Quantifying Particulate Matter Emissions from Wind Blown Dust Using Real-time Sand Flux Measurements

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Two Methods to Estimate PM-10 Emissions Due to Wind Blown Dust

- AP-42 method for Industrial Wind Erosion (Section 13.2.5)
- Dust ID method developed at Owens Lake

AP-42 PM-10 Emissions

$$e = k \sum_{i=1}^{N} P_i$$

e = PM-10 emission factor [g/m^2/yr]

k = 0.5 for PM-10

P_i = erosion potential corresponding to the i^{th} period

N = number of disturbances per year

$P_i = 58(u_i^* - u_t^*)^2 + 25(u_i^* - u_t^*)$ [g/m^2/period]

$P_i = 0$, for $u_i^* \leq u_t^*$

u_i^* = Friction velocity for the fastest mile [m/s]

u_t^* = Threshold friction velocity

Dust ID Method

based on Shao, et al., 1993

$$F_a = g \; m_d \left(\frac{g}{Y} \right) \; Q \; f\left(\frac{V_H}{u*} \right)$$

$$\frac{F_a}{Q} \approx Constant$$

Dust ID Method

$$F_a = K_f \; x \; q$$

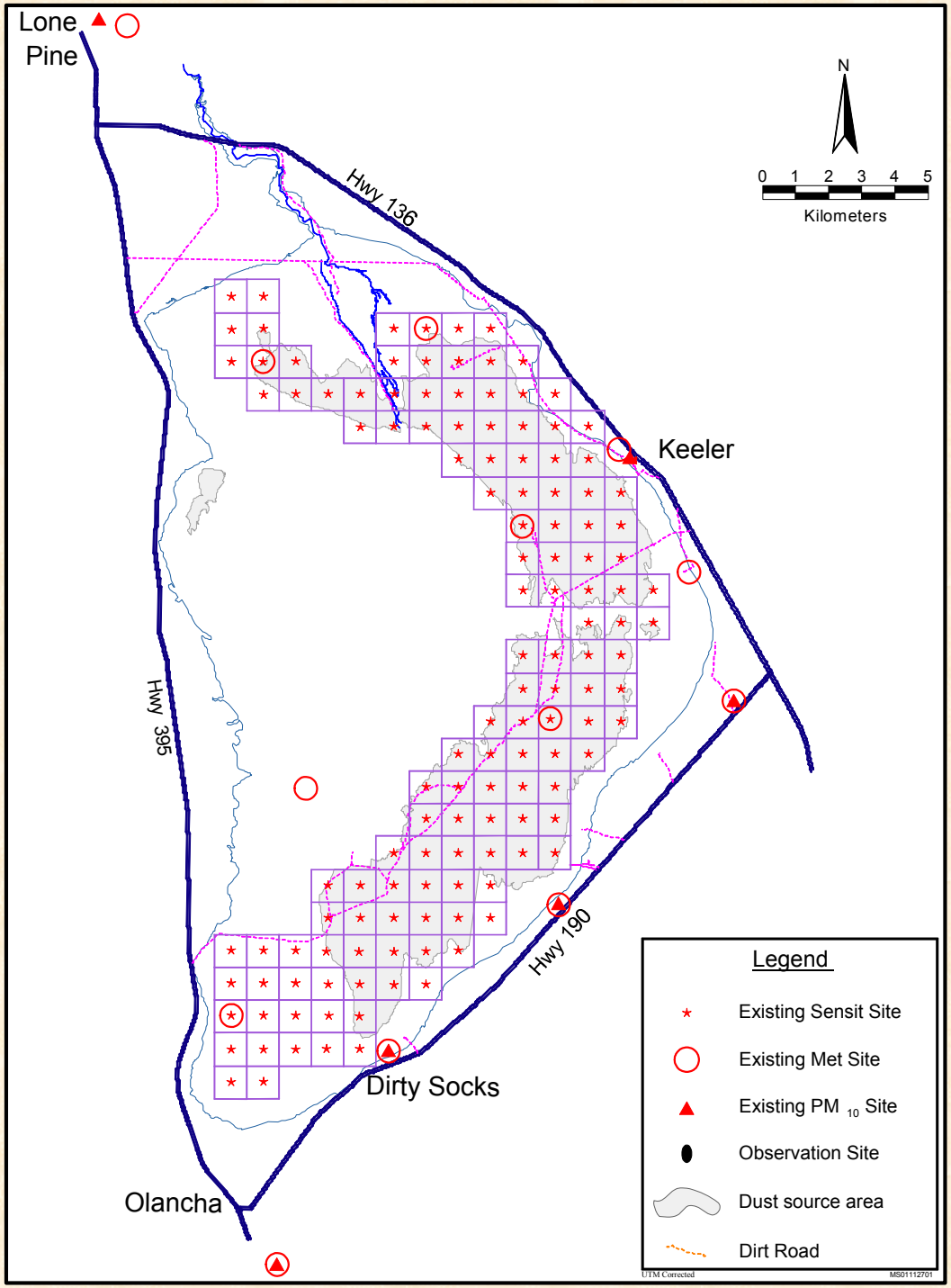
F_a = PM-10 emissions [g/cm^2/hr]

