Clearing the Air in the Owens Valley—Status of the Owens Lake Dust Control Effort

March 27, 2002

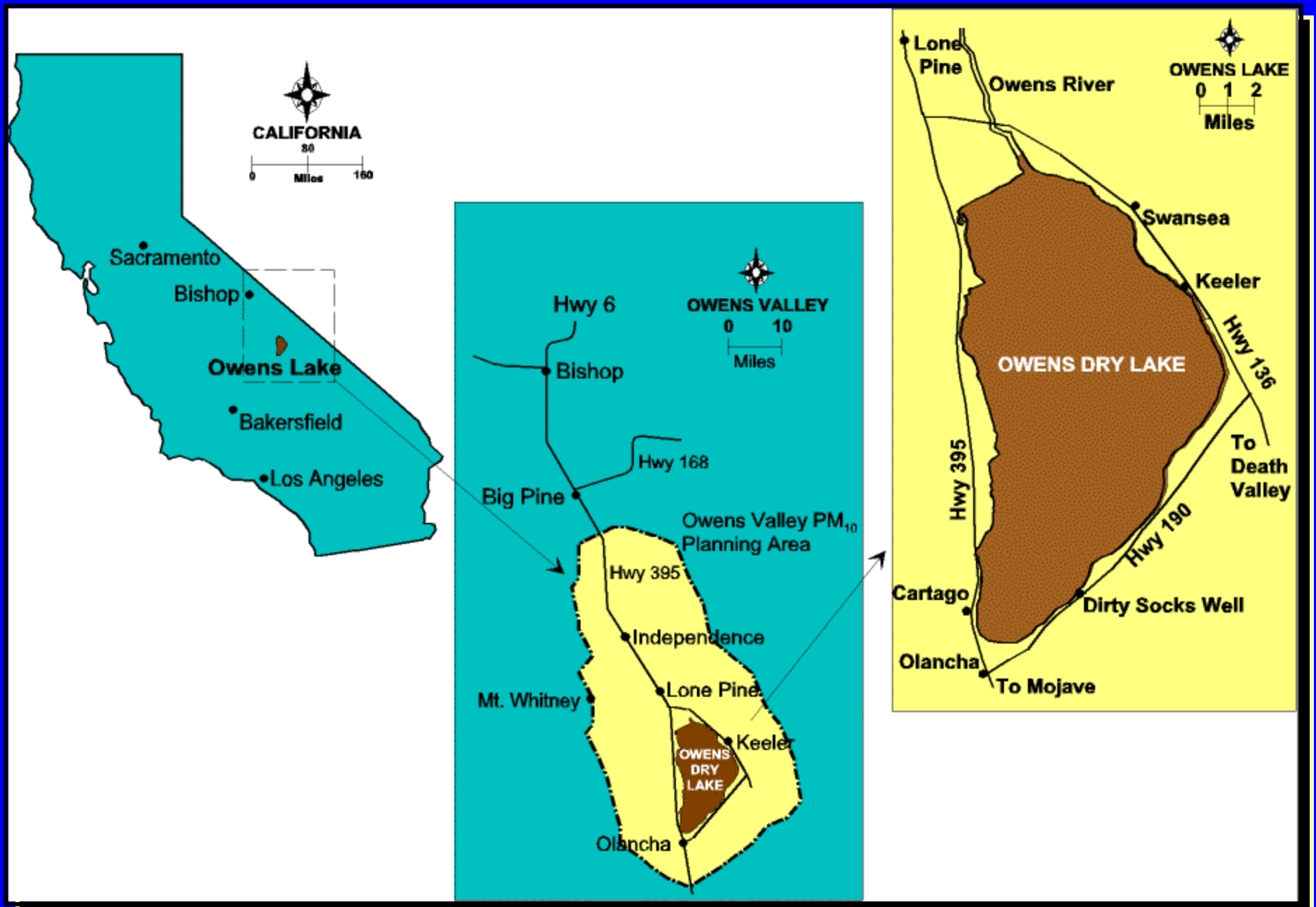
Presented to:

California Air Resources Board

By:

Great Basin Unified Air Pollution Control District
Bishop, California

Owens Lake Vicinity Map



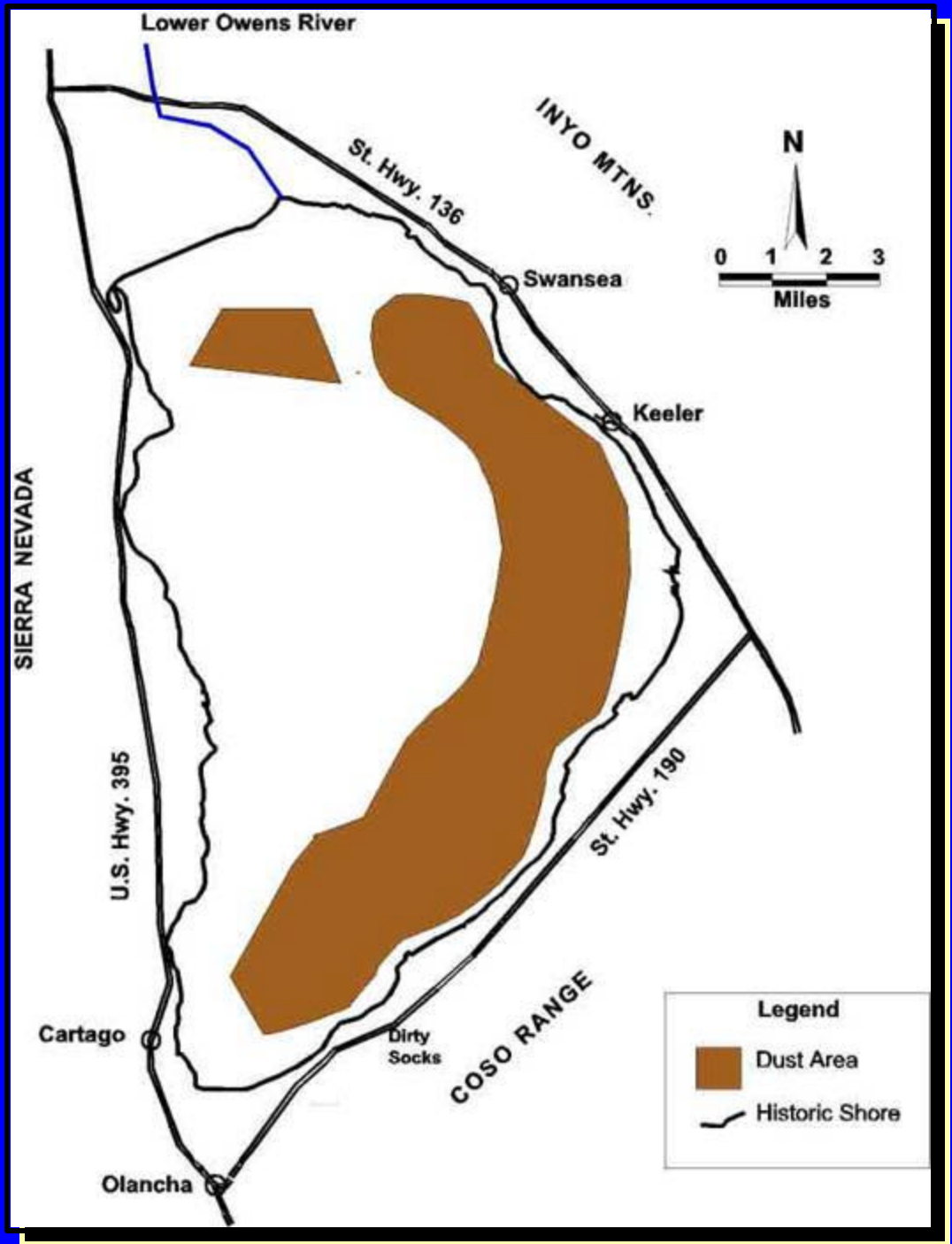
In the late 1800s, Owens Lake, at about 110 square miles, was one of the largest natural lakes in California. It was a saline terminal lake with a salinity about 1½ that of seawater.

This photo, taken in 1891, from the eastern shore of Owens Lake near Keeler, shows the crest of the Sierra in the background.

(Collection of the Henry E. Huntington Library)

In 1913, after purchasing nearly all the private property and attendant water rights in the Owens Valley, the City of Los Angeles constructed the Los Angeles Aqueduct. The Aqueduct diverted Owens River water destined for Owens Lake 230 miles south to Los Angeles.

With the lake's main source of water diverted, by the mid-1920s, Owens Lake had shrunk to a small hyper-saline remnant brine pool of about 40 square miles, but only 1 to 2 feet deep.



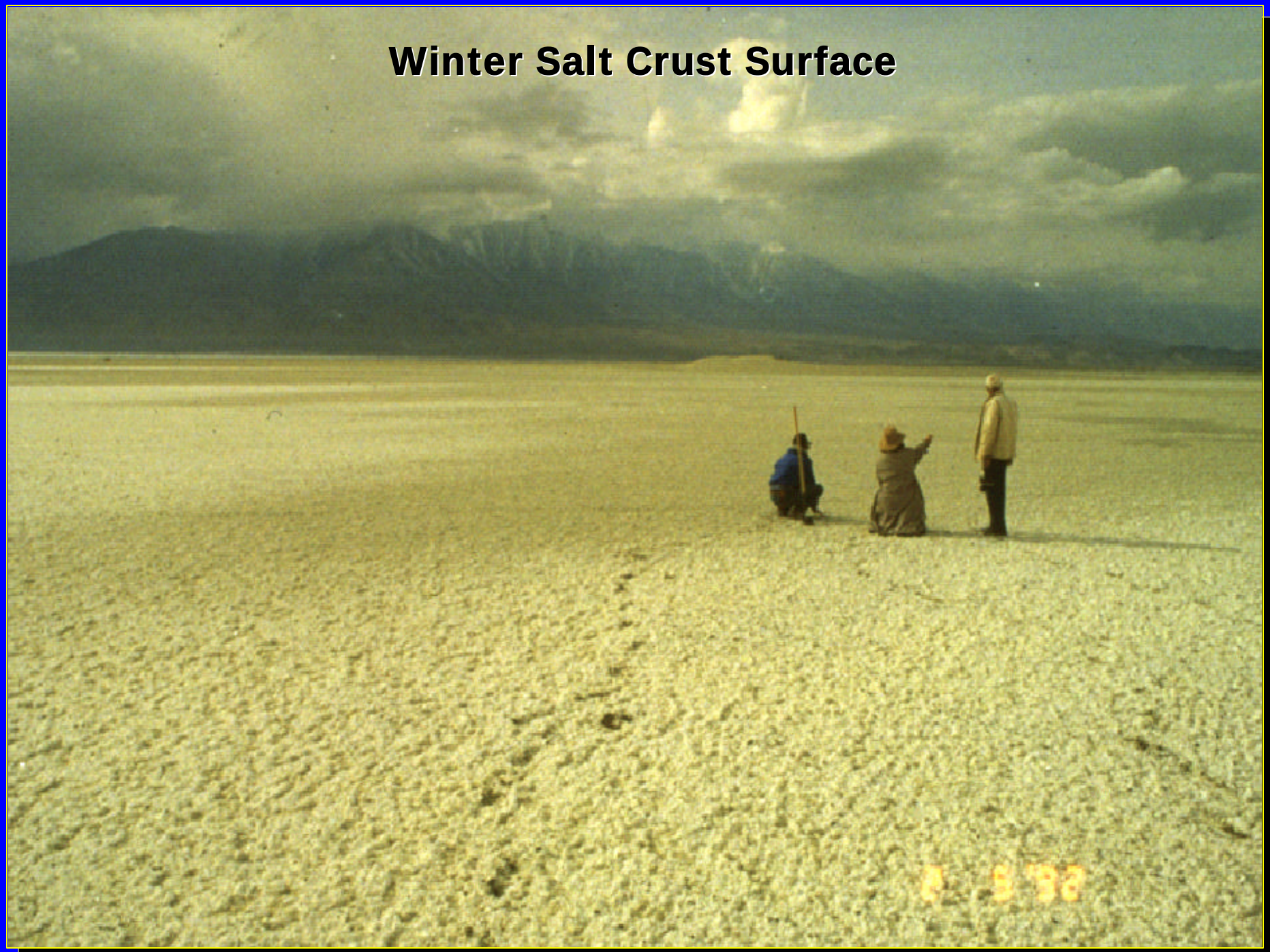
The newly exposed bed of Owens Lake, with its unstable saline soils, began to emit large amounts of fugitive dust and has become the largest single source of particulate matter air pollution in the U.S.

Currently, approx. 25 to 40 sq. mi. (16,000 to 26,000 acres) along the eastern shore of the lake bed emits dust on a regular basis.

