METALS RETENTION AND REMOBILIZATION IN A SMALL MINE DRAINAGE IMPACTED STREAM COLONIZED BY *CASTOR CANADENSIS* (NORTH AMERICAN BEAVER)

Nicholas L. Shepherd and Dr. Robert W Nairn

University of Oklahoma

Background

Hypotheses & Objectives

Methods

Results

Conclusions

Background

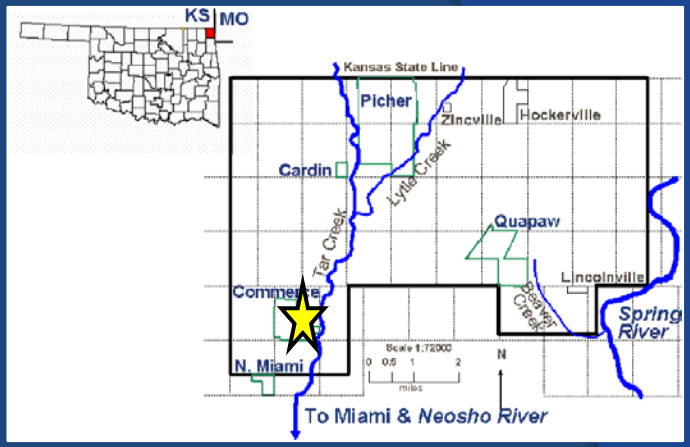
Castor canadensis

- Life cycle
  - 10 year life expectancy in wild
  - Sexual maturity in 1.5 to 2 years
  - Average 5 kits per birth at a 100 day gestation period
    - 2.7% mortality rate for first 2 years
- Site preferences
  - Dam narrow portions of waterways to create larger water surface area and increase water depth
  - Abundant food sources
    - Aquatic vegetation: duckweed and pondweed
    - Woody plants: Trembling aspen and willow

Castor canadensis

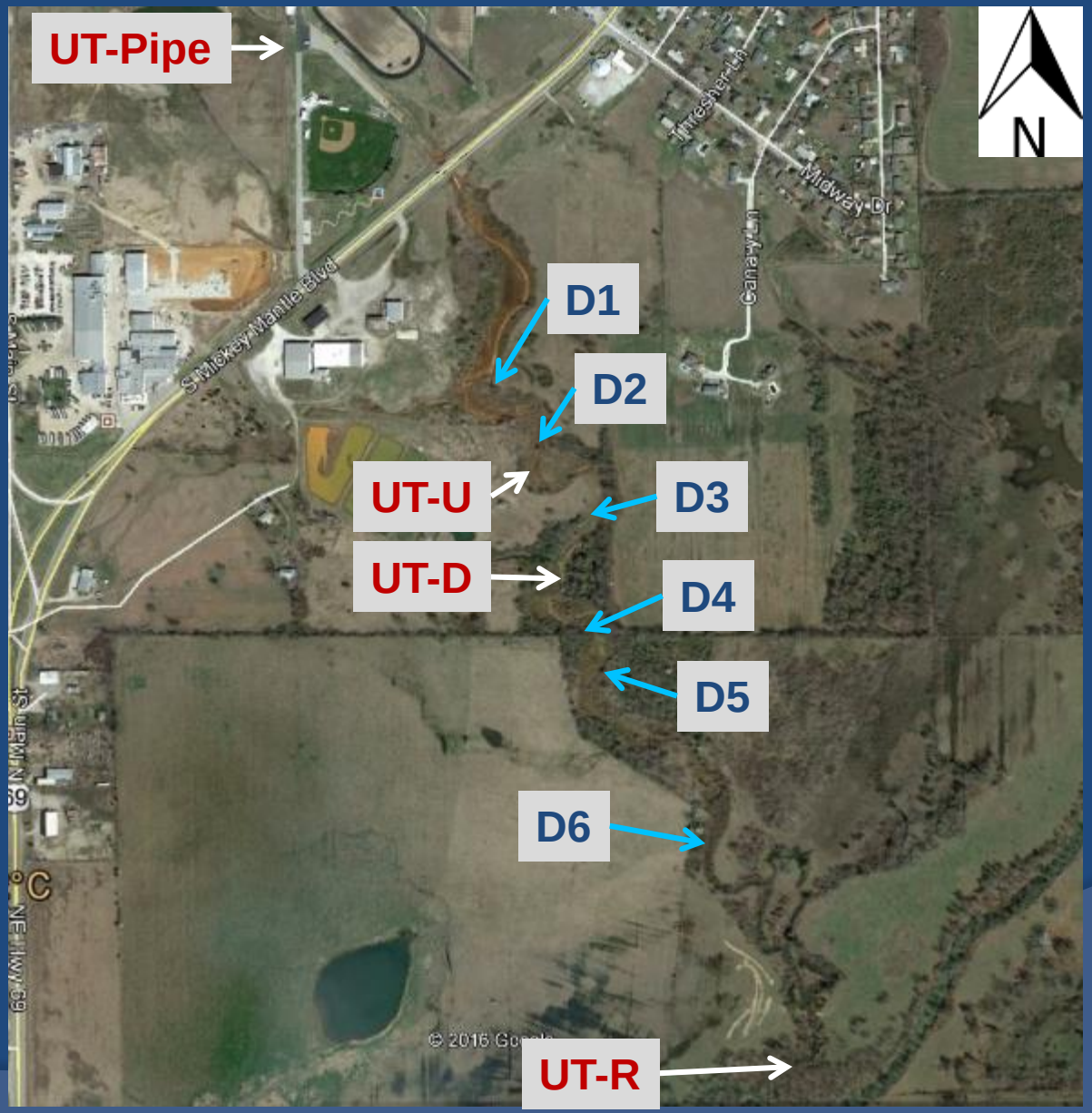
- Ecosystem engineers
  - Alter riparian area and forms extensive wetlands
  - Provide habitat variety
  - Increase plant and animal species richness
- Water quality impacts
  - Largely inconclusive, mainly regarding nutrients

Site: Unnamed Tributary (UT)