K_f = K-factor

q = sand flux at 15 cm [g/cm^2/hr]

Owens Lake Dust ID Monitoring Network

135 sand flux sites
6 PM-10 TEOM sites
13 10-m met towers
Upper air profiler
Time-lapse camera sites
Dust observer sites

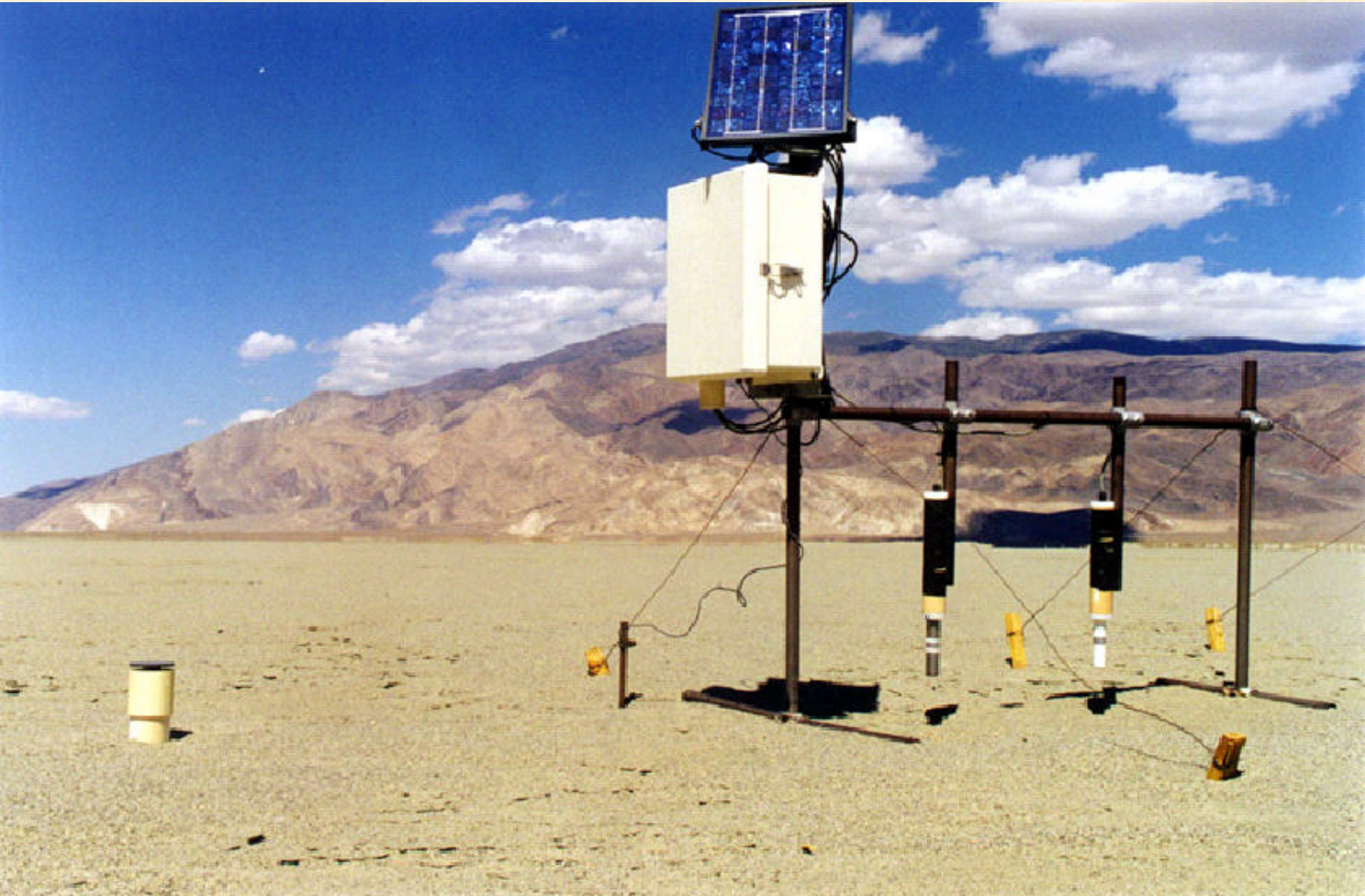


Sand Flux Monitors

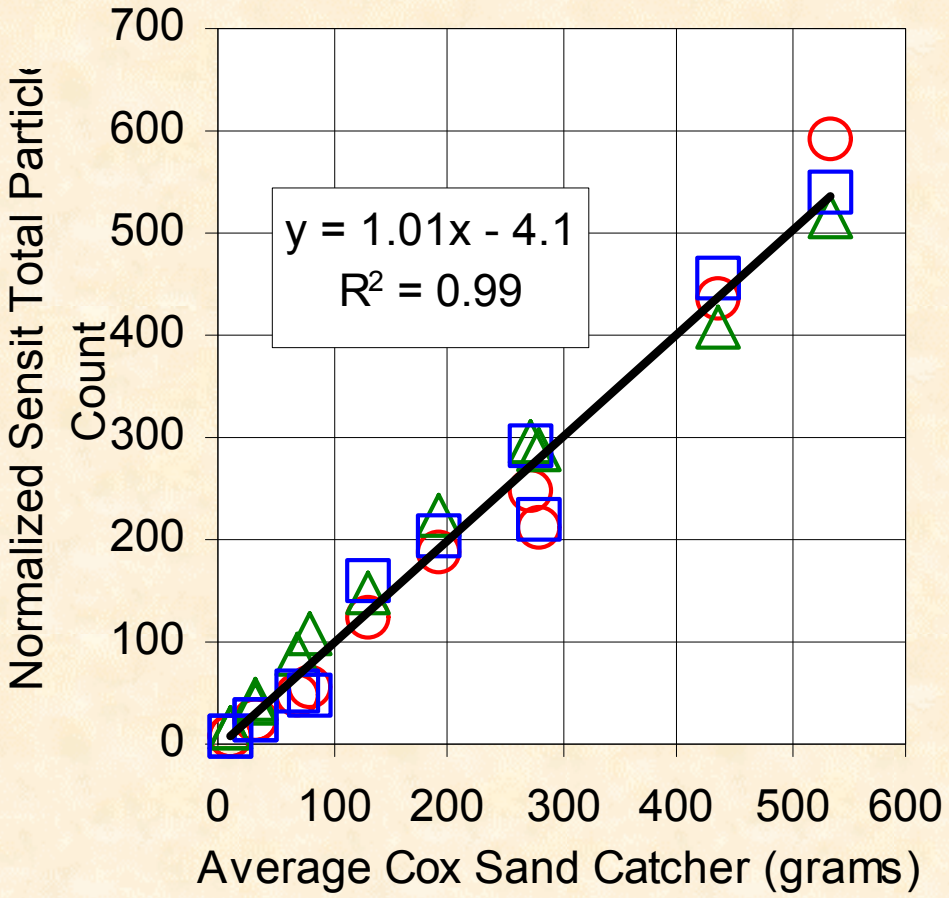
Cox Sand Catcher - Collects saltation-size particles

Sensit ™ - Electronically records sand flux.

Sensits & Cox Sand Catcher



Sensit Reading vs. Sand Catch



PM-10 Monitors Sites

K-factor Calculations

$$K_f = K_i \left(\frac{C_{obs.} - C_{bac.}}{C_{mod.}} \right)$$

K_f = Hourly K-factor

K_i = Initial K-factor (5×10^{-5})

