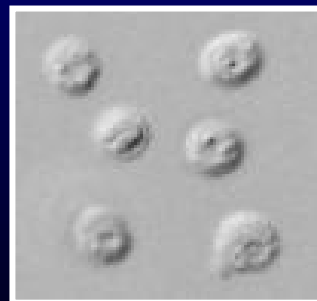
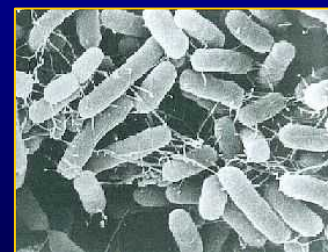
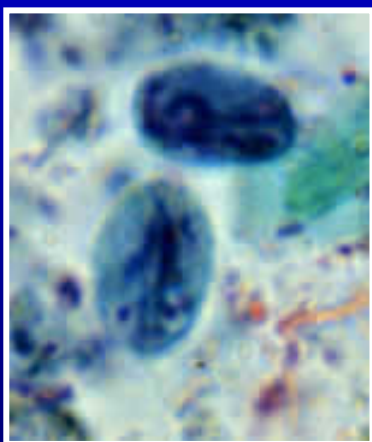


Manure-borne Microorganisms in Agricultural Environments



Jeanette Thurston-Enriquez

A few definitions...



- **Pathogen** = microbial agent causing disease
- **Enteric pathogen** = agent causing intestinal disease
- **Zoonotic pathogen** = a pathogen of animals that can infect humans

To Take Away...

- Pathogens are a concern in animal manure
 - *Enteric Pathogens & others...*
- Livestock can excrete high levels of some enteric pathogens infectious to humans
- Several characteristics enable enteric pathogen persistence and transmission in the environment
- Many exposure routes from livestock environments

To Take Away...

- Many data gaps concerning pathogens in Ag environments
 - Fate
 - Transport
 - Detection
 - Health Risks (human and animal)
 - Reduction strategies
 - Microbial ecology
- Pathogen research is closing in these gaps for multiple Ag environments but we have a long way to go!

Manure-borne Pathogens Implicated In Outbreaks of Disease

- New Jersey, USA *Salmonella typhimurium* outbreak apple cider (1974)
- Walkerton, Ontario *E. coli* O157:H7 & *Campylobacter* outbreak in drinking water supply (2001)

Waterborne Disease in the U.S.

- <20 drinking and recreational water outbreaks/yr
- ****10-100 x higher**
 - This does not include foodborne outbreaks!



Water Sources That Can Be Threatened By Manure-borne Pathogens

Recreational



Irrigation



Drinking



Seafood

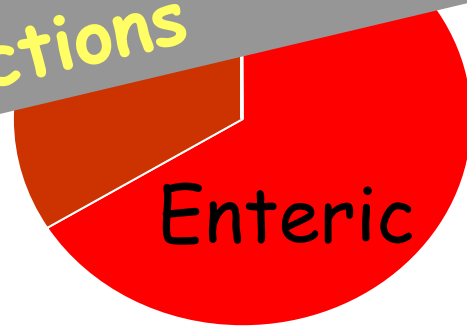
Enteric vs. Non-Enteric Pathogens Implicated in Waterborne Disease Outbreaks; 1991-2000

