CALIFORNIA
AIR RESOURCES BOARD

PQAO TRAINING 2019

Technology Update Regulatory PM Monitoring

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Overview

- Introduction
- PM History
- T640 Evaluation
- Next Steps

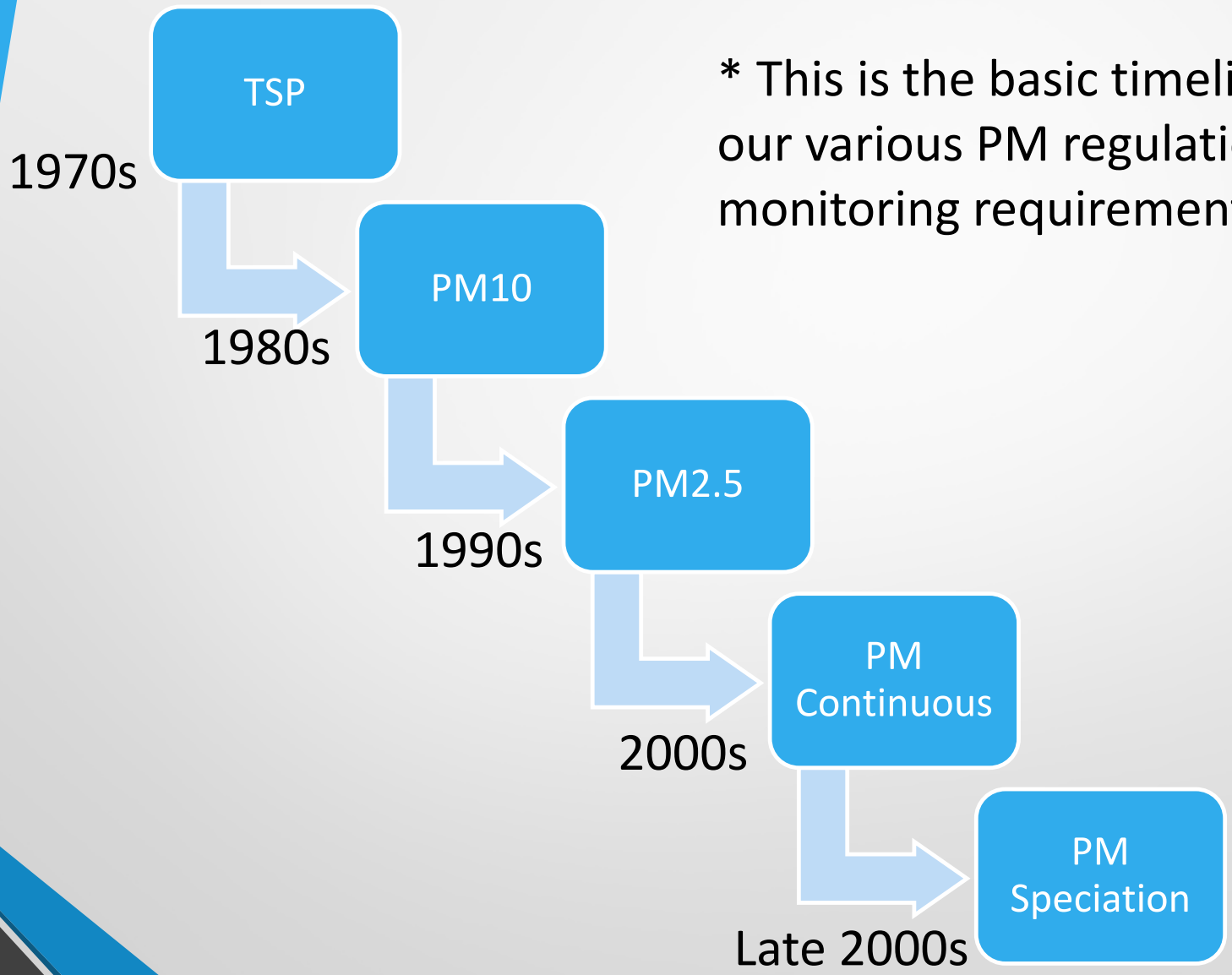
Introduction

- A function of my section is to look for better and more reliable technology for our PM monitoring program.
- Talk and share our experience with recent PM instrument evaluation.
- Highlight three field studies with the Teledyne API (TAPI) T640.
- Next Steps?

Particulate Matter

- Is a criteria pollutant.
- Regulated in CA: PM10 and PM2.5.
- Poses risk to our health.
- Measured primarily for areas to determine attainment status.
- Data reporting: AQI, AIRNOW, Ag Burn, etc.
- Requires reliable instrument to provide accurate measurement.

CARB's PM Monitoring History



* This is the basic timeline for our various PM regulation and monitoring requirements.

CARB's PM Program

- Dated back to 1970s.
- First started with filter-based FRM sampler.
- Manual sampling.
- Daily averages only.
- Demands for more time-resolved data led to continuous monitoring.

Thermo Partisol 2000

CARB's PM Program (cont.)

- In early 2000s BAM had become popular.
- Continuous sampling.
- Different options of cut head (FEM vs non-FEM).
- Hourly averages.
- Been used widely by PQAO as a standard PM instrument.

Met One BAM 1020

New PM Technologies

Met One
BAM 1022

Met One
BC 1054

Met One
SASS 22L

New PM Technologies (cont.)

Met One
EBAM Plus

Thermo
5030i SHARP

TAPI
602 Beta Plus

Teledyne API T640

- Continuous monitor.
- Uses scattered light spectrometry.
- FEM designated PM2.5 but also measures PM10 and PMC.
- Minute averages.
- Indoor or outdoor installation

TAPI T640

* TAPI has an enhanced version called T640X for FEM PM10 and PMC as well.

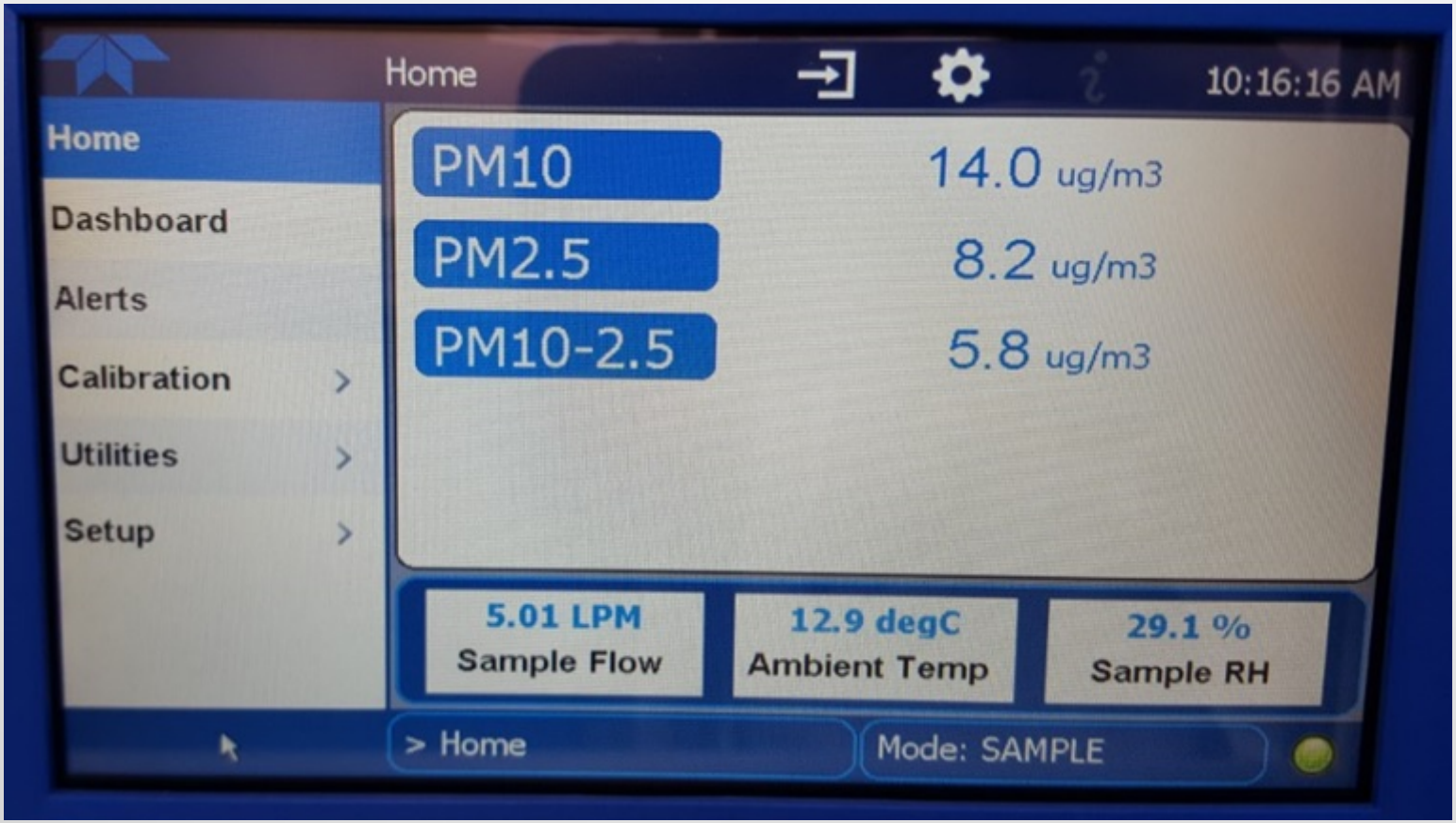
T640's Quick Specs

Parameter	Specification
Measurement Principle	Broadband spectroscopy using 90° white light scattering with Polychromatic LED
PM Mass Measurements	PM2.5, PM10, PM Coarse (10-2.5)
Measurement Range	0.1 – 10,000 µg/m3
Data Resolution	0.1 µg/m3
Lower Detectable Limit	<0.1 µg/m3 (1-hr average)
Data Rate	10s to 48hr (user selectable)
Sample Flow Rate	5.0 LPM within ±1% accuracy
Communication	Ethernet (TCP/IP Modbus & HTTP Protocols)
Operating Temp. Range	-40 to +60°C
Operating Humidity Range	0 to 100% RH, non-condensing
Dimensions	7"x17"x14" (Unit) + 43" (Heater Tube)
Weights	19lbs (Unit) + 6lbs (Heater Tube)
US EPA Designation	US EPA Class III FEM (EQPM-0516-236)

