

---

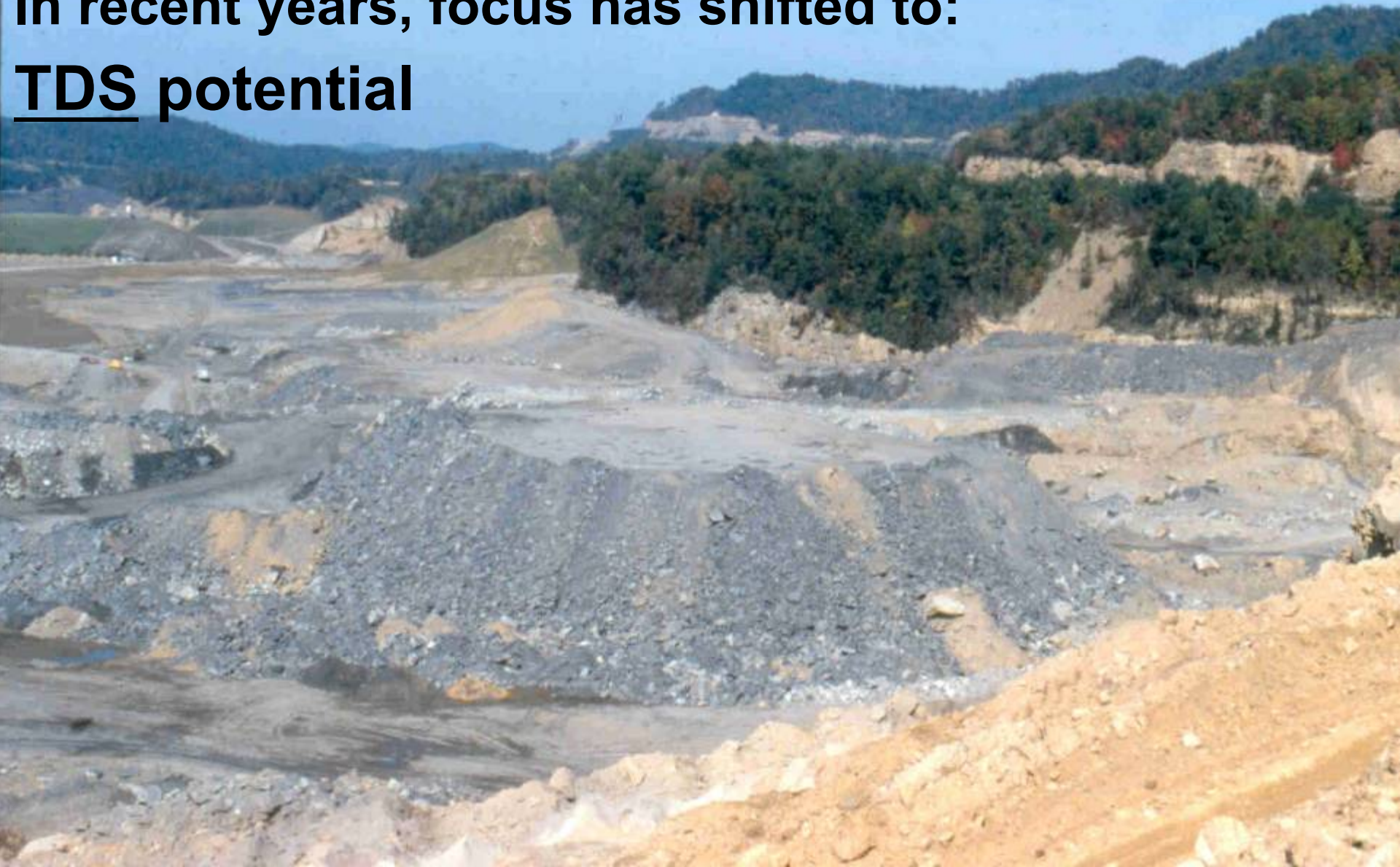
# **PREDICTING TDS RELEASE FROM OVERBURDEN**

---

Zenah W. Orndorff, W. Lee Daniels - Virginia Tech  
Jeff Skousen, Louis McDonald - WVU

Historically, coal mine pre-mining analytics focused on:  
**AMD potential and revegetation potential**

In recent years, focus has shifted to:  
**TDS potential**



# Overall Objective

---

**The primary objective of this research program is to develop and evaluate methods for predicting potential TDS release from coal overburden and refuse materials, and for characterizing the constituent elements (Se, and other elements of concern)**

**Prediction methods must predict short-term peak discharges and long-term release characteristics and component ions.**

# RECLAIMED VALLEY FILL

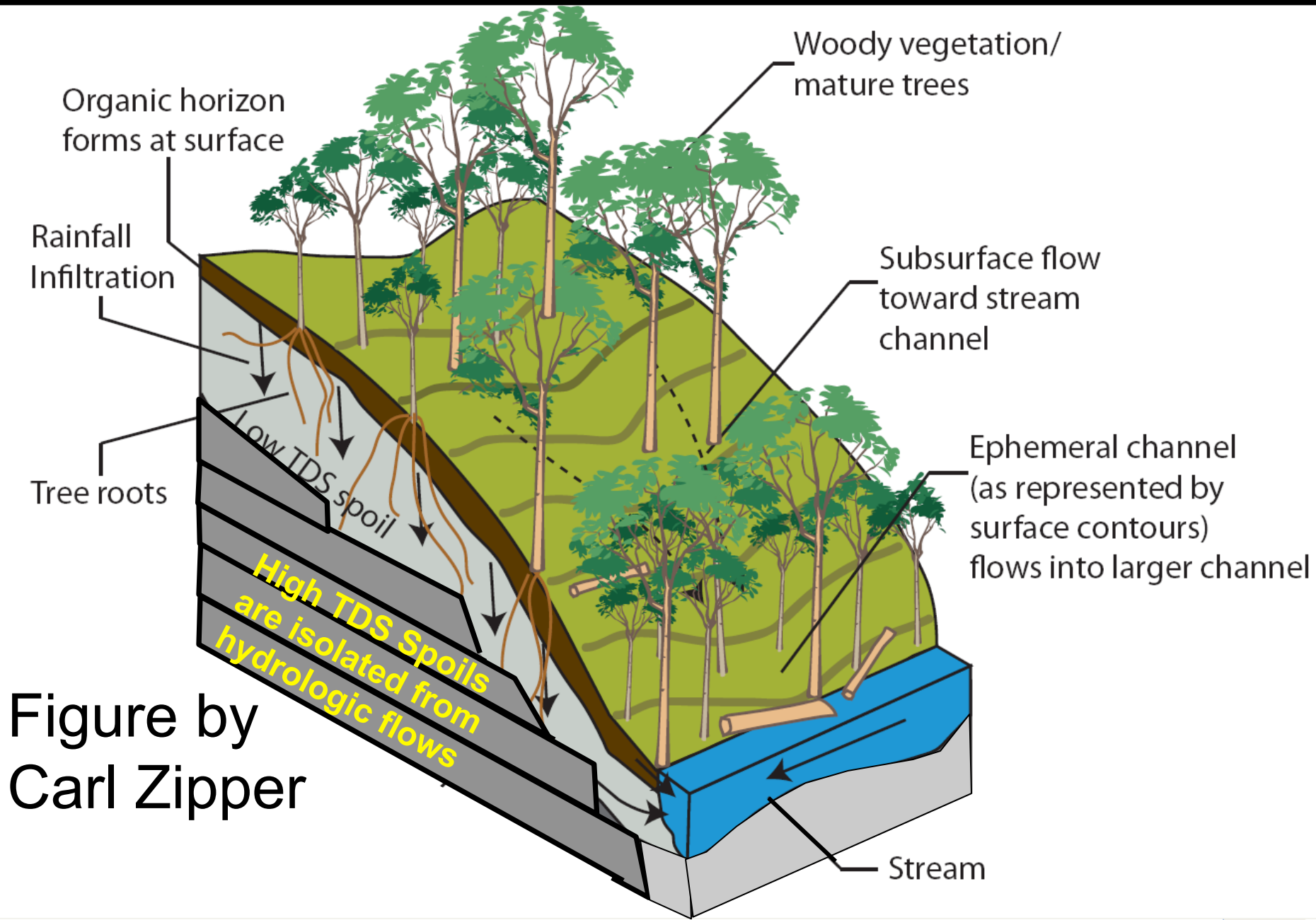


Figure by  
Carl Zipper



# Multiple Projects and Sponsors!

- Powell River Project supported original leaching studies (to 2011) and currently supports spoil weathering x depth profiles.
- OSM funded TDS prediction studies for TN spoils and refuse materials and regional discharge x time study from 2011 to 2013.
- ARIES supports integrated TDS prediction studies for a wide suite (45+ spoils) of regional overburden materials. Our project is joint with UK and WVU (2010 to 2014).