Non-Enteric



Drinking water

Non-Enteric



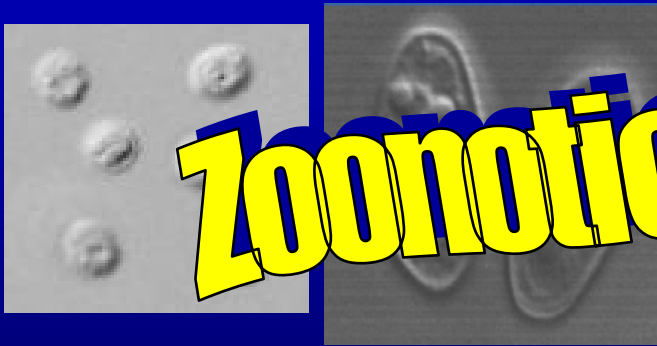
Enteric

Recreational/Surface Water

****Enteric pathogens most important in waterborne infections**

Manure-Borne Pathogens that May Threaten U.S. Water Supplies

Protozoan Parasites



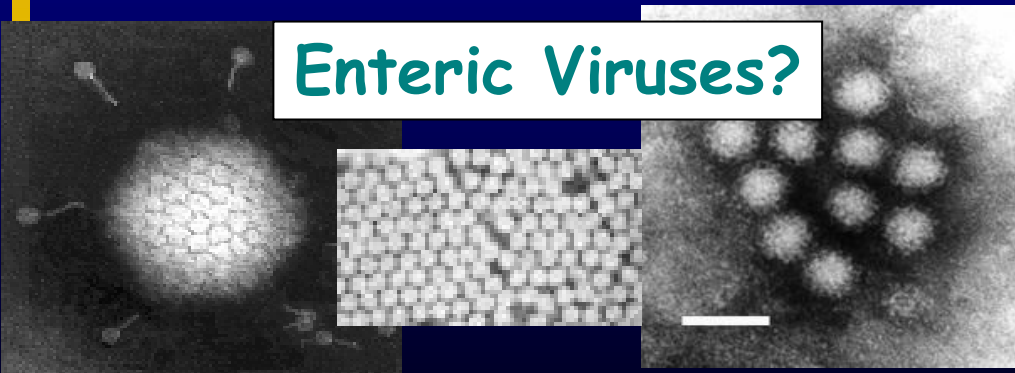
Bacteria



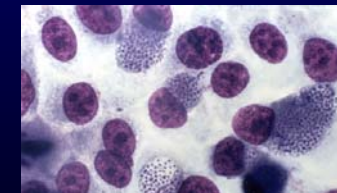
Zoonotic Pathogens

Antibiotic Resistance

Enteric Viruses?



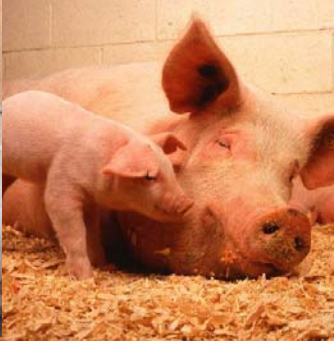
Other Pathogens



Microsporidia

Enteric Pathogens: Contributing Factors for Environmental Persistence and Transmission

- High numbers shed in feces
- Increased survival
- Low infectious dose
- Increased resistance to disinfection/treatment
- Multiple routes of transmission
- Animal and human infections