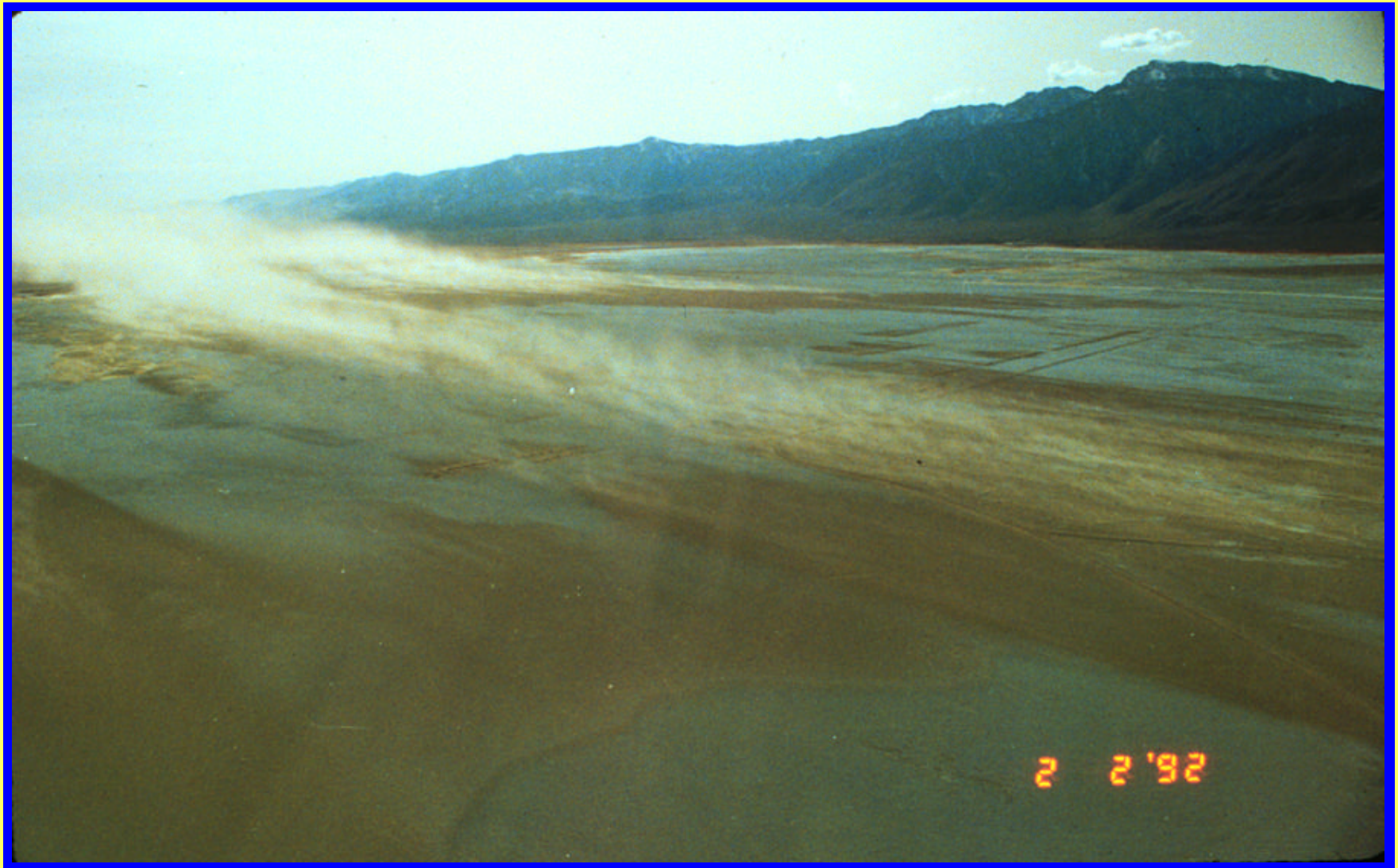
The Owens Lake bed today showing wind eroded salt crust

Owens Lake Today
Summer Surface

Winter Salt Crust Surface

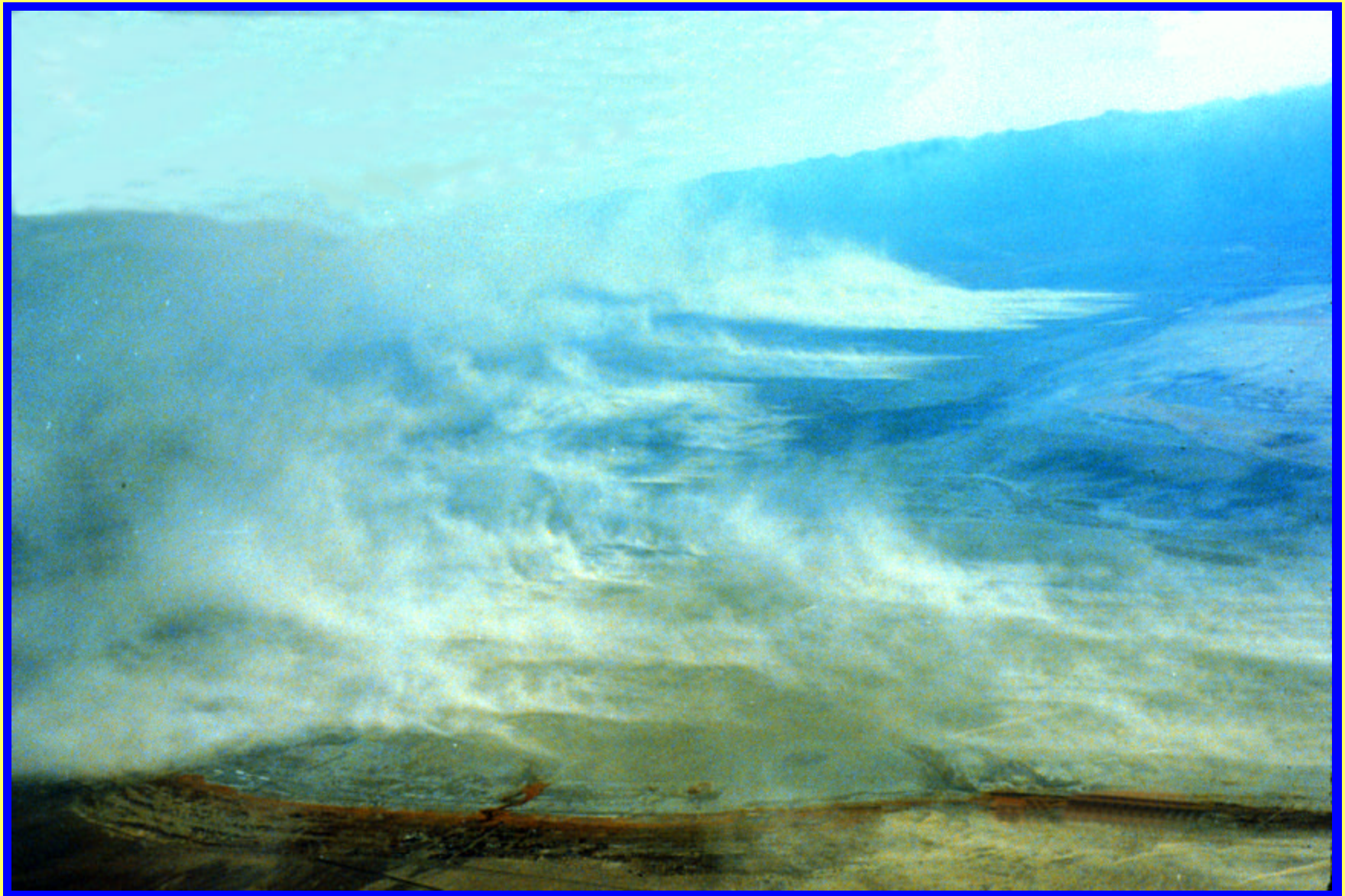


Close-up of Heaved Salt Crust Exposing Emissive Material



Visible Plumes

Leading Edge of an Owens Lake Dust Plume



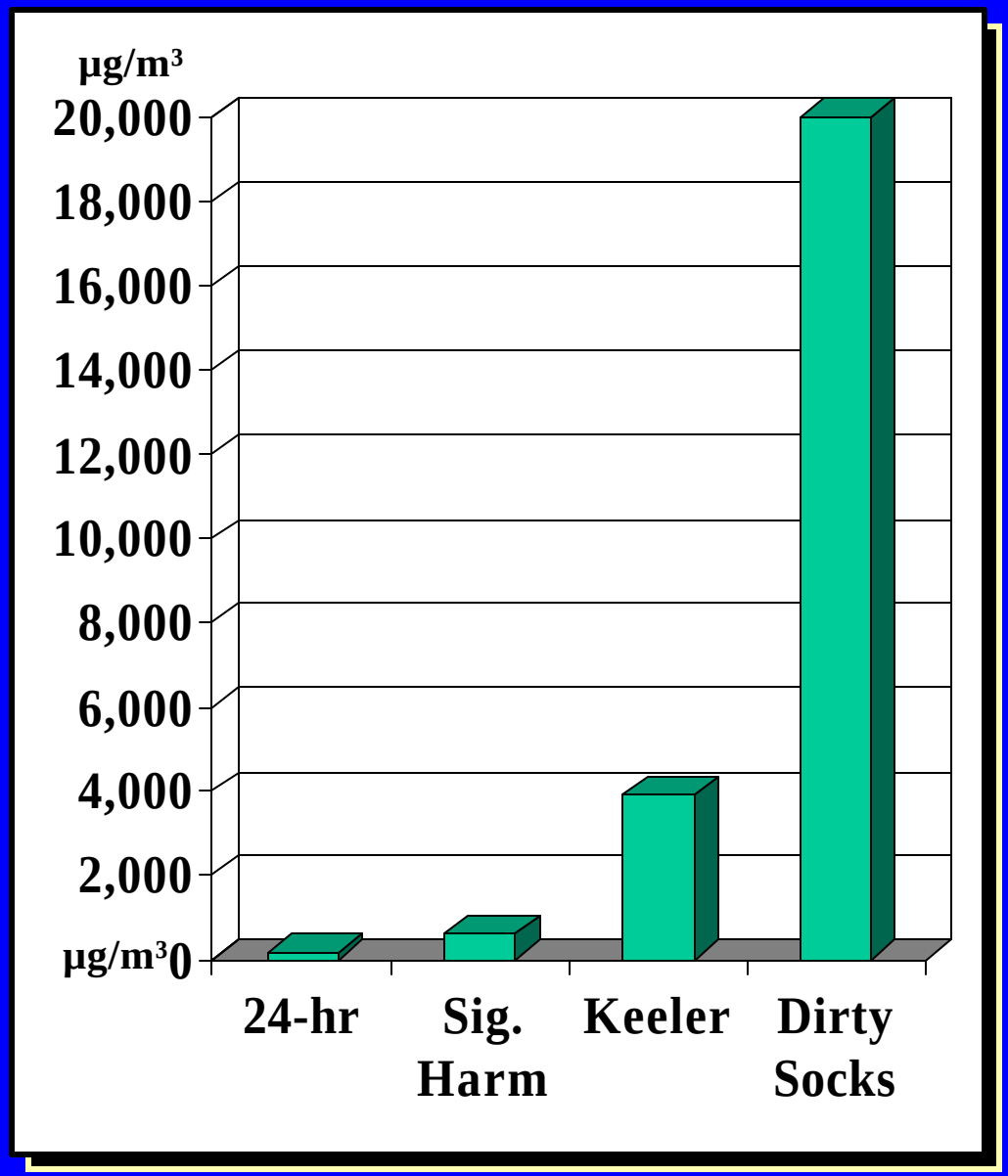
Dust Storm on Owens Lake

Two views of the Owens Valley from the same aerial vantage point - the above photo was taken on a calm day, the bottom photo on a windy day.

Why is the Dust a Problem?

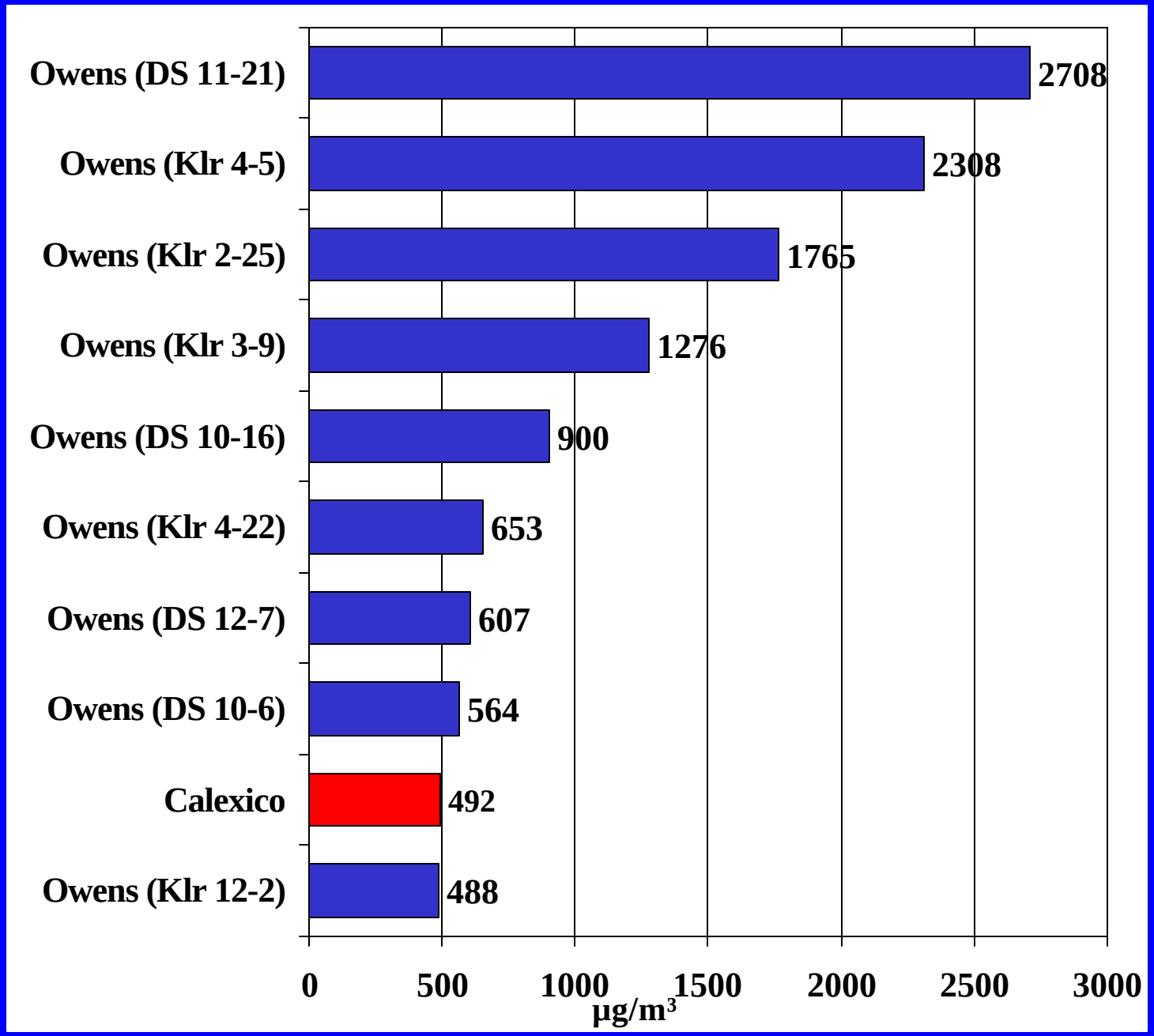
Owens Lake Dust Descending on Ridgecrest, California (1977)

1. Because the PM-10 Values are Very High



- The Federal 24-hr standard for particulate matter is 150 µg/m³.
- The "significant harm to health" level is 600 µg/m³.
- 24-hr levels of 3,900 µg/m³ (26 times Std.) have been measured in Keeler and 20,000 µg/m³ (130 times Std.) at Dirty Socks.

