Characterizing Sources of Stream Turbidity in the Marcellus Shale Gas-Well Drilling Region in Central Pennsylvania

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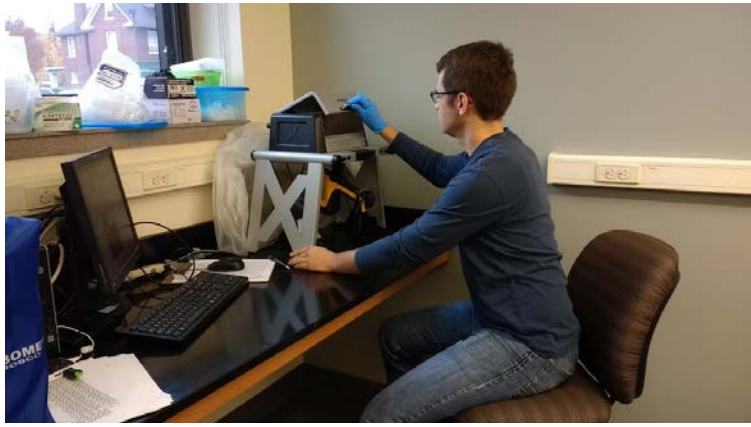
Purpose and Scope

- Main focus was to determine if Marcellus Shale gas play and road infrastructure contribute to turbidity in receiving streams
- We hypothesized that increased Marcellus Shale infrastructure would contribute to turbidity in receiving streams
- Determine link between landuse practices and sources of turbidity
  - Stream-Bed Sediment (turbidity proxy)
  - Adjacent Stream Bank Sediment
  - Surrounding Farmland/Forest
  - Dirt/Gravel Road Sediment

Methods and Analysis

- Topographic Wetness Index (TWI) and ArcSWAT modeling
- X-ray fluorescence (XRF) analysis of sediments
- Statistical analysis (student's t-test) to compare elemental concentrations observed in various sediment types collected from different watersheds
  - Ca, Sr, Mn, Si, Al+K, Ni+Zn
- Graphically compare sediment types to determine their contribution to turbidity
  - Ternary diagrams constructed with above elements
- Compare results of two watersheds
  - Baker Run, with extensive Marcellus Shale gas play
  - Marsh Creek, void of Marcellus Shale gas play (control)



Comparing the Watersheds

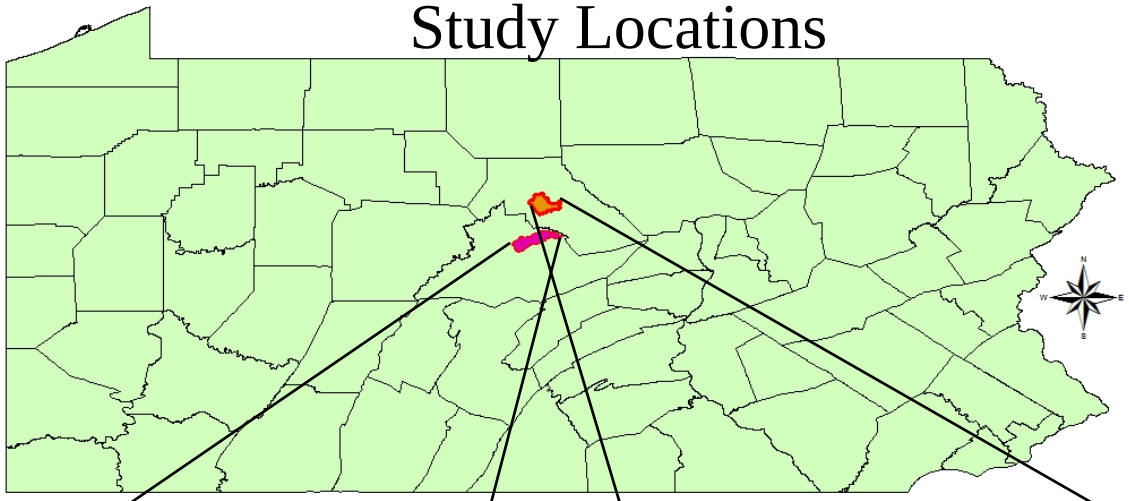
Marsh Creek (control)

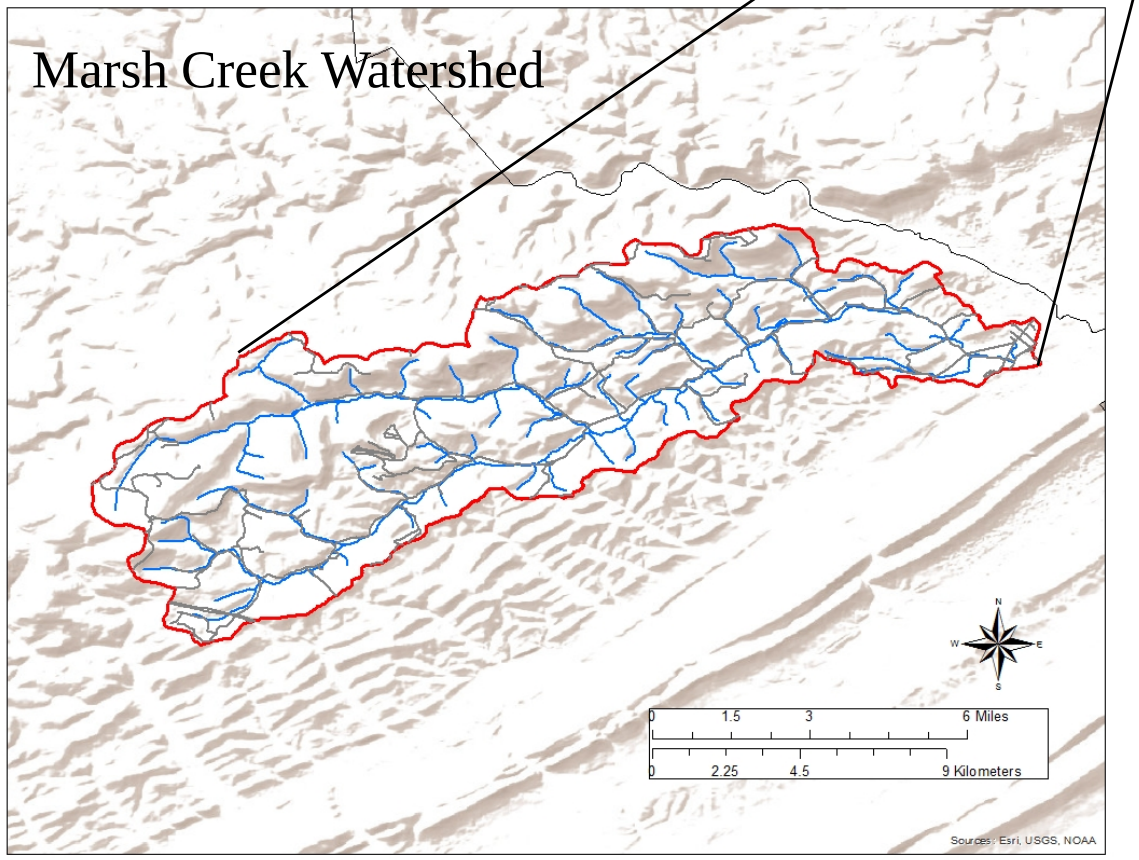
- No Marcellus extraction activities
- Gravel roads with little upkeep
  - Coated, dilapidated, broken-down limestone
- Siliciclastic surficial geology
  - Catskill Fm, Rockwell Fm, Lock Haven group
- Mixed landuse