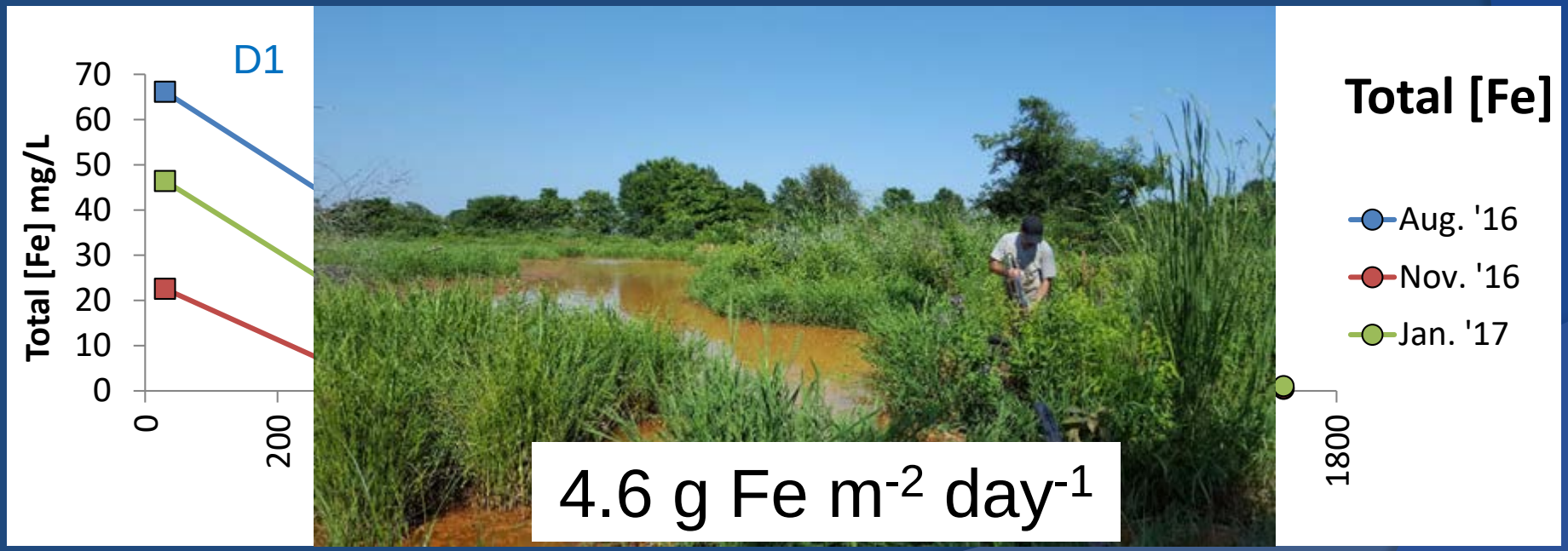
- Located in Commerce, OK
  - Tar Creek Superfund Site
- Impacted by mine drainage
  - SEC: Start of study reach, untreated mine drainage
    - Treatment began after completion of this study (Feb. 2017)
  - MRPTS: Second source 1/3 mile downstream
    - Treatment began Nov. 2008
- Tributary one mile long and flows into Tar Creek
- Evidence of beaver presence in 2013/2014

Site: Unnamed Tributary (UT)



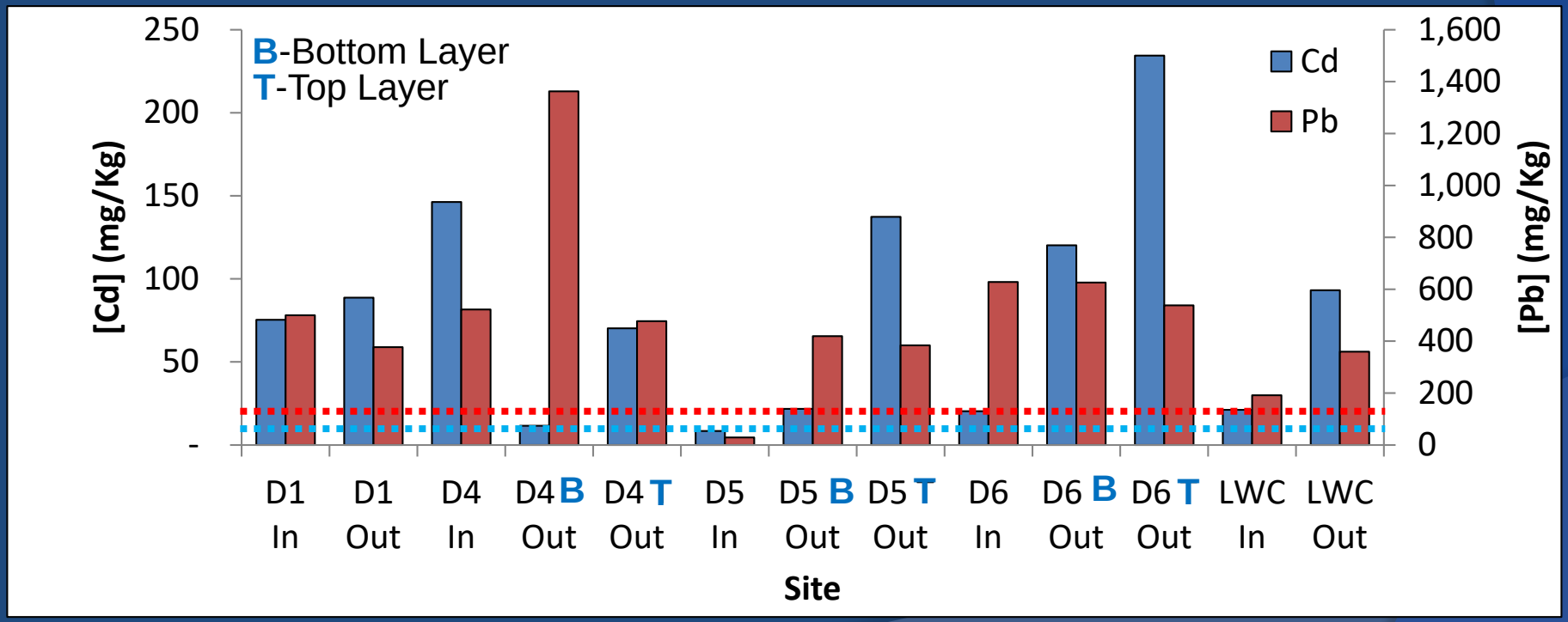
Previous Findings: Water Quality

- The presence of beaver dams decrease [Fe], [Cd], and [Zn] in a net alkaline mine drainage impacted stream