$C_{obs.}$ = Monitored hourly PM-10

$C_{bac.}$ = Hourly background PM-10

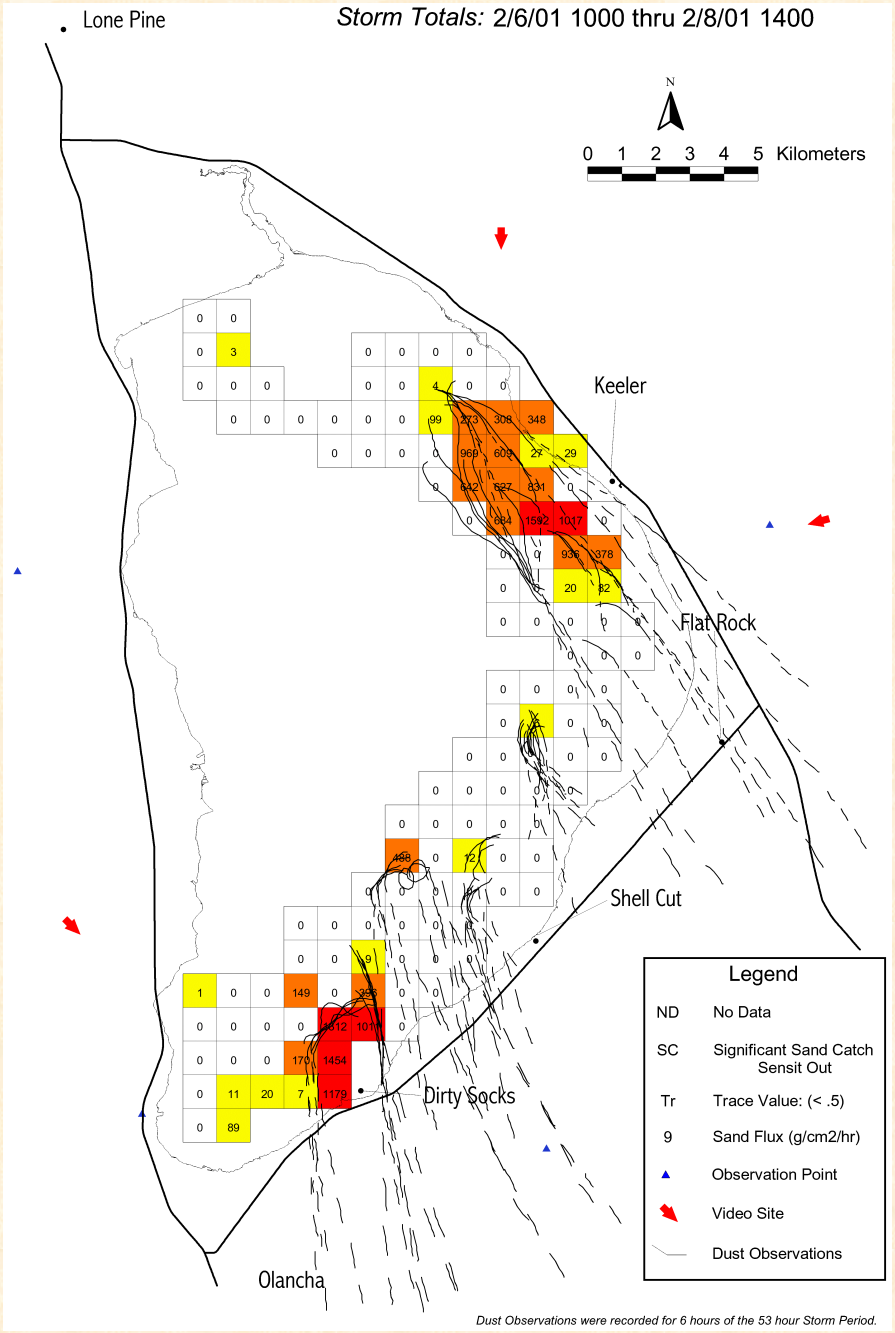
$C_{mod.}$ = Modeled PM-10 at monitor site

