(2022 *Visit Big Sky*)

Five Years of Monitoring in the Big Sky Meadow Village Aquifer: Patterns in nutrients and wastewater tracers

- Nick Banish, Gallatin Local Water Quality District

Acknowledgments

- **Staff at MBMG, John L., Mike R., Alan E.**
- **GLWQD Project Support Staff: Drew Shafer, Lulu McMahon**

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- **Meggie Olson, now at Montana Tech**

Talk Overview

- **Evaluate changes in N and Cl**
- **Nutrient and wastewater concentrations in study area 2018 - 2022**
- **Comparison to reference conditions**
- **Isotopic data**

Project Oveview

- **Big Sky Sustainable Solutions Forum 2018 -> 10-year project**
- **Goal: Compile a water quality dataset to evaluate changes over time**

Methods

- **Collecting aquifer chemical and hydrologic data**
- **Eight wells and one spring sampled for N, P and Cl, other ions**
- **Measure SWLs, water quality/purge parameters physicochemical conditions**
- **Analysis for dissolved inorganic constituents following standard methods**

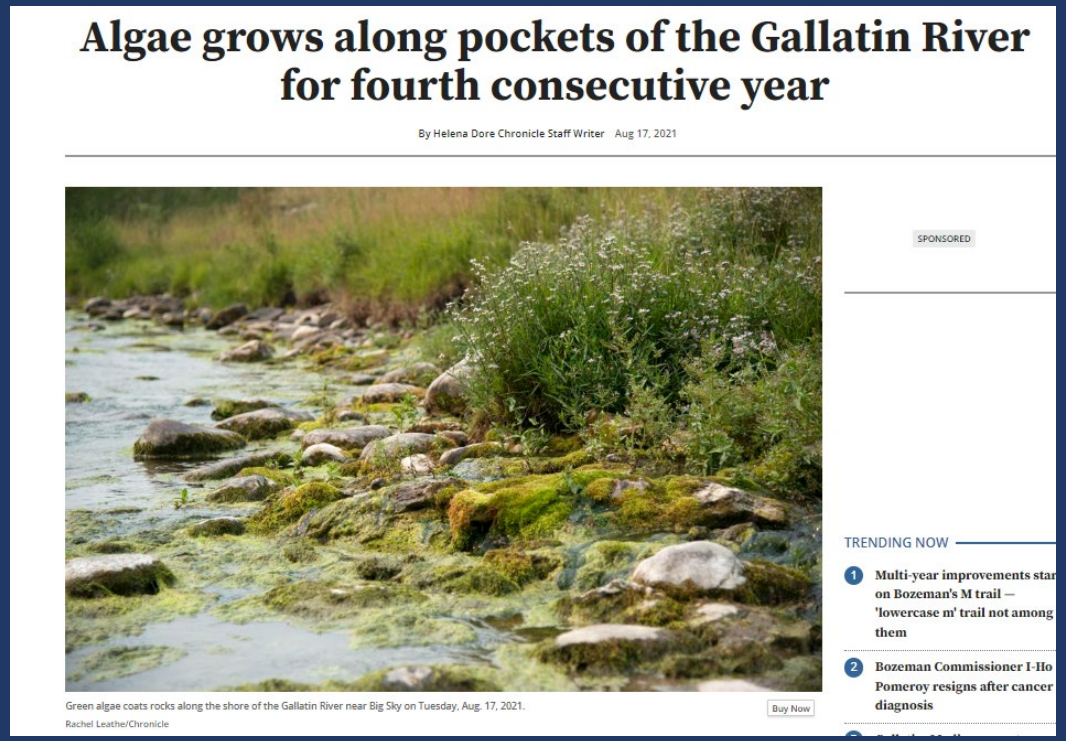
Project Oveview

Why do we care about these things?

A concentrated area of human activity adjacent to a pristine mid-order river that drains a portion of the Greater Yellowstone Ecosystem

Structure and function of river ecosystem impaired by nutrient pollution

Algal Blooms = *Cladophora glomerata*



Algae grows along pockets of the Gallatin River for fourth consecutive year

By Helena Dore Chronicle Staff Writer Aug 17, 2021

SPONSORED

Green algae coats rocks along the shore of the Gallatin River near Big Sky on Tuesday, Aug. 17, 2021.

Rachel Leathe/Chronicle

Buy Now

TRENDING NOW

1 Multi-year improvements star on Bozeman's M trail — 'lowercase m' trail not among them

2 Bozeman Commissioner I-Ho Pomeroy resigns after cancer diagnosis

Algal bloom crops up along Gallatin River for fifth year in a row

By Helena Dore Chronicle Staff Writer Aug 17, 2022

2 of 6

SPONSORED

A bright green algae bloom grows in the Gallatin River on Wednesday, Aug. 17, 2022.

Rachel Leathe/Chronicle

Buy Now

TRENDING NOW

1 Multi-year improvements on Bozeman's M trail —

- Growth in Big Sky has produced a lot of nitrogen that drains to a N-limited ecosystem
- Eutrophication manifests as blooms in the Gallatin River downgradient of Big Sky

Research Question

PREAMBLE: Collected five years of data on dissolved nutrients, inorganics

- **How do nutrient and wastewater solutes vary spatiotemporally in the Big Sky area?**

Study area characteristics

- **Shallow, unconfined aquifer made of alluvial and glacial sediments**
- **Highly transmissive (3,057 - 27,400 ft^2/d), productive (Rose and Waren 2022)**
- **Aquifer pumping effects on stream baseflow: increased pumping = decreased baseflow**
- **“Assume MVA is hydrologically connected to the Middle Fork Gallatin.”**