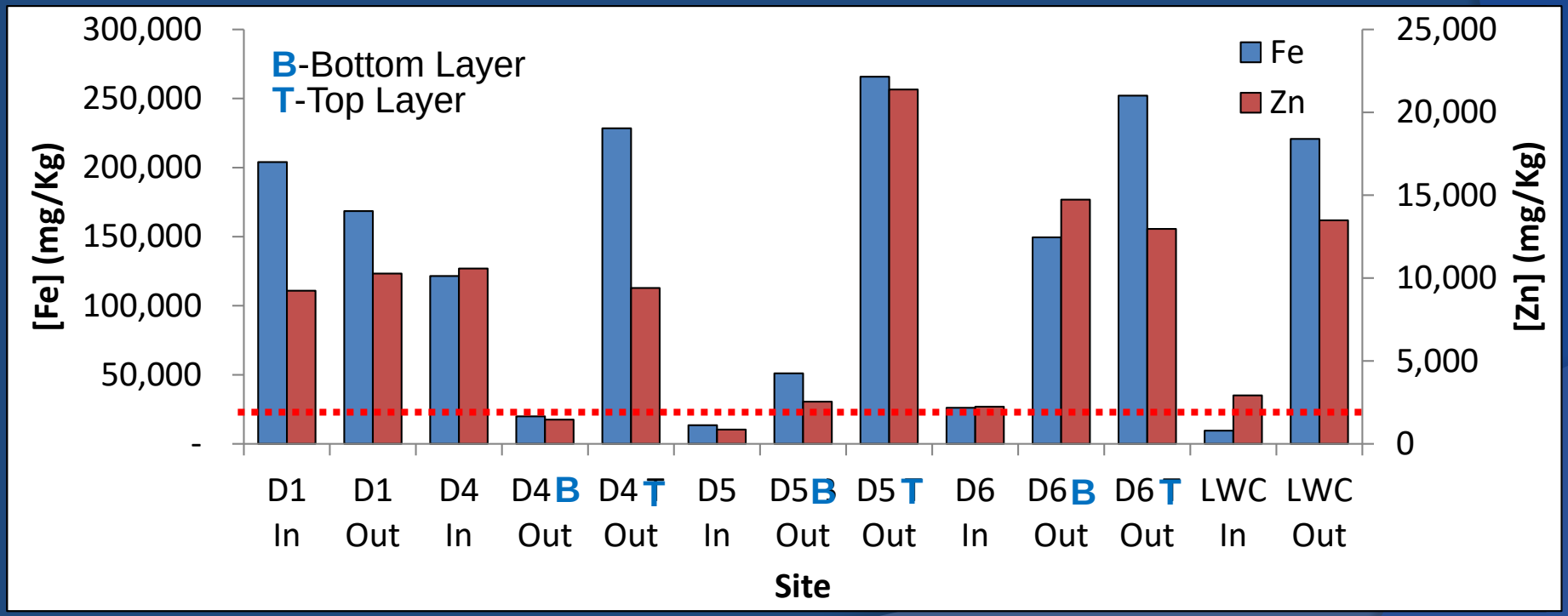
Previous Findings: Sediment Quality

- Stream sediments contain elevated metals concentrations, exceeding site-specific probable effects concentrations
  - 2,083 mg/kg Zn, 150 mg/kg Pb, 11.1 mg/kg Cd



Previous Findings: Sediment Quality

- Stream sediments contain elevated metals concentrations, exceeding site-specific probable effects concentrations
  - 2,083 mg/kg Zn, 150 mg/kg Pb, 11.1 mg/kg Cd



Hypotheses & Objectives

Hypotheses

1. Total and dissolved aqueous metals concentrations will increase immediately after dam destruction, but will decrease with respect to decreasing velocity of water flowing through the destroyed dam.

2. Residence time of the stream is longer in the presence of beaver dams with lower tracer recovery compared to those with the absence of beaver dams.

Objectives

1. Determine the impact on water quality in the scenario that beaver dams are destroyed by natural events through collection of timed water quality samples of “flush events” created by destroying the dams.

2. Determine retention time and dispersion due to the presence of beaver dams by conducting a conservative tracer study with and without beaver dams.

Methods

Metals Remobilization

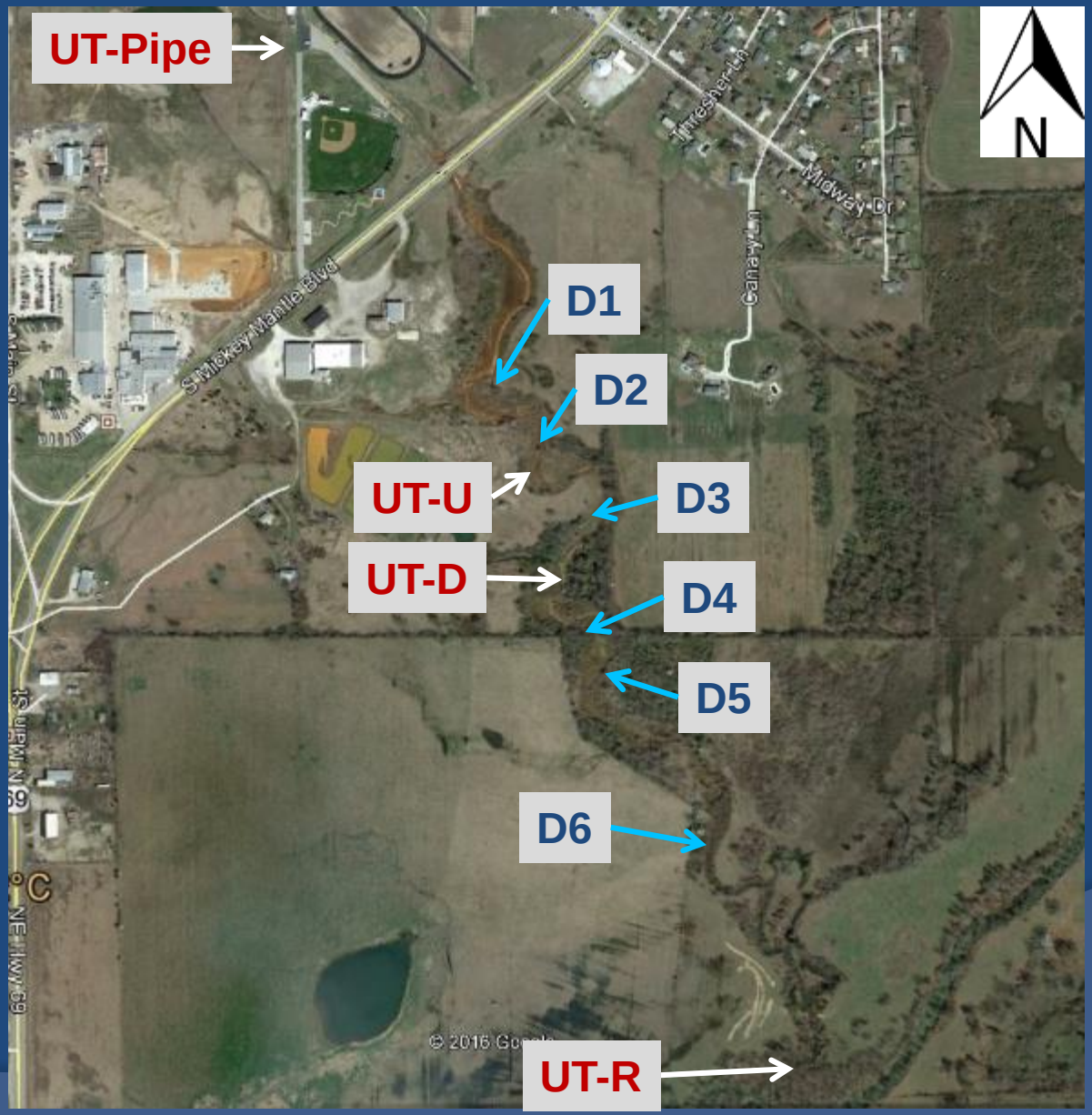
- Sequential dam removal
  - Dams manually removed starting downstream
  - Selected dams sampled for one hour period at 30 min intervals (5 min., 35 min., and 65 min.)
    - Total and dissolved metals and YSI water quality parameters

