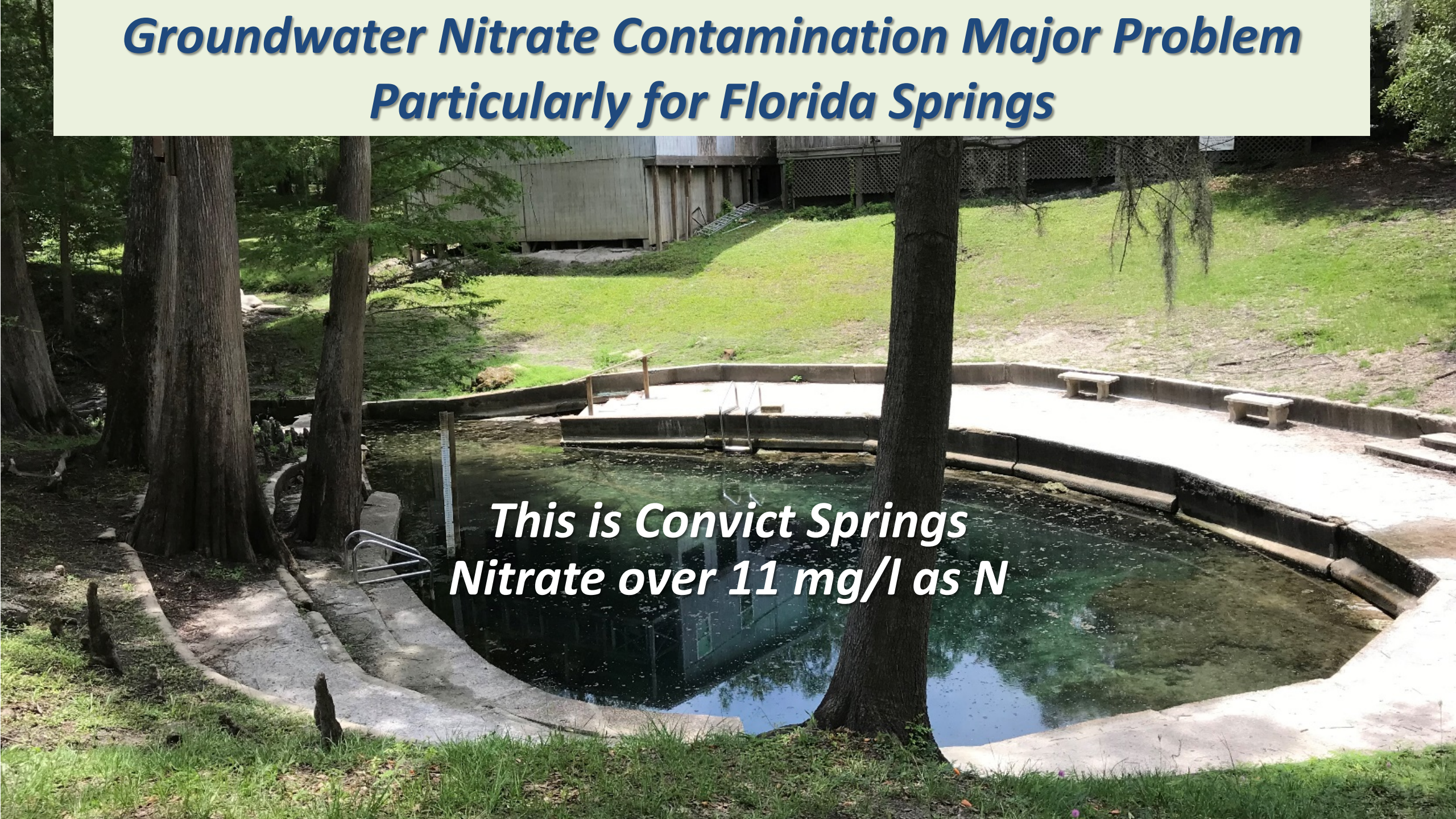
GROUNDWATER NITRATE MITIGATION SYSTEMS FOR AGRICULTURAL AND URBAN SOURCES

DEL BOTTCHER

SOIL AND WATER ENGINEERING TECHNOLOGY, INC.