# Specific Objectives

---

- 1) Characterizing the potential leaching behavior (pH, EC, major cations and anions) of mine spoils and refuse materials using laboratory leaching columns.**
- 2) Evaluating effects of saturation levels on TDS release from spoil in laboratory leaching columns.**
- 3) Evaluating scaling effects by comparing leachate data from laboratory columns, intermediate field scale barrels and tanks, and larger field scale plots.**
- 4) Evaluating static test predictors in comparison to laboratory leaching columns.**

# Laboratory Column Leaching Method

---

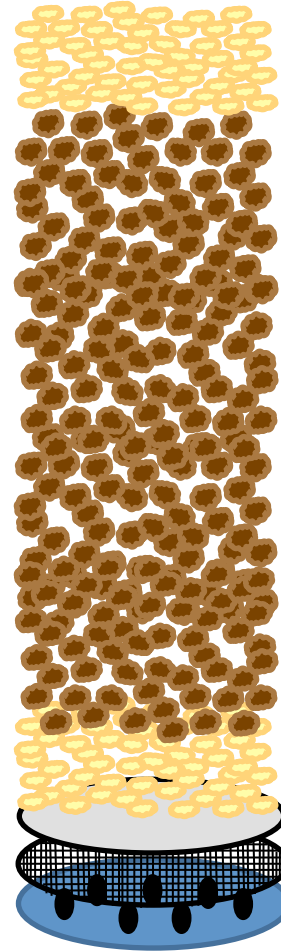
BULK SAMPLES (typically 2 5-gal buckets) are each:

- Spread out to air-dry.
- Passed through a 1.25 cm (0.5") sieve.
- Coarse fraction crushed to <1.25 cm.
- All material thoroughly re-blended.
- Subsamples (1200 cm<sup>3</sup>, with mass recorded) were collected (cone and quarter) for column leaching, to determine pore volume (within columns), and to determine coarse particle size distribution.
- Subsamples were collected and crushed as appropriate for basic characterization including saturated paste pH/EC and total-S.

# COLUMN SETUP

Capped with 5 cm sand

- Sample volume:  $1200 \text{ cm}^3$
- Inside diameter = 7.5 cm
- Height of spoil = ~ 27 cm
- Inside bottom of column:
  - 5 cm (2") sand
  - Whatman #1 filter
  - 0.1 mm nylon mesh
  - perforated plastic disc
- PVC pipe nipple and Tygon tubing for drainage





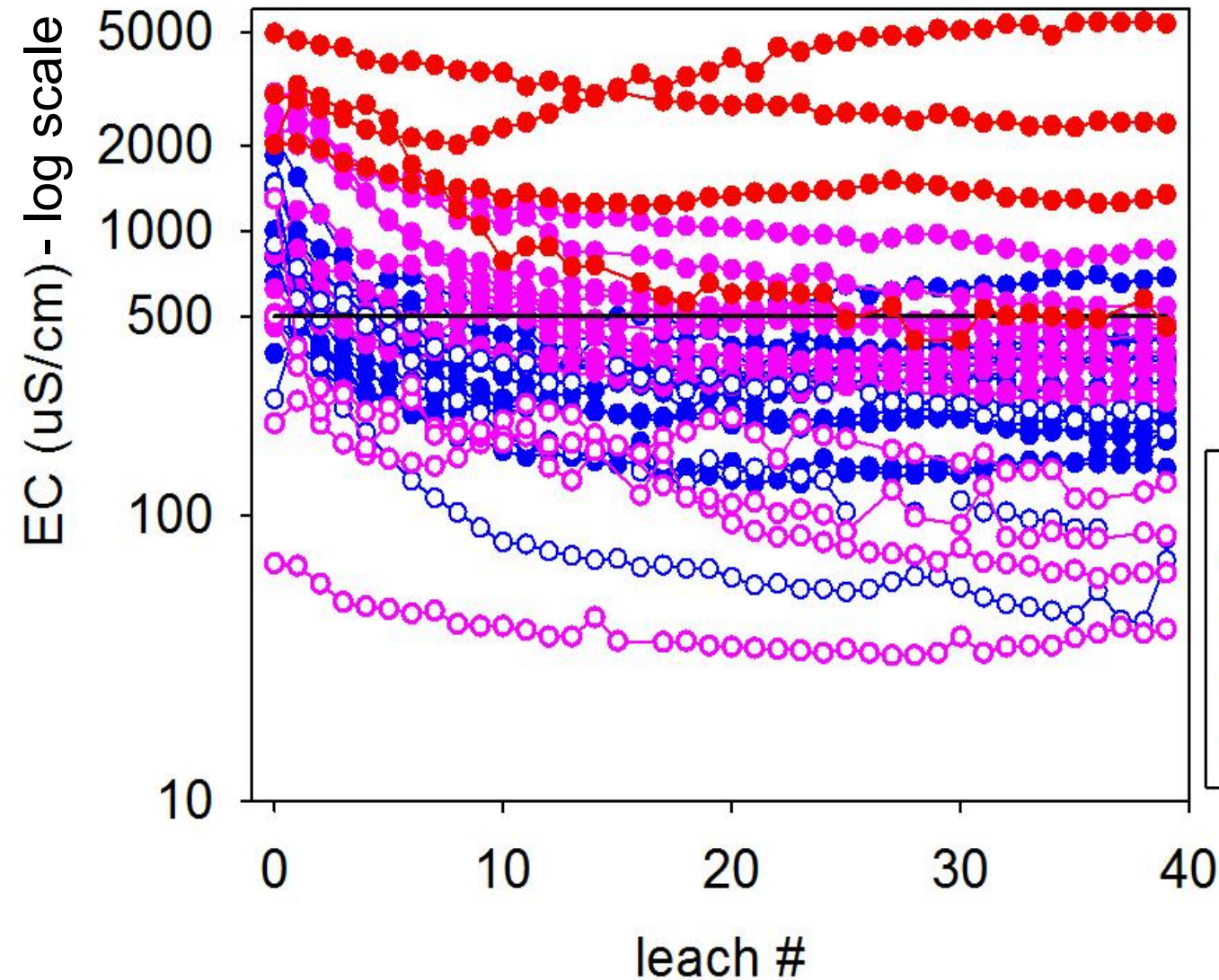
# Laboratory Column Leaching Method

---

- Each material run in triplicate (3 columns/material)
- Unsaturated: samples initially moistened to maximum water holding, then any amount added = amount drained.
- Saturated: drain tube clamped, samples moistened so saturation, drain tube unclamped to collect sample.
- Leaching solution: synthetic acid rain with pH=4.6
- Simulated rainfall was applied 2x/week (Mon/Thurs)
- Each rainfall event = 125 ml (~2.5 cm; 1")
- Leachate (~125 ml) collected after ~24 hrs (Tues/Fri).
- Samples analyzed for: pH, EC, major cations and anions.

