

UPPER GREEN RIVER BASIN AIR EMISSIONS STUDY

Commercial Oilfield Waste Disposal Ponds



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COWD POND EMISSIONS- *Upper Green River Basin, WY*

Background

- Exceedances of the 8-hr NAAQS for ozone in the Upper Green River Basin
- Facilities perform crude emission estimates for emissions inventories

Ozone levels plague valley

By Kaitlyn McAvoy

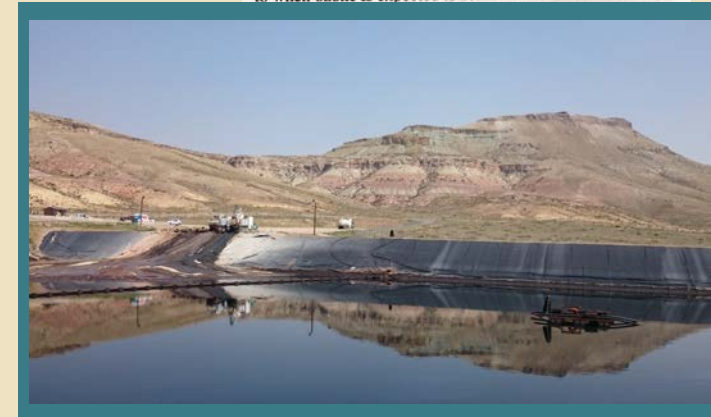
Ozone advisories were issued for Monday, Tuesday, Wednesday and today for the Upper Green River Basin in Sublette County. Ozone levels were reported to have surpassed the national threshold on Tuesday both in Boulder and Pinedale, according to the Wyoming Department of Environmental Quality Air Quality Division (DEQ-AQD), who issued the advisories. Levels were above the threshold Wednesday afternoon in Boulder, as well.

An advisory means conditions are favorable for ozone levels to rise above the 75 parts per billion (ppb) threshold, not that it has yet. Advisories are issued by noon of the day prior to when ozone is expected to form.

Need

- WDEQ desires technically sound emission estimation methodology for disposal ponds
- Establish correlation between pond VOC content and airborne concentrations to estimate future emissions

Objective



OUTCOME:

Develop easy-to-use software tool to predict air emissions from disposal pit water concentrations.

WHAT ARE COMMERCIAL OILFIELD WASTE DISPOSAL PONDS?

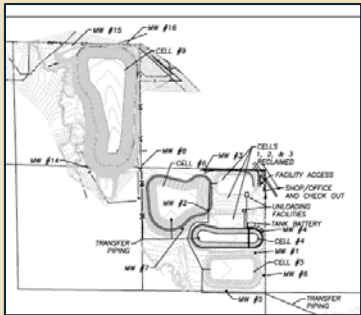


- Large lined ponds for treatment and evaporation of produced water and other liquid waste from oilfield operations



UGRB PROJECT APPROACH

1 Data Collection: Summer and Winter air/water sampling events at 2 Facilities.



Flux Chambers
(Utah State)



OP-FTIR
(TAMU)



Air
Sampling



Water
Sampling



On-site
Meteorology

2 Predictive Model Development

VOLUME II: CHAPTER 5
PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM WASTEWATER COLLECTION AND TREATMENT
Final Report
March 1997

7-3.3 Example calculation for storage requirements

This section presents a step-by-step example calculation for emissions from storage requirements. The equations described in Section 7.3.1 are used with the model unit parameters given in Section 7.3.2 to estimate emissions from an agitated waste containing 10 gpd of methane.

• Calculate liquid-phase mass transfer coefficient, k_L . The Springer's model (see table 7-1):

$$k_L = 0.023 \frac{D^{1/4} v^{1/4}}{d} \quad \text{Equation 7-1}$$

Effective diameter = $\frac{10 \text{ gpd}}{24 \text{ hr}} \times \frac{1 \text{ m}^3}{1000 \text{ L}} \times \frac{1 \text{ m}^3}{3.785 \text{ m}^3} \times 24 \text{ hr} = 0.000104 \text{ m}^3$

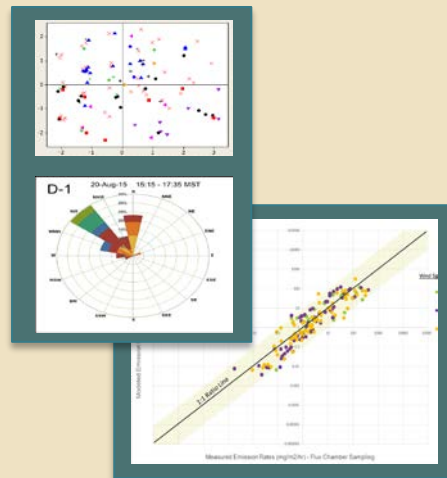
$d = \sqrt[3]{0.000104 \text{ m}^3} = 0.047 \text{ m}$

$k_L = 0.023 \frac{(0.000104 \text{ m}^3)^{1/4} (0.000104 \text{ m}^3)^{1/4}}{0.047 \text{ m}} = 0.000104 \text{ m}^3/\text{s}$

$k_L = 0.000104 \text{ m}^3/\text{s} \times \frac{1 \text{ hr}}{3600 \text{ s}} = 2.9 \times 10^{-5} \text{ m}^3/\text{hr}$

$k_L = 2.9 \times 10^{-5} \text{ m}^3/\text{hr} \times \frac{1 \text{ m}^3}{1000 \text{ L}} \times \frac{1 \text{ m}^3}{3.785 \text{ m}^3} \times 24 \text{ hr} = 1.8 \times 10^{-4} \text{ m}^3/\text{hr}$

