A Program to Determine ROG Emissions From Different Manure Handling Methods at California Dairies.

Charles Krauter

Center for Irrigation Technology and Plant Science Department

California State University, Fresno

5370 N. Chestnut Ave. M/S OF18

Fresno CA. 93720

charles_krauter@csufresno.edu

Matt Beene and Dave Goorahoo

Center for Irrigation Technology, California State University, Fresno

Donald Blake

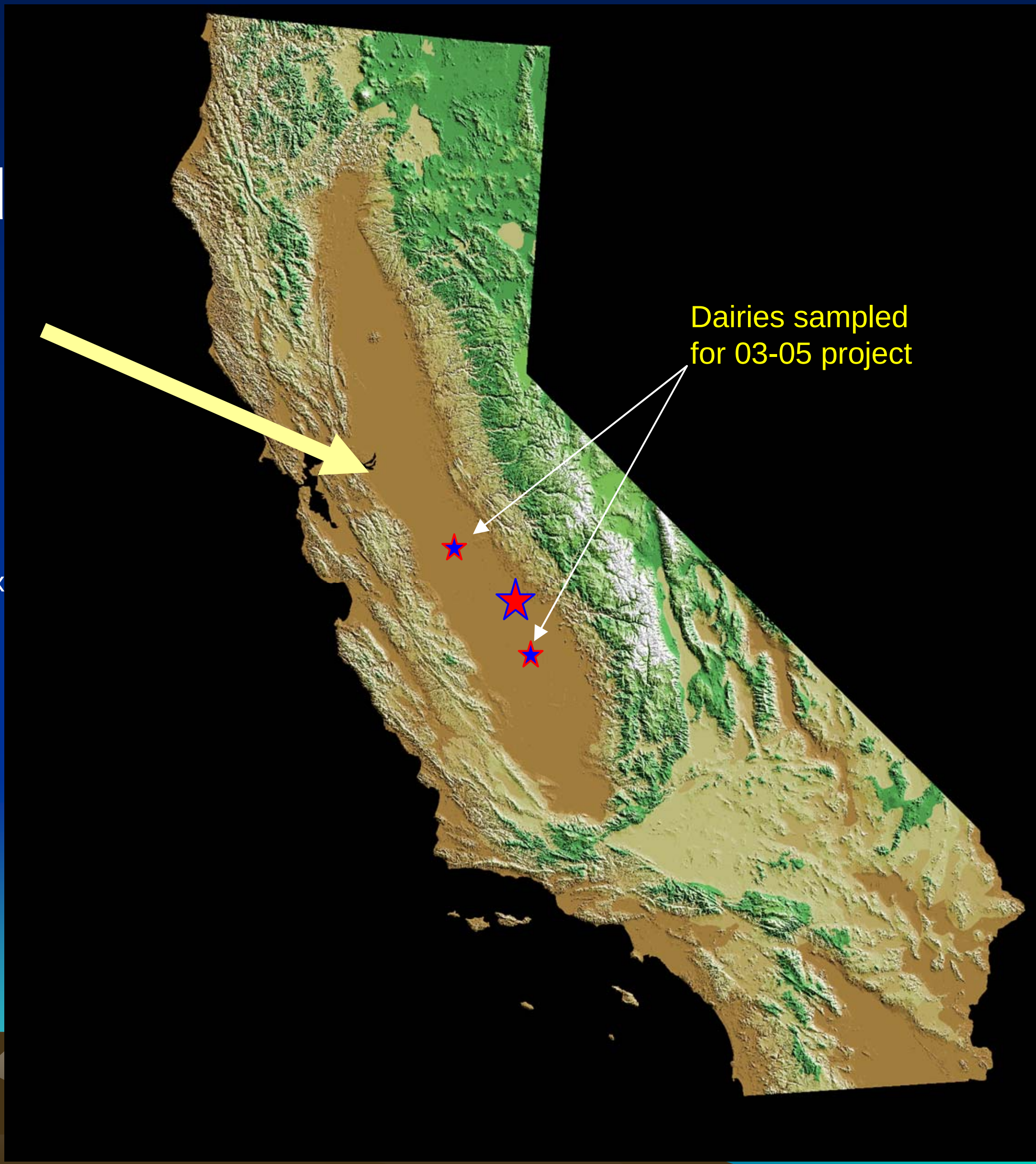
Department of Chemistry, University of California at Irvine

Abstract

A study of ROG emissions related to dairy operations was conducted at two Central California locations in 2003-04. Results from that study were presented at the ’05 EPA Emissions Inventory Conference. Monitoring and modeling methods developed for that project will be applied to a more comprehensive study to be conducted in 2005-08. The development of that program will be the focus of this paper.

Why does the Central Valley have air quality problems?

- Topography
  - bowl shaped
  - mountains and wind patterns
- Climate
  - long, hot summers
    produce ozone from ROG and NO_x
  - winter inversions
    trap particulates near the surface in a thin layer of atmosphere
- Growth
  - 10% of CA pop.



Sampling and modeling at selected dairies in the San Joaquin Valley (2003 to present)

- 1. Select "typical dairies" – about 2000 cows with flush-lane, free stall, lagoon systems

- 2. Determine field sampling procedure – collect samples in canisters upwind and downwind of each significant dairy process. Assume the difference between them is the emission from that process

