EMISSIONS ANALYTICS

Brake and Tire Wear Exposure Concentrations in the South Coast Air Basin and Coachella Valley

Technical proposal

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27 September 2024

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Agenda

1. Essential processes
2. Team
3. Timing
4. South Coast Air Quality Management District assistance
5. Objectives
6. Tasks

Source: Emissions Analytics 2024

Overview

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Essential processes

- Take environmental samples to identify and quantify tire and brake concentrations
- Add these measurements to air quality, traffic and dispersion models to get fine spatial resolution, and improve uncertainties
- Estimate airborne concentration and human health risk

➢ Transparent and robust methods that can be repeated in the future

Source: Emissions Analytics 2024

Team – a unique combination of expertise

Nick Molden, Emissions Analytics

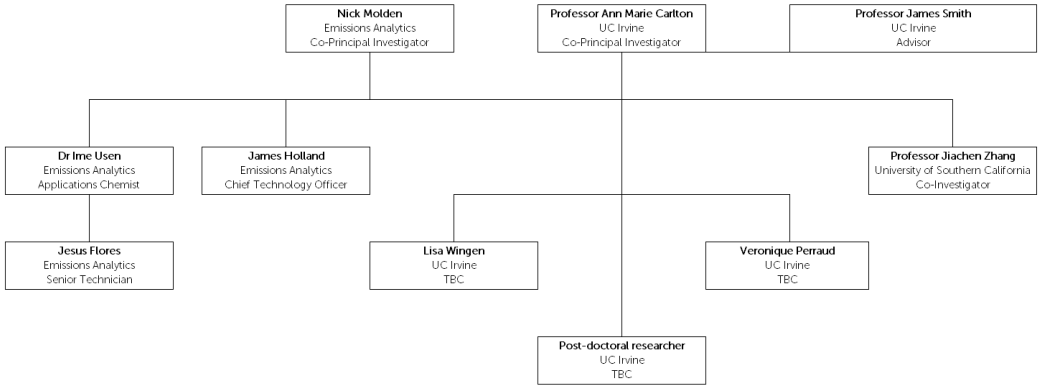
Dr Ime Usen, Emissions Analytics

James Holland, Emissions Analytics

Professor James Smith, UC Irvine

Professor Ann Marie Carlton, UC Irvine

Professor Jiachen Zhang, University of Southern California



Source: Emissions Analytics 2024

Timing – summary

2024 – Project set-up; literature review

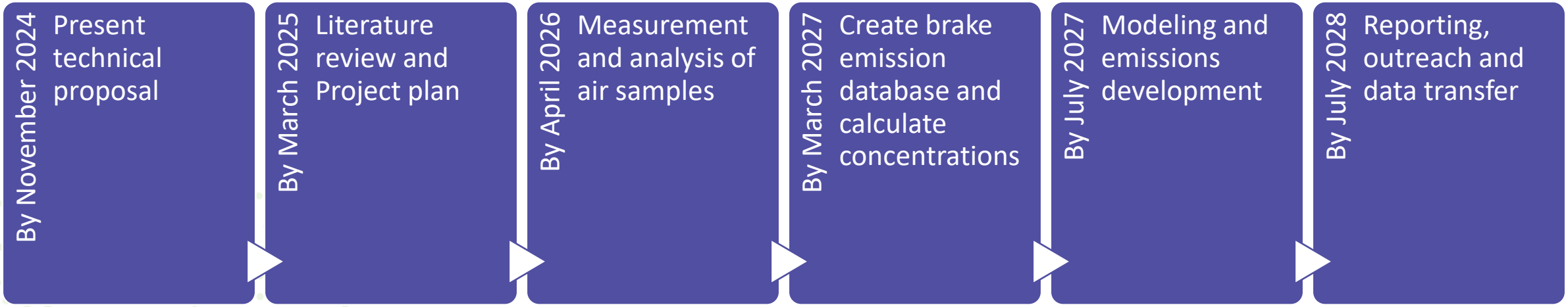
2025 – Sampling and testing

2026 – Analysis and modelling

2027 – Report and outreach

Source: Emissions Analytics 2024

Milestones and schedule

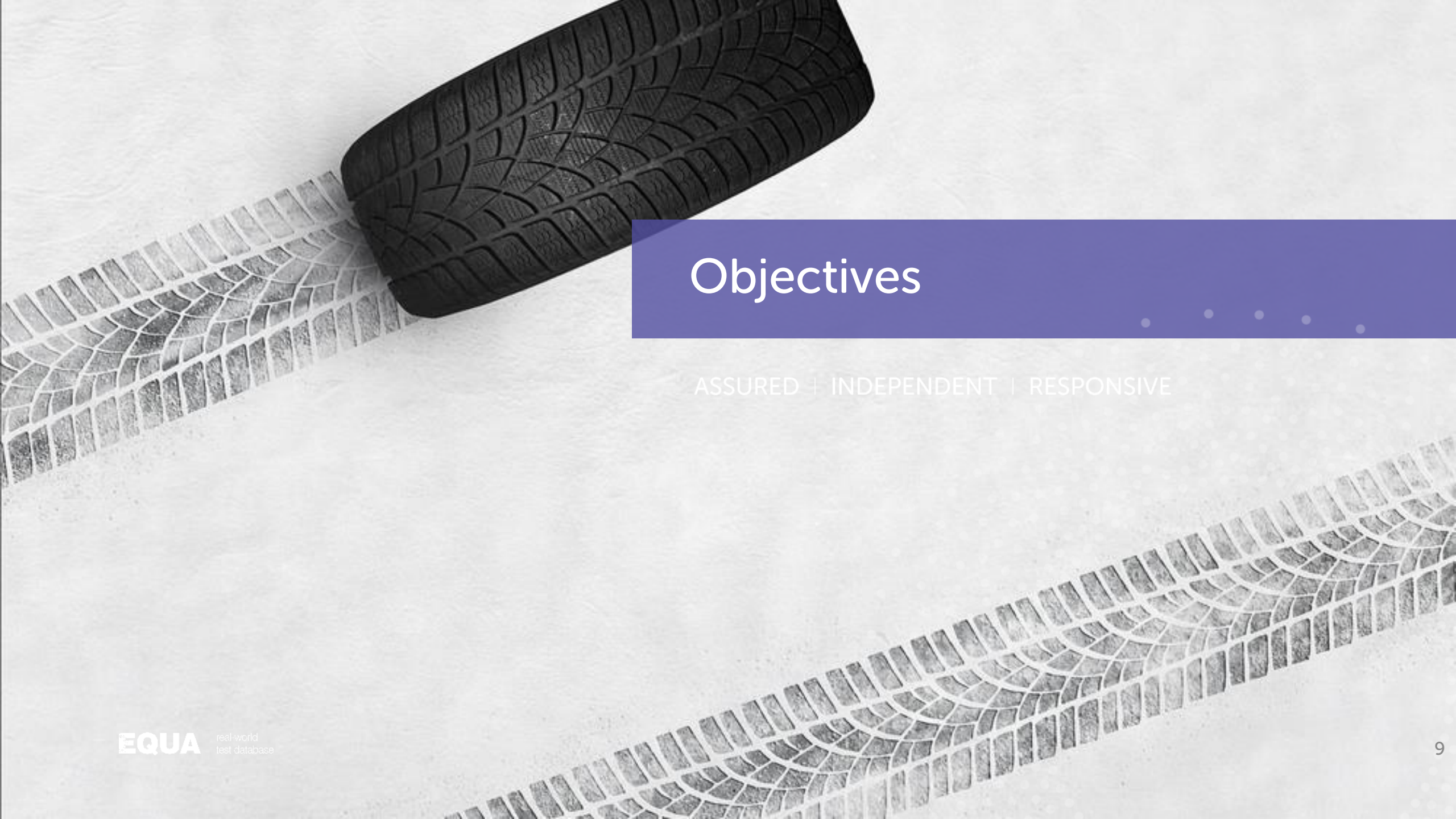


Source: Emissions Analytics 2024

SCAQMD support

- 600 PM10 filter samples from MATES VI monitoring stations from January 2025
- ICP-MS test results from its laboratories
- VOC, SVOC and carbonyl measurements
- Preliminary CMAQ model output data under MATES VI
- EMFAC emissions factors, SCAG vehicle activity data, vehicle emissions data
- Acetate filters for sampling of hexavalent chromium
- Data portal for data transfer

Source: Emissions Analytics 2024



Objectives

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Objective 1

- Database of substances that are in brake and tire emissions
- Delineation of brake from tire substances
- Compilation of compounds with OEHHA inhalation factors
- Identification of compounds without OEHHA risk factors, for potential further research outside of the scope of this project

Source: Emissions Analytics 2024

Objective 2

- Measurement data on concentrations of brake and tire emissions at sampling locations across South Coast Air Basin and Coachella Valley
- Focus on substances with OEHHA cancer potency factors and reference exposures levels
- Gather data with temporal resolution

Source: Emissions Analytics 2024

Objective 3

- Estimate of ambient concentrations attributable to brake and tire emissions from on-road vehicles
- 2 km grid spatial resolution
- Leverage existing work within MATES VI
- Coordination of modeling techniques with SCAQMD
- Cancer and non-cancer potential exposure risks
- Primary and resuspended brake and tire emissions
- Distinguishing brakes and tires from other emissions sources
- Fleet, traffic and driving dependencies

Source: Emissions Analytics 2024

Objective 4

- Reduction of uncertainties for brake and tire concentrations
- Compared to previous work

Source: Emissions Analytics 2024

Tasks

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Tasks (1)

#	Task
1	Present technical proposal to TAG; report on organic analysis methodology
2	Literature review of brake and tire emissions – known chemicals, OEHHA factors, build database
3	Write Project Plan – data quality, uncertainty estimation
4	Prepare and train for taking ambient measurements
5	Analysis of air samples – untargeted analysis

Source: Emissions Analytics 2024

Tasks (2)

#	Task
6	Compile brake wear compound database – sampling, analysis, fingerprinting, gas and PM analysis
7	Calculate brake and tire concentrations – using fingerprinting, Monte Carlo uncertainty estimation
8	Modeling and emissions development – CMAQ, AERMOD, RLINE – inventory, simulation, validation
9	Prepare draft report and data transfer
10	Present technical report and study publication – seminar, presentation, peer-review, data transfer
11	Licence databases for future use

Source: Emissions Analytics 2024

Task 2

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Literature review

Human health effects

Tyre Wear Particles (TWPs) are respirable and will deposit in the lower airway, possibly exacerbating lung cancer and COPD risk.