$k_L = 1.8 \times 10^{-4} \text{ m}^3/\text{hr} \times \frac{1 \text{ m}^3}{1000 \text{ L}} \times \frac{1 \text{ m}^3}{3.785 \text{ m}^3} \times 24 \text{ hr} = 1.1 \times 10^{-4} \text{ m}^3/\text{hr}$



Spreadsheet Tool

DEQ
DIVISION OF ENVIRONMENTAL QUALITY

Pond-Specific Variables

Variable	Units	Value
Pond Surface Area	m ²	122
Average Water Depth	m	0.8
Wind Speed measurement height	m	1.82

Daily Air Temperature

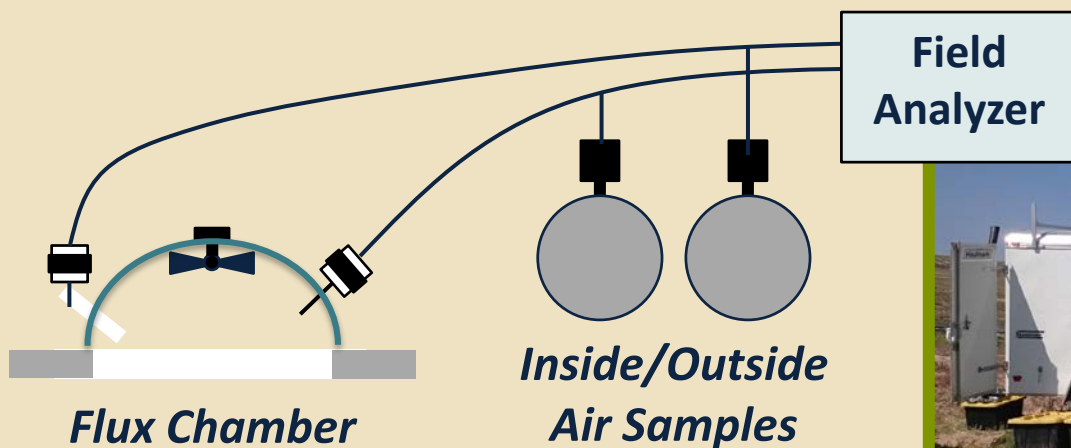
Start Date	End Date	Avg Temp (deg C)	Avg Wind Speed (m/s)	Avg Wind Temp (deg C)	Water Level (m)	% of pond surface covered by ice	Ice Layer Thickness (cm)
1/1/2015	1/31/2015	1.0	1.0	2.0	2.5	0	0
2/1/2015	2/28/2015	1.3	1.0	2.5	2.5	0	0
3/1/2015	3/31/2015	4.2	1.0	2.5	2.5	0	0
4/1/2015	4/30/2015	10.3	1.0	2.5	2.5	0	0
5/1/2015	5/31/2015	16.0	1.6	2.2	2.5	0	0
6/1/2015	6/30/2015	21.1	3.1	1.0	2.5	0	0
7/1/2015	7/31/2015	25.3	3.8	1.0	2.5	0	0
8/1/2015	8/31/2015	25.2	4.1	1.0	2.5	0	0
9/1/2015	9/30/2015	19.7	3.3	1.0	2.5	0	0
10/1/2015	10/31/2015	13.8	3.8	1.0	2.5	0	0
11/1/2015	11/30/2015	3.3	1.1	2.5	2.5	80	0
12/1/2015	12/31/2015	-2.7	1.0	2.0	2.5	95	0
Annual Avg		10.0	2.0	1.5	2.5	82	

Annual Average Emissions

Constituent	Average Concentration (mg/L)	Average Emission Rate (kg/d)	Average Emission Rate (lb/d)
Acetaldehyde	0.034	0	1.7E-01
Benzene	0.02	0	1.0E-01
Bromoform	0.129	0	2.8E-01
Chloroform	0.27	0	7.0E-01
Ethanol	10	0	3.8E-00
Ethylbenzene	0.35	0	7.7E-01
Hexane	0	0	8.4E-04
Formaldehyde	0.082	0	2.9E-03
Isopropanol	0.0	0	3.0E-03
Methanol	4.8	0	2.4E-01
Methanol	57.9	0	1.2E-02
Methylene Chloride	0.002	0	4.6E-01
Toluene	8.67	0	2.2E-01
Xylene, m,p	0.66	0	1.7E-00
Xylene, o	3.86	0	5.3E-00

Average Annual Emissions (lb/yr)