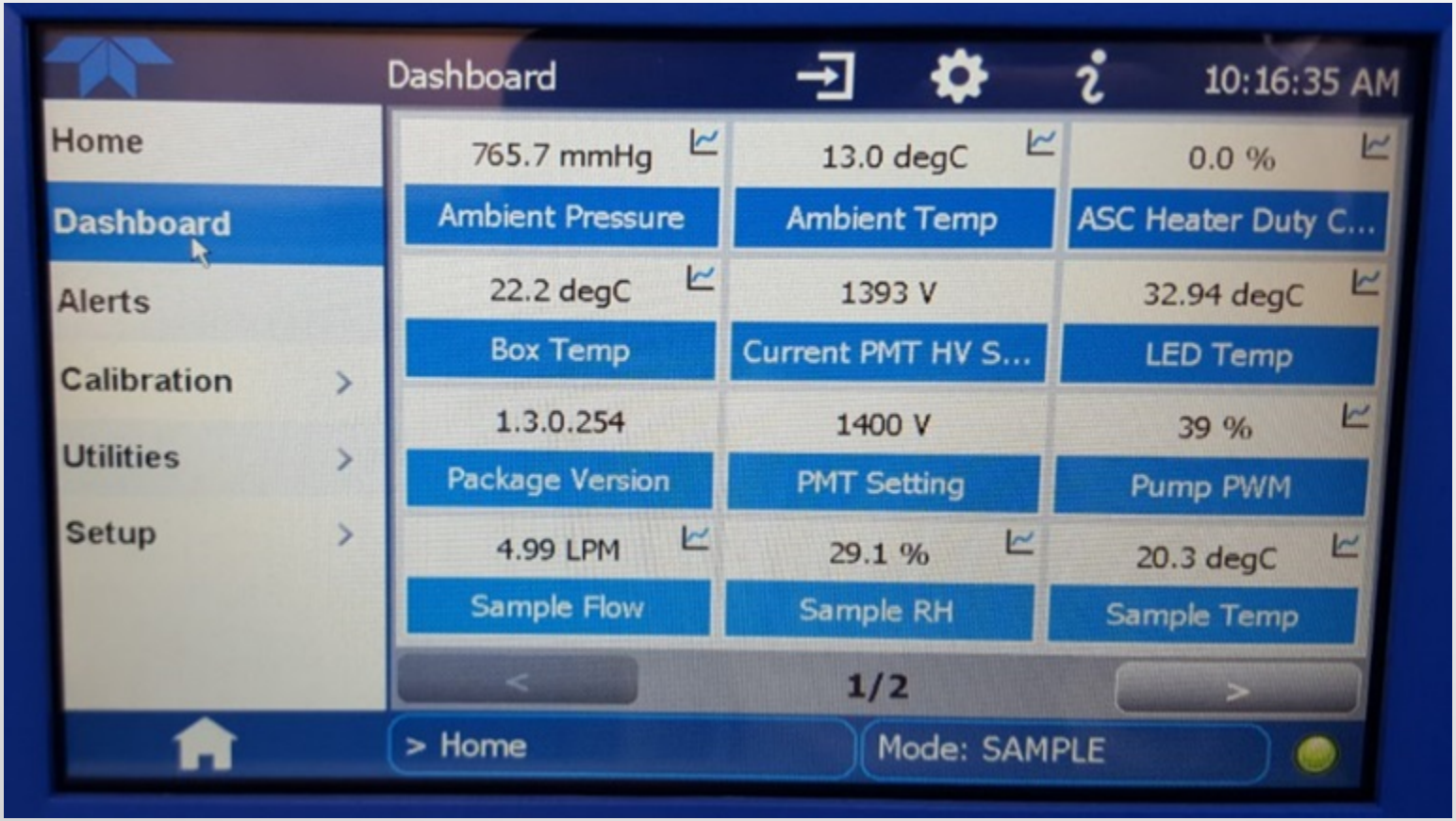
How the T640 setup looks?

New Enclosure

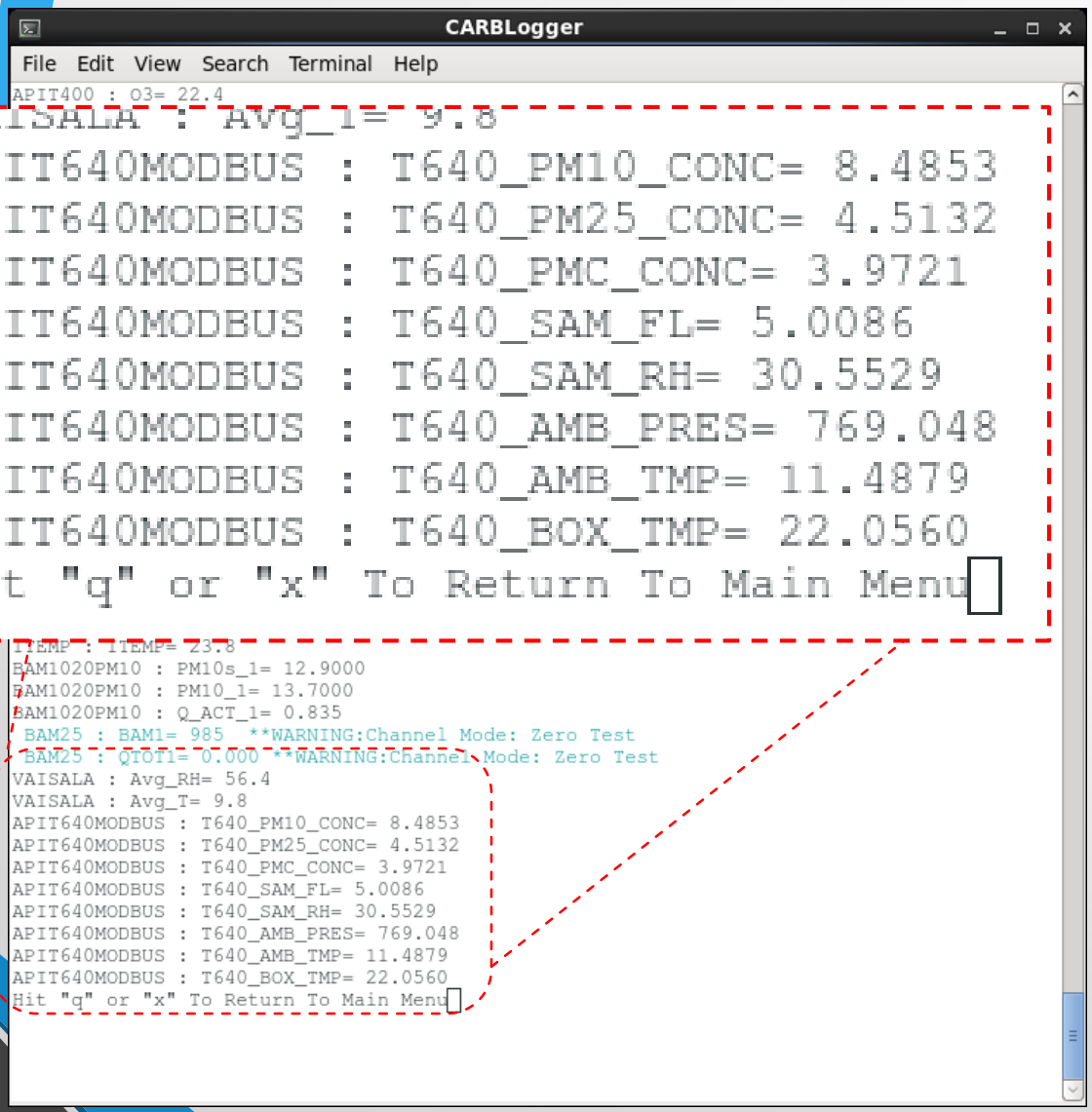
The Touchscreen Interface



The Dashboard



Parameters of Interest



- PM2.5
- PM10
- PM Coarse
- Flowrate
- Relative Humidity
- Ambient Pressure
- Ambient Temp
- Box Temp
- LED Temp
- Sample Temp
- Pump Duty Cycle

Maintenance Checklist

CARB INSTRUMENT MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET

API T640 PM MASS MONITOR

Location: _____ Month/Year: _____

Station Number: _____ Technician: _____

Property Number: _____ Agency: _____

Operator Instructions:

1) Daily: Review station data logger values for correct operation of T640 monitor.
2) Biweekly: Check the system clock.
Check the ambient temperature and pressure.
Perform T640 flow check. (5.0LPM ± 0.25LPM)
Perform T640 zero check. *** No vacuum leak check on this instrument.
3) Monthly: Complete this Monthly Quality Control Maintenance Check Sheet.
Thoroughly clean the T640 inlet.
Check pump performance. (PWM value < 80%)
Check/Adjust PMT with SpanDust™. (Measured peak, limit: 11.3 ± 0.5)
PMT Peak: _____ Date Last Performed: _____
4) Semi-annual: Inspect and clean optical chamber and RH/T sensor.
Change the disposable filter unit (DFU).
5) Annual: Inspect sampling line, or as needed.