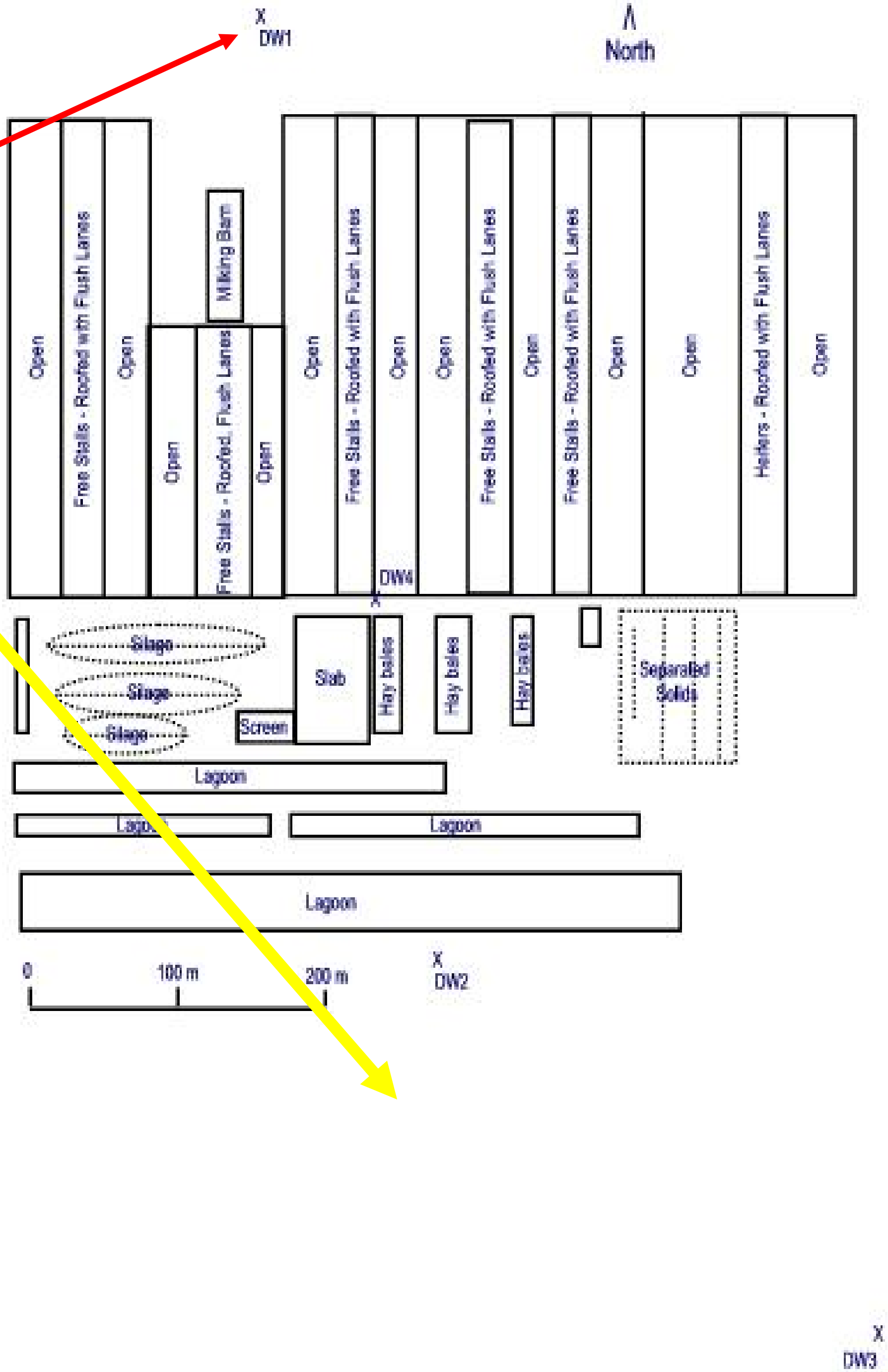
- 3. Collect and analyze samples –ROG analysis was initially for TNMHC at an outside lab and later EPA method TO-15 (GCMS utilizing an appropriate standard) to identify and determine the quantity of each gas.

- 4. Model emissions – estimate emission rates from the net concentration difference using an EPA approved computer model (ISC-STv3) to calculate the emissions from an area source and report in pounds per animal per year.

Dairy A
Sampling Locations:

Upwind

Prevailing wind = 320 degrees

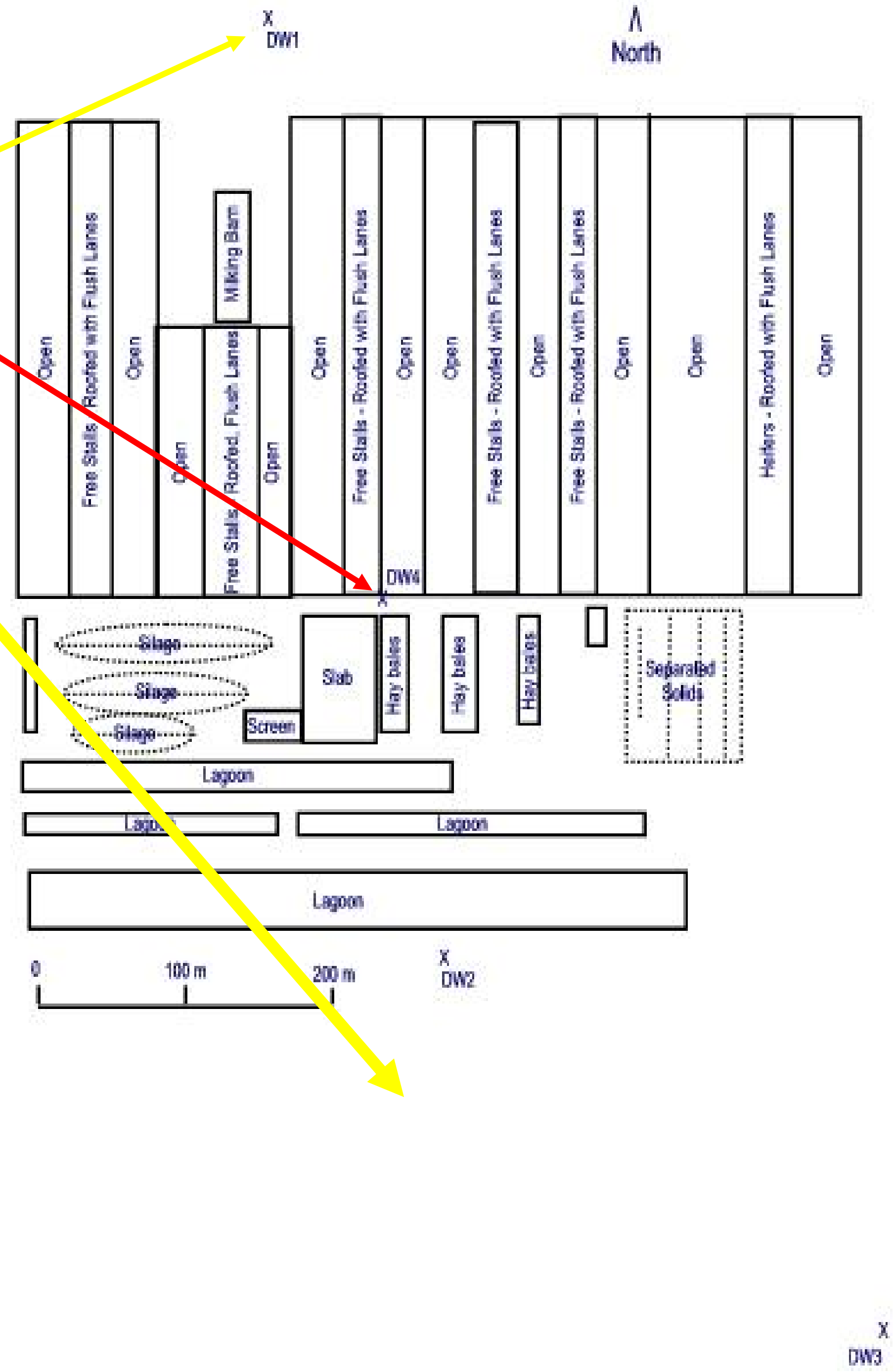


Dairy A
Sampling Locations:

Upwind

Downwind of the Free Stalls

Prevailing wind = 320 degrees



Dairy A

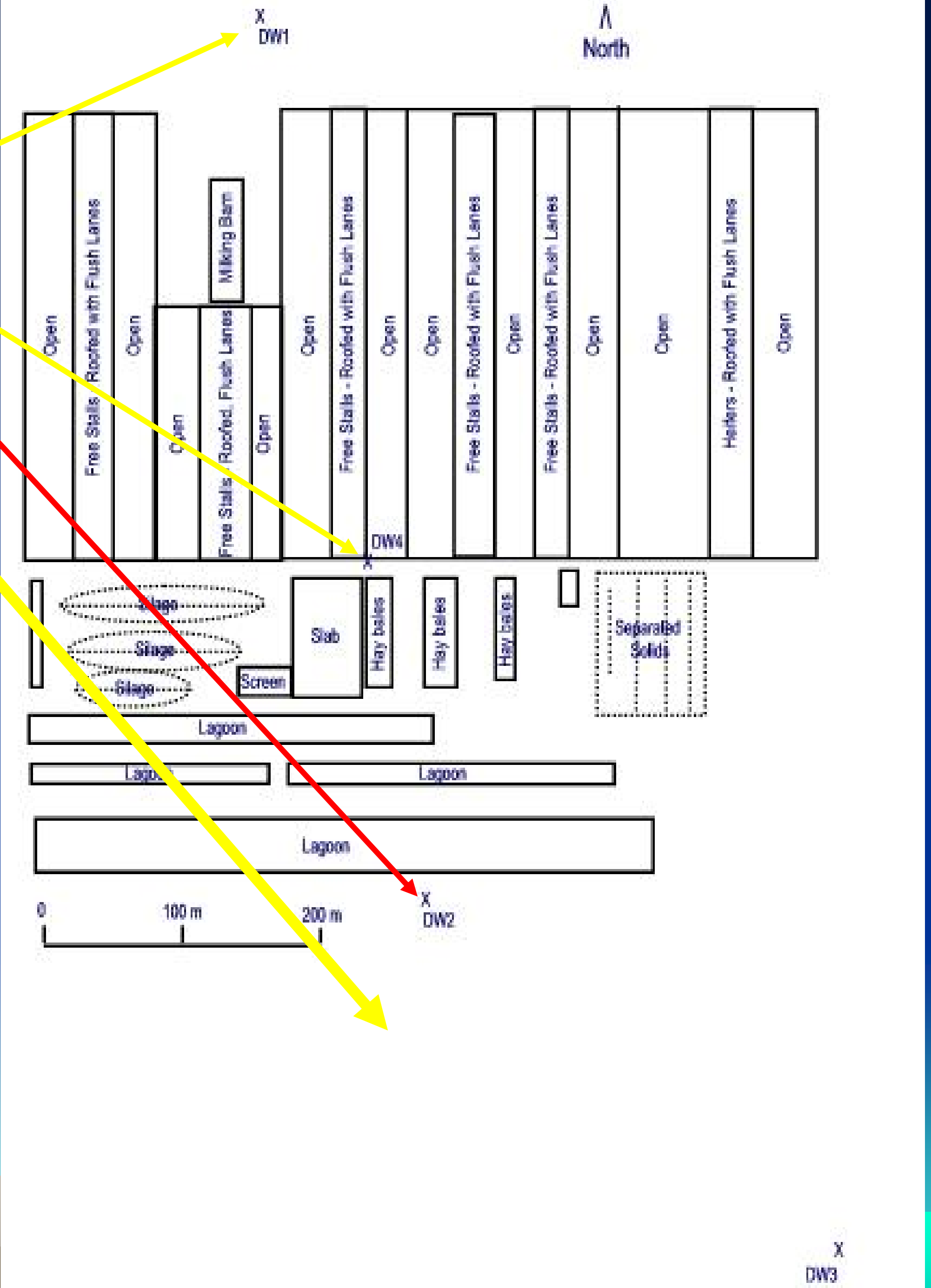
Sampling Locations:

