SPATIAL DATA ANALYSIS TECHNICAL EXCHANGE WORKSHOP

Sponsored by:

U.S. EPA

at

Sheraton Imperial Hotel & Convention Center

Research Triangle Park, North Carolina

December 3-5, 2001

Network Design – Mixed Monitoring Technologies presented by:

Steven M. Bortnick

Battelle

SDAS

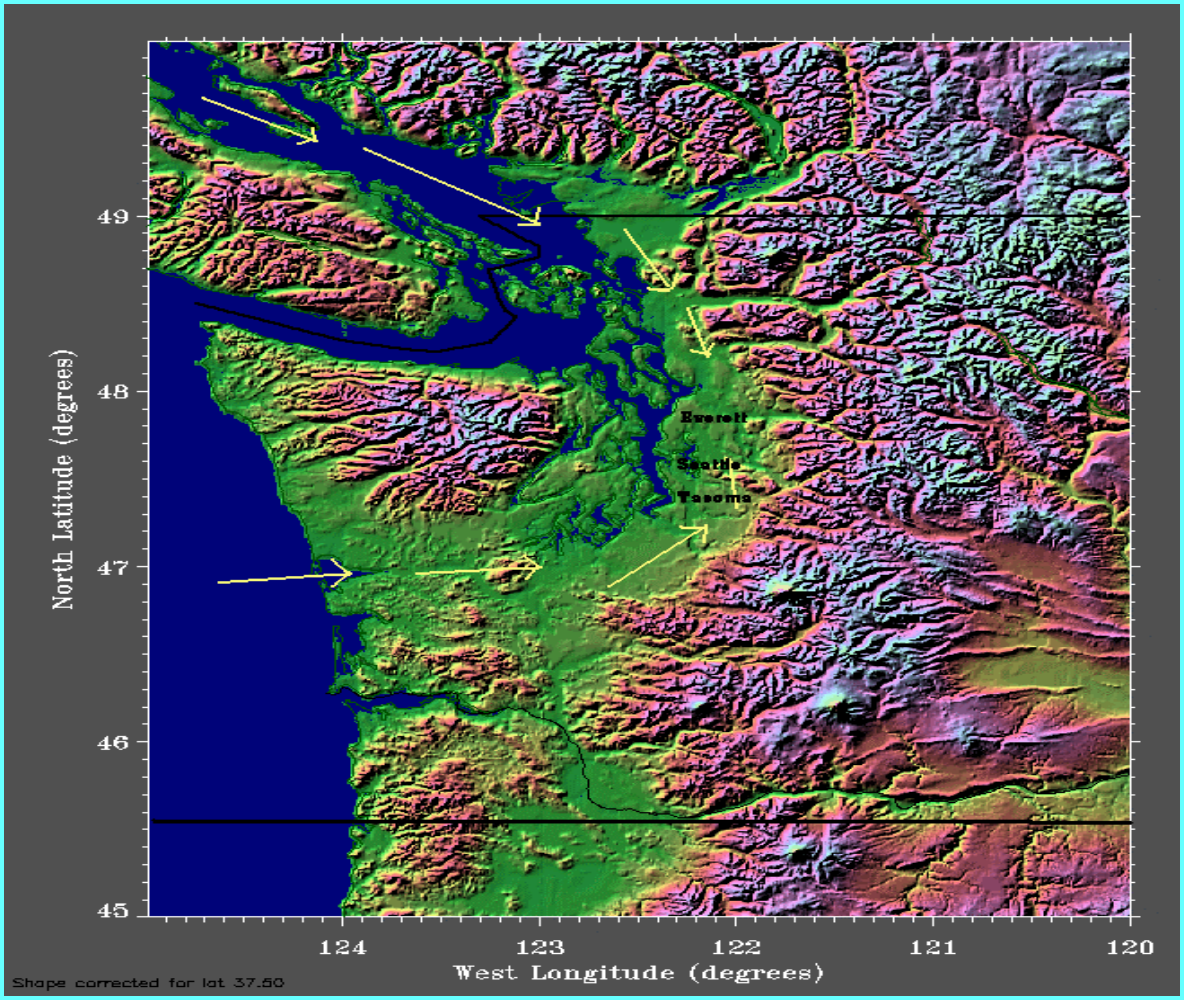
Acknowledgments

Gardar Johannesson, Battelle
David Wendt, Battelle
Shannon Stetzer, Battelle
Shelly Eberly, U.S. EPA
Bill Cox, U.S. EPA