FLUX CHAMBER SAMPLING



OPEN PATH FTIR SAMPLING



TEXAS
A&M

Institute of Renewable
Natural Resources



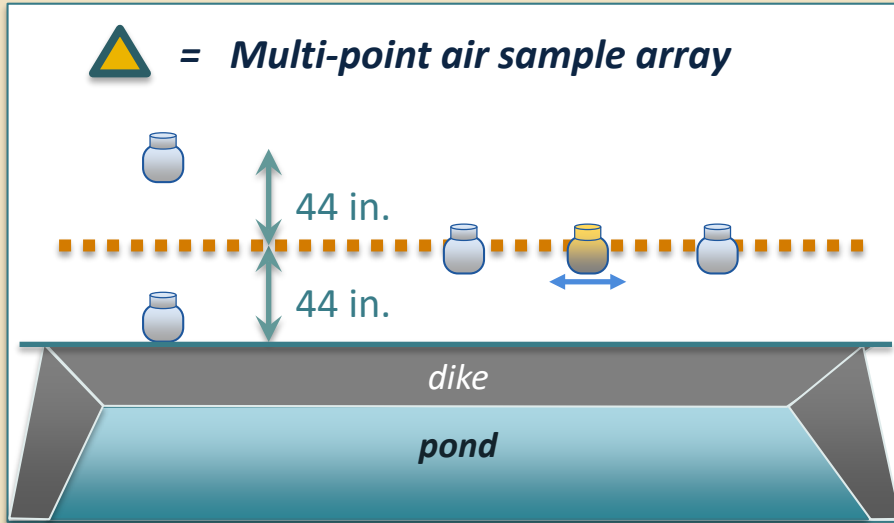
*OP-FTIR
Spectrometer
and Met Station*






“Walking” Air Samples (quantify FTIR NDs)



CANISTER ARRAY SAMPLING



LEGEND

-  OP-FTIR transect
-  Walking air sample
-  Stationary air sample point



WATER SAMPLING

Key Analytes:

- *BTEX, Alcohols, Dissolved gases*
- *Formaldehyde/ Acetaldehyde*
- *Oil & Grease*



3D WIND SPEED MONITORING

Sonic Float



Site Specific AQD Met Stations



FACILITY LAYOUT AND BACKGROUND

Facility 1



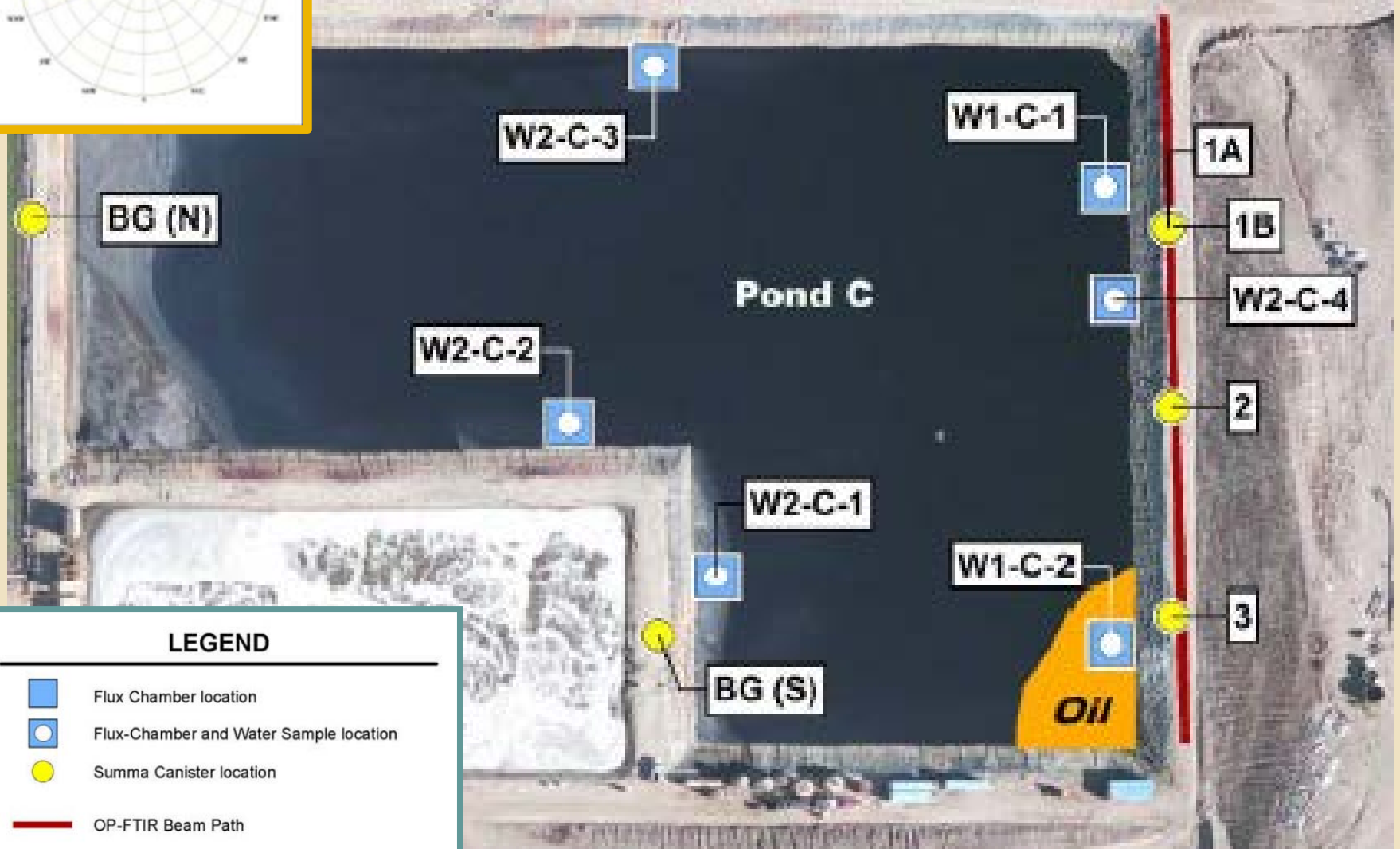
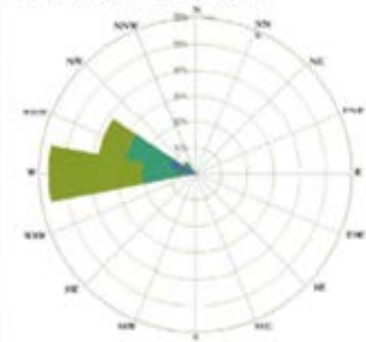
Facility 2