TWPs tend to induce a negative cellular response, with inflammation increasing with dosage.

More research is required to distinguish the health impacts of TWPs from other Non-Exhaust Emissions.

The health effects of a particle are highly dependent on its physicochemical characteristics[1] and in this domain, Tyre Wear Particles (TWPs) are no different. It is well known that exposure to PM2.5, the size fraction of PM defined as respirable, can reach the lower airway. PM2.5 exacerbates asthma and chronic obstructive pulmonary disease (COPD), as well as causing death through lung cancer and other cardiovascular diseases[2]. These problems are exacerbated by the presence of Ultrafine particles (UFPs) where dp <100 nm a major component of TWPs are particularly worrisome as they reach and deposit efficiently in the alveolar region and cross cellular membranes[3].

There are few epidemiological studies, which are the golden standard of toxicological research on the health effects of TWPs, our literature search for these studies led to few results and it is worth noting that these studies can't differentiate effectively between all types of Non-Exhaust Emissions (NEEs) and most

References

1. Baensch-Baltruschat, B., Kocher, B., Stock, F. & Reifferscheid, G. *Tyre and road wear particles (TRWP) – A review of generation, properties, emissions, human health risk, ecotoxicity, and fate in the environment.* Science of the Total Environment vol. 733 137823 (2020).

Source: Emissions Analytics 2024

Compounds of interest

- 15,916 unique compounds so far identified from tires
- Six notable compounds of potential concern…

Compound	Formula	Uses	Chronic effects (non-cancer)	Cancer risk
Aniline	$C_6H_5NH_2$	Chemical intermediate; solvent	Cyanosis; irritant to eyes, skin, upper respiratory	EPA probably carcinogen
Diphenylamine	$C_{12}H_{11}N$	Antioxidant	Skin, eye irritant; kidney, bladder, liver damage	Not likely
Ethylbenzene	C_8H_{10}	Styrene intermediate; solvent	Acute respiratory; eye irritation; dizziness	n/a
Naphthalene	$C_{10}H_8$	Intermediate in plasticisers, resins	Cataracts and retinal damage; respiratory inflammation	EPA possible carcinogen
Phenol	C_6H_6O	Intermediate in phenolic resins	Weight loss; diarrhoea; stomach irritation; liver effects	n/a
Styrene	C_8H_8	Intermediate in plastics, resins	Effects on central nervous system	Possible link to leukaemia

Task 5

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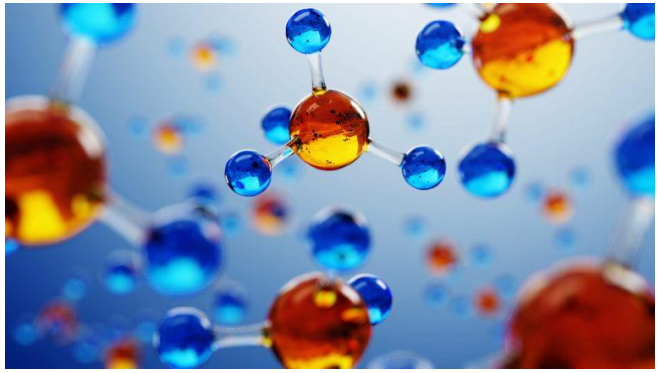
Untargeted approach

Pyr-GCxGC-TOF-MS

Breakdown products



Potential toxicity

TD-GCxGC-TOF-MS

Reaction products

Source: Emissions Analytics 2024

Chemical fingerprinting

- Two-dimensional gas chromatography with mass spectrometry
- INSIGHT flow modulator from SepSolve Analytical for separation
- BENCH-TOF time-of flight mass spectrometer
- Multi-stage pyrolysis method

Source: Emissions Analytics 2024

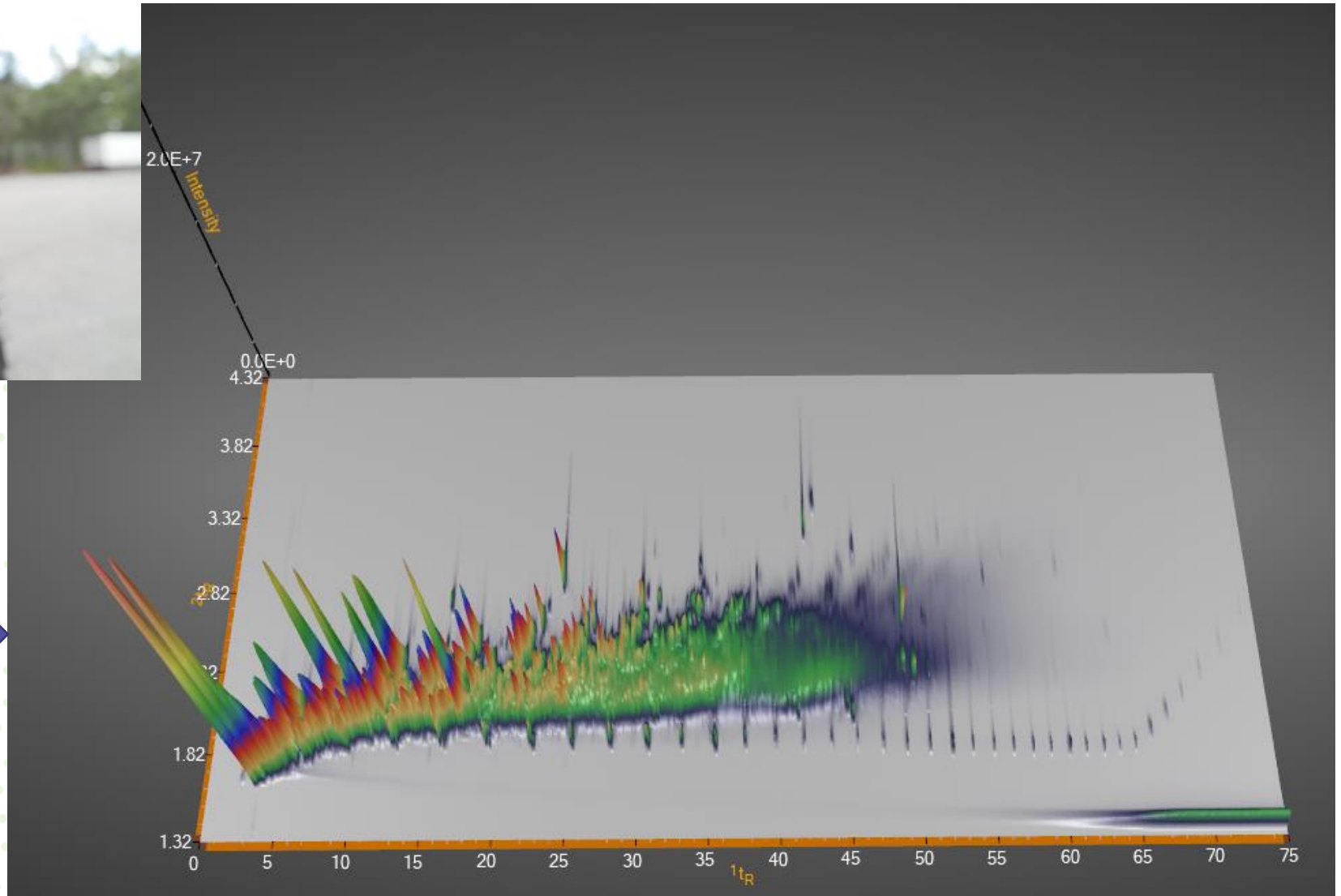
Method development

- Objective to determine all compounds in tire
- Quantification of measurement uncertainty – National Physical Laboratory, UK
- Required development of specialist spectral library
- Peer reviewed