2. Because Severe Exceedances are Frequent

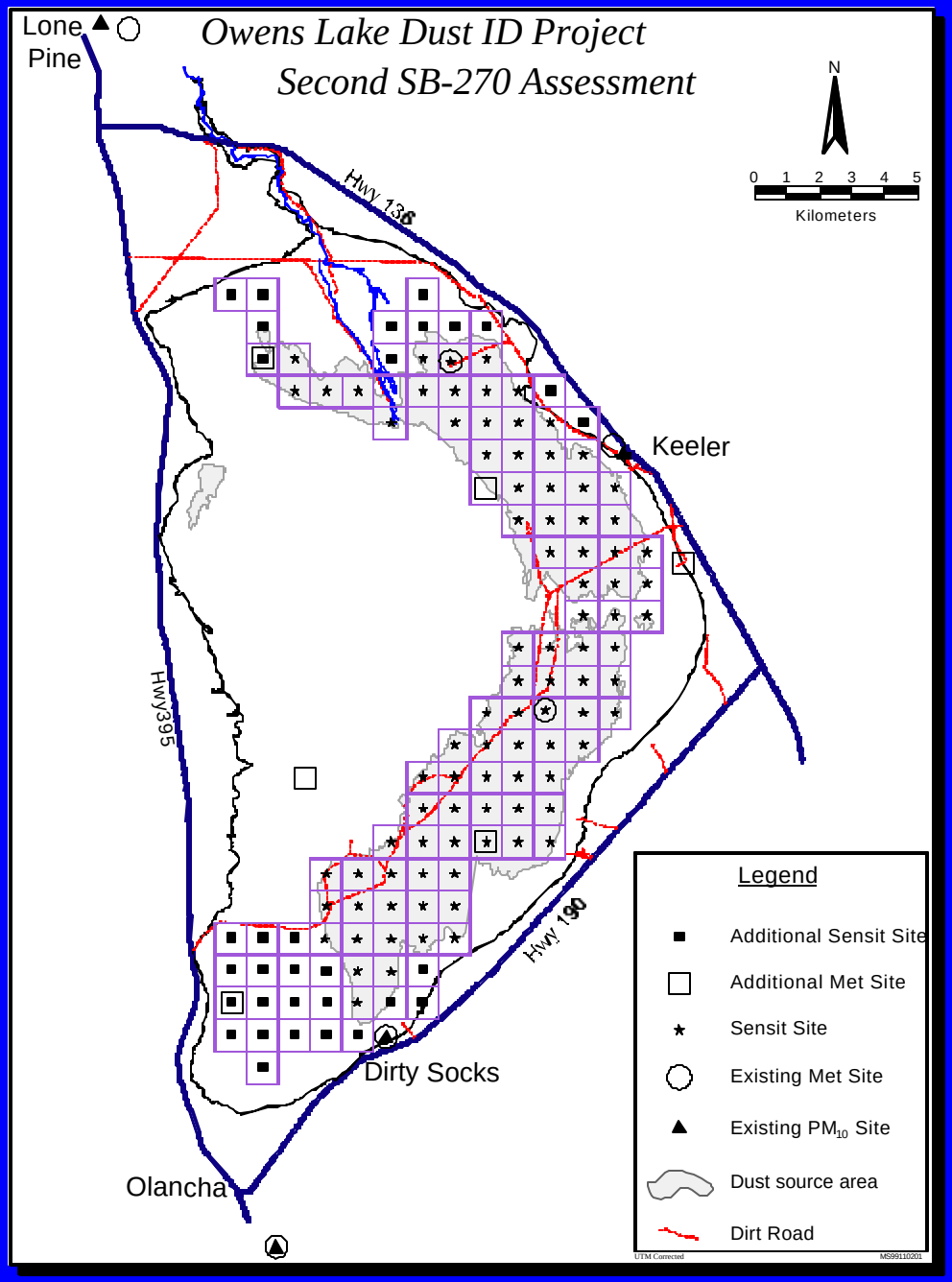


The US EPA AIRS Data for 1999 shows that of the highest 10 PMn10 values reported, 9 occurred at Owens Lake.

Owens Lake's highest value of 2708 was 5.5 times higher than the highest non-Owens value (492 at Calexico).

To develop a solution we first need to understand the Lake

- In the early 1980s, the State of California acknowledged that Owens Lake was a problem that needed to be solved. A law was passed (SB-270) that gave the Great Basin APCD the responsibility for coming up with a plan.
- The same law made the City of Los Angeles responsible for paying for plan development and allowed Great Basin to order LA to implement dust control measures.
- Since the late 1980s, Great Basin has been conducting research to understand the Owens Lake basin and develop measures that will solve the dust problem.



Owens Lake Dust ID Project

In order to determine precisely where dust control measures are needed, Great Basin has 135 monitoring devices on a one km grid (covering 52 sq. miles or more than 33,000 acres) on those areas of the lake bed that may emit dust.

LA will be required to install dust control measures on all areas that contribute to violations of the PM-10 standard.

In addition to mapping dust emission areas, Great Basin:

- Monitors air quality at a number of sites around the lake
- Monitors deep and shallow groundwater levels and quality
- Monitors wetland extent and natural vegetation health
- Has surveyed for rare plants and animals around the lake
- Has mapped the lake bed soils

Owens Lake Control Measure Research Programs

PM_{10} Control Measures Tested at Owens Lake

Chemical Sprays

Surface Compaction

Sand Fences

Tilling

Shallow Flooding

Vegetation

Gravel Blanket
86 6 23

The Solution

- In November 1998, Great Basin adopted a State Implementation Plan (SIP) to control the fine dust (PM_{10}) emissions from the dried bed of Owens Lake.
- This plan ordered the City of Los Angeles to begin implementing control measures on the lake bed according to a timetable that provided for the dust problem to be solved by the end of 2006.
- The SIP provides for Great Basin to continue its dust control measure research during Los Angeles' implementation of control measures in order to improve the efficiency of the approved measures.

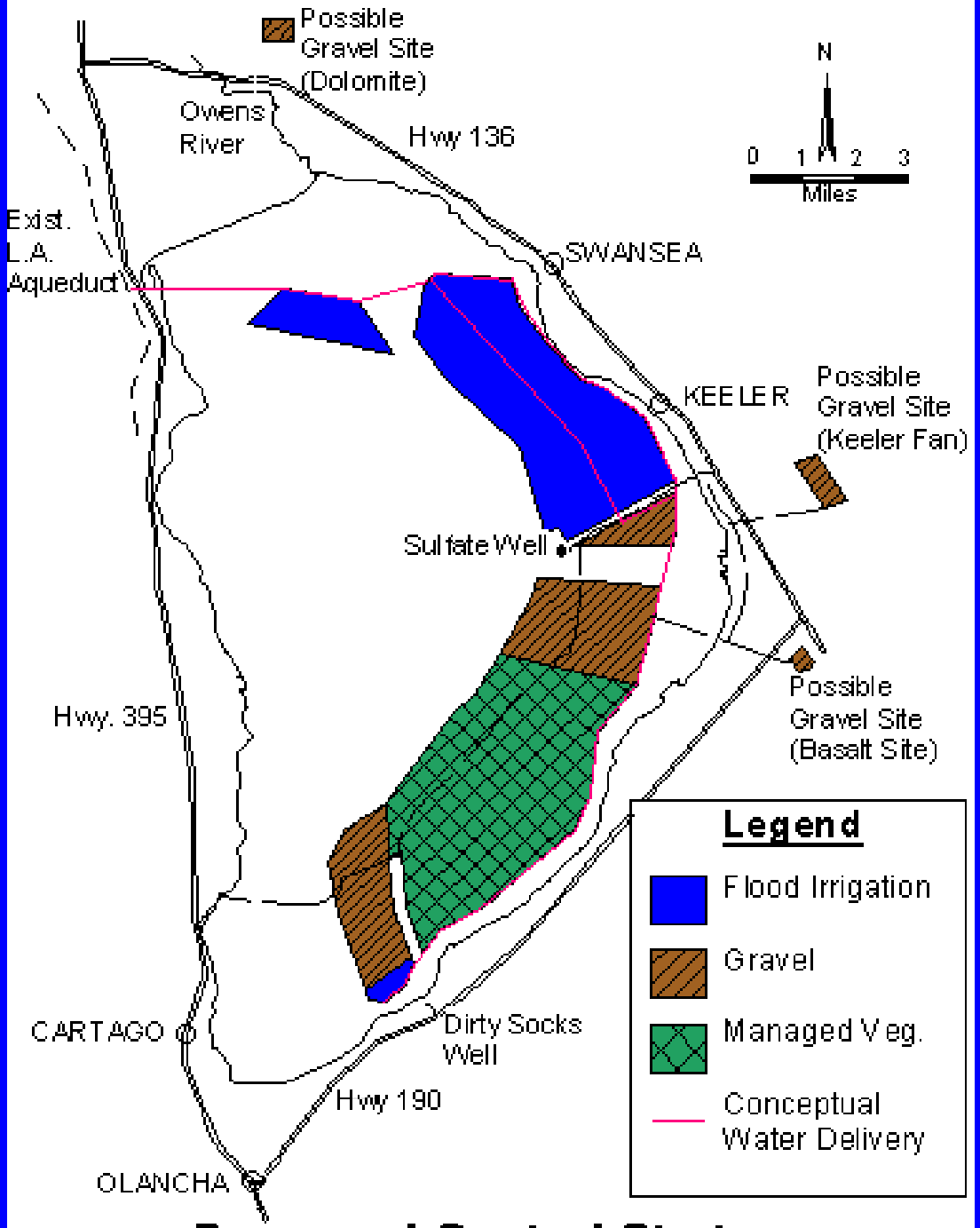
Owens Lake State Implementation Plan

- LA will implement controls on 16½ sq. mi. of the lake bed by 2003.
- In 2003, a new plan will be prepared that provides for Federal Standard attainment by 2006 (2003 SIP Revision).
- If LA challenges the 2003 SIP Revision, they will implement controls on 2 sq. mi. of lake bed per year until the Federal Standard is attained.

The SIP contains three approved control measures:

- **Shallow Flooding** – creates a non-emissive surface by keeping the lake bed wet.
- **Vegetation** – creates a non-emissive surface by protecting it with vegetation.
- **Gravel** – creates a non-emissive surface by covering the lake bed with a 4-inch thick blanket of coarse gravel.
- LA is allowed to implement any of these three control measures anywhere in the dust producing area in order to meet their deadlines.

The Proposed Control Strategy contained in the District's SIP



Proposed Control Strategy

Great Basin's continuing research to improve the cost and water use efficiency of the control measures focuses on <u>shallow flooding</u> and <u>managed vegetation</u>—both of which are occurring naturally on the lake bed.

Shallow Flooding

Great Basin conducted two large-scale tests of shallow flooding on the lake bed. These tests indicated that:

%if 75% of a dust producing area consists of standing water or saturated soil, dust emissions will be reduced by 99%, and

%that 4 acre-feet of water per year was required to control the dust from one acre of lake bed.

Great Basin Shallow Flood Test Site

Shallow Flood Ground Level Views

Wildlife Attracted to Shallow Flood

Managed Vegetation

- Great Basin's research indicates that if 50% of a dust producing area consists of live or dead vegetative cover, dust emissions will be reduced by 99%.

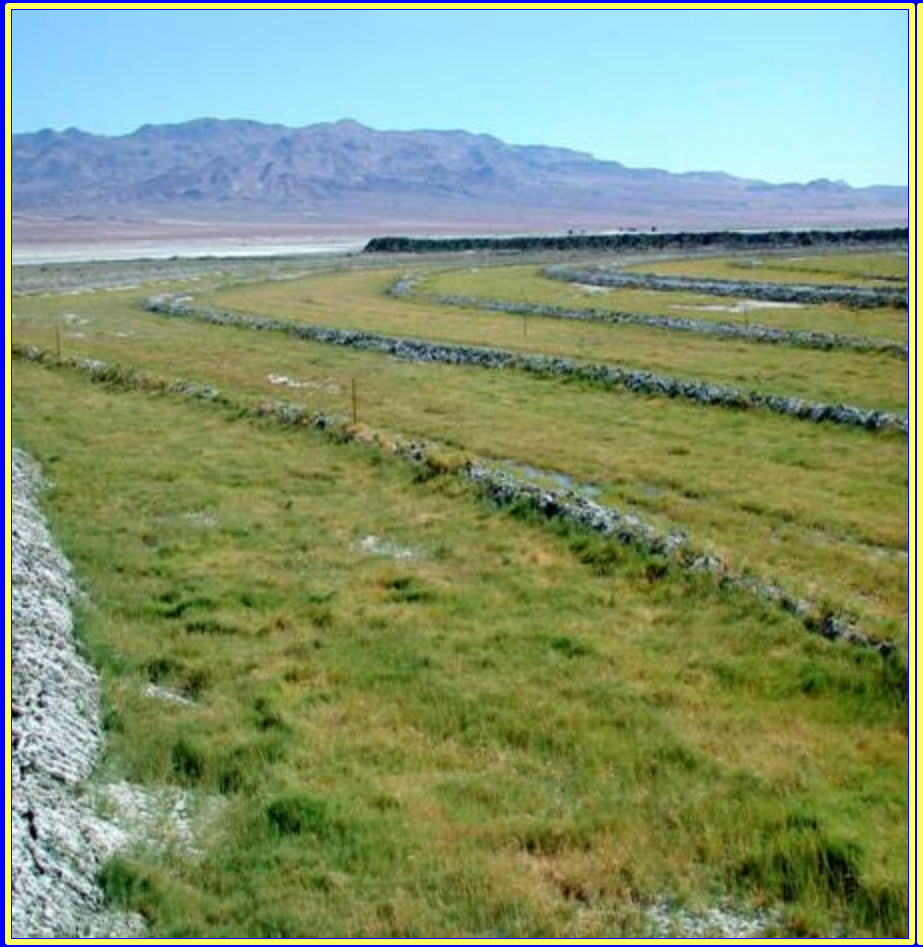
- Our research also determined that it takes approximately 7 acre-feet of water per acre to reclaim the saline soils and establish vegetation the first year. In subsequent years it takes about 2.5 acre-feet of water per year per acre to maintain the 50% vegetative cover necessary to control PM-10.

Saltgrass (*Distichlis spicata*)

Saltgrass is attractive for use at Owens Lake because:

- **It is a locally adapted native species.**
- **It is very salt-tolerant.**
- **It spreads via underground runners and thus new growth is protected from wind damage.**
- **It creates a surface-protecting mat.**

<u>However</u>, it is not particularly drought tolerant.



Great Basin’s early research developed techniques to reclaim saline soils and establish 50% vegetative cover with **flood irrigation**. This technique works on both sand and clay soils.

We also used micro-sprinklers to successfully establish saltgrass on sandy soils.

We have been successful at establishing native shrubs and trees on the sandy soils present on about half the lake bed.

In order to reduce the total water demand, we are now exploring the use of drip irrigation to reclaim the soil and establish the plants.

This results in a pattern of nodes, instead of a meadow.