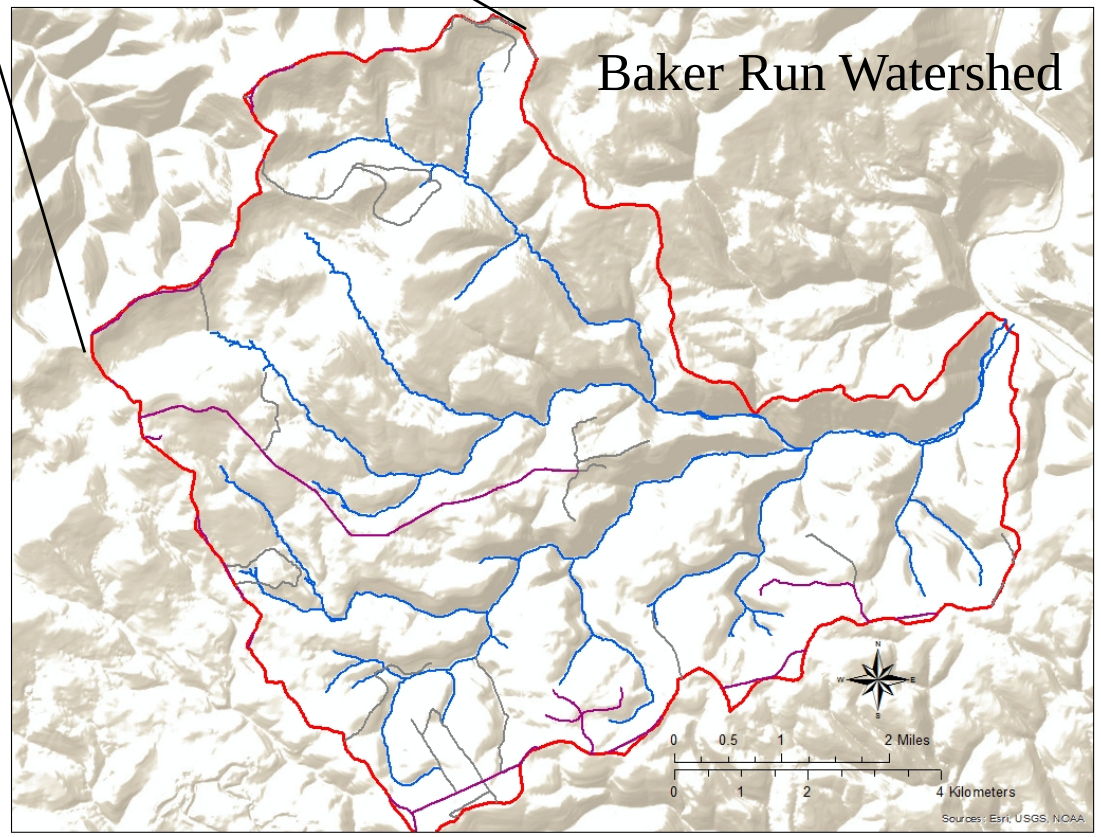
Baker Run (case study)

- 9 Marcellus extraction pads
- Increased gravel road infrastructure
  - Gravel roads resurfaced often
- Siliciclastic surficial geology
  - Catskill Fm, Burgoon SS, Pottsville Fm
- Predominantly forested