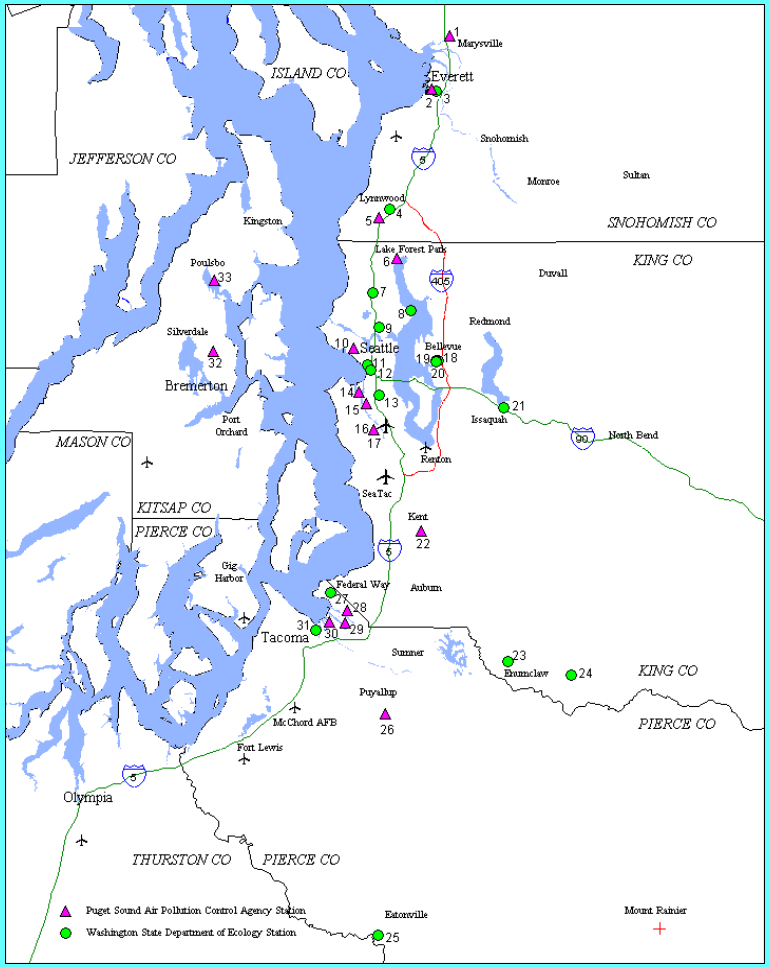
Scenario

- $PM_{2.5}$ monitoring in Puget Sound
  - Federal Reference Method (FRM) monitors at 14+ sites
  - Continuous monitors
    - Tapered Element Oscillating Microbalance (TEOM) monitors at 6+ sites
    - Nephelometers at 8+ sites
    - Others
- In other words, “network” of mixed monitoring technologies