*Site Specific
OP-FTIR Meas.
Background*





Methane:
*1.2 ppm Facility 1
1.6 ppm Facility 2*

FACILITY 1: *Pond C* Sampling

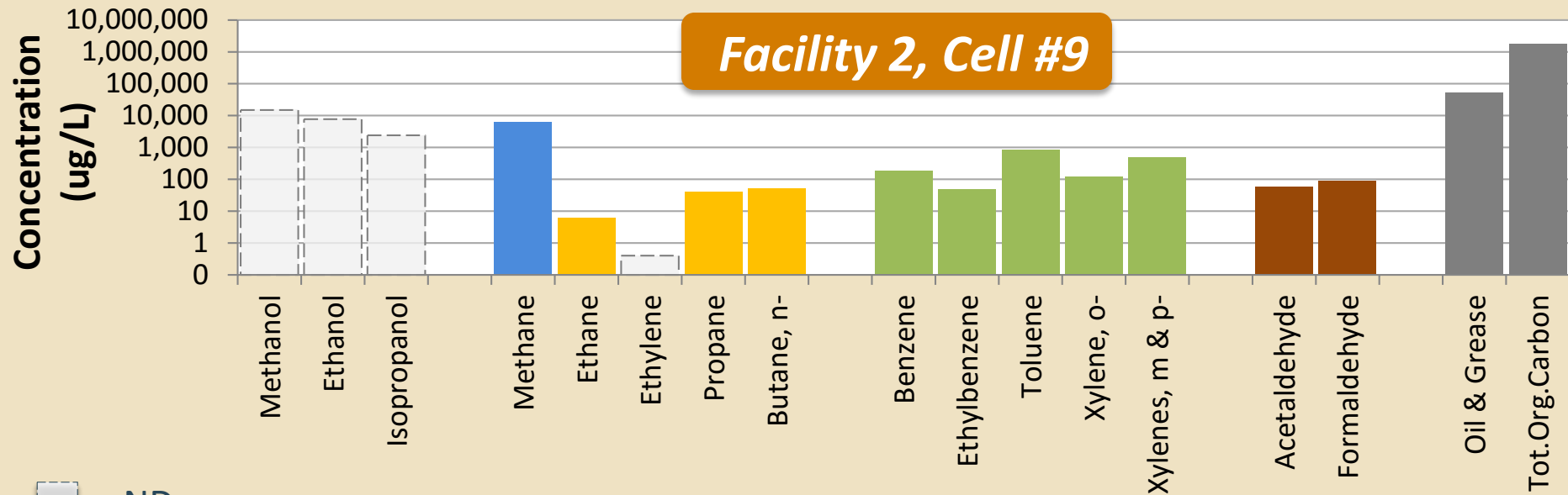
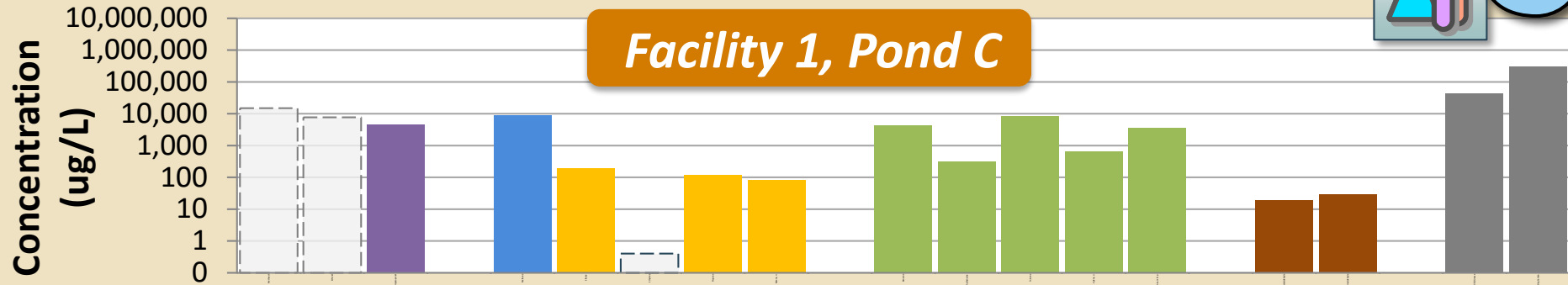
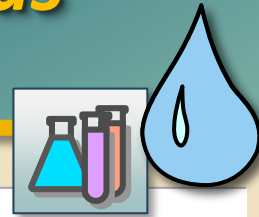
Anticline Day#1 (02 Mar-16) 0:00 - 17:30 MST



LEGEND

-  Flux Chamber location
-  Flux-Chamber and Water Sample location
-  Summa Canister location
-  OP-FTIR Beam Path