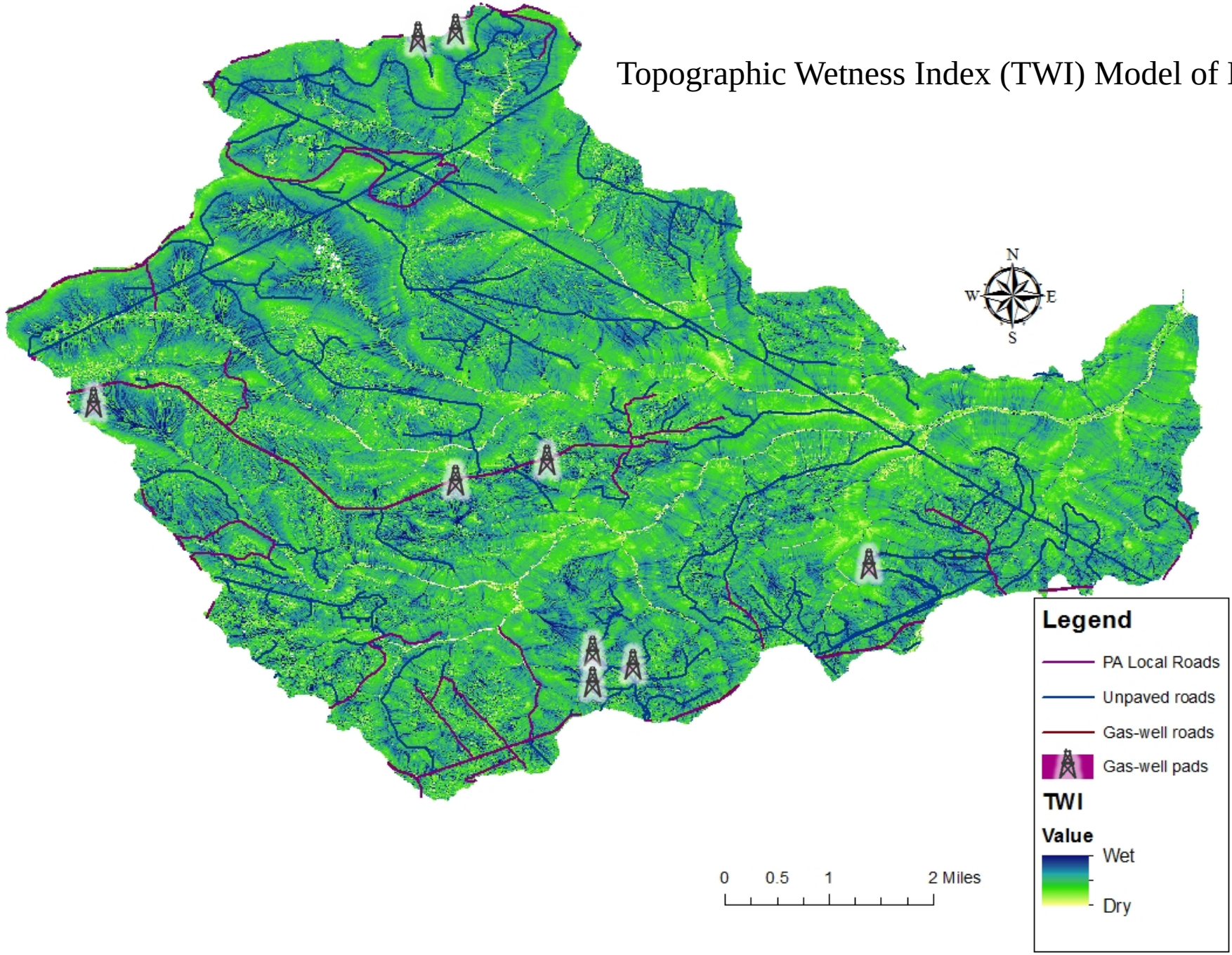
Study Locations

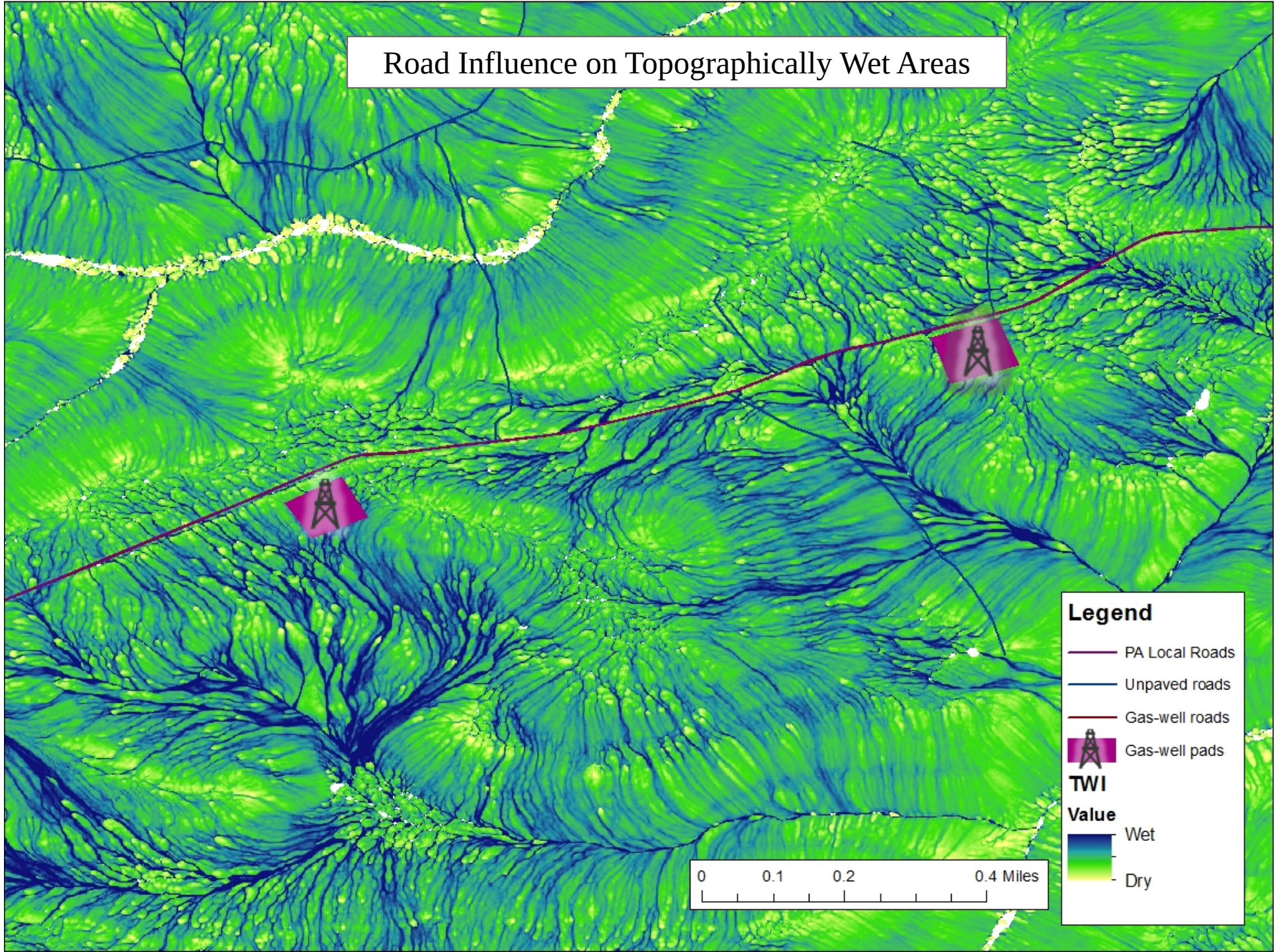


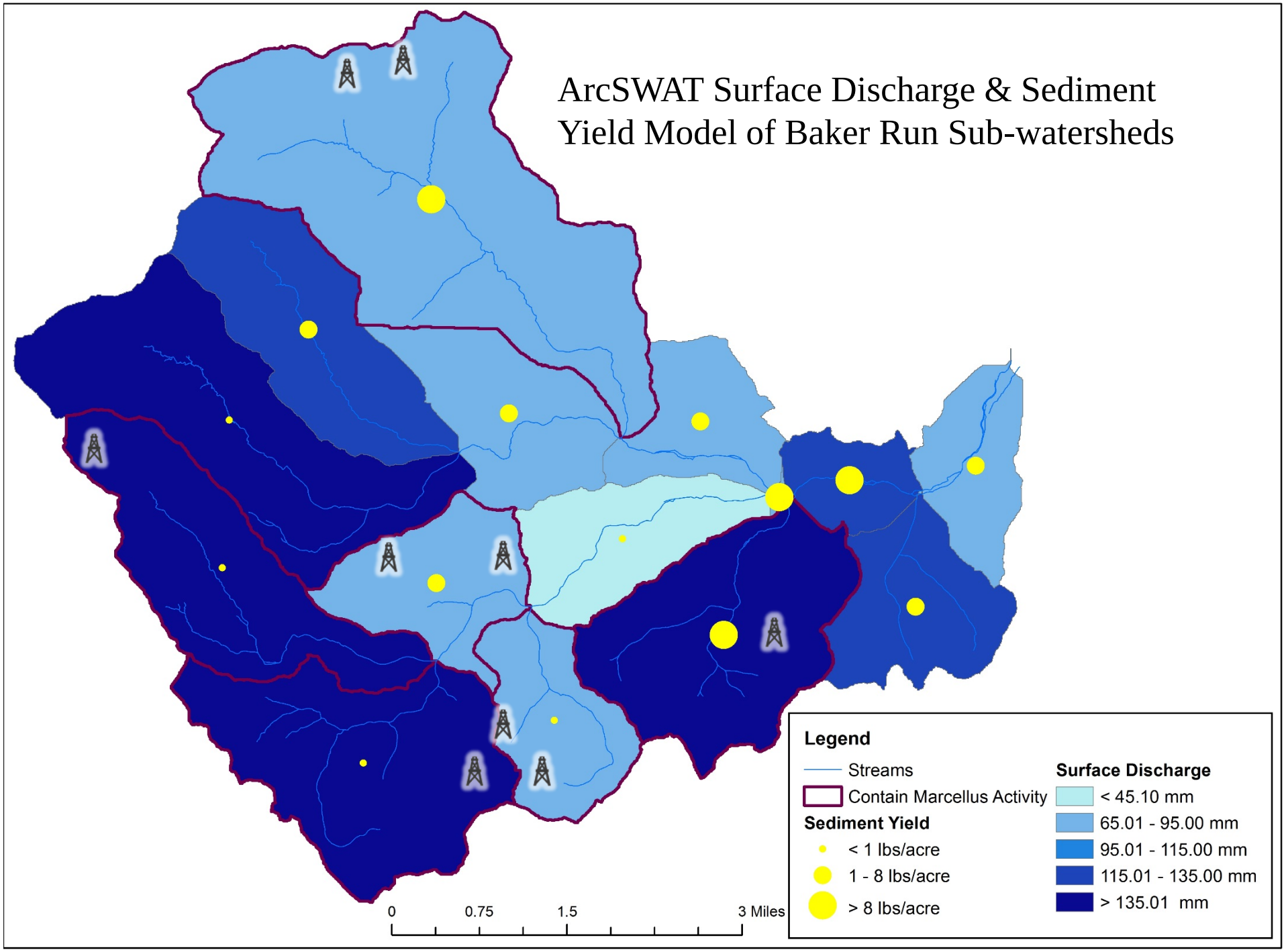




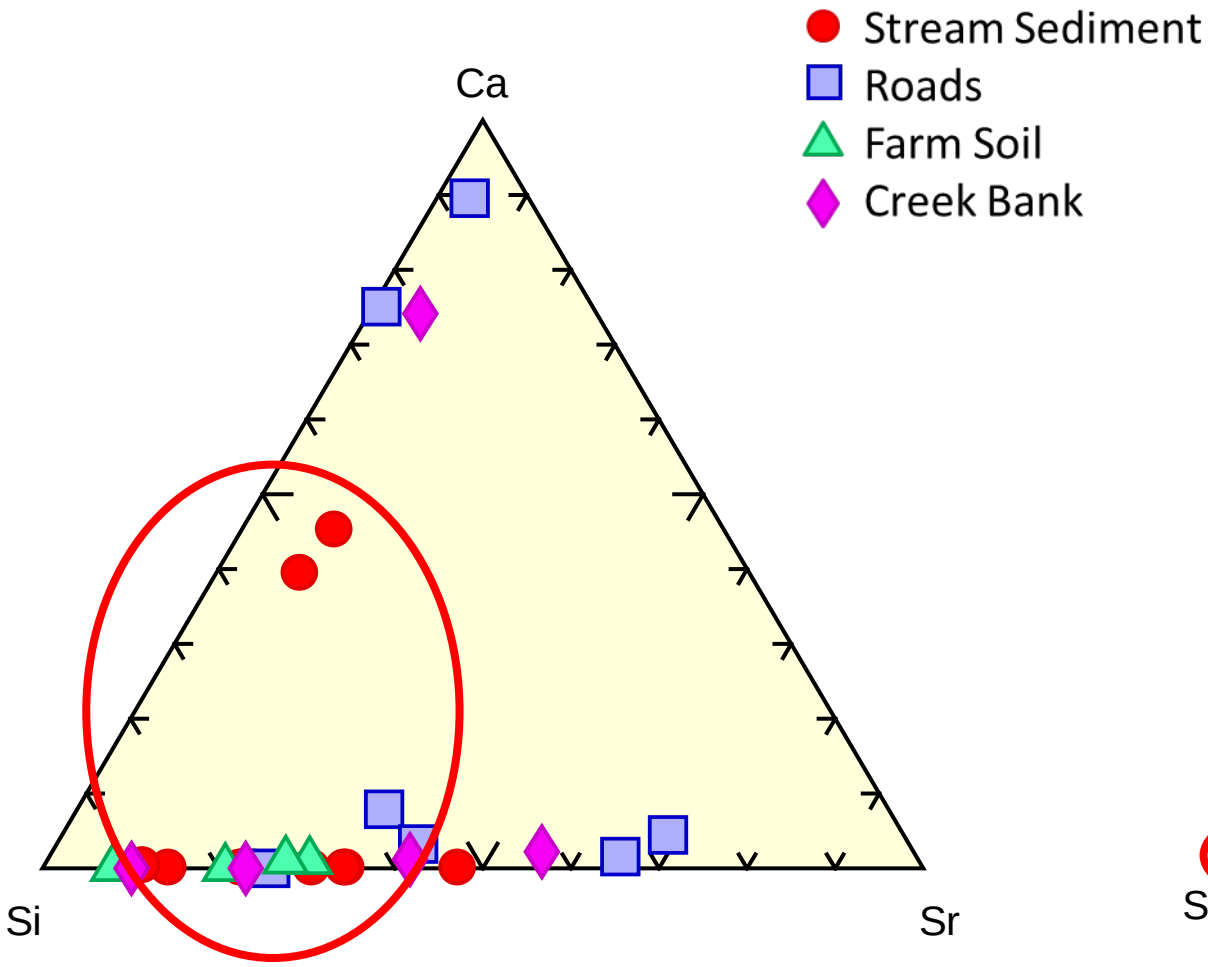
Topographic Wetness Index (TWI) Model of Baker Run Watershed



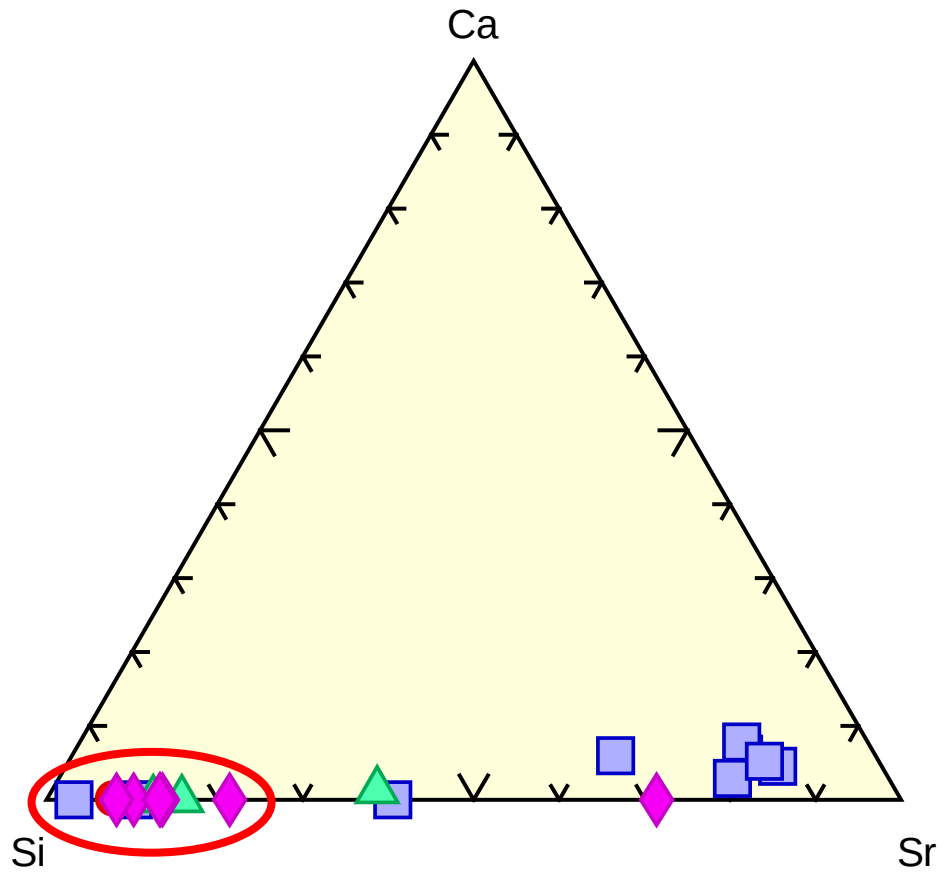

Road Influence on Topographically Wet Areas
Legend
PA Local Roads
Unpaved roads
Gas-well roads
Gas-well pads
TWI
Value
Wet
Dry
0
0.1
0.2
0.4 Miles


