Manure Irrigation
Controlling Odor On-Farm

January 22, 2019

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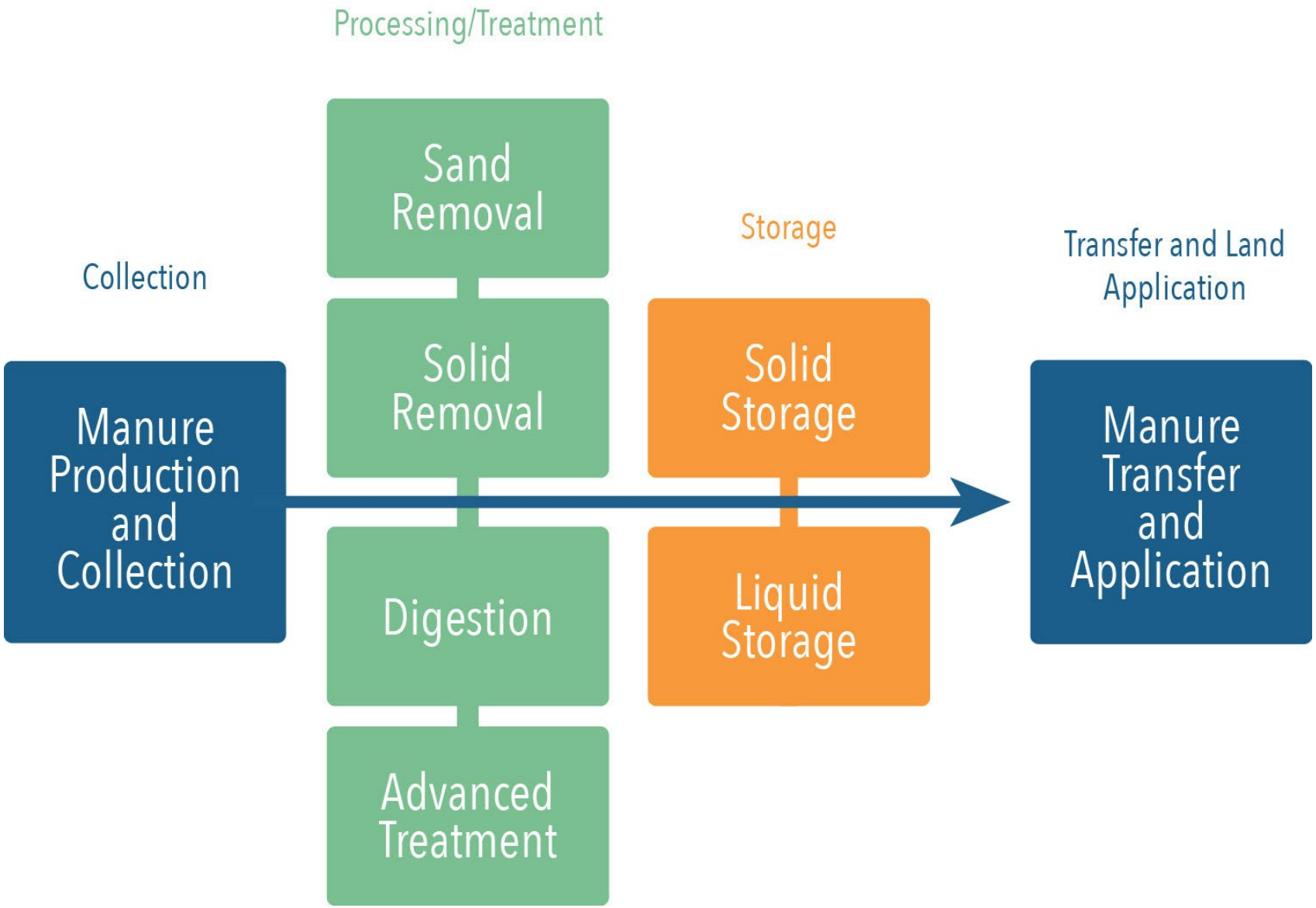
Manure Systems




Center Pivot

Traveling Gun

Issues identified by public

Benefits

- Timing of manure application
- Road safety and reduced road damage
- Farm management and economic benefits

Concerns

- Public health risk from airborne pathogens and other contaminants
- Drift
- Odor and other quality of life concerns
- Surface water quality
- Groundwater
- Implementation and compliance

Manure Irrigation Workgroup

Convened Spring 2013

Purpose:

Review issues and develop guidance on the practices of applying livestock manure or process wastewater through irrigation equipment

Audience:

- State and local agencies and officials
- Interested/concerned stakeholders
- Producers interested in the practices

Manure Irrigation Workgroup

UW-Madison/Extension (3)
USDA-ARS (1)
USDA-NRCS (1)
WDNR (2)
WDATCP (1)
WDHS (2)

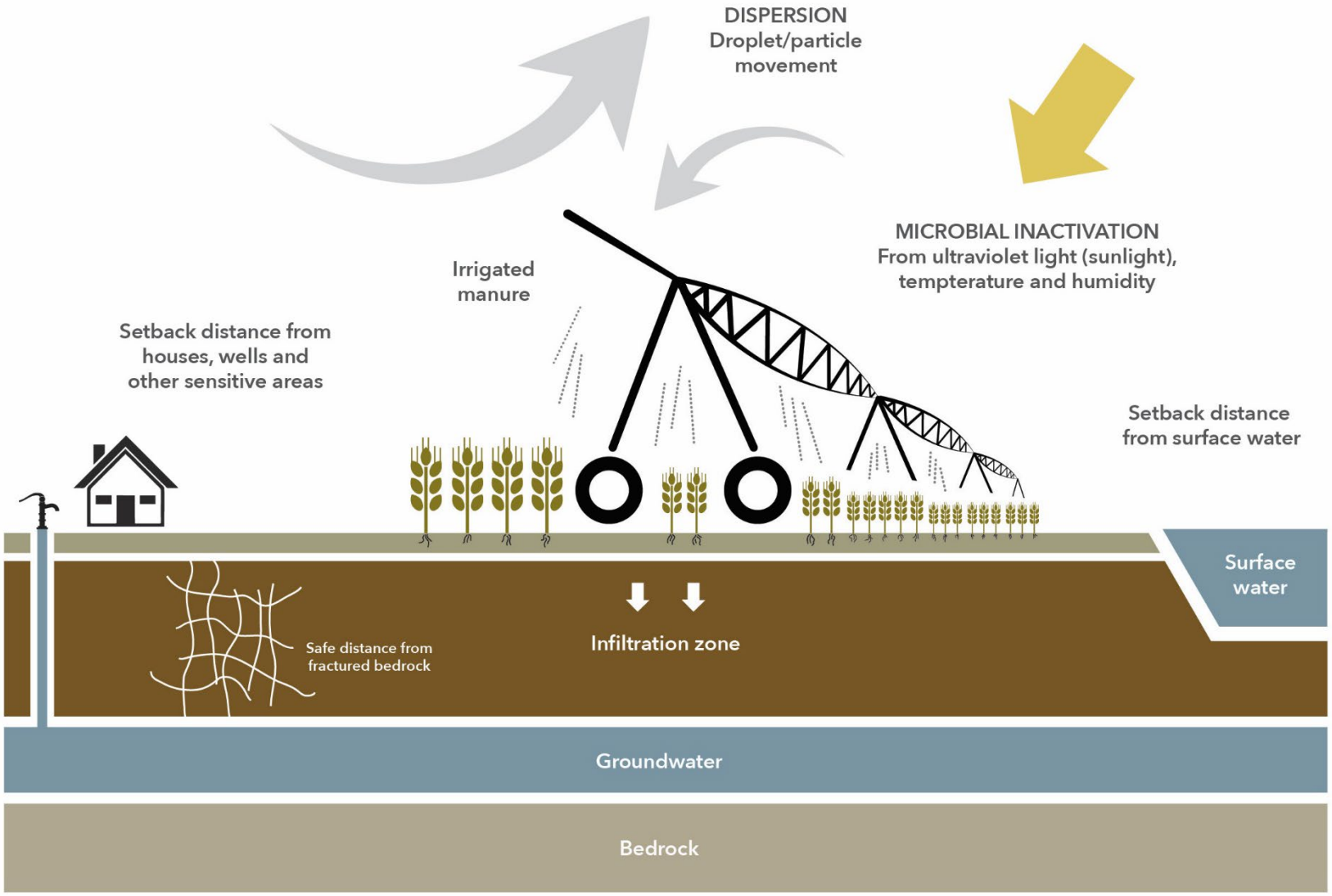
County Health Departments (2)
Dairy Farmers (3)
Professional agronomist (1)
Nutrient applicator (1)
Organic Farmer/concerned citizen (1)
Wisconsin Land+Water Assoc (1)

Public Forums May 2013

Workgroup meetings: July 2013 – September 2015 (16 meetings)

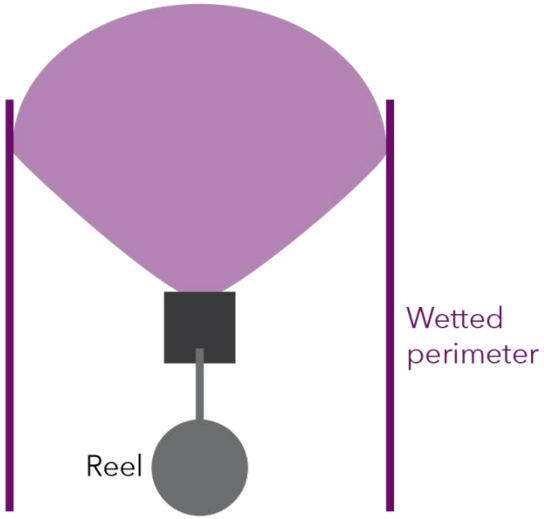
Concurrent pathogen drift study by USDA-ARS & UW-Madison: 2013-2015

