **2010-2012:** Transitioned network from TEOM to BAM-1020
- **2016:** USEPA initiates change to more reliance on continuous monitors
- **2017:** Convert BAM-1020 to FEM. Field test of Teledyne API T640/T640x
- **2018-2020:** Transition network from 2025i and BAM-1020 to T640/T640x
 - Due for replacement
 - Real-time and efficiency



PM Monitors

Annual PM_{2.5} Design Values: 2015-2017



Training

- Basic operations of instrument
 - Tape changes, data downloads
- Verification and Calibration
- Routine checks and maintenance
- Troubleshooting



Verification/Calibrations

- Clock
- Leak Check
- Ambient temperature sensor
- Barometric pressure sensor
- Flow sensor
- Leak check
- Self-test



Routine Checks and Maintenance

Maintenance Item	Period
Nozzle and vane cleaning.	Monthly
Leak check.	Monthly
Flow system check/audit.	Monthly
Clean capstan shaft and pinch roller tires.	Monthly
Clean VSCC	Monthly
Download and save digital data log and error log.	Monthly
Compare BAM-1020 digital data to external analog data logger data, if used.	Monthly ¹
Check or set BAM real-time clock.	Monthly
Run the SELF-TEST function in the TAPE menu.	Monthly ²
Test smart heater function.	Monthly ³
Replace filter tape roll.	2 Months
Completely disassemble and clean PM ₁₀ inlet.	Quarterly ⁴
Download and verify BAM-1020 settings file.	Quarterly
Perform 72 hour BKGD test (BX-302 zero filter).	6 months ⁵
Replace or clean pump muffler.	6 months ⁶
Test filter RH and filter temperature sensors.	6 months ⁷
Complete flow system calibration.	12 Months ⁸
Clean internal debris filter.	12 Months
Remove and check membrane span foil.	12 Months
Beta detector count rate and dark count test.	12 Months
Clean vertical inlet tube (BX-344 cleaning kit).	12 months
Test analog DAC output, if used.	12 Months
Replace lithium battery if necessary.	12 Months
Rebuild vacuum pump.	24 months
Service nozzle system and replace nozzle o-ring.	24 months
Replace pump tubing, if necessary.	24 Months
Factory recalibration is not required except for units sent for major repairs.	---



Troubleshooting

Operation Manual has extensive troubleshooting section (Section 7)

Problem	Potential Cause
Pin holes in filter tape	Nozzle needs to be cleaned Incorrect filter tape being used Nozzle tension may need to be adjusted
Non-uniform spots on filter tape	Nozzle needs to be cleaned Nozzle o-ring needs to be replaced
Sticky or gritty nozzle movement	Nozzle needs to be cleaned Nozzle o-ring needs to be replaced
Filter tape movement issues	Inspect and service shuttle beam bearings
Membrane density errors	Perform Span Membrane Mass test Membrane assembly may need to be disassembled and cleaned
Flow Rate does not go up to 18.4 lpm when selected	Pump muffler needs to be cleaned Pump needs to be rebuilt/replaced



BAM-1020

Pros

- Continuous
- Analog/digital data reporting
- Limited checks and maintenance
- Hourly average
- Ground-truthing of results
- Operator manual

Cons

- C14
- Filter-media
- Specialized tools
- Interruptions
- Instruments spikes
- Dew points