Waren et al. 2021

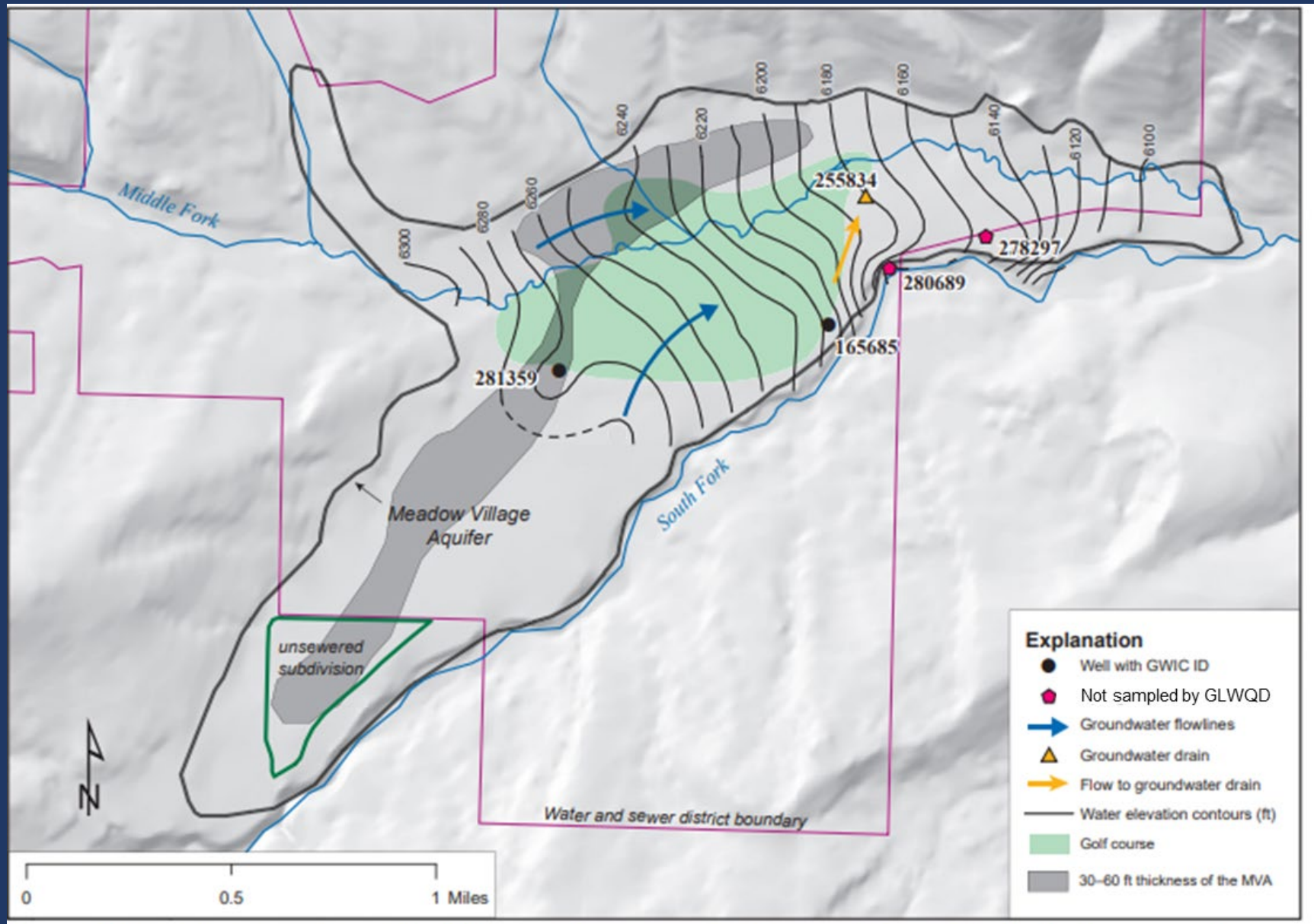
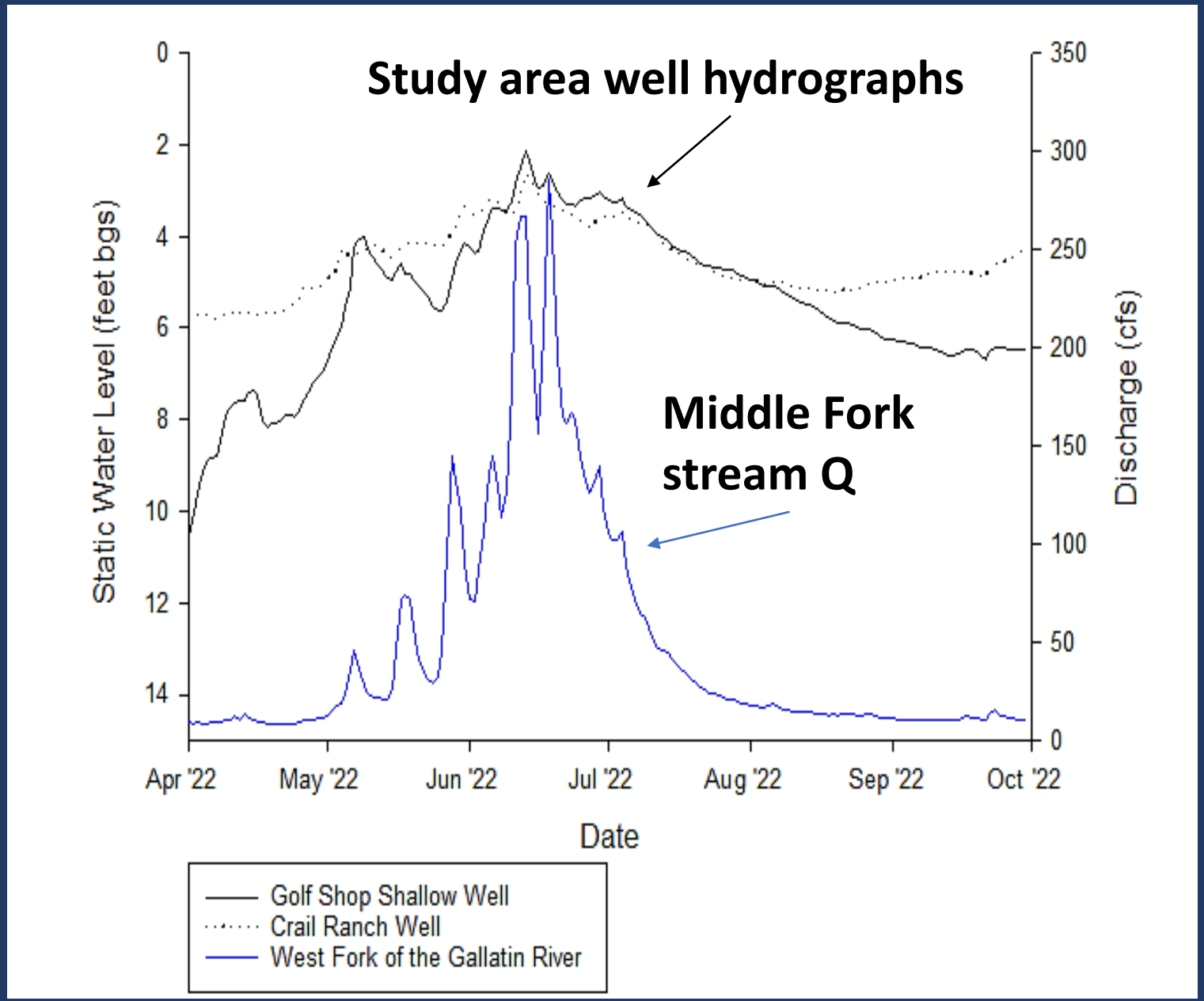


Figure 11. Potentiometric surface of the MVA groundwater generally flows west to east. The shaded area approximates a trough in the surface of the shale bedrock that forms the thickest part of the alluvial aquifer. Groundwater elevation contours are presented from Waren and others (2021).

Figure from Rose and Waren, 2022 (used with permission)


Study area well hydrographs
Middle Fork stream Q
Static Water Level (feet bgs)
Discharge (cfs)
0
2
4
6
8
10
12
14
350
300
250
200
150
100
50
0
Apr '22
May '22
Jun '22
Jul '22
Aug '22
Sep '22
Oct '22
Date
Golf Shop Shallow Well
Crail Ranch Well
West Fork of the Gallatin River