Considerations for Practice

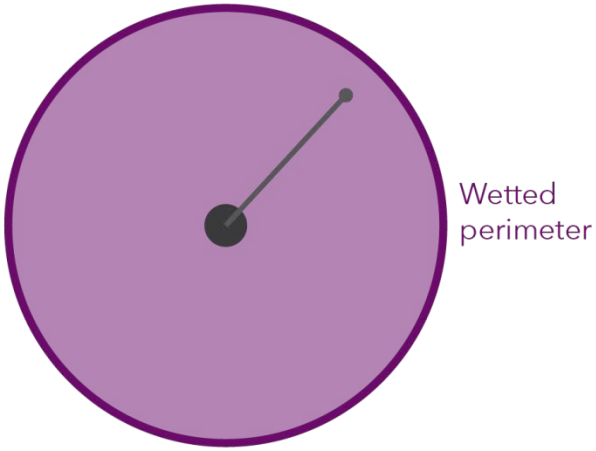


Wetted Perimeter

Traveling gun



Center pivot



Operation

Can control many pieces on the system:

- Speed of travel
- Pressure
- Nozzle type
- End gun shut off
- Computerized systems which detect wind speed, etc.
- More specialized application

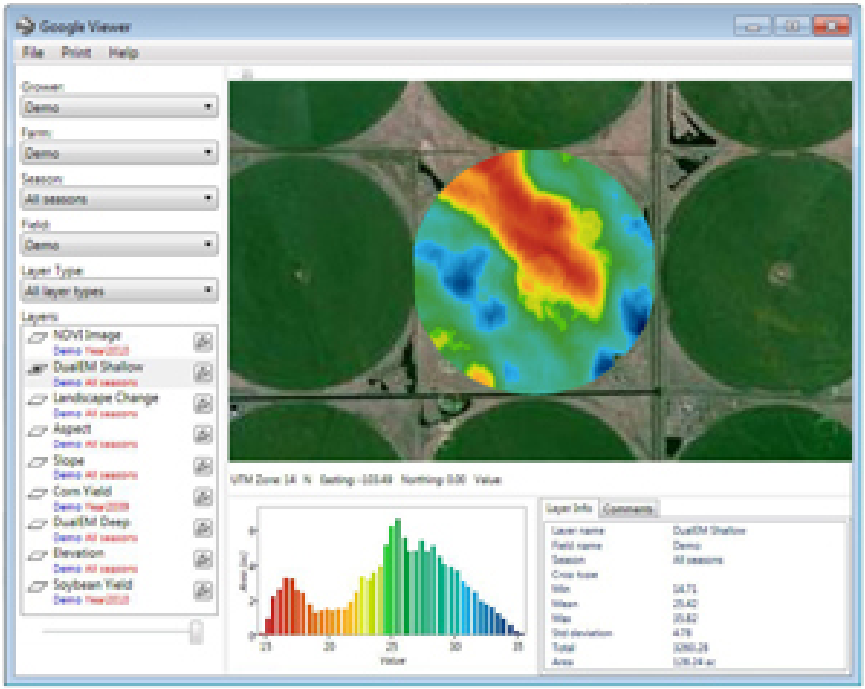
Drift

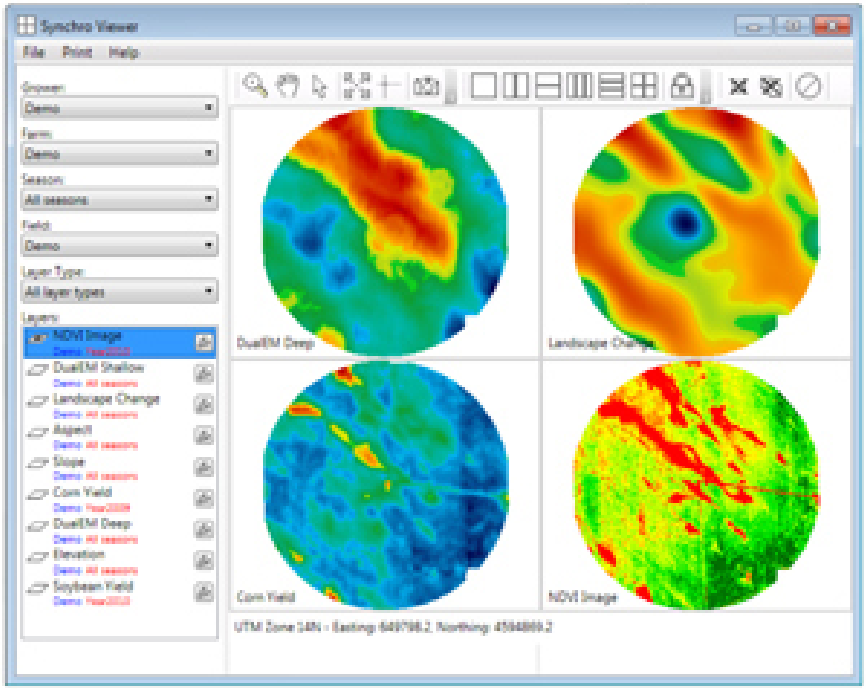
- Aerial movement of liquid outside the intended application area
- Different than overspray
- Concerns for surface waters, residences, public areas, other crops, etc.
- No regulations for other manure application methods
- Drift from manure irrigation can be minimized by:
  - Maximizing droplet size
  - Minimizing release height (e.g. drop nozzles)
  - Minimizing wind speeds
  - Using barriers (e.g. tree lines)

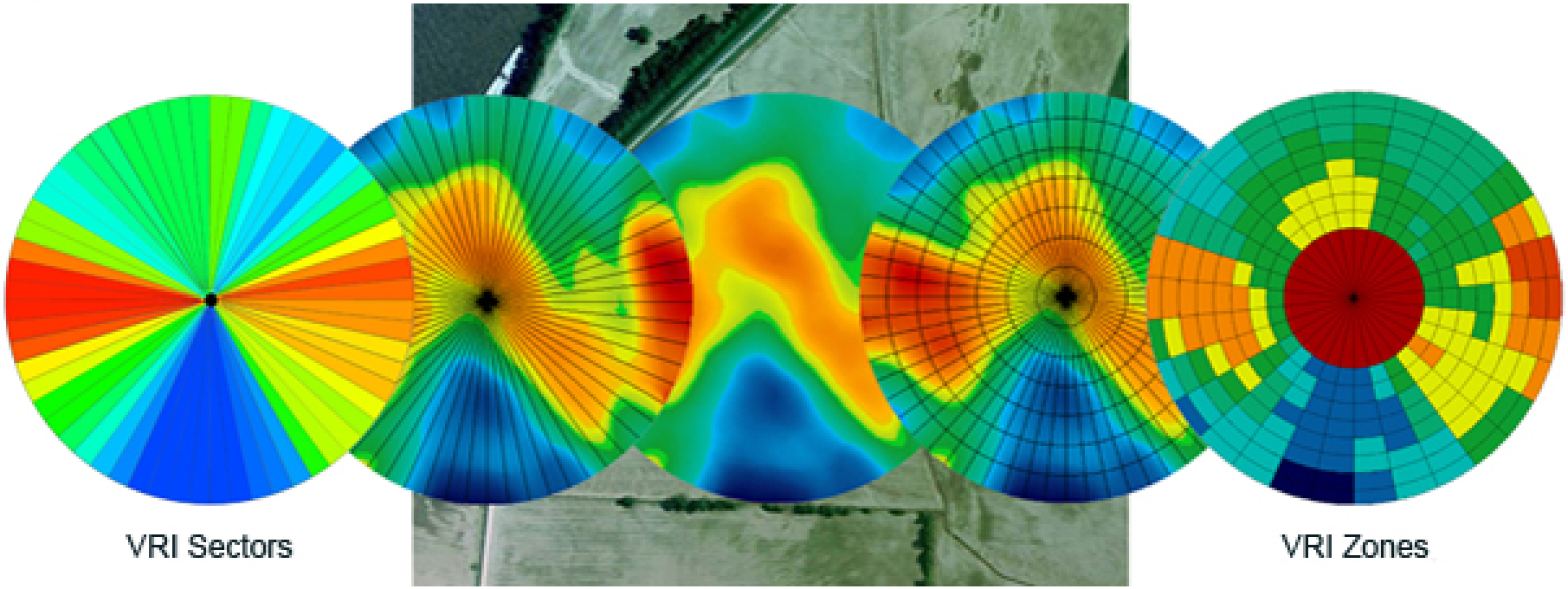
Water Quality

- Concerns for runoff and impact to groundwater
- May decrease runoff and leaching due reduced volume applied for each application period
- Need to apply to current regulations including NRCS CPS 590
- Issues with compliance/monitoring and enforcement

http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1088801071&topicorder=14&maxto=16