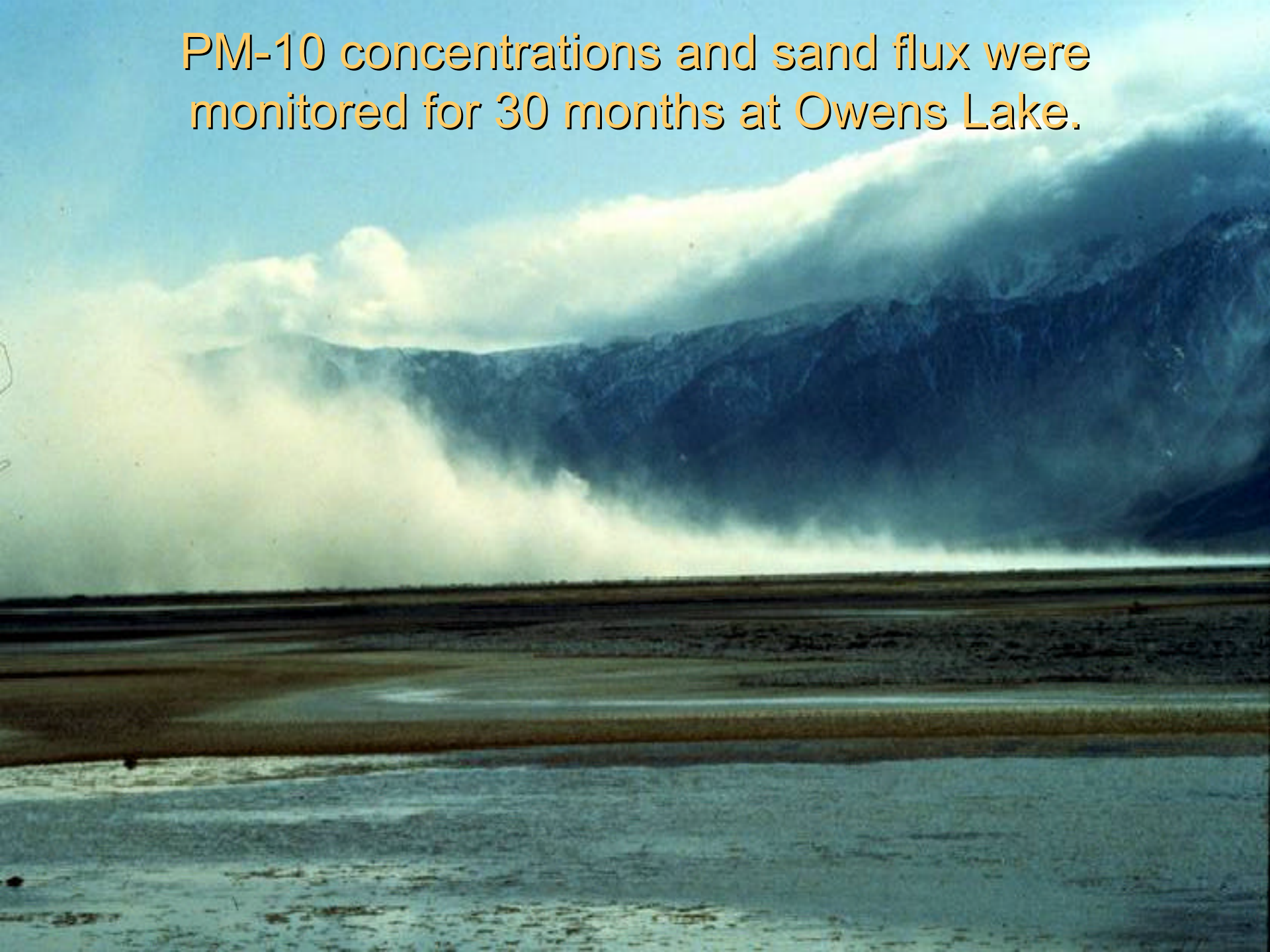
Dust Storm at Owens Lake

VISIBLE DUST PLUMES & SAND FLUX

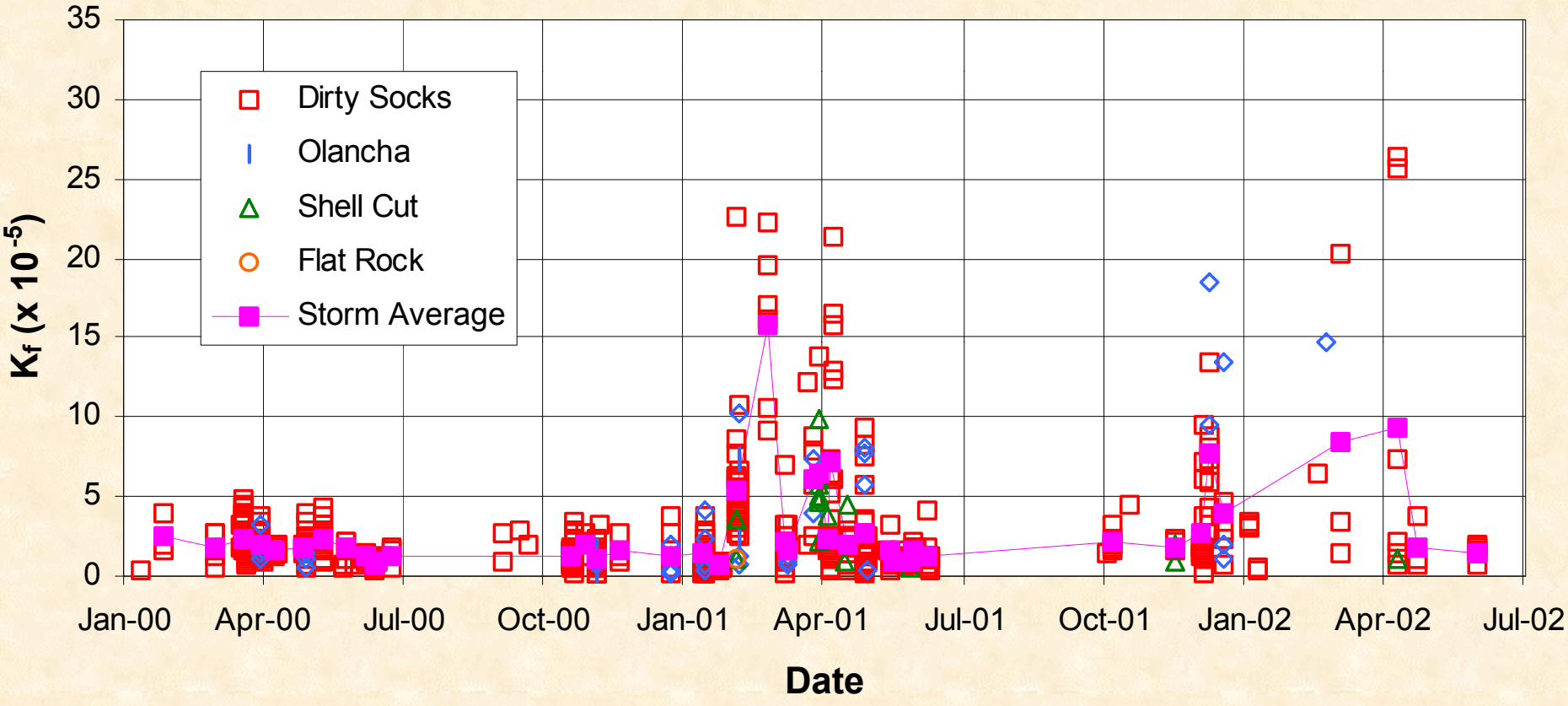
Observed dust plume locations corresponded to the hotspot areas identified by the sand flux monitoring network.