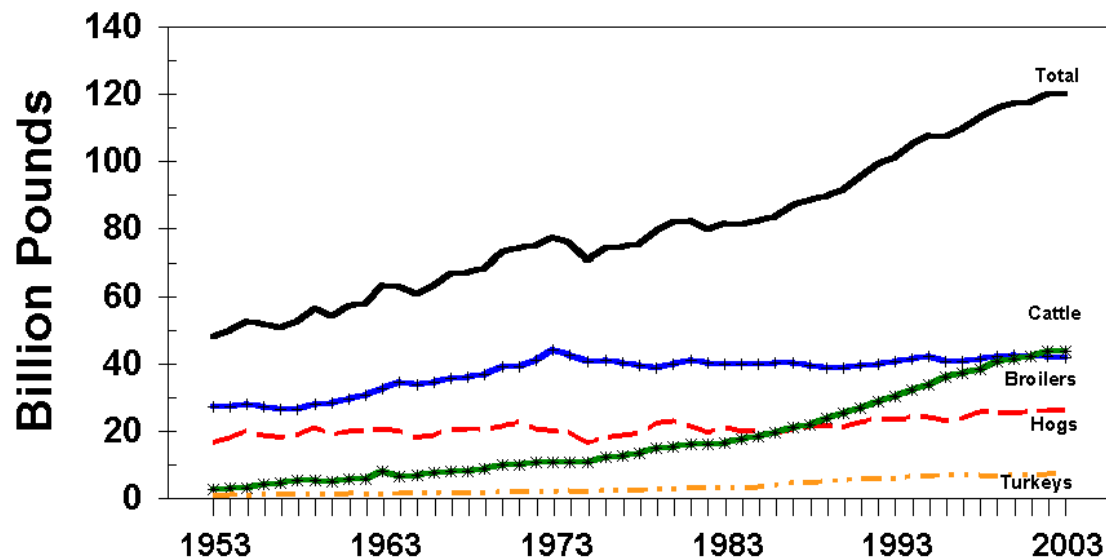


Agricultural Environments



More Animals... More Concentrated...

**CATTLE, BROILERS, HOGS, TURKEYS
POUNDS PRODUCED, 1953-2003**



USDA-NASS
April 2004

More Manure...

- Increase in CAFOs
- >500 million tons/year in U.S.
- 26 million tons/yr in NE



Livestock Environments

- Large amounts of manure produced
- High levels of pathogens excreted in manure
 - Up to 10,000,000 *Cryptosporidium* oocysts per gram of feces (calves)
 - ~3,000,000 *E. coli* per gram feces (cattle)
 - ~600,000 *E. coli* per gram feces (swine)
 - Young & sick animals ↑ levels
- Long duration of excretion
 - *E. coli* O157:H7: months
- Other sources: Insects, wildlife, inanimate objects (farm equip, shoes, etc)

Livestock Environments

Manure management practices can disseminate pathogens into water and air, onto soil and crops, or direct contact with inanimate objects or susceptible individuals (humans or animals)

Manure-borne Microbial Transport & Manure Management Practices

- Land application of manure solids
 - Irrigation of livestock wastewater
- Direct deposition
- Runoff from other manure laden areas (manure and compost piles, etc)
- Holding pond or lagoon overflow or leakage
- Other transport mechanisms