WATER SAMPLING RESULTS – *Receiving Ponds (Summer)*



= ND

Alcohols

Dissolved gases

Aromatics

Carbonyls

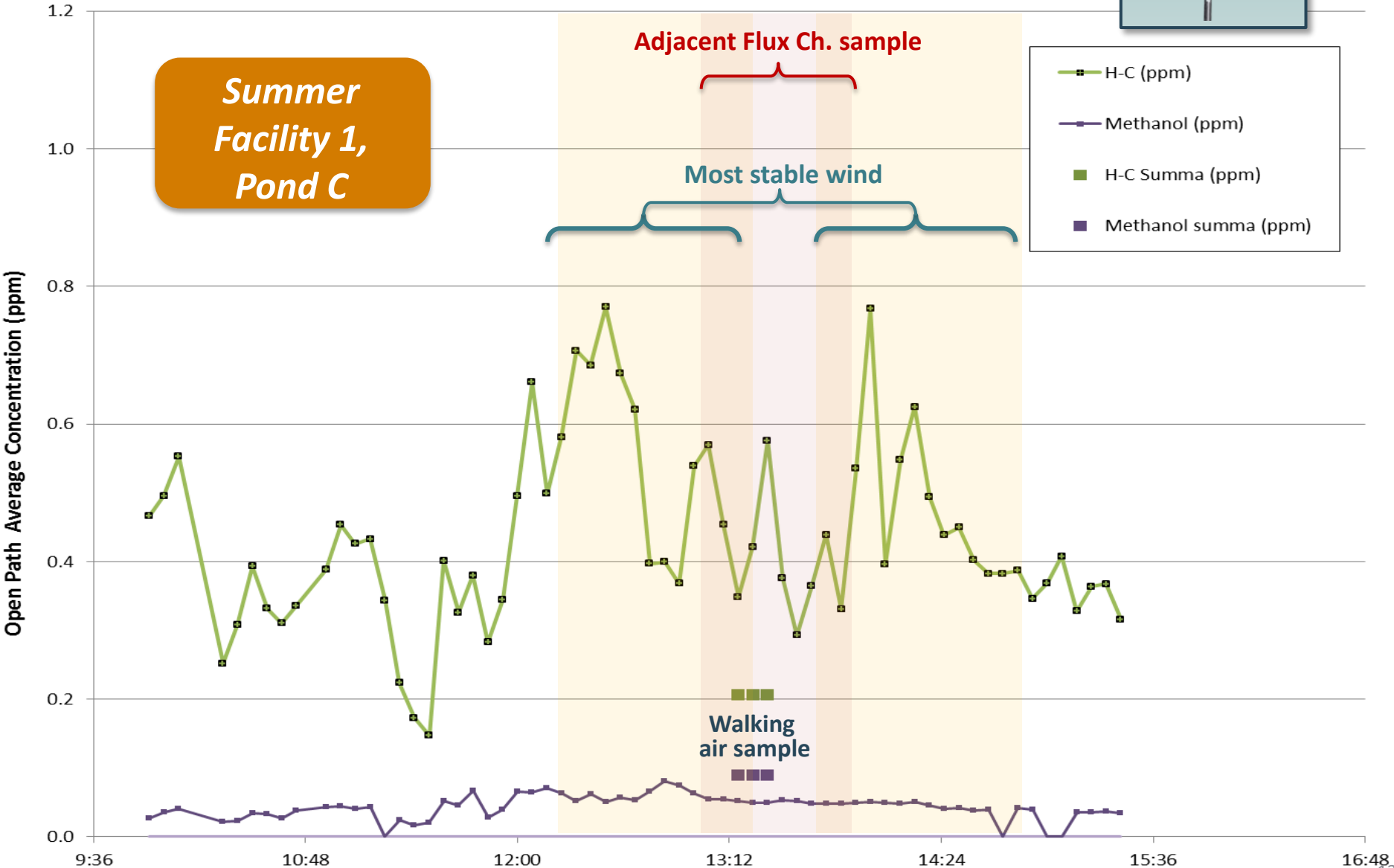
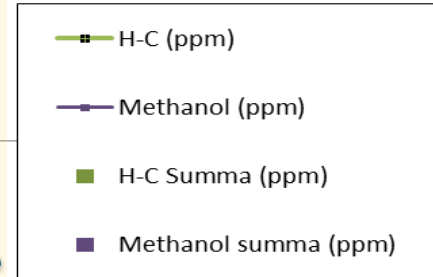
OPEN PATH CONCENTRATIONS