Example Storm: Feb. 6-8, 2001 (52 hour total)




PM-10 concentrations and sand flux were monitored for 30 months at Owens Lake.

Hourly & Storm Average K_f for the South Area



Temporal & Spatial K-factors

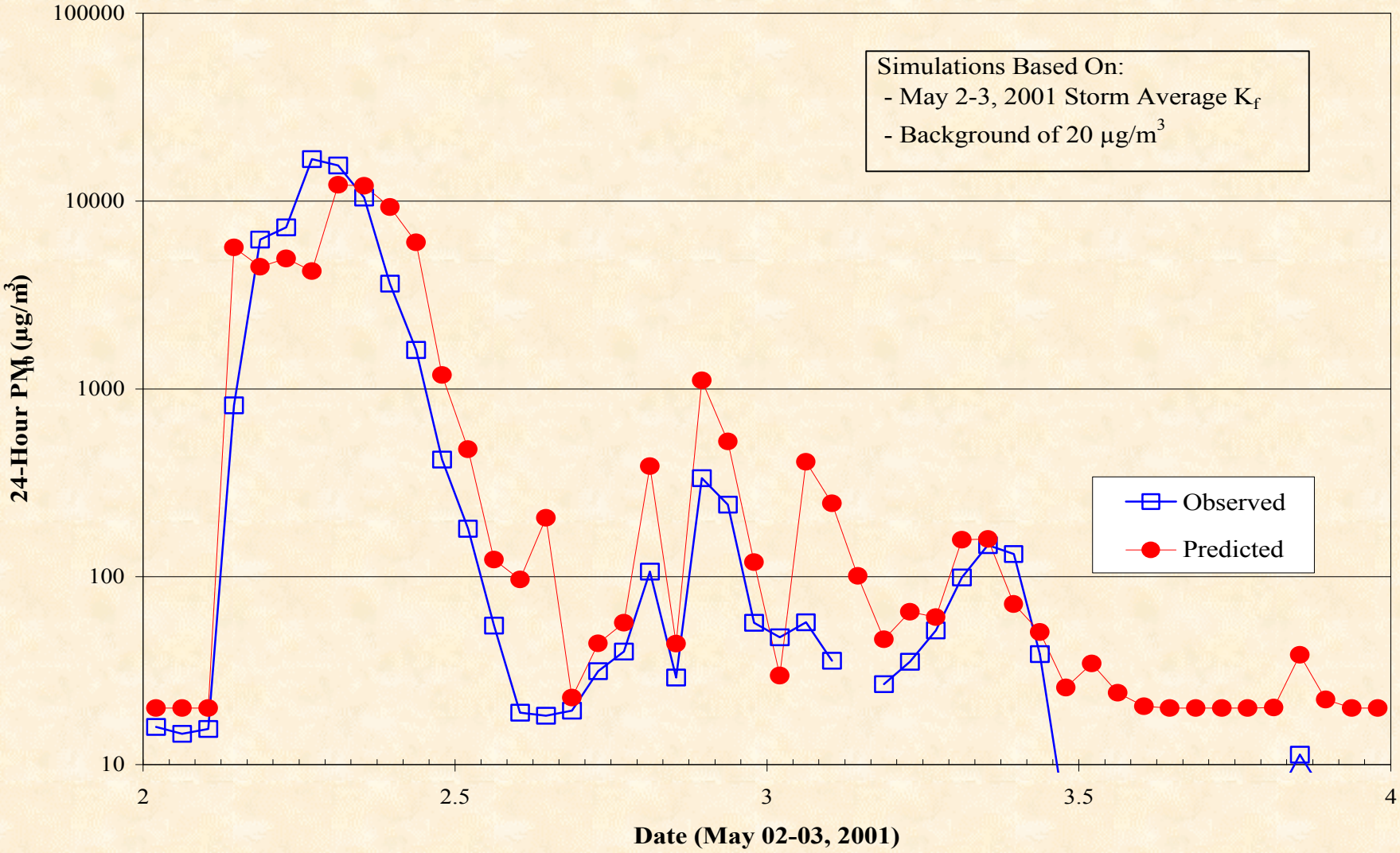
Period	Keeler Dunes	North Area	Central Area	South Area
1/1/00-2/3/01	5.1	2.1	6.6	1.9
2/4/01-4/18/01	5.1	2.1	26.0	6.7
4/19/01-11/30/01	5.1	2.1	6.3	1.9
12/1/01-3/8/02	20.0	7.6	36.0	5.8
3/9/02-4/18/02	5.5	5.0	6.9	9.0
4/19/02-6/30/02	5.5	5.0	6.6	1.8