March 2001 – after 6 months of growth and winter dormancy

July 2001 – after 15 months in the ground

August 2001 – after 16 months in the ground

October 2001 – after 18 months in the ground

Implementing the Solution

Fixing the PM-10 problem at Owens Lake means implementing the approved control measures over very large areas. In December 2001, the City of Los Angeles completed the first phase of dust control—a $70 million, 12 square mile shallow flood project that has already made a difference in the observed levels of PM-10. (show video)

Owens Lake Dust Identification Program

Duane Ono
Deputy Air Pollution Control Officer
Great Basin Unified APCD

Dust ID Program Objective

Objective: Determine which dust producing areas need to be controlled to attain the federal PM-10 standards.

Time-lapse Video of Dust Storms at Owens Lake

Viewed from northeast side of Owens Lake looking south, January – June 2001.

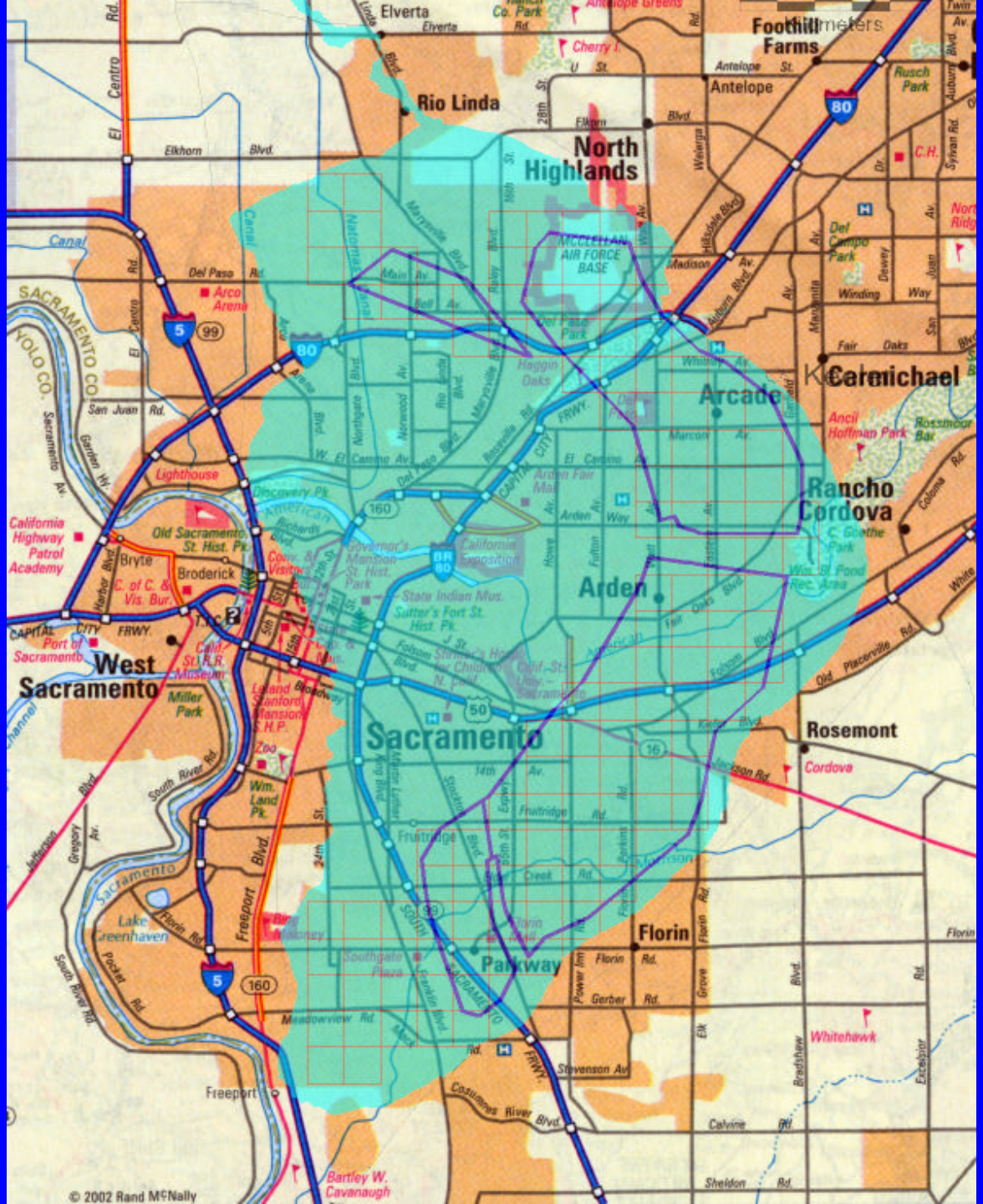
Methods to determine dust source area locations:

- Video Cameras
- Observers
- GPS Mapping of Source Areas
- Sand Flux Monitors
- Continuous PM-10 Monitors

Model PM-10 Emissions and Ambient Impact

- Determine PM-10 emissions from each area.
- Model source area impacts using CALPUFF dispersion model.
- Reduce emissions from selected areas to model attainment at the shoreline.

Elverta
Rio Linda
Foothill Farms
Antelope
North Highlands
MCCLELLAN AIR FORCE BASE
Arcade
Carmichael
Rancho Cordova
Arden
Rosemont
Sacramento
West Sacramento
Florin
Parkway
Freeport
Elkhorn Blvd.
Del Paso Rd.
Main Av.
Bell Av.
Madison Av.
Whitney Av.
Fair Oaks
Winding Way
Marconi Av.
El Camino Av.
Arden Way
Fair Oaks Blvd.
Folsom Blvd.
Kiefer Blvd.
Jackson Rd.
Fruitridge Rd.
Elder Creek Rd.
Morrison
Florin Rd.
Gerber Rd.
Meadowview Rd.
Stevenson Av.
Calvine Rd.
Sheldon Rd.
Sacramento
Canal
American
Arco Arena
Del Paso Park
Haggin Oaks
Arden Fair Mall
Lighthouse
Discovery Pk.
Old Sacramento St. Hist. Pk.
California Highway Patrol Academy
Port of Sacramento
Miller Park
Zoo
Wm. Land Pk.
Lake Greenhaven
Southgate Plaza
Florin Mall
Rusch Park
Del Campo Park
Ancil Hoffman Park
Rossmoor Bar
C. Goethe Park
Win. B. Pond Rec. Area
Cordova
Whitehawk
Bartley W. Cavanaugh
Governor's Mansion St. Hist. Park
State Indian Mus.
Sutter's Fort St. Hist. Pk.
California Exposition
Calif. St. R.R. Museum
Leland Stanford Mansion S.H.P.
Conv. & Visitors Bur.
C. of C. & Vis. Bur.
Broderick
Bryte
Elverta
Cherry I.
Antelope Greens
Rusch Park
C.H.
Yolo Co.
Sacramento Co.
Placer Co.
Sacramento Int'l Arpt.
Sacramento Int'l Arpt.
Sacramento Int'l Arpt



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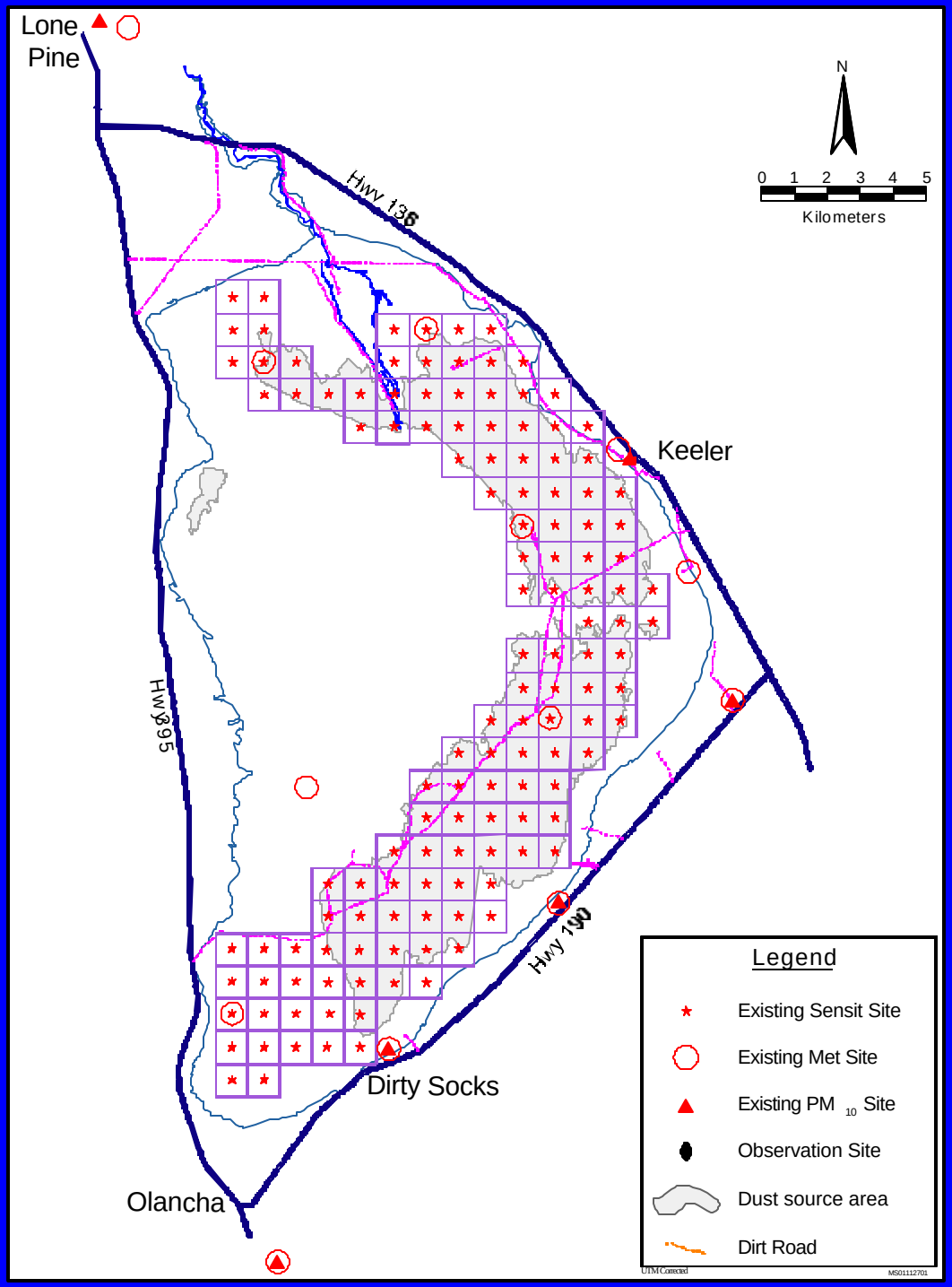
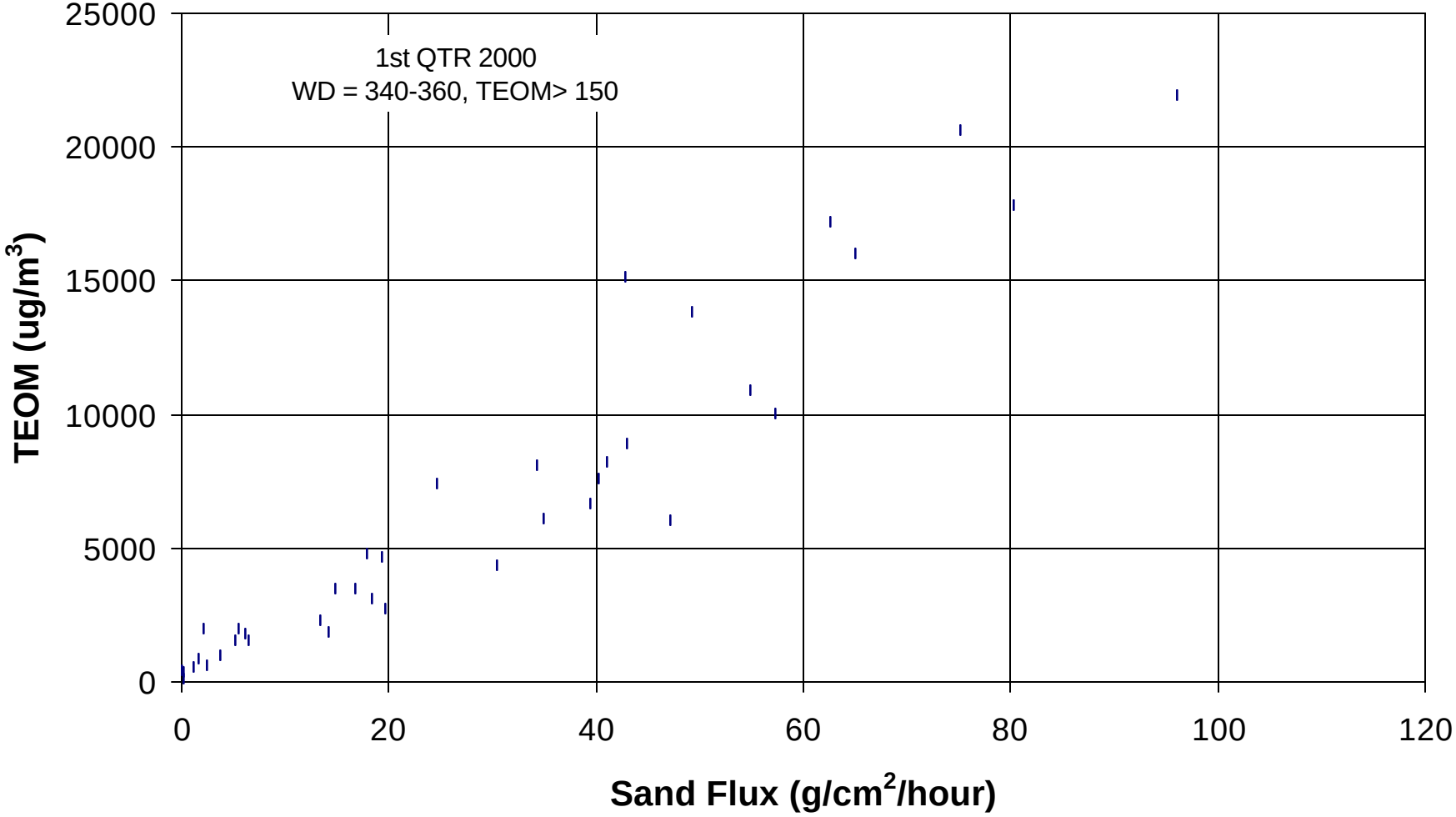

Lone Pine
Hwy 136
Keeler
Hwy 395
Hwy 190
Dirty Socks
Olancha
N
0 1 2 3 4 5
Kilometers
Legend
Existing Sensit Site
Existing Met Site
Existing PM 10 Site
Observation Site
Dust source area
Dirt Road
UTM Corrected
MS01112701