**Overall: 1) increased weathering = lower EC/TDS**  
**2) coarser grain size = lower EC/TDS**

**55 samples unsaturated**



**By the end of  
the study 48  
samples were  
equilibrated to  
<500 uS/cm**

# Evaluation of Column Leaching Method: Potential Saturation Zones

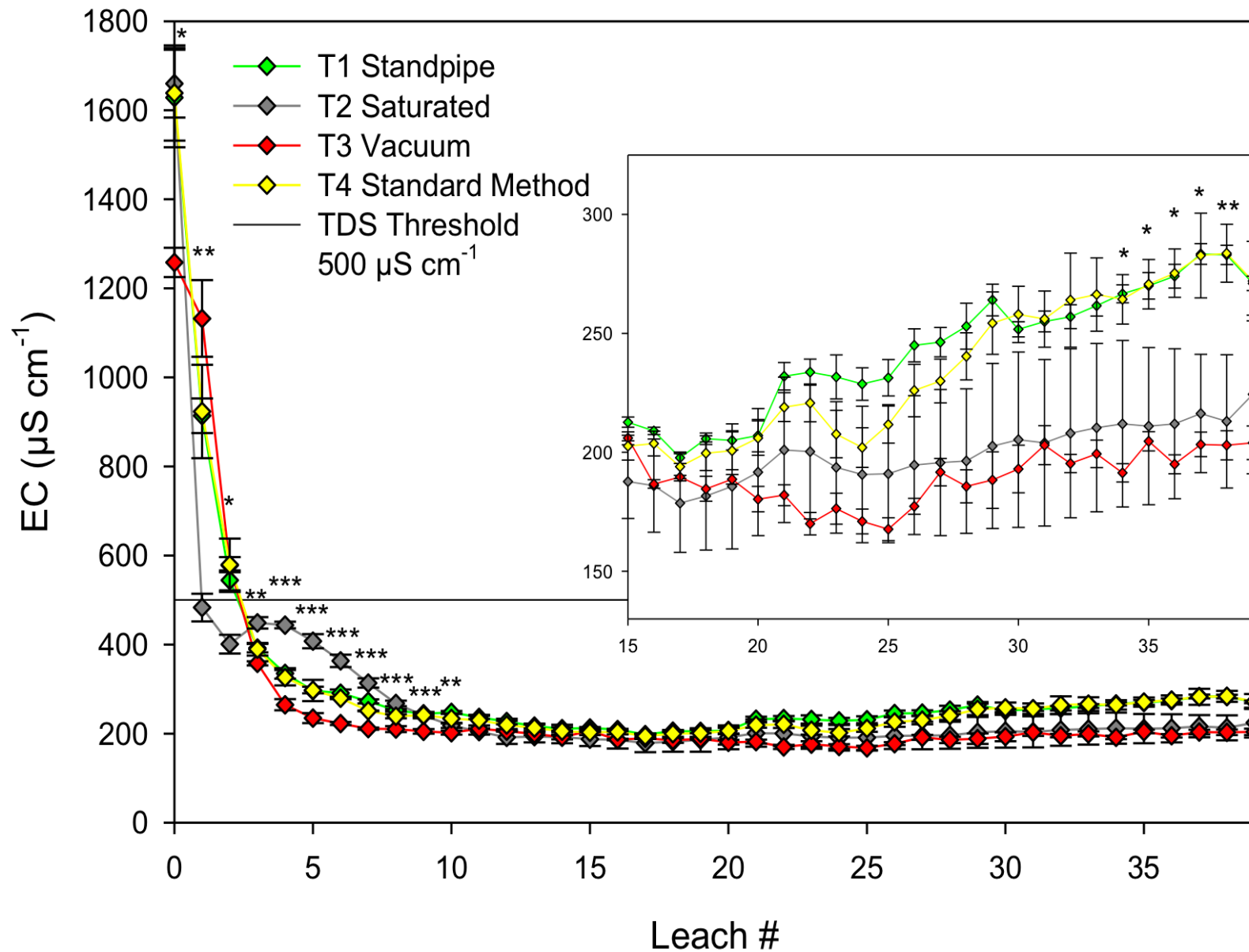
MS work completed by John Parker at Virginia Tech, 2013



- Visually confirmed once (< 15 min in duration)
- Staining on tubing indicated other minor perching events.

# Effect of Various Saturation Levels on Electrical Conductance

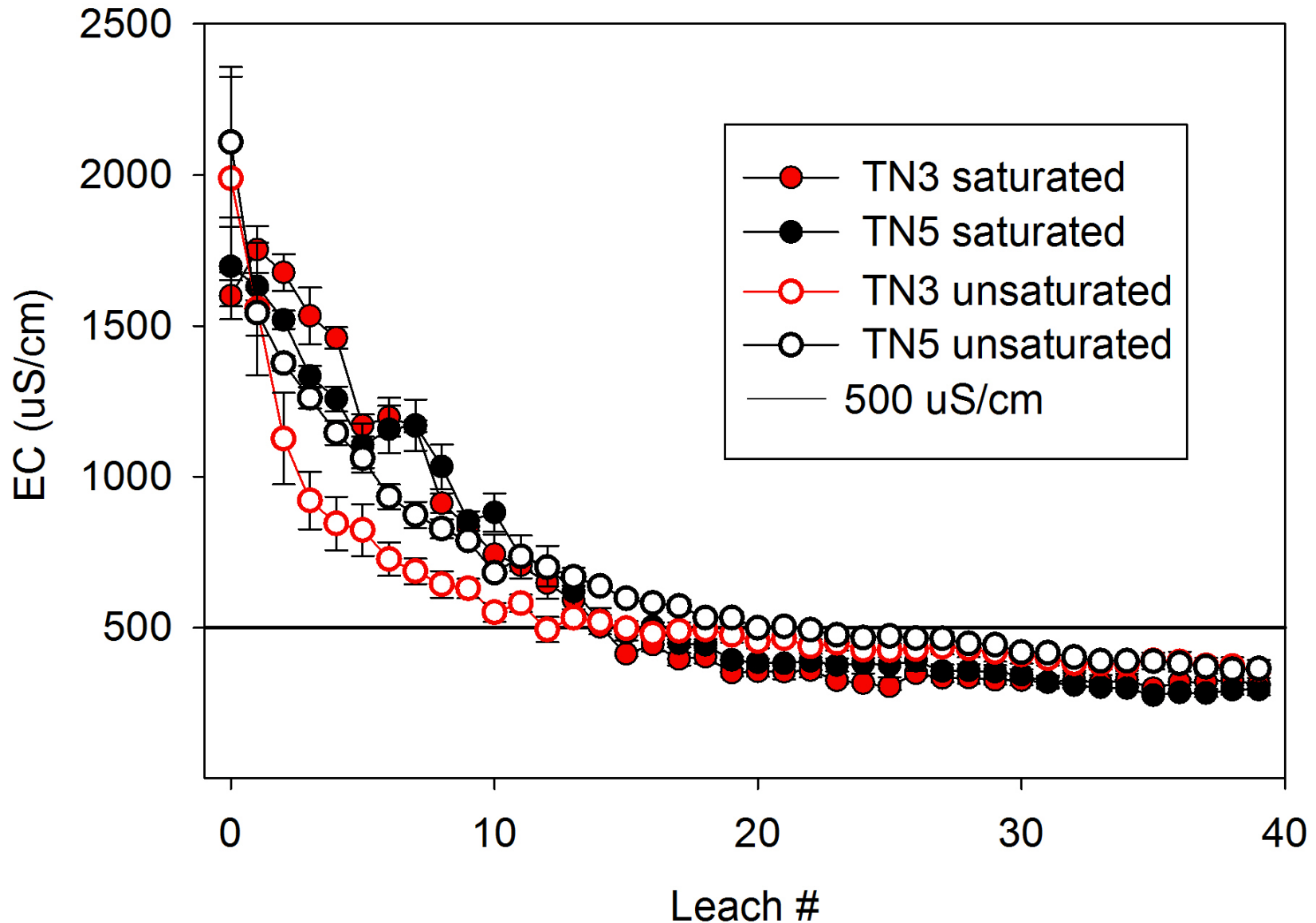
MS work completed by John Parker at Virginia Tech, 2013