Groundwater Nitrate Contamination Major Problem Particularly for Florida Springs

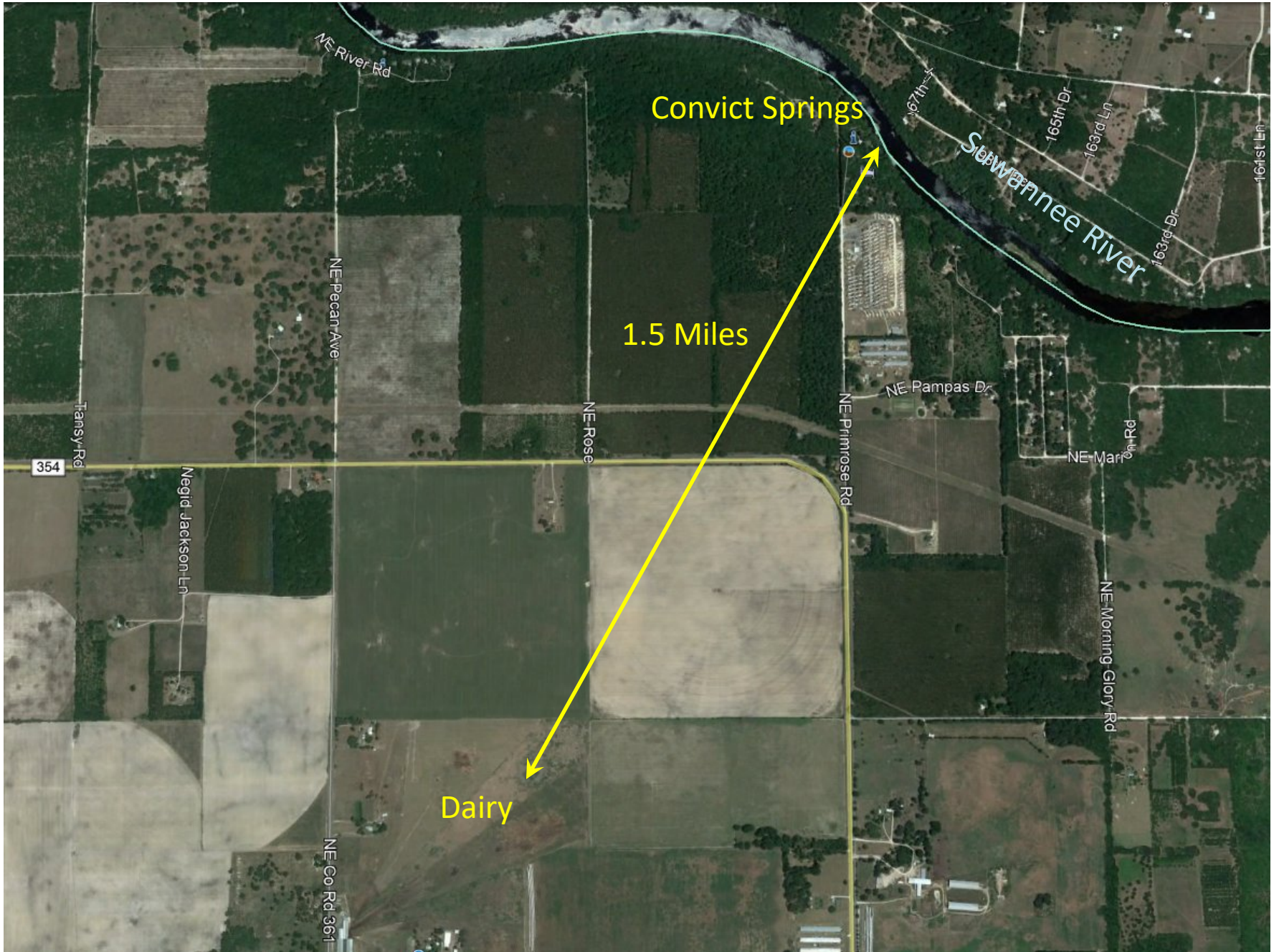


Sources of Nitrate Leaching to Groundwater

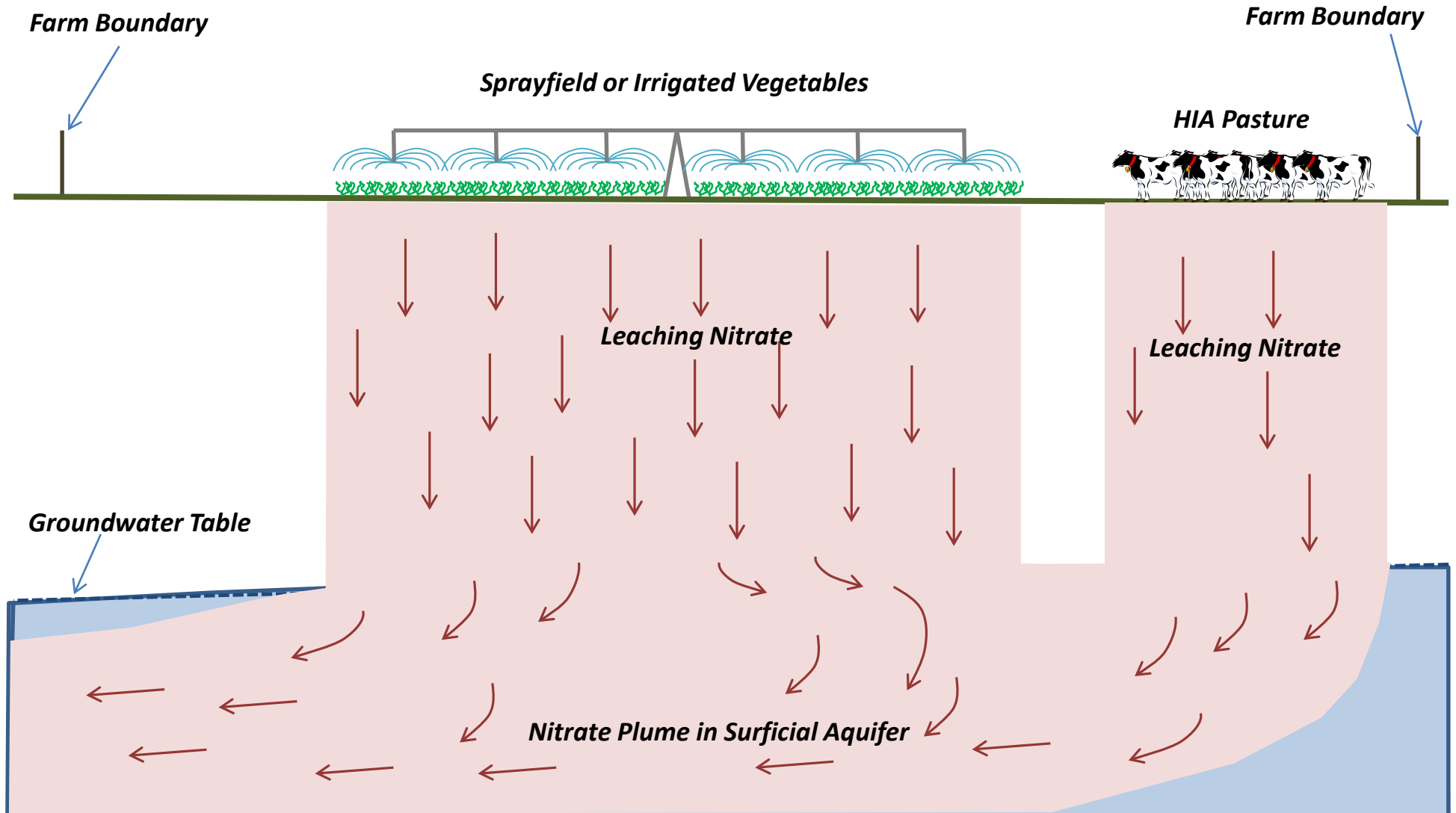
- Agricultural and Urban Fertilizer
- Septic Tanks
- Municipal Wastewater Treatment Systems
- Agricultural Livestock Operations, such as Dairy, Cattle, Horses, and Poultry Operations

Relative Contributions Vary by Watershed

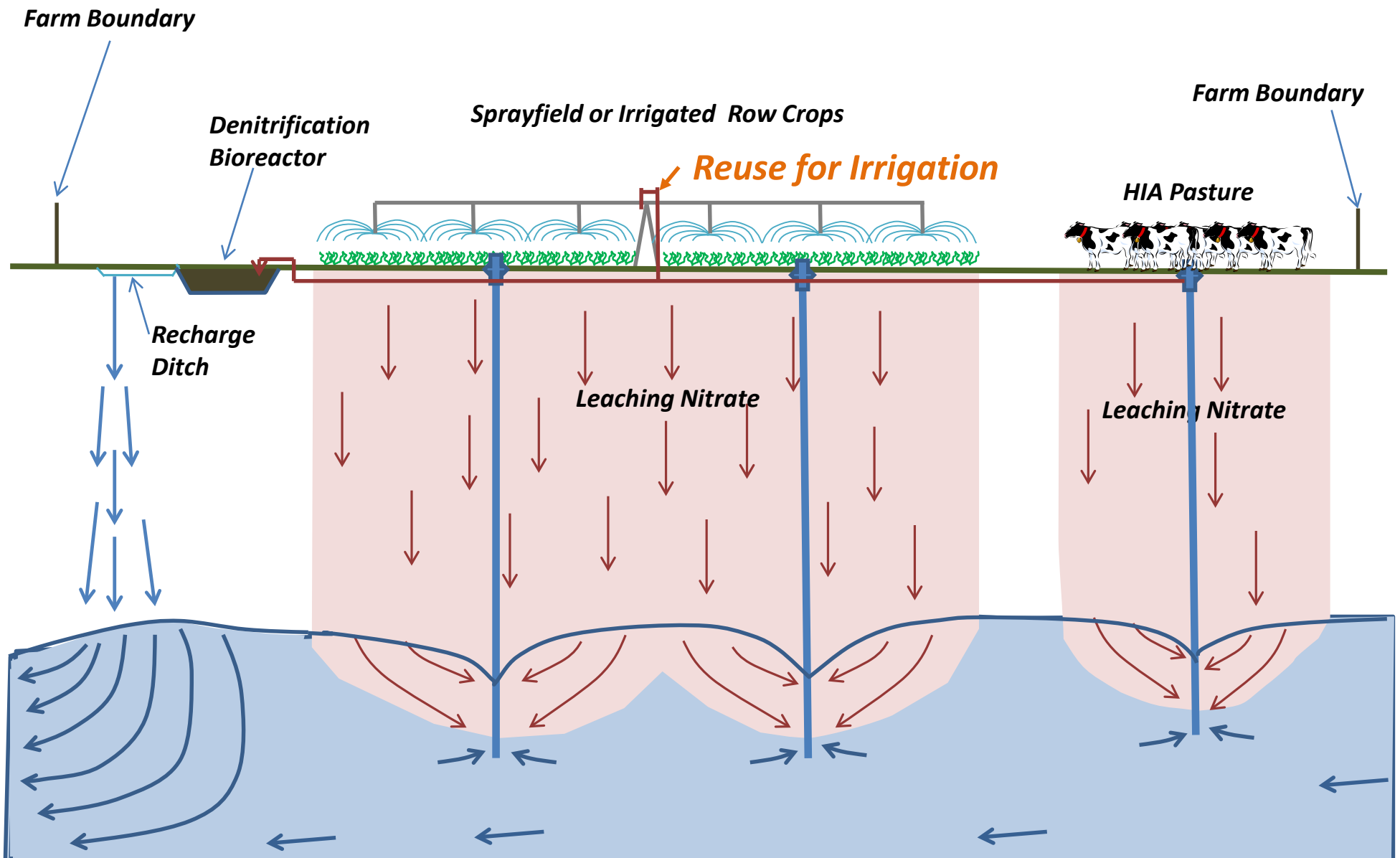
Example of Nitrate Source Close to a Spring Targeted for a Nitrate Mitigation System