PM-10 = K-factor x Sand Flux

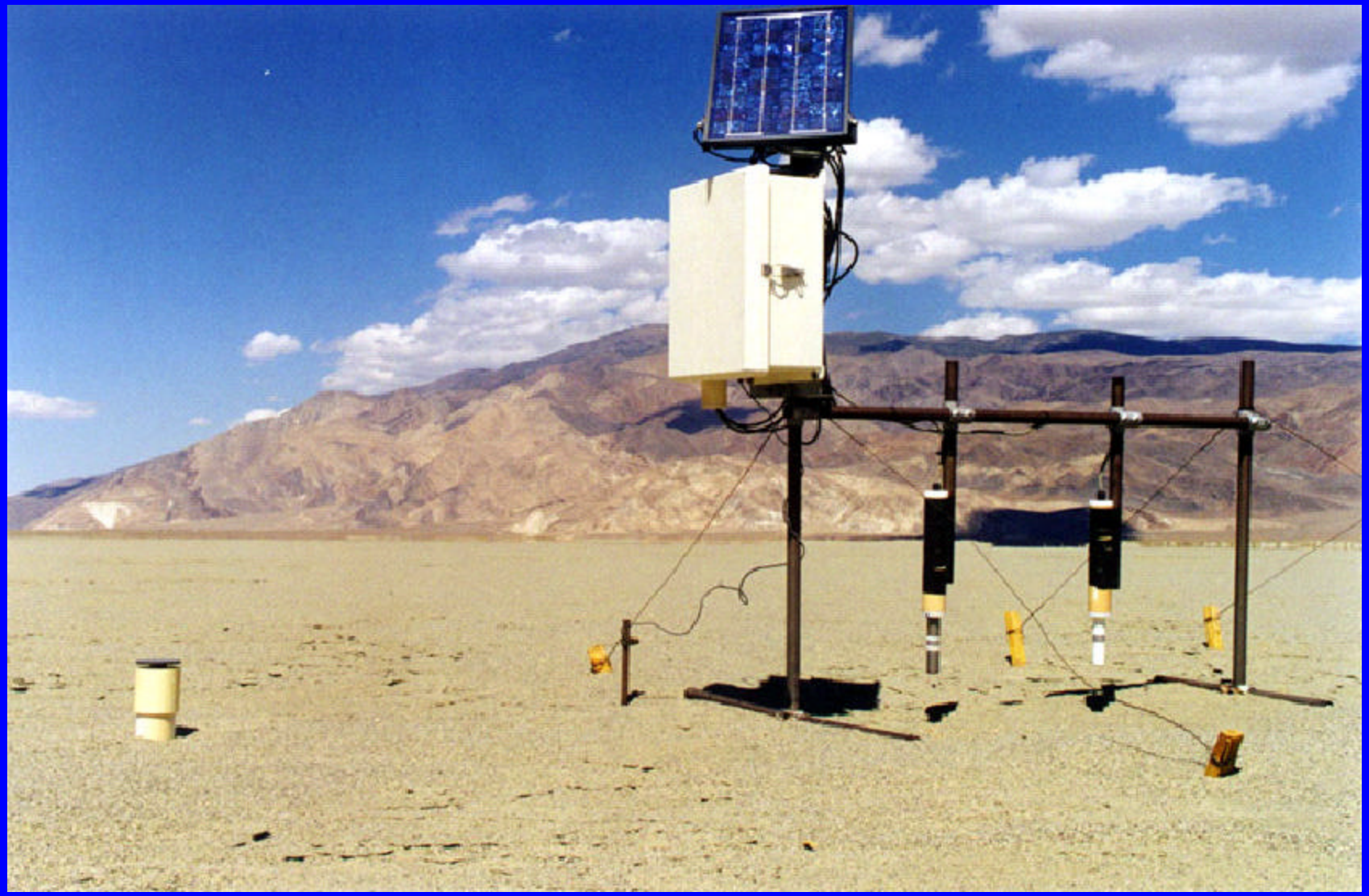
- The K-factor periodically changes with the surface conditions on different areas of the lake.
- Hourly sand flux measurements are taken in each square kilometer on the lake bed.

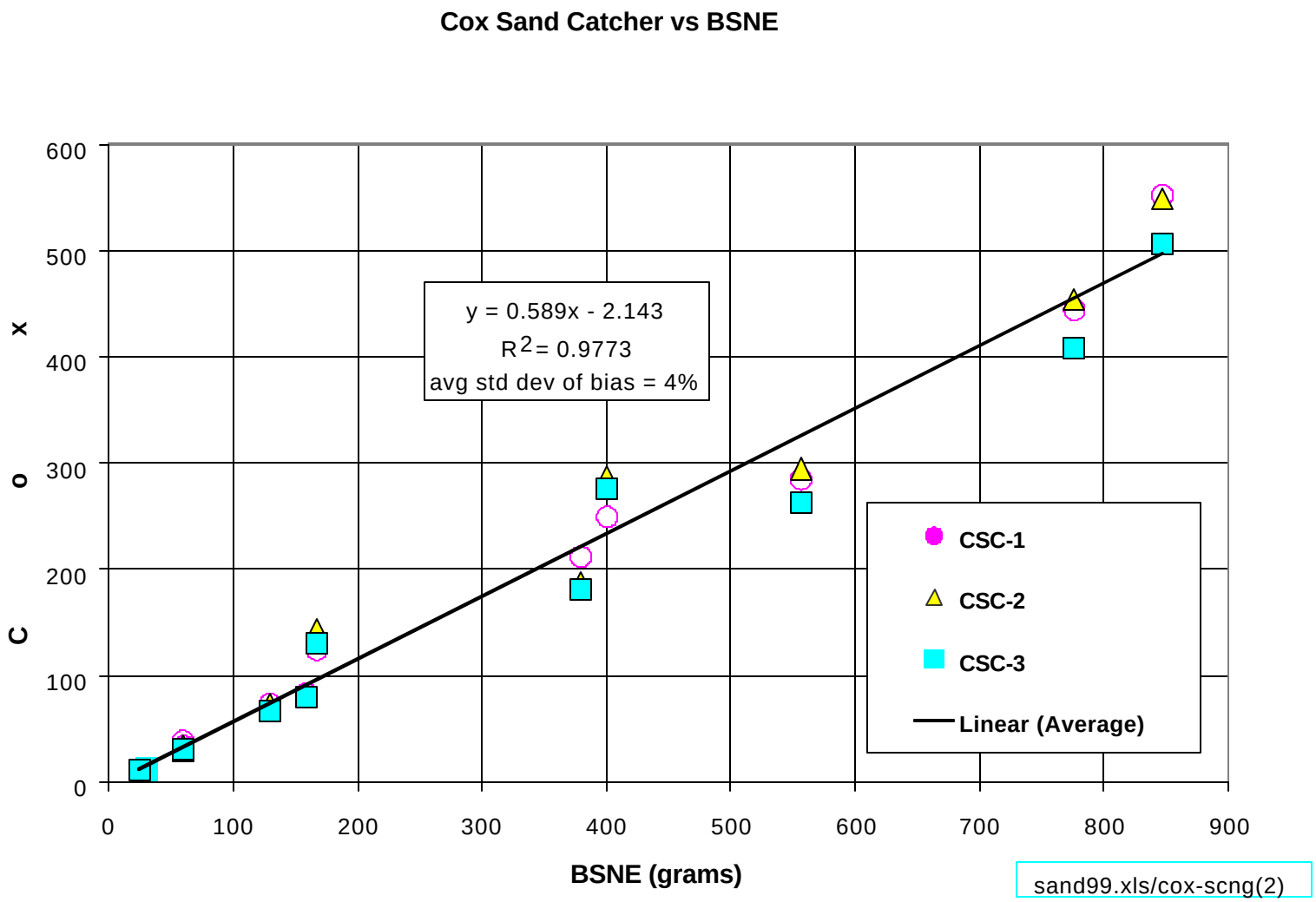
Dirty Socks TEOM vs 7631 Sand Flux

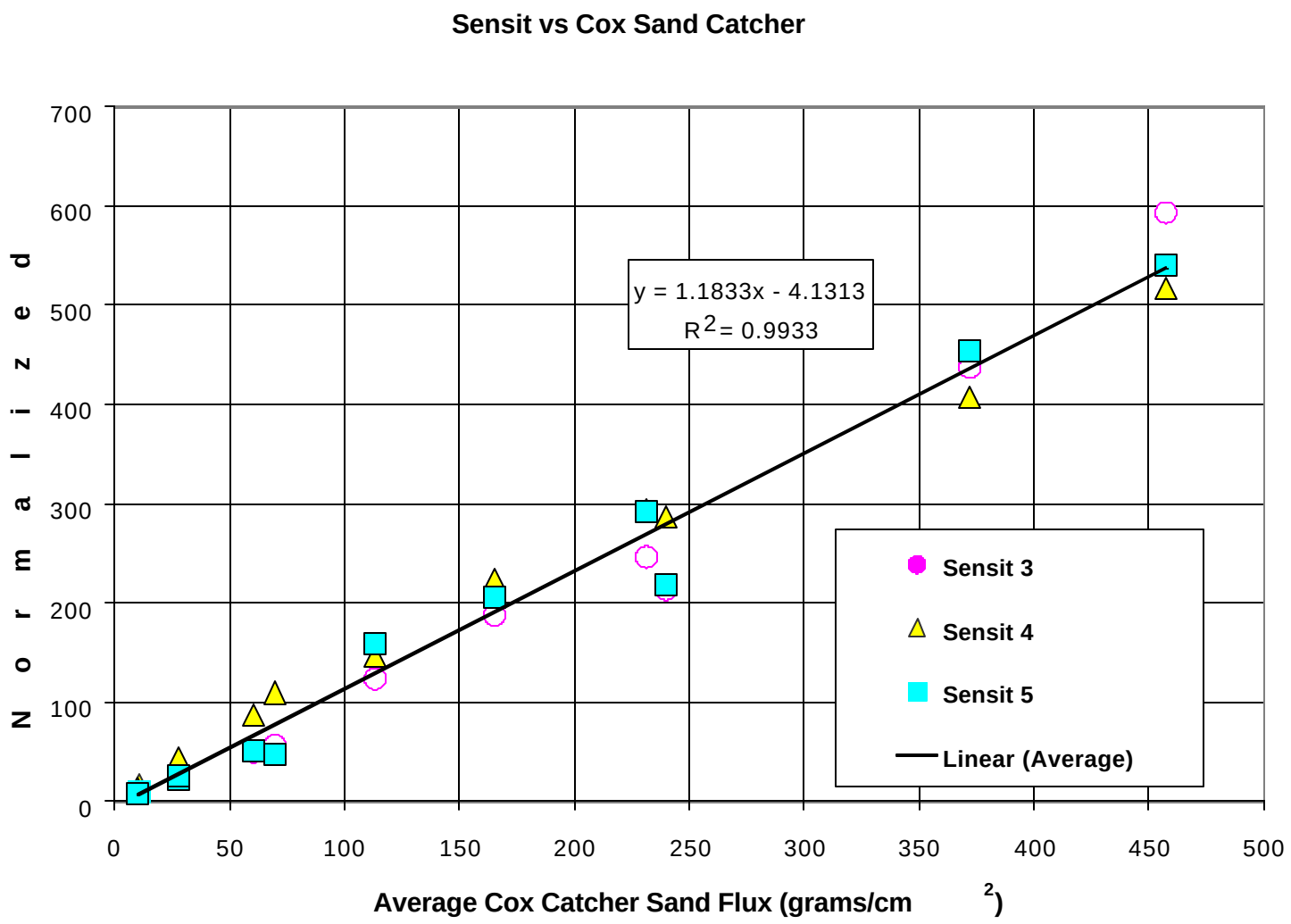


Sand Flux Monitors

- Cox Sand Catcher - Collects saltation-size particles
- Sensit ™ - Electronically records sand flux.

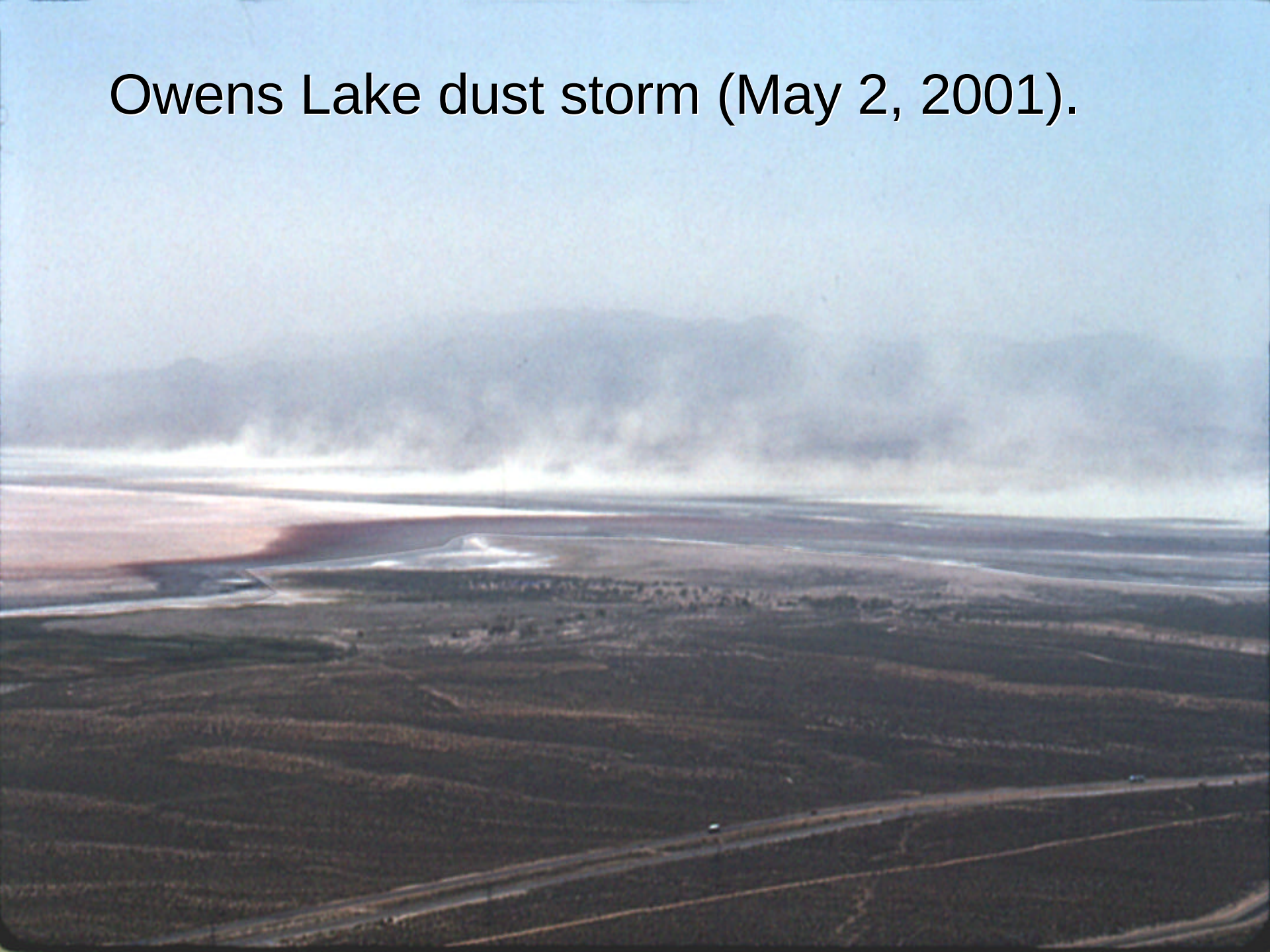



Cox Sand Catcher vs BSNE
y = 0.589x - 2.143
R2= 0.9773
avg std dev of bias = 4%
CSC-1
CSC-2
CSC-3
Linear (Average)
Cox
BSNE (grams)
0
100
200
300
400
500
600
700
800
900
sand99.xls/cox-scng(2)