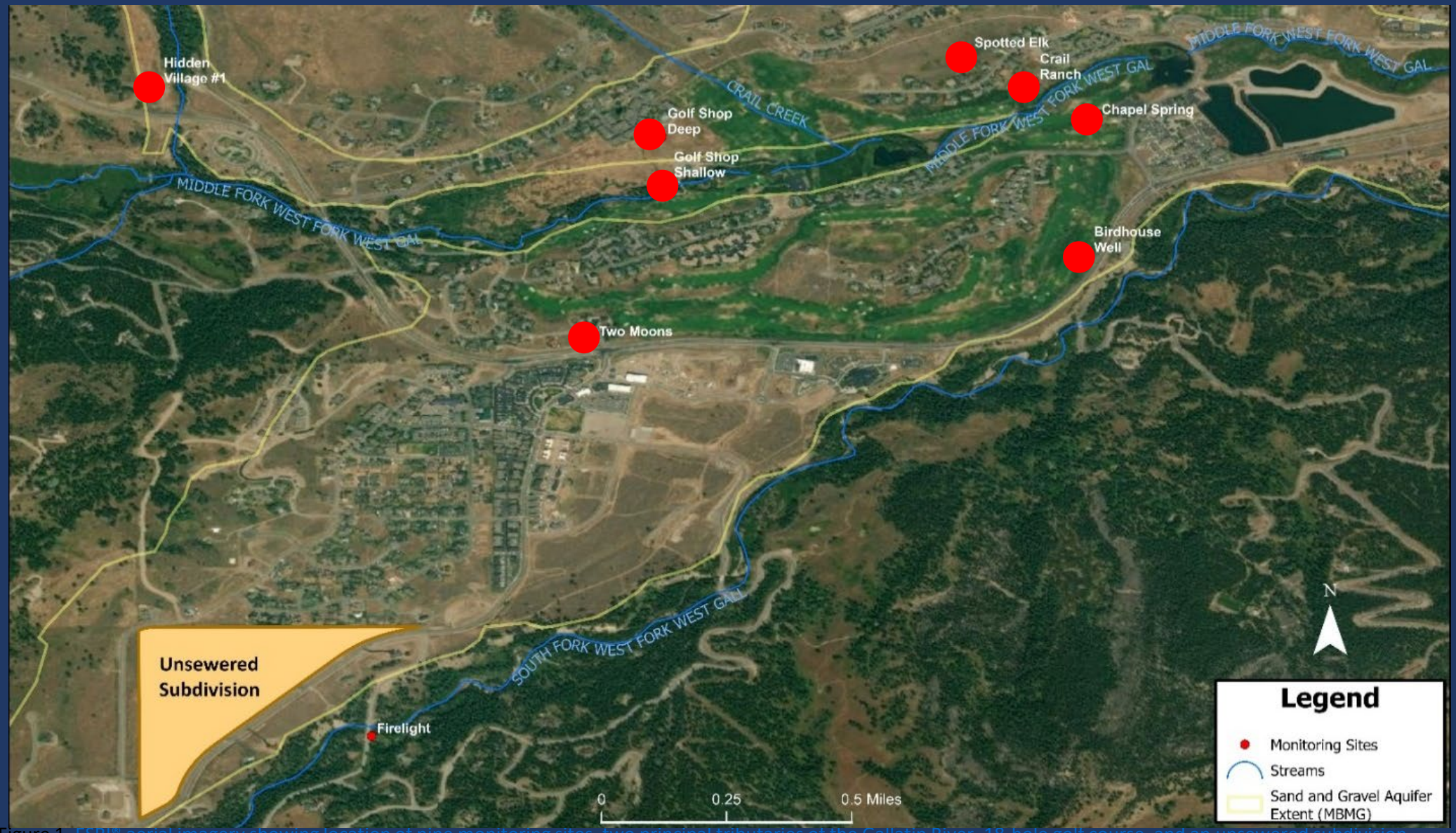


Figure 1. ESRI® aerial imagery showing location of nine monitoring sites, two principal tributaries of the Gallatin River, 18-hole golf course, and an unsewered subdivision within Meadow Village, Big Sky, Montana.

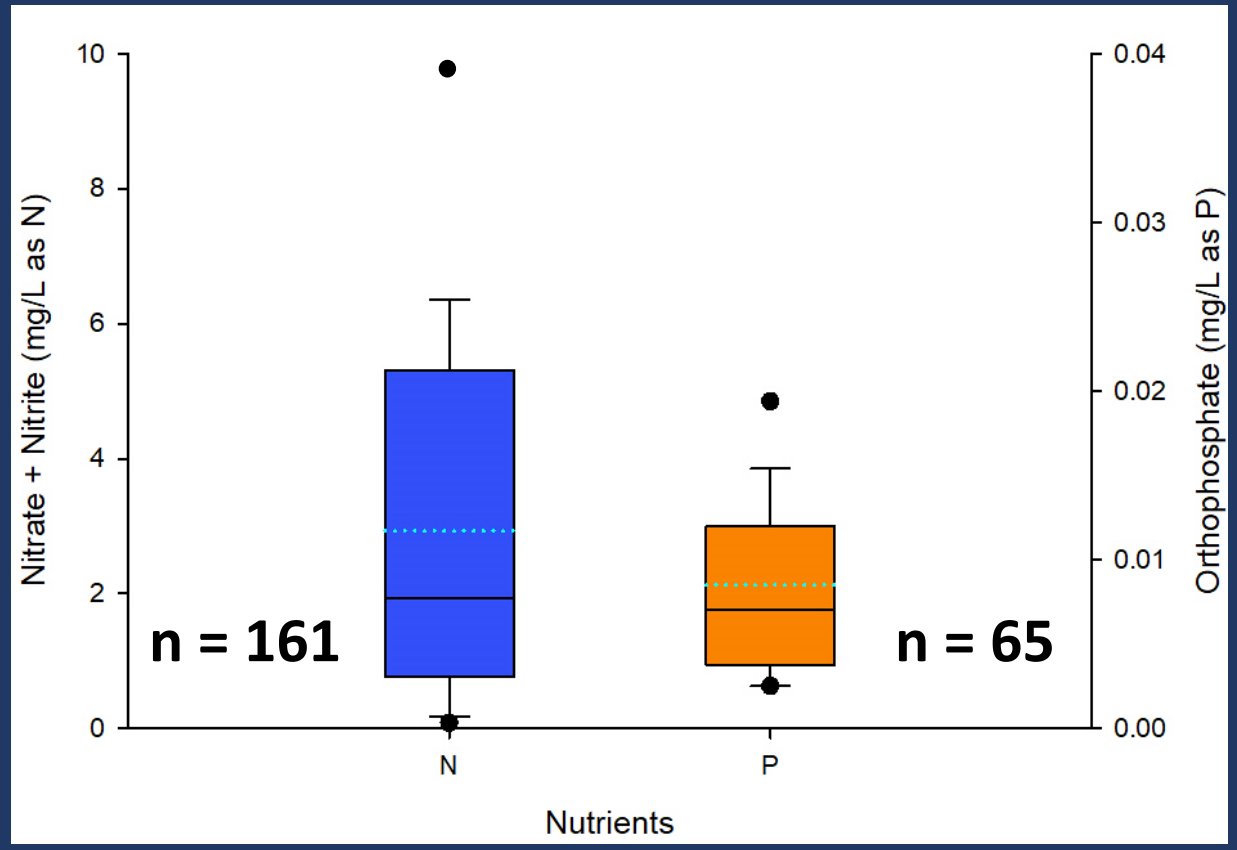
Potential Sources of solutes

Nitrate-N: atmospheric deposition, N fixation, fertilizer, pet waste, lithology, and wastewater (onsite septic wastewater treatment and effluent applications), snowmaking

Orthophosphate (P) - Geology, soils, pet waste, wastewater

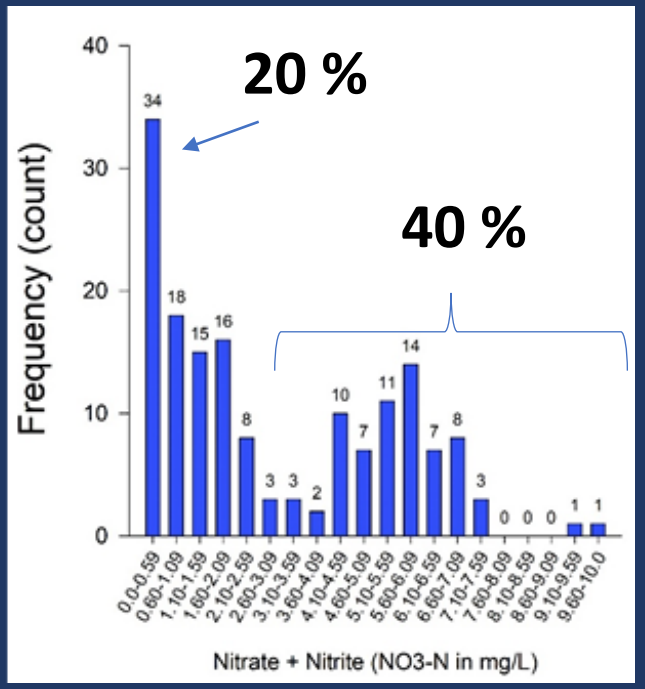
Chloride - septics, road salt, lithology, wastewater irrigation

Results – Nutrients



	Nitrate (mg/L)	Ortho P (mg/L)
Max	9.8	0.032
Mean	2.93	0.011
Median	1.93	0.009
Min	0.03	0.005