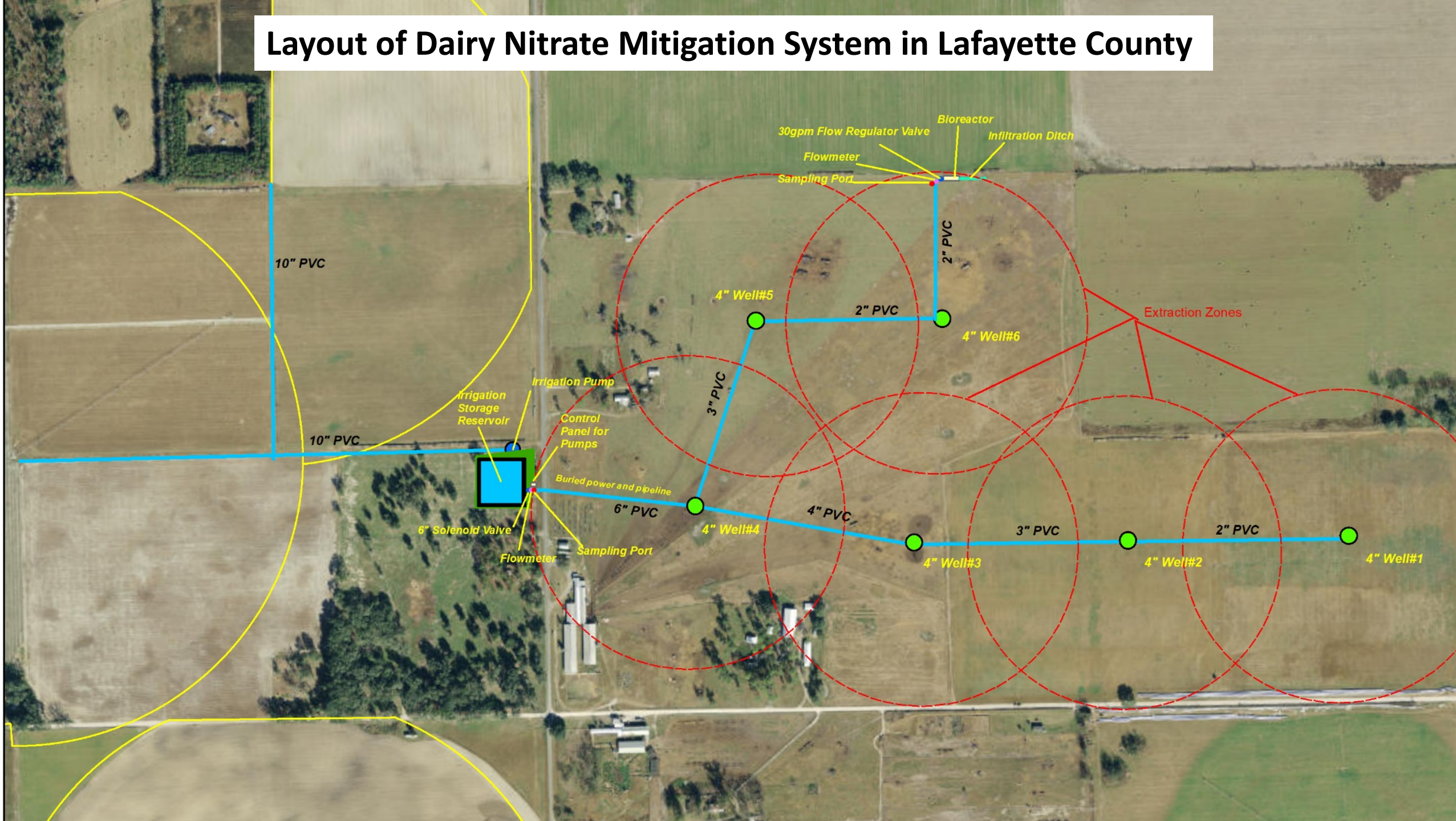
Nitrate Mitigation for Agricultural Fields – Existing Condition