# Saturated vs unsaturated leachate EC

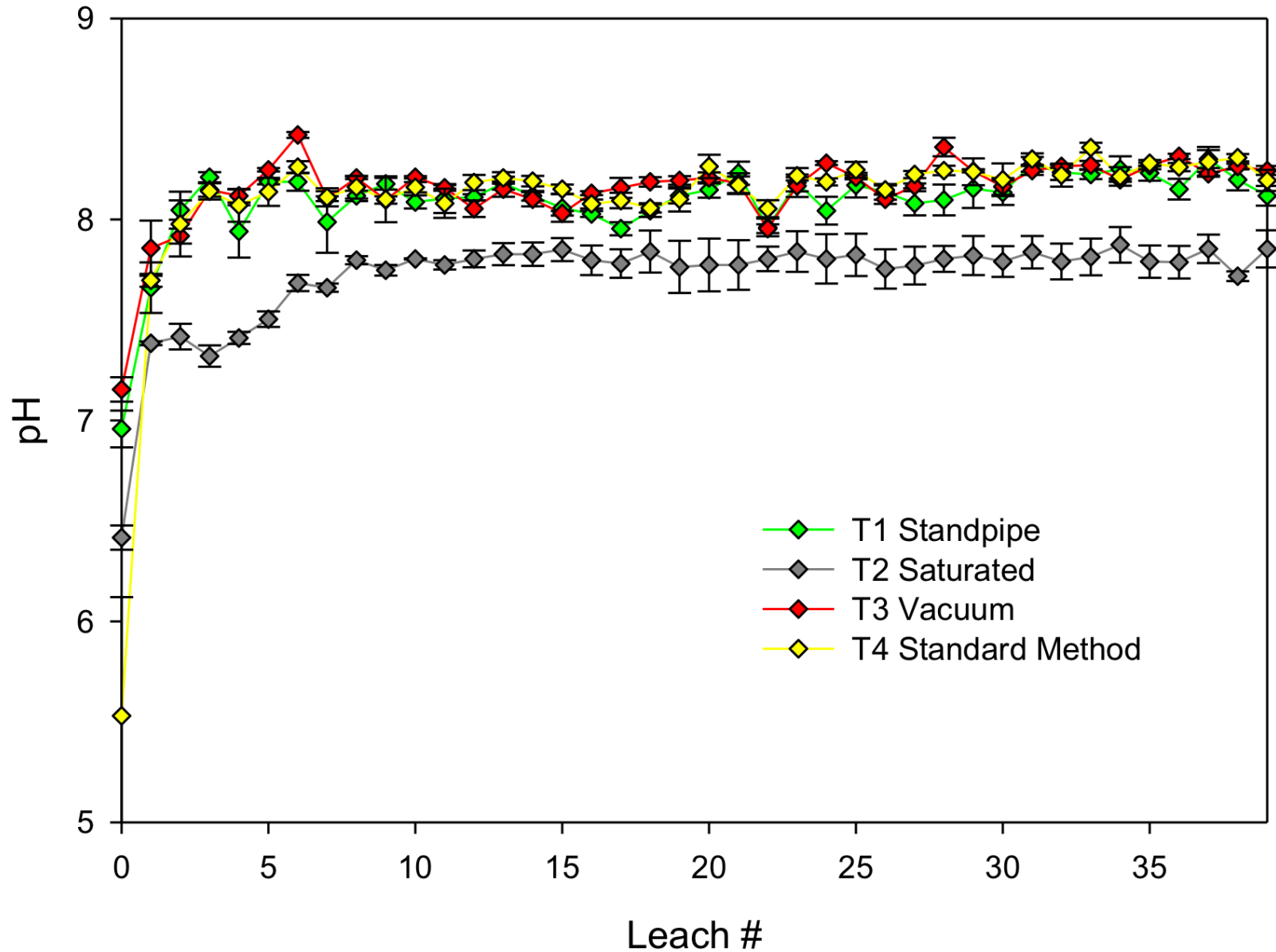
## Low-sulfide spoils (mixed mudstone/sandstone)





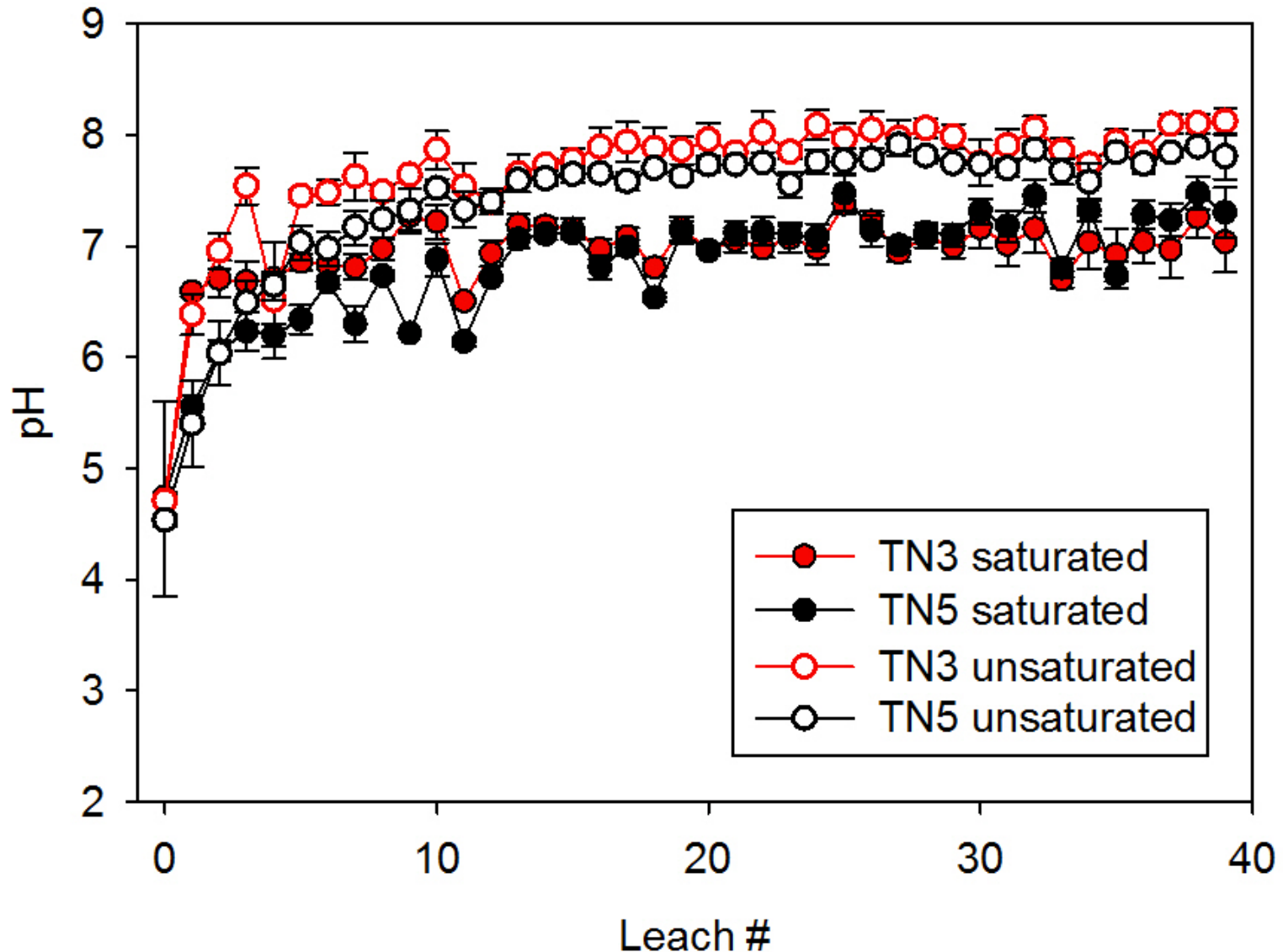
# Effect of Various Saturation Levels on Leachate pH