*Summer
Facility 1,
Pond C*

Adjacent Flux Ch. sample

Most stable wind



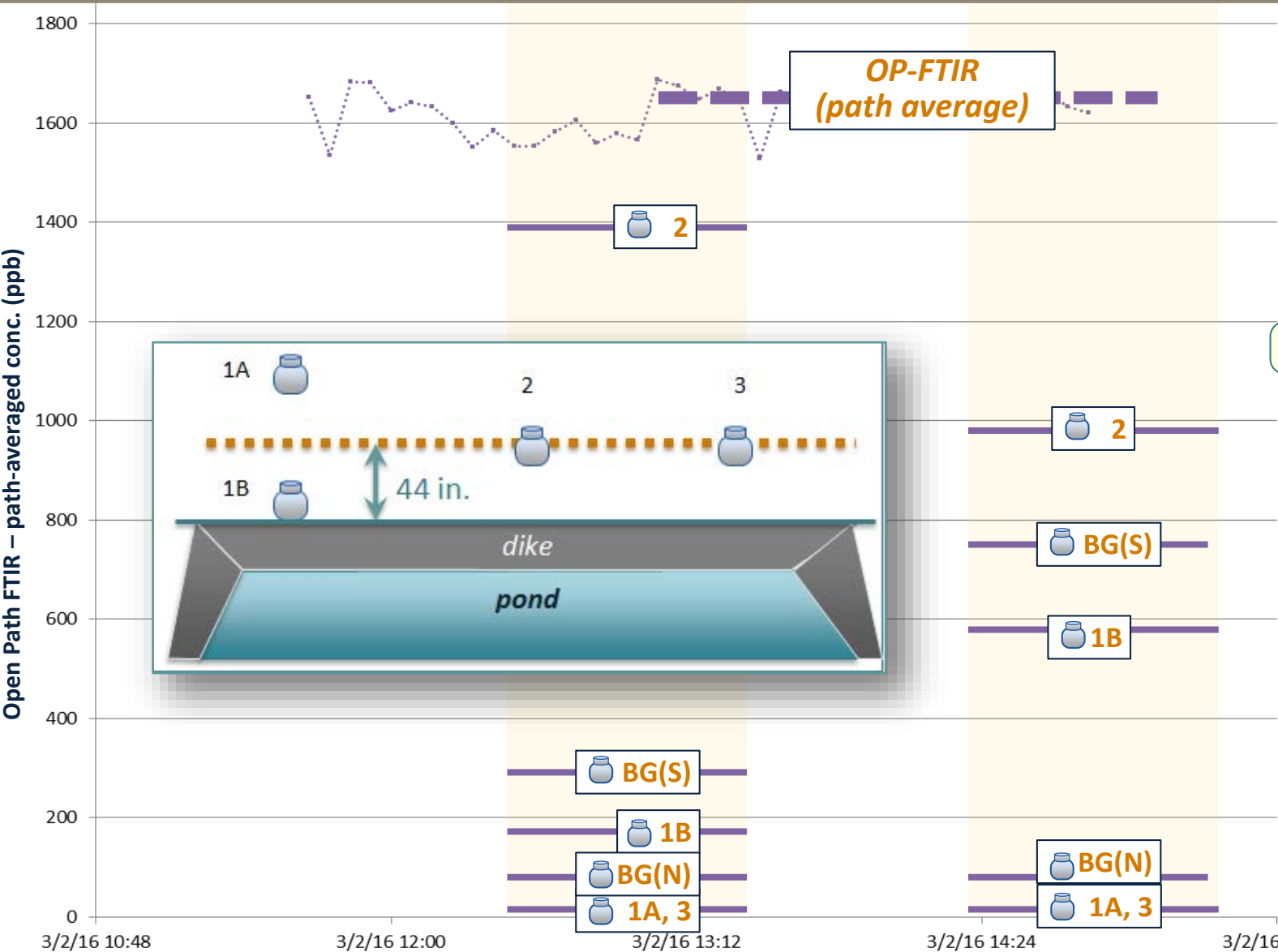
CANISTER ARRAY RESULTS

Winter
Facility 1,
Pond C

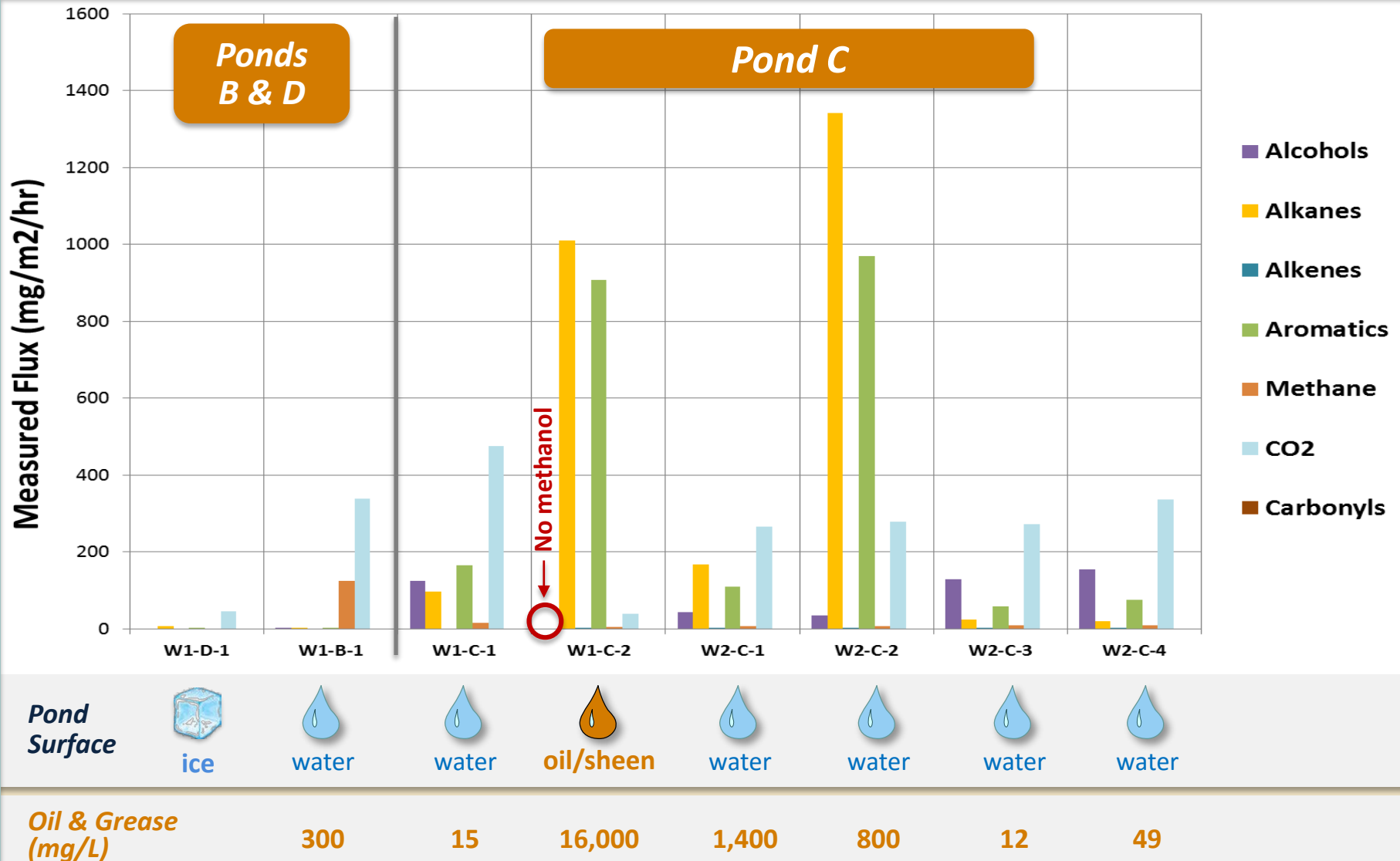


— Methanol

BG = background



FLUX CHAMBER RESULTS *Facility 1*



PREDICTIVE TOOL *Water-Based Model*

Pond-Specific Variables

	acres	m ²	ft ²
Pond Surface Area	12.2	49372	531432
Average Water Depth		m	ft
Wind Speed measurement height (above top of dike)		9	29.5
		6	19.7

Pond Name **EXAMPLE**

Oil density **0.8** kg/L

Start Date	End Date	Daily Air Temperature (deg C)		Avg Water Temp @surf. (deg C)	Avg Wind Speed (m/s)	Water Level (below top of dike)		% of pond surface covered by...		Oil Layer Thickness (mm)