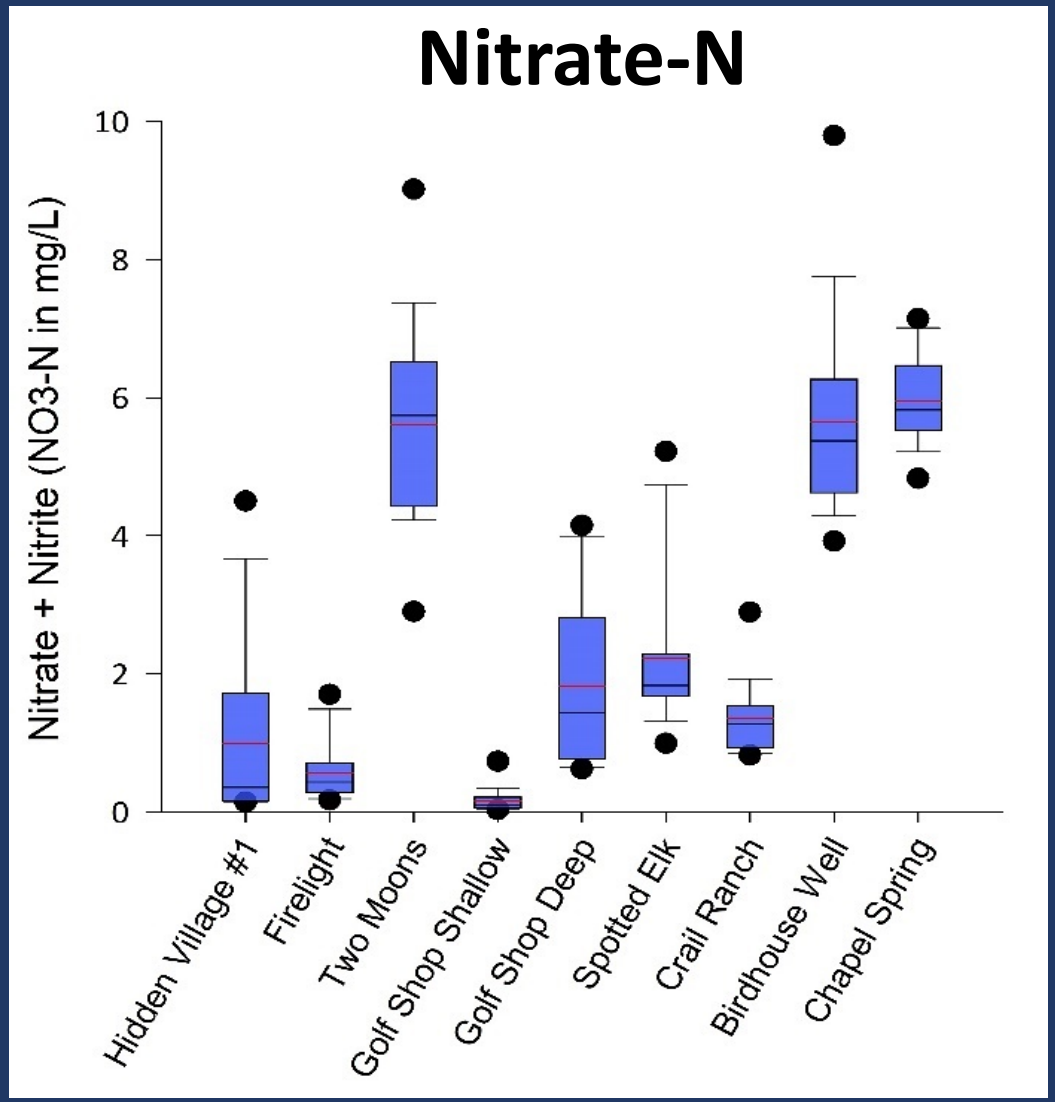
- **Nitrate-N:**
  - 20 % of observations at or below ~ 0.6 mg/L
  - ~ 40% of observations > 4.1 mg/L



- **Ortho-P:** About a quarter of values were non-detects; most observations 7 and 13 ppb

- **Chloride:** 2/3rd of values are above 20 mg/L
  - 25% of observations in the 20-29 mg/L range; 14 above 100 mg/L

Variation in solute concentrations by site

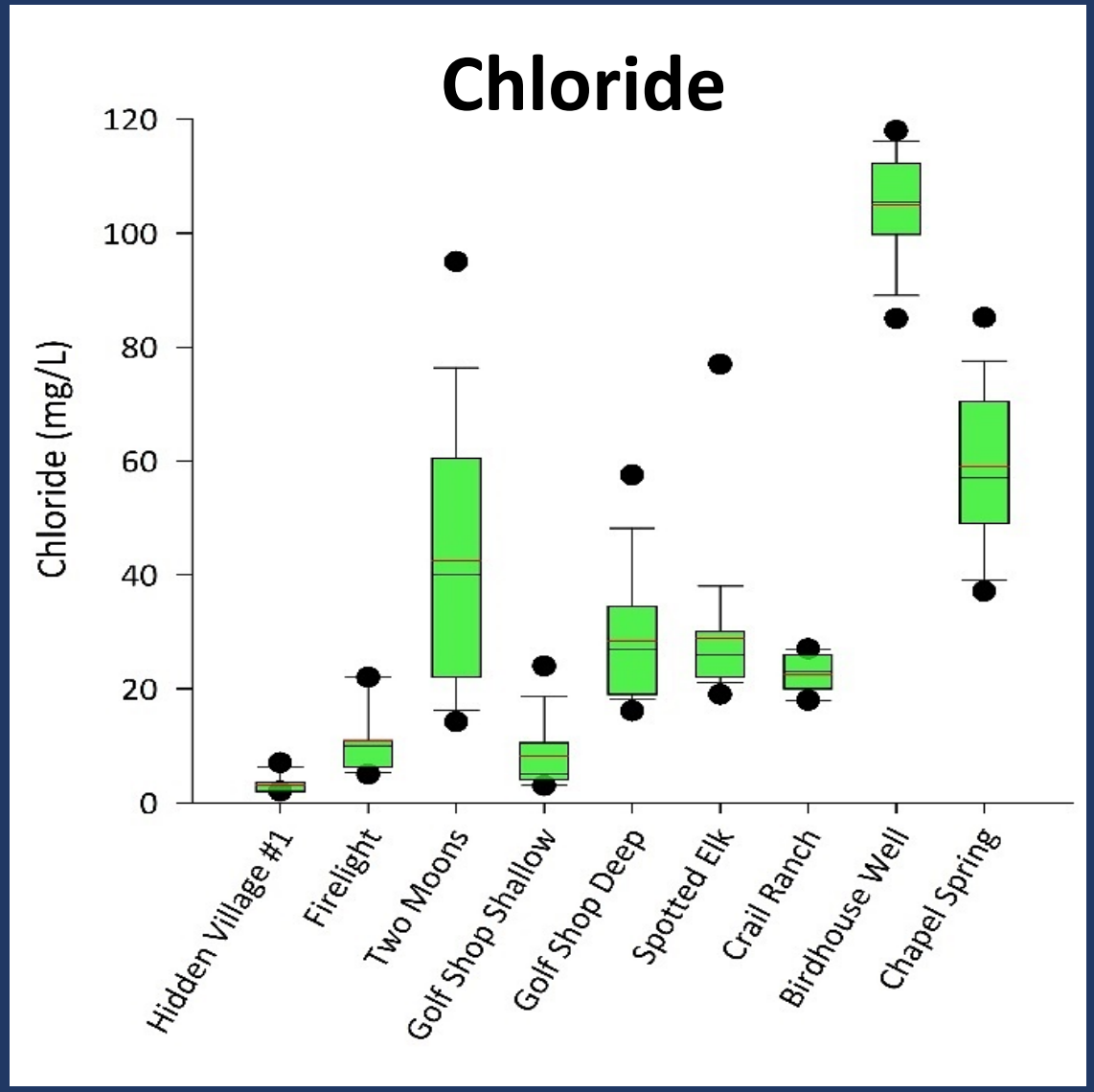


HOT SITES Nitrate-N: (mg/L)