Upwind

Downwind of the Free Stalls

Downwind of the Lagoon System

Prevailing wind = 320 degrees

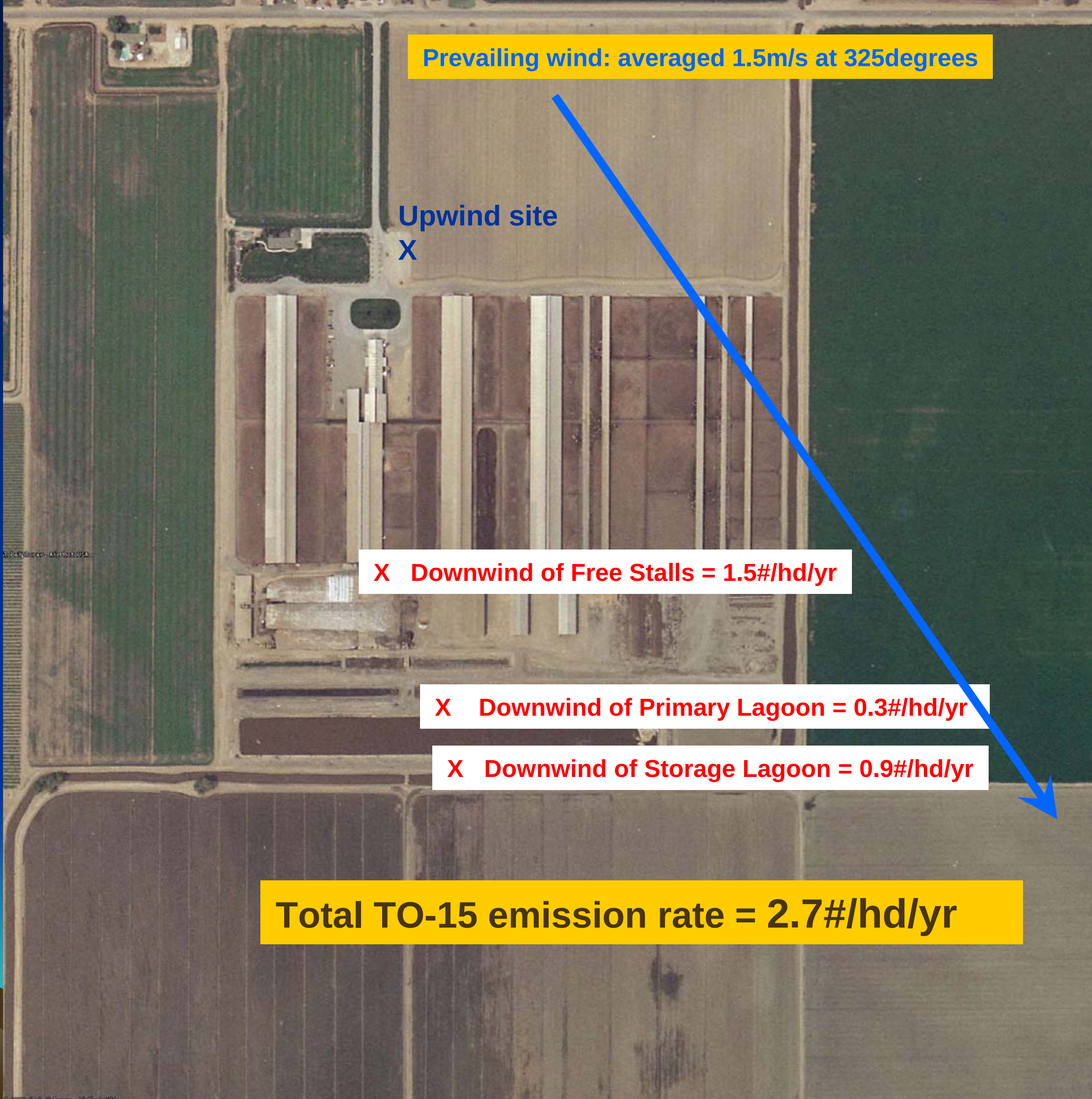


Dairy A

July 22, 2004

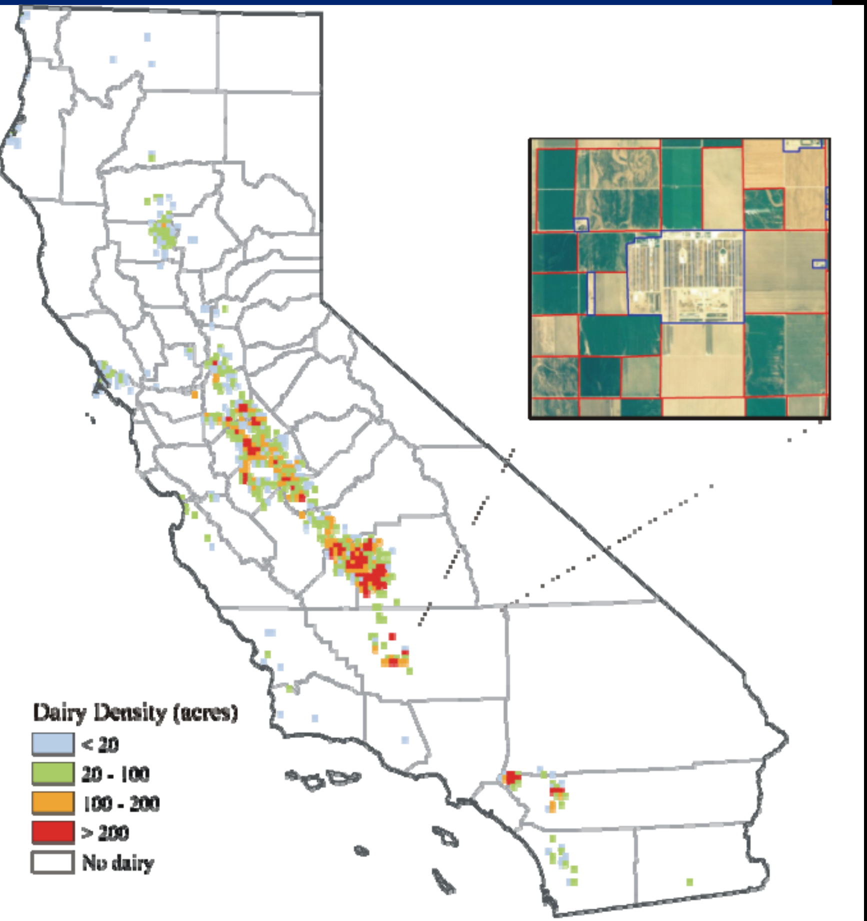
1330 to 1600

Summer wind direction (325) and speed (1.5m/s) were typical for this location. Wind speed in the early afternoon was less than at other locations but the direction was sufficiently consistent for modeling.

