# TDS Release Prediction Based on Acid-base Account Parameters

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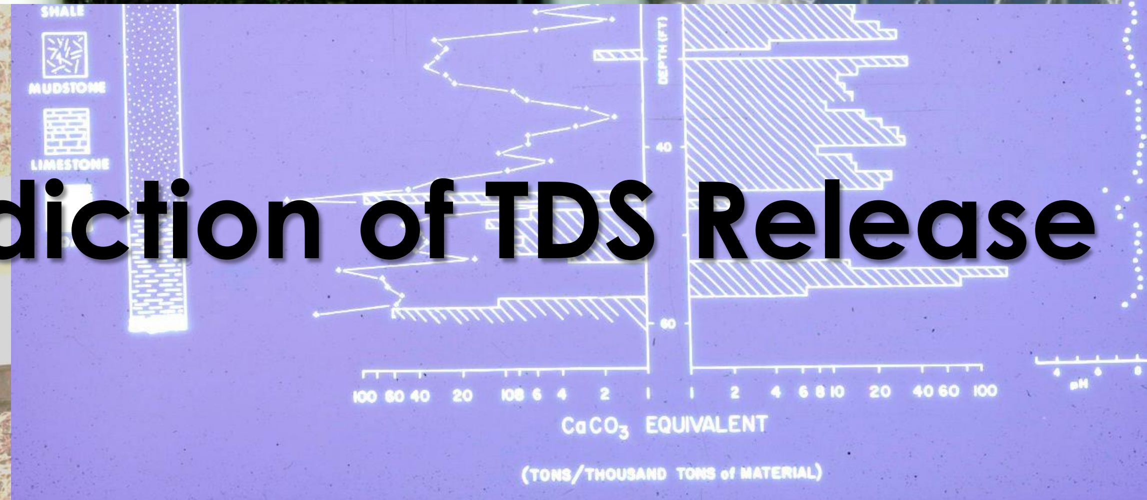
- **ARIES**
  - Study the impacts of the coal mining industry
  - Focusing on water, land, and air issues
    - Virginia Tech, West Virginia University, Marshall University, University of Pittsburgh, Penn State, Ohio State, Via College of Osteopathic Medicine, Georgetown University, and John Hopkins University


- **Currently divided into four areas:**

  1. Stream protection and restoration
  2. Materials characterization and handling
  3. Water Impacts of coal mining
  4. Community and health impacts

Appalachian Research Initiative for Environmental Science (ARIES)