MS work completed by John Parker at Virginia Tech, 2013

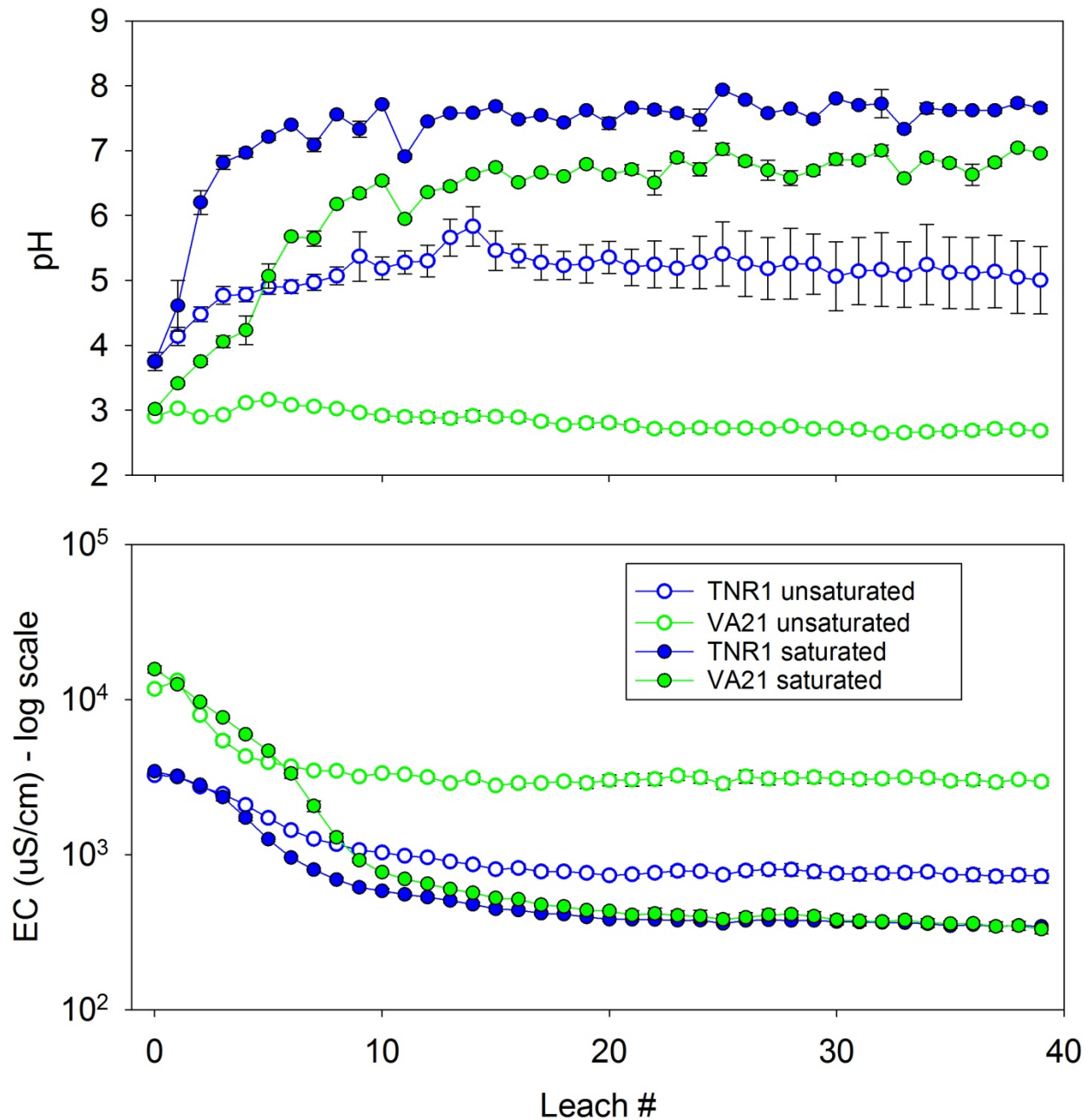


# Saturated vs unsaturated leachate pH

## Low-sulfide spoils (mixed mudstone/sandstone)



# Saturated vs unsaturated leachate pH (high-sulfide material)



# Scaling Issues and Studies

---

- Leaching columns may serve as a reliable predictor of TDS leaching potentials over time, but how well do they estimate maximum short term and equilibrium long-term concentrations?
- In general, we assume that column data are worst-case and need to be “scaled” to better resemble and predict field data.

# Scaling Issues and Studies

---

- For one scaling study (OSM+ARIES), we are testing one common spoil (Harlan fm; raw saturated paste EC ~ 850) using laboratory columns (0.0012 m<sup>3</sup>), and field-scale barrels (~0.15 m<sup>3</sup>) and mesocosm tanks (~1 m<sup>3</sup>).
- For a second scaling study (OSM), we are comparing two refuse samples from TN in columns and barrels.
- In a third scaling study (ARIES), our column leaching data will be compared to large field-scale lysimeter data from overburden plots at Bent Mountain (UK) using the same spoil.



# Harlan fm Spoil Collection –Wise





**Filter fabric was placed over drainage layer and then spoils placed in tanks.**







**Raw spoil (up to 18") placed into mesocosms over filter fabric and 10 cm of acid washed gravel. Initiated in October of 2012 and will be continued through 2014?**

**Large mesocosms (here) supported by OSM and ARIES. OSM supported smaller "barrels" on same site with same spoil (Harlan fm) and two coal refuse materials from TN. Barrels received  $\leq 5''$  screened spoils.**