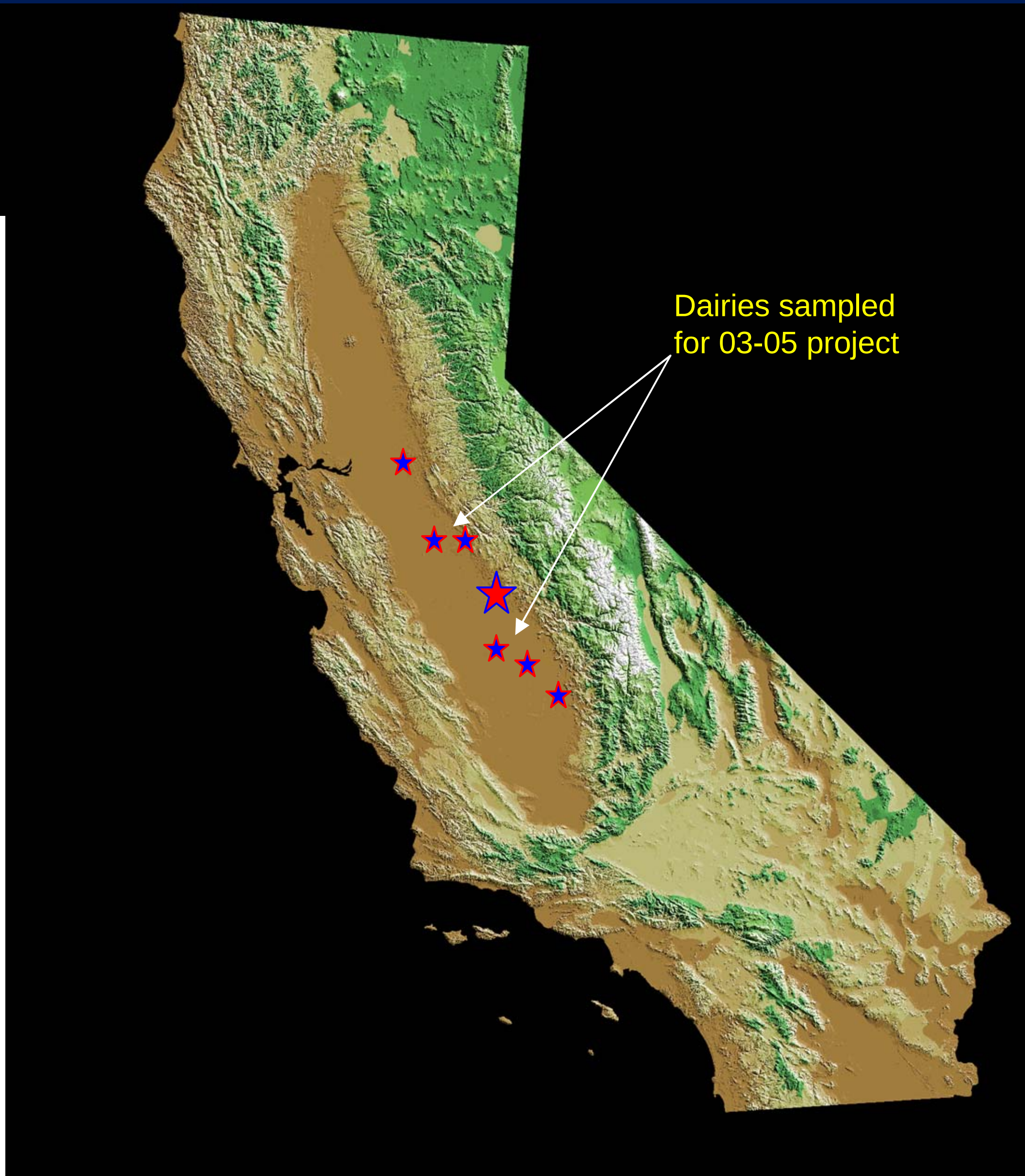


Dairy Air Quality Projects in the Central Valley

- Currently, a second project funded by the CARB and CSU-ARI will monitor emissions from six dairies in the valley to document practices that can reduce ROG emissions.



Data Source: California Department of Water Resources land use survey database (http://www.landwateruse.water.ca.gov)



Planned Projects:

- Phase 2 of CARB funded project will add 4 dairies with innovative management systems to the 2 typical dairies and analyze for additional compounds. Emphasis will be on comparing emissions from different manure handling systems and evaluation of seasonal and day/night differences in emissions (July'05 to June'07)

- Matching CSU Ag Research Initiative funding will add analytical capability for VFA's, alcohols, and other non-canister procedures as well as an additional year (September'05 to June'08)

- USDA and UNH funding to study Nitrogen/Carbon ratios at the same 6 dairies. (July'05 to June'08)

“Typical” CA Dairy

- Free stalls and exercise corrals.
- Flush lane manure collection system.
- Separation of solids and liquid.
- Solids used for bedding and field spreading.
- Storage of liquid in lagoon system for flush water and recycling of nutrients to cropland
- Dairies A, B, C, and D


Exercise Pen
Free-stall
Animal Housing
Screen
Fresh Water
Lagoon
Field


Feed Lane
Flush Water
Flush Lane

Solids Separation

Paddle screen for better separation efficiency

Dairy C: solids separation slab

Dairy E: Solids separation by screw press

Dairy A: spreading coarse solids in a corral


Spreading solids on cropland


Flush water and fine solids are treated and stored in ponds called “lagoons”
Dairy C: secondary lagoon

Dairy B: Lagoon

1. Source of flush-lane water
2. Source of irrigation/fertilizer for surrounding cropland
3. Flood control and runoff capture

Dairy C: Processing pit for initial separation by settling of heavy solids and floating of light solids


Dairy C: Sequential, high volume, low loading lagoons with mechanical circulation


Dairy C: Low organic loading supports sulfur reducing, photosynthetic, purple bacteria that appears to reduce odors and may affect ROG emissions.

Alternative Dairy E

- Free stalls and exercise corrals.
- Manure/urine slurry is vacuumed into a truck to avoid the use of flush water.
- Manure slurry is fed into a digester to generate methane and possibly to reduce ROG emissions.
- Treated slurry is separated with solids used for bedding and liquid stored in a lagoon for subsequent cropland application.