Two Moons = 5.6 ± 0.3
Birdhouse = 5.7 ± 0.3
Chapel Spring = 5.9 ± 0.1

Three sites show consistently elevated levels of dissolved constituents

Variation in solute concentrations by site

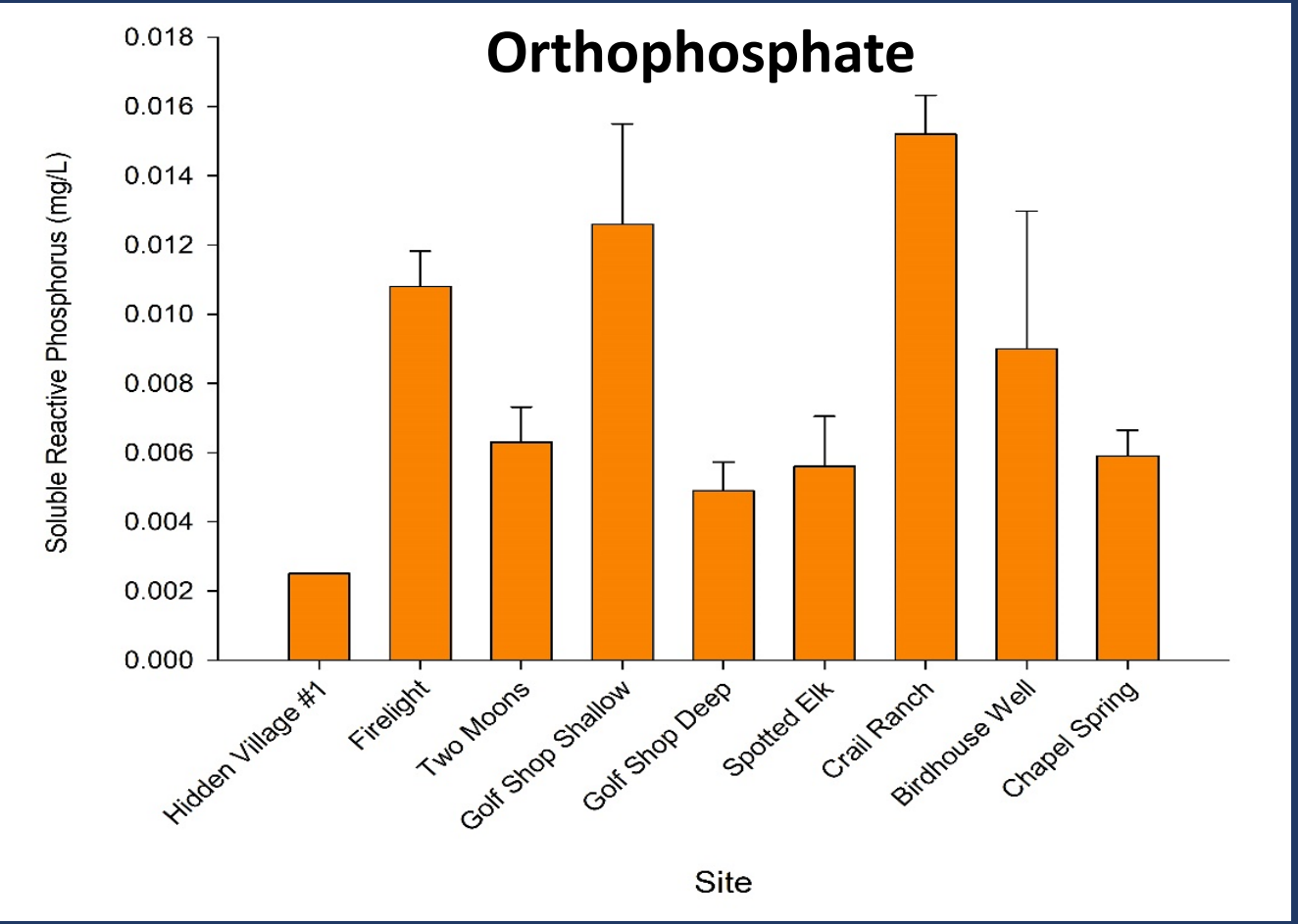


HOT SITES Chloride (mg/L):

Two Moons = 42.4 ± 5.2
Birdhouse = 104.9 ± 2.0
Chapel Spring = 59.1 ± 2.9

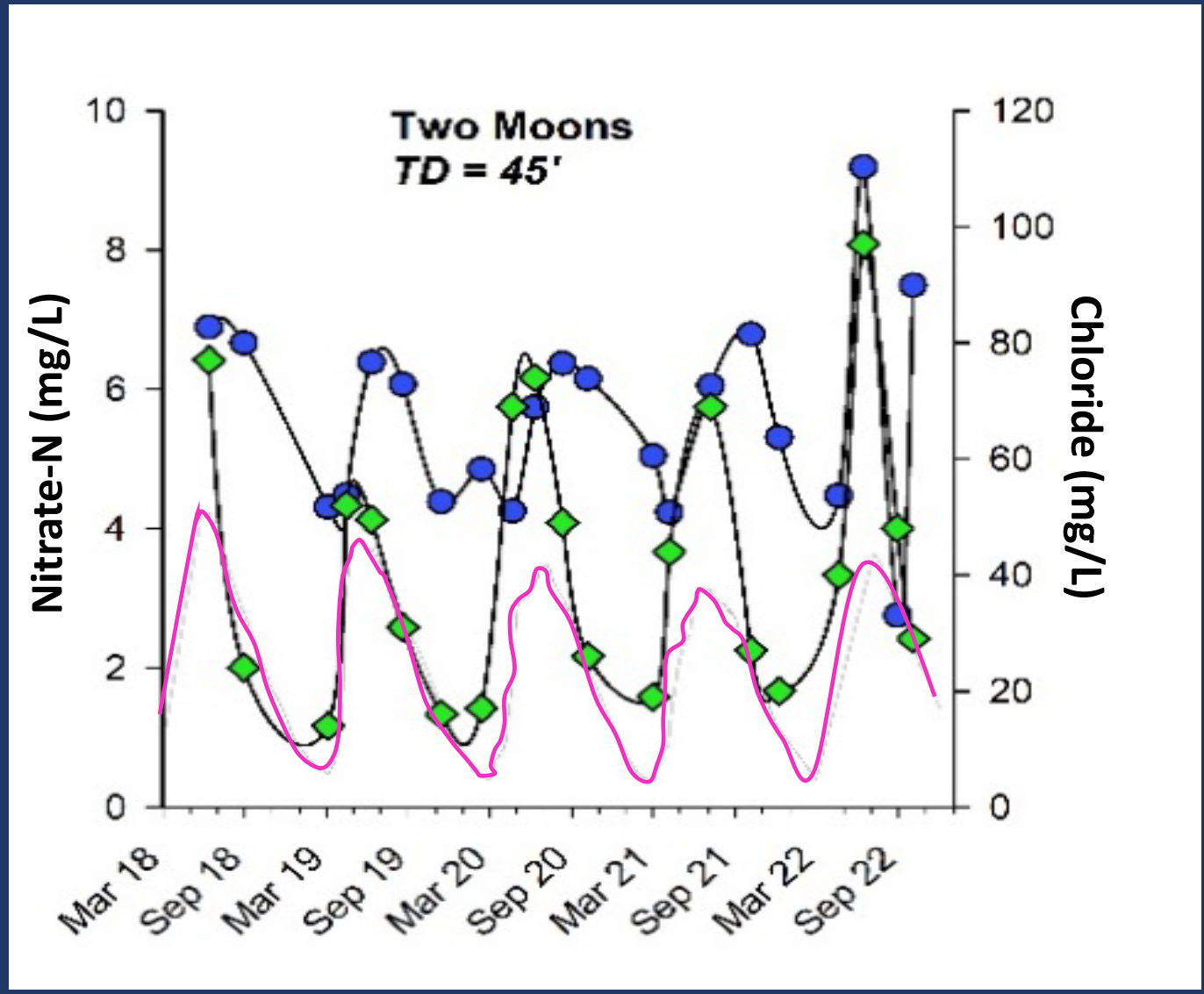
Three sites show consistently elevated levels of dissolved constituents