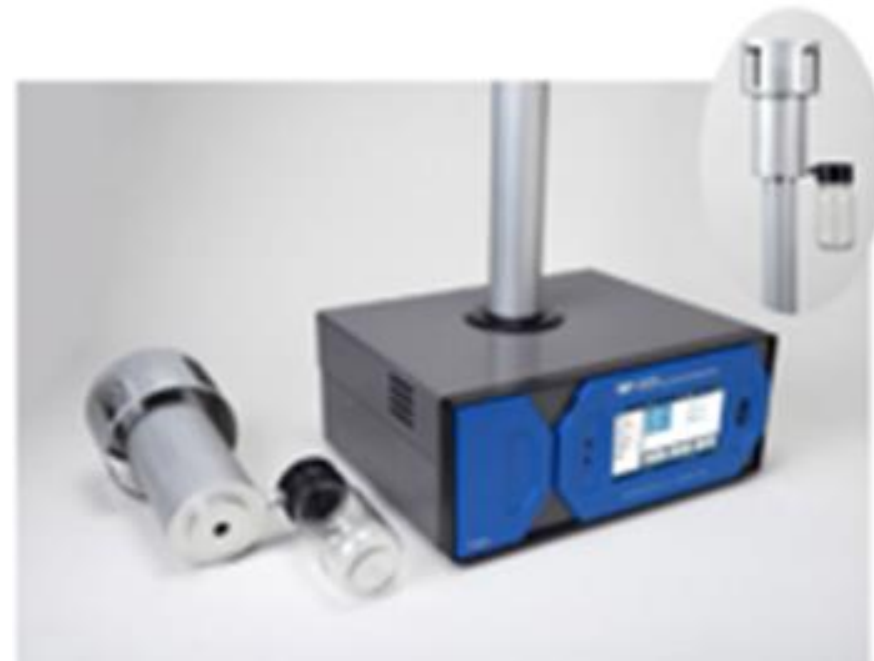
T640/T640x

Pros

- Continuous
- Real-time
- Analog/digital data reporting
- Efficiency
- Resolution helps with identifying issues

Cons

- New technology
- Span dust
- Grappling with QC
- Repair and maintenance issues



Sensor Technology

Pros

- User-friendly
- Low-cost
- Portable/flexible
- Continuous
- Real-time (potentially)
- Data reporting options
- Efficiency
- Resolution helps with identifying issues

Cons

- New technology
- Uncertainty about operations and performance
- Do not always compare well



BAM-1020 in Addis Ababa

- Operating at the Addis Ababa Central (Embassy) site since August 2016 and at the Addis Ababa School (International Community School) site since June 2016.
- Data available of AirNow.gov
- 2017 annual average for Addis Ababa Central was $25.6 \mu\text{g}/\text{m}^3$ and the annual average for Addis Ababa School was $35.4 \mu\text{g}/\text{m}^3$.
- Missing data.
 - Power, communications and instrument downtime.
- Data analyzed on an annual basis
 - August 2016-July 2017
 - August 2017-July 2018
- Most recent data has been uploaded to WDNR data manager



Missing Data

Addis Ababa Central Instrument Downtime

09/08/2018 12:00-09/09/2018 23:00-09/10/2018 0:00

09/15/2018 13:00-09/18/2018 16:00

11/19/2018 12:00-11/19/2018 16:00

12/03/2018 18:00-12/03/2018 19:00

02/03/2019 20:00-02/04/2019 10:00

02/14/2019 16:00-02/14/2019 18:00

02/26/2019 16:00-02/26/2019 18:00

03/05/2019 3:00 (invalid result)