Dairy E: Vacuum truck to collect manure slurry

Dairy E: Vacuum truck delivering manure slurry to a digester

Dairy E: Methane digester. Residence time = 21 days, Supplies 100kW generator

Dairy E: Digested slurry in storage pit prior to solids separation


Dairy E: Solids separation by screw press

Alternative Dairy F

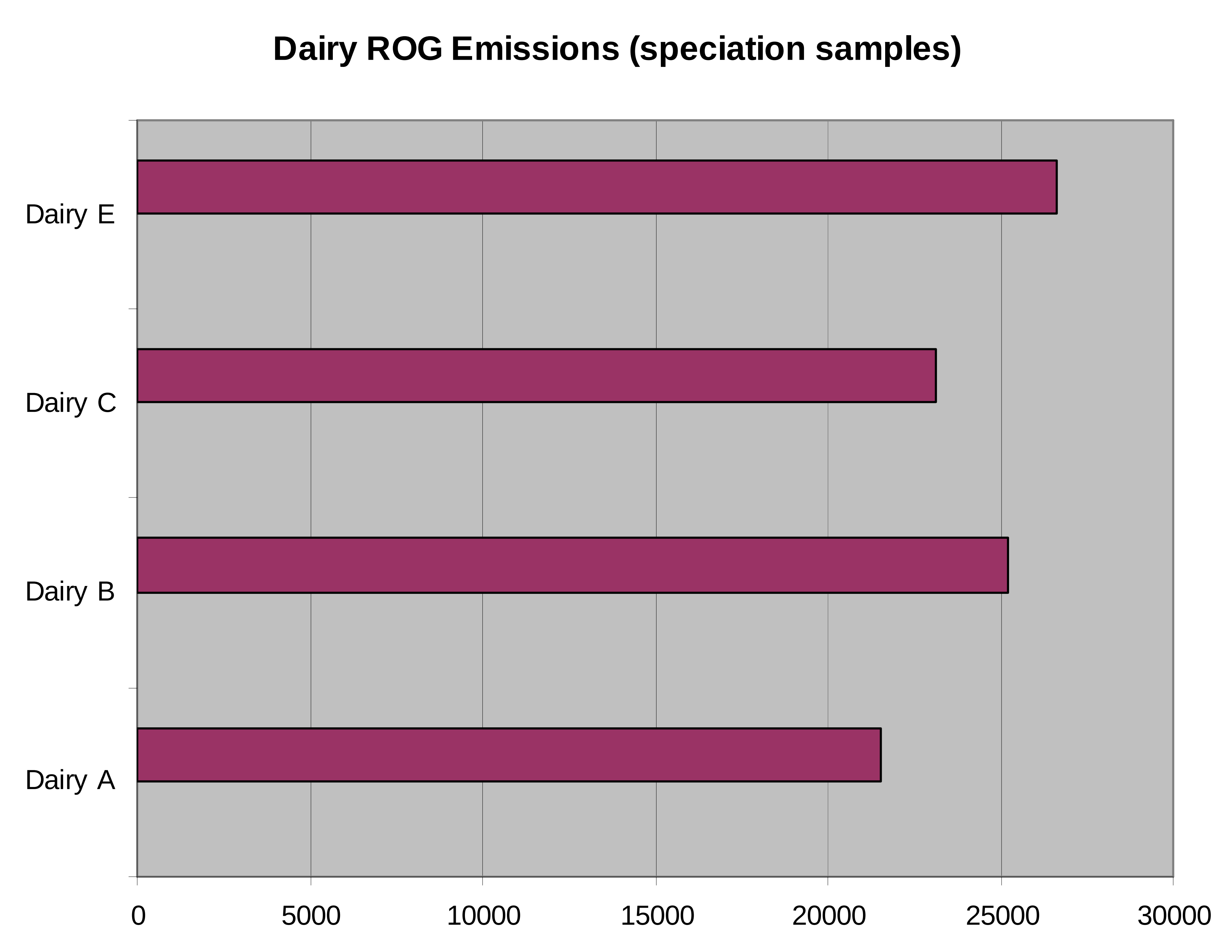
- Free stalls and exercise corrals
- Manure/urine slurry scraped into a collection pit.
- Manure slurry pumped into a large tank-trailer for injection below the soil surface of cropland.