**Buried barrels receive gravity leachate drainage from the mesocosms.**

**Clay Ross, this is his  
MS project**

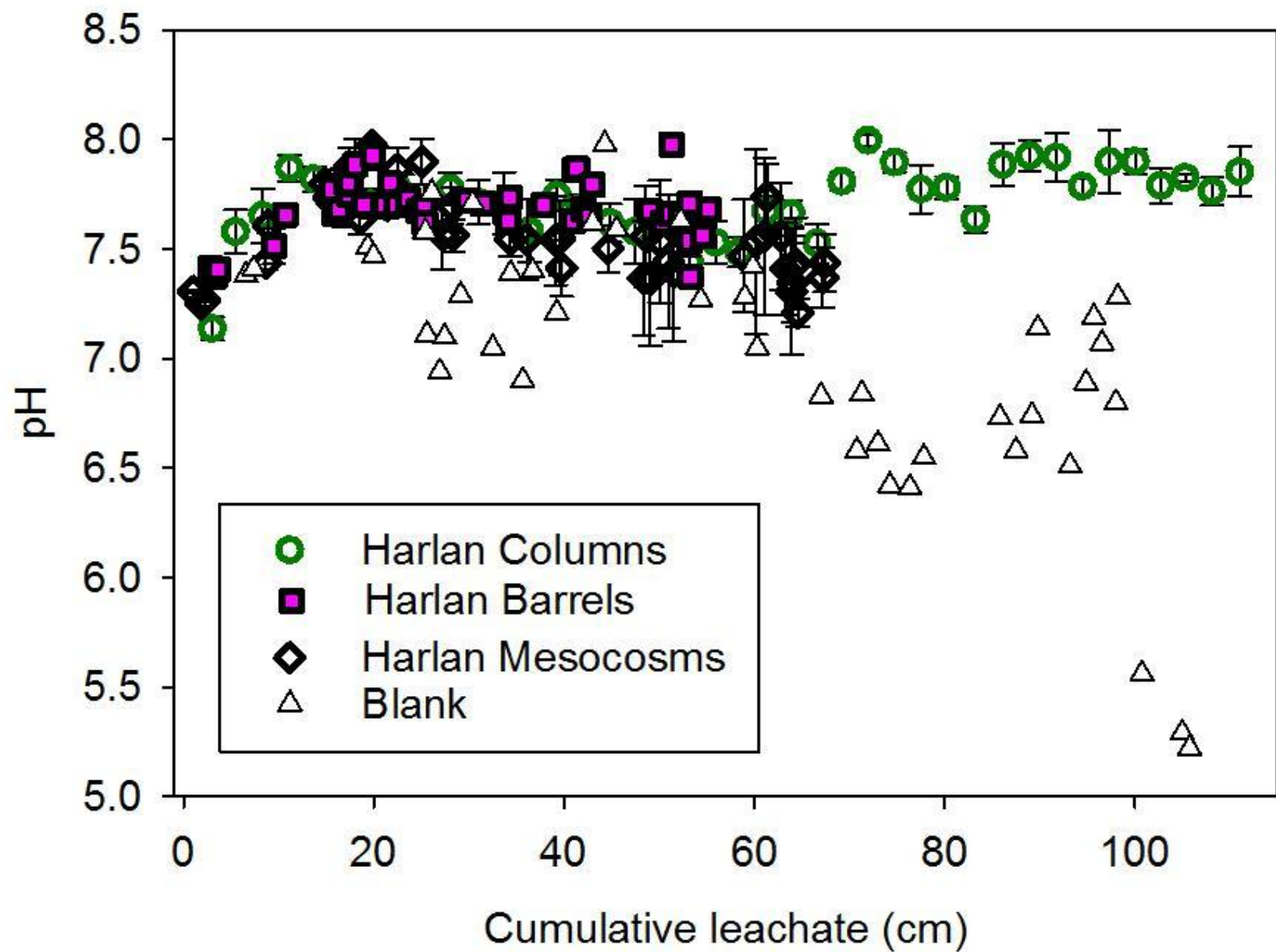


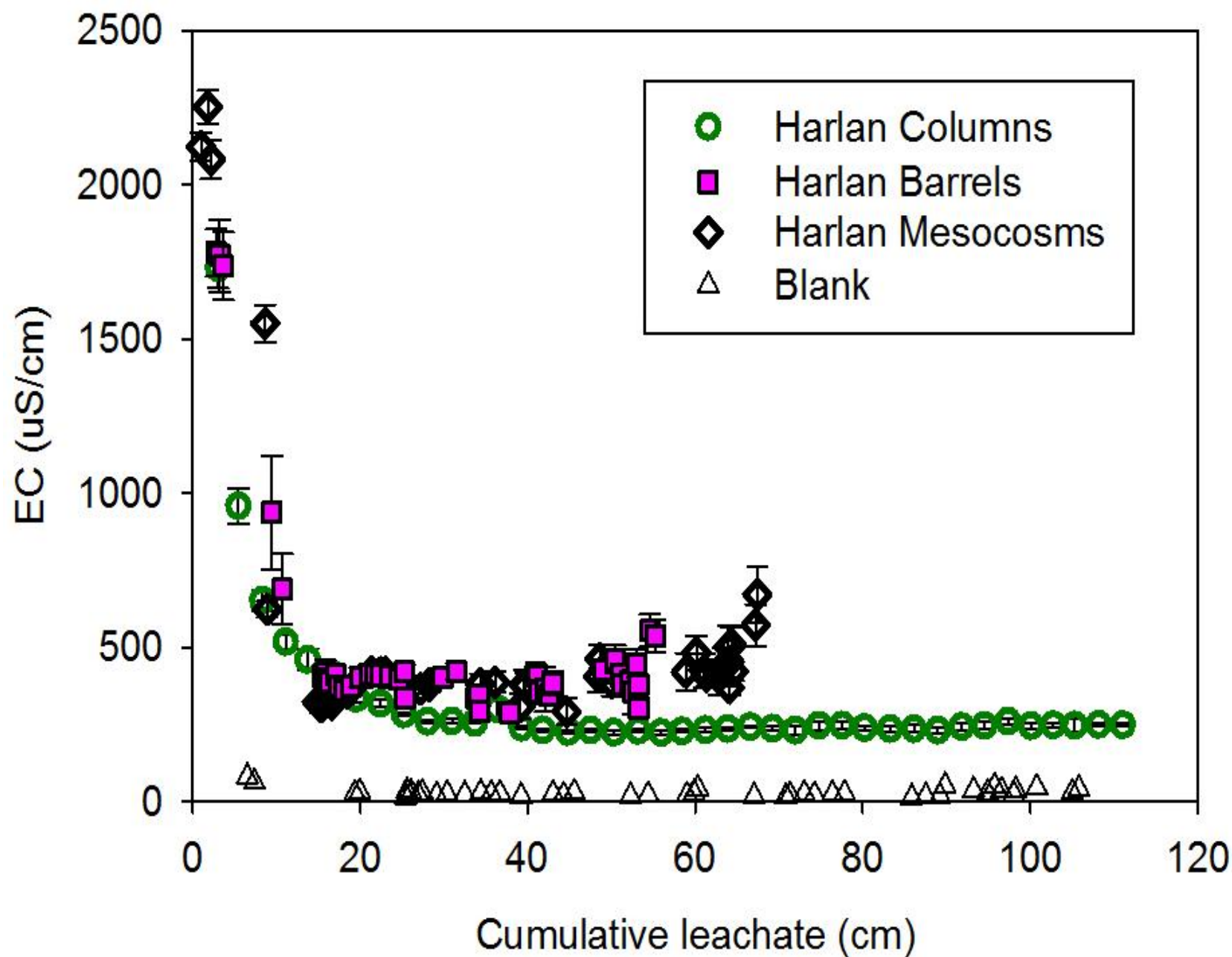


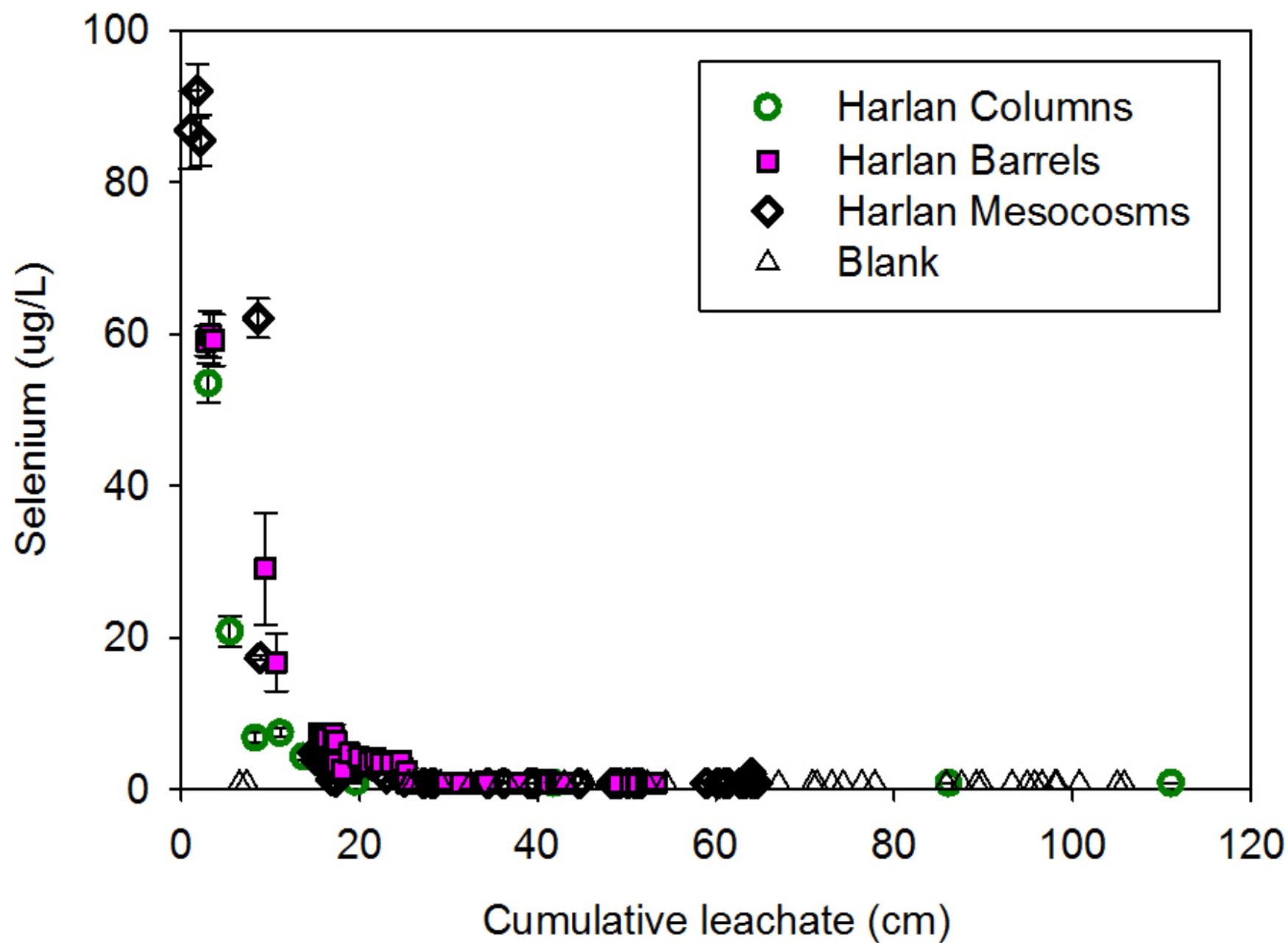


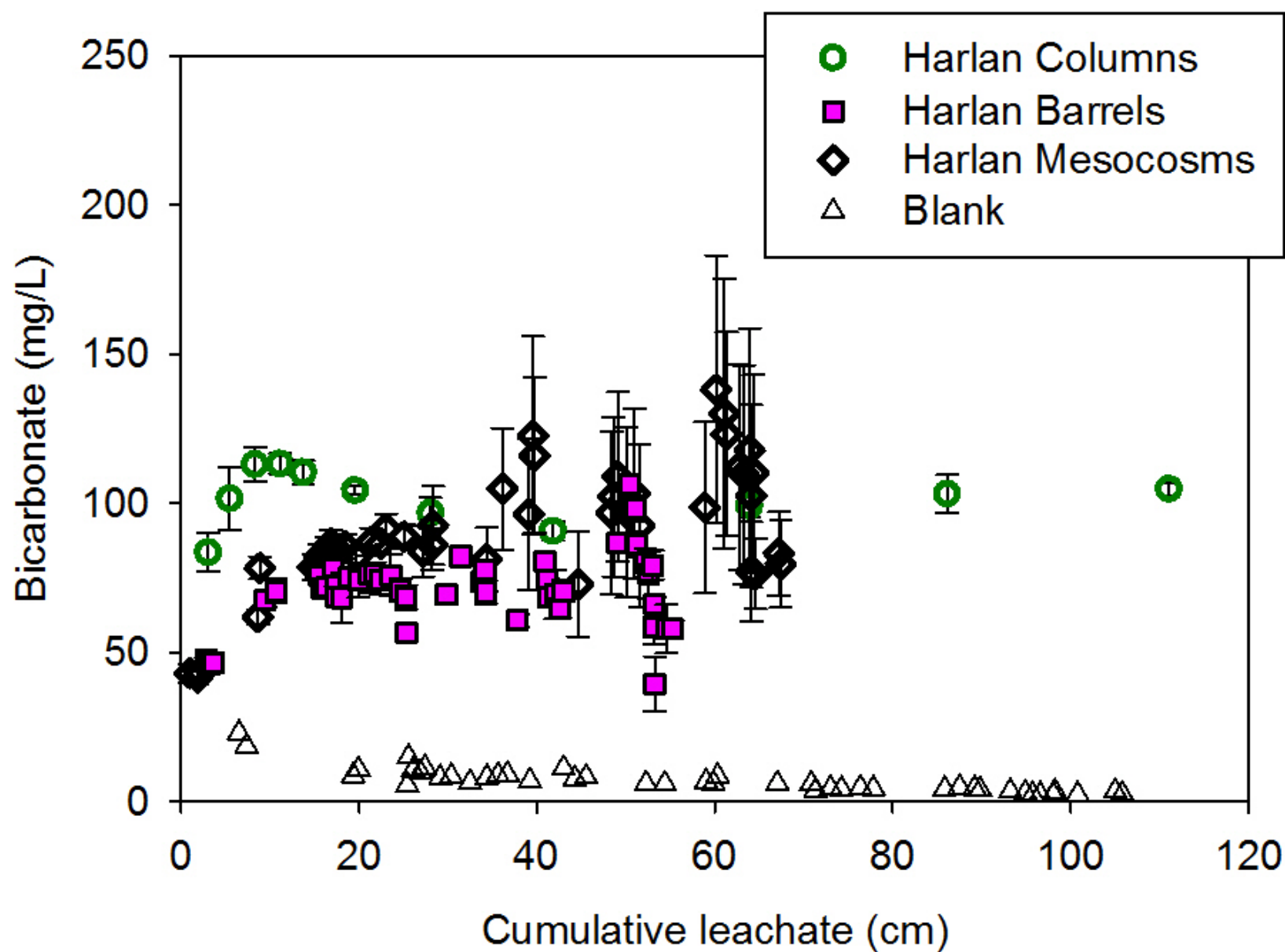
**One set of leaching barrels in foreground, mesocosm tanks in background.**













# Field/Bulk Scaling Factor Development

An aerial photograph of a large-scale construction or land reclamation site. The image shows several rectangular plots of land, some covered in dark, textured material (possibly organic matter or specific soil types) and others in lighter, more uniform material (possibly sand or gravel). A wide, light-colored dirt road or access path runs diagonally across the center of the image. In the upper right, there is a parking area with several vehicles and some construction equipment. The overall scene suggests a controlled environment for studying infiltration and leachate response.