Univ. of Guelph Wind Tunnel

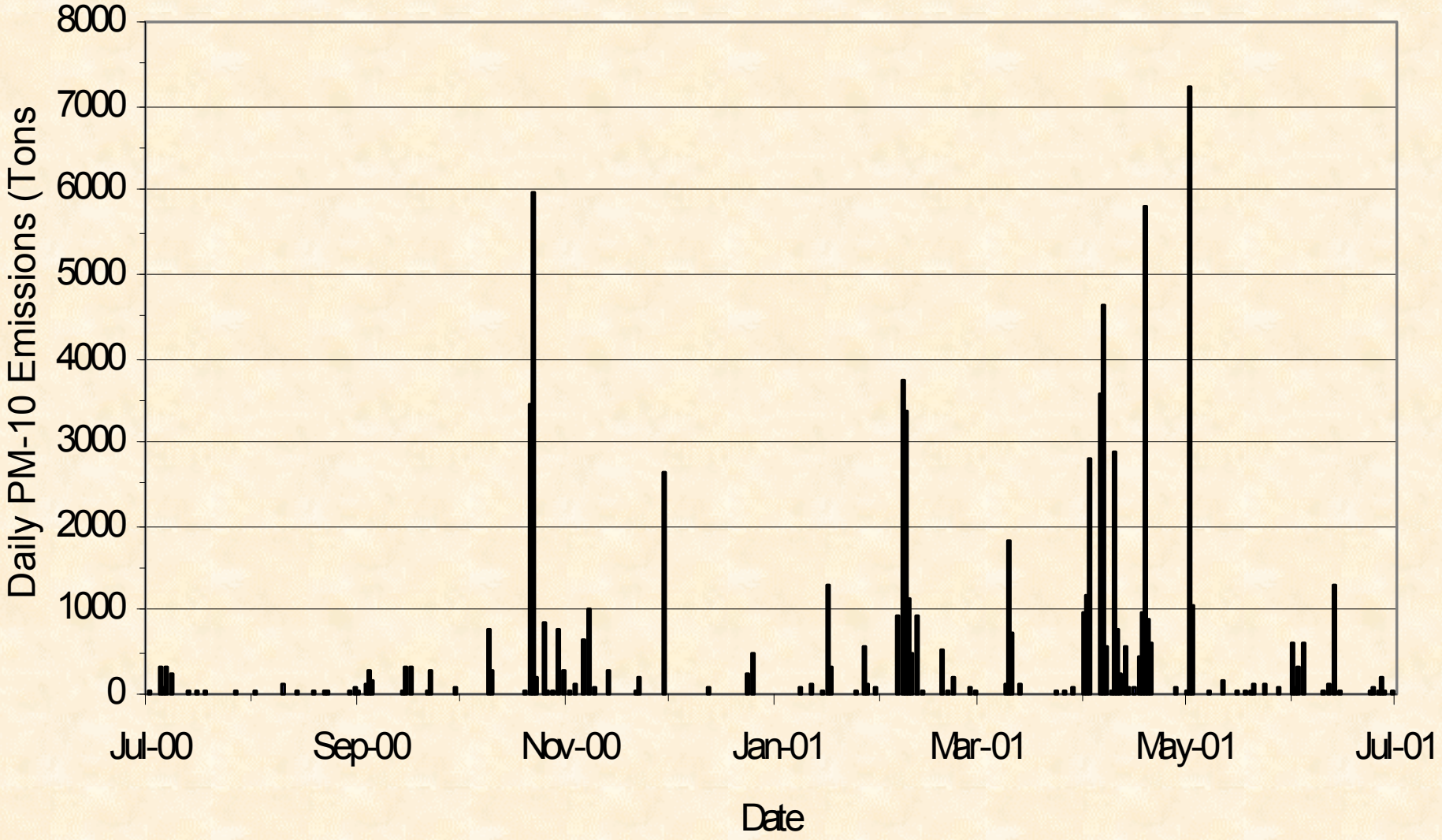
Comparison of Wind Tunnel & Dust ID K-factors

Dust ID Period	Area	Wind Tunnel	Dust ID
1/1/00 - 2/3/01	North Area	2.3×10^{-5}	1.8×10^{-5}
1/1/00 – 2/3/01	Keeler Dunes	1.3×10^{-5}	3.5×10^{-5}
2/4/01 - 4/18/01	Central Area	9.7×10^{-5}	24.1×10^{-5}
2/4/01 - 4/18/01	South Area	6.6×10^{-5}	5.9×10^{-5}
4/19/01 - 11/30/01	Central Area	16.0×10^{-5}	5.7×10^{-5}
4/19/01 - 11/30/01	South Area	3.1×10^{-5}	2.0×10^{-5}