Dairy F: Manure slurry collected by scraper and applied to cropland

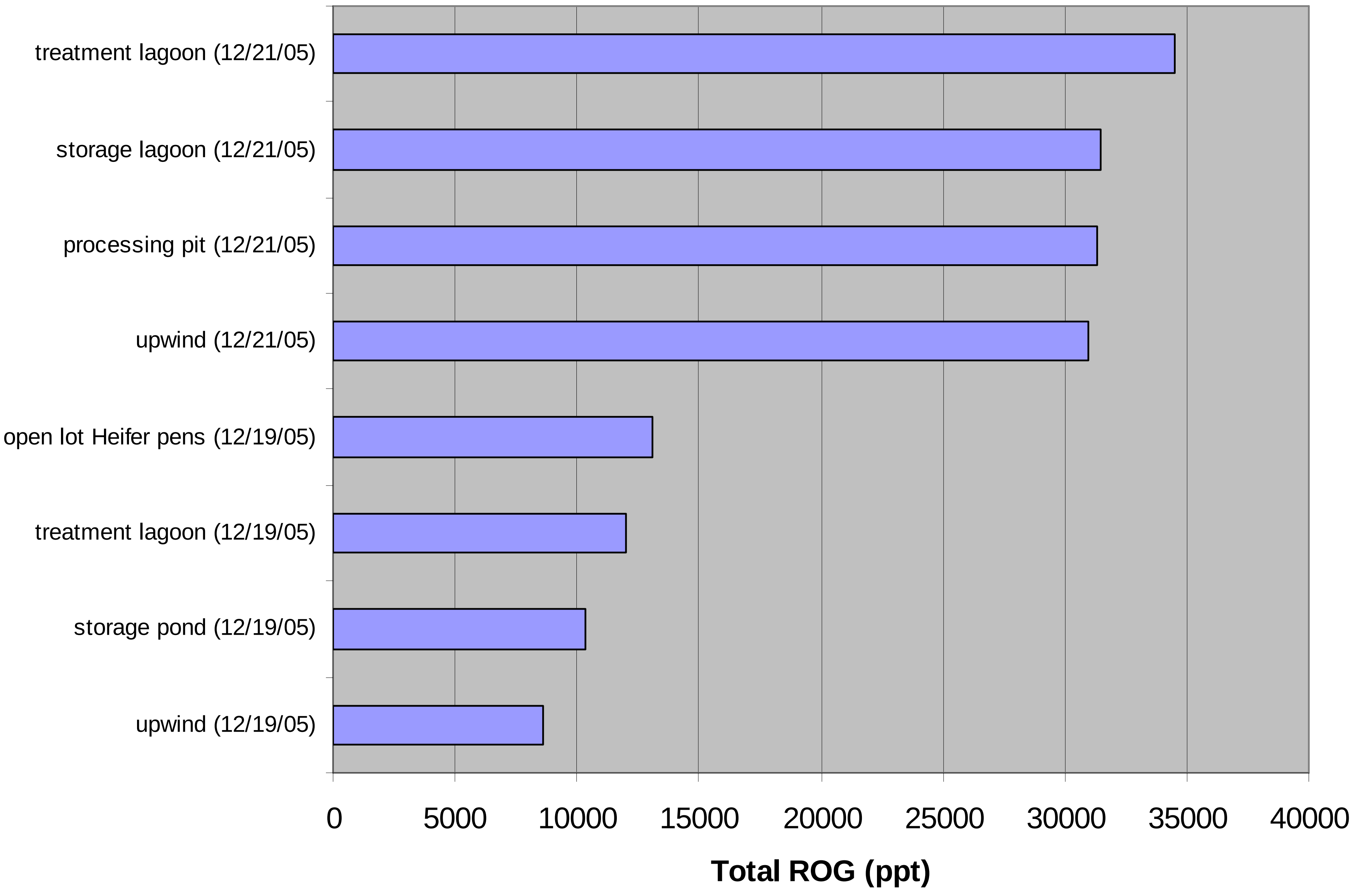
Initial sampling for ROG's in the Fall of 2005 was to provide a variety of dairy sources to the UC Irvine lab to begin the development of a "dairy fingerprint" by speciation of the samples into a list of identified gasses.

These gasses have been identified by Dr. Blake at UC Irvine from canisters sampled for speciation.