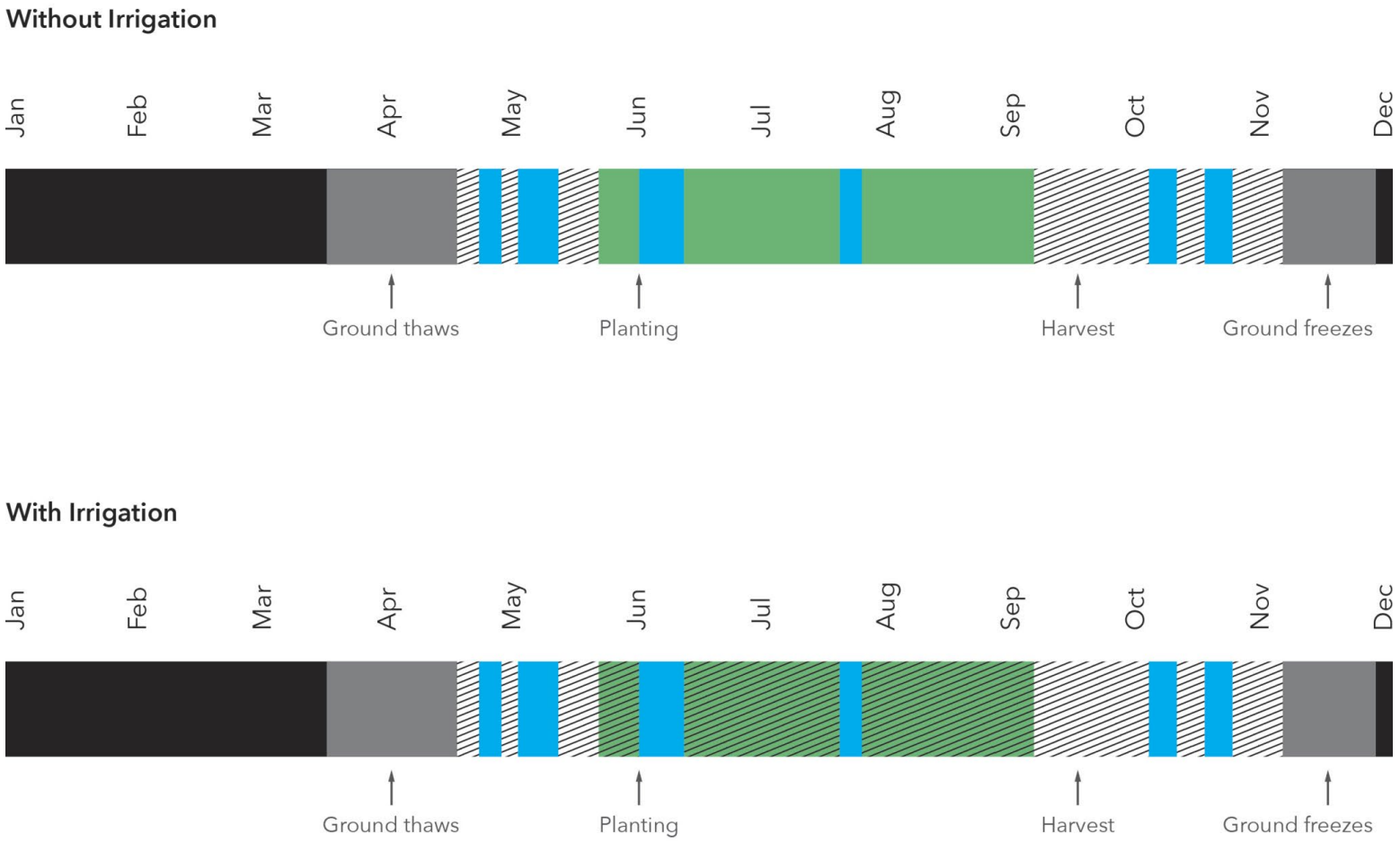






http://cropmetrics.com/features/variable-rate-irrigation/

Application Timing



Air Quality

- Issues of concern include
  - Particulate matter
  - Greenhouse gas emissions
  - Hazardous air pollutants (including ammonia and hydrogen sulfide)
- OSHA Occupational Standards and Wisconsin Ambient Air Standards
- Field concentrations of many hazardous air pollutants are below standards (more of a concern at the farmstead near the manure storage)
- Mitigation techniques
  - Edge of field barriers
  - Large droplets
  - Low release height

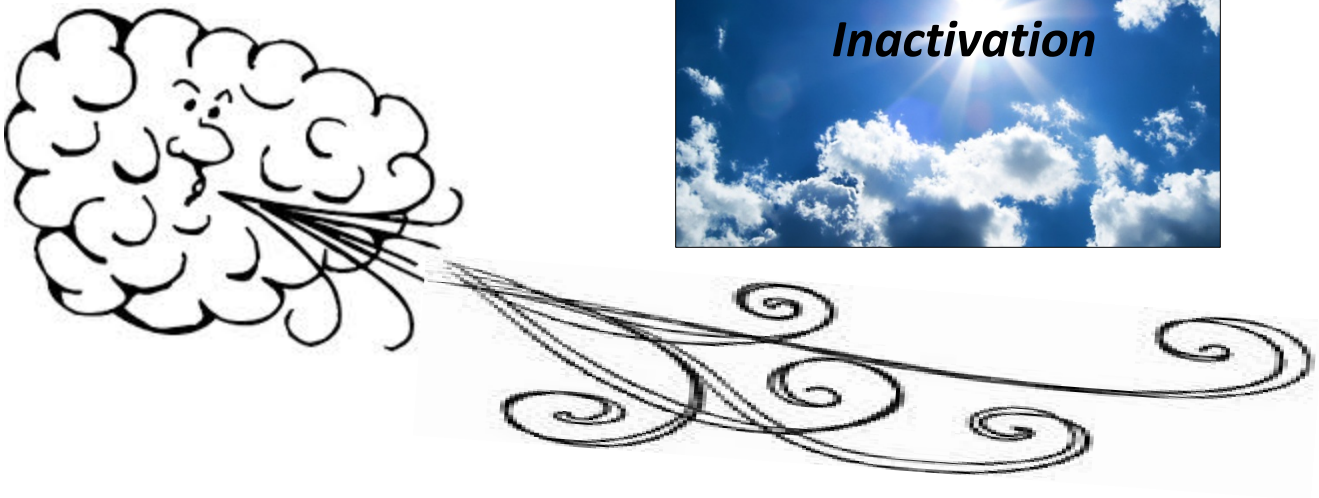
Pathogens

Field Experiments and a Quantitative Microbial Risk Assessment for Estimating Setback Distance from Irrigation of Dairy Manure

- Mark Borchardt, Tucker Burch, and Susan Spencer; USDA – Agricultural Research Service
- Joel Stokdyk and Aaron Firnstahl; US Geological Survey Wisconsin Water Science Center
- Becky Larson; Biological Systems Engineering UW-Madison
- Burney Kieke; Marshfield Clinic Research Foundation
- Ana Rule; Bloomberg School of Public Health, Johns Hopkins University

Burch, T., S. Spencer, J. Stokdyk, B. Kieke, R.A. Larson, A. Firnstahl, A. Rule, and M. Borchardt. 2017. Quantitative Microbial Risk Assessment for Spray Irrigation of Dairy Manure Based on an Empirical Fate and Transport Model. *Environmental Health Perspectives*, 125(8):087009.

Conceptual Model



Irrigation

Aerosols and Droplets

Exposure

Inhalation
Fomite deposition

Garden/Food

Vector

Project Objectives

1. Identify the risk of acute gastrointestinal illness from airborne pathogens during manure irrigation. Relate risk levels to distance from irrigated manure.

2. Identify other variables (e.g., weather conditions) most important for airborne pathogen transport during manure irrigation

Definitions

Risk: cases of illness/people exposed

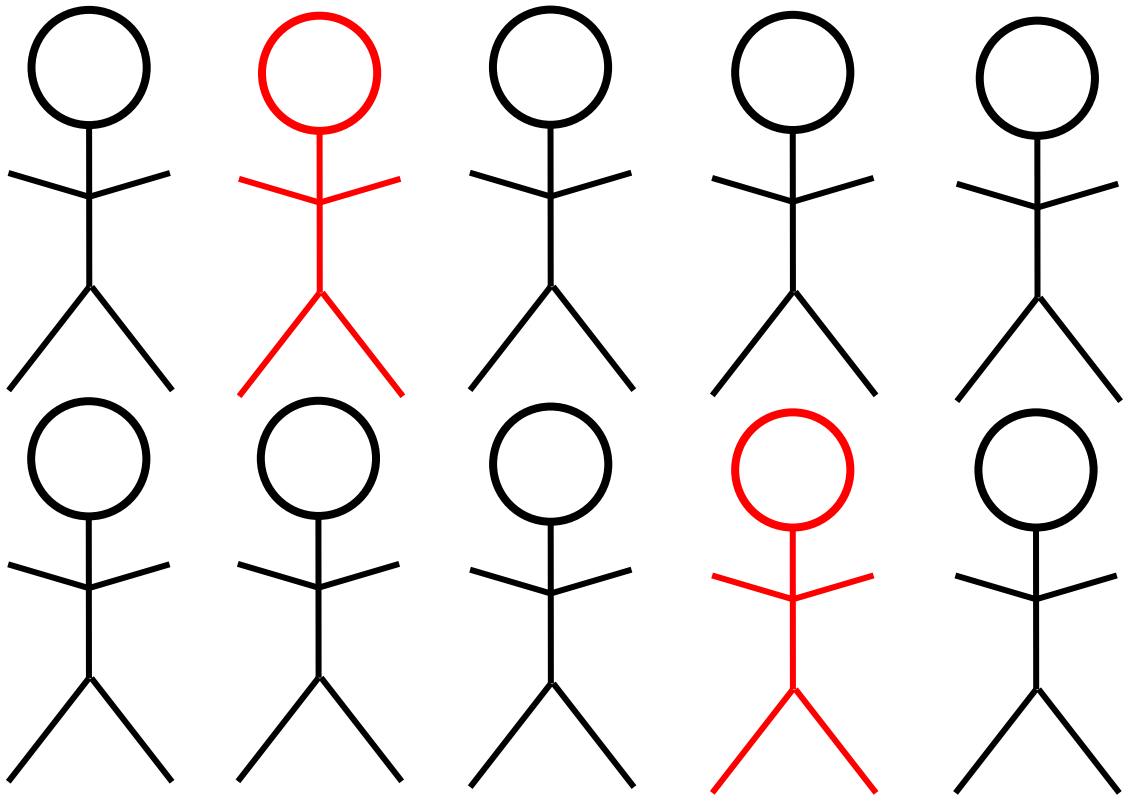
- Can also be interpreted as probability

Example:

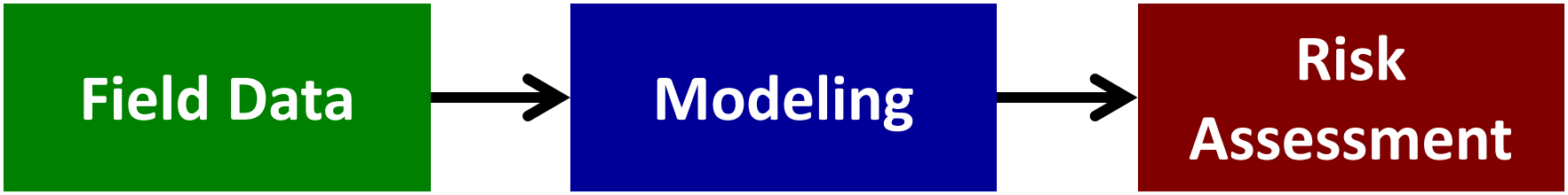
10 people exposed
2 cases of illness (red)