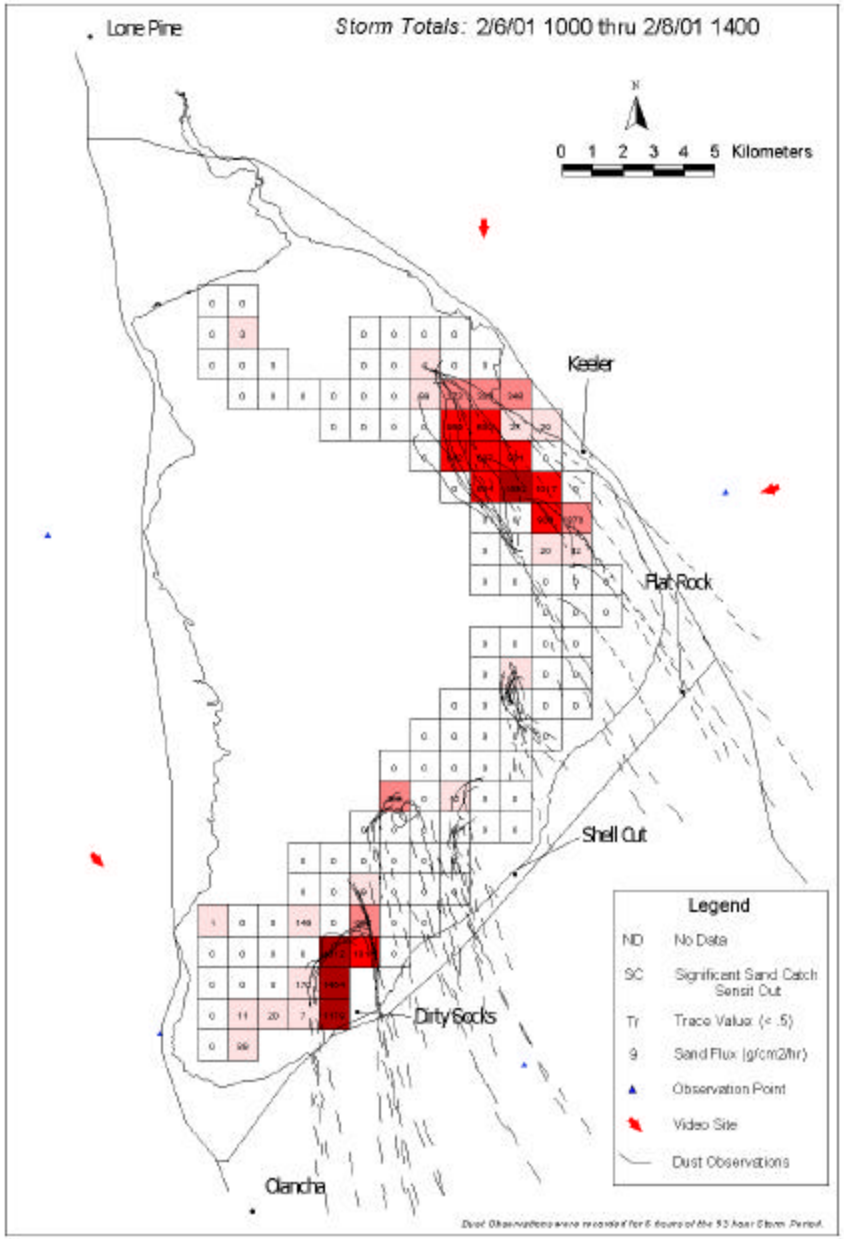

Sensit vs Cox Sand Catcher
Normalized
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
500
Average Cox Catcher Sand Flux (grams/cm 2)
y = 1.1833x - 4.1313
R2 = 0.9933
Sensit 3
Sensit 4
Sensit 5
Linear (Average)

A-TO-BODY

Owens Lake dust storm (May 2, 2001).

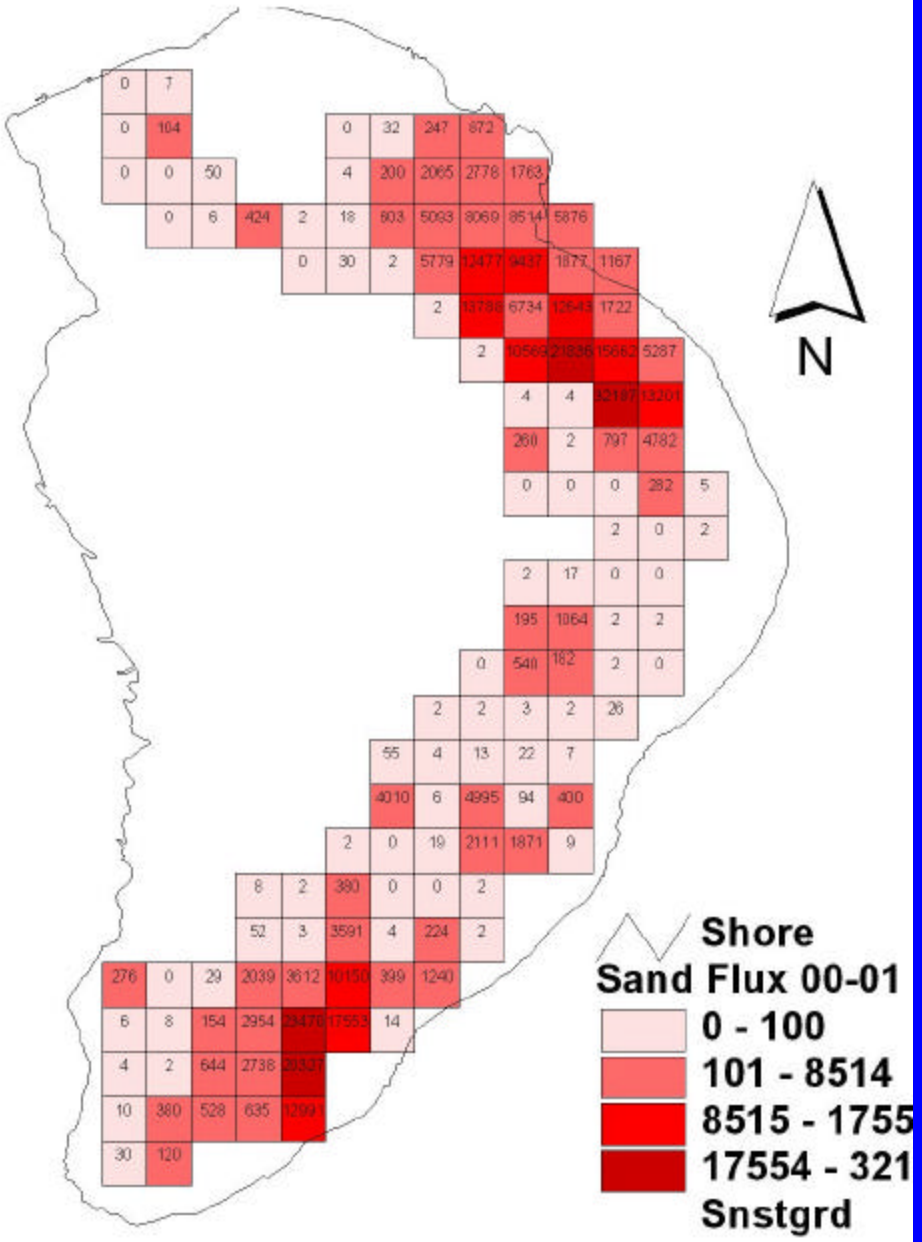


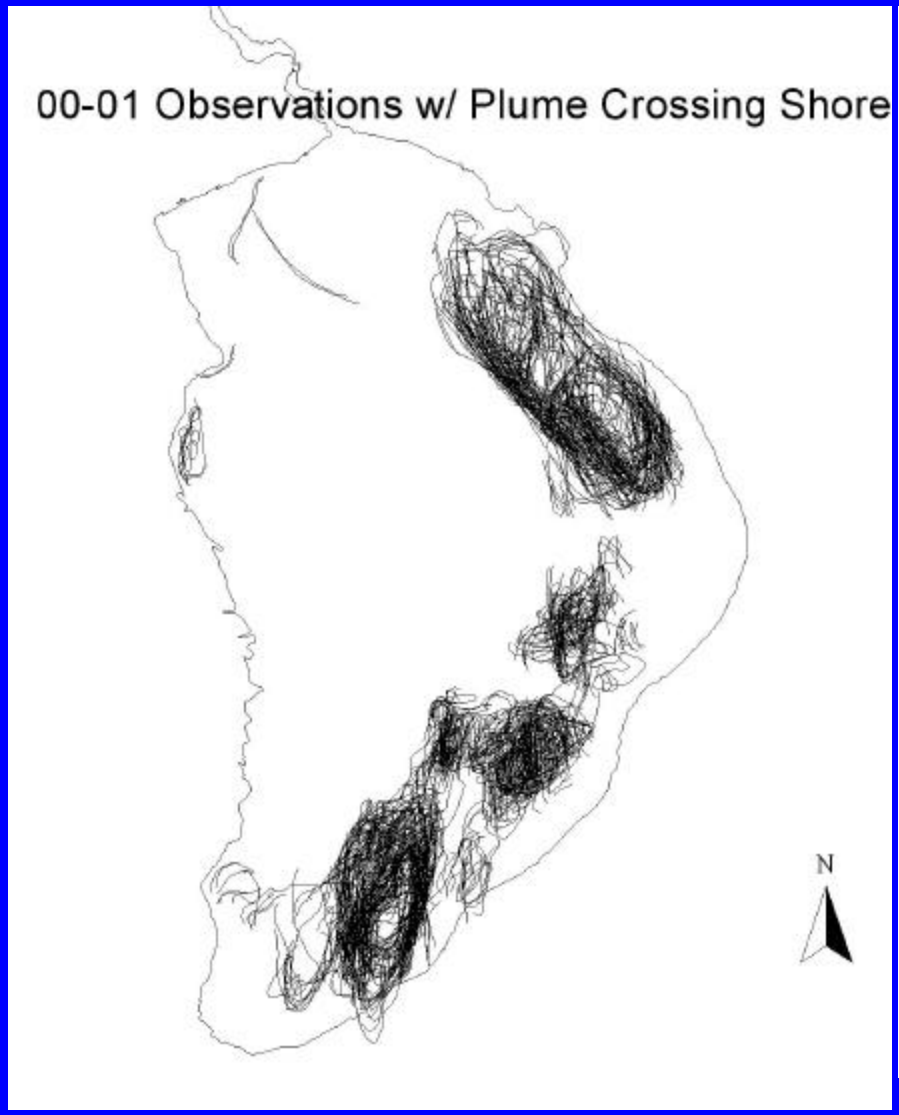
Owens Lake Dust ID Project

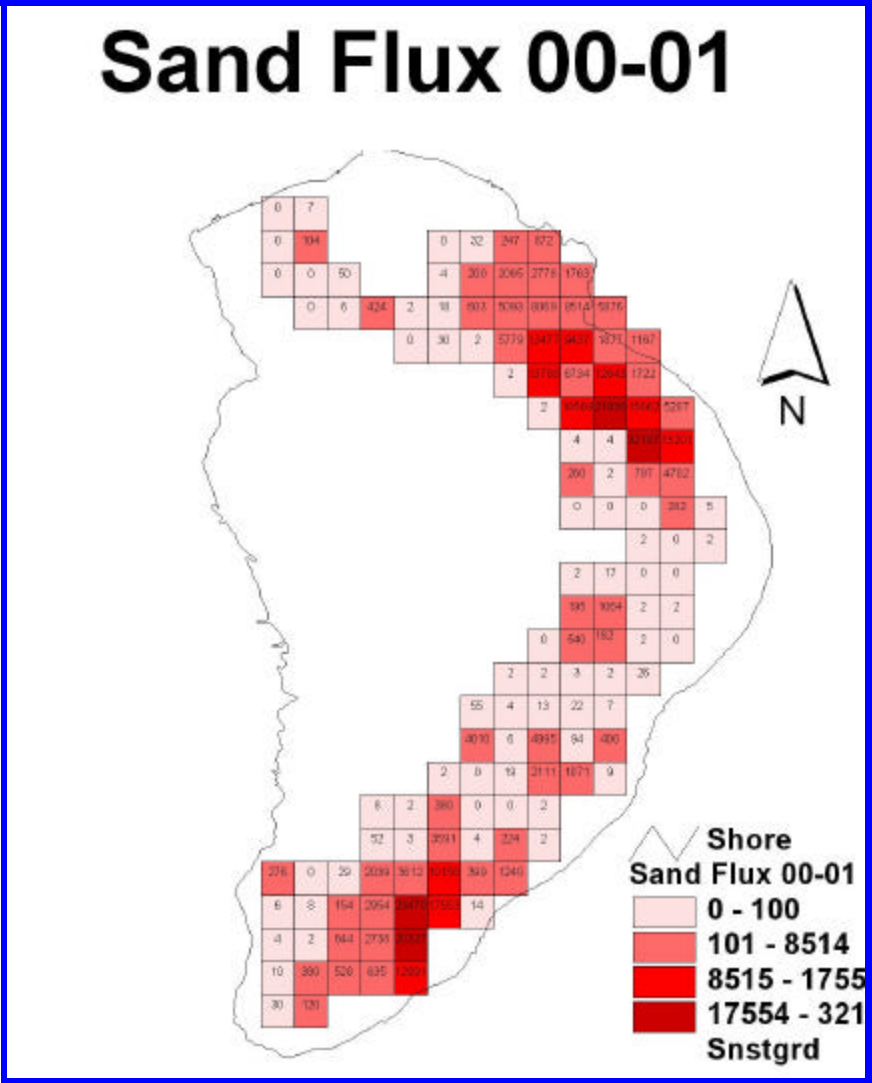


00-01 Observations w/ Plume Crossing Shore

Sand Flux 00-01




00-01 Observations w/ Plume Crossing Shore
N


Sand Flux 00-01
N
Shore
Sand Flux 00-01
0 - 100
101 - 8514
8515 - 1755
17554 - 321
Snstgrd