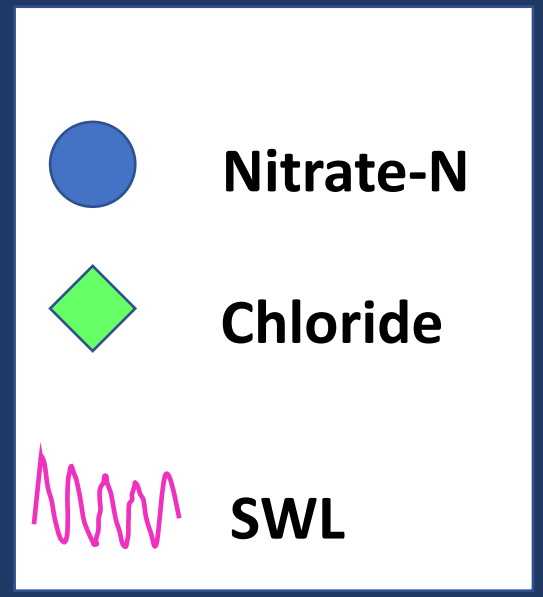
Variation in solute concentrations by site



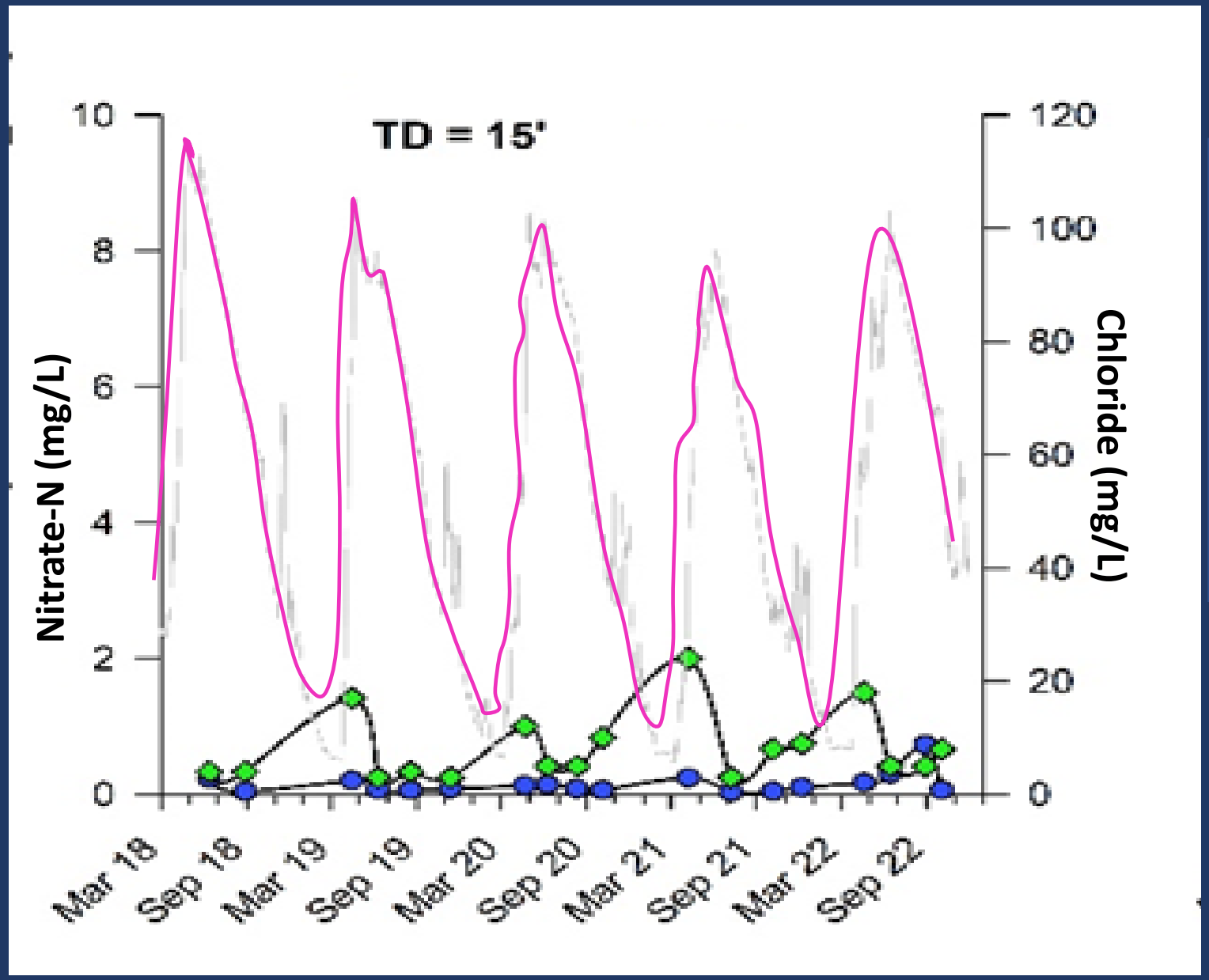
Shallower wells and wells near streams tend to have more P

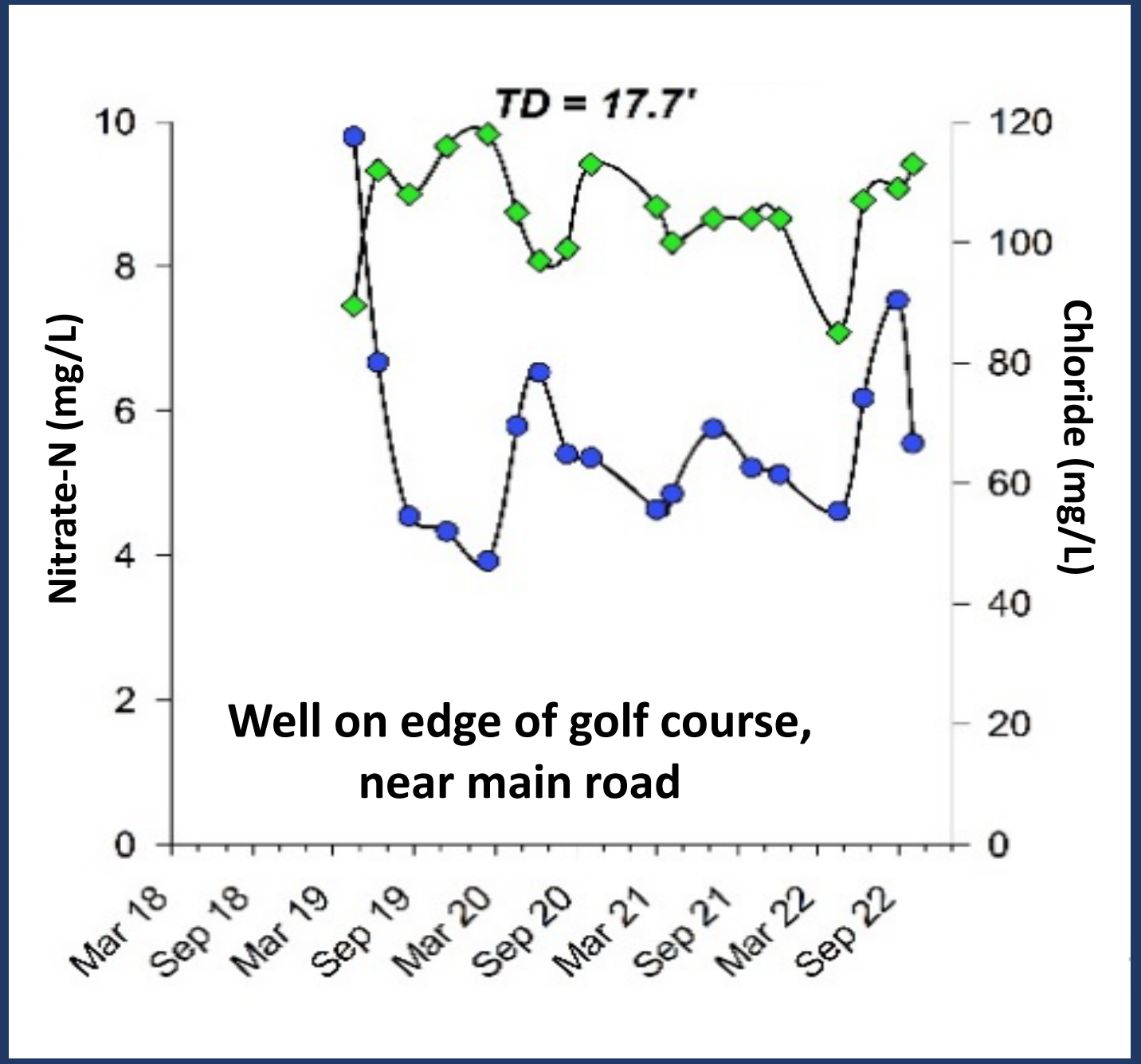
Deep well @ bedrock contact; downgradient of unsewered; no effluent irrigation