03/22/2019 17:00-03/22/2019 19:00

04/19/2019 23:00-04/22/2019 11:00

06/23/2019 2:00-

Addis Ababa School Instrument Downtime

08/03/2018 17:00-08/05/2018 12:00

08/05/2018 23:00-08/10/2018 15:00

08/10/2018 23:00-09/11/2018 15:00

09/11/2018 23:00-09/12/2018 13:00-09/12/2018 19:00-

09/13/2018 14:00-09/14/2018 12:00

09/15/2018 0:00-09/15/2018 15:00-09/16/2018 12:00-

09/16/2018 18:00-09/17/2018 14:00-09/17/2018 18:00

09/17/2018 23:00-09/18/2018 15:00

09/18/2018 20:00-09/19/2018 13:00

09/19/2018 22:00-09/28/2018 09/29/2018 1:00-09/29/2018
12:00

09/30/2018 0:00-09/30/2018 14:00

10/04/2018 22:00-10/05/2018 15:00

10/05/2018 23:00-10/06/2018 13:00

10/06/2018 23:00-10/07/2018 13:00

10/08/2018 14:00-10/08/2018 16:00

10/10/2018 6:00-10/10/2018 12:00

10/15/2018 9:00-10/15/2018 13:00

10/16/2018 7:00-10/16/2018 18:00

10/16/2018 23:00-10/18/2018 11:00

10/24/2018 22:00-10/25/2018 2:00

10/25/2018 23:00-11/11/2018 13:00

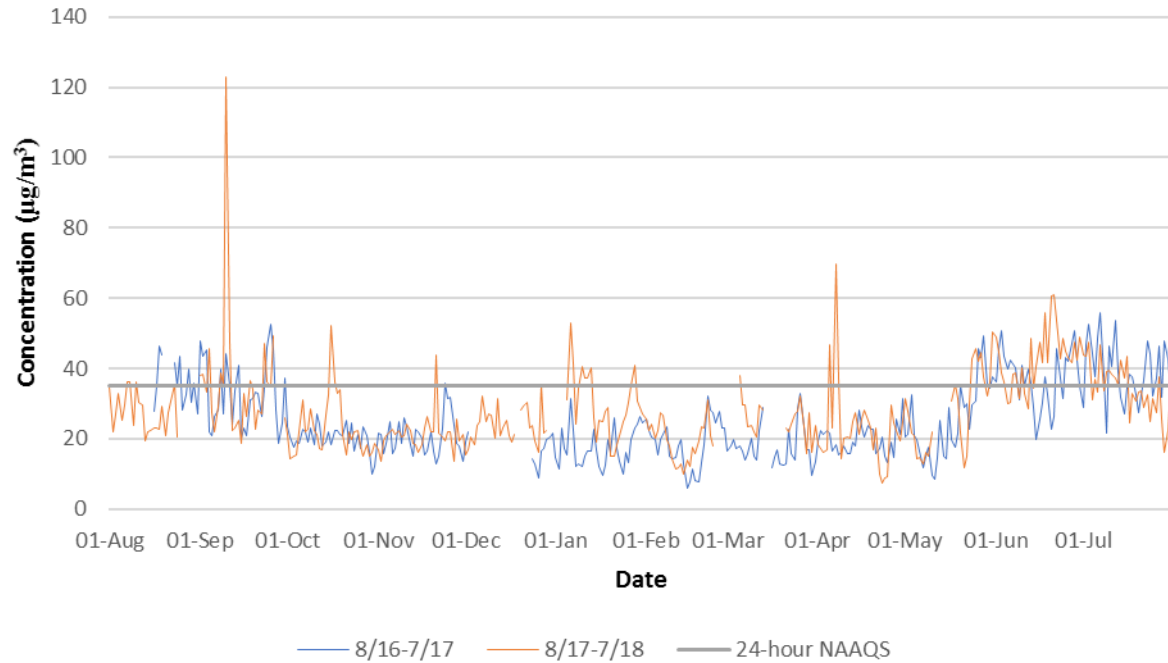
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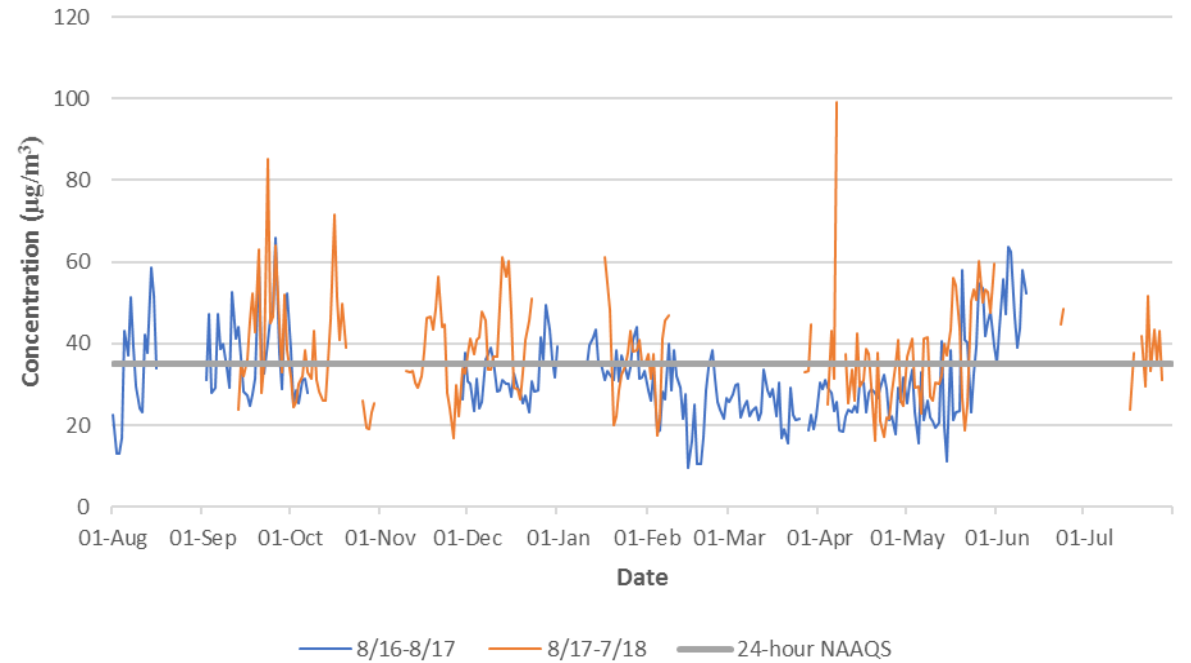