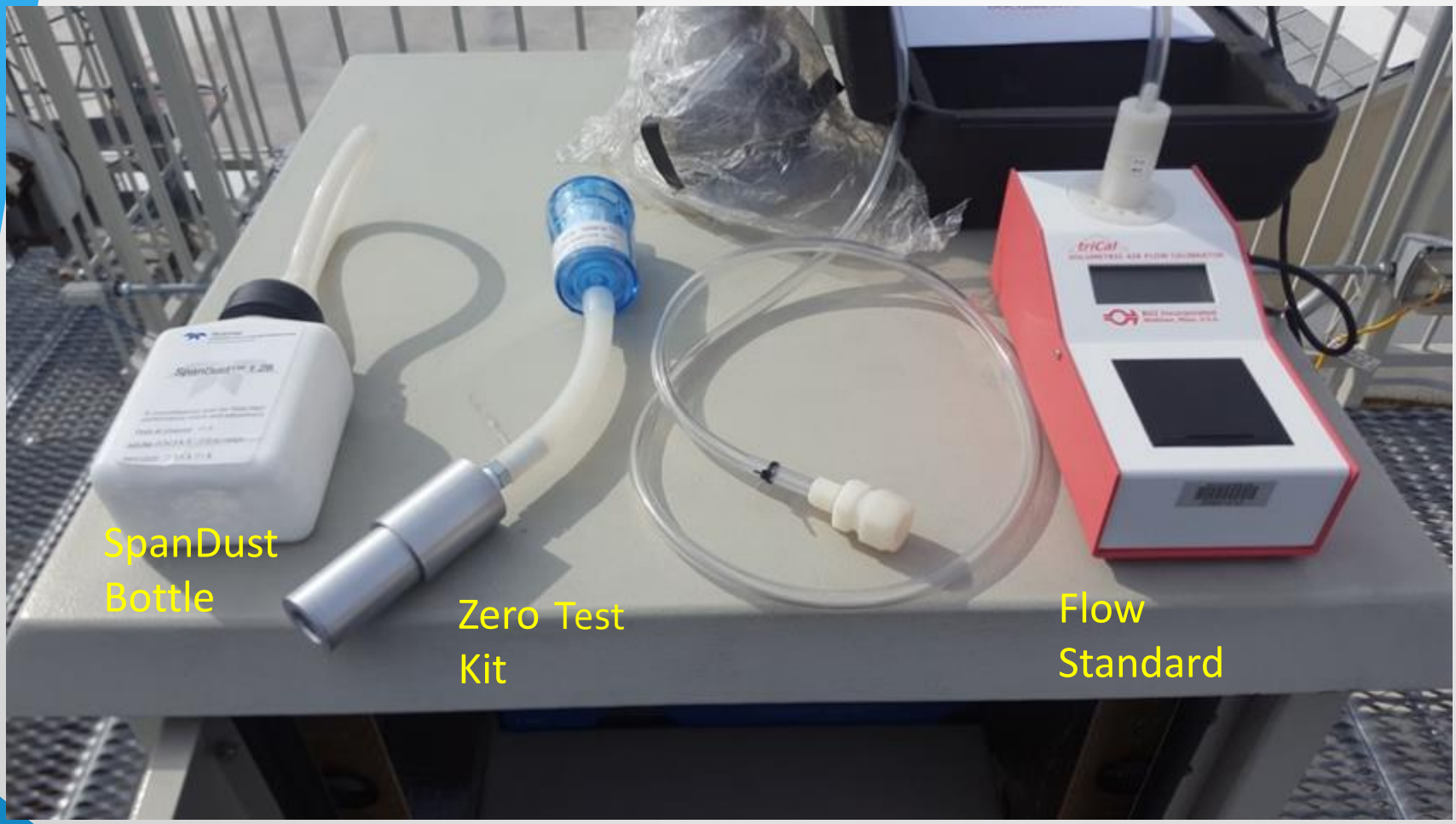
Transfer Standard Used:

Make/Model	Serial/I.D. Number	Date Certified

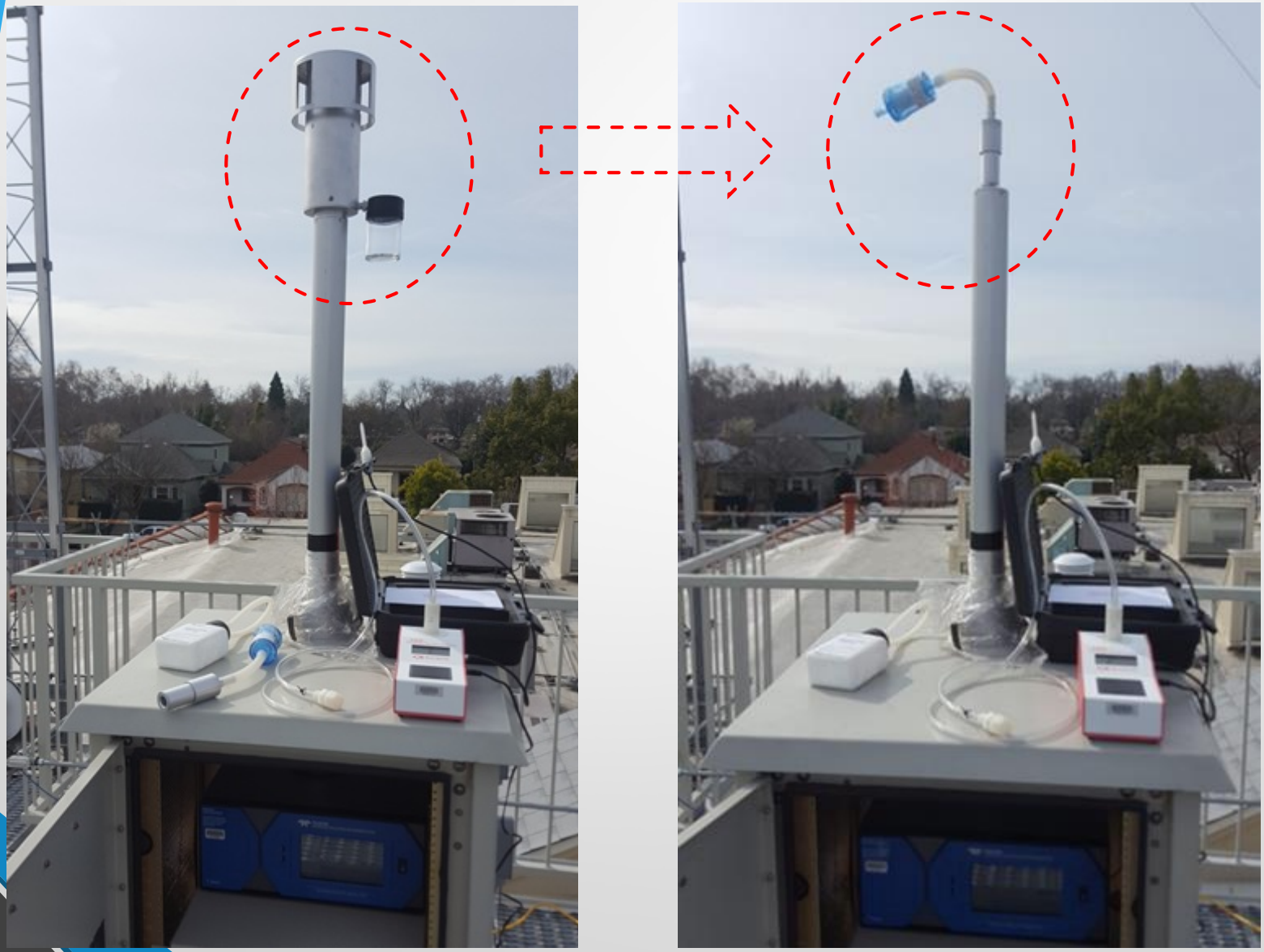
Bi-Weekly Sampler Flow Rate, Ambient Temp, and Pressure Check Results:

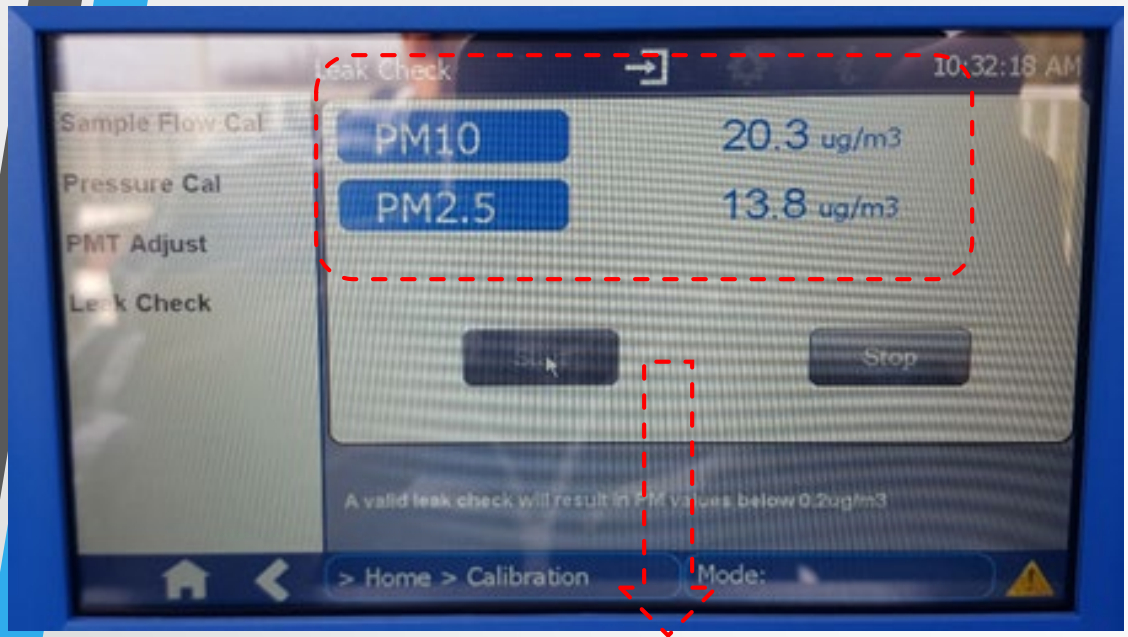
Date:	Sampler	Standard	Difference	Control Limits*
Flow Rate				5.0 ± 0.25 LPM
Ambient Temp.				± 2 °C
Ambient Press.				± 10 mm Hg
Zero Check				< 0.1 µg/m³

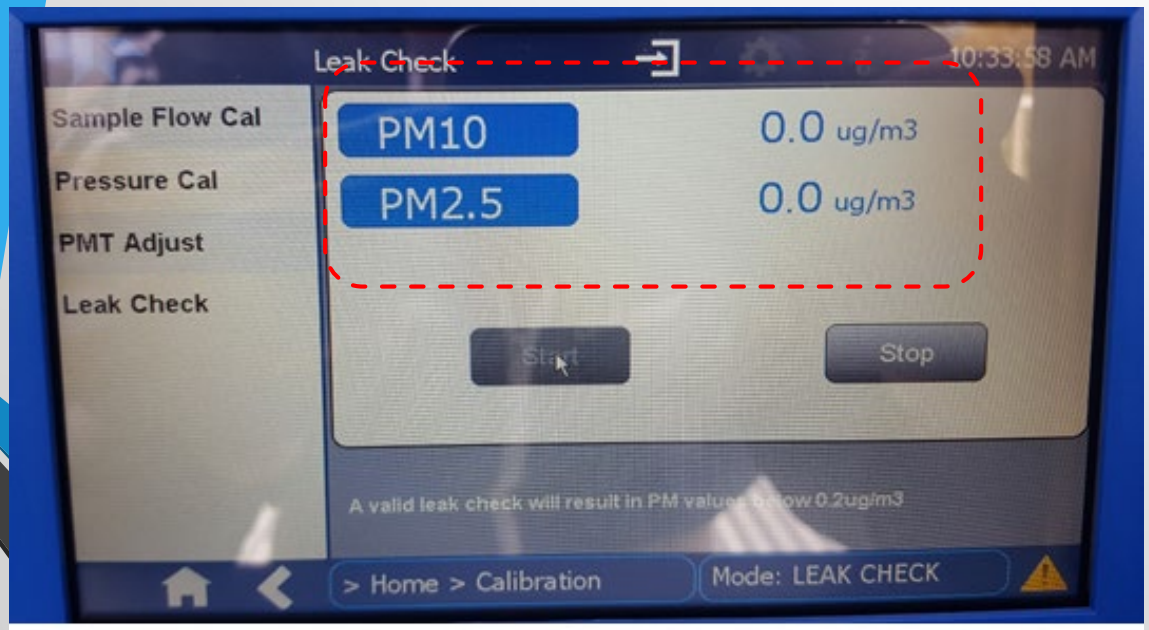
Tools Needed for Checks



Zero Test

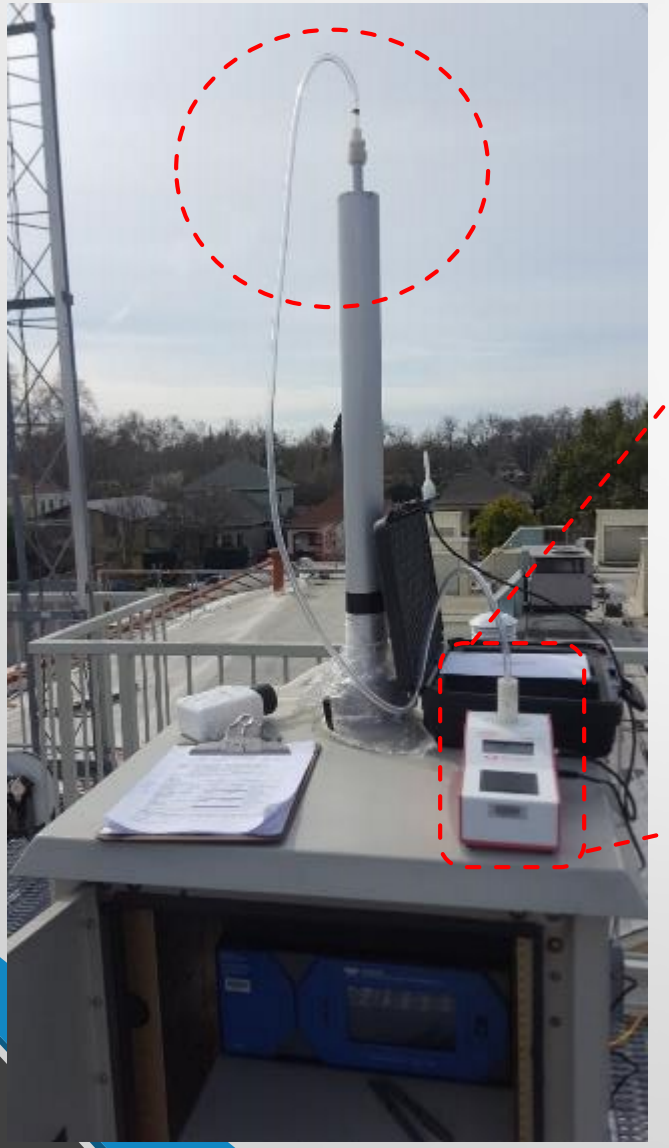






- Initiate the "Leak Check" from Calibration screen, and watch the PM monitors to drop to zero.