Groundwater Nitrate Mitigation System



Layout of Dairy Nitrate Mitigation System in Lafayette County

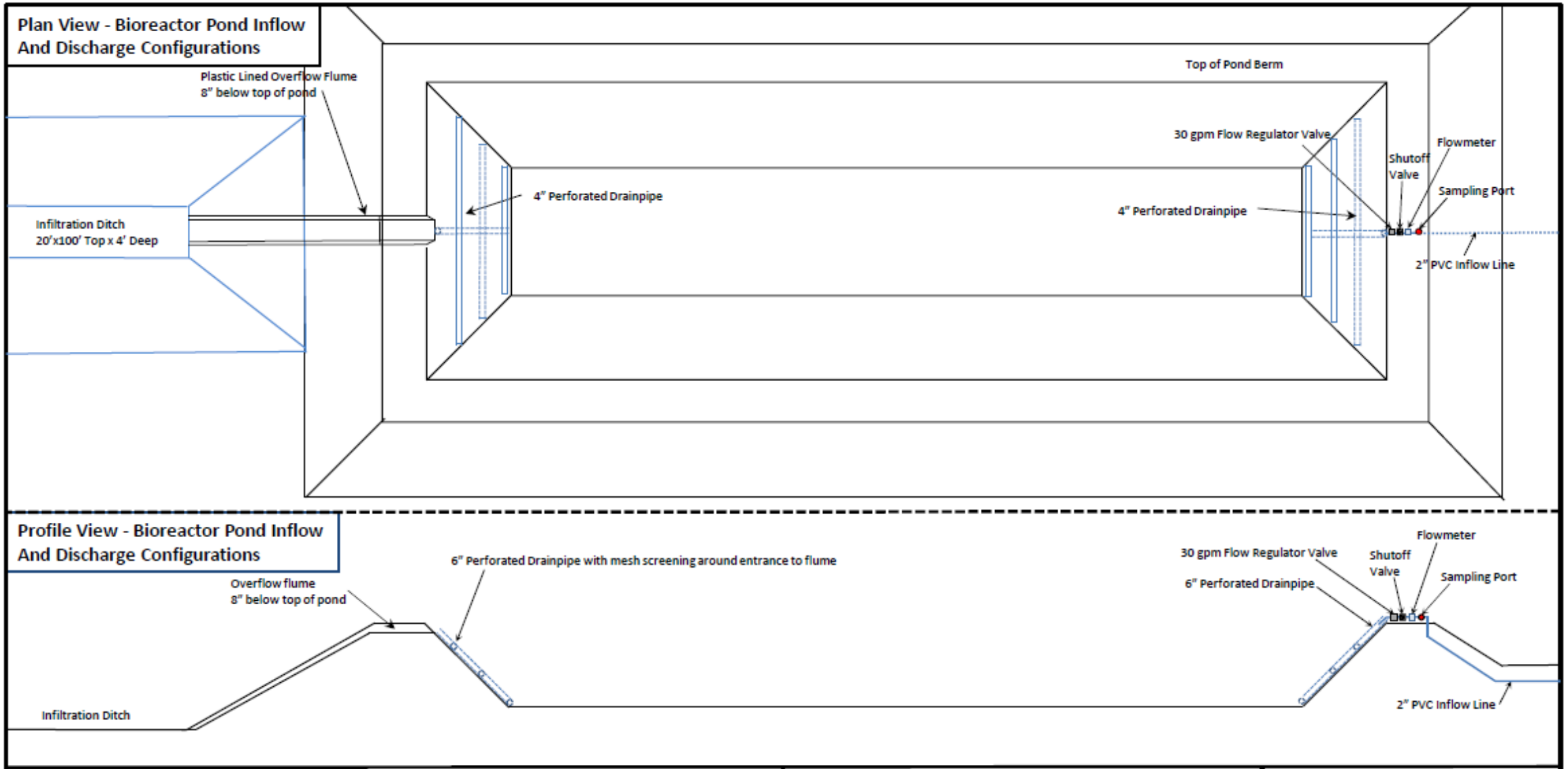


Lafayette Co. Dairy Target Extraction Rate

- Target 18” of pumping over 190-acre field
  - Bioreactor flow = 3” per year
  - Irrigation Reuse = 9” per year
  - Barn Reuse = 6” per year
- Provides about 8 in 10 year 100% capture
- Nitrate in reuse irrigation water calculated and farmer reduces fertilizer accordingly
  - ~ 6 lbs-N / 1 inch of irrigation

Interceptor Wells

Dairy Bioreactor Design



Dairy Construction Plan

Sheet 2. Bioreactor Pond – Inflow and Outflow Drainpipes Detail

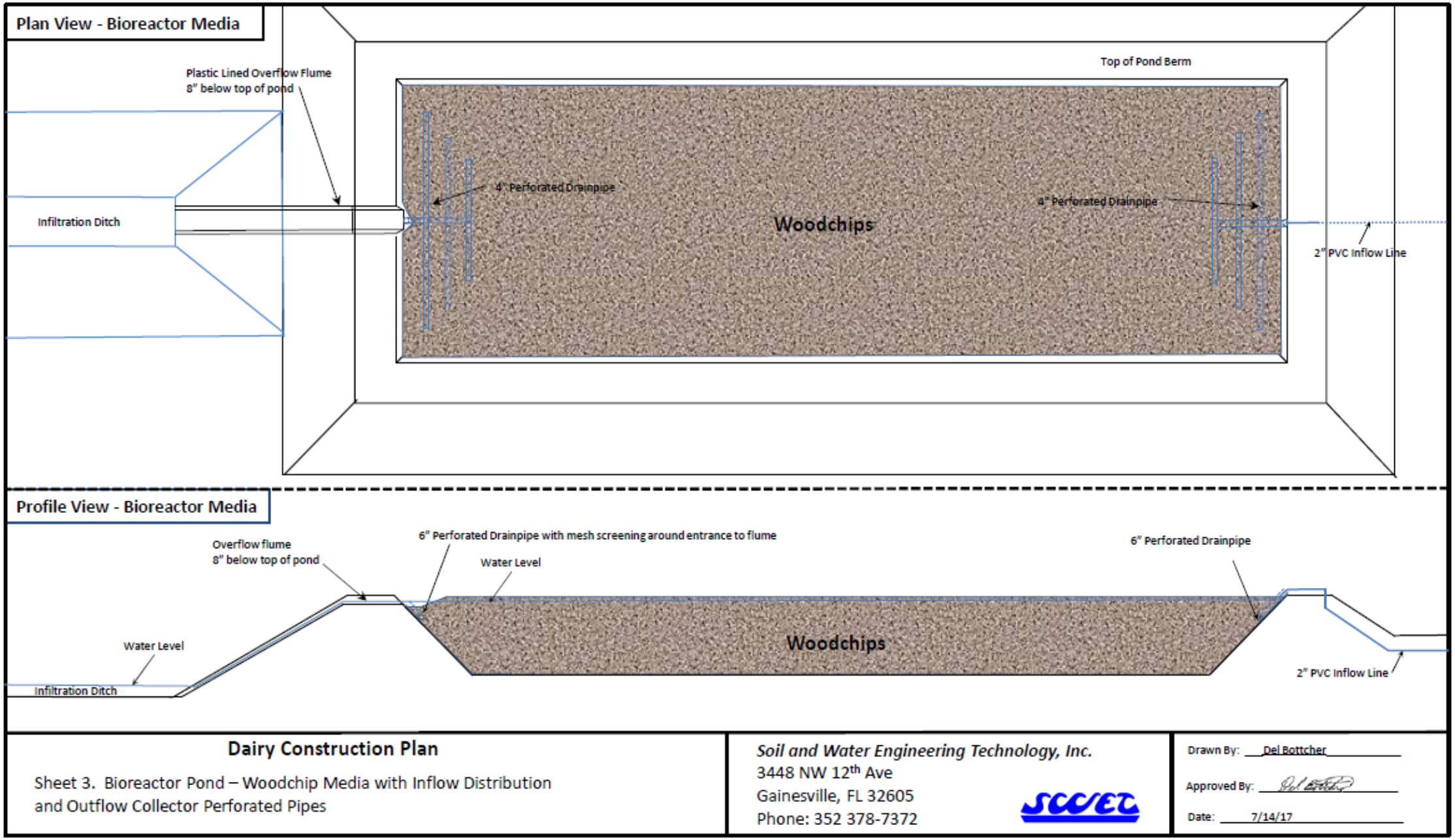
Soil and Water Engineering Technology, Inc.
3448 NW 12th Ave
Gainesville, FL 32605
Phone: 352 378-7372

Drawn By: Del Bottcher

Approved By:

Date: 7/14/17

With Woodchips Added



Dairy Construction Plan

Sheet 3. Bioreactor Pond – Woodchip Media with Inflow Distribution and Outflow Collector Perforated Pipes

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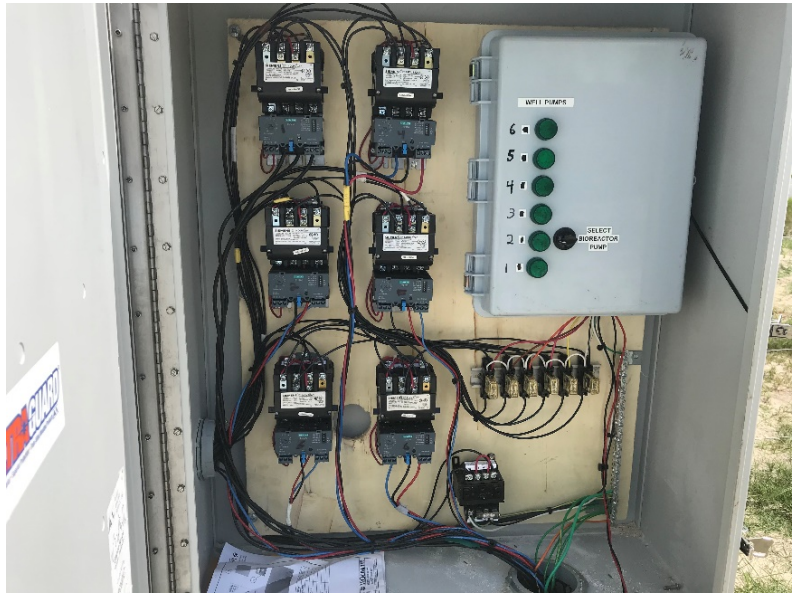
Woodchips