- **Task 3 – Prediction of TDS Release**

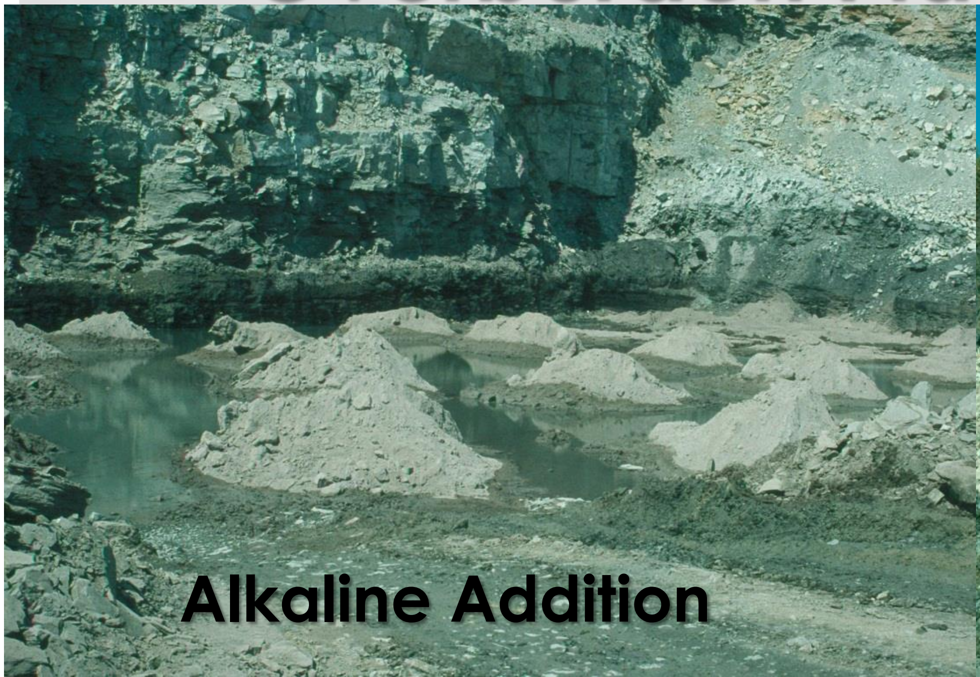




# Recommended EPA guideline for TDS release:

- 300 mg/L monthly average
- 500 mg/L maximum

# Goal: Quick Test


# Overburden Placement Plans




# The Acid-Base Account

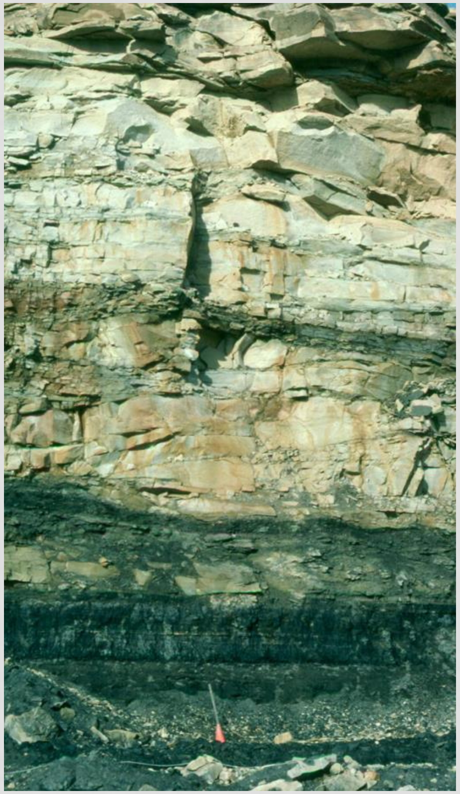
- **ABA was the first technology to assess the chemical quality of overburdens prior to disturbance**
- **ABA was applied to predict post-mining drainage quality**
  - **(Knabe, Smith, Sobek, Grube, Erikson, Hedin, Perry, Freeman, Sturm, and many others)**