24-Hour Averages

Addis Ababa Central Daily 24-Hour Averages

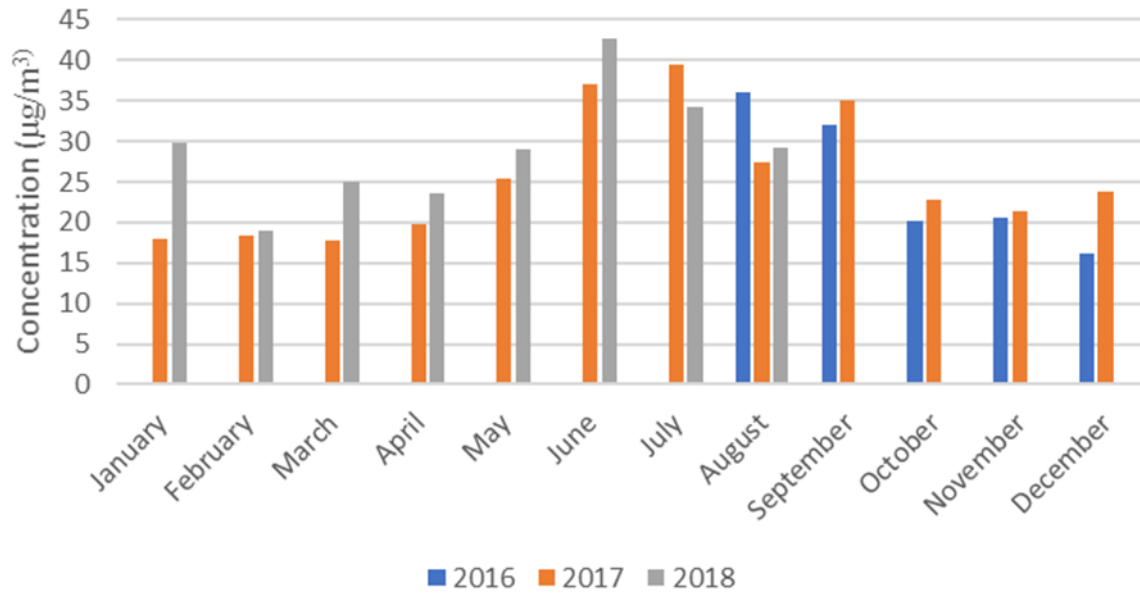


Addis Ababa School Daily 24-hour Averages

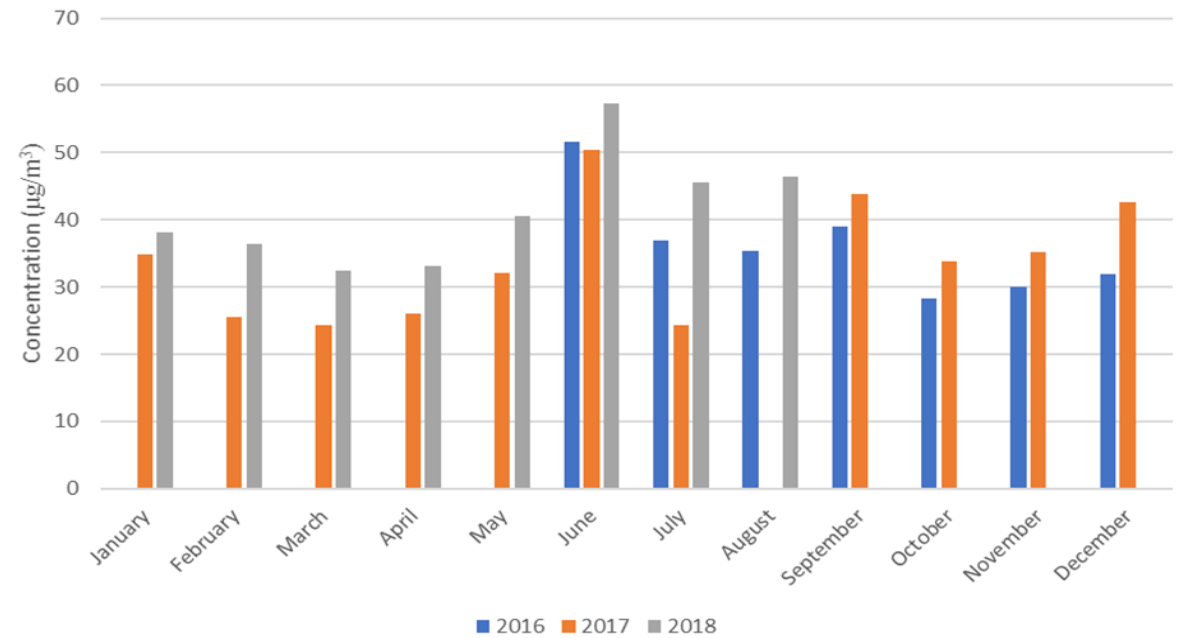


Monthly Averages