		AvgHigh	AvgLow			(m)	(ft)	Ice	Oil	
1/1/2015	1/31/2015	1.0	-11.0	2.0	2.0	2.5	8.2	95	0	0
2/1/2015	2/28/2015	-1.3	-16.7	2.5	1.5	2.5	8.2	90	0	0
3/1/2015	3/31/2015	4.2	-10.5	2.5	2.5	2.5	8.2	75	0	0
4/1/2015	4/30/2015	10.3	-3.4	2.5	1.3	2.5	8.2	0	0	0
5/1/2015	5/31/2015	16.0	-1.6	7.2	1.4	2.5	8.2	0	0	0
6/1/2015	6/30/2015	21.1	3.1	12.1	1.0	2.5	8.2	0	0	0
7/1/2015	7/31/2015	25.9	6.8	15.9	1.0	2.5	8.2	0	0	0
8/1/2015	8/31/2015	25.2	4.1	14.7	2.5	2.5	8.2	0	0	0
9/1/2015	9/30/2015	19.7	0.3	9.7	1.0	2.5	8.2	0	0	0
10/1/2015	10/31/2015	12.6	-5.0	3.8	1.5	2.5	8.2	0	0	0
11/1/2015	11/30/2015	3.3	-11.1	2.5	1.5	2.5	8.2	80	0	0
12/1/2015	12/31/2015	-2.7	-16.7	2.0	1.0	2.5	8.2	95	0	0
Annual Avg		3.0		6.5	1.5	2.5	8.2			