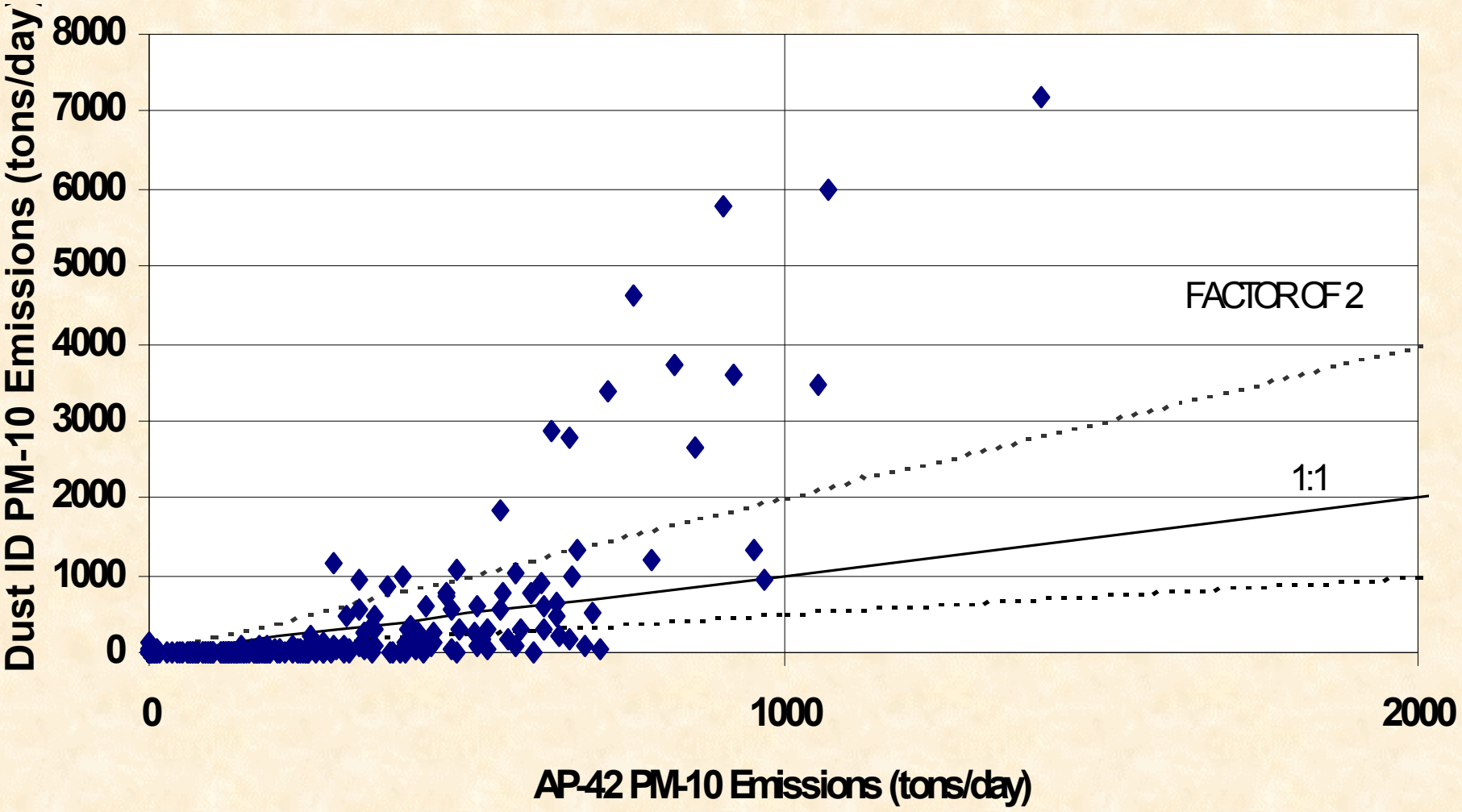
Comparison of Hourly Monitored and Modeled PM-10 at Shell Cut, May 2-3, 2001



Daily PM-10 Emissions



Dust ID vs AP-42 PM-10 Emission Estimates



Owens Lake
PM-10 Emissions

Peak Daily PM-10 = 7,200 tons

Annual PM-10 = 79,200 tons

Dust ID Period: July 2000 - June 2001.

Conclusions

- **PM-10 emissions due to wind erosion were found to be proportional to the saltation flux and could be estimated from measured sand flux.**
- **Proportionality factors, or K-factors could be derived by comparing monitored PM-10 concentrations to modeled values using the measured sand flux with an initial K-factor.**
- **Average K-factors were found to vary spatially and temporally at Owens Lake.**