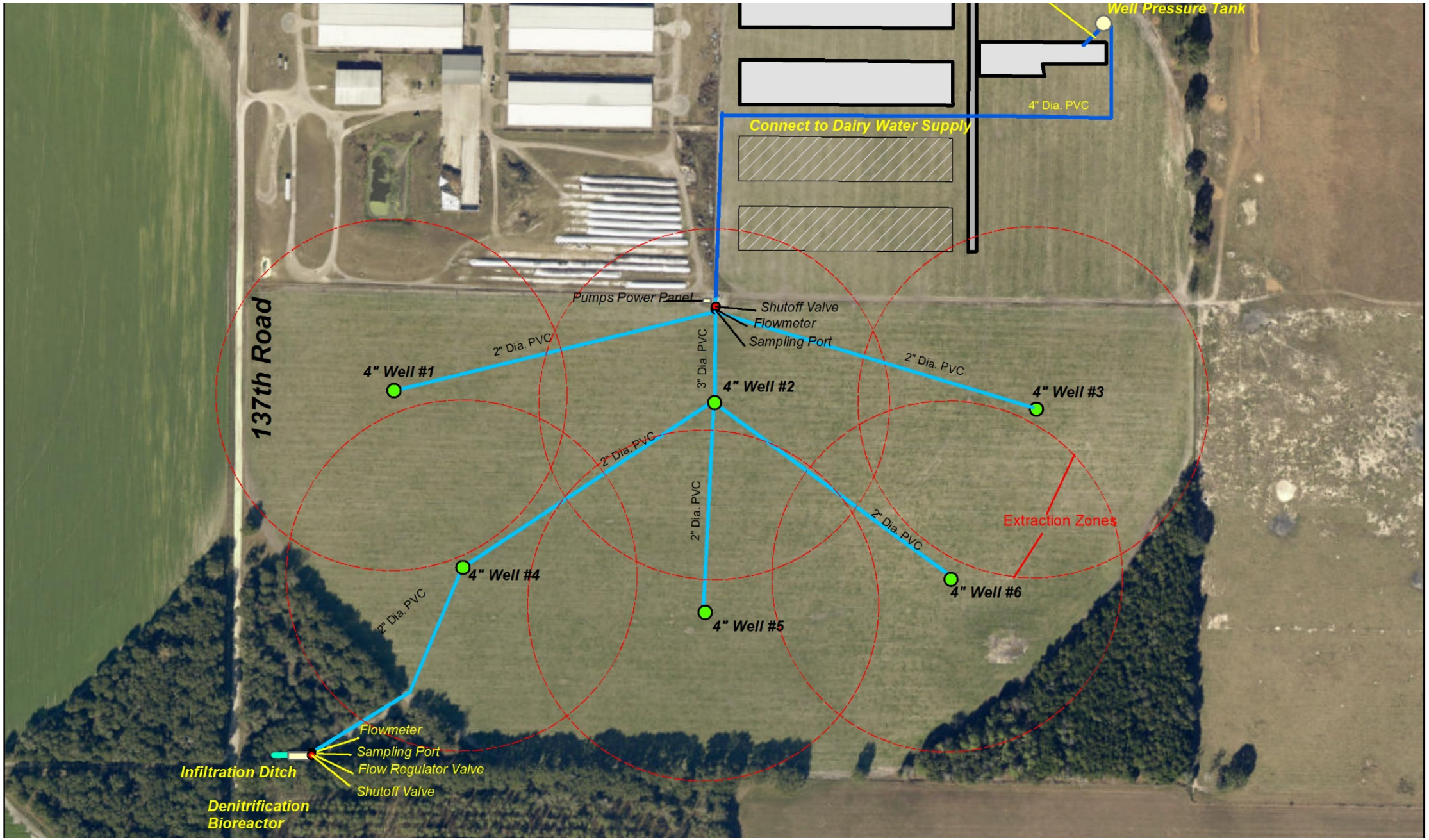
“Mill Grade”

Bioreactor and Infiltration Ditch

Irrigation Reuse Pond



Layout of Dairy Nitrate Mitigations System in Suwannee County



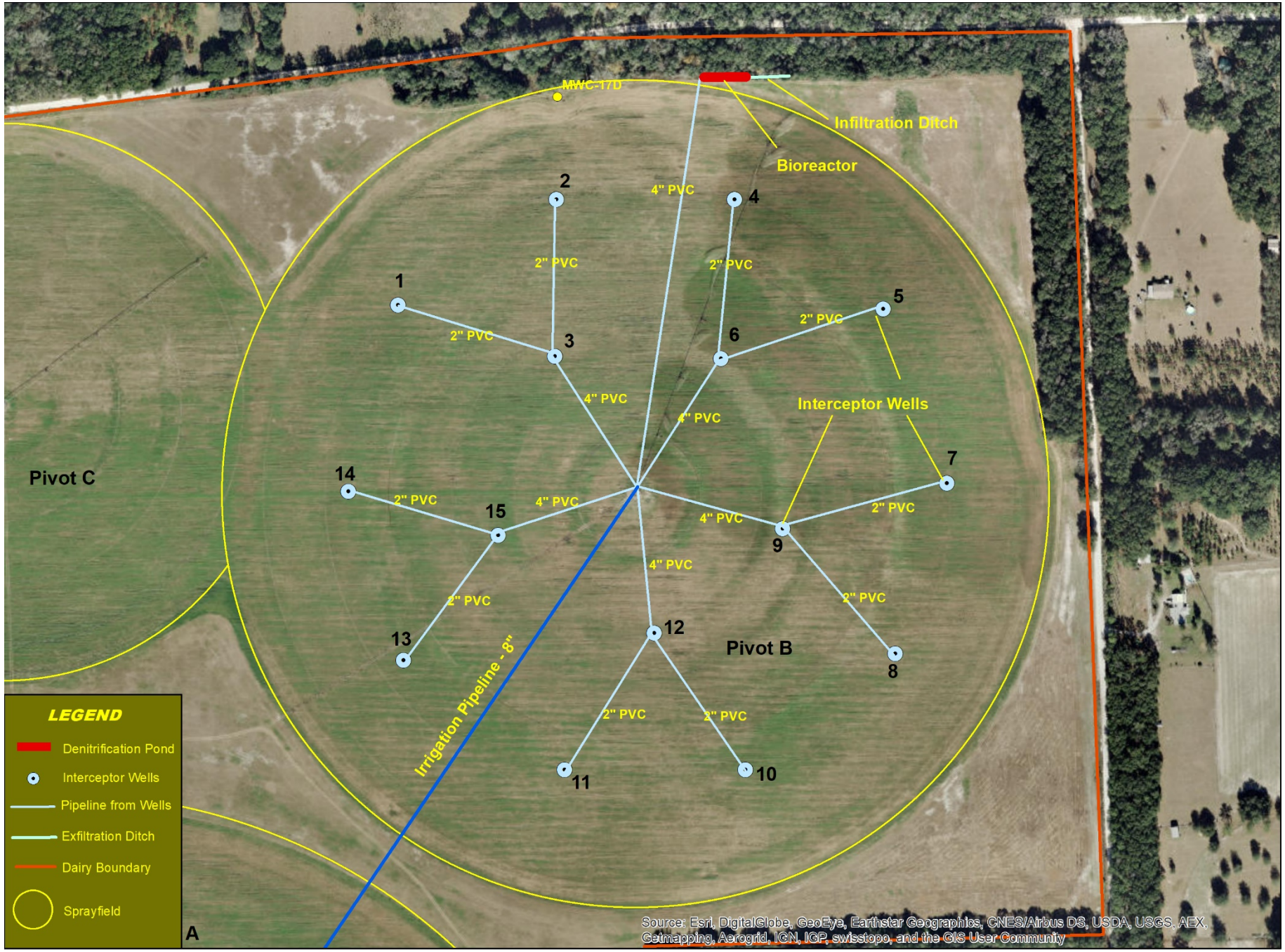
Suwannee Co. Dairy
Target Extraction Rate

- Target 18” of pumping over 70-acre field
  - Bioreactor flow = 3” per year
  - Barn Reuse = 15” per year, which ultimately irrigated onto crops
- Provides about 8 in 10 year 100% capture
- 100% of nitrate in barn reuse water is denitrified to N_2 gas as it passes through the anaerobic digester and storage pond.