CALPUFF Dispersion Model

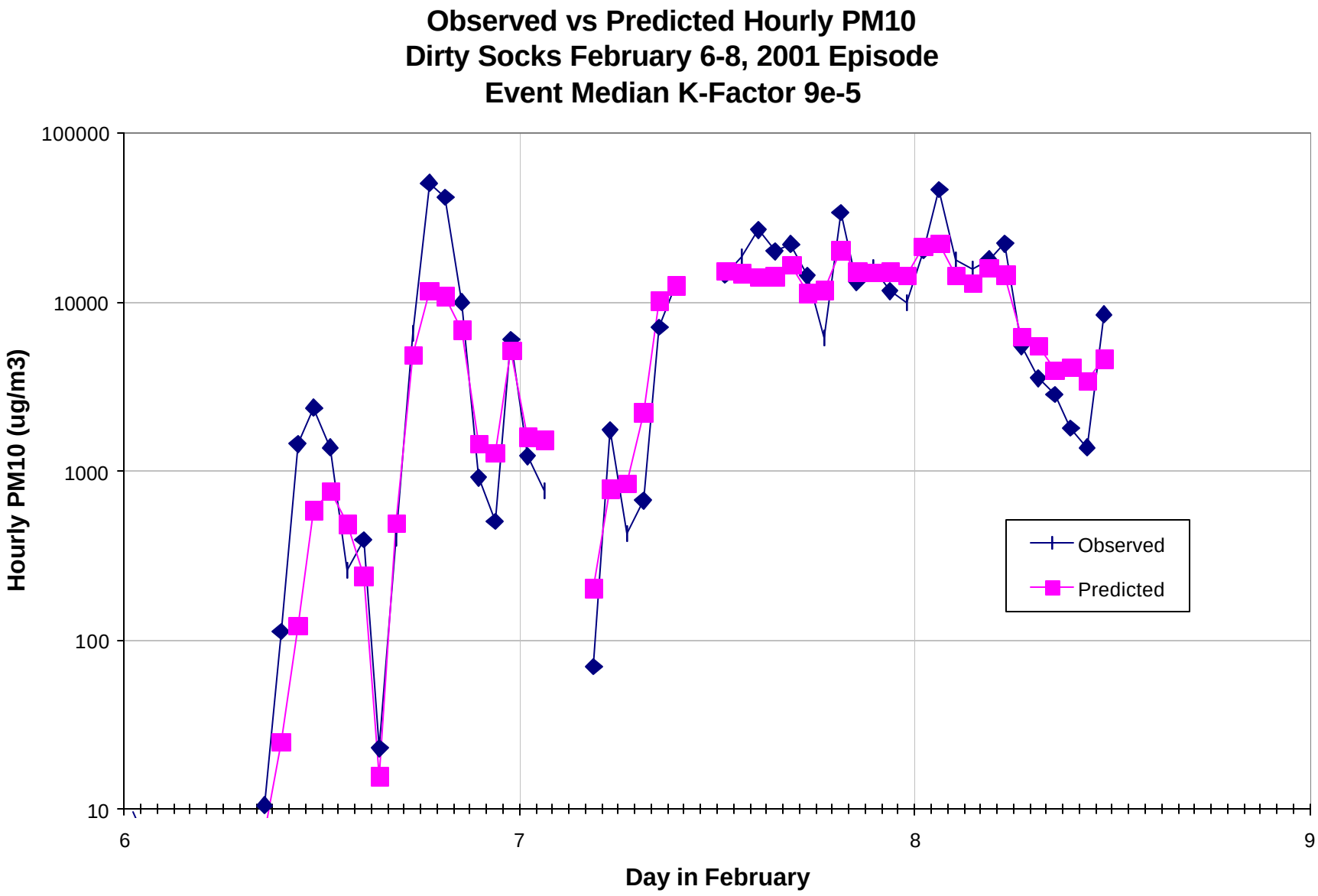
- CALPUFF is a gridded air dispersion model and uses CALMET generated wind fields.
- PM-10 emissions from each of 135 grid cells are based on hourly sand flux * K_f.
- K_f values are back-calculated by comparing the model prediction to the PM-10 monitor.

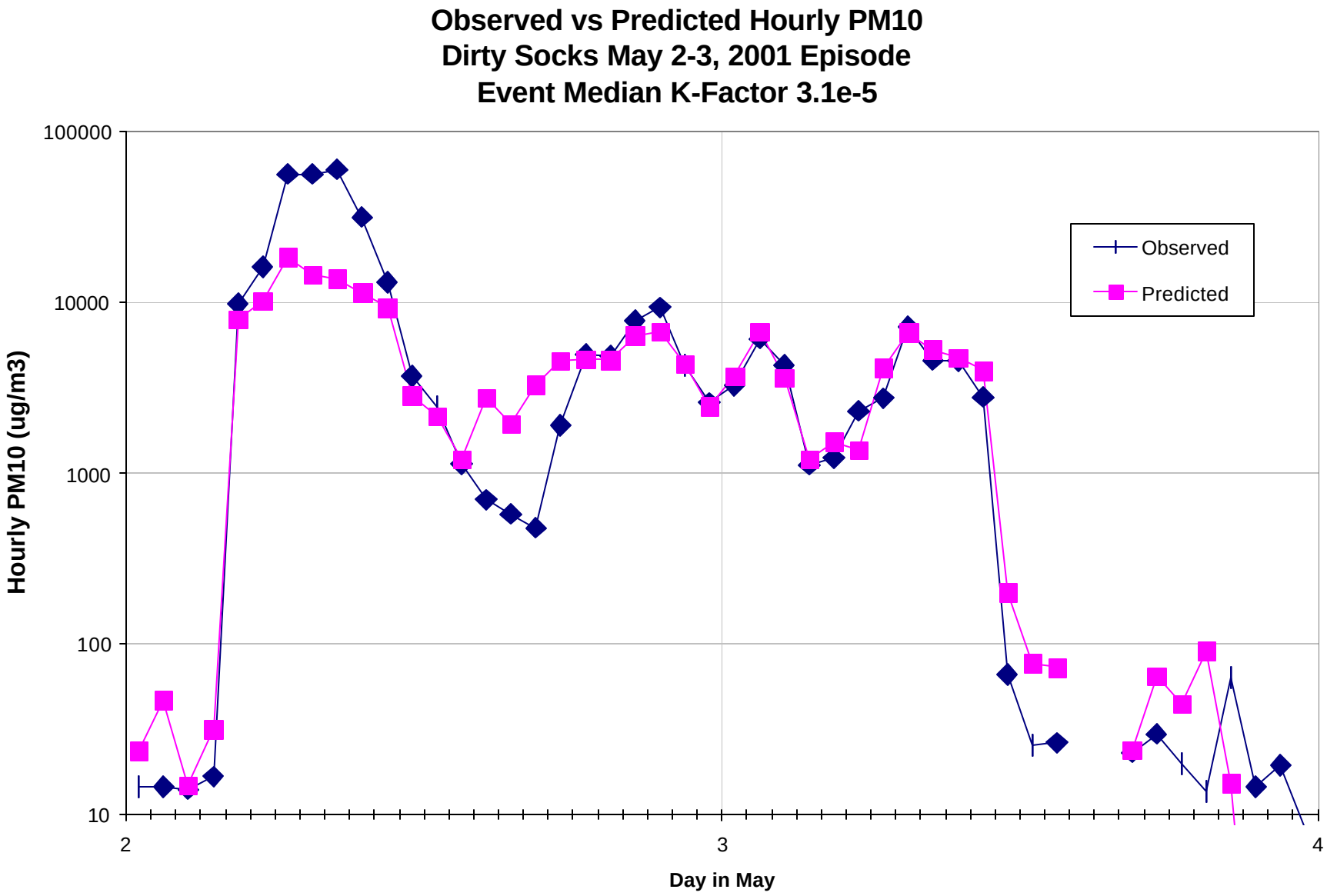
CALPUFF Model Animations

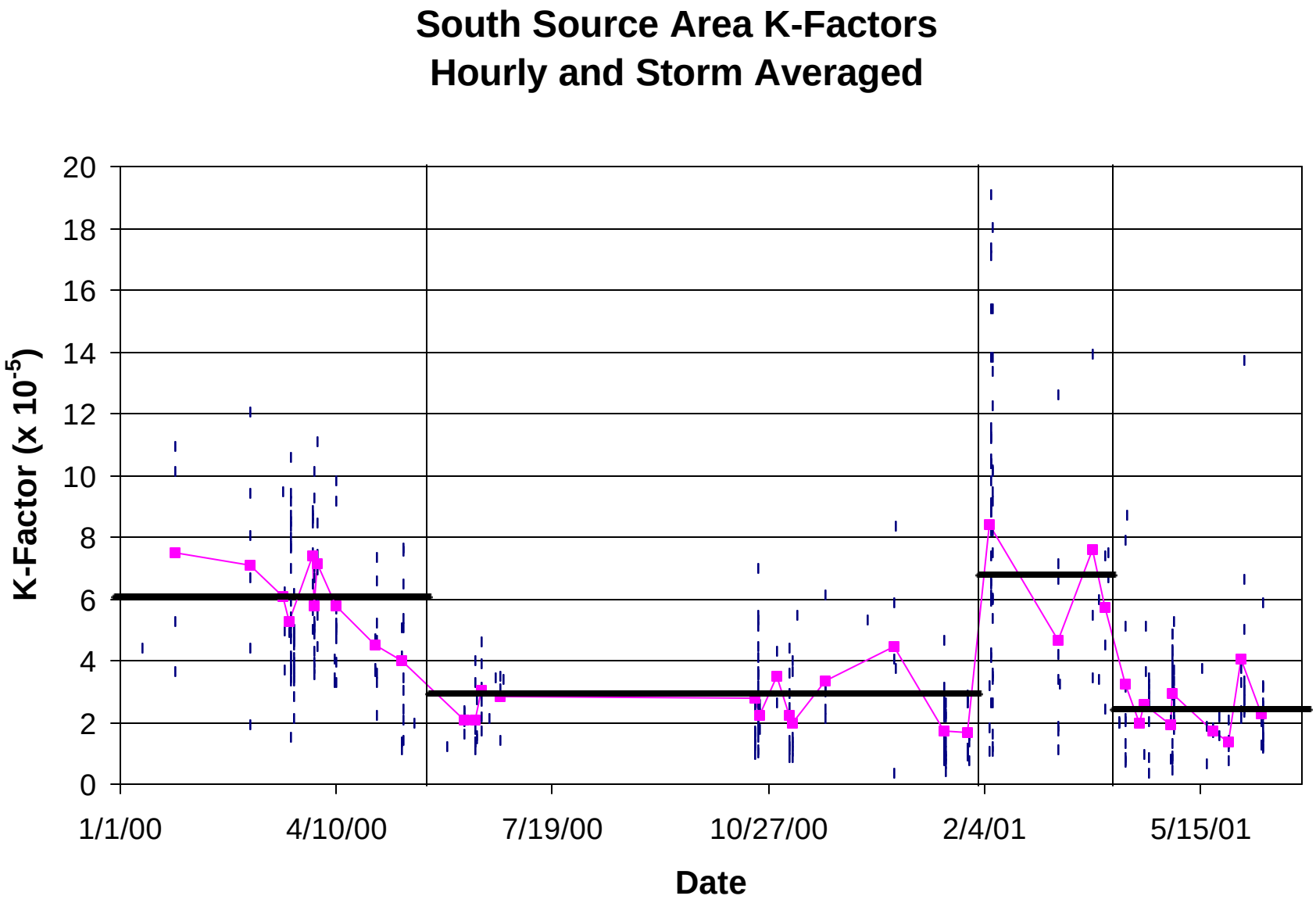
- **Dust Storm - February 6-8, 2001**
- **Dust Storm - May 2-3, 2001**

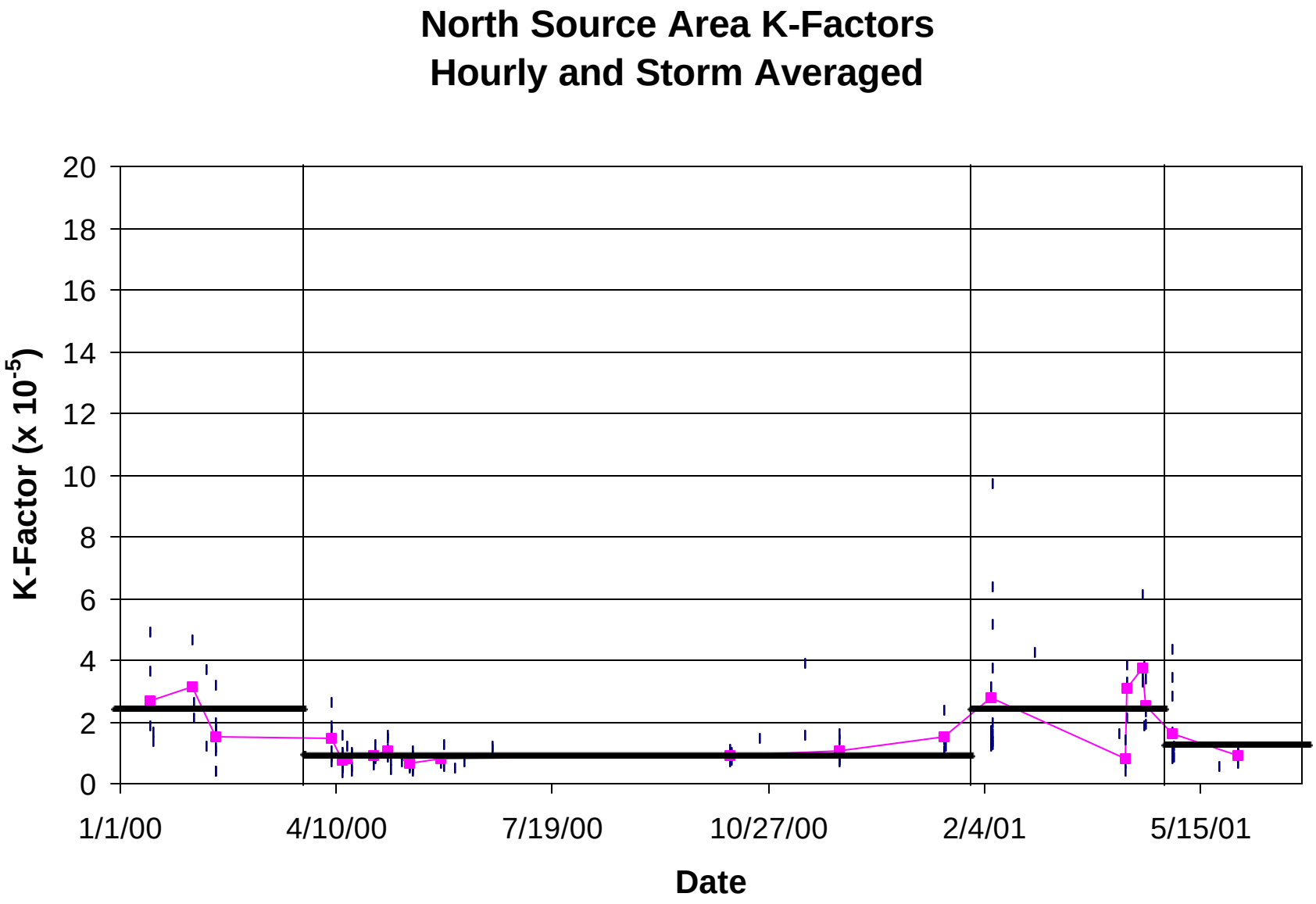
Model Concentrations Compared to Monitor Concentrations