Risk = 2/10

Probability = 0.2 (or 20%)



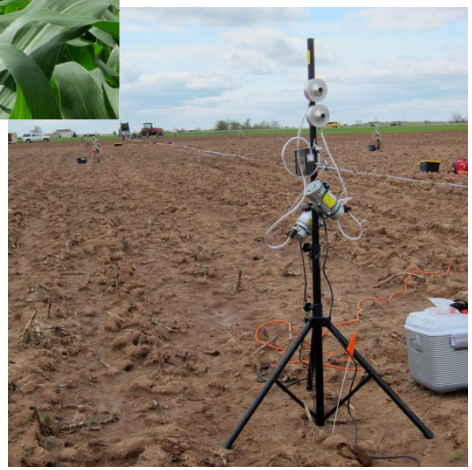
Research Approach



- 25 field trials
  - 15 traveling gun, 8 center pivot, 2 tanker
- Measured microbe concentrations in manure and at multiple distances for each trial
  - qPCR and culture
- Collected weather data for each trial

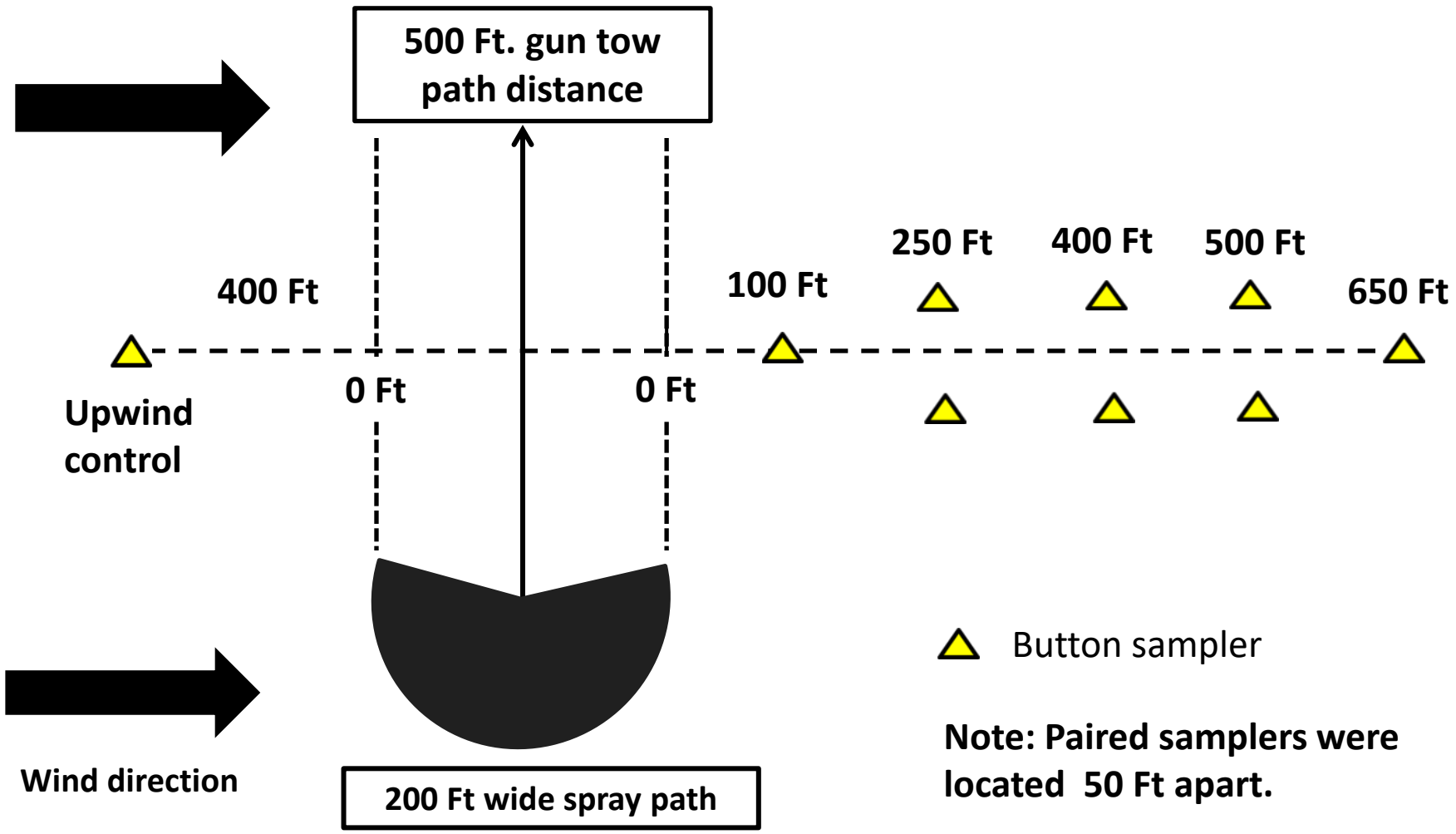
Measurement during Irrigation Trials

Commensal Microbes and Pathogens
- qPCR
- conventional culture

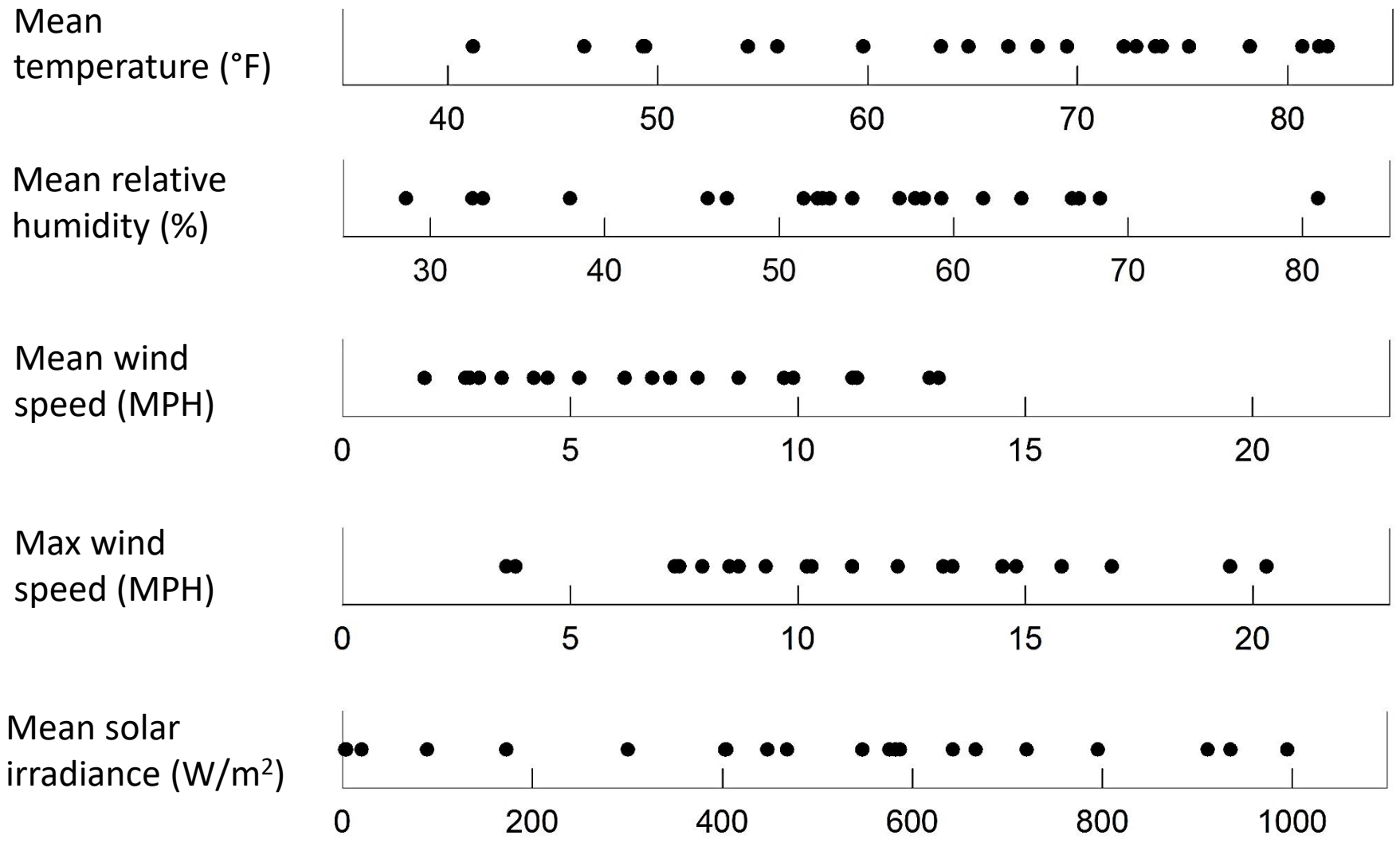


Portable Weather Station
- wind direction and speed
- air temperature
- solar radiation
- relative humidity
- precipitation (always = 0)