Aerosol Transport & Deposition

Manure storage

Direct Deposition

Land Application

Holding Pond

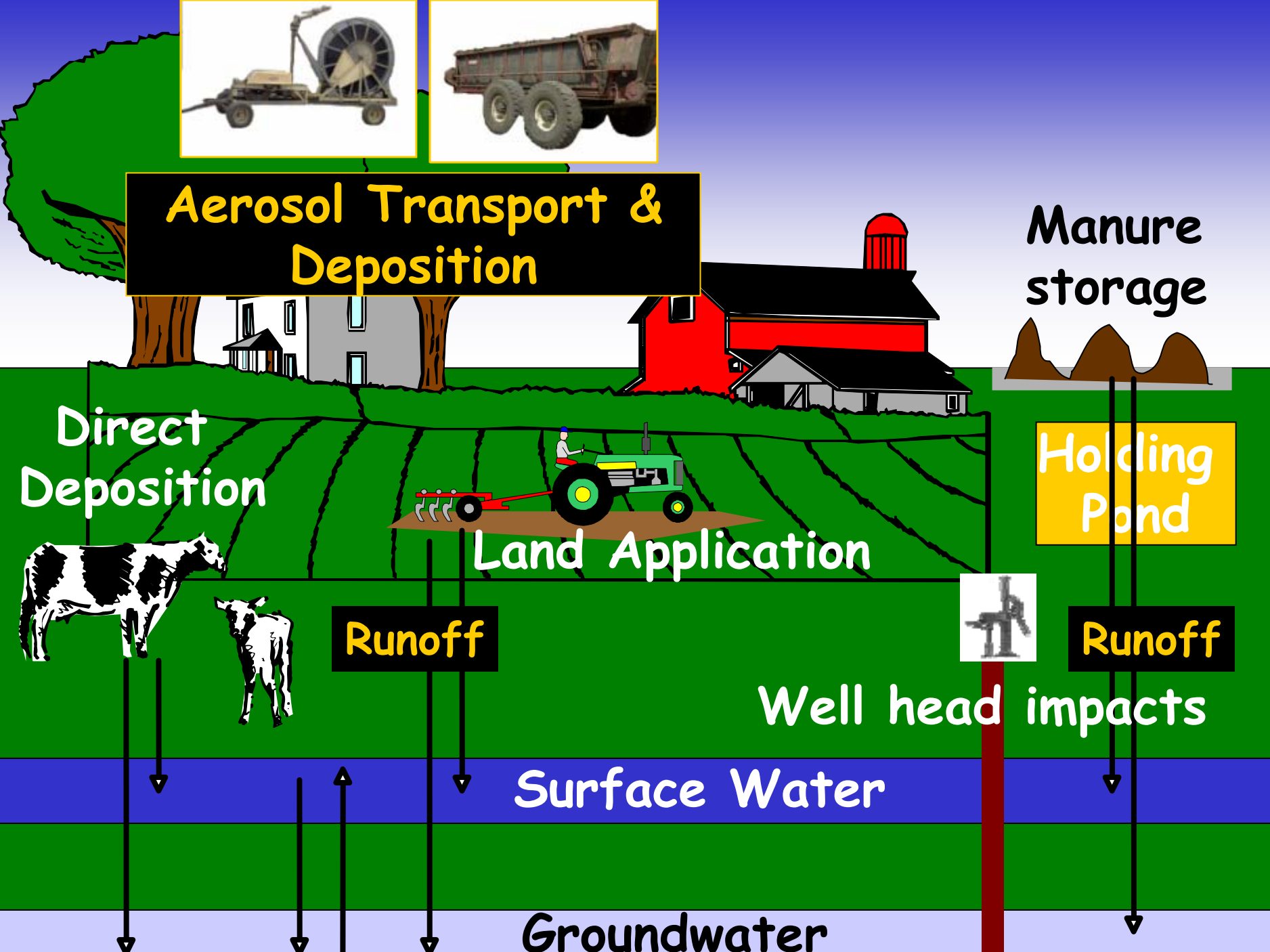
Runoff

Runoff

Well head impacts

Surface Water

Groundwater



Land Application

- Manure Spreading
- Liquid Manure Injection
- Liquid Manure Spray Irrigation

AIR

WATER

SOIL



Land Application & Aerosol Drift



Big Gun



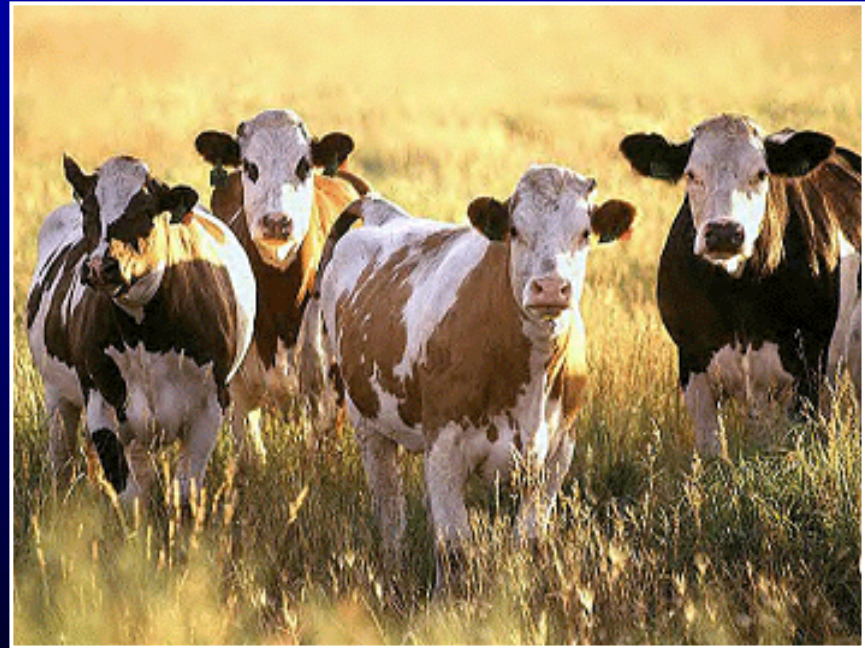
Center Pivot

Solid & Liquid Manure Land Application

- Runoff
- Air transport
- Direct contact
- Vector transport



Direct Deposition



Runoff from Manure Piles



Other Ways Pathogens can be Transported in Ag Environments

- Insects
- Wildlife
- Farm Equipment
- Others



- Environmental Loading
- Environmental Fate
- Treatment Effectiveness
- Alternative Treatments/Tech.
- !!!Microbial ecology!!!



Manure-borne Pathogen Information Gaps

- Detection Methods
 - Viability
 - Sensitivity
 - Specificity
- Emerging Pathogens
- **Risk Assessments
 - Requires above information

USDA-ARS Research



USDA-ARS Pathogen Research*

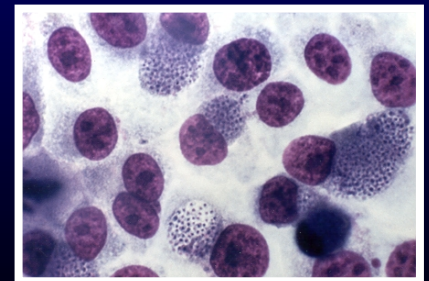