Flow Check

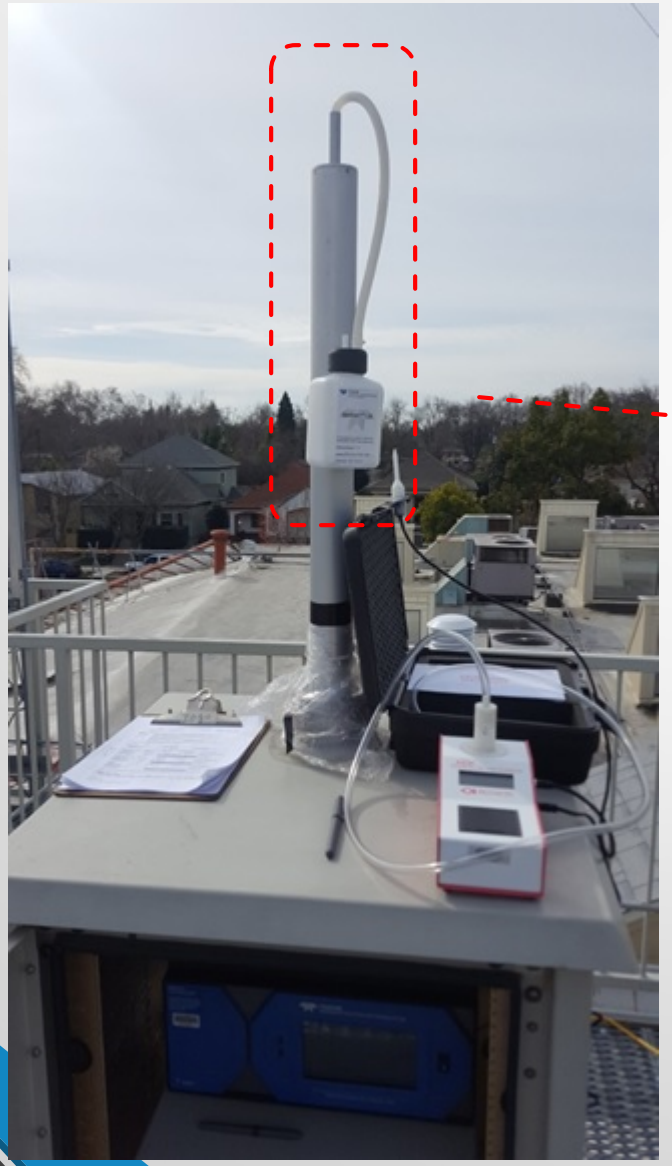


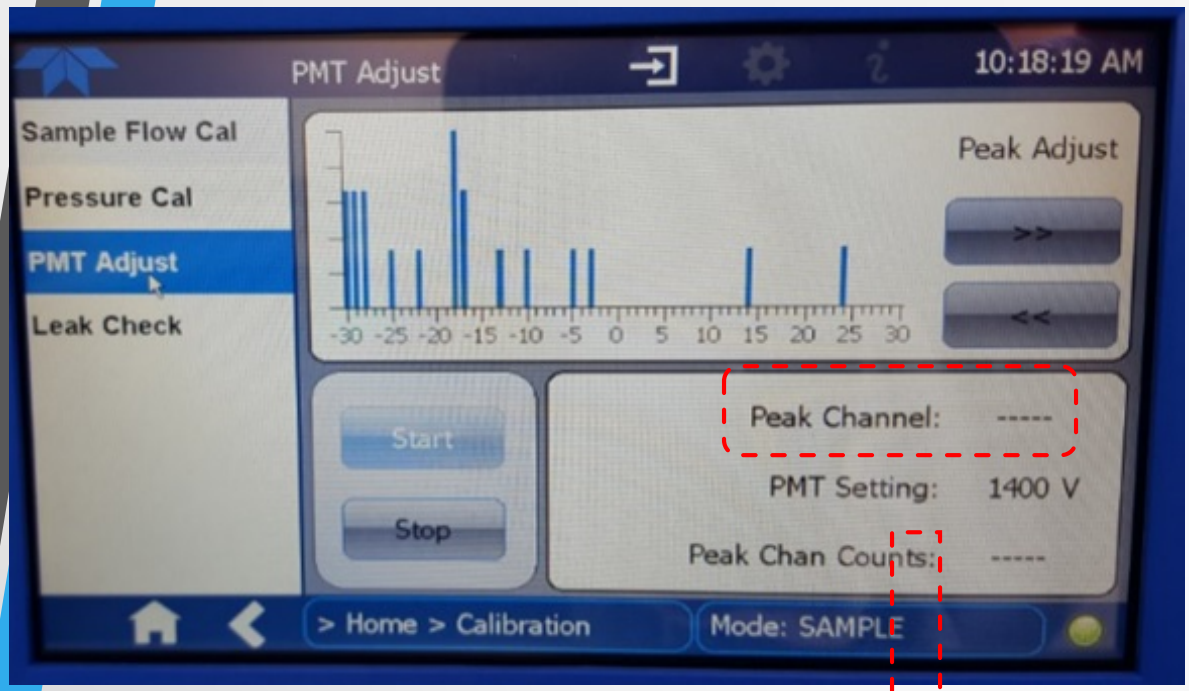

triCal
VOLUMETRIC AIR FLOW CALIBRATOR
BP:763.5 mmHg
Tf:12.1 °C
Qa:5.01 LPM Ext
Qs:5.21 LPM Pwr
BGI Incorporated
Waltham, Mass. U.S.A.

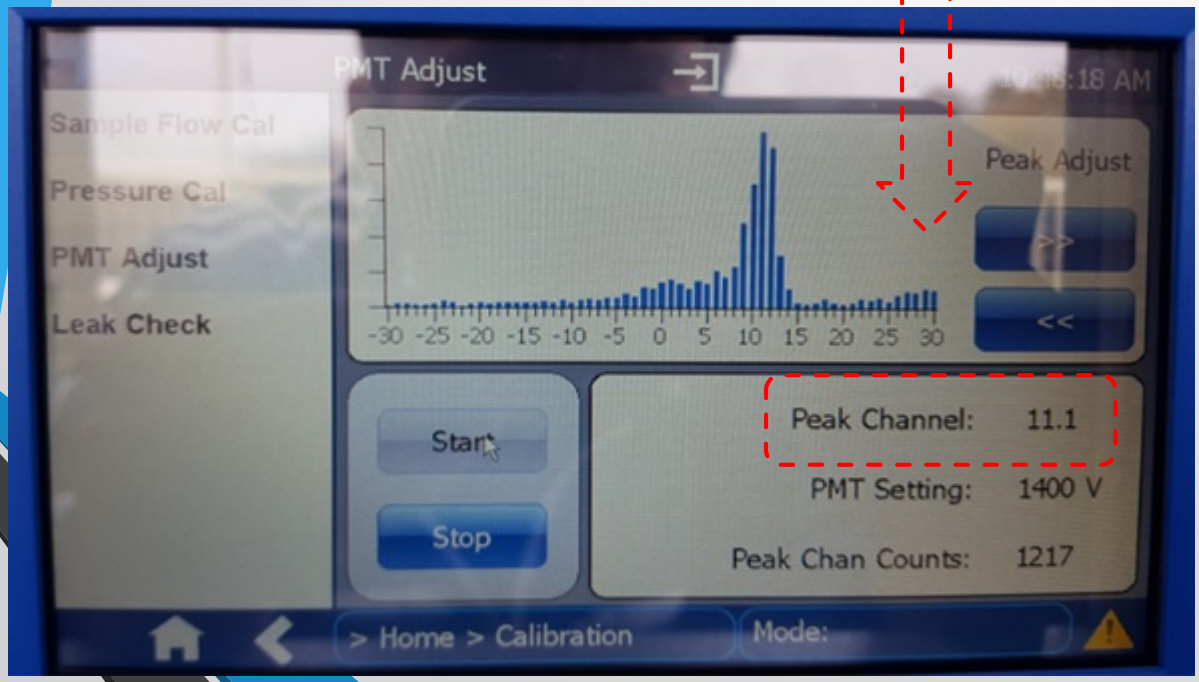
Bi-Weekly Sampler Flow Rate, Ambient Temp, and Pressure Check Results:

Date:	Sampler	Standard	Difference	Control Limits*
Flow Rate	4.98	5.01	0.03	5.0 ± 0.25 LPM
Ambient Temp.	10.9	12.1	1.2	± 2 °C
Ambient Press.	766.2	763.5	2.7	± 10 mm Hg
Zero Check	0.0			< 0.1 µg/m³

SpanDust Check



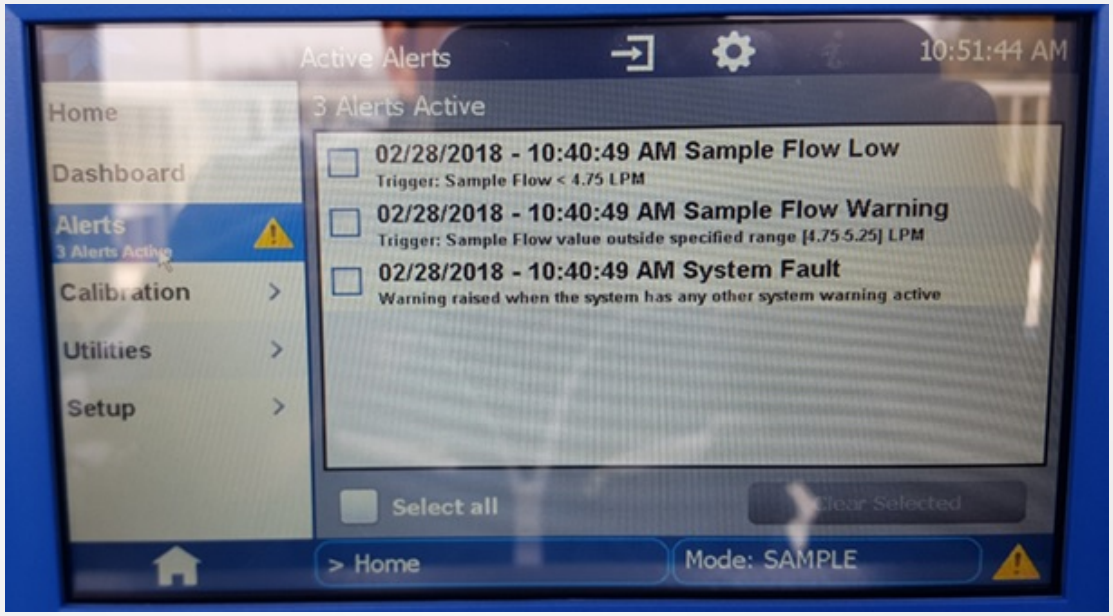




- Initiate the “PMT Adjust” and check for the Peak Channel reading.
- The allowed range is ±0.5 of the specified target.
- If PMT check fails, inspect the optical chamber.

After Maintenance Checks

- Alert Messages



- Abnormal Readings (~10 mins)