Typical field sampler configuration

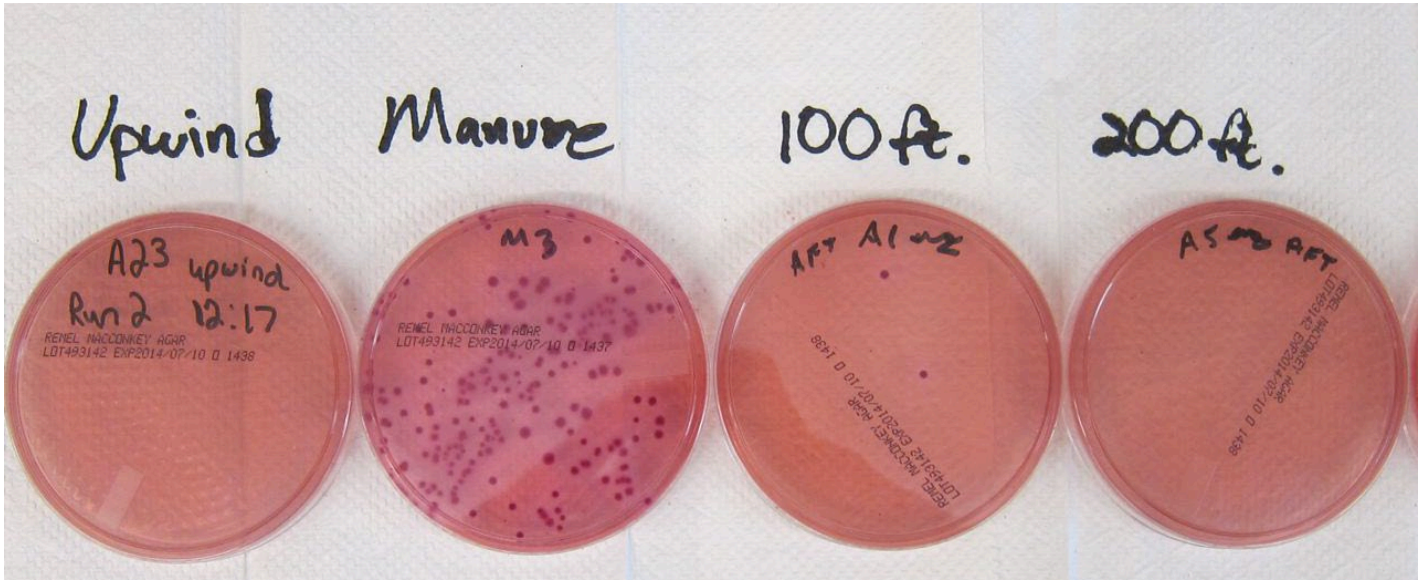


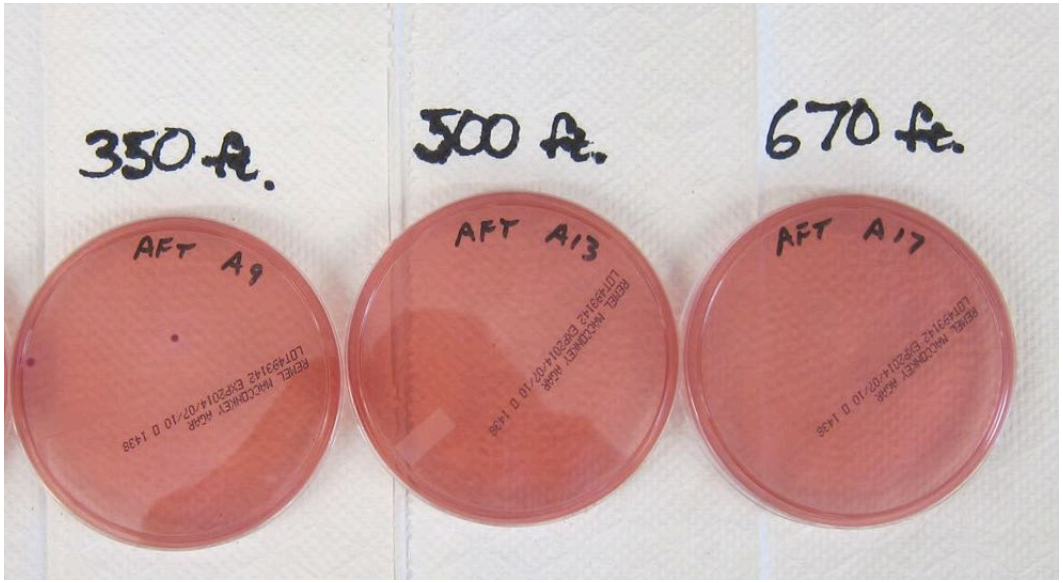
Weather Conditions during Trials



Gram-Negative Bacteria in Air During Travelling Gun Manure Irrigation

May 22, 2014; 11 mph wind; 530 W/m^2 solar irradiance; 50% relative humidity; 68 °F temp

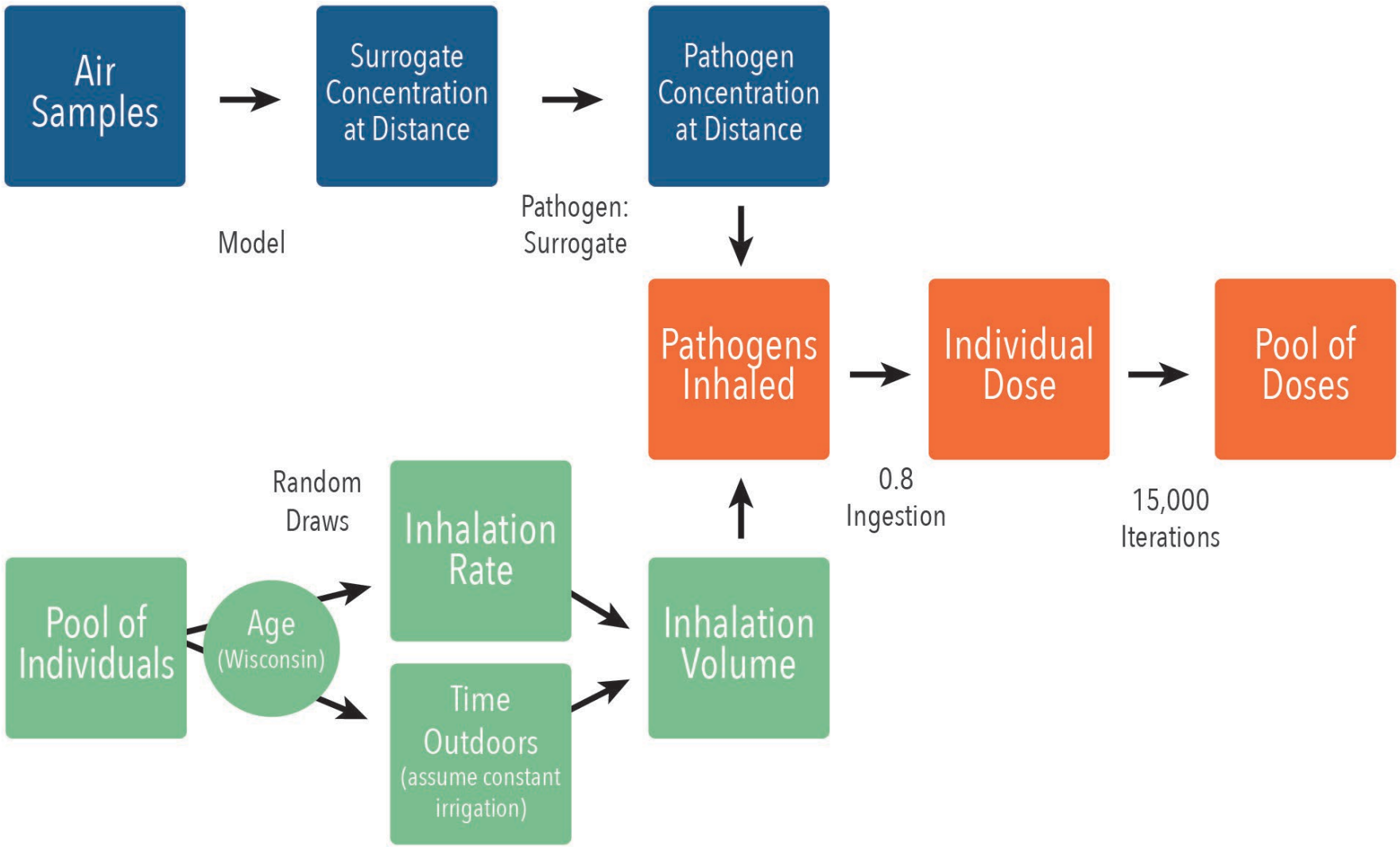




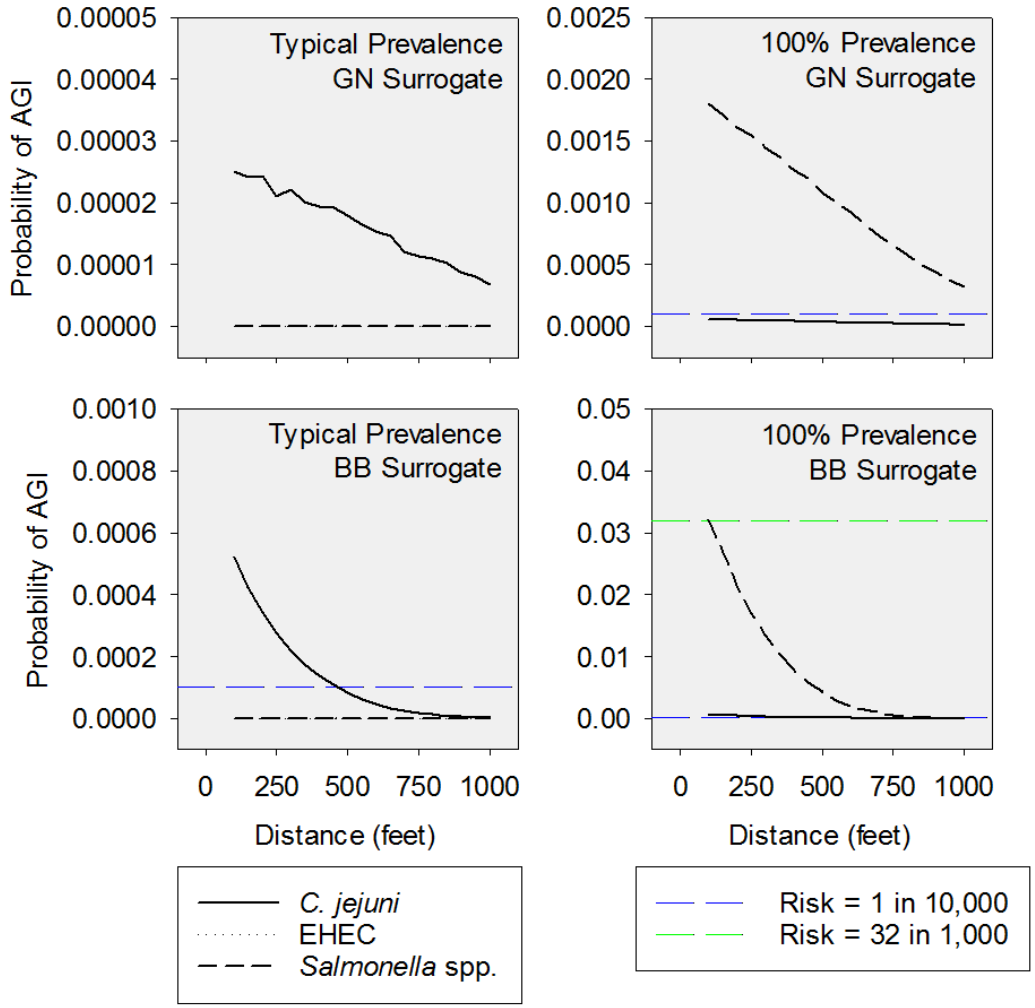
Notes

- MacConkey agar in Anderson samplers
- Air sample volume was 540 liters
- Downwind distances were perpendicular to gun movement
- Manure diluted 1:100 before plating 100 µl