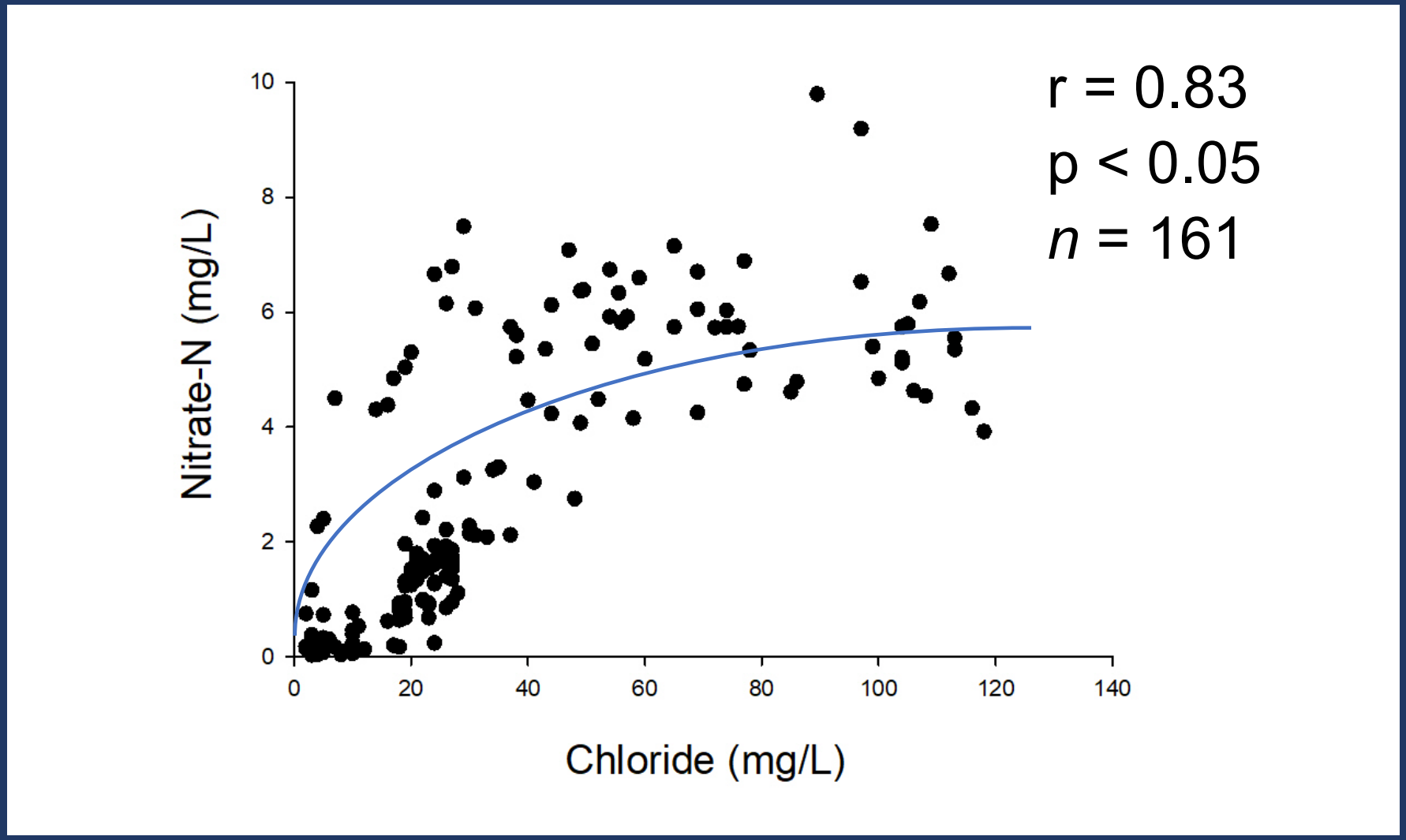


Shallow well near stream

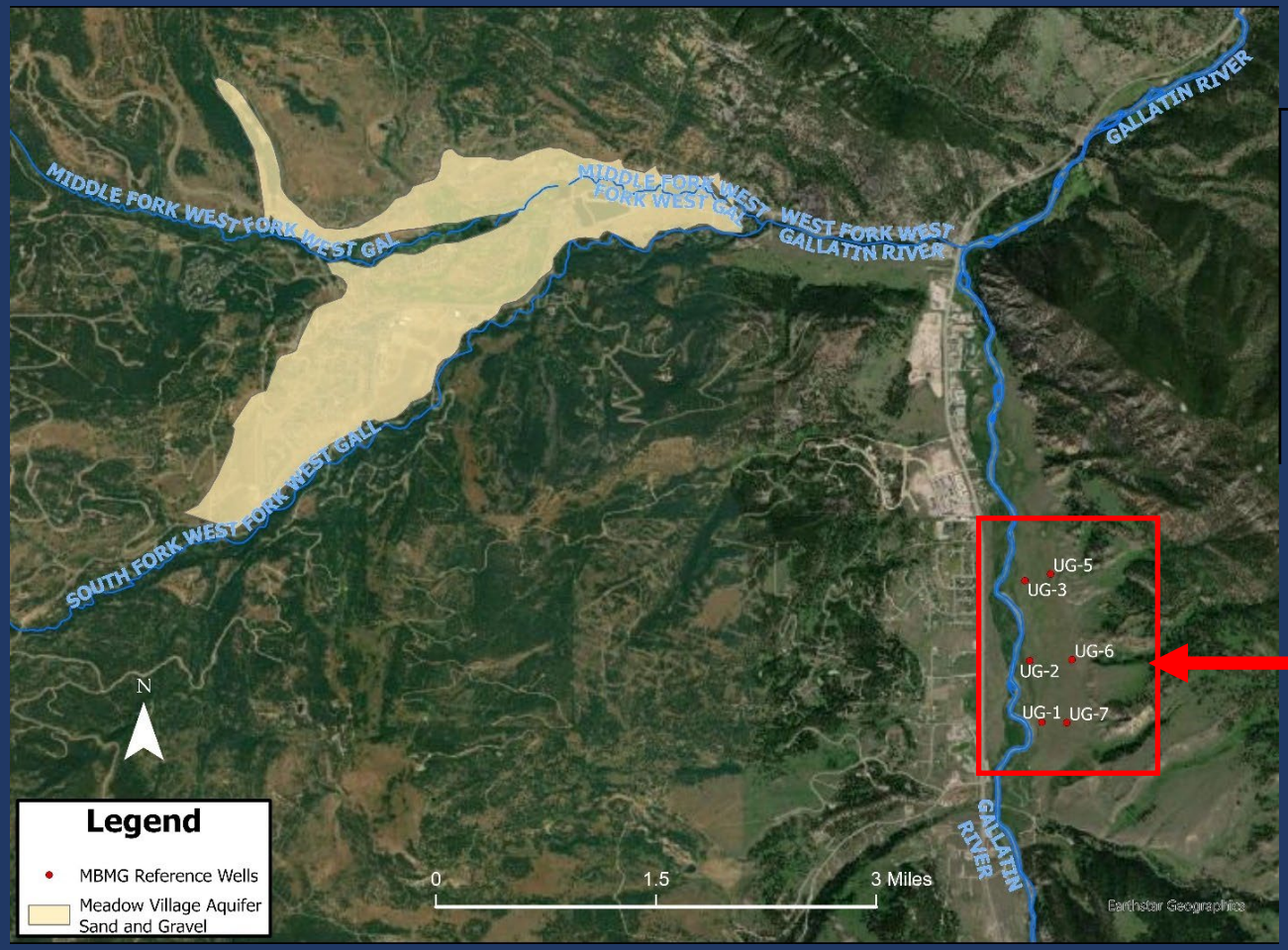



TD = 17.7'
Nitrate-N (mg/L)
Chloride (mg/L)
10
8
6
4
2
0
120
100
80
60
40
20
0
Mar 18
Sep 18
Mar 19
Sep 19
Mar 20
Sep 20
Mar 21
Sep 21
Mar 22
Sep 22
Well on edge of golf course,
near main road
Nitrate-N
Chloride

Meadow Village Aquifer Nitrate-N – Chloride Correlation



How do these results compare to reference conditions?



	Nitrate (mg/L)	Chloride(mg/L)
Max	1.24	22.71
Mean ± SE	0.37 ± 0.07	8.83 ± 1.22

Reference well N & Cl levels

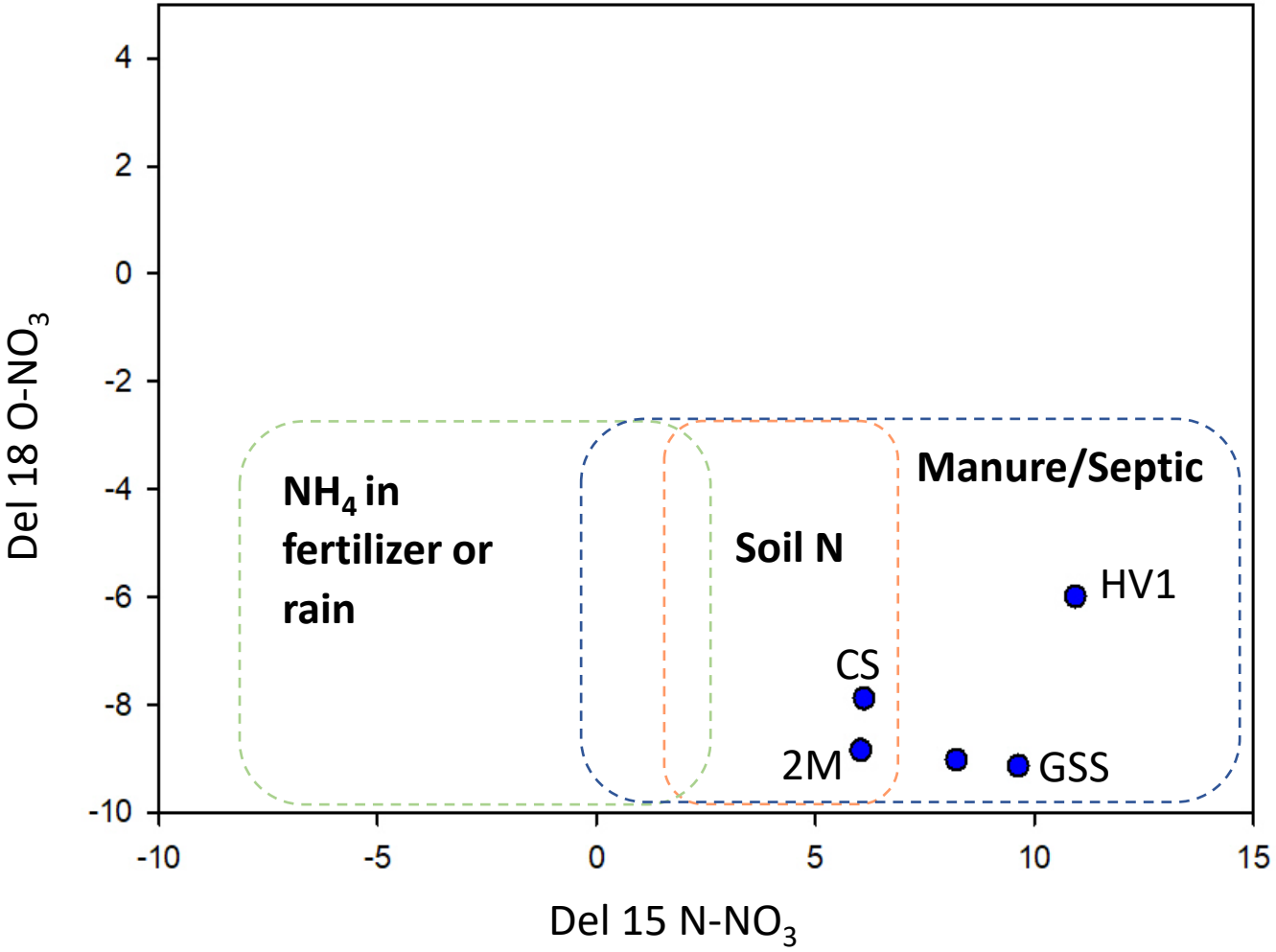