Puget Sound Picture

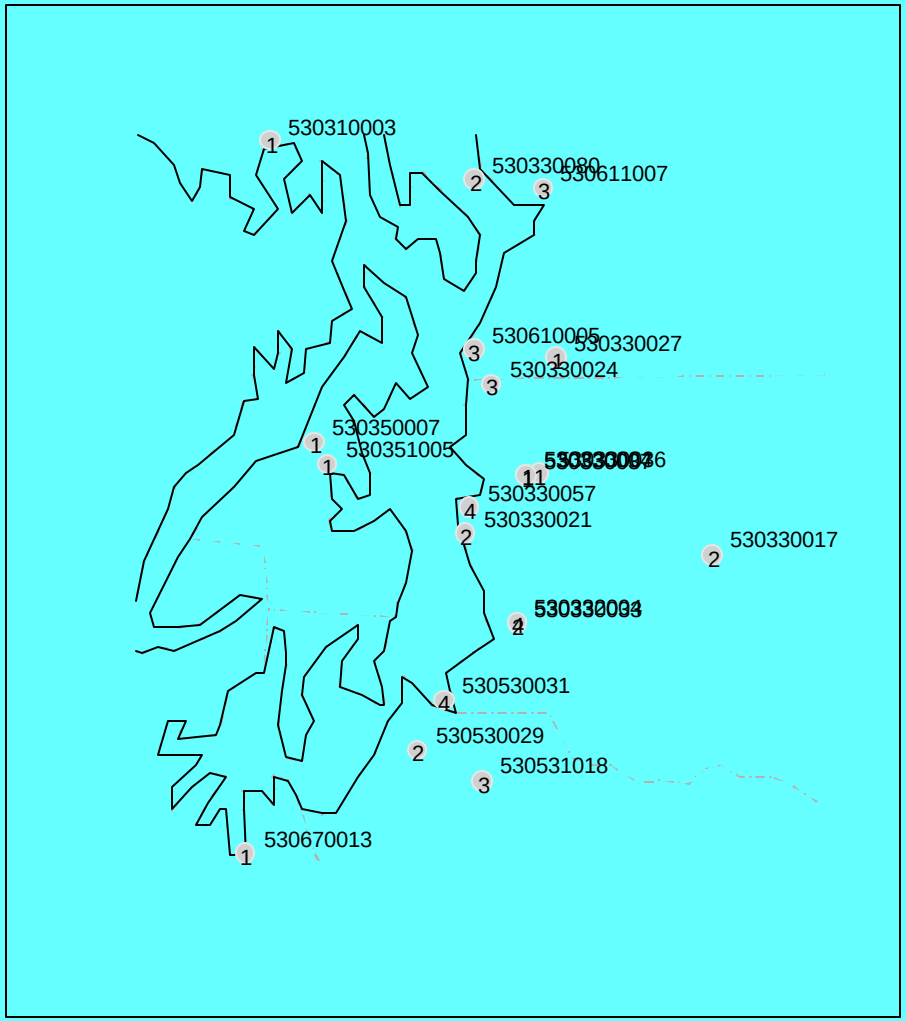


Puget Sound Picture (continued)



Puget Sound Air Monitoring Network

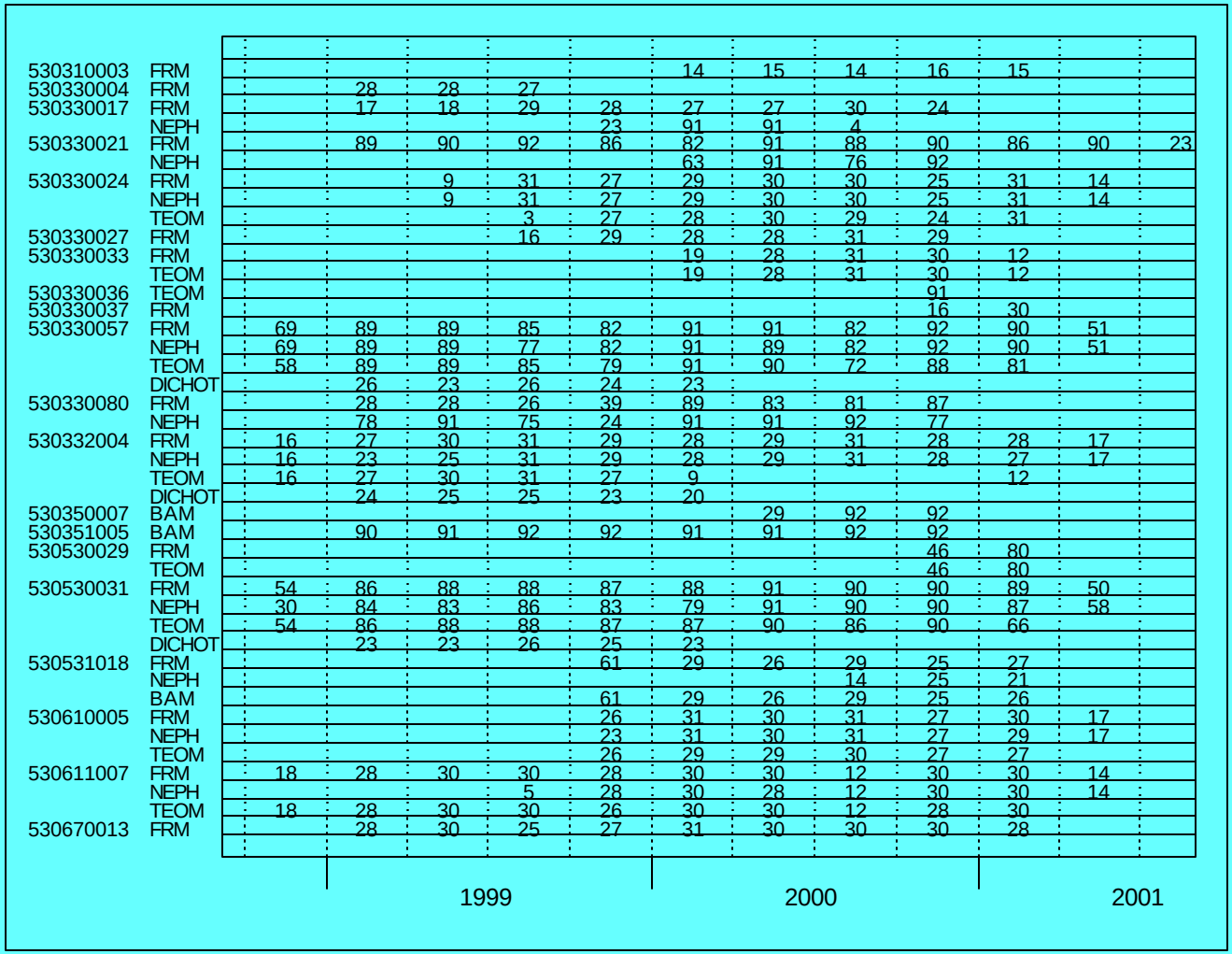
Data Summary Picture



Battelle

SDAS

Data Summary Picture (continued)