Wellheads were buried for farming convenience

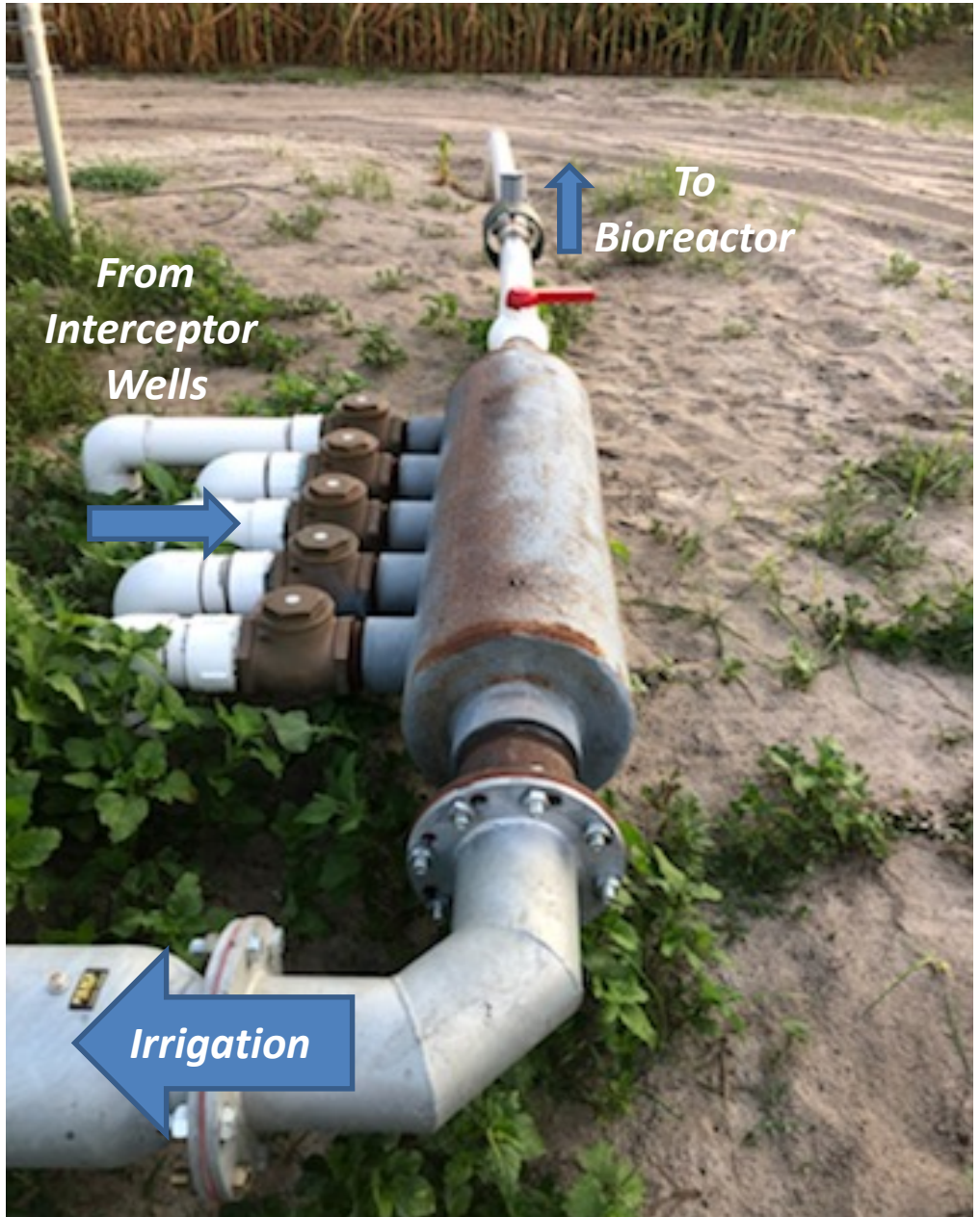

A Friend Found Swimming in Pond
before woodchips added

Layout of Dairy Nitrate Mitigation System in Gilchrist County



Interceptor Well

Irrigation Manifold



Gilchrist Co. Dairy Target Extraction Rate

- Target 18” of pumping over 130-acre field
  - Bioreactor flow = 3” per year
  - Irrigation Reuse onto 250 acres of Row Crop
    = 15” per year
- Provides about 8 in 10 year 100% capture
- Nitrate in reuse irrigation water calculated and farmer reduces fertilizer/wastewater accordingly

Nitrate Removal Performance of Dairy Systems

Lafayette Co. Dairy (Started 9/2018)

Groundwater Extracted as of 12/12/19: ***29 Million Gallons***

Bioreactor : (60% N Removal Efficiency)

Nitrate-N removed as of 12/12/19: 2,400 lbs

Irrigation Reuse: (100% N Removal Efficiency) **Total: 6,700 lbs**

Nitrate-N removed as of 12/12/19: 4,300 lbs

Suwannee Co. Dairy (Started 12/2018)

Groundwater Extracted as of 12/12/19: ***25 Million Gallons***

Bioreactor : (95% N Removal Efficiency)

Nitrate-N removed as of 12/12/19: 480 lbs

Irrigation Reuse: (100% N Removal Efficiency) **Total: 5,600 lbs**

Nitrate-N removed as of 12/12/19: 5,100 lbs

Gilchrist Co. Dairy (Started 5/2019)

Groundwater Extracted as of 12/12/19: ***56 Million Gallons***

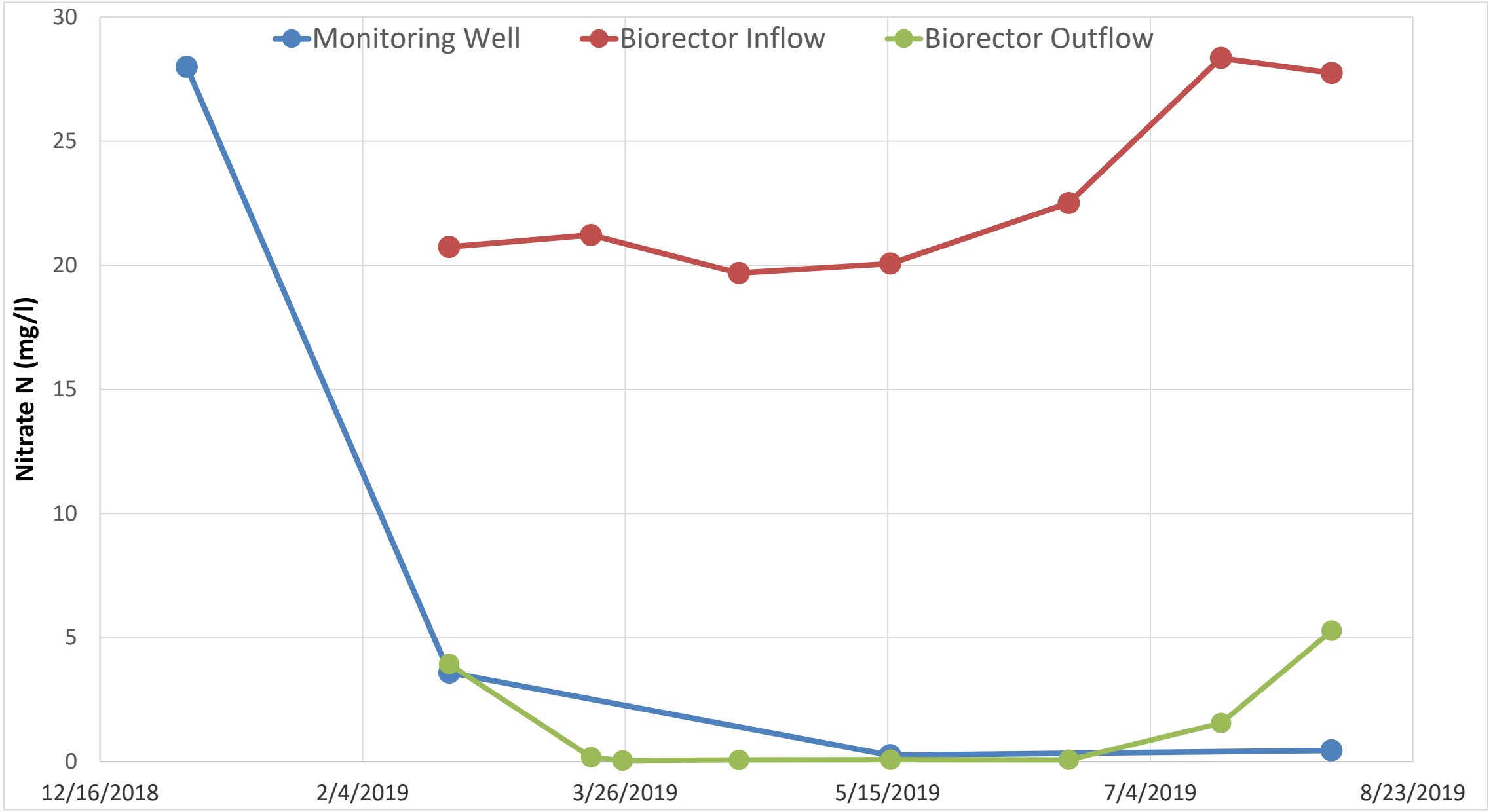
Bioreactor : (80% N Removal Efficiency)