REMINDER:

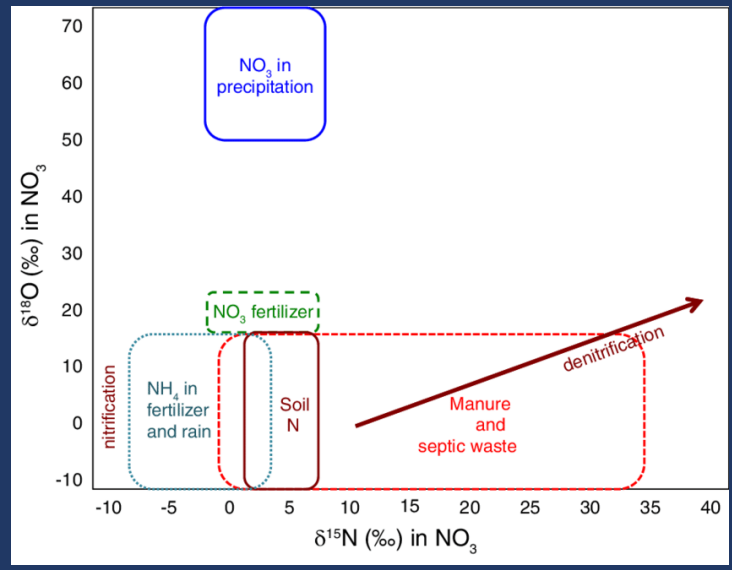
Two Moons = 5.6 ± 0.3; 42.4 ± 5.2

Birdhouse = 5.7 ± 0.3; 104.9 ± 2.0

Chapel Spring = 5.9 ± 0.1; 59.1 ± 2.9

Isotopic Analysis – Kendall Plot





Key Findings

- 50% of NO_3^- values are above background level; ⅔ of Cl^- values above 20 mg/L
- 3 sites display consistently elevated nitrate and chloride levels
- Seasonal variation differs between sites
- Study area conditions ≠ reference well conditions
- Chloride not a great predictor of Nitrate-N

Mitigating N pollution is a path towards curbing algal blooms in the Gallatin