Risk Assessment – Calculating Pathogen Dose

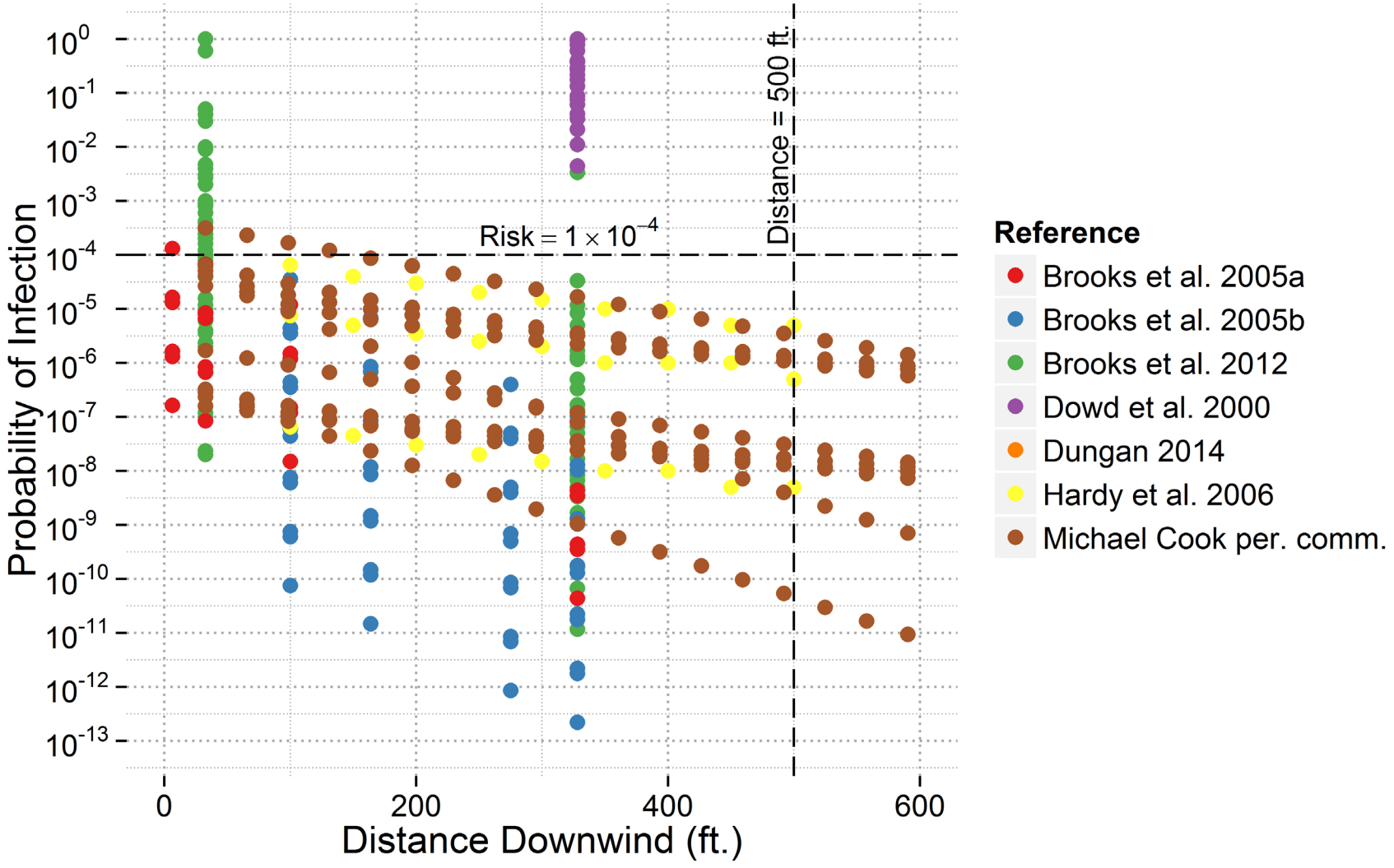


Risk vs. Distance
Median of the Risk Distribution

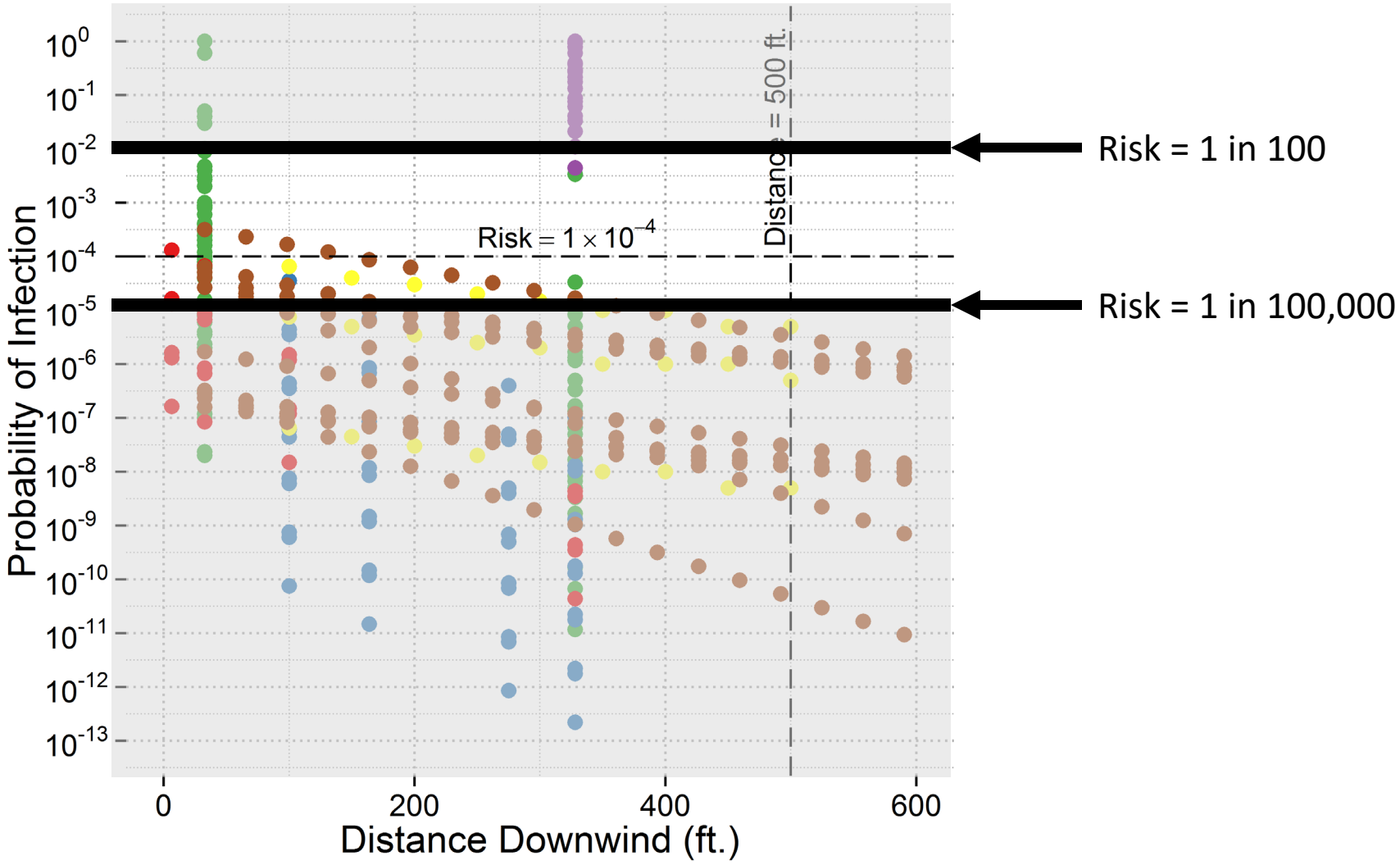


AGI: acute gastrointestinal illness, GN: gram negative bacteria, BB: bovine *Bacteroides*

Previous Risk Assessments



This Study's Risk Estimates Relative to Previous Risk Assessments



Acknowledgements

- We thank …
- Jan Altmann, Jordan Gonnering, Hana Millen and Zach Zopp for field and laboratory work
- John Panuska for contributions to the study design
- Scott Fischer and owners and staff of participating dairy farms
- Philip Schmidt, Peter Teunis, and Norval Strachan for dose-response parameter distributions
- This study was funded in part by the Wisconsin Department of Natural Resources