➢ Not yet published, but report available on request

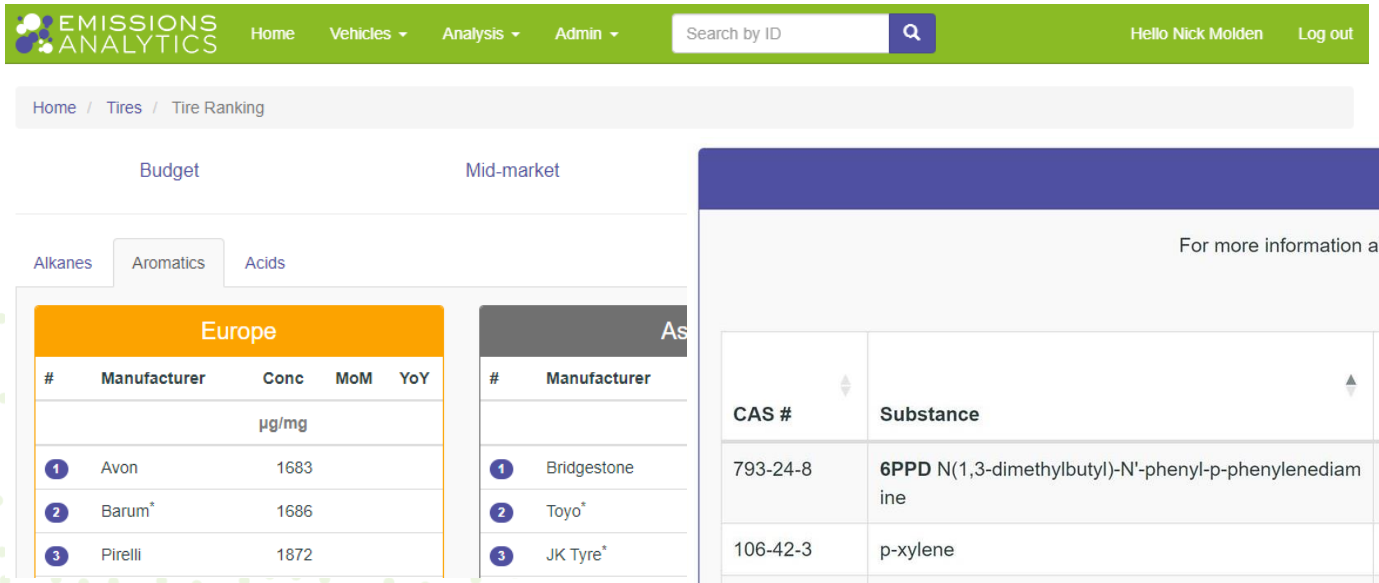
Source: Emissions Analytics 2024

Two-dimensional pyrolysis chromatogram



BTAS brake and tyres analysis system

Tire chemical fingerprint database



CalSAFER

For more information about this target list, visit https://calsafer.dtsc.ca.gov.

Search:

CAS #	Substance	Formula	Functional Group	Tires found # (% of tyres)	Average concentration µg/mg	Maximum concentration µg/mg
793-24-8	**6PPD** N(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine	$C_{18}H_{24}N_2$	Aromatics	281 (100.0%)	0.814	3.832
106-42-3	p-xylene	C_8H_{10}	Aromatics	274 (97.5%)	9.323	31.148
108-88-3	Toluene	C_7H_8	Aromatics	267 (95.0%)	7.992	42.333
122-39-4	Diphenylamine	$C_{12}H_{11}N$	Aromatics	230 (81.9%)	0.088	0.758
71-43-2	Benzene	C_6H_6	Aromatics	226 (80.4%)	2.919	12.840
100-40-3	**4-VCH** 4-Vinylcyclohexene	C_8H_{12}	Aromatics	221 (78.6%)	3.355	23.166
129-00-0	Pyrene	$C_{16}H_{10}$	Aromatics	215 (76.5%)	0.123	0.661
106-87-6	4-Vinyl-1-cyclohexene diepoxide	$C_8H_{12}O_2$	Aromatics	213 (75.8%)	1.666	16.727

Source: Emissions Analytics 2024

Task 6

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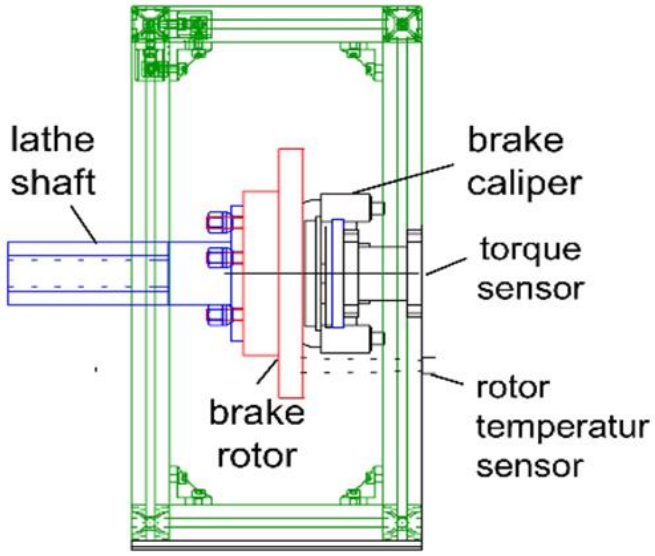
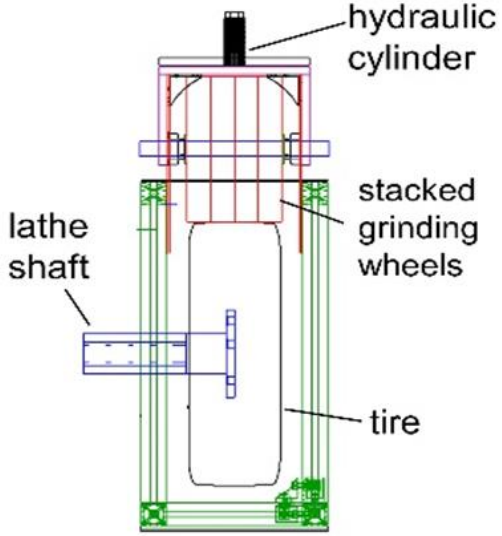
Brake wear compound database

- Test range of market brake pads on laboratory dynamometer at UC Irvine
- ICP-MS analysis to calculate metal concentrations of each





Source: Emissions Analytics 2024

Task 7

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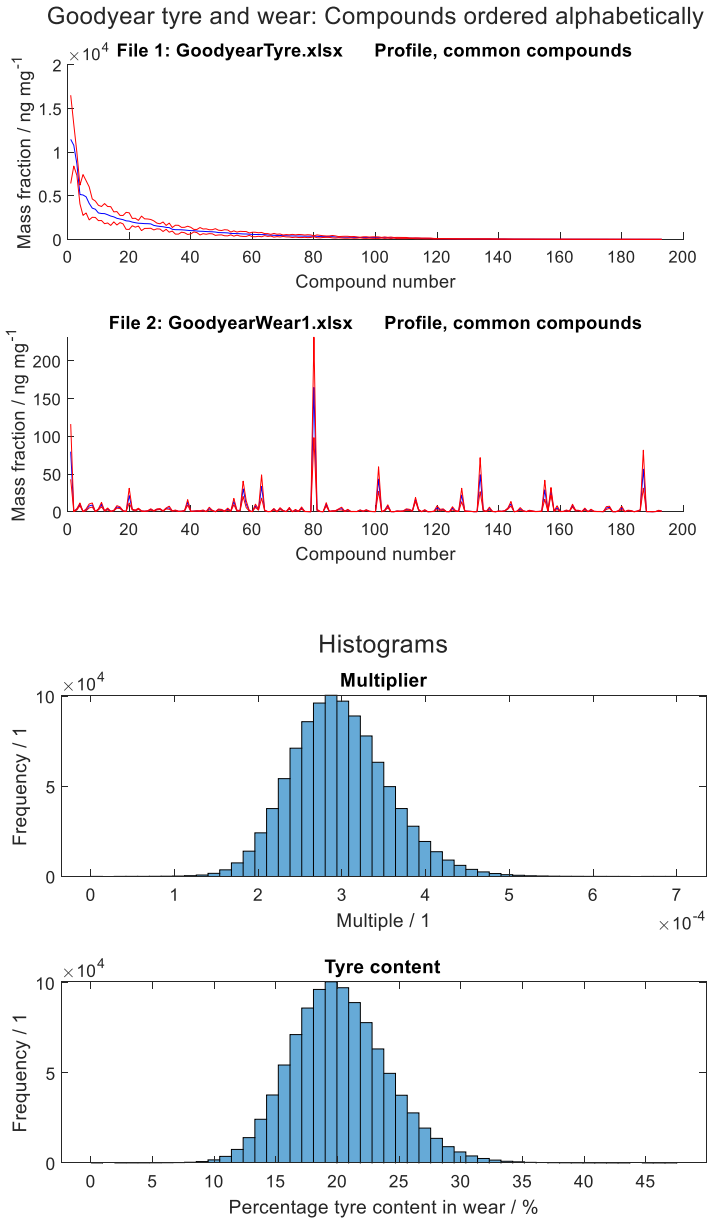
Calculating concentrations

- Subject air samples to same Pyr-GCxGC-TOF-MS test as original tires; ICP-MS for brakes
- Identifying multiple relevant compounds to made up fingerprint
- Develop “Californian tire and brake pad”
- Algorithm to calculate proportion of tire or brake material in the sample
- Using Monte Carlo method to estimate uncertainties