- Singular dam removal
  - Autosampler, flow meter and YSI deployed at most upstream dam
    - Samples collected every 30 minutes for six hours
  - Dam manually removed

Stream Characterization

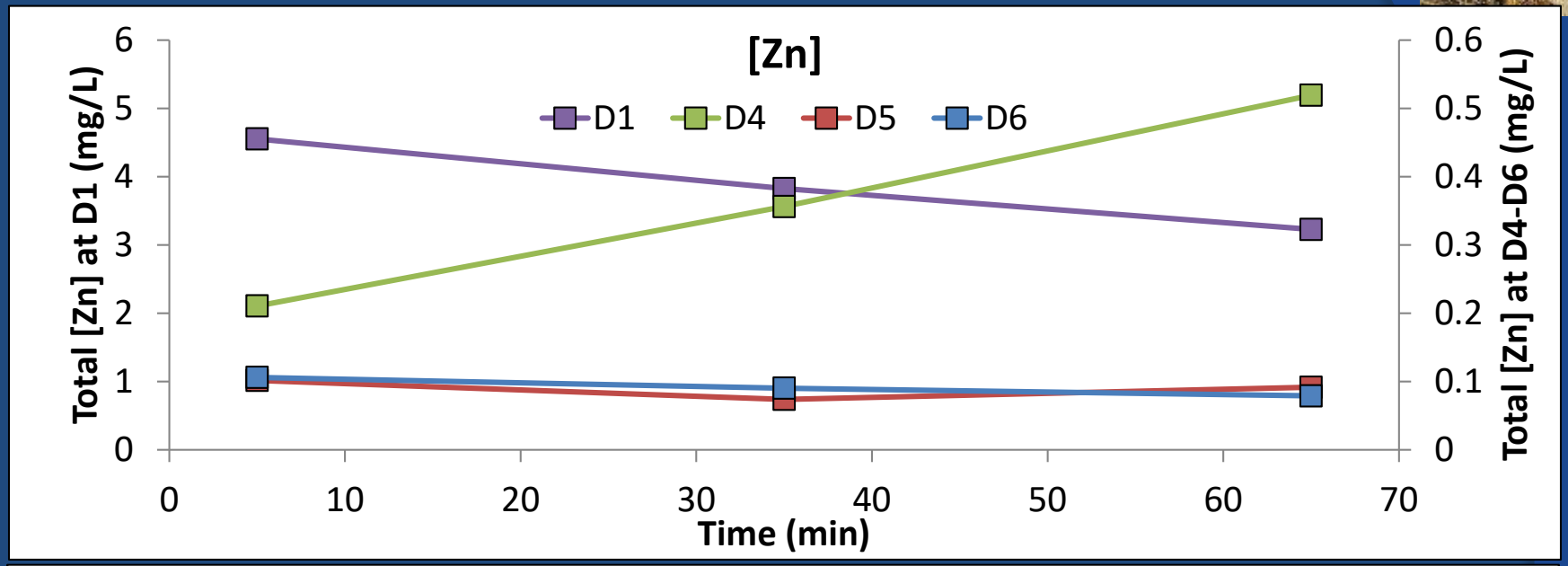
- Conservative Tracer Study
  - Sensors deployed at UT-U and UT-R recording every 30 minutes
  - Injected rhodamine dye at UT-Pipe with and without beaver dams
- Geomorphic assessment
  - Conducted U.S. EPA Rapid Habitat Assessment every 30m