ArcSWAT Surface Discharge & Sediment Yield Model of Baker Run Sub-watersheds
Legend
Streams
Contain Marcellus Activity
Sediment Yield
< 1 lbs/acre
1 - 8 lbs/acre
> 8 lbs/acre
Surface Discharge
< 45.10 mm
65.01 - 95.00 mm
95.01 - 115.00 mm
115.01 - 135.00 mm
> 135.01 mm
0
0.75
1.5
3 Miles

Marsh Creek (control)



Baker Run (case study)



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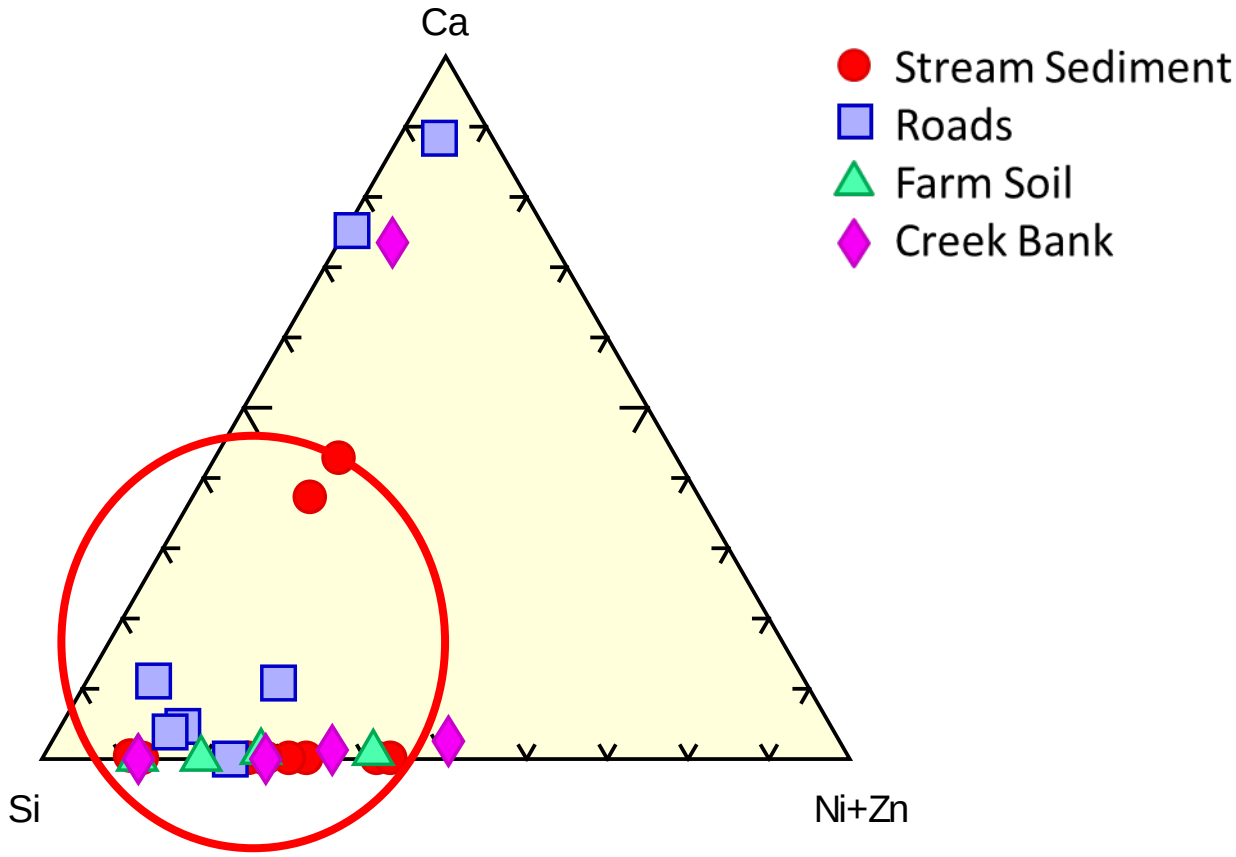