- **February 6-8, 2001**
- **May 2-3, 2001**


Observed vs Predicted Hourly PM10
Dirty Socks February 6-8, 2001 Episode
Event Median K-Factor 9e-5
Hourly PM10 (ug/m3)
100000
10000
1000
100
10
6
7
8
9
Day in February
Observed
Predicted


Observed vs Predicted Hourly PM10
Dirty Socks May 2-3, 2001 Episode
Event Median K-Factor 3.1e-5
Hourly PM10 (ug/m3)
100000
10000
1000
100
10
2
3
4
Day in May
Observed
Predicted


South Source Area K-Factors
Hourly and Storm Averaged
K-Factor (x 10-5)
20
18
16
14
12
10
8
6
4
2
0
1/1/00
4/10/00
7/19/00
10/27/00
2/4/01
5/15/01
Date

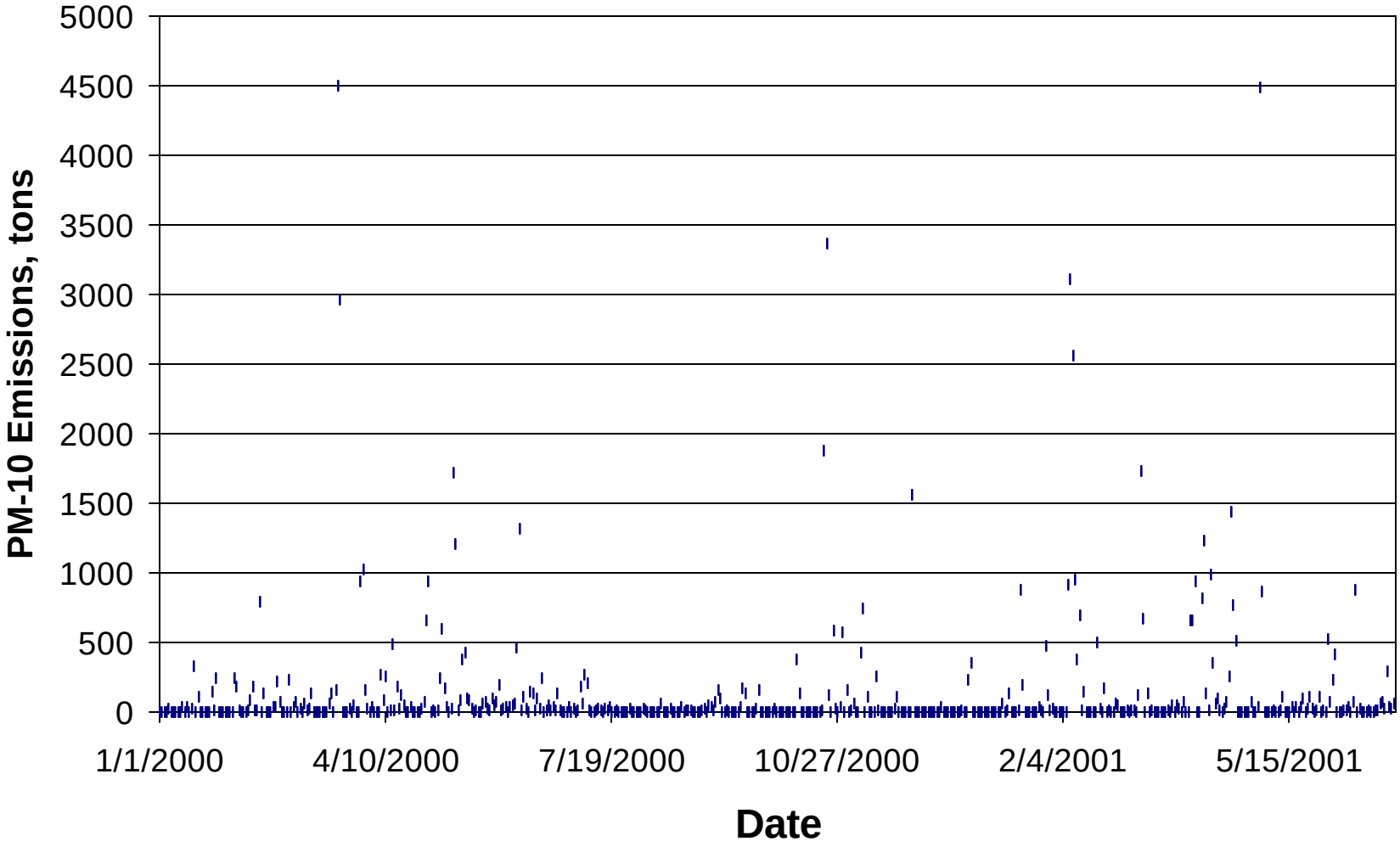

North Source Area K-Factors
Hourly and Storm Averaged
K-Factor (x 10-5)
20
18
16
14
12
10
8
6
4
2
0
1/1/00
4/10/00
7/19/00
10/27/00
2/4/01
5/15/01
Date

Owens Lake PM-10 Emissions

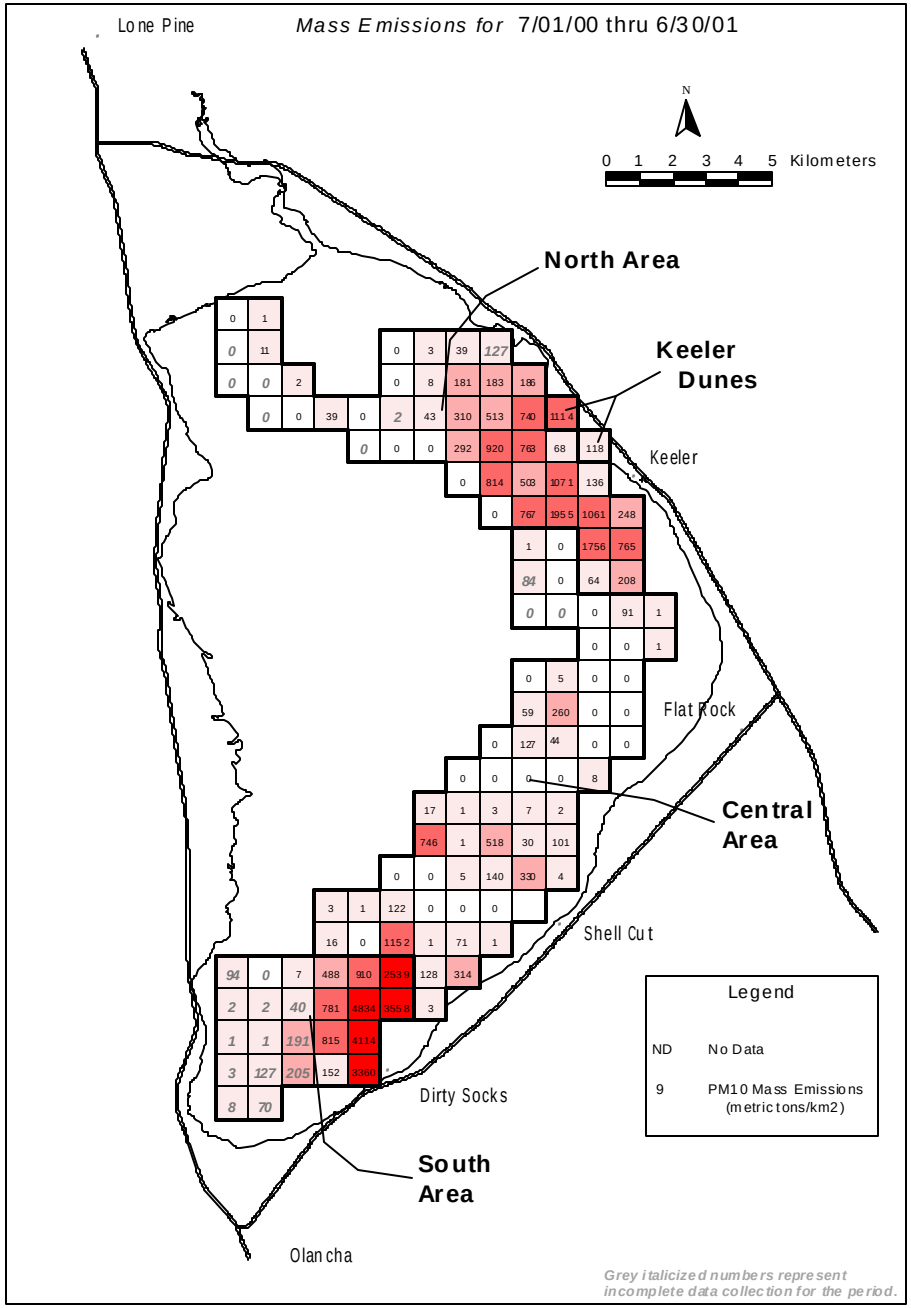
- **Wind Tunnel Emission Estimates**
- **Dust ID Emission Estimates**

Univ. of Guelph Wind Tunnel

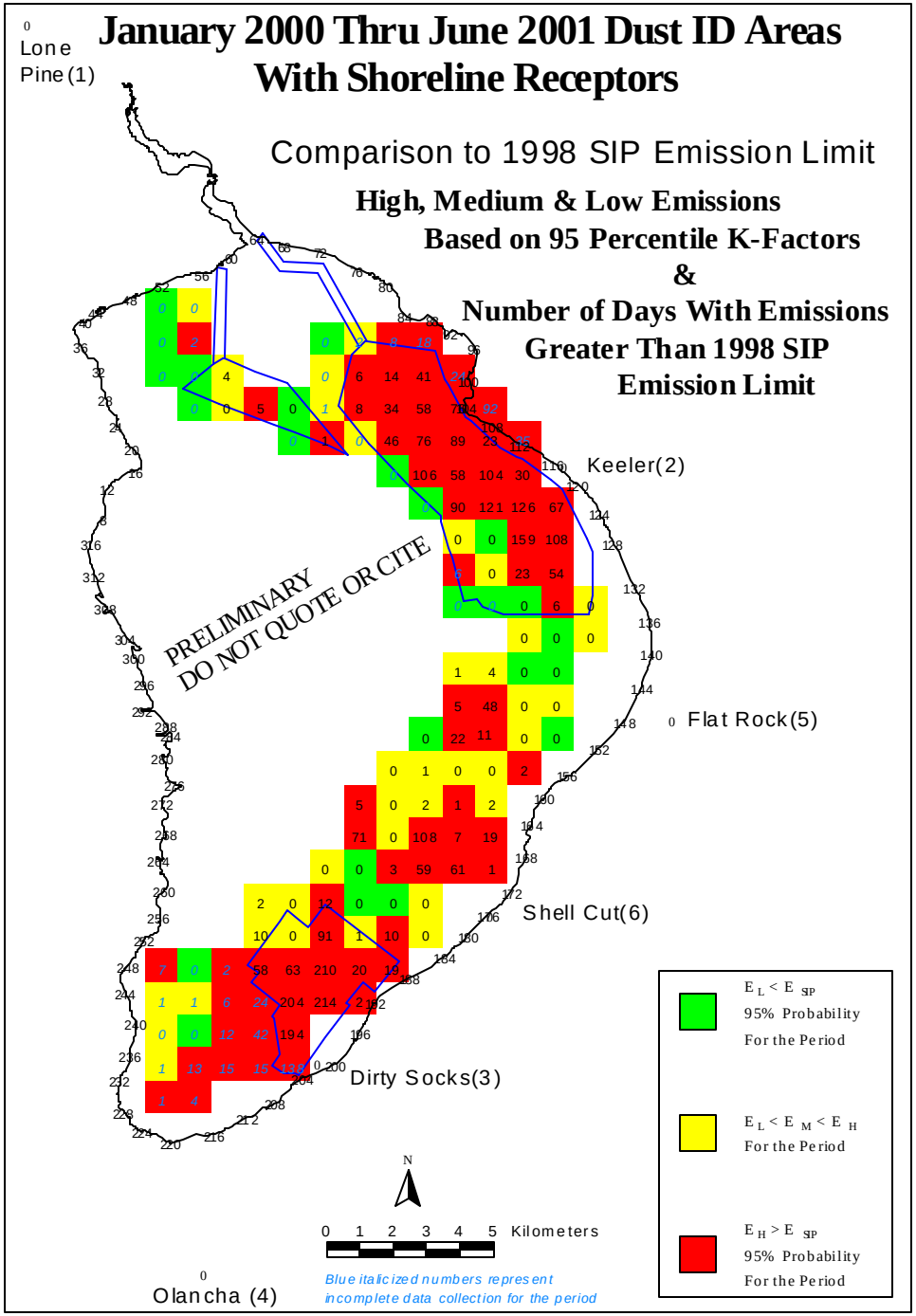
Estimated Daily PM-10 Emissions



Owens Lake Dust ID Project



January 2000 Thru June 2001 Dust ID Areas With Shoreline Receptors



Conclusions

- The Dust ID network of sand flux monitors and visual observations can identify dust source areas.
- PM-10 emissions from wind erosion can be estimated by using sand flux measurements.
- The Dust ID data can be used select control areas and to model attainment with the federal PM-10 standard for the 2003 SIP revision.