- Pathogen Detection Methods
 - Assessment and Development
- Bioaerosol Transport
- Antibiotic Resistance
- Cropland Runoff
- Constructed Wetlands
- Constructed Cattle Crossings
- Reclaimed Water Treatment
- Others

* Agroecosystem Management Research Unit, Lincoln, NE

Microsporidia Detection Method

- Sensitive and specific detection in manure
 - Detection down to 100/ml
 - Cattle and swine liquid and solid manure
 - Less sensitive detection in adult cattle feces
- First reported detection of human pathogenic microsporidia species in swine feces and wastewater

Kahler & Thurston-Enriquez, 2007.
Parasitol. Res. 100: 529-538.



Bioaerosols

- Aerosol transport
 - Indicator and pathogenic bacteria

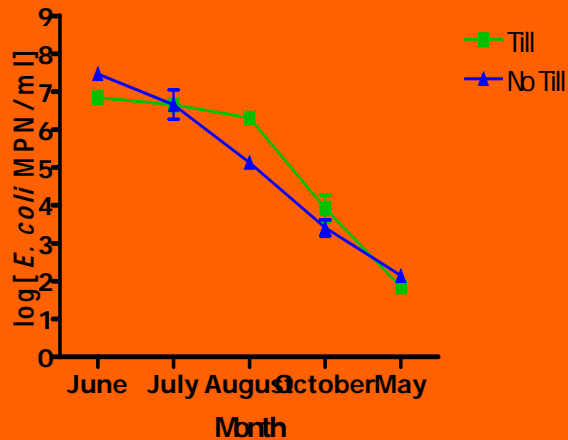


Findings: Fecal indicators and pathogen DNA was detected from 115 m & 81 m downwind of livestock liquid manure irrigation

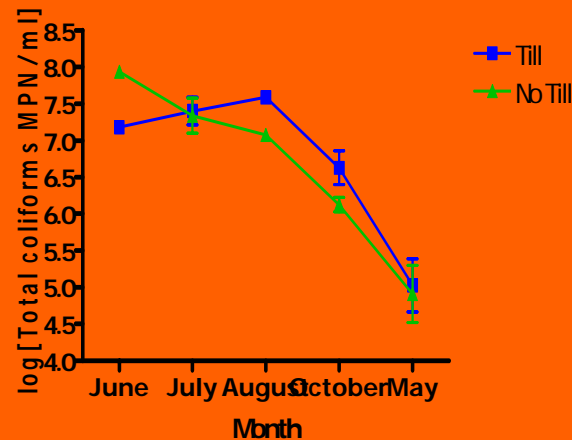
Temporal Runoff Studies

Fate of Fecal Indicators in Manured Till and No-Till Cropland
(average of three plots per treatment; per sampling date)