Field Evaluations

- Three different campaigns:
  - Sacramento – T Street : Nov-2017 to Sep-2018

    → an urban site in downtown Sacramento

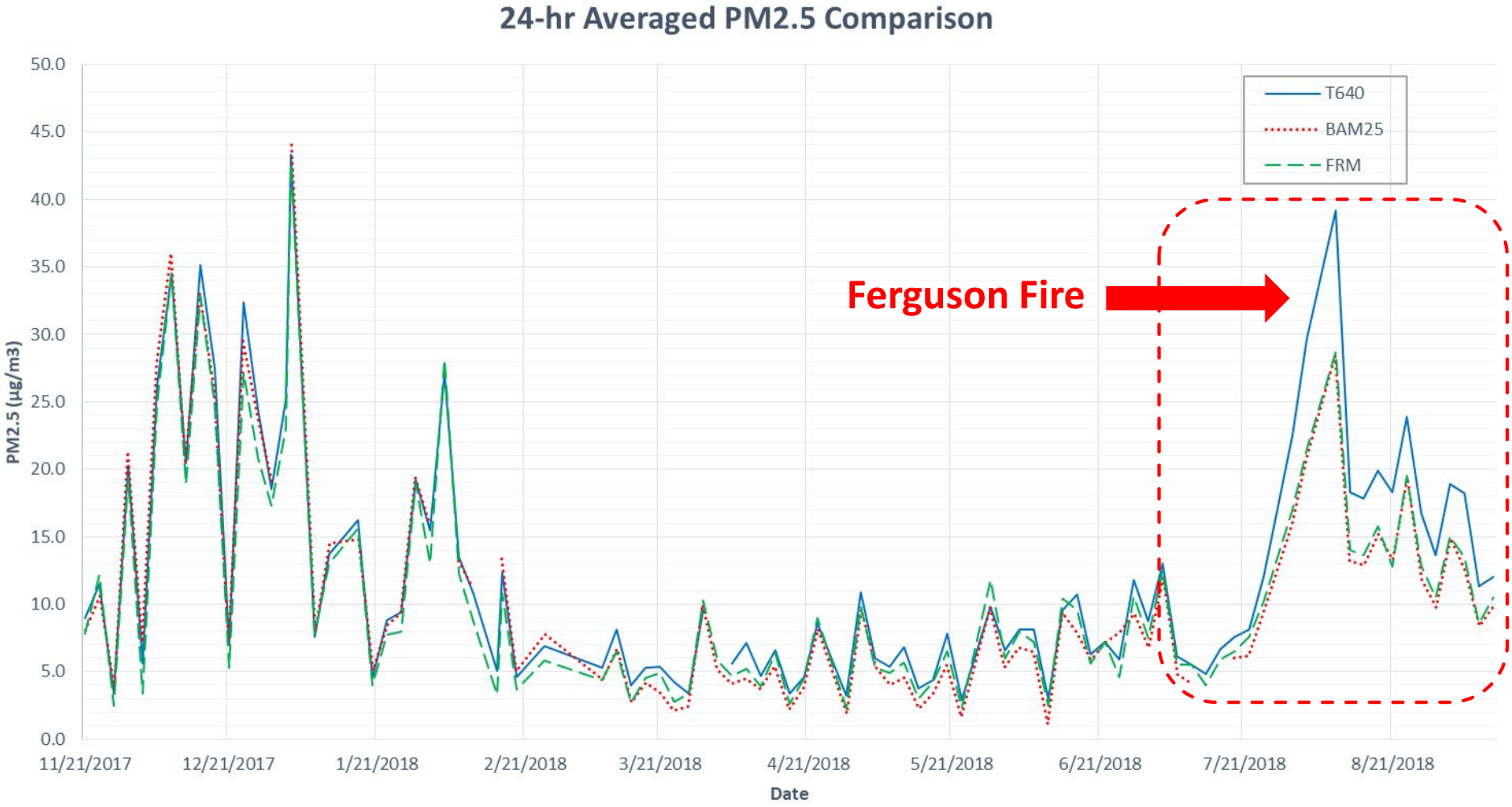
  - Chico – East Ave : Oct-2018 to Mar-2019

    → a rural site surrounded with agriculture

  - Brawley (Imperial County) : Jul-2018 to Mar-2019

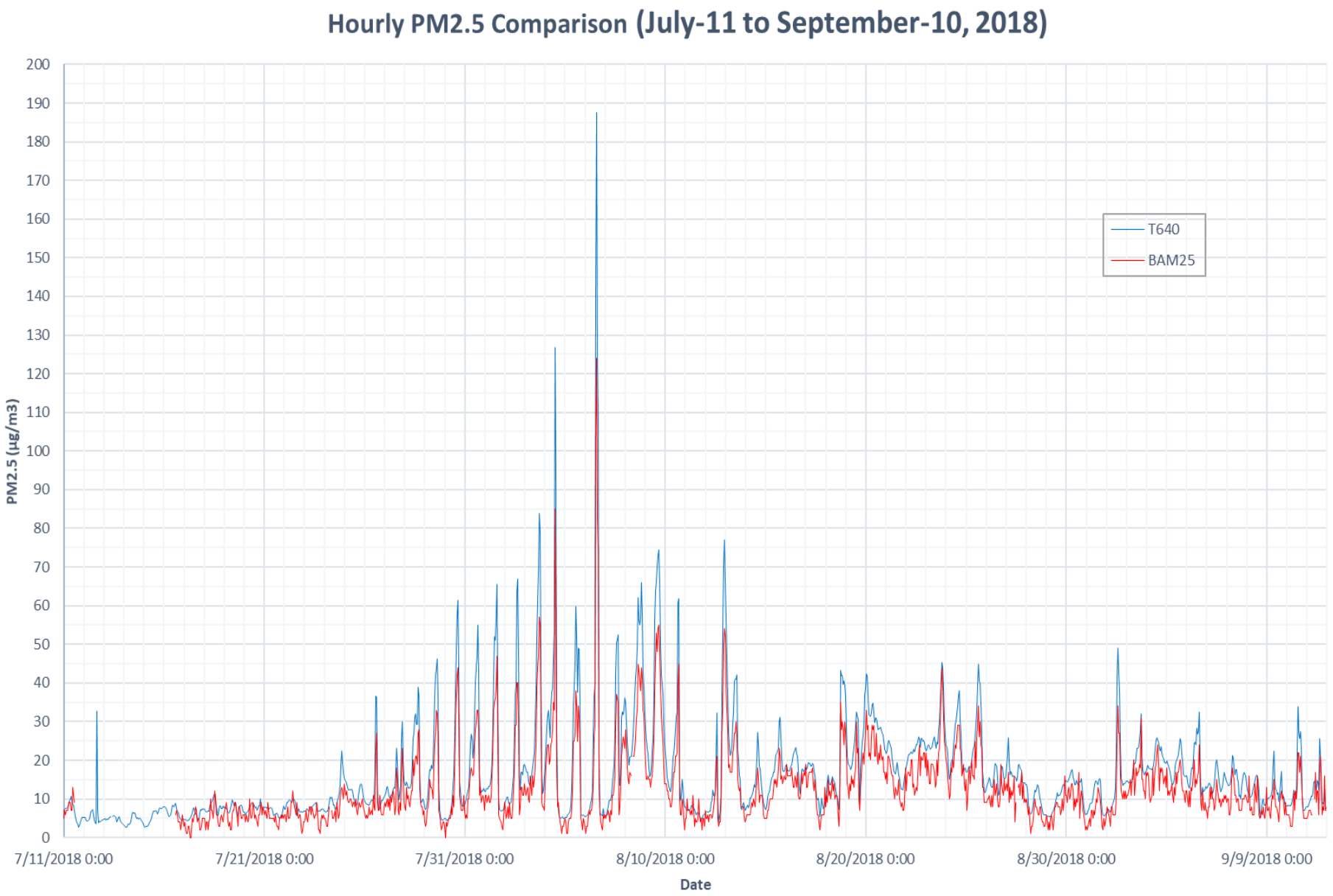
    → a rural site in SoCal near the desert

Sacramento – T Street



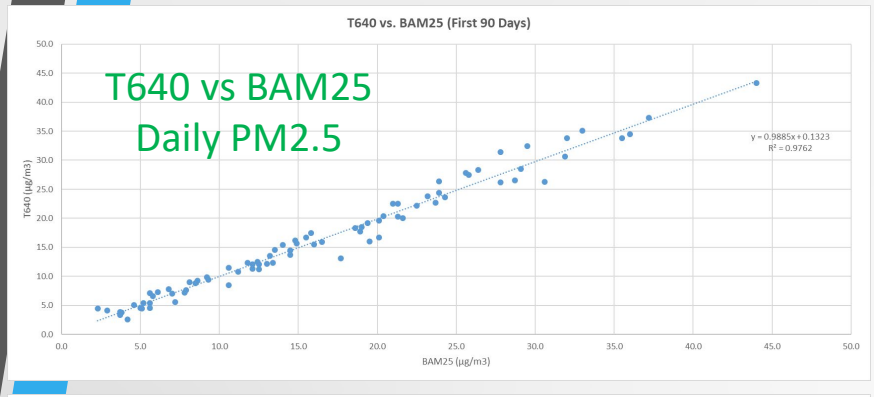
Time series of Daily PM2.5 measurements: T640, BAM25, and FRM from 11/21/2017 thru 9/11/2018

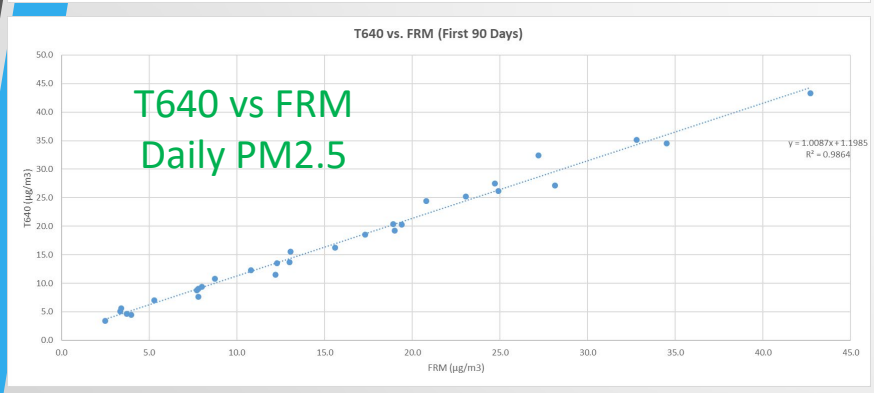
Sacramento – T Street

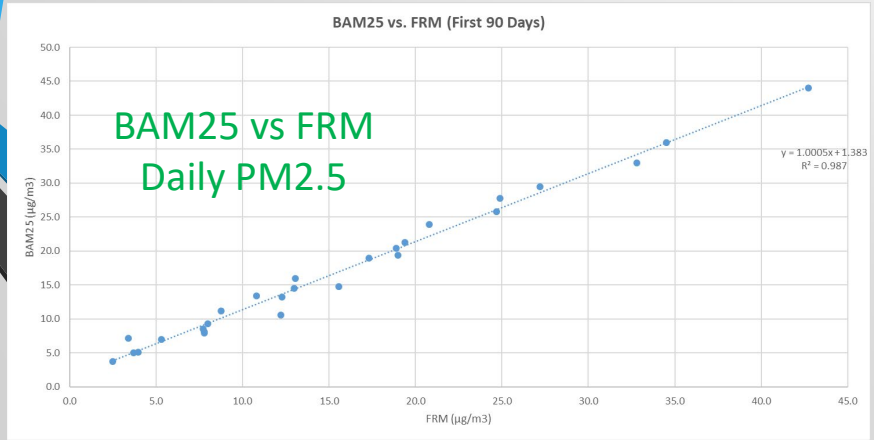


Linear Regression (24-hr Averaged PM2.5)