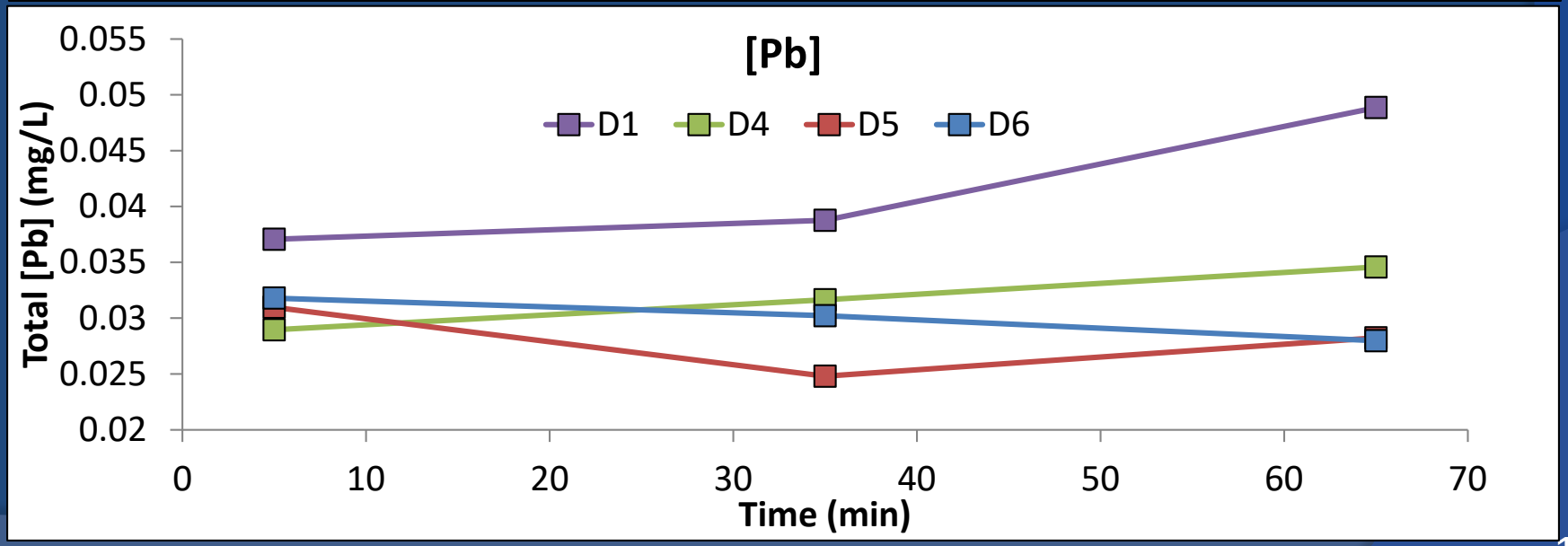
Site: Unnamed Tributary (UT)