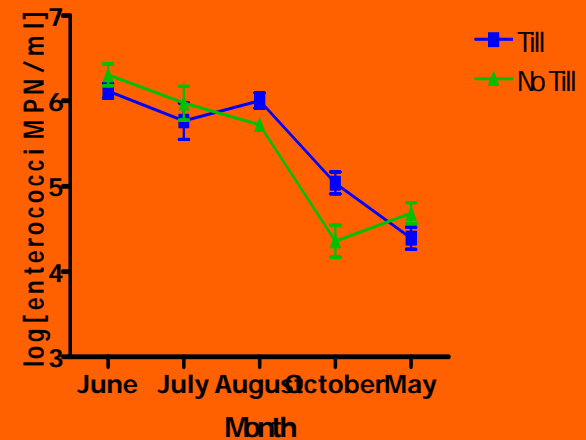
E. coli



Total Coliforms



Enterococci



Salmonella persisted for at least 121 days post application

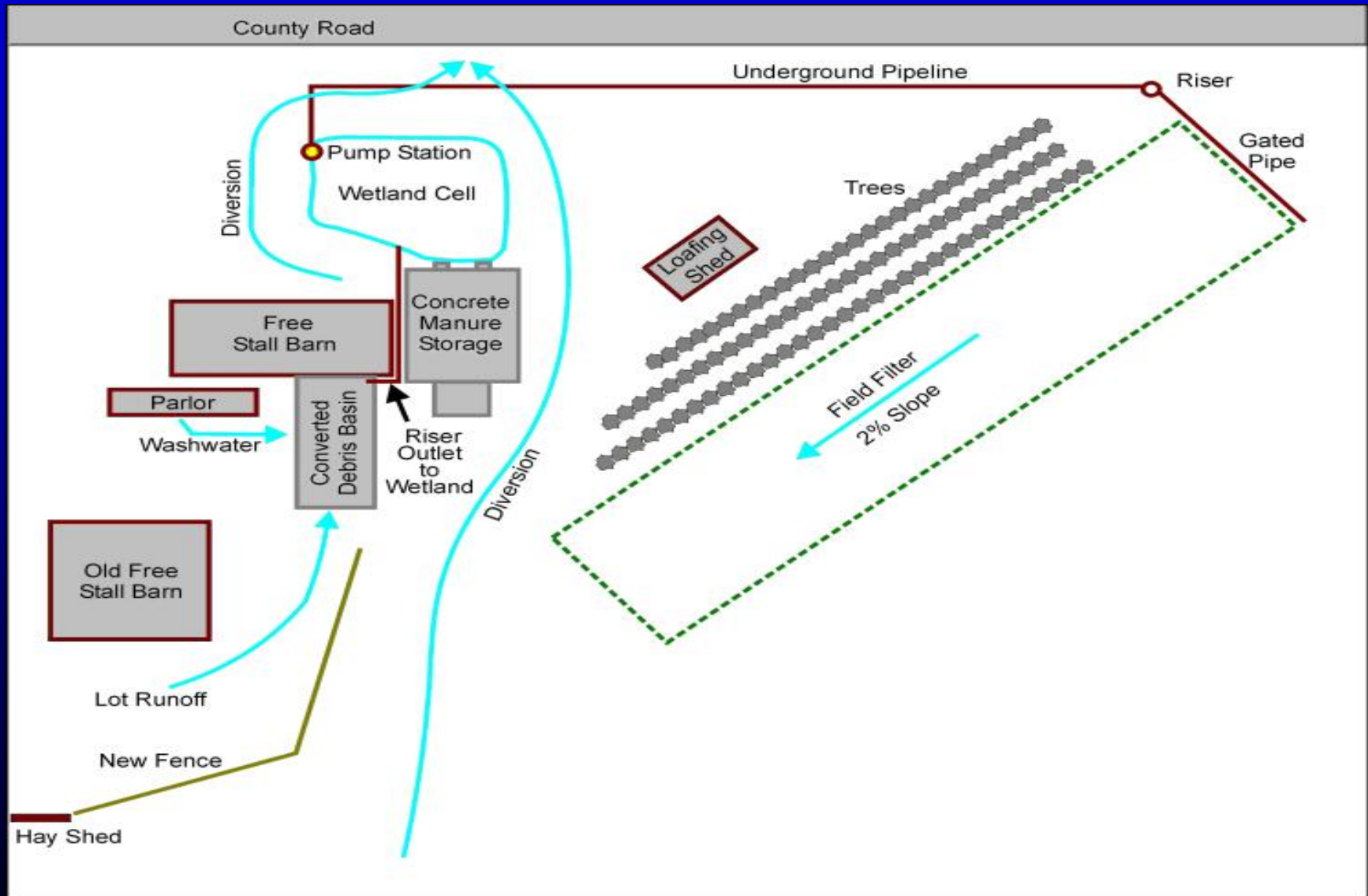
Constructed Wetlands

- Alternative waste management and treatment technology
- Dairy wastewater influent, surface flow, vegetated filter strip



- Contaminant reduction
 - Nutrients
 - Microbial pathogens
- Vegetation effects
- Microbial diversity