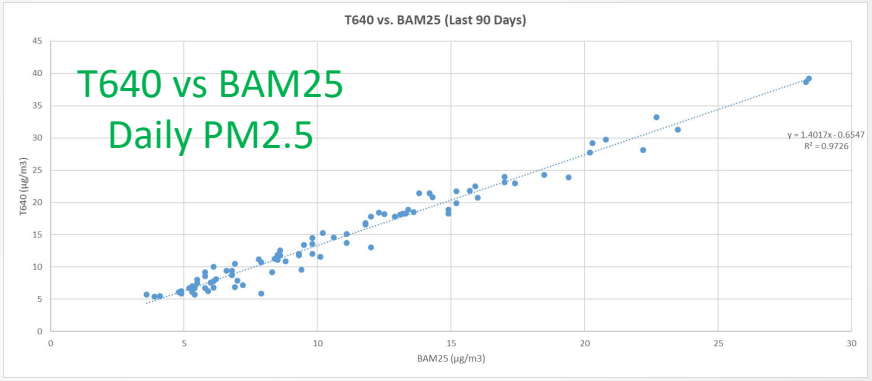
First 90 Days @ Sac-T

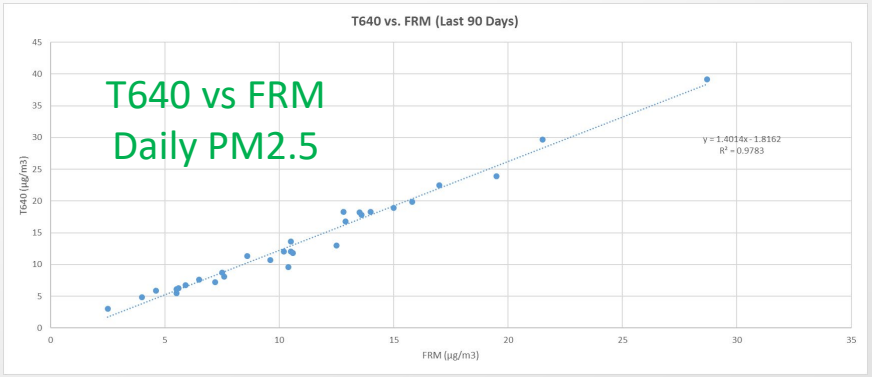


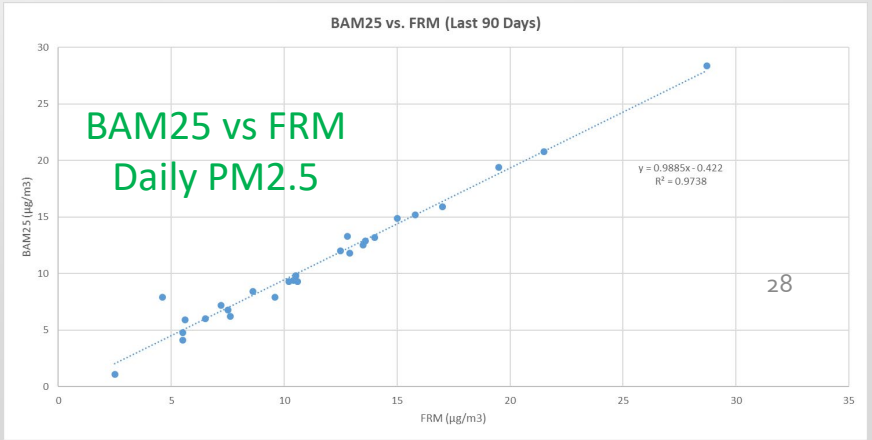




Last 90 Days @ Sac-T







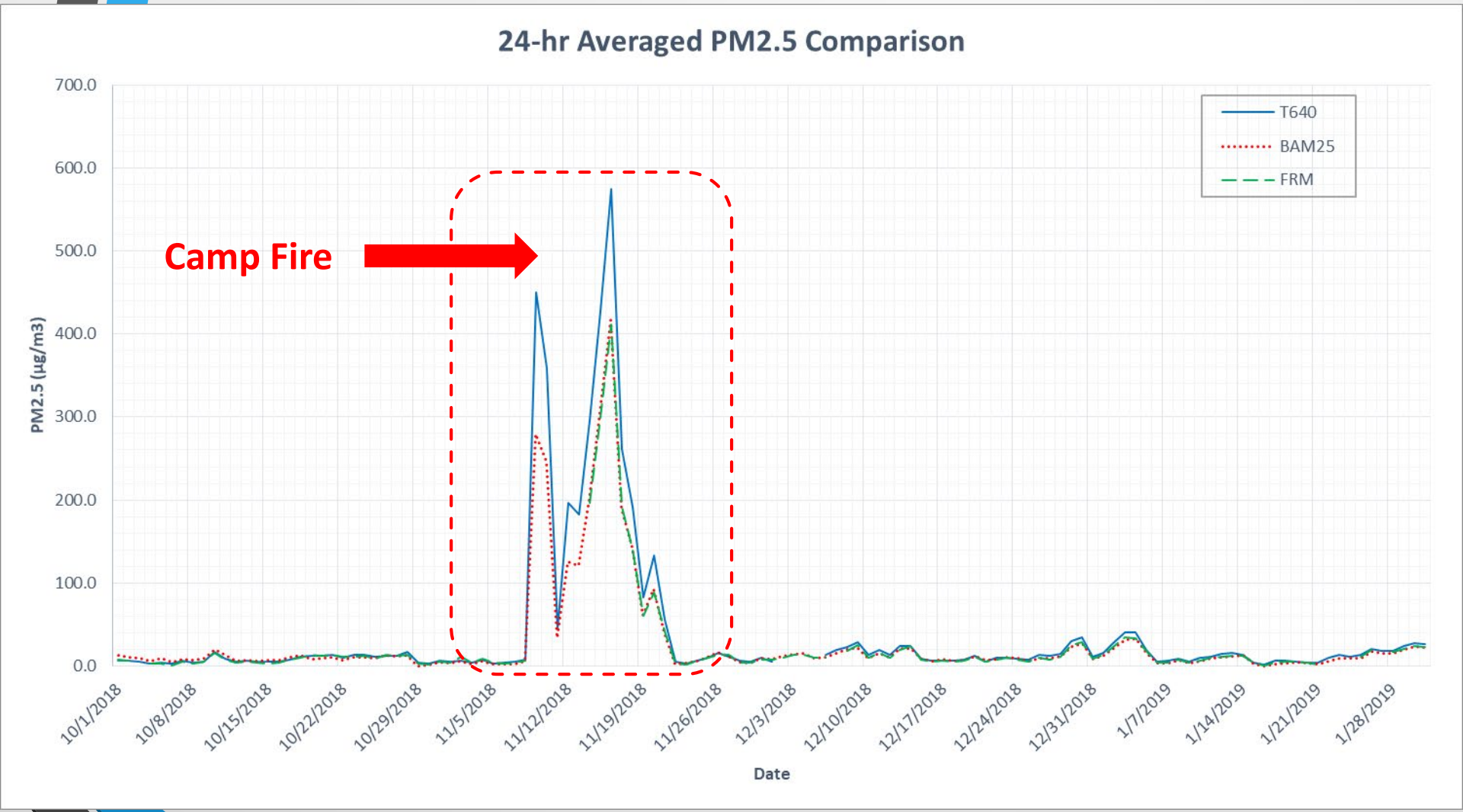
Linear Regression (24-hr Averaged PM2.5)

Summary of Sac-T's Daily PM2.5 comparison between T640, BAM25, and FRM.