530310003	FRM						14	15	14	16	15			
530330004	FRM		28	28	27									
530330017	FRM		17	18	29	28	27	27	30	24				
	NEPH					23	91	91	4					
530330021	FRM		89	90	92	86	82	91	88	90	86	90	23	
	NEPH						63	91	76	92				
530330024	FRM			9	31	27	29	30	30	25	31	14		
	NEPH			9	31	27	29	30	30	25	31	14		
	TEOM				3	27	28	30	29	24	31			
530330027	FRM				16	29	28	28	31	29				
530330033	FRM						19	28	31	30	12			
	TEOM						19	28	31	30	12			
530330036	TEOM									91				
530330037	FRM									16	30			
530330057	FRM	69	89	89	85	82	91	91	82	92	90	51		
	NEPH	69	89	89	77	82	91	89	82	92	90	51		
	TEOM	58	89	89	85	79	91	90	72	88	81			
	DICHOT		26	23	26	24	23							
530330080	FRM		28	28	26	39	89	83	81	87				
	NEPH		78	91	75	24	91	91	92	77				
530332004	FRM	16	27	30	31	29	28	29	31	28	28	17		
	NEPH	16	23	25	31	29	28	29	31	28	27	17		
	TEOM	16	27	30	31	27	9				12			
	DICHOT		24	25	25	23	20							
530350007	BAM							29	92	92				
530351005	BAM		90	91	92	92	91	91	92	92				
530530029	FRM									46	80			
	TEOM									46	80			
530530031	FRM	54	86	88	88	87	88	91	90	90	89	50		
	NEPH	30	84	83	86	83	79	91	90	90	87	58		
	TEOM	54	86	88	88	87	87	90	86	90	66			
	DICHOT		23	23	26	25	23							
530531018	FRM					61	29	26	29	25	27			
	NEPH								14	25	21			
	BAM					61	29	26	29	25	26			
530610005	FRM					26	31	30	31	27	30	17		
	NEPH					23	31	30	31	27	29	17		
	TEOM					26	29	29	30	27	27			
530611007	FRM	18	28	30	30	28	30	30	12	30	30	14		
	NEPH				5	28	30	28	12	30	30	14		
	TEOM	18	28	30	30	26	30	30	12	28	30			
530670013	FRM		28	30	25	27	31	30	30	30	28			

1999 2000 2001

Battelle

SDAS

Data Summary Picture (continued)

	FRM	NEPH	TEOM
530310003	2.05		
530330017	1.57		
530330021	2.28	-0.92	
530330024	2.31	-1.06	2.27
530330027	2.04		
530330033	2.36		2.39
530330057	2.40	-1.12	2.49
530330080	2.06	-1.48	
530332004	2.32	-1.13	
530530031	2.37	-1.10	2.49
530531018	2.27		
530610005	2.18	-1.17	2.27
530611007	2.36	-1.00	2.28
530670013	2.03		

Goals

- Evaluate/understand “performance” of current network
  - Annual average time scale
  - Seasonal resolution of interest
  - Problem addressed from spatial perspective
- Consider alternative networks
  - With an eye toward continuous technologies
    - temporally resolved data
    - near real-time measurements
    - E.g., daily Air Quality Index (AQI) reporting, emergency control
  - Constrained *(or guided)* by regulations (CFR Part 58)
    - Treat FRMs as “gold standard” to which other methods are compared
    - Continuous methods may satisfy Class III equiv. ($\$_0$, $\$_1$, R^2, precision)

Conceptual Model

- Each monitor type has some associated measurement error (precision)
  - Not instrument-specific
  - Not site-specific
- FRMs are unbiased (or, our frame of reference is to view the true spatial process through the biased eyes of an FRM)
- Continuous monitoring may be biased
  - Linear on natural log scale
  - Specific to monitor type
  - ?? Not instrument-specific ??
  - ?? Not site-specific ??

Real World

- Co-located FRM/continuous data used in developing area-wide bias estimate for each continuous monitor type

- Issues
  - Uncertainty in bias parameter estimation
  - Appropriateness of spatially-homogenous bias assumption
  - Role for FRMs – dual:
    - Provide data on spatial process AND calibrate continuous monitors
    - Implies need for minimum of one co-located FRM in local “network”

Summary of Approach

- Develop spatial model for true annual process
- Account for uncertainties in mixed monitor type network (precision, bias, bias estimation)
- Consider Mean Square Prediction Error (MSPE)
  - Across grid of points covering Puget Sound
  - Summary statistics (average, maximum, etc.)
  - Assess current network performance
  - Compare alternative designs (e.g., fewer FRMs, more continuous)

Summary of Approach (continued)

- Highlights
  - Consistent with $PM_{2.5}$ monitoring perspective of Federal regulations
  - Incorporates uncertainty introduced by real-world treatment of data
  - Development is like “peeling back the layers of an onion”