Nitrate-N removed as of 12/2/19: 3,700 lbs

Irrigation Reuse: (100% N Removal Efficiency) **Total: 23,700 lbs**

Nitrate-N removed as of 12/2/19: 22,000 lbs

Nitrate Removal Performance for Suwannee Co. Dairy Bioreactor



Estimated Cost Effectiveness of Nitrate Removal Systems

Lafayette Co. Dairy

Annual Cost over twenty year project life	= $56,700 /year
Bioreactor N removal	= 15,000 lbs-N/year
Irrigation Reuse Removal	= 2,600 lbs-N/year
Cost Effectiveness	**= $ 3.20 /lb-N Removed**

Suwannee Co. Dairy

Annual Cost over twenty year project life	= $12,700 /year
Bioreactor N removal	= 5,900 lbs-N/year
Irrigation Reuse Removal	= 950 lbs-N/year
Cost Effectiveness	**= $ 1.80 /lb-N Removed**

Gilchrist Co. Dairy

Annual Cost over twenty year project life	= $30,800 /year
Bioreactor N removal	= 25,000 lbs-N/year
Irrigation Reuse Removal	= 5,000 lbs-N/year
Cost Effectiveness	**= $ 1.00 /lb-N Removed**

GROUNDWATER NITRATE MITIGATION FOR SEPTIC TANKS

Current Treatment Options for Septic Tanks - Onsite Sewage Treatment and Disposal Systems (OSTDS)

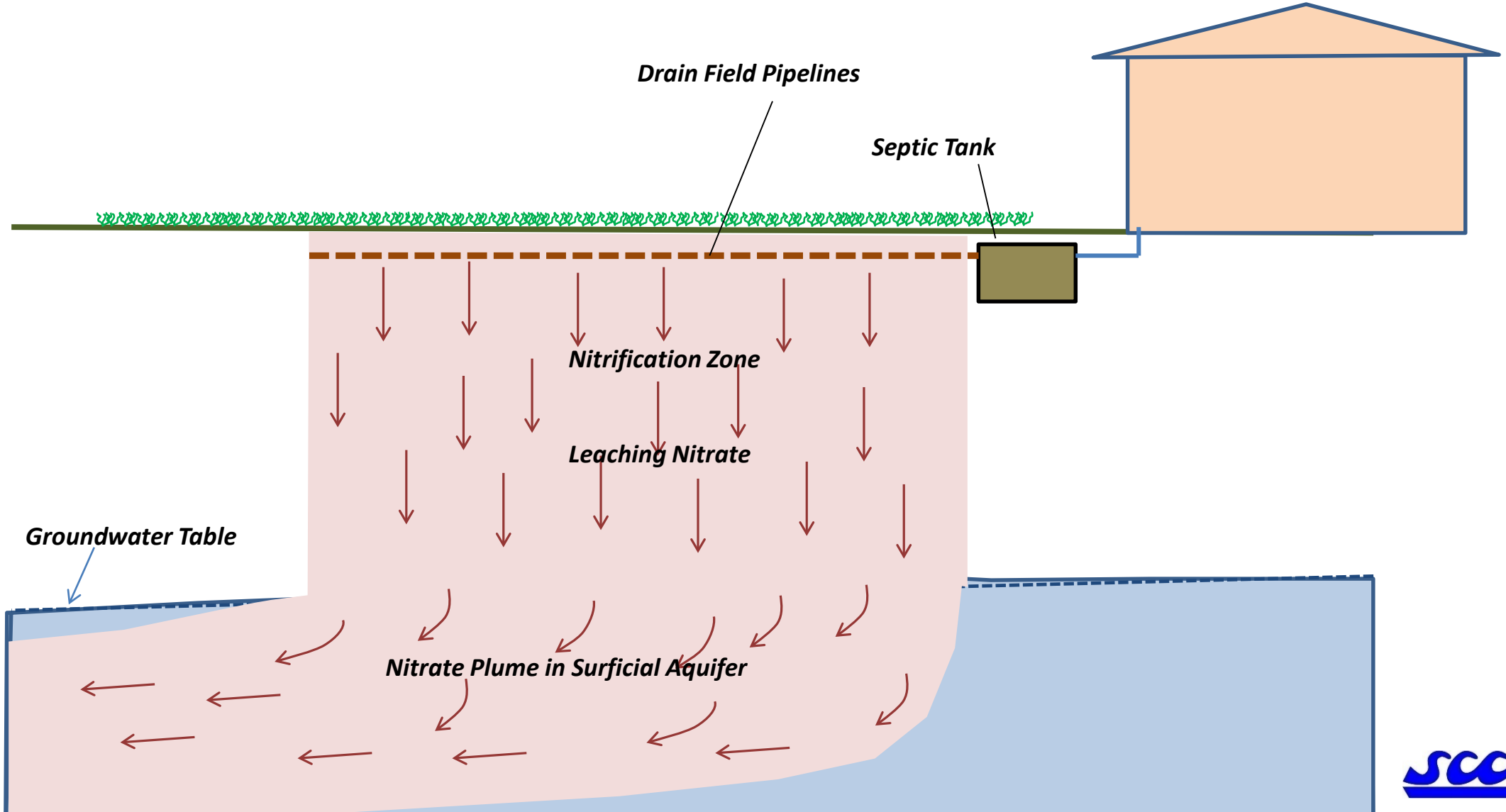
Existing Options

- Typical OSTDS is a Septic Tank with a Drain Field
  - Has high nitrate losses to groundwater, low cost
- Connection to Municipal Wastewater Treatment System
  - High cost - $15,000 to $25,000 per system, plus annual fee
- Advanced OSTDS - Aeration and Reactive Media Denitrification Systems
  - High cost - $10,000 to $20,000 per system, high maintenance and energy costs