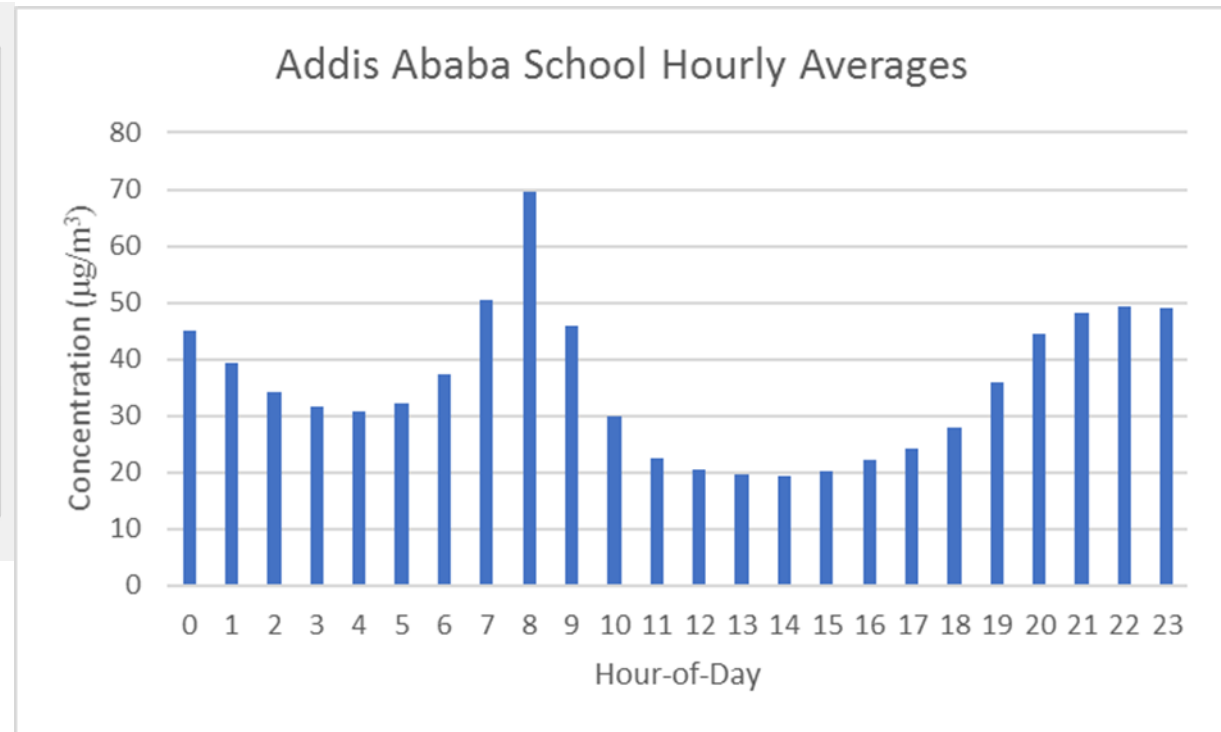
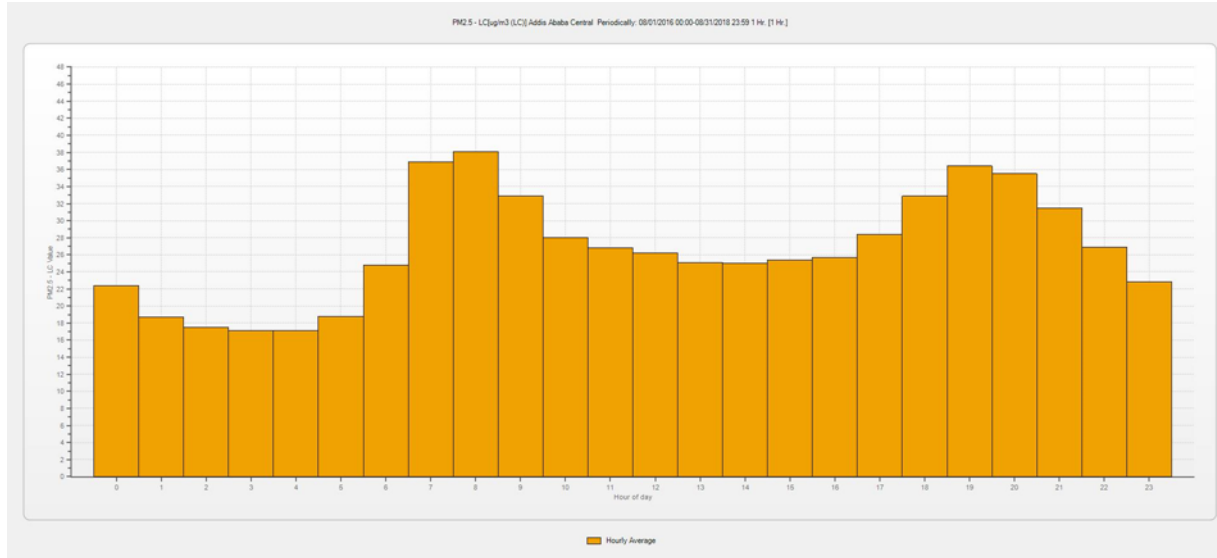
Addis Ababa Central Monthly Averages



Addis Ababa School Monthly Averages



Hourly Averages



Thank you.

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