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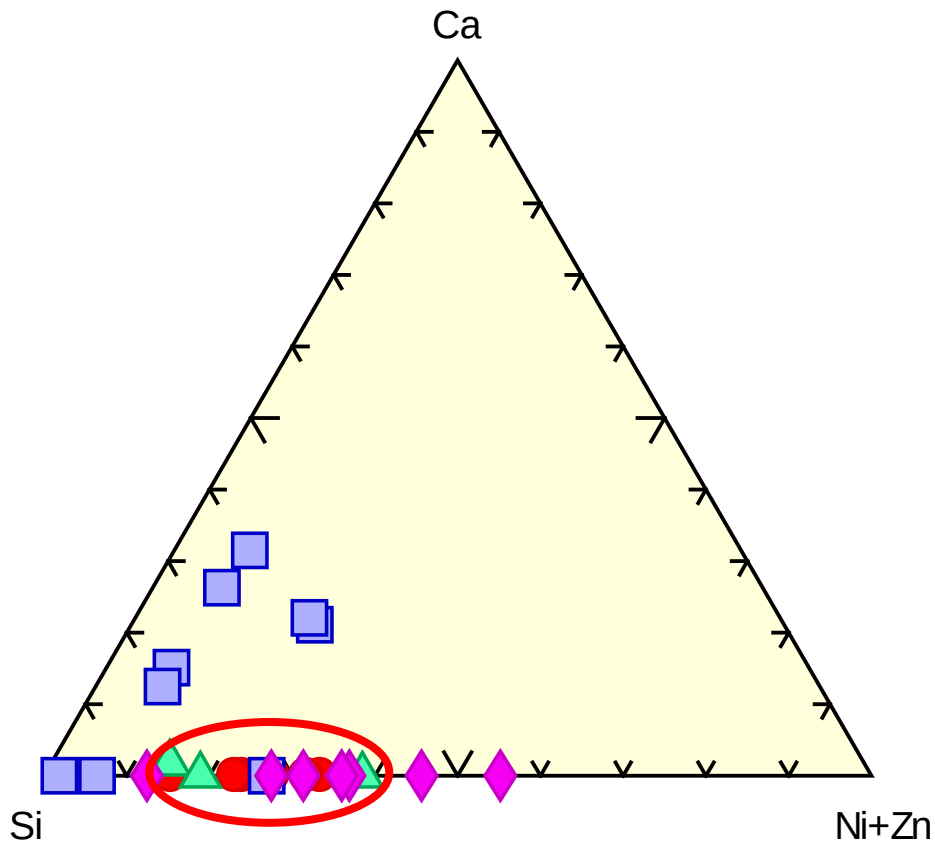

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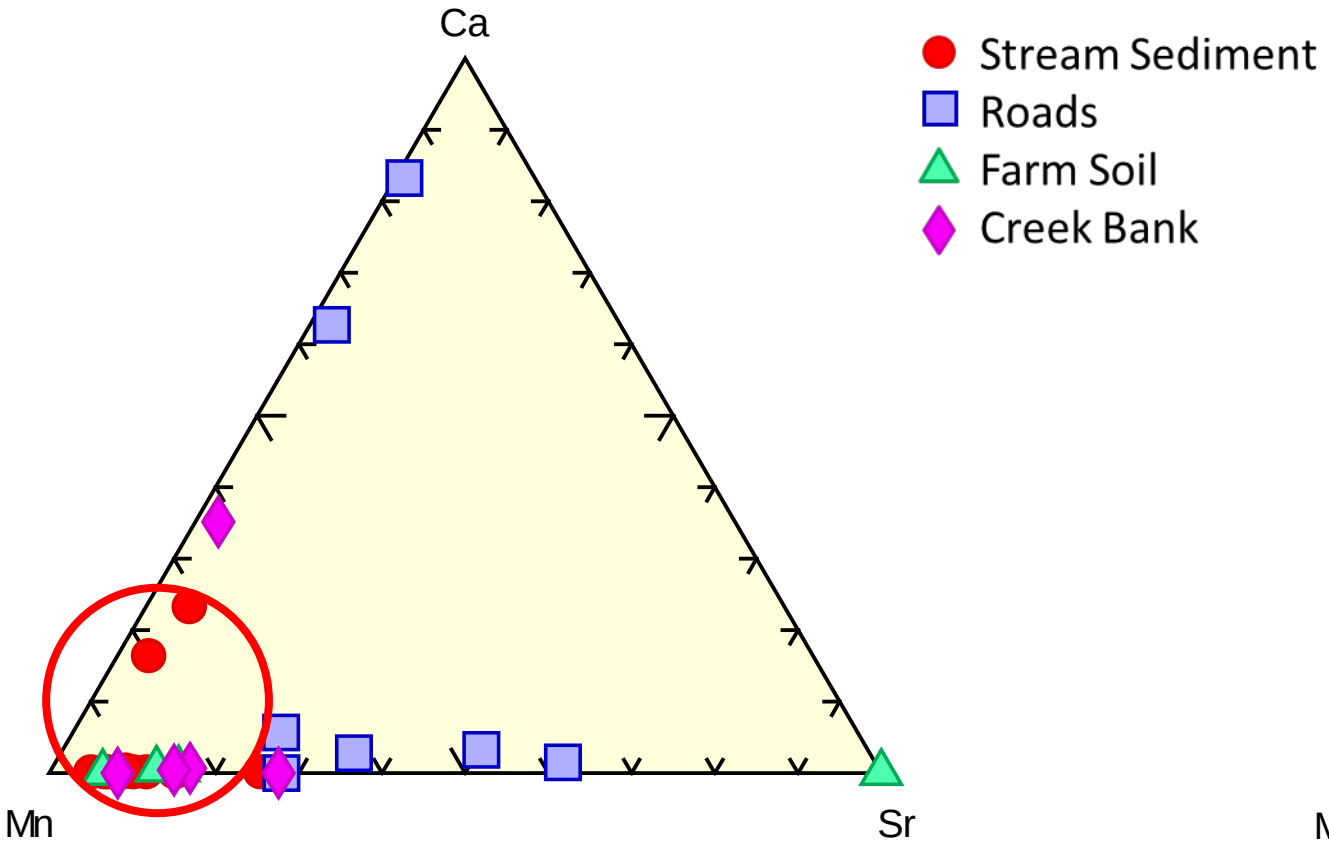