Y vs. X	First 90 Days	Last 90 Days
T640 vs. BAM25	$Y = 0.9885X + 0.1323$ $R^2 = 0.9762$	$Y = 1.4017X - 0.6547$ $R^2 = 0.9726$
T640 vs. FRM	$Y = 1.0087X + 1.1985$ $R^2 = 0.9864$	$Y = 1.4014X - 1.8162$ $R^2 = 0.9783$
BAM25 vs. FRM	$Y = 1.0005X + 1.3830$ $R^2 = 0.9870$	$Y = 0.9885X - 0.4220$ $R^2 = 0.9738$

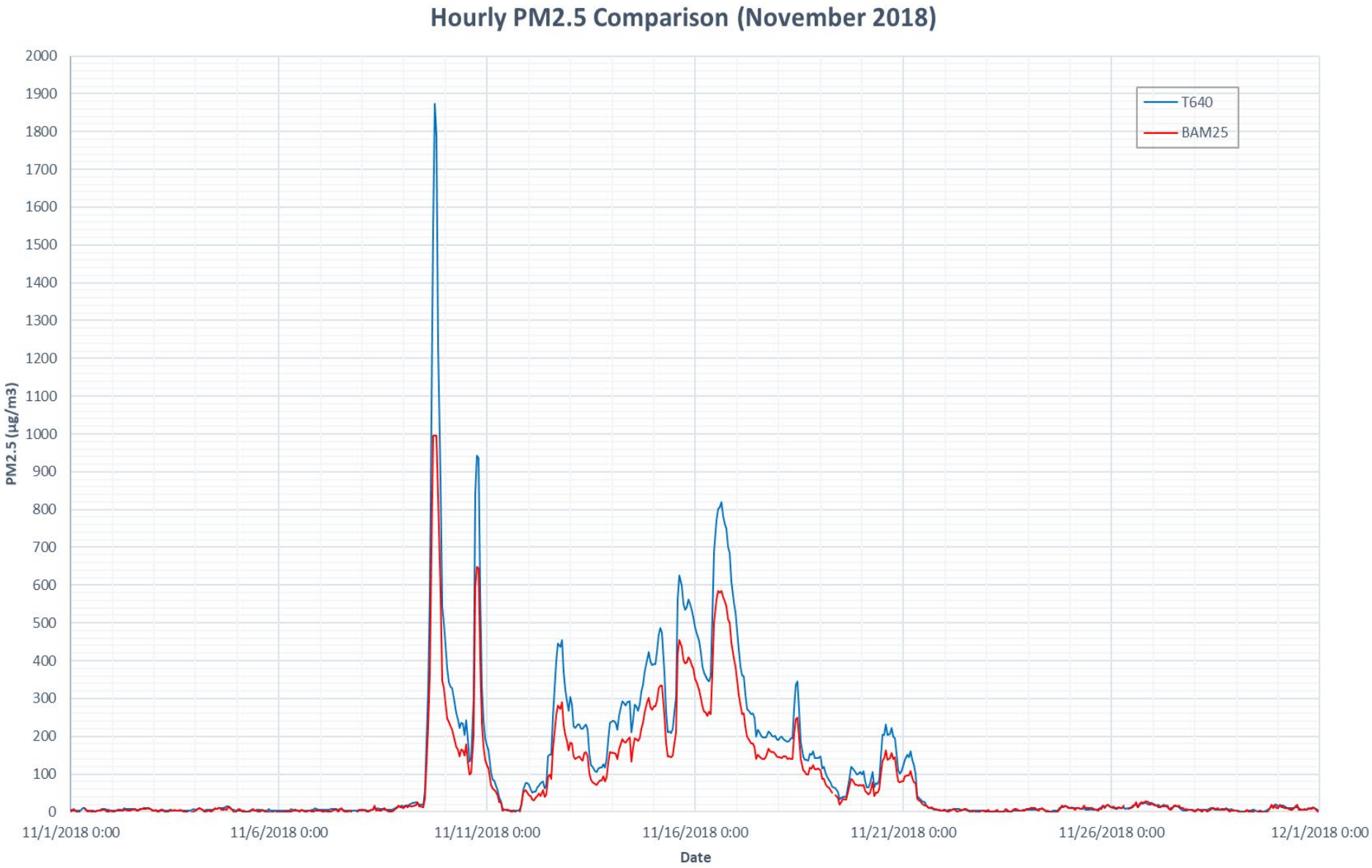
* During the smoky days, T640 reported ~40% higher than the collocated monitors.

Chico – East Avenue



Time series of Daily PM2.5 measurements: T640, BAM25, and FRM from 10/1/2018 thru 1/31/2019

Chico – East Avenue



Linear Regression (24-hr Averaged PM2.5)

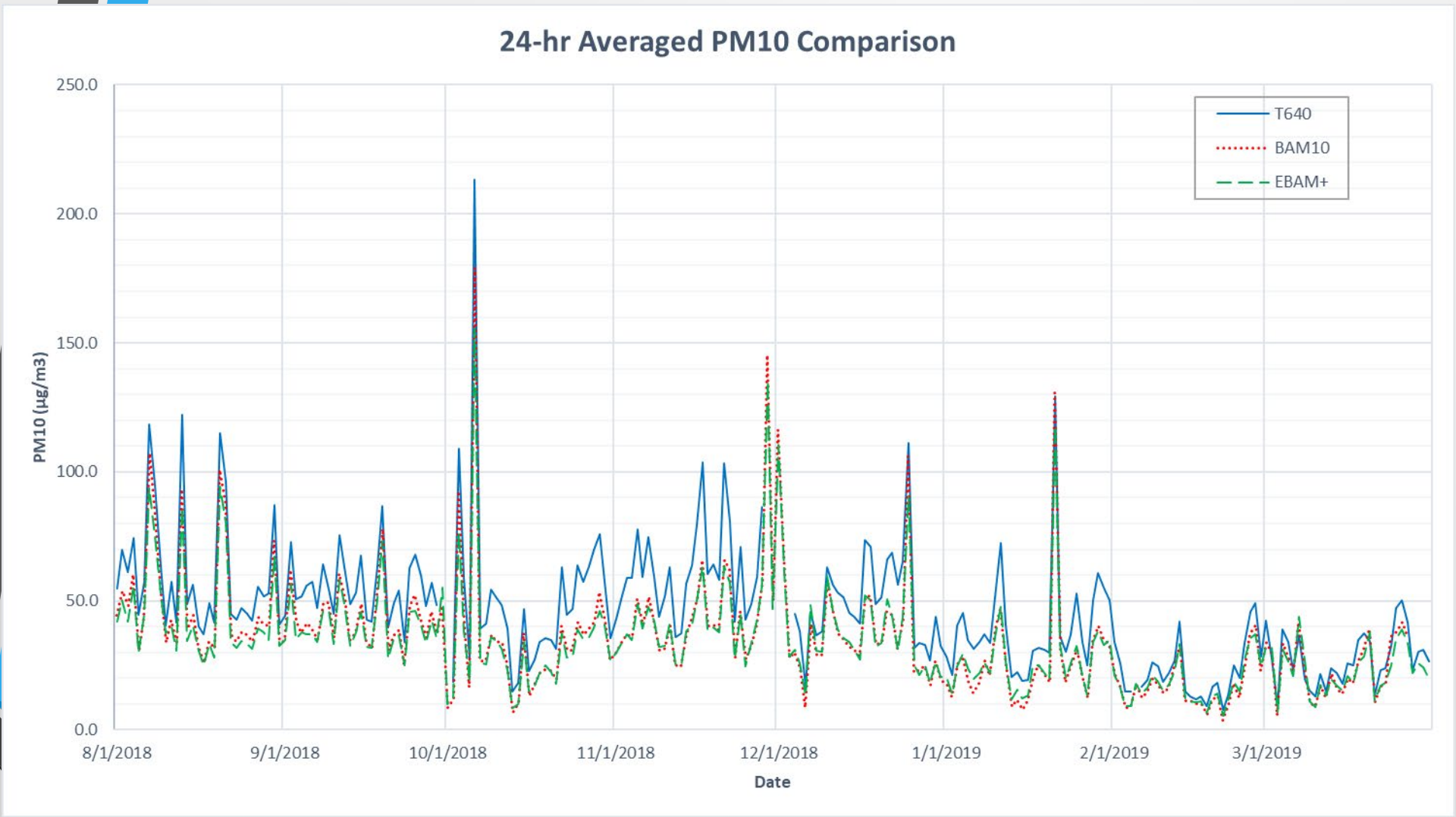
Summary of Chico-East's Daily PM2.5 comparison between T640, BAM25, and FRM.

Y vs. X	Nov-2018	Dec-2018 to Jan-2019
T640 vs. BAM25	Y = 1.4388X – 0.6300 R^2 = 0.9946	Y = 1.1999X + 0.4338 R^2 = 0.9703
T640 vs. FRM	Y = 1.4173X – 1.9535 R^2 = 0.9986	Y = 1.1429 X + 0.4944 R^2 = 0.9798
BAM25 vs. FRM	Y = 1.0174X – 0.8161 R^2 = 0.9996	Y = 0.9343X + 0.4103 R^2 = 0.9754

* T640 reported ~43% higher during Camp Fire.

** For wood burning season, T640 reported around 15~20% higher.

Brawley (Imperial County)



Time series of PM10S measurements: T640, BAM10, and EBAM+ from 8/1/2018 thru 3/31/2019

Linear Regression (24-hr Averaged PM10)

Summary of Brawley's Daily PM10 comparison between T640, BAM10, and EBAM+.

Y vs. X	Overall
T640 vs. BAM10	$Y = 1.1294X + 7.6089$ $R^2 = 0.9319$
T640 vs. EBAM+	$Y = 1.2973X + 3.1476$ $R^2 = 0.9351$
EBAM+ vs. BAM10	$Y = 0.8782X + 3.1809$ $R^2 = 0.9879$

* T640's PM10 in general correlated with other monitors but reported higher. Could it be due to the lower flowrate?

Overall Feedback

- Wood smoke influence on performance… 😐
- More expensive than the BAMs… ☹
- Ethernet-only telemetry… 😐
- Good portability… ☺
- Real-time minute data… ☺
- Multi-parameter measurements… ☺
- Do not require sample filter or tape… ☺
- Low maintenance requirement…☺

What now?

- Field evaluation for T640 is done.
- All data and findings have been shared with TAPI.
- CARB has no plan for T640 deployment yet.
- T640 still has the potential to be used for other types of monitoring (e.g. oil & gas, or community air).
- Write a staff report to summarize these evaluations.

Questions?

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