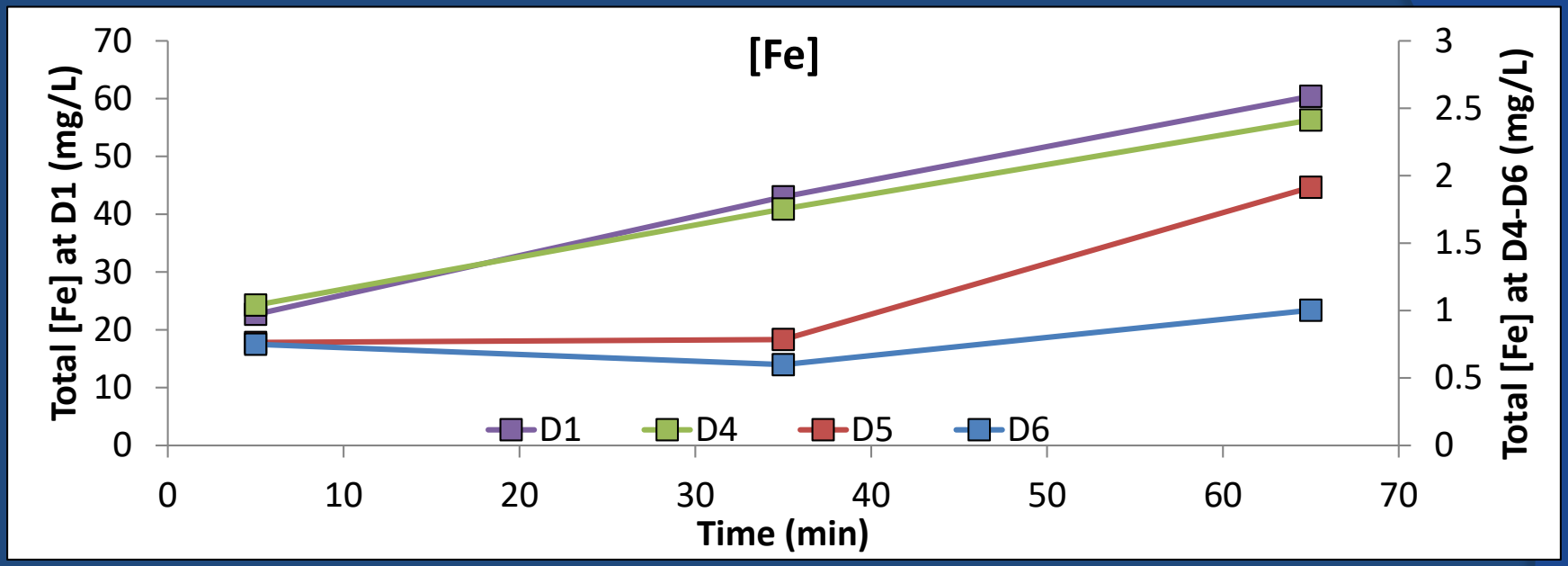
Results

Sequential Dam Removal





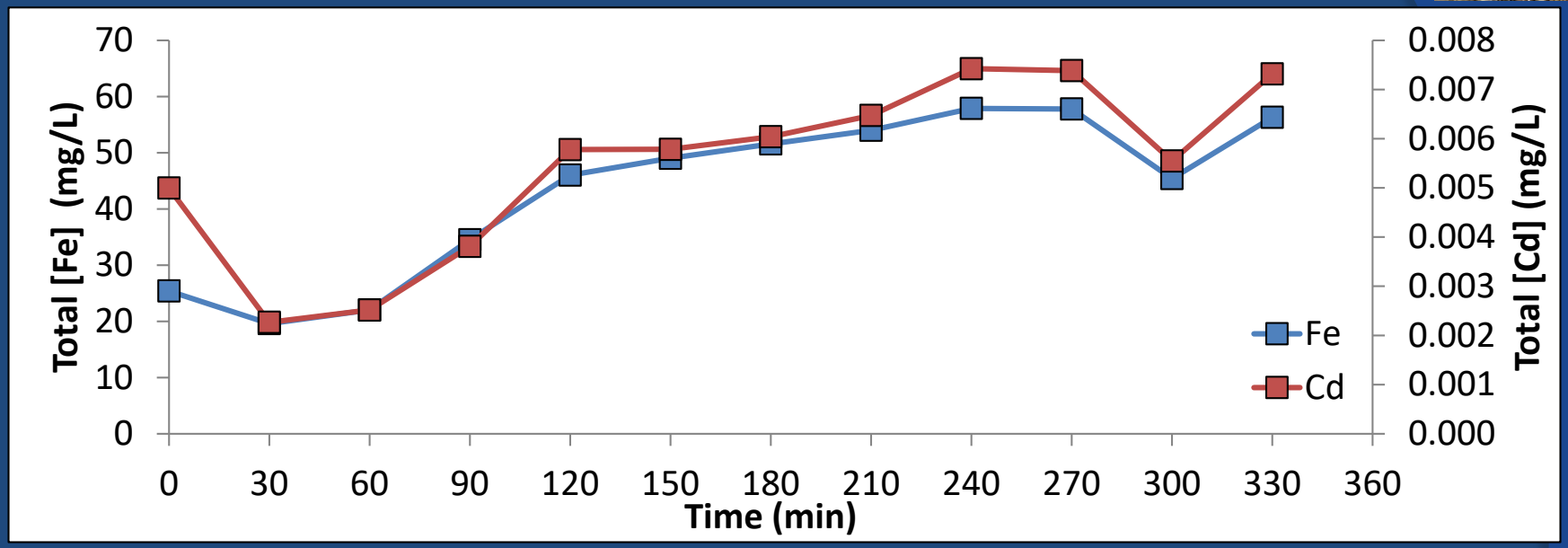
Sequential Dam Removal

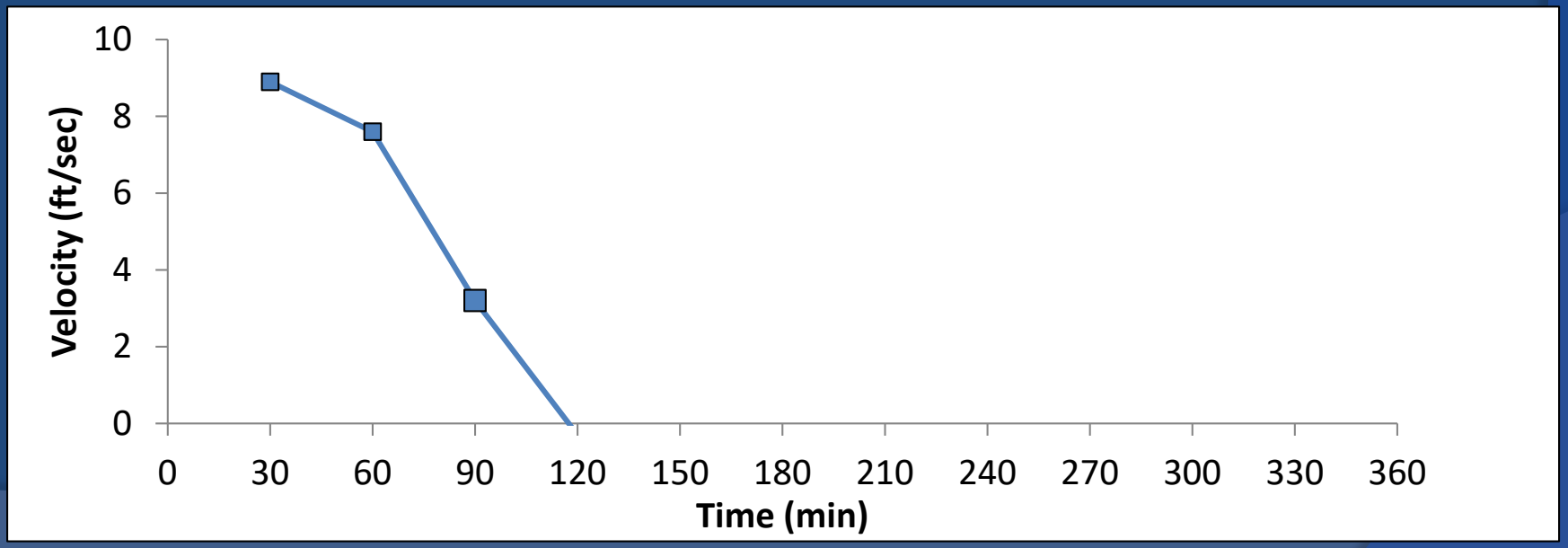


Approximate mass of mobilized Metals

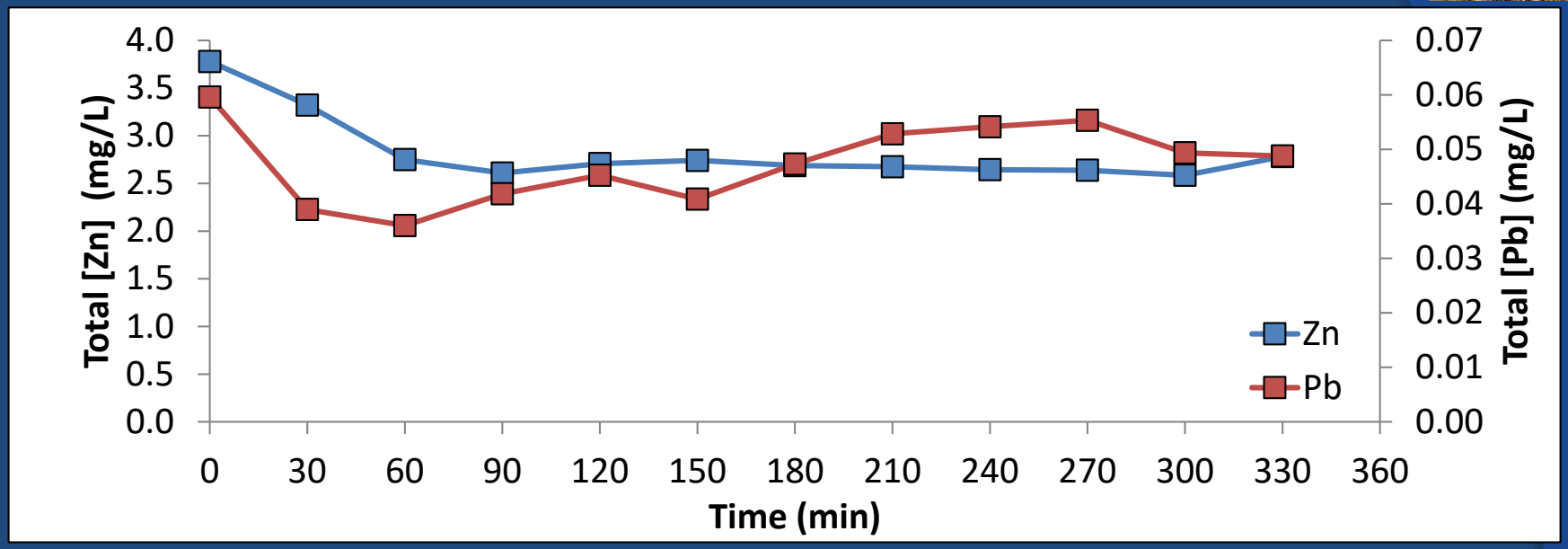
		All Metals Masses in grams			
Dam #	Vol. (m^3)	Cd	Fe	Pb	Zn
D1	1315	9.16	55,276	54.66	4,577
D4	296		513.0	9.380	93.98
D5	503		580.4	14.08	44.81
D6	96		75.53	2.890	8.852
Summed Mass		**9.16**	**56,445**	**81.0**	**4,725**