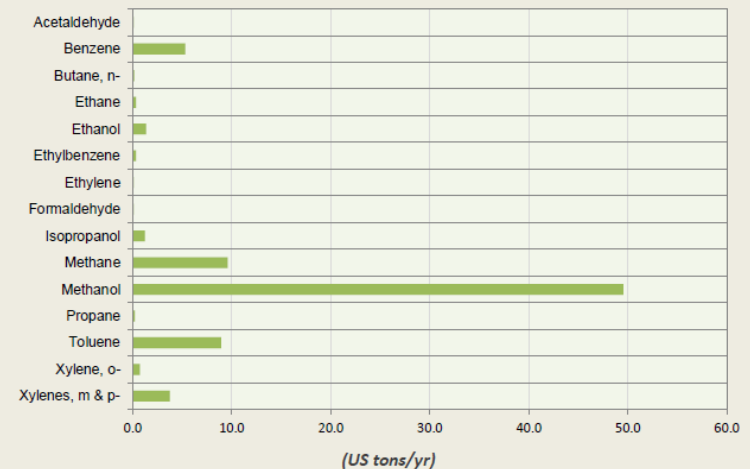
EXAMPLE

Basic Inputs

Annual Average Emissions

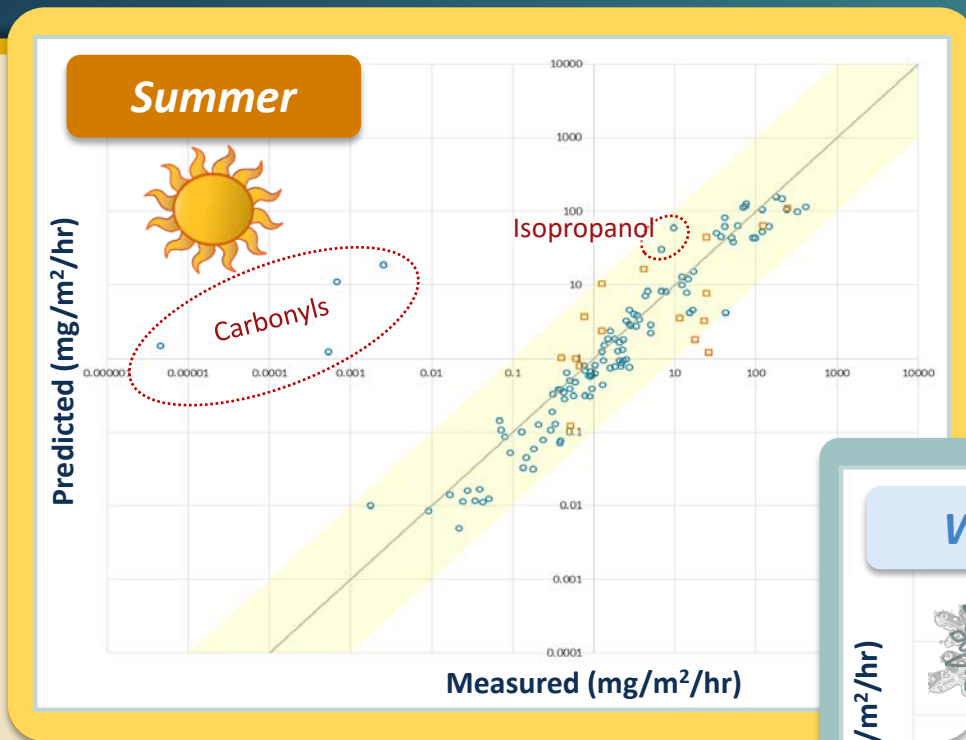
Constituent	Average Concentration		Average Emission Rate	
	Water (mg/L)	Oil (mole fraction)	kg/d	(US tons/yr)
Acetaldehyde	0.0348	0	1.7E-01	6.8E-02
Benzene	5.02	0	1.3E+01	5.3E+00
Butane, n-	0.129	0	2.9E-01	1.2E-01
Ethane	0.27	0	7.0E-01	2.8E-01
Ethanol	10	0	3.3E+00	1.3E+00
Ethylbenzene	0.35	0	7.7E-01	3.1E-01
Ethylene	0	0	8.4E-04	3.4E-04
Formaldehyde	0.082	0	2.9E-03	1.2E-03
Isopropanol	5.0	0	3.0E+00	1.2E+00
Methane	4.8	0	2.4E+01	9.6E+00
Methanol	571.9	0	1.2E+02	5.0E+01
Propane	0.202	0	4.6E-01	1.8E-01
Toluene	8.67	0	2.2E+01	8.9E+00
Xylene, o-	0.766	0	1.7E+00	6.8E-01
Xylenes, m & p-	3.86	0	9.3E+00	3.7E+00

Average Annual Emissions



Output

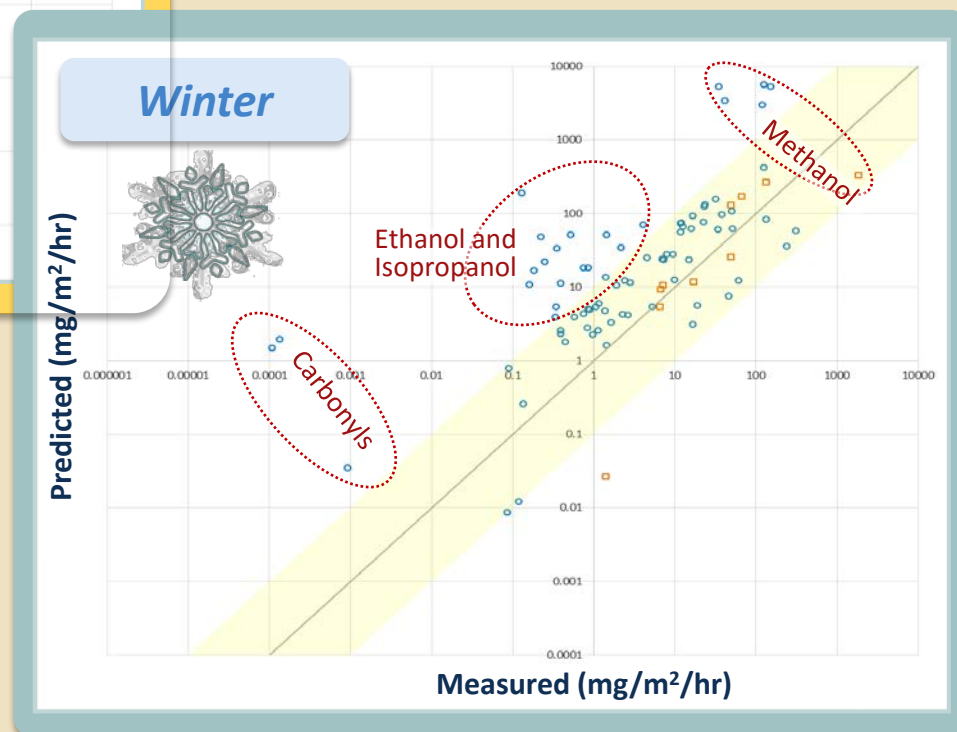
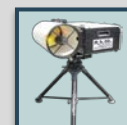
PREDICTED VS. MEASURED EMISSIONS – *Calibrated Model*



○ Flux Chamber Measurement



□ OP-FTIR Measurement



KEY POINT:

Reduce uncertainty in *average* annual emissions estimates from COWD facilities.



FURTHER WORK

2016 – 2017 Wyoming Pond Emissions Project

- Two additional ponds, different fields and formations, to support tool calibration/modification
- Correlation of source air emissions to water concentrations to support model refinement/calibration
- Incorporation of suggested modifications from current pond emissions study
- Further analysis of oil/sheen impacts on emissions
- Further analysis of microbial activity
- Evaluation of additional backward modeling techniques to use with FTIR and canister measurements
- Calculation of annual emission rate for all facilities





Photo courtesy of WDEQ AQD

THANKS! QUESTIONS?