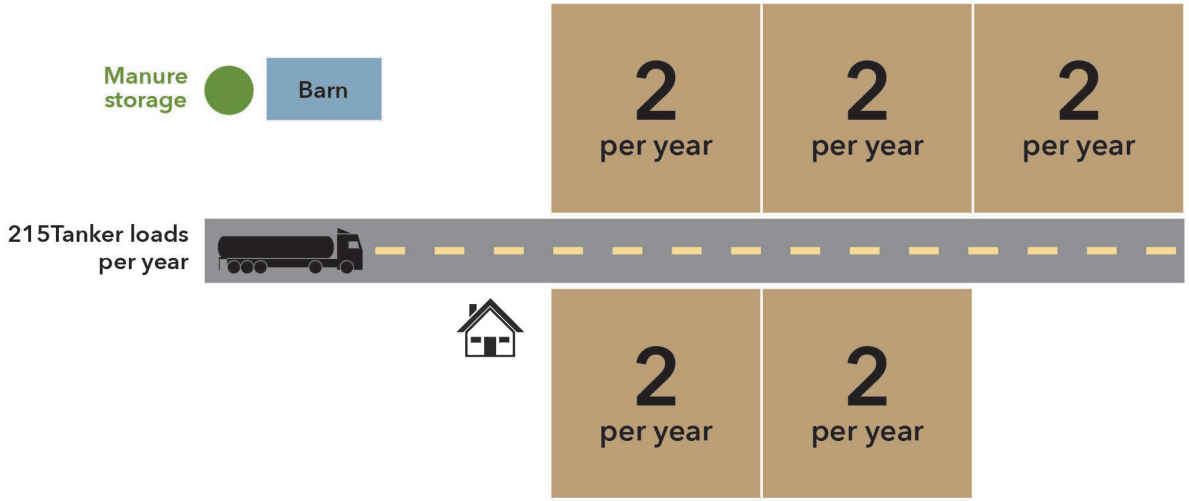
Odor

- Odor perception is variable
- Manure odors can be from 300+ compounds (quantification is difficult)
- There is no one indicator that can be used to assess odor
- Great citizen concern for odors produced
- Odors can result in negative impacts to wellbeing and state of mind
- Result in diminished quality of life and stress
- Can cause negative economic impacts to area
- Odor will be generally be greater for manure irrigation systems compared to other application methods

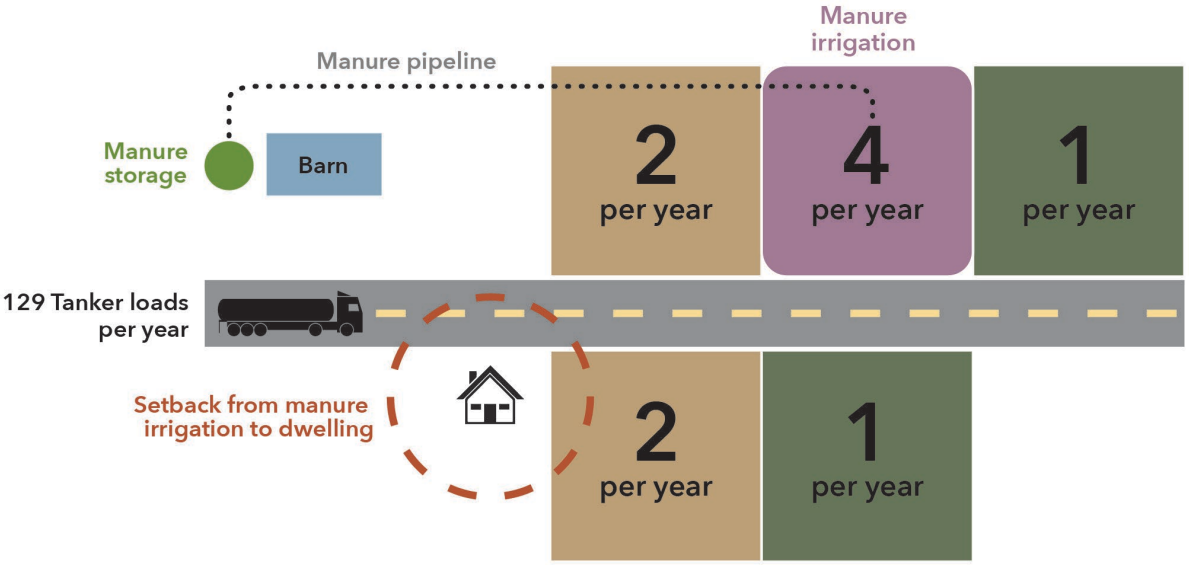
Odor

- Manure systems aerosolize odor causing compounds
- Nuisance odors depend on:
  - Material
  - Length of storage
  - Conditions during storage
  - Processing or treatment
  - Proximity to receptors
  - Weather conditions
- While the nuisance odors can be greater they may be shorter in time
- Number of application events is important as typically manure application events increase in frequency when an irrigation system is present

Manure Applications with Conventional Methods



Manure Applications with Conventional Methods & Irrigation



Odor – Manure processing

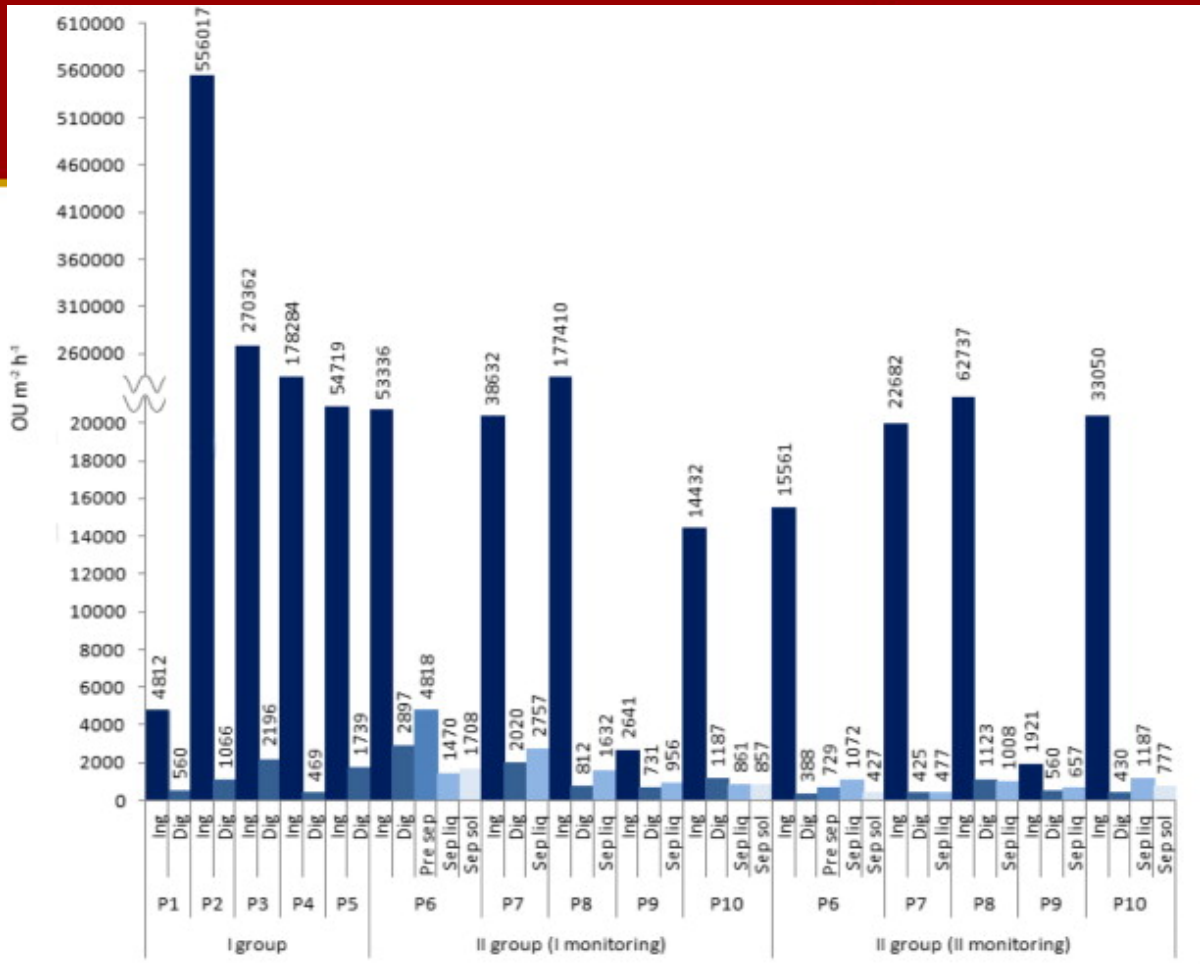
- Anaerobic digestion
- Solid liquid separation
- Dilution with clean water
- Clean water application following manure application
- Biological and chemical additives
- Avoiding manure inputs into storage 2 weeks prior to application
- Mid summer to late fall after degradation and activity may reduce odors
- Avoid adding odorous materials
- Dilution
  - 2:1 for processed manures
  - 15:1 for unprocessed manures