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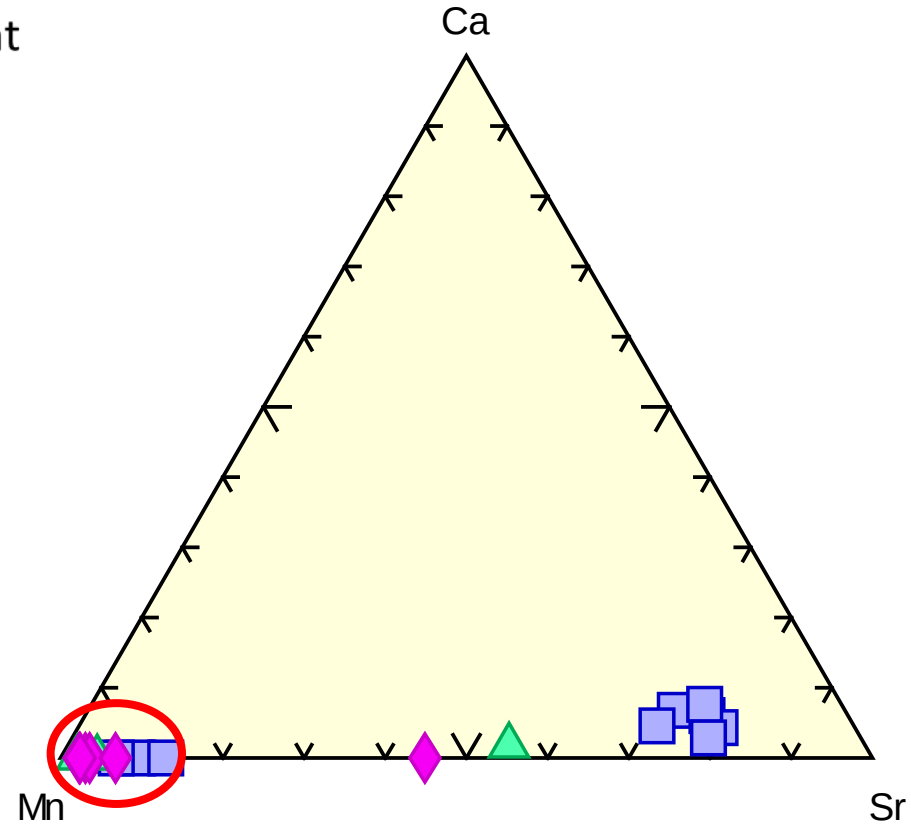

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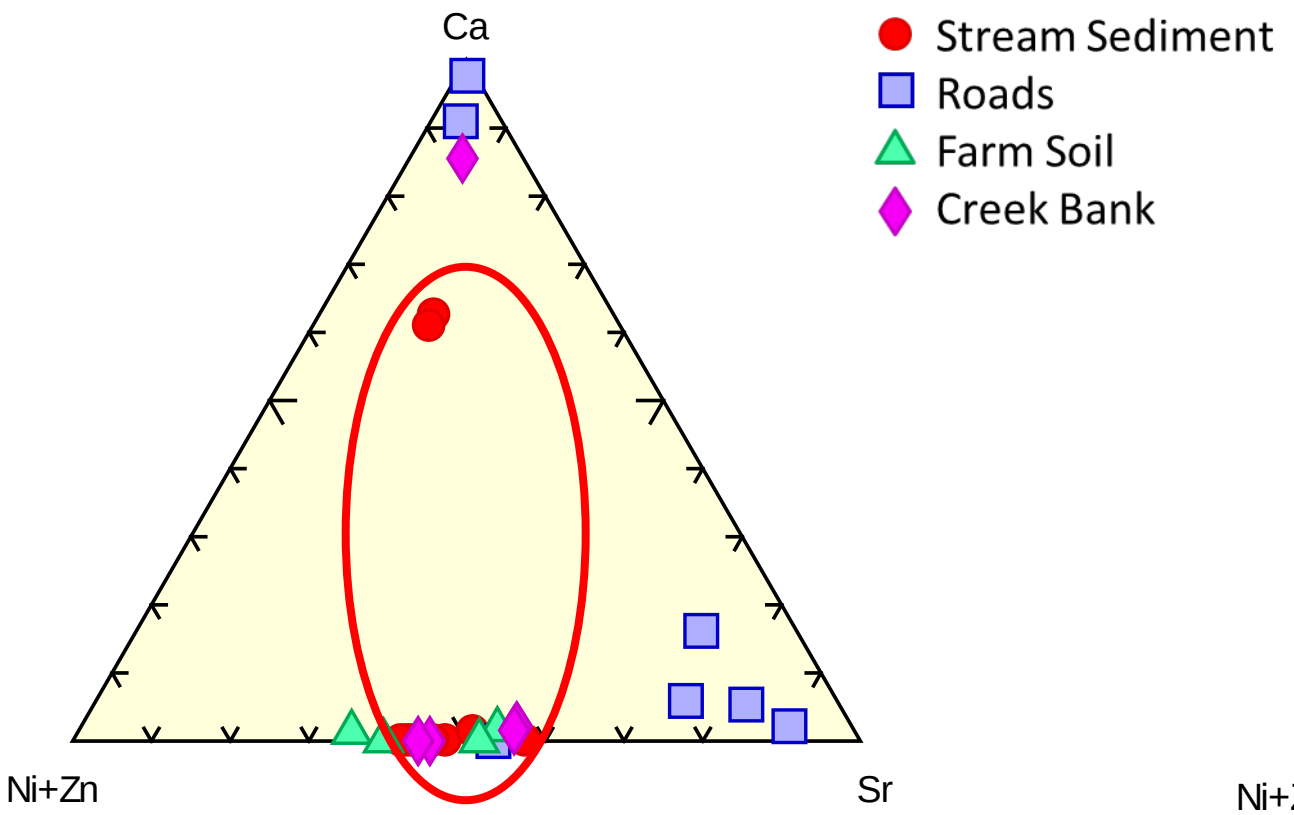

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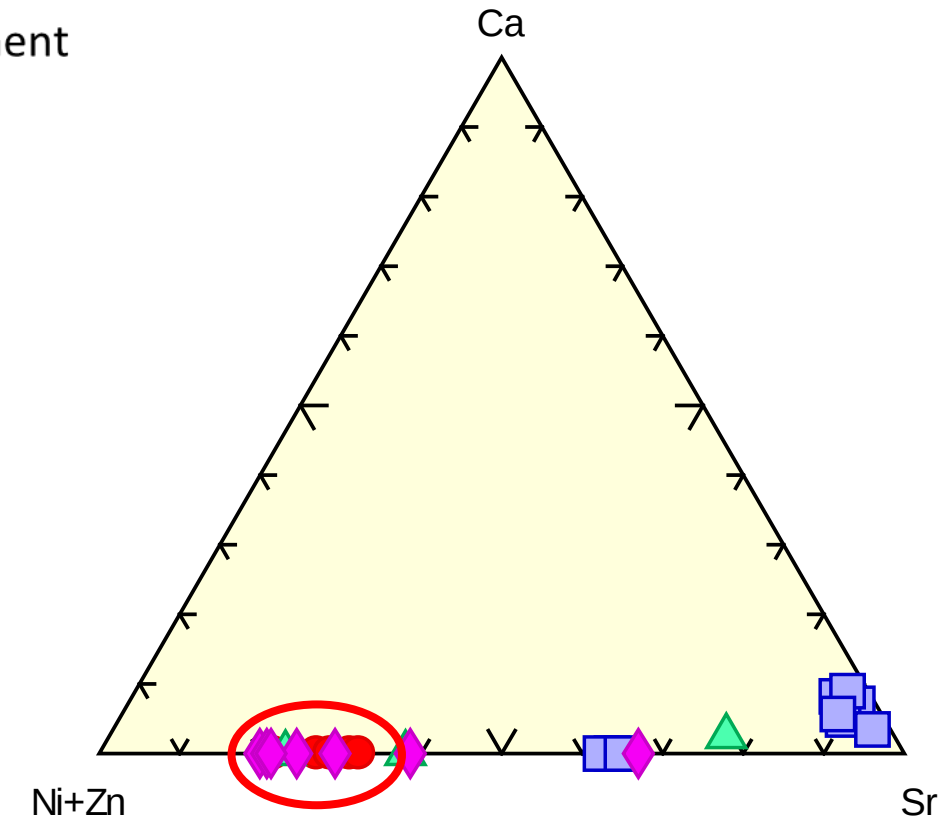