**Bent Mt. KY Infiltration Plots monitored by Agouridis et al. (2010); field leachate response is very similar to VT columns in both peak and long term EC.**



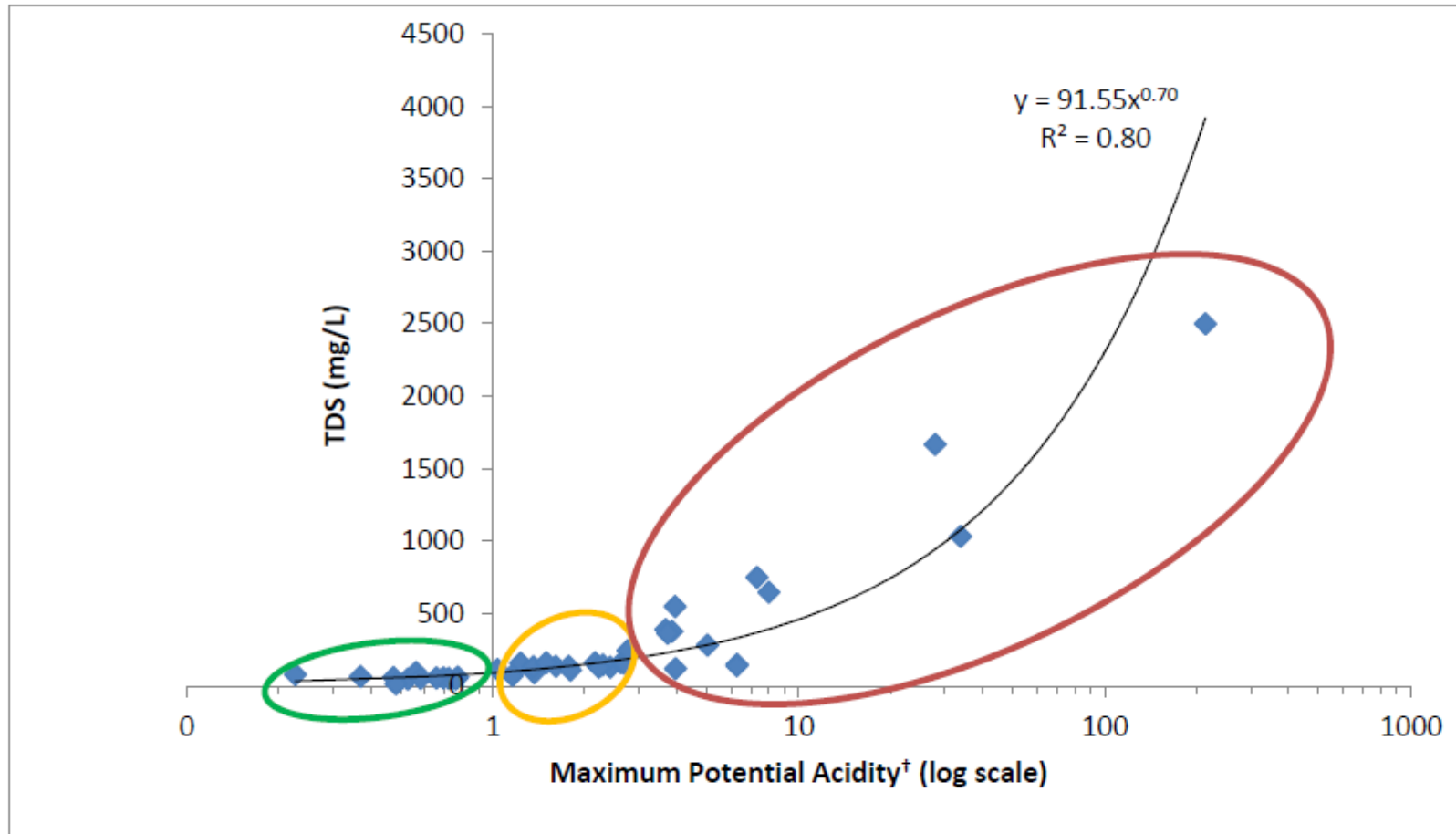
# Conclusions – Scaling

---

- In the leaching scale study for spoil, two important differences were noted: (a) initial EC levels were higher in the larger mesocosm tanks and (b) the EC in the barrels and mesocosms began to rise again slowly at the end of the study.
- We believe the column leaching procedure gives us a reasonably accurate prediction of the propensity for a non-acid forming spoil to generate TDS over time and also provides important information about both peak and long-term levels of TDS release.
- We are encouraged by the fact that observed levels of SC in the field are quite similar to the peak and average EC levels that we have observed for a wide range of spoils in our column studies.