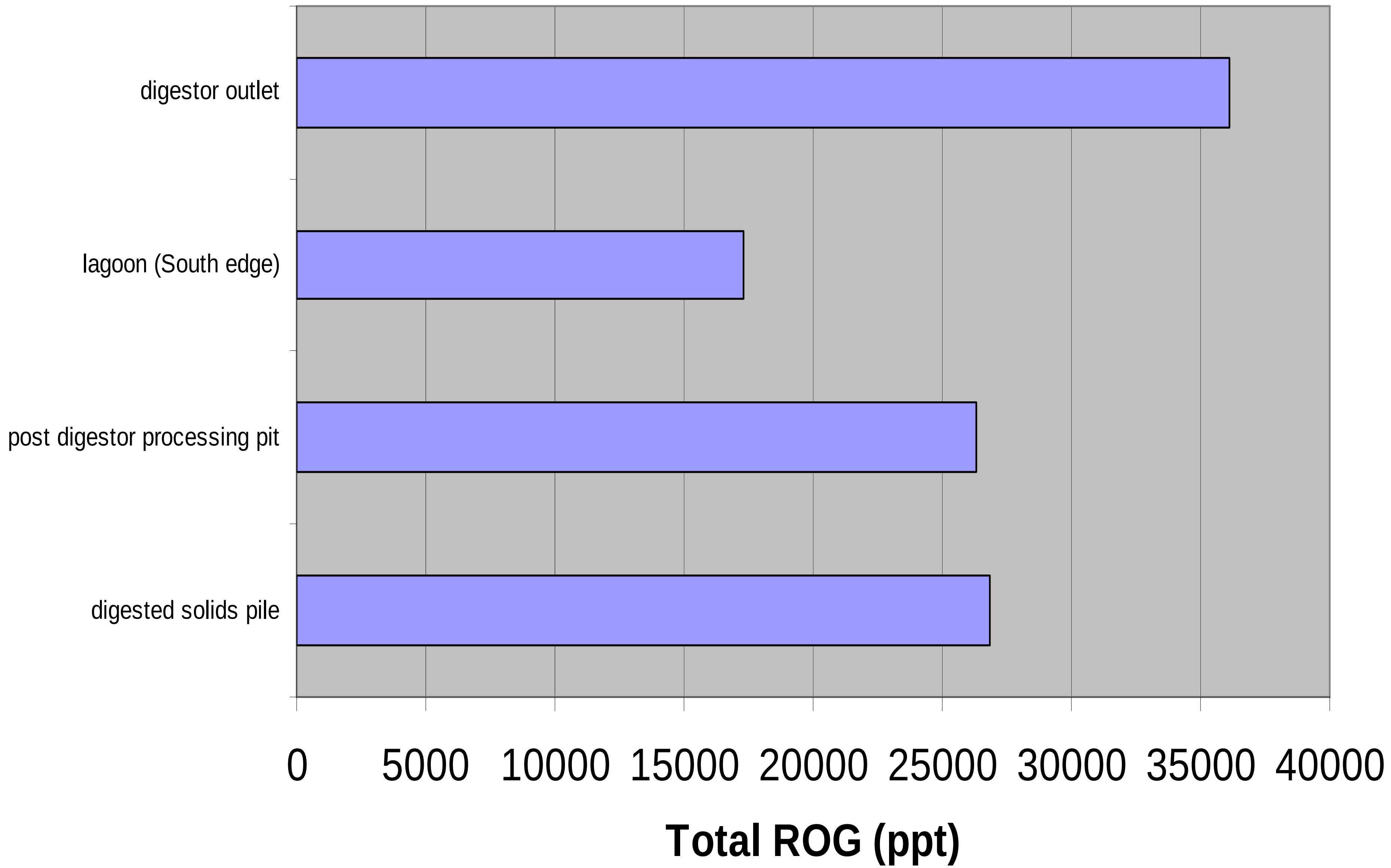
Compound	**Compound Name**	Molecular Weight (g/mol)	CAS #
Methane			
OCS (MS)	Carbonyl Sulfide	60.07	463-58-1
DMS (MS)	Dimethylsulfide	62.14	75-18-3
CS2 (MS)	Carbon Disulfide	76.14	75-15-0
CFC-12 (C/D/MS)	Dichlorodifluoromethane	120.91	75-71-8
CFC-11 (C/D/MS)	Trichlorofluoromethane	137.38	75694
CFC-113 (D/MS)	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-	187.37	
CFC-114 (MS)	1,2-Dichloro-1,1,2,2-tetrafluoroethane	170.92	
H-1211 (D/MS)	hexadecane	226.45	544-76-3
HFC-134a (MS)	hafnium carbide	190.50	12069-85-1
HCFC-22 (MS)	chlorodifluoromethane		75-45-6
HCFC-142b (MS)	1-Chloro-1,1-difluoroethane	100.50	
HCFC-141b (MS)	1,1-dichloro-1-fluoroethane	116.95	1717-00-6
CHCl3 (C/D/MS)	Chloroform	119.38	67-66-3
CH3CCl3 (C)	Ethane, 1,1,1-trichloro-	133.40	71-55-6
CCl4 (C/MS)	Carbon tetrachloride	153.82	56-23-5
CH2Cl2 (C/MS)	Methylene chloride	84.93	75-09-2
C2HCl3 (D)	Trichloroethylene	131.39	79-01-6
C2Cl4 (C/MS)	Tetrachloroethylene	165.83	127-18-4
CH3Cl (MS)	Methyl chloride	50.49	74-87-3
CH3Br (MS)	Methyl bromide	94.94	74-83-9
CH3I (C/D)	Methyl iodide	141.94	74-88-4
CH2Br2 (D)	Methane, dibromo-	173.83	74-95-3
CHBr3 (MS)	Methane, tribromo-	252.73	75-25-2
MeONO2 (C/D)	Methyl nitrate	77.04	598-58-3
EtONO2 (C/D)			
i-PrONO2 (C/D)			
n-PrONO2 (C/D)			
2-BuONO2 (C/D)			
3-PeONO2 (D)			
2-PeONO2 (D)			
Ethane (E)		30.07	74-84-0
Ethene (E)		28.05	74-85-1
Ethyne (E)	Acetylene	26.04	74-86-2
Propane (E/B)		44.10	74-98-6
Propene (E/B)		42.08	115-07-1
i-Butane (E/B)	isobutane	58.12	75-28-5
n-Butane (E/B)	butane	58.12	106-97-8
1-Butene (E)		56.11	106-98-9
i-Butene (E)		56.11	115-11-7
trans-2-Butene (MS)		56.11	624-64-6
cis-2-Butene (MS)		56.11	590-18-1
i-Pentane (E)		72.15	
n-Pentane (E)		72.15	109-66-0
1,3-Butadiene (E)		54.09	106-99-0
Isoprene (E/B/MS)		68.12	78-79-5
n-Hexane (E/B/MS)		86.18	110-54-3
2-Methylpentane (B)		86.18	107-83-5
3-Methylpentane (B)		86.18	96-14-0
Benzene (E/B/MS)		78.11	71-43-2
Toluene (E/B/MS)		92.14	108-88-3
Ethylbenzene (MS)		106.17	100-41-4
m-Xylene (MS)		106.17	108-38-3
p-Xylene (MS)		106.17	106-42-3
o-Xylene (MS)		106.17	95-47-6
m-Ethyltoluene (MS)		120.19	620-14-4
o-Ethyltoluene (MS)		120.19	611-14-3
1,3,5-Trimethylbenzene (MS)		120.19	108-67-8
1,2,4-Trimethylbenzene (MS)		120.19	95-63-6
alpha Pinene (MS)		136.23	80-56-8
beta Pinene (MS)		136.23	127-91-3
Acetone (MS)		58.08	67-64-1


Dairy ROG Emissions (speciation samples)
Dairy E
Dairy C
Dairy B
Dairy A
0
5000
10000
15000
20000
25000
30000

Dairy A (speciation samples)



Dairy E (speciation samples)



APPENDIX H

RECENT DAIRY EMISSIONS RESEARCH FOR PROPOSED RULE 4570 (CONFINED ANIMAL FACILITIES)

May 18, 2006

A study at two operating dairies in the San Joaquin Valley, led by Dr. Chuck Schmidt, in which measurements were made at many locations on and around the dairy facilities including the corrals and turnouts, bedding areas, lagoons, feed storage areas, flush lanes, and bunker feed.

A study by Dr. Schmidt to validate the effectiveness and capture efficiency of using flux chambers to quantify emissions.

The testing portions of these studies are now complete and detailed final reports are being prepared. When available, reports will be posted at: www.arb.ca.gov/ag/caf/caf.htm. The studies build upon the existing body of research. The new studies put California solidly at the forefront of dairy emissions research. They have produced significant findings that underscore the importance of science-based regulations and addressing the complexity of dairy emissions. ***Perhaps the most important finding of all is that dairy emissions are extraordinarily complex, varying not only season to season, but from dairy to dairy, and from place to place within a dairy.*** Emissions can vary substantially depending on weather, types of feed, and management styles and many other factors. ARB sponsored research is underway with the goal of modeling emission at individual dairies based on site-specific characteristics. Other key findings include:

Cattle feed stored on California dairies may be a larger source of ozone-forming emissions than the cows or their manure;

Emissions of ethanol and methanol from cows and their fresh manure appear to be the dominant variety of VOCs emitted, and are more significant than previously thought;

Manure in drylot corrals appears to be an important source of VOC and ammonia emissions on some dairies;

Manure storage ponds, also known as lagoons, once suspected as a major source of air emissions, appear to emit a comparatively small share of overall dairy emissions;

Emissions of a class of VOC compounds known as volatile fatty acids (VFAs) are not as significant as previously thought;

Emissions can vary considerably from dairy-to-dairy and seasonally.


Alternative CA Dairy
<1% of the dairies in California
<0.05% of the dairy cows in California


Dairy E: lagoon for liquid from the digester