Marsh Creek (control)

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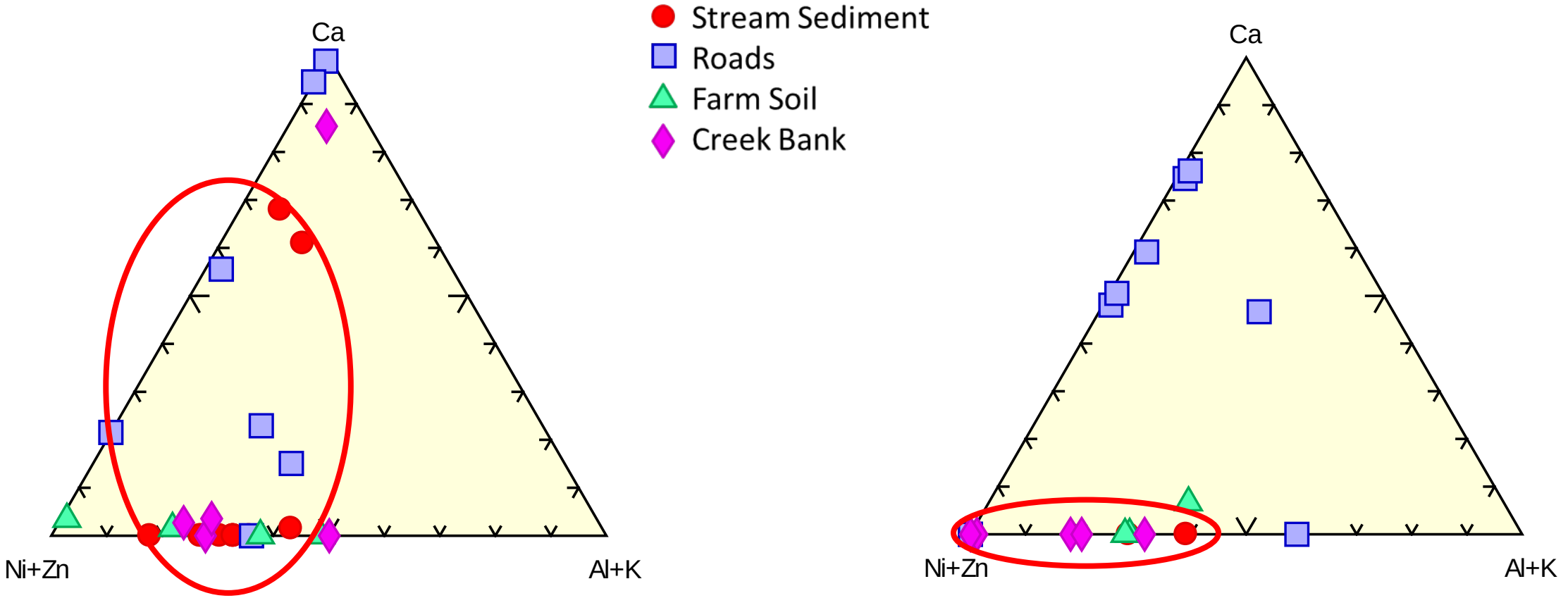

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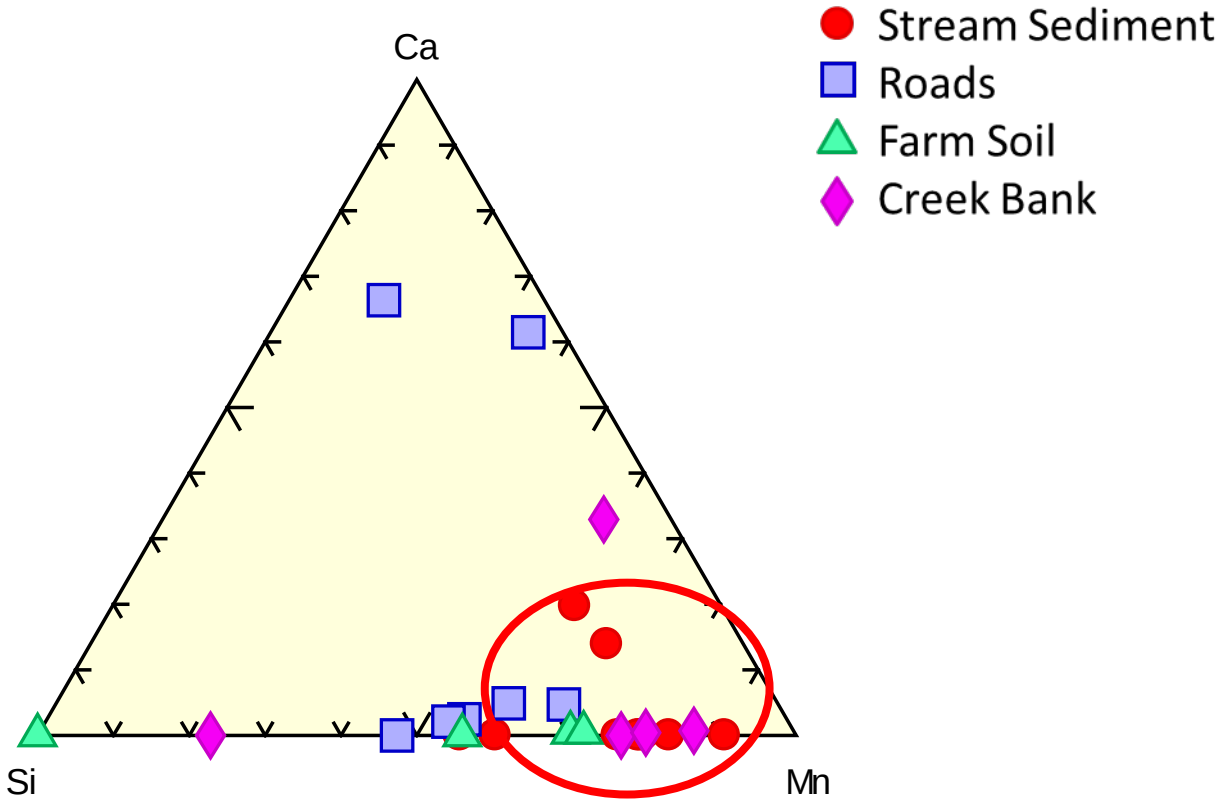