## Static Test Predictors:

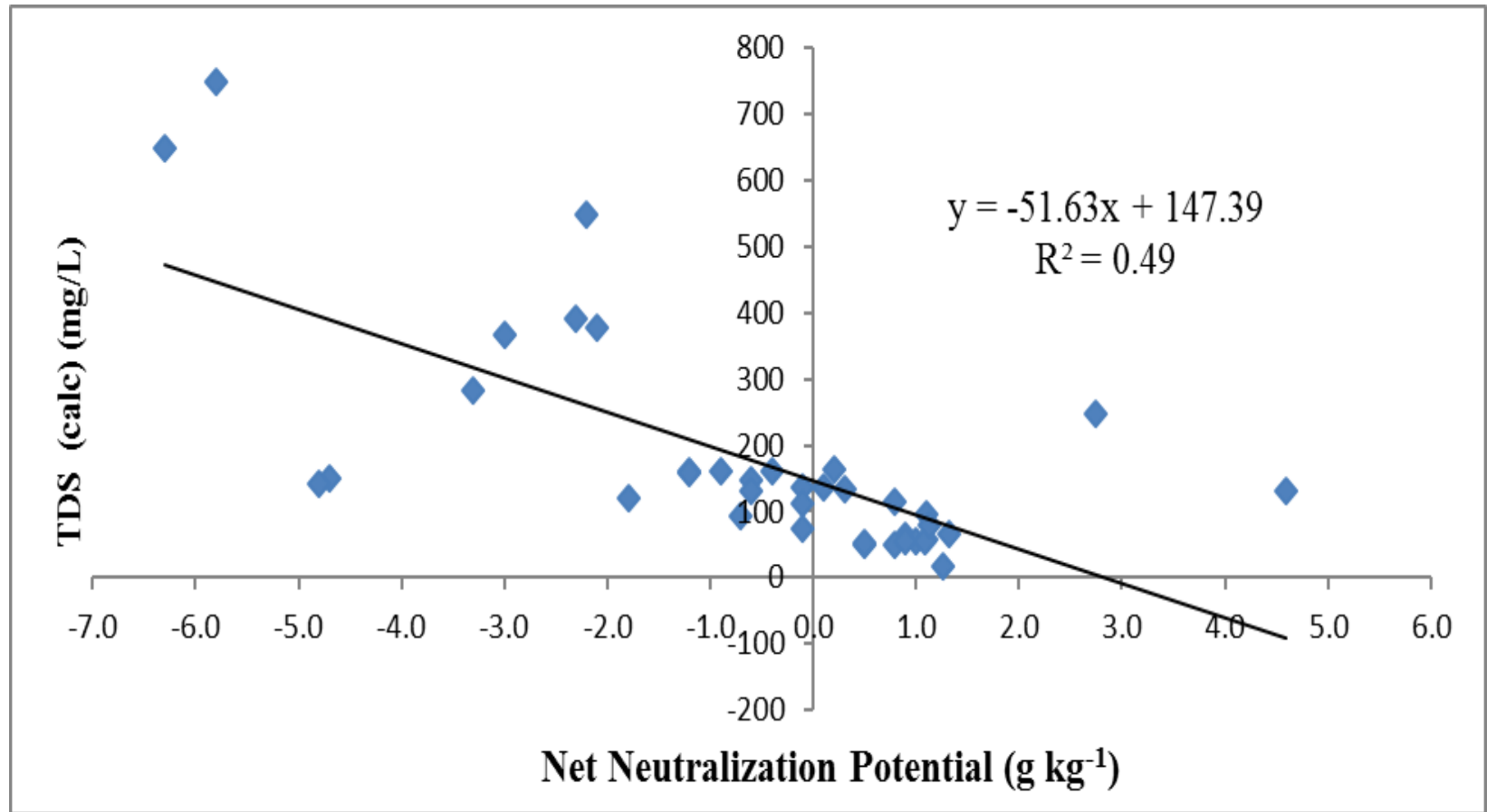
Work completed for MS by Jessica Odenheimer, WVU, 2013



TDS Release Index	TDS (calc) Concentration	MPA Range
	----- mg L <sup>-1</sup> -----	----- g kg <sup>-1</sup> -----
Low	< 300	0.0 to < 1.0
Medium	300 to 500	1.0 to < 3.0
High	> 500	3.0 +

# Static Test Predictors:

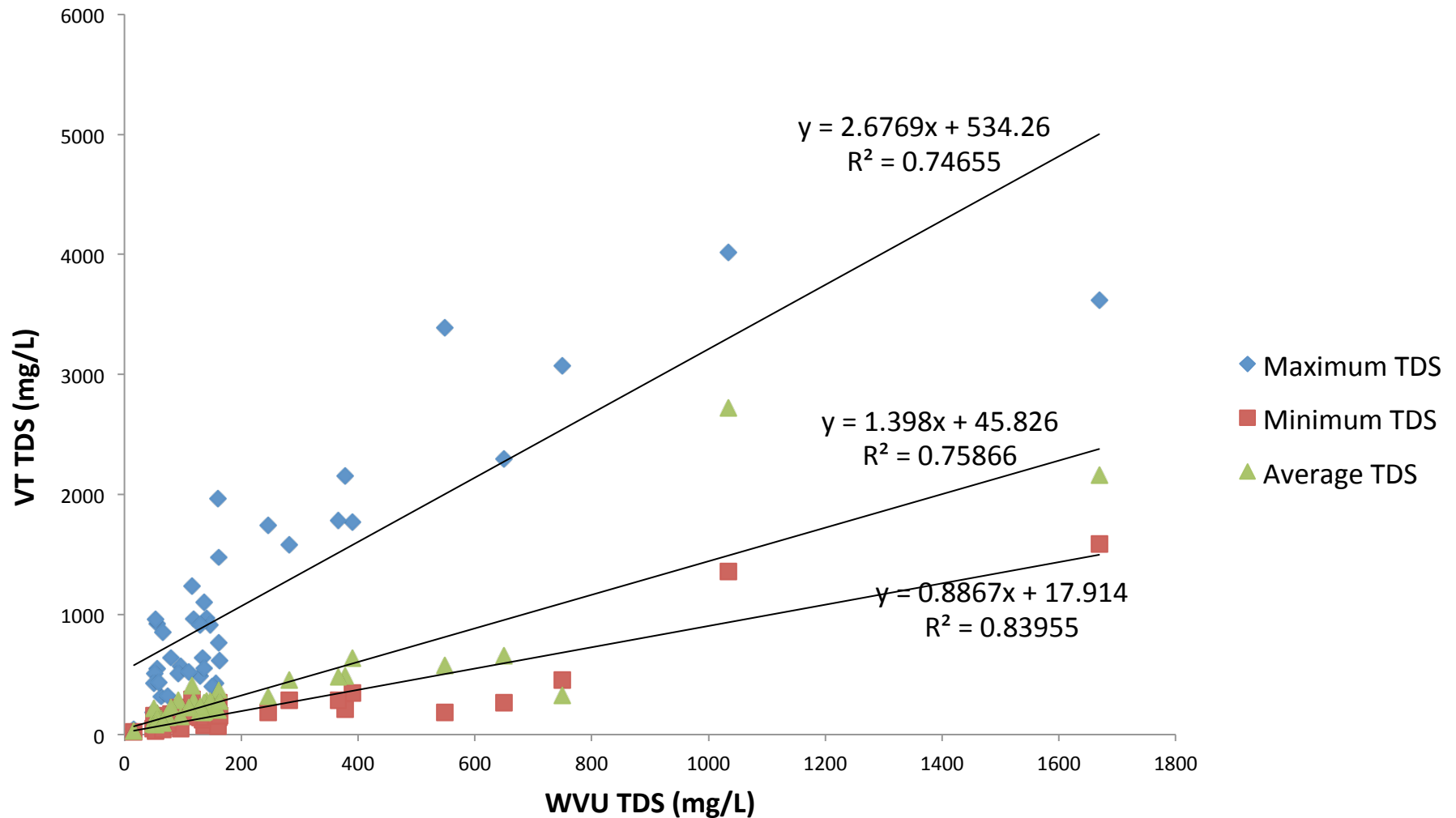
Work completed for MS by Jessica Odenheimer, WVU, 2013



TDS Release Index	TDS (calc) Concentration	NNP Range
	----- mg L <sup>-1</sup> -----	---- g kg <sup>-1</sup> ----
Low	< 500	≥ -2.0
High	≥ 500	< -2.0

# Static Test Predictors:

Work completed for MS by Jessica Odenheimer, WVU, 2013



# Acknowledgments

---

- **Direct financial support by OSM Applied Research Program-Pittsburgh, Powell River Project, and ARIES (see next slide).**
- **Whitney Nash and OSM Staff from Knoxville.**
- **Cooperative work with Jessica Odenheimer at WVU and Carmen Agouridis, Chris Barton, and Richard Warner at UK.**
- **There are simply way too many individuals and mining industry cooperators to list here. We deeply appreciate them all!**

# ARIES Statement

---

**A portion of the work reported today was sponsored by the Appalachian Research Initiative for Environmental Science (ARIES). ARIES is an industrial affiliates program at Virginia Tech, supported by members that include companies in the energy sector. The research under ARIES is conducted by independent researchers in accordance with the policies on scientific integrity of their institutions. The views, opinions and recommendations expressed herein are solely those of the authors and do not imply any endorsement by ARIES employees, other ARIES-affiliated researchers or industrial members. Information about ARIES can be found at <http://www.energy.vt.edu/ARIES>**