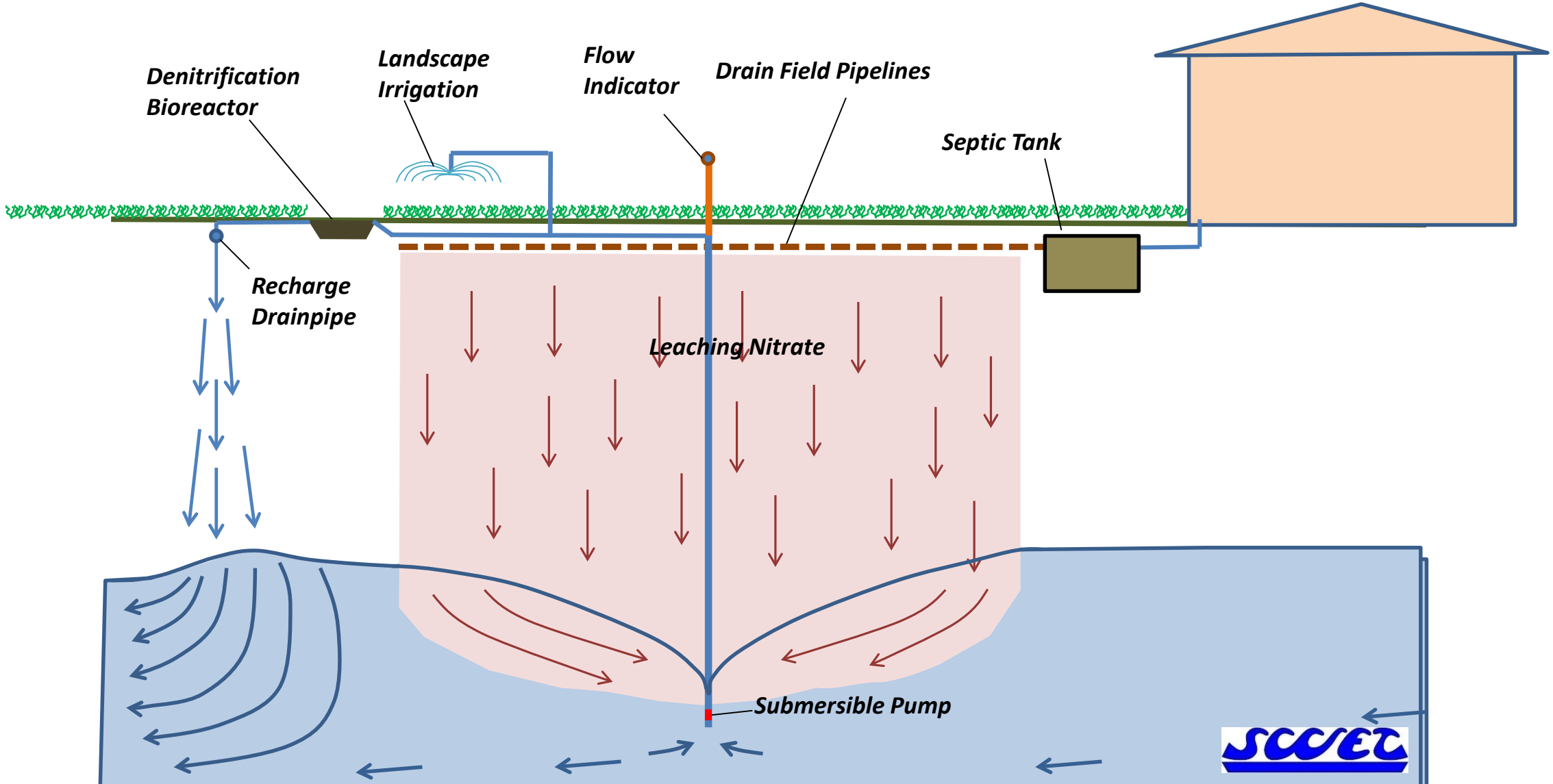
New System Being Proposed

- Denitrification via interceptor well and bioreactor
  - Adapts to existing systems, limited visual footprint
  - Single intercept well and underground bioreactor (like a 2nd septic tank)
  - Low energy cost because native soils does the nitrification work
  - Low maintenance

Denitrification Via Interceptor Well and Bioreactor for Septic Drainage Field

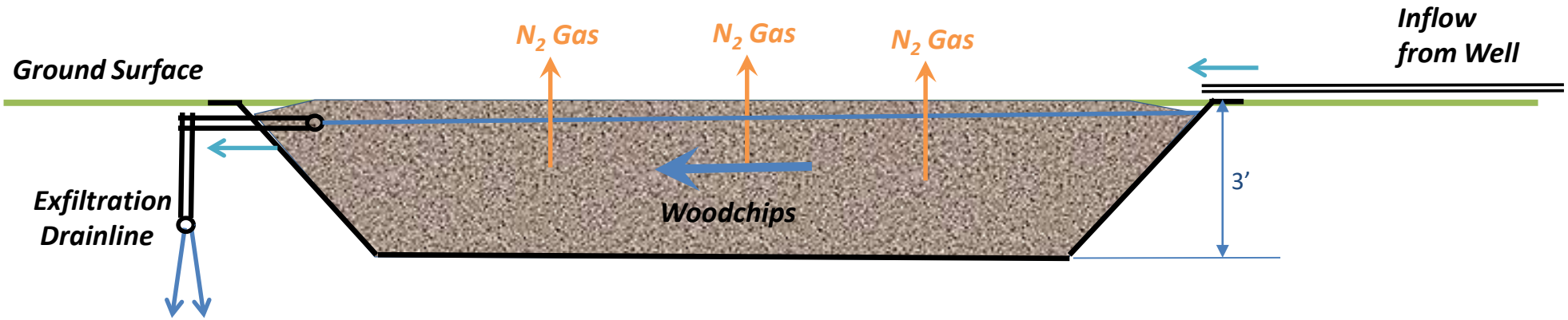


Denitrification Via Interceptor Well and Bioreactor for Septic Drainage Field



Denitrification Bioreactor for Septic Drainage Field

500 gal Plastic Bioreactor



Denitrification Via Interceptor Well and Bioreactor for Septic Drainage Field

- Theory
  - Nitrates are denitrified in an anaerobic environment.
  - Therefore, the organic and ammonia forms of N in the septic effluent must be nitrified in an aerobic environment before N can be removed via denitrification.
  - Using the natural soil matrix to do the nitrification and then collecting the nitrate laden groundwater via a shallow interceptor well that has a pump rate that will ensure a 100% capture of nitrate contaminated groundwater is a very low energy and low cost capture system.
  - The captured groundwater will be pumped through a carbon (wood chips) based bioreactor to create the anaerobic condition with sufficient carbon to denitrify the nitrates.
  - The nitrate striped effluent will be recharged back to groundwater via an exfiltration drainline down gradient of the drainfield.
- Design Assumptions:
  - 75 gallons of septic effluent per person per day to be treated
  - 11.2 grams of nitrogen per day per person in the septic effluent or ~50ppm N
  - Pump rate to capture leachate from drainfield serving 3-person household is calculated:
    3 persons x 75gpd/person +18in/y recharge over 4500 sq.ft = 363 gpd or 0.25 gpm
  - Bioreactor size for 1.5 day retention serving 3 person household = 500 gallons

Costs of Septic Drainage Field Interceptor Well / Bioreactor

Item Description	Quanity	Units	Unit Cost	Cost
Well (2" dia, 40' deep)	1	ea	$1,500	**$1,500**
Pump and Piping				**$105**
Pump (0.25 gpm)	1	ea	$120	$120
Piping (1/2" PVC)	50	ft	$0.60	$30
Wiring	50	ft	$1.50	$75
Electrical Cost (O&M)	45	kwh/yr	$0.15	$7
Denitrification Bioreactor				**$1,356**
Excavation	3.7	yd3	$250.00	$926
Plaster Liner	120	ft2	$1.75	$210
Organic Matrix	3.7	yd3	$50.00	$185
Exfiltration drainpipe	10	ft	$3.50	$35
Total Capital Cost				**$2,961**
Amortized Annual Cost (15yr-life)				**$292**

* Cost for connecting to municipal system = $10,000 to $25,000, then monthly fee