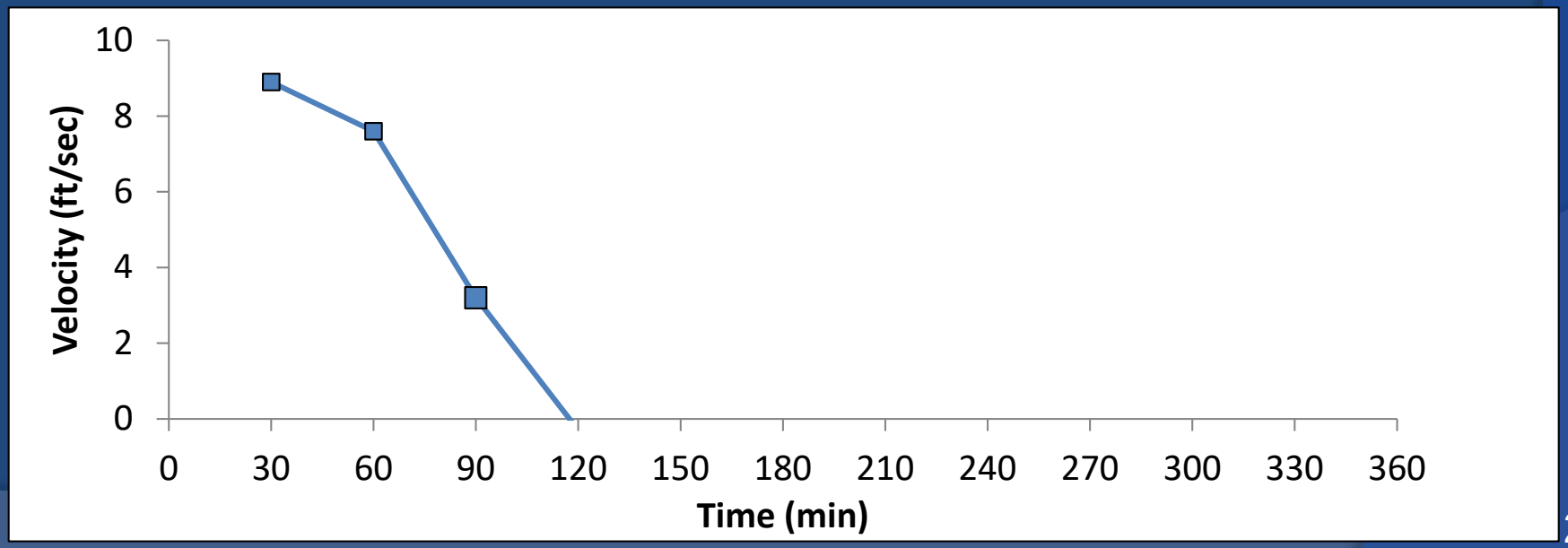
Single Dam Removal



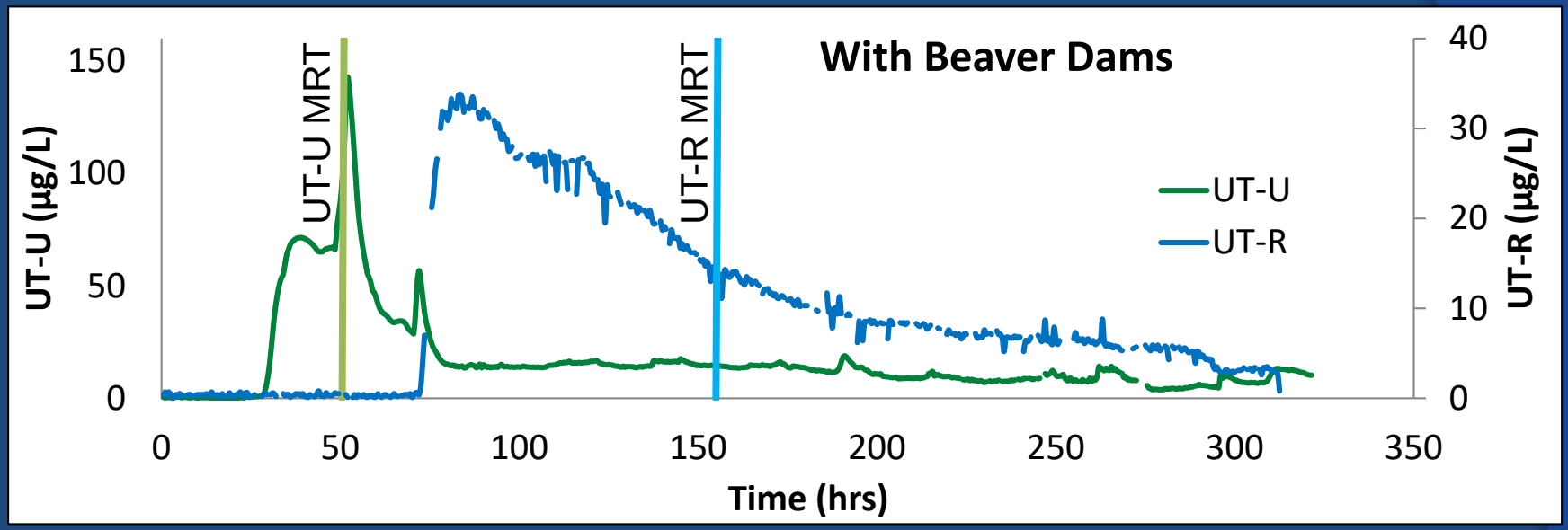


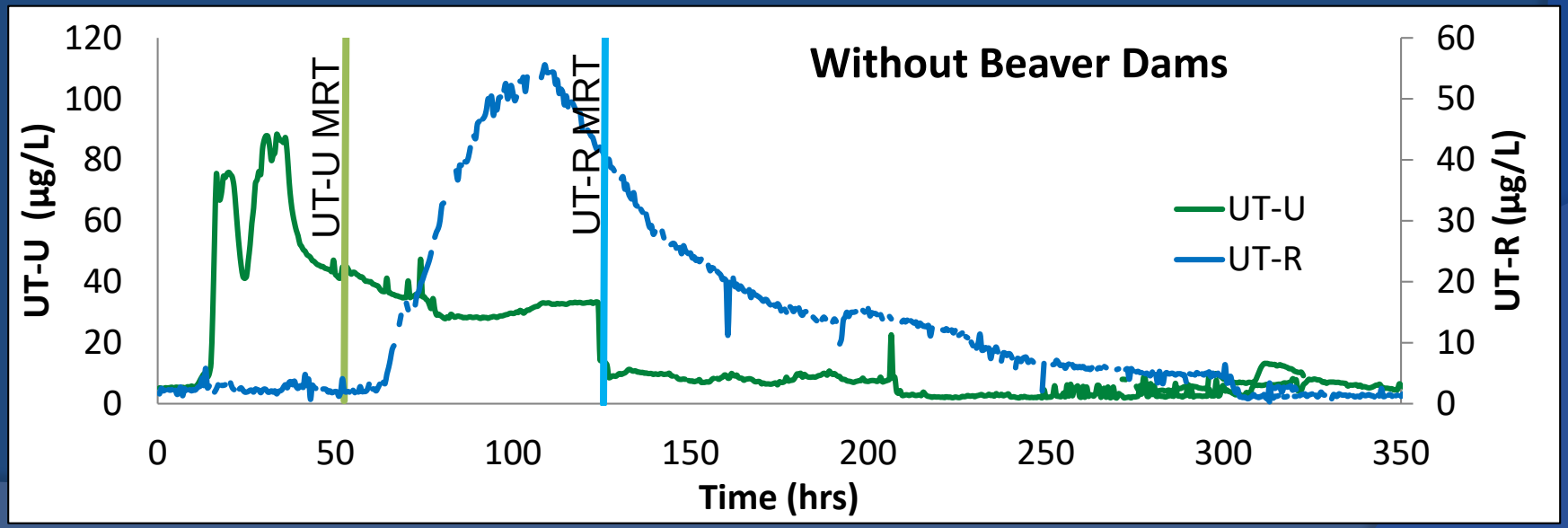
Single Dam Removal





Conservative Tracer Study





Conservative Tracer Study

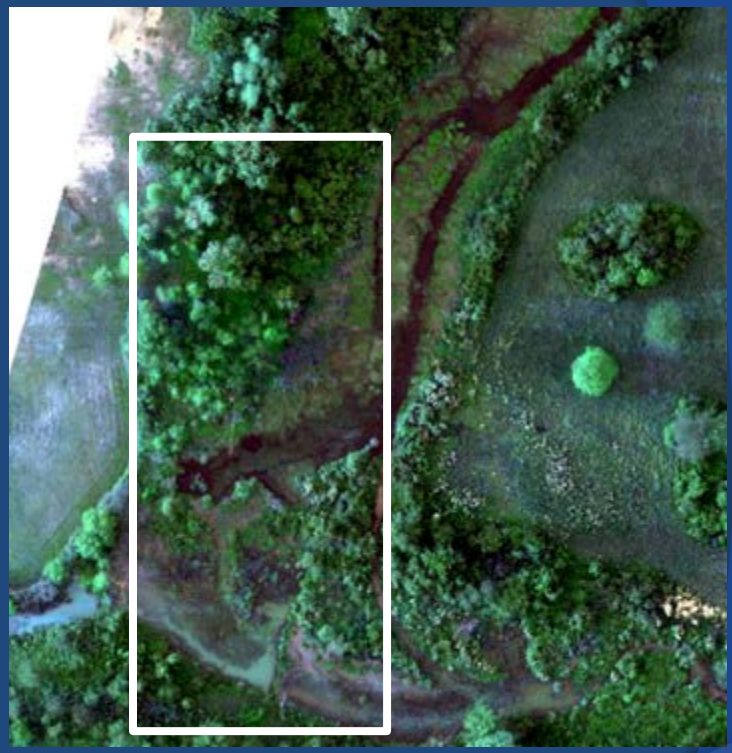
Parameter	With Dams		Without Dams	
	UT-U	UT-R	UT-U	UT-R
Total Mass of Rhodamine Injected (g)	697.35		373.58	
Total Mass of Rhodamine Recovered (g)	60.04	63.79	106.36	87.78
Recovery (%)	8.61	9.15	28.47	23.50
Mean Retention Time (hrs. after injection)	48.0	155.0	52.2	126.0
Mean Retention Time (pulse start)	19.5	74.0	41.5	63.5
Calculated Retention Time	102.6	244.5	19.9	68.2
Dispersion Coefficient (m^2/s)	0.14	20.87	1.61	5.13
Dead volume per bulk volume	53.2	36.6	-162.3	-84.8
Index of Short Circuiting	-0.21	0.85	0.46	0.27

Estimated storage due to beaver dams:

- Habitat Assessment: 2.0 ac-ft
- USGS Stream gauge stations: 2.6 ac-ft

Conservative Tracer Study

Aerial image at D1 (2011)



Aerial image at D1 (2017)

Conclusions

Conclusions

1. Total and dissolved aqueous metals concentrations would increase immediately after dam destruction, but would decrease with respect to decreasing velocity of water flowing through the destroyed dam.

Partially accepted:

- **[Fe] and [Cd] increase following dam removal**
  - **Not correlated to velocity**
- **No change in [Zn] and [Pb]**

2. Residence time of the stream would be longer in the presence of beaver dams with lower rhodamine recovery compared to the absence of beaver dams.

Accepted

Conclusions

- Beaver have potential to improve water quality through wetland creation
- View beaver as an asset rather than a nuisance


Bushnell
CameraName 80°F26 °C
08-02-2017 07:07:44

Acknowledgements

- Property Owners: Mayer and Martin Families
- Grand River Dam Authority
- City of Commerce
- University of Oklahoma: School of CEES
- Oklahoma Department of Environmental Quality
- Center for Restoration of Ecosystems and Watersheds (CREW)
  - Especially Brandon Holzbauer-Schweitzer and Bryan Page


Worlds Largest Beaver Dam 2,790 ft
Wood Buffalo National Park, Canada

Questions?