Odor Improvements

Swine Manure

Hansen et al. 2006, Applied Engineering in Agriculture

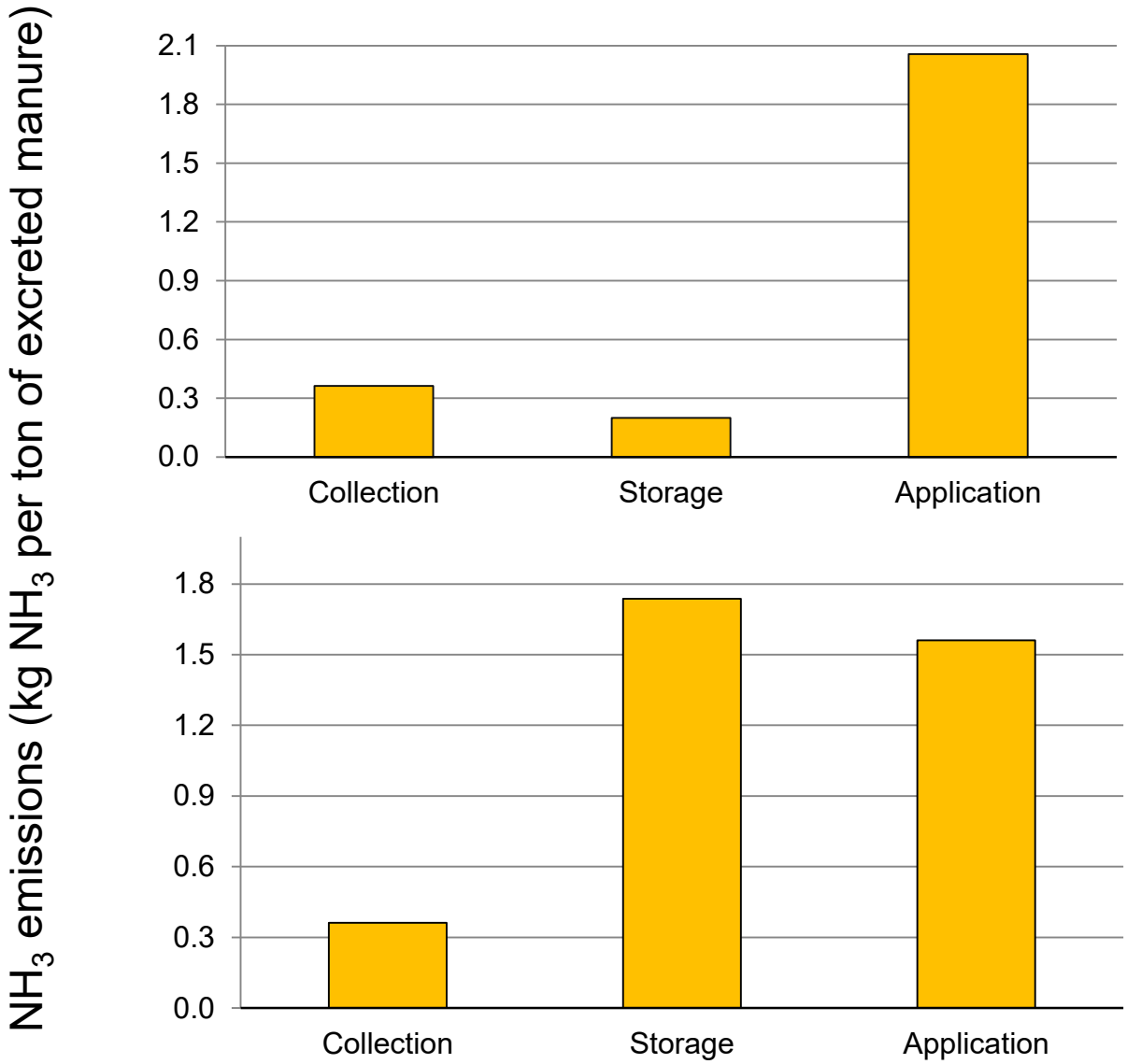
- Slurry concentrations of malodorous VFA were reduced 79-97% from AD
- Odor concentration above undisturbed slurry store reduced (higher odors after mixing)
- Land application odor reductions:
  - 17% anaerobic digestion
  - 50% anaerobic digestion and solid liquid separation



Orzi et al., 2015, Science of the Total Environment

- Odors reduced 98%
- P2-P6 are pig slurries
- VFA destruction related to measured odor reductions

Ammonia Emissions



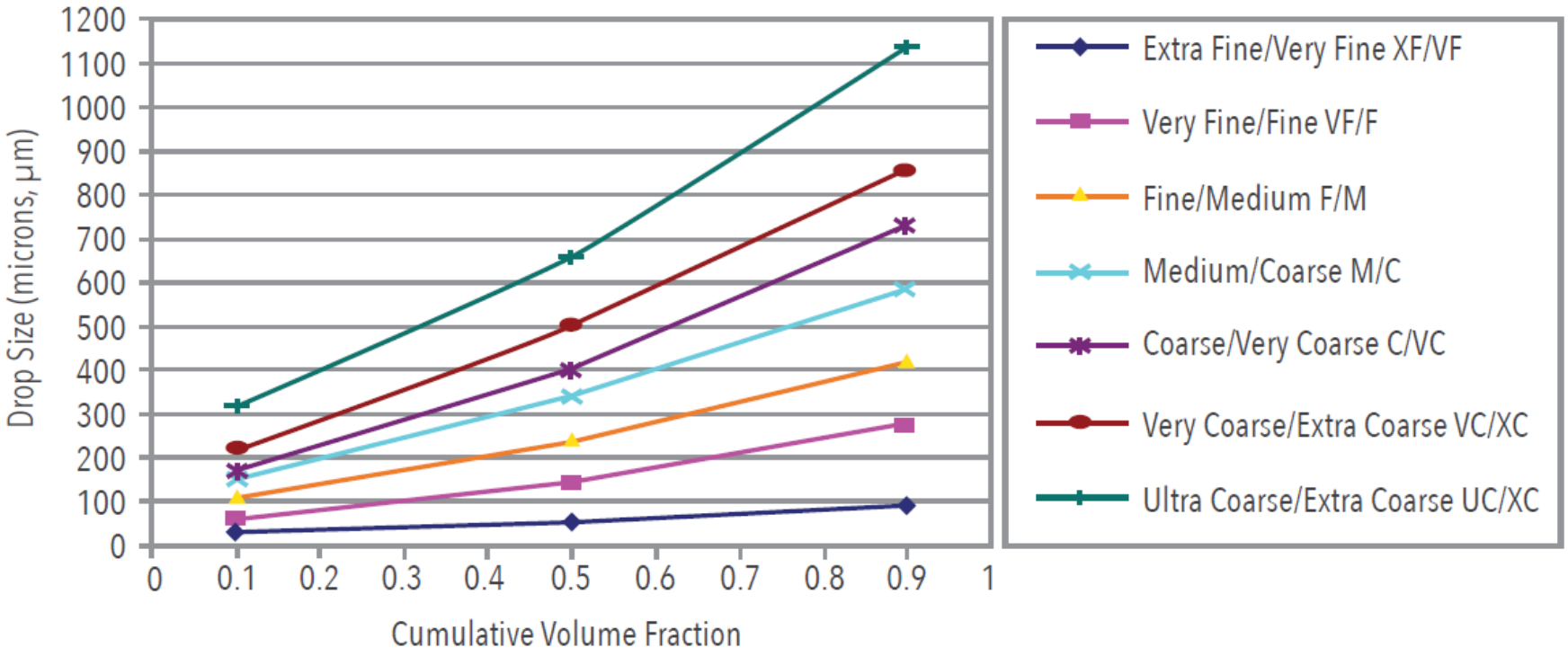
Base case (no digestion)

Anaerobic digestion

Odor - Equipment

- Application below canopy
- Avoiding end gun
- Avoiding impact sprinklers on top of irrigation equipment
- Larger droplet sizes (less surface area) recommended greater than 150 um
  - Coarse
  - Very coarse
  - Extremely coarse
  - Ultra coarse

Droplet Size Classification



Source:.ANSI/ASAE (2013) S572.1, Figure 1. Used with permission.

Odor - Siting

- Avoid odors from reaching receptors
- Avoid periods when winds are blowing toward people (receptors)
- Avoid periods when neighbors may be outside, particularly for an event
- Neighbor relations are important
- Edge of field barriers, e.g. tree lines

Odor - Weather

- Avoid periods of inversion
- Operate when air is warming (morning to afternoon), increases dispersion
- Operate when winds are above 5 mph, increases dispersion

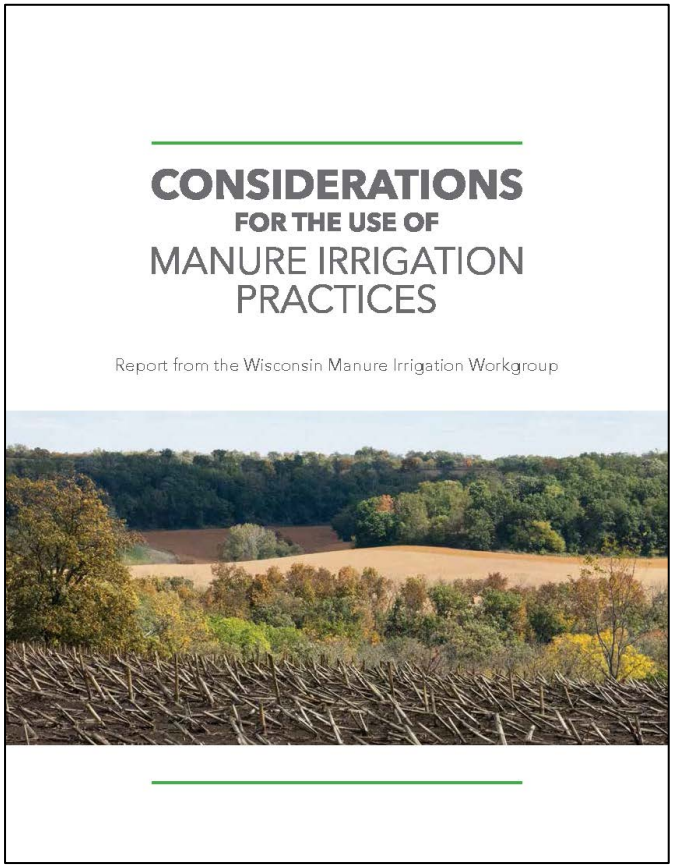
Consensus Baseline Recommendations

In all cases must:

- Follow all existing laws for animal waste and nutrient management
- Have and follow 590-standard Nutrient Management Plan
- Take appropriate steps to minimize drift
- Ensure no overspray of irrigated manure
- Have suitable means of supervising/controlling equipment
- Have suitable means of determining relevant weather info
- Have means of preventing backflow if connected to water
- Ensure no human waste or septage is processed with manure
- Drop nozzles if center pivot
- Nozzles and pressures for “coarse” or larger droplet size

Recommended Setback Distance

- Distance from wetted perimeter
- Consensus or near consensus
  - Road right of way – 0 feet
  - Public forests with no recreational access – 0 feet
  - Private forests – 0 feet
  - Adjacent pasture and cropland/agricultural land that are not organic or consumed raw – 0 feet
  - Dwelling – 500 to 750 feet for various conditions



Report and additional resources available at:

http://fyi.uwex.edu/manureirrigation/

Thank You!

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