Constructed Dairy Wetland System





Dairy Cattle Constructed Wetlands

Unplanted Wetland

% Reduction

<i>E. coli</i> :	89
Enterococci:	83
Protozoa:	40-63



Constructed Cattle Crossings



- Cattle Use of Crossing
- Microbial Water Quality Impacts

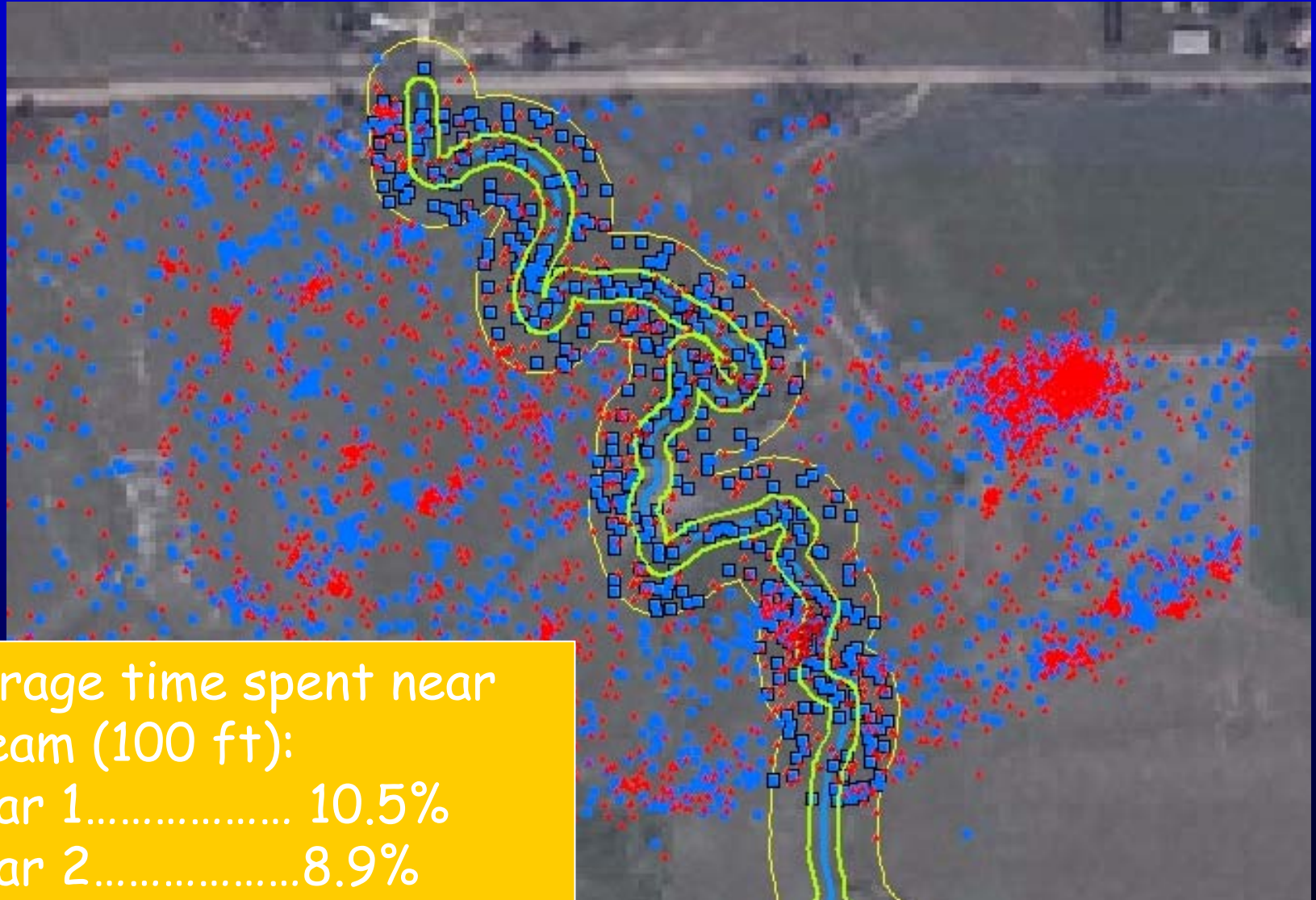


Results: Cattle Movement



- Cattle Used the LWSC
 - During a 1 week period:
 - 80% of cattle stream crossings were at the LWSC
 - Microbial water quality data support collar data

GPS Data Demonstrating Cattle Presence Nearby Stream



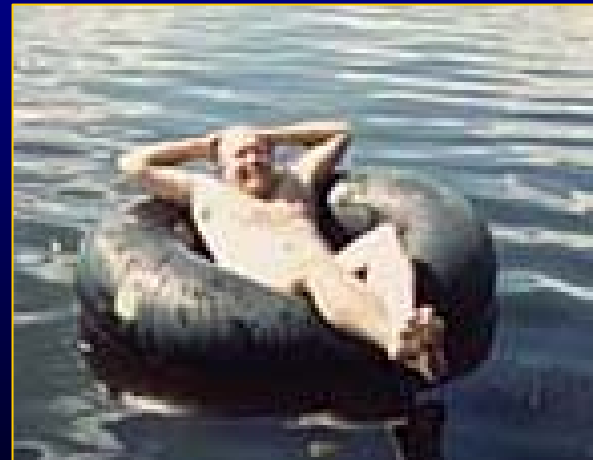
Average time spent near
stream (100 ft):

Collar 1..... 10.5%

Collar 2..... 8.9%

Results: Microbial Water Quality

- EPA 2° Contact Recreation standards exceeded during cattle presence & absence
 - Cattle Presence: 56% of samples assayed
 - Cattle Absence: 11 % of samples assayed



Reclaimed Water in Ag Environments

- Use of reclaimed water for irrigation of food crops-Microbial water quality?

Food Safety

- Current Project:
- Assessment of alternative technologies for reduction of enteric viruses, protozoan parasites, and fecal indicators in reclamation water
- Bench and pilot scale studies
 - UV, ozone, others...
- Adenovirus mouse infectivity



Other Pathogen Projects

- Bioaerosol Transport Modeling
 - Manure Composting
- Innovative/alternative BMPs
 - Stream sediment stores
- Genetic analysis of pathogen and tetracycline resistant isolates

- Environmental Loading
- Environmental Fate
- Treatment Effectiveness
- Alternative Treatments/Tech.
- !!!Microbial ecology!!!



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Questions/Comments?