Source: Emissions Analytics 2024

Task 8

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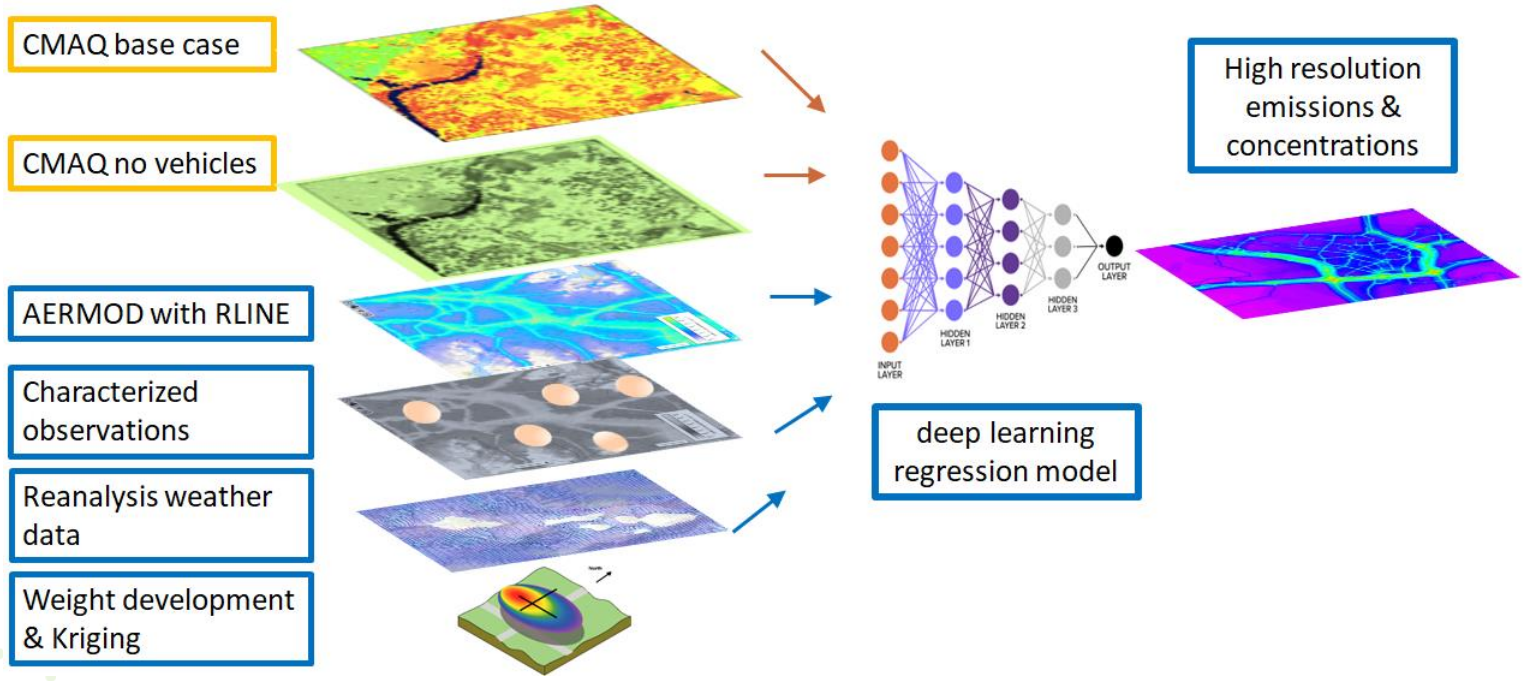
Modeling and emissions development

- Collaborative work between project team (blue) and AQMD (orange)



Source: Emissions Analytics 2024

Summary

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Summary

- Extensive, innovative programme to measure and model the prevalence and effect of brake and tire emissions
- Significant development to the MATES program
- Four-year programme, with most measurements taken in 2025
- Fit with existing modelling of SCAQMD
- Transparency of methodology to allow future work

BTAS brake and tyres analysis system

Thank you.

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3. Interactive Data Visualizations in MATES VI

Nico Schulte, PhD
Program Supervisor
Planning, Rule Development
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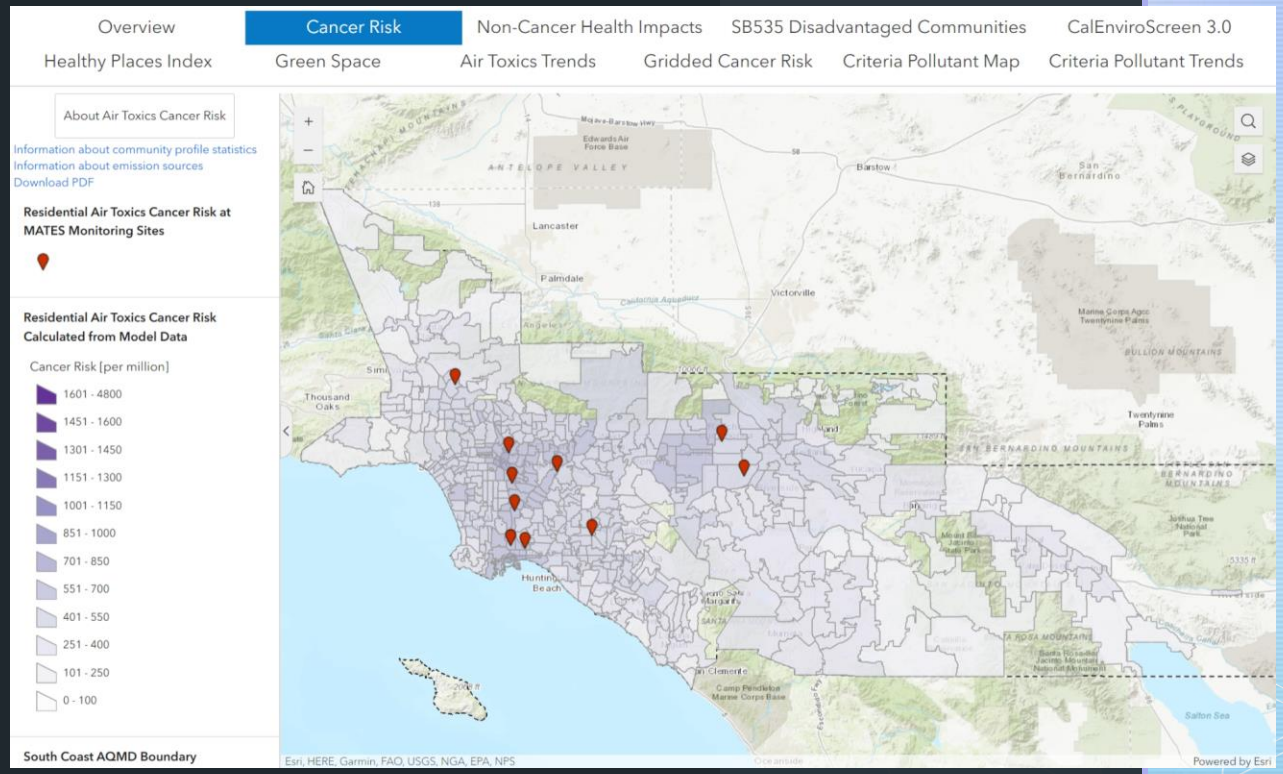
Christopher Lim, PhD
Air Quality Specialist
Advanced Monitoring
Technologies

MATES VI Technical
Advisory Committee
Mtg. #4

September 27, 2024

Outline

- Goals
- Demo of data visualization tools for MATES V
- MATES VI data visualization preliminary plan
- Questions and feedback