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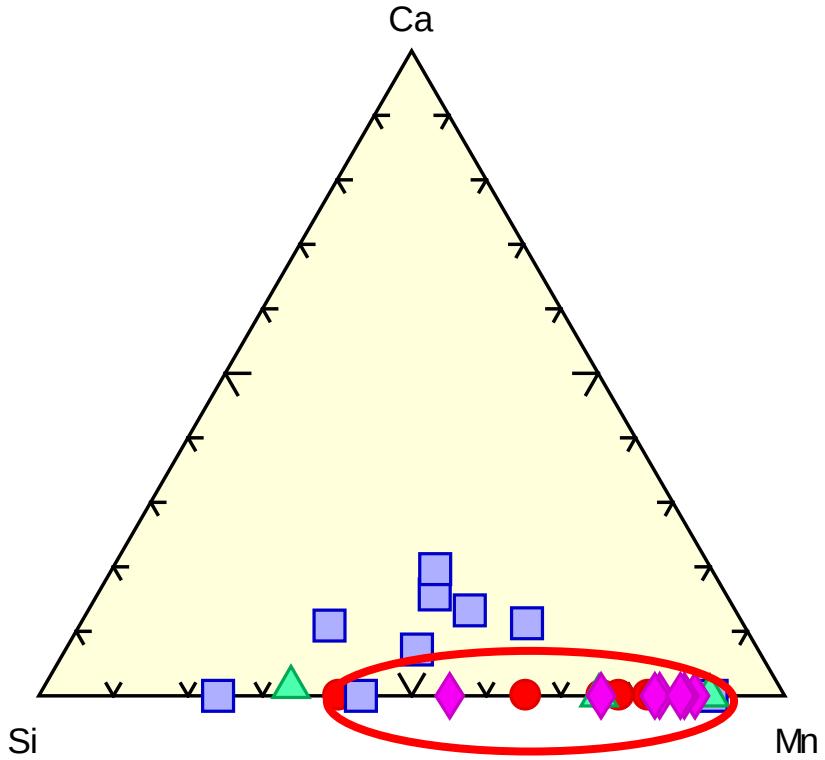

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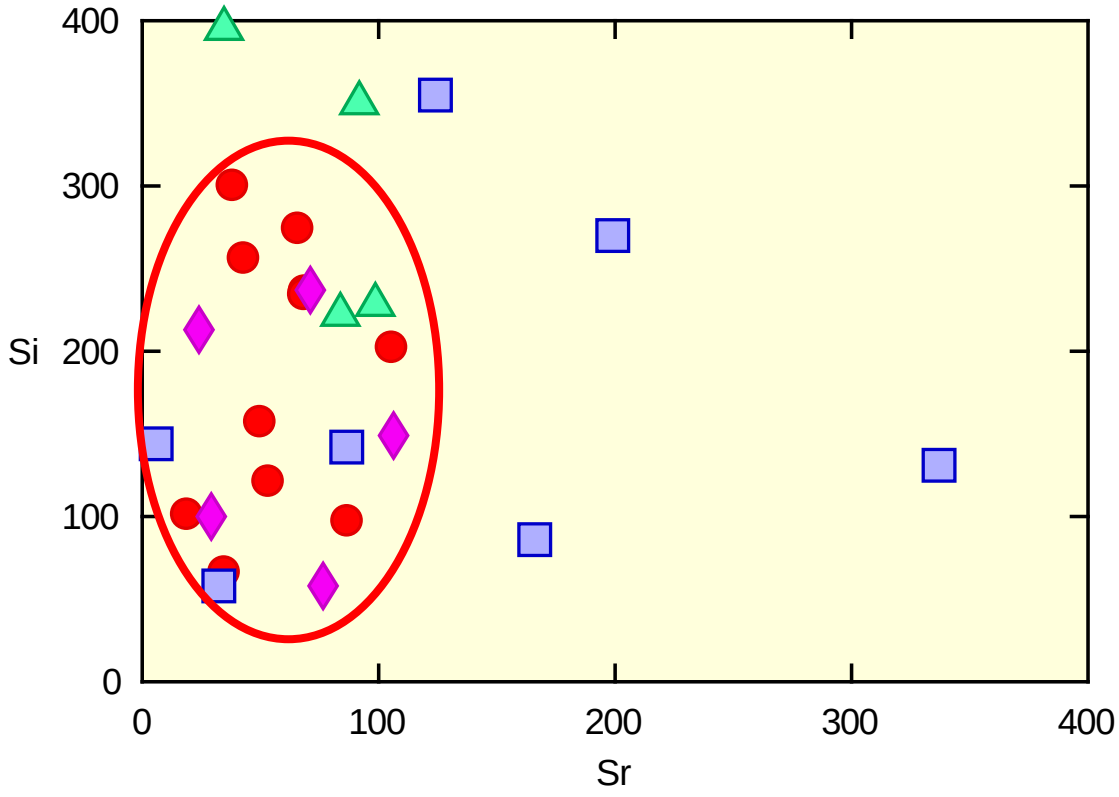

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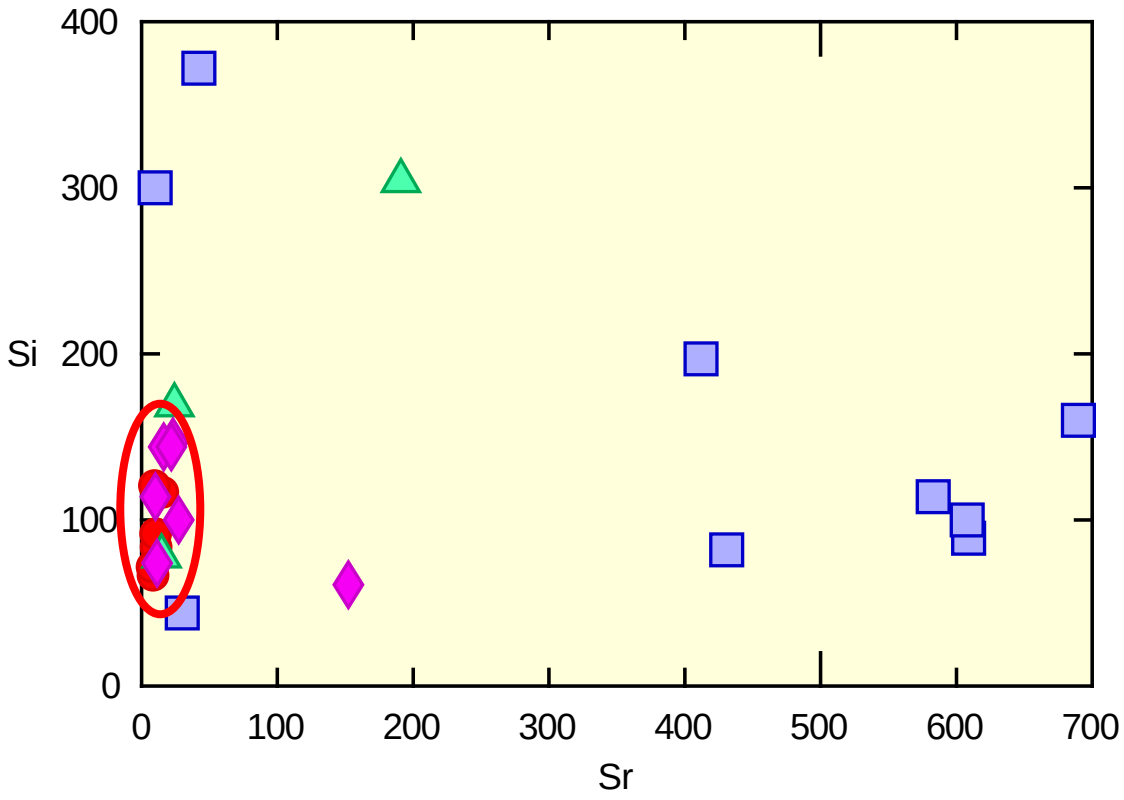

Summary of Results

Marsh Creek (control)

- Sediments from different localities were NOT statistically separable by elemental concentrations in terms of all elements analyzed
  - Fouling of road sediment over time, causing road sediment to read similar to other localities
- 28-78% of gravel road samples were plotted in close proximity to stream-bed samples in ternary diagrams

Baker Run (case study)

- Road sediments were statistically different from other localities in terms of Ca, Sr, and Mn
  - Road sediments are relatively unaffected by physical and chemical breakdown, resulting in an identifiable geochemical signature compared to other sediment types
- 11-44% of gravel road samples were plotted in close proximity to stream bed-samples in ternary diagrams

Conclusions

- Marcellus Shale infrastructures in our study area do not contribute to stream turbidity more than other landuse practices

- Statistical analysis indicated that stream turbidity in both watersheds is influenced by sediments originating from all landuse practices

This study has implications for determining sources of turbidity in other geographic and geologic settings

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