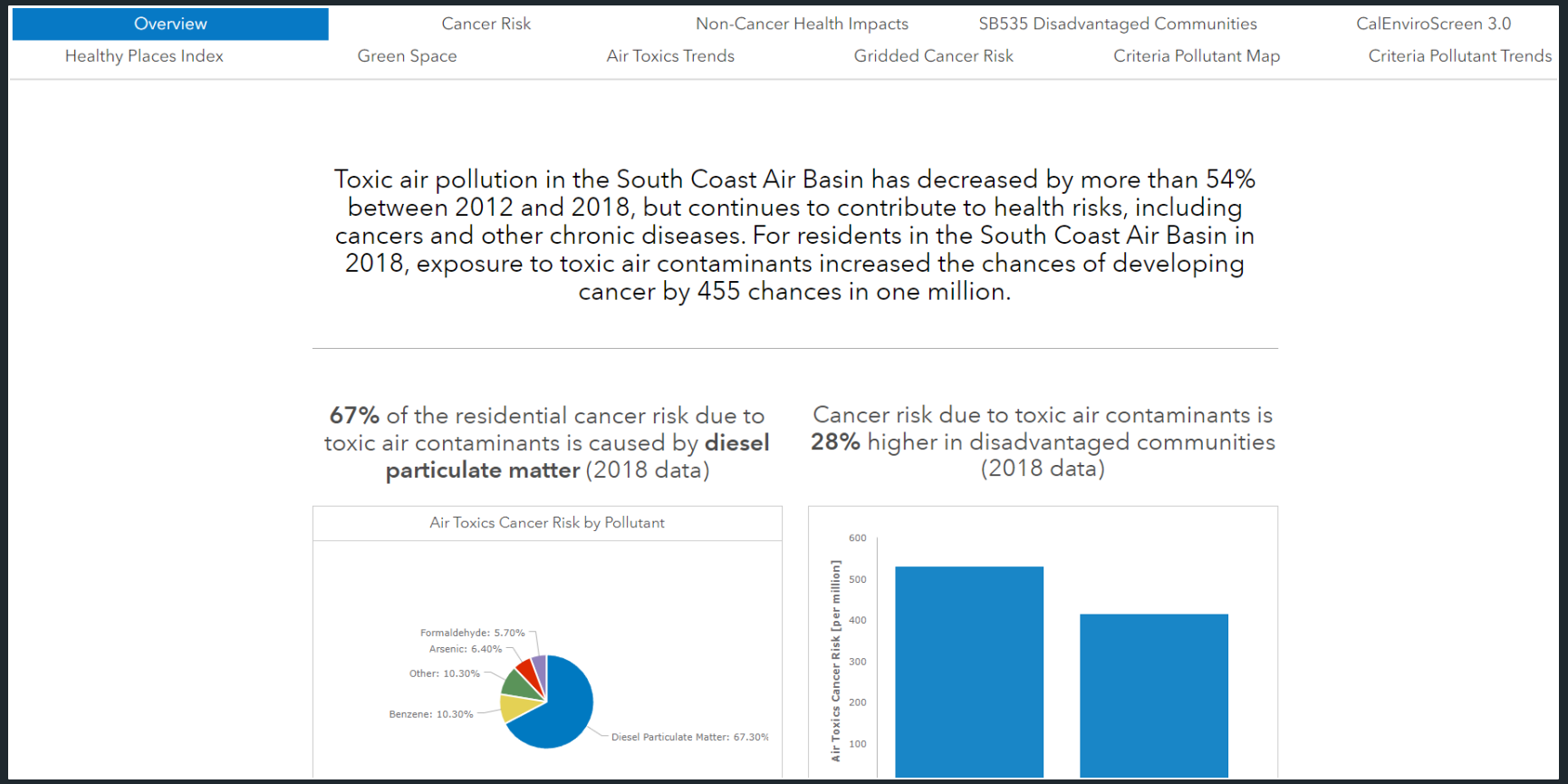


Goals

Design a data visualization tool that

- Present the major elements of MATES VI for a general public audience
- Answer common questions about air toxics and criteria air pollution:
  - What is air toxics health risk at a selected location?
  - How does air toxics health risk compare with risk in other locations?
  - What other pollutants are of concern (criteria pollutants) and how do those levels compare with other locations?
  - How have air pollution levels and air toxics health risk changed over time?
- Provide high-level summary and more detail by interacting with the page
- Provide a visualization, data export, and download of all MATES air monitoring data

Live Demo of MATES V Risk Data Visualization Tool

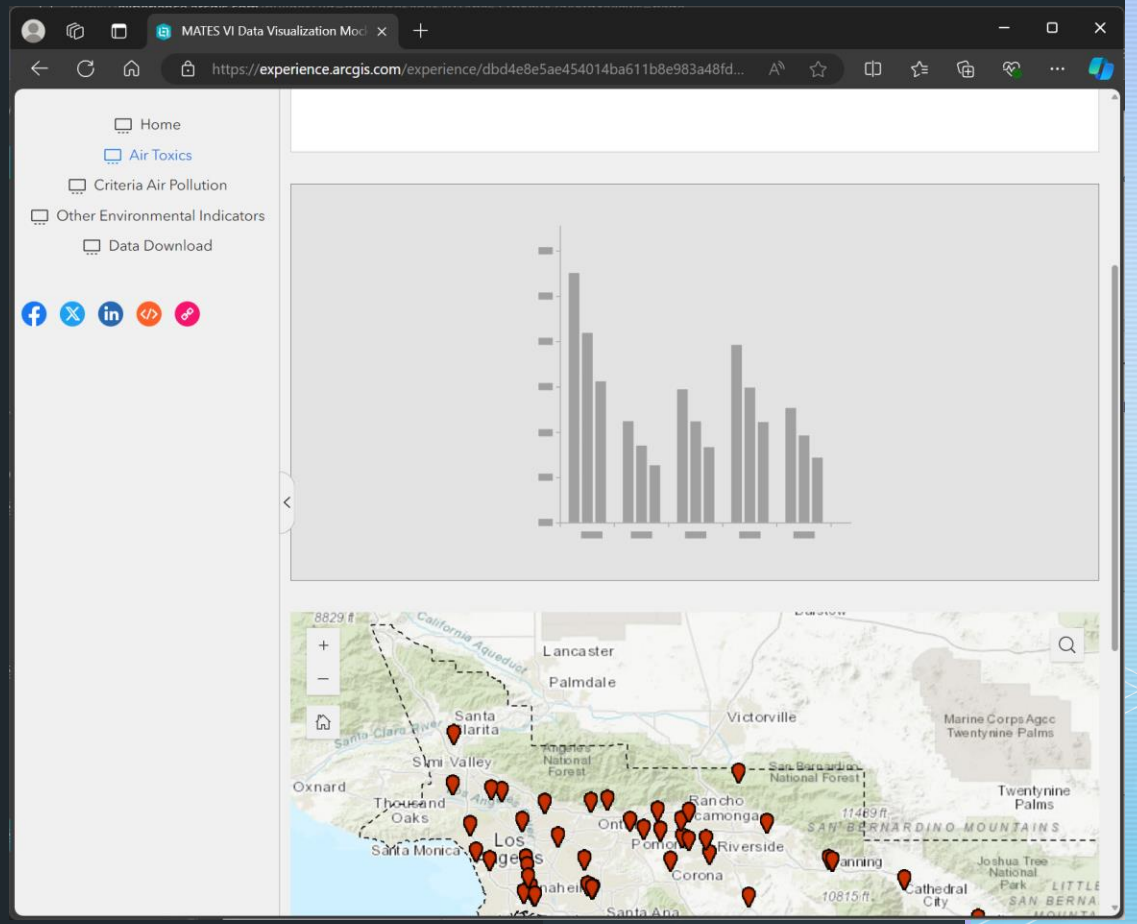


[MATES V Risk Data Visualization Tool]

MATES VI Data Visualization Overall Layout (preliminary plan)

- Page Layout (tabs)
  - Home Page
  - Air toxics
  - Criteria air pollution
  - Other environmental indicators
  - Data download
- User can scroll in each page (tab) to view all the data in the page
- Simplify and clarify presentation
  - Website enhanced for mobile devices (new since MATES V)
  - Use of map layers and enhanced GUI features to select and visualize data

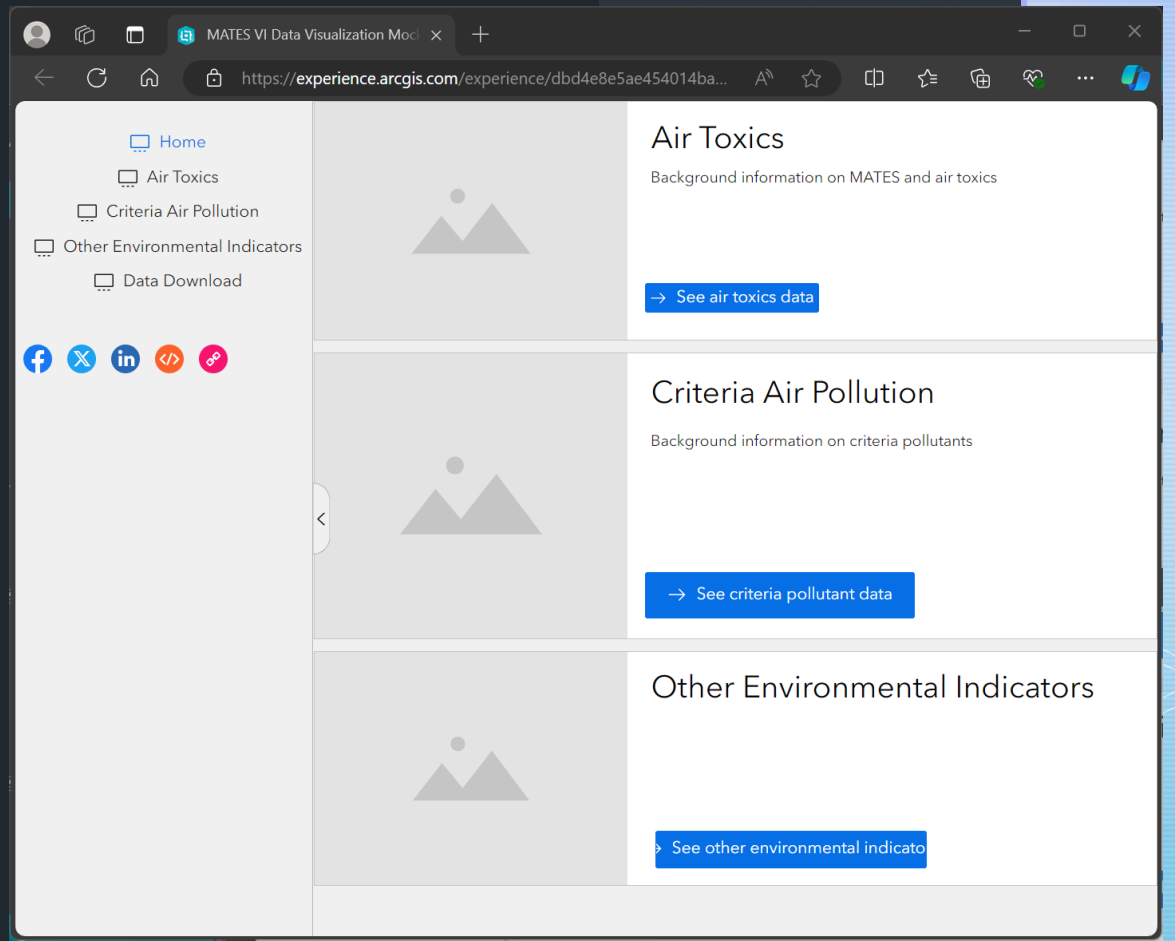
Data visualization website layout (preliminary)



Home Page (preliminary plan)

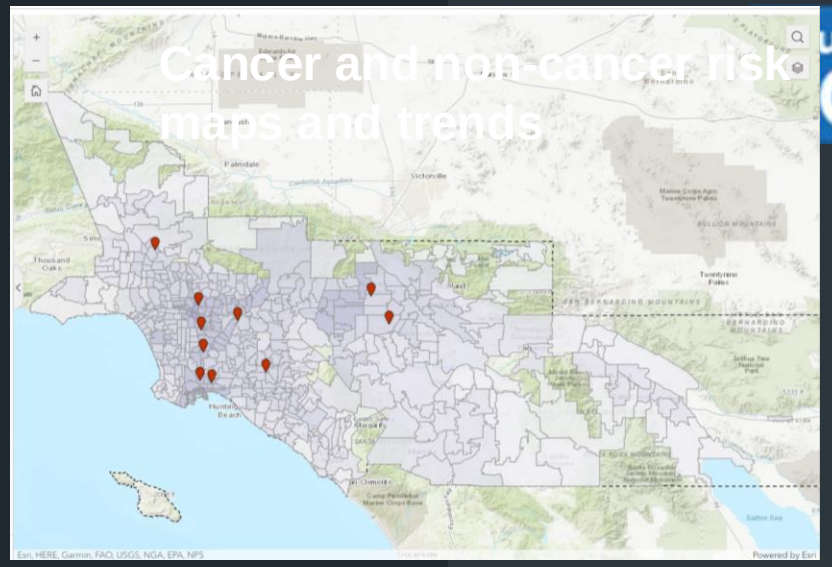
- Background information on criteria and air toxic pollutants
- Purpose of MATES program
- Directs user to other pages based within the application

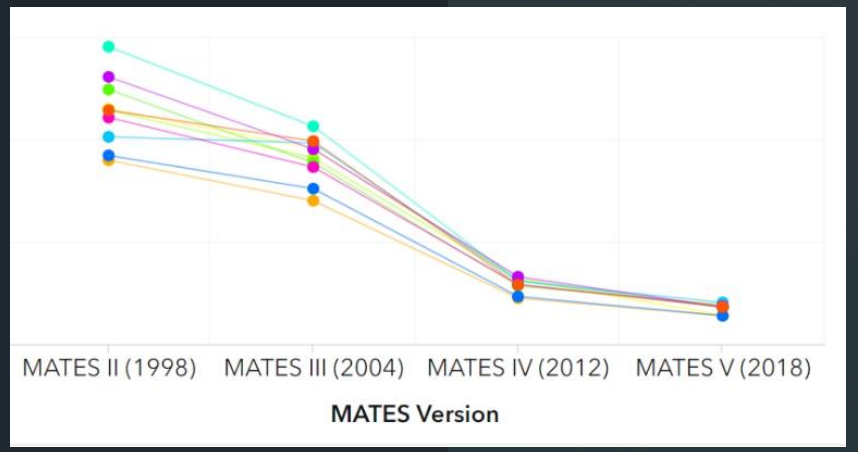
Home page mockup (preliminary)



Air Toxics (preliminary plan)

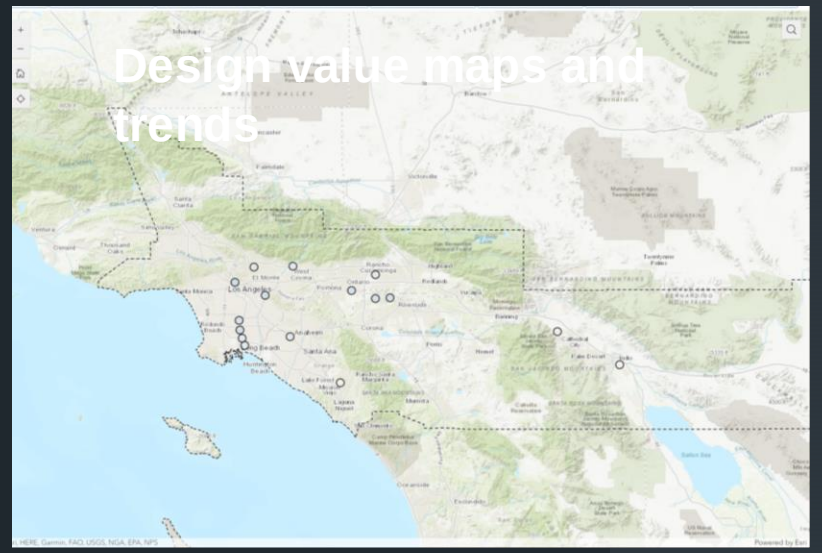
- Summary of major elements of MATES VI
  - History and purpose of MATES program
  - Monitoring and modeling methods
  - Major findings
  - Conclusions
- Cancer and non-cancer health risks maps and trends through MATES VI

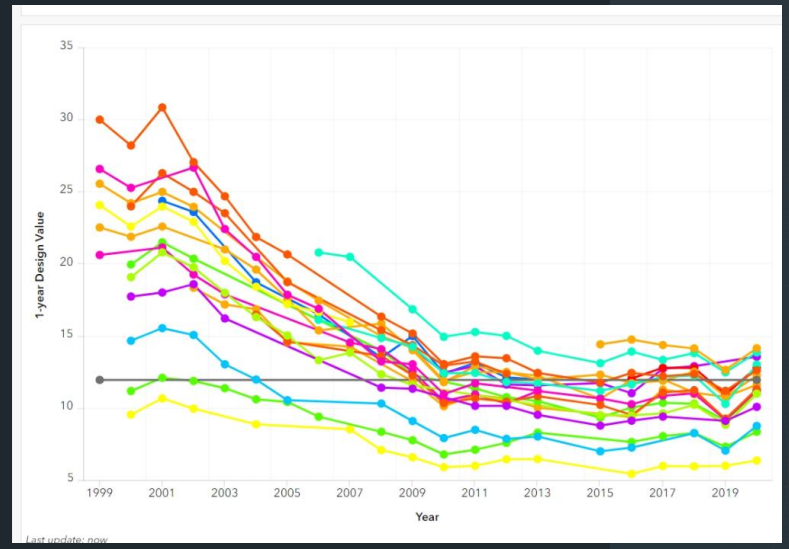




Criteria Air Pollution (preliminary plan)

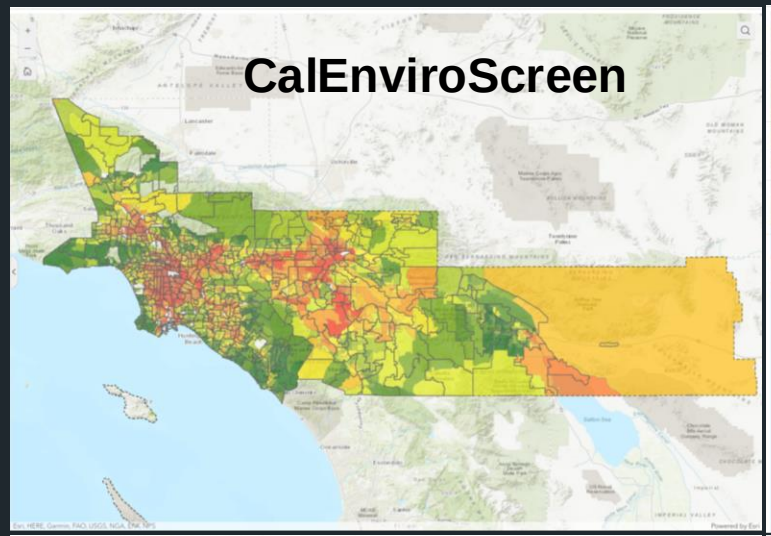
- Annual design value maps for PM2.5, PM10, O3, NO2, CO, SO2
- Design value trends since 1999

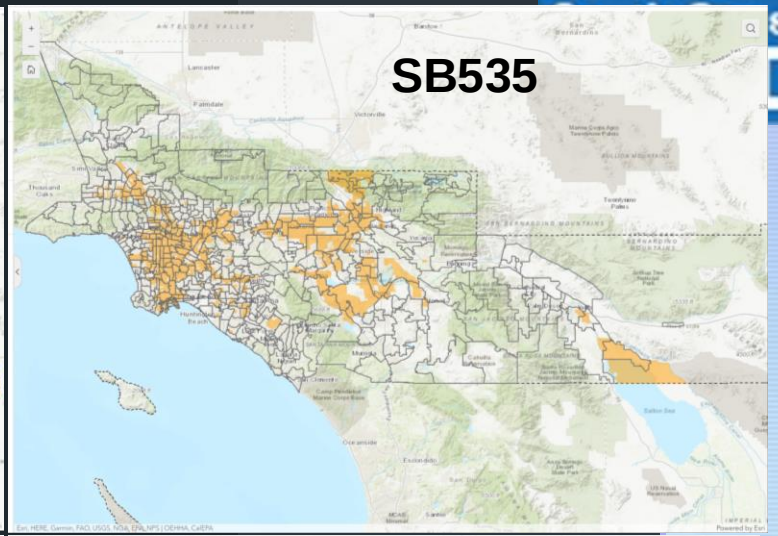


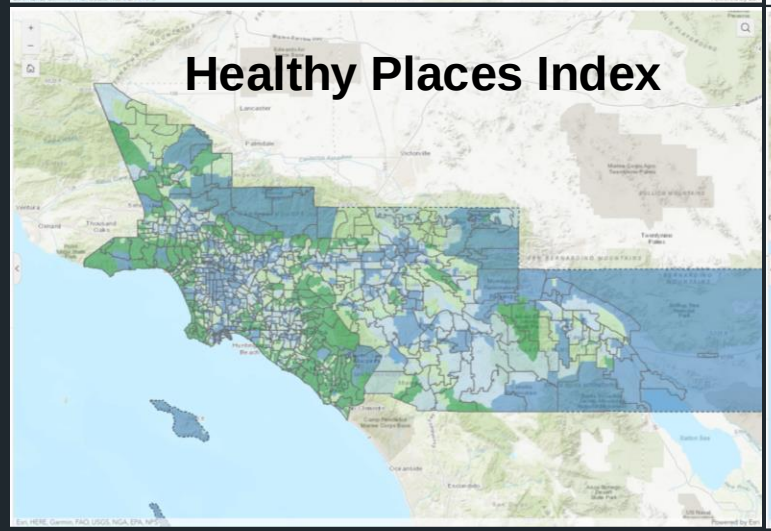


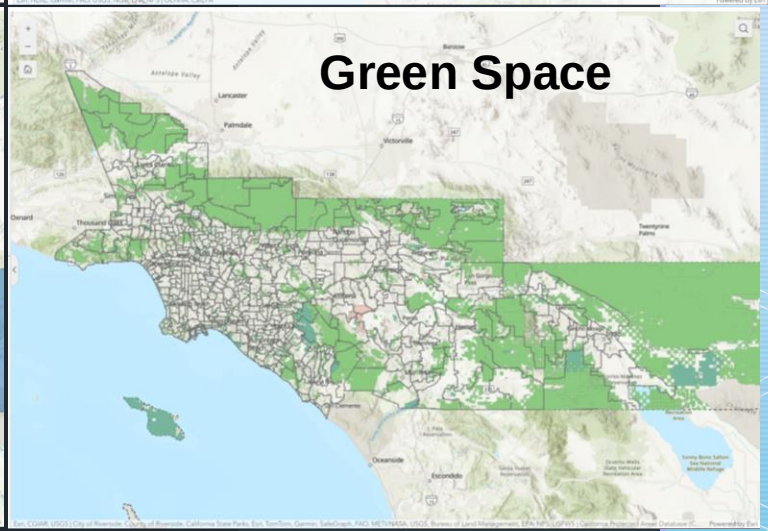
Other Environmental Indicators (preliminary plan)

- Plan to include this data:
  - SB535 areas
  - CalEnviroScreen 4.0
  - Healthy Places Index
  - Green Space
- Seeking feedback on data to include (or remove)





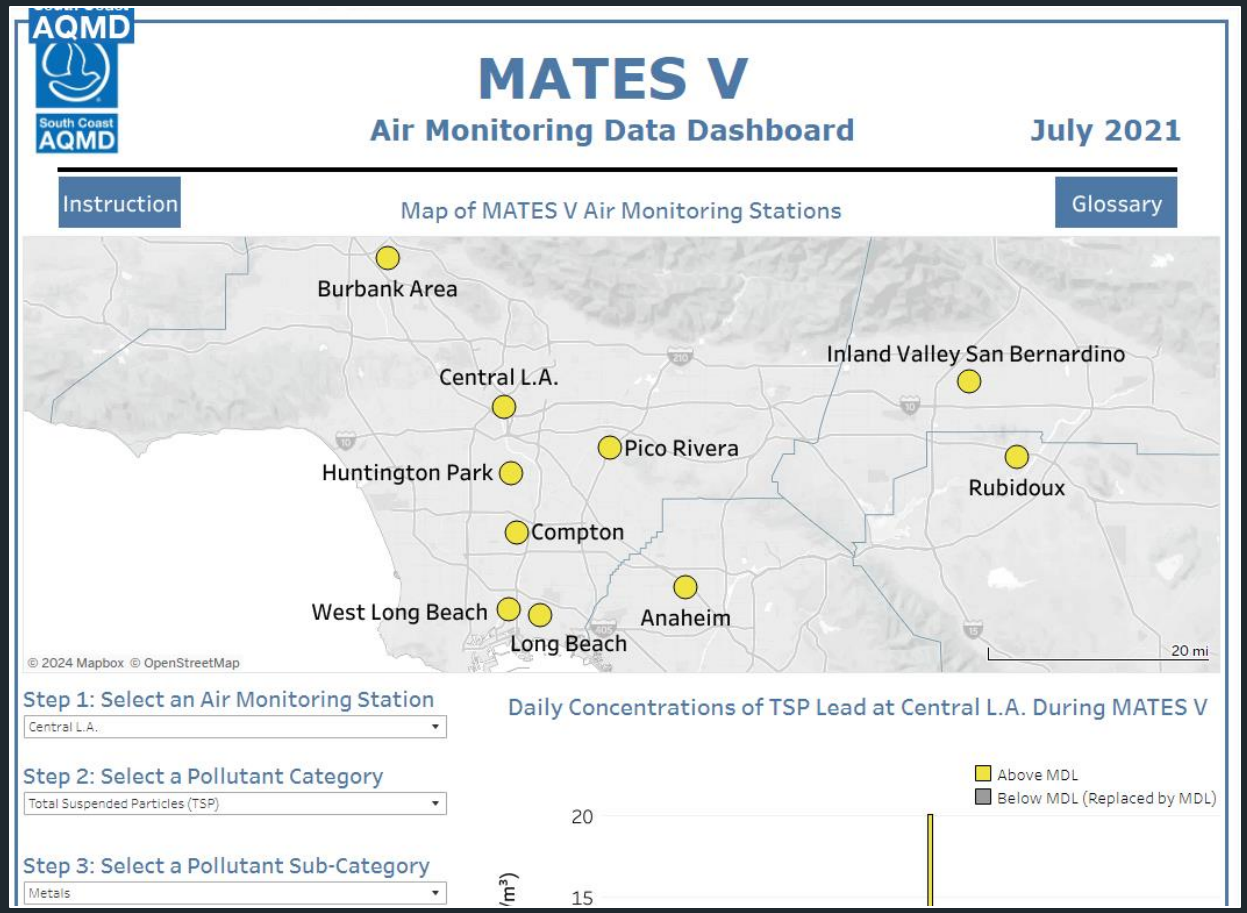




Other Improvements (preliminary plan)

- Reduce loading times by optimizing data that is downloaded
- Add data export/downloads for researchers (shapefiles, geodatabase)
- Additional documentation to increase accessibility of the data
  - This will be useful for government agencies and community organizations

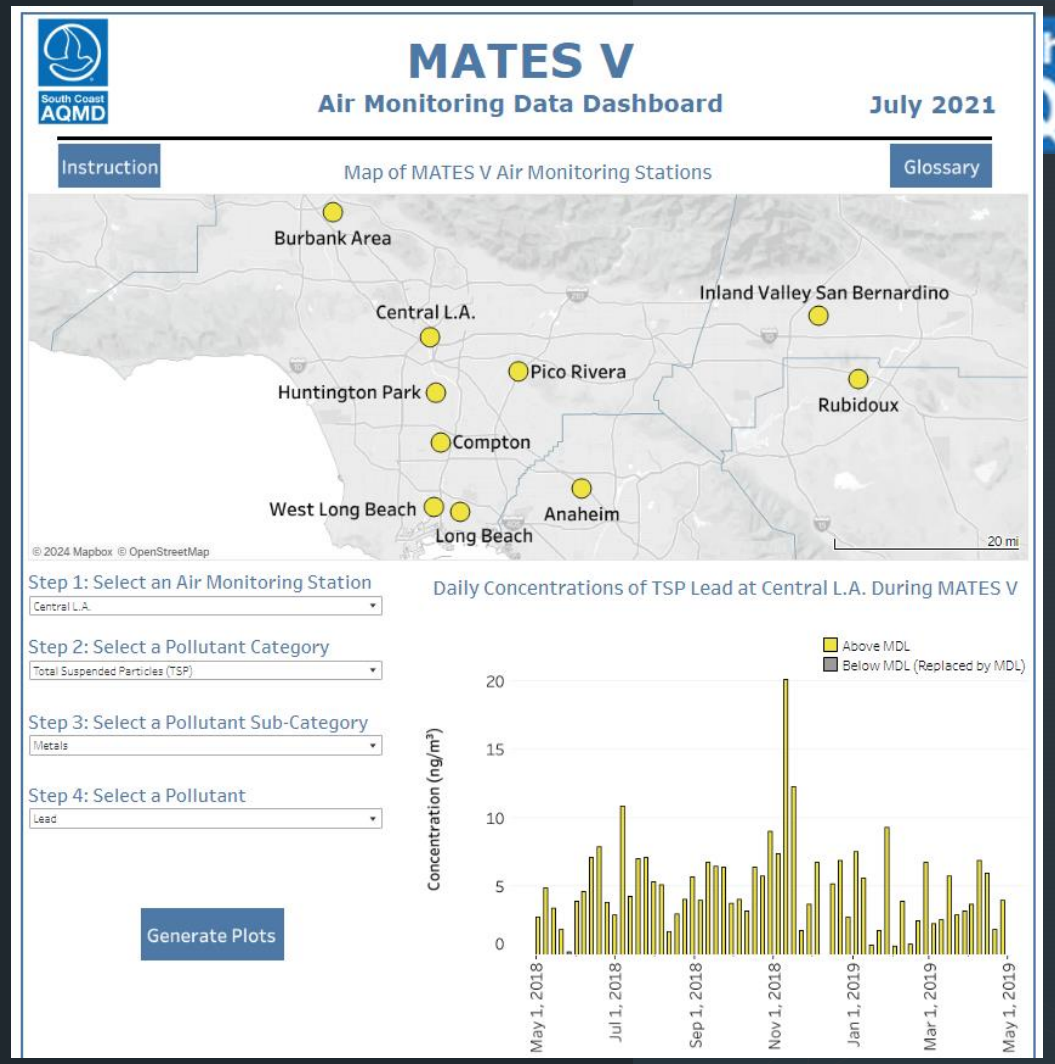
Live Demo of MATES V Air Monitoring Dashboard



[MATES V Air Monitoring Dashboard]

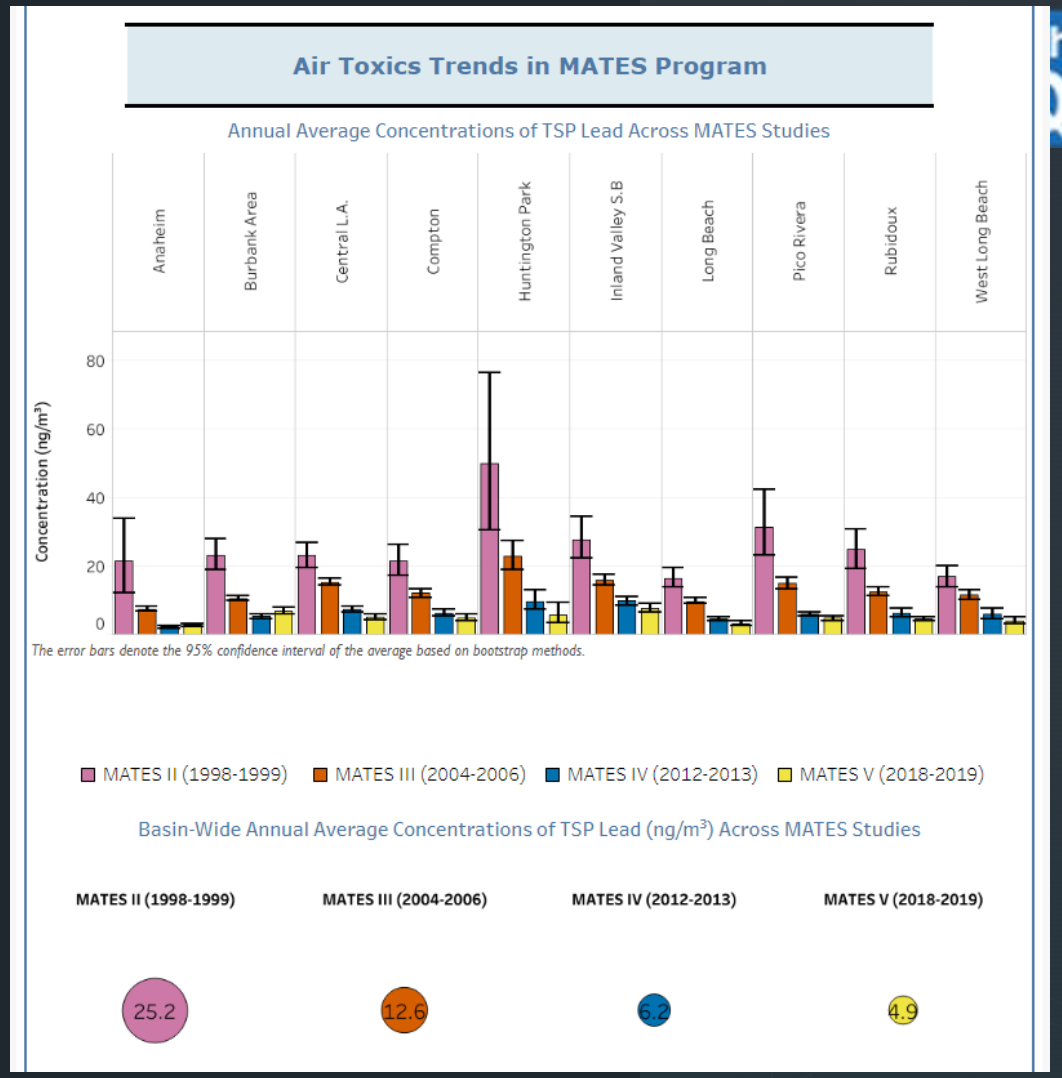
MATES VI Air Monitoring Dashboard

- Based on MATES V Air Monitoring Data Dashboard (time-integrated data)
- Contents
  - Time series
  - Weekday vs. weekend comparison
  - Average seasonal concentration
  - Trends across MATES program
- Will allow for data download
- Simply menu structure for data filters or allow user to search for pollutant



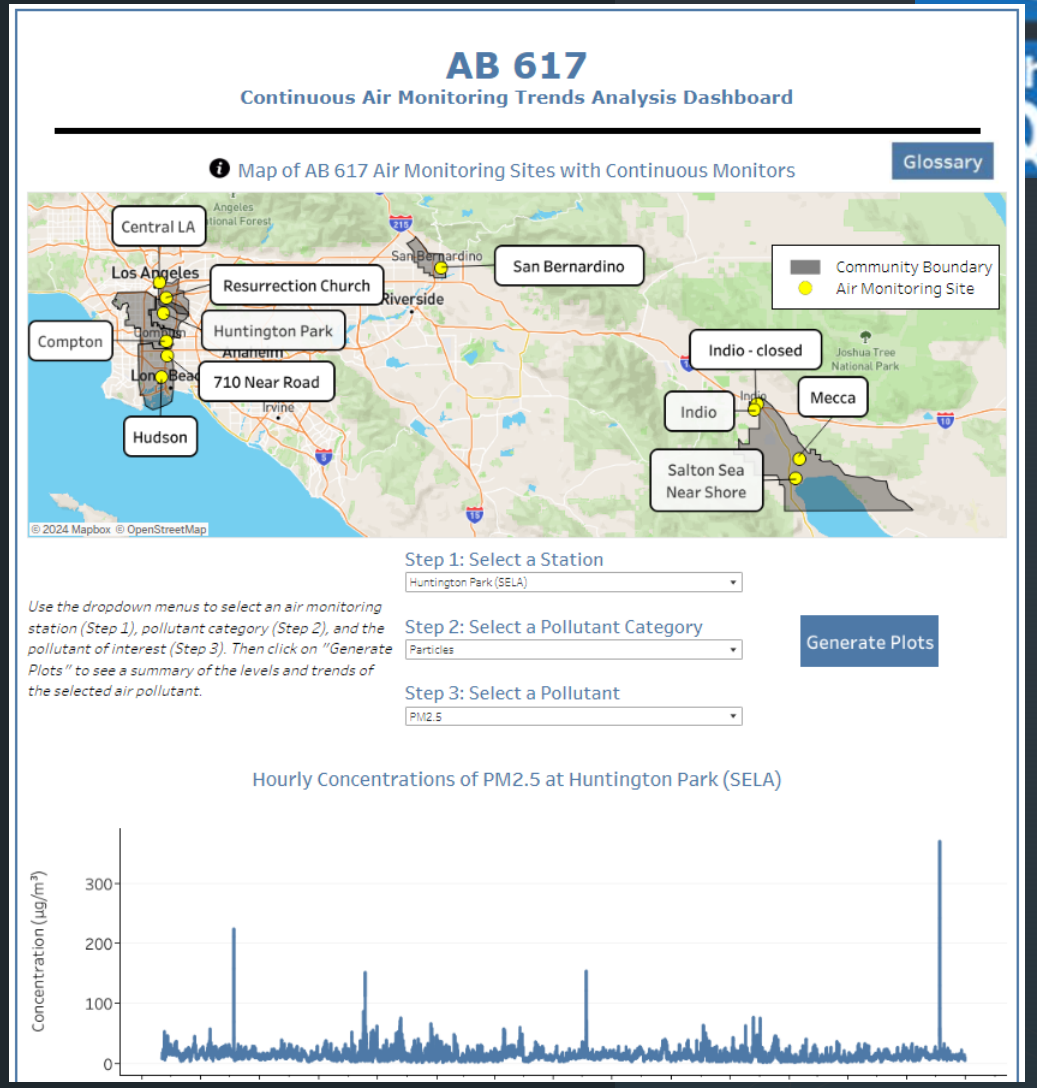
PM10 Speciation

- MATES VI will have more complete speciation of PM10 size fraction (previously TSP)
  - Two sites (Central LA and Riverside-Rubidoux) will continue TSP metals speciation
- Previous dashboard tracked trends in concentration across MATES studies
- Trends in previously measured TSP species at most sites will be discontinued



MATES VI Continuous Monitoring Data

- Integrate continuous data into MATES VI air monitoring dashboard
  - Separate dashboard link or integrate as a separate tab with time-integrated data
- Based on AB 617 Continuous Trends Analysis Dashboard
- Contents
  - Hourly time series
  - Average diurnal profile, day of week, and seasonal concentrations
  - Comparison across sites (histogram)
- Will allow for data download



[AB 617 Continuous Air Monitoring Dashboard (aqmd.gov)]

Questions for the TAG

- Other interactive display software that should be considered?
- Any modifications to our proposed MATES VI tools to make them more user friendly for the public?
- Suggestions for additional visualizations?
- Suggestions for providing information on how to use the tools?