# The Acid-Base Account

**ACID <----------> BASE**

**MPA <------------->NP**

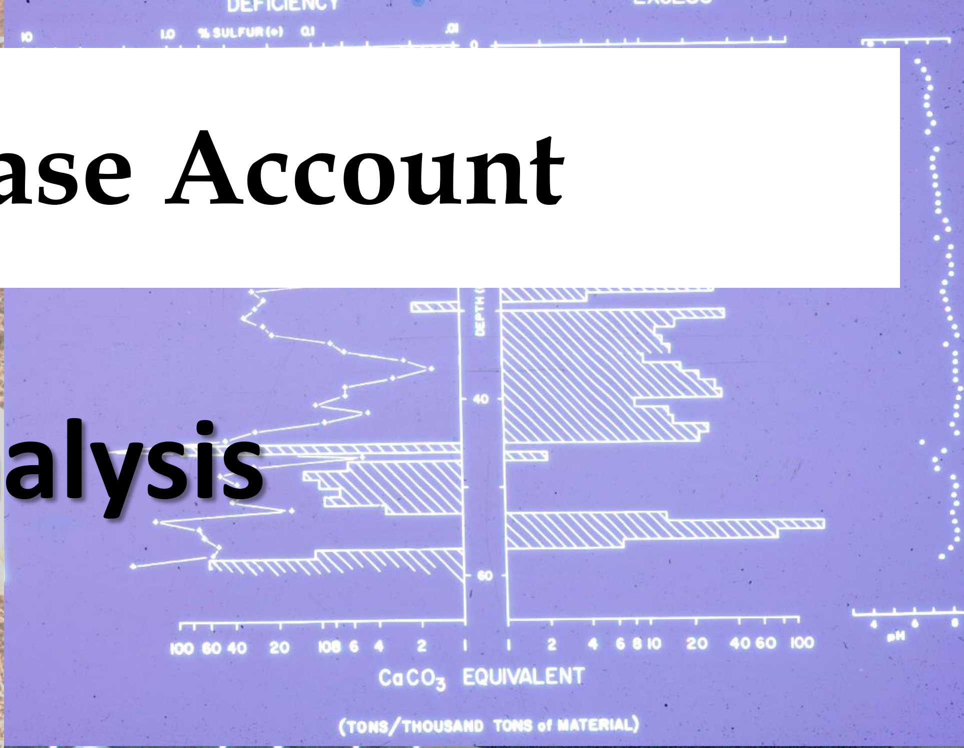
**% S**



- **Carbonates**
- **Exchangeable bases**
- **Weatherable silicates**

# The Acid-Base Account

- **Overburden Analysis**
- **Leaching Tests**




# The Acid-Base Account

Excess Acidity | Excess Alkalinity

| | | | | | | $CaCO_3$ equivalent - tons/1000 tons of material | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Number | Bottom depth (feet) | Rock type | Fizz | Color | %S | Max. from %S | Amount present (NP) | Max. needed (pH7) | Excess | Paste pH |
| 1 | 3 | Soil | 0 | 7/3 | .035 | 1.09 | 3.52 | | 2.53 | 4.4 |
| 2 | 6 | SS | 0 | 8/6 | .029 | 0.91 | -1.51 | 2.42 | | 4.3 |
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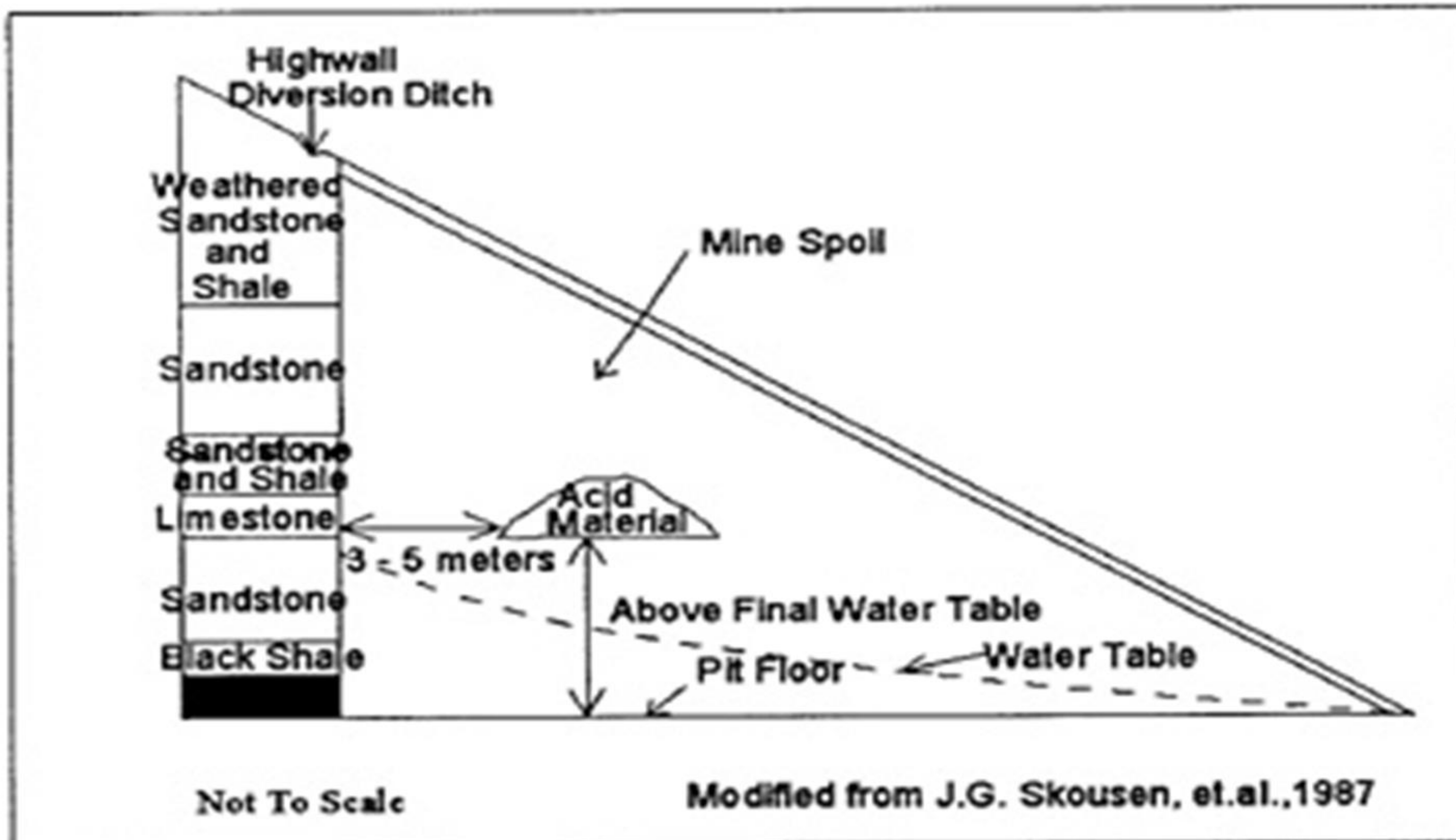



Figure 1 Dry Disposal of Acid Material

# Purpose

It would be ideal to have a technique similar to ABA to determine a Total Dissolved Release Index:

**High**, **Moderate**, or **Low**

so that operators can properly treat, isolate, and/or handle their overburden in a manner that will decrease TDS runoff from their site.

# Introduction

# Total Dissolved Solids (TDS)

- All inorganic and organic substances contained in water that can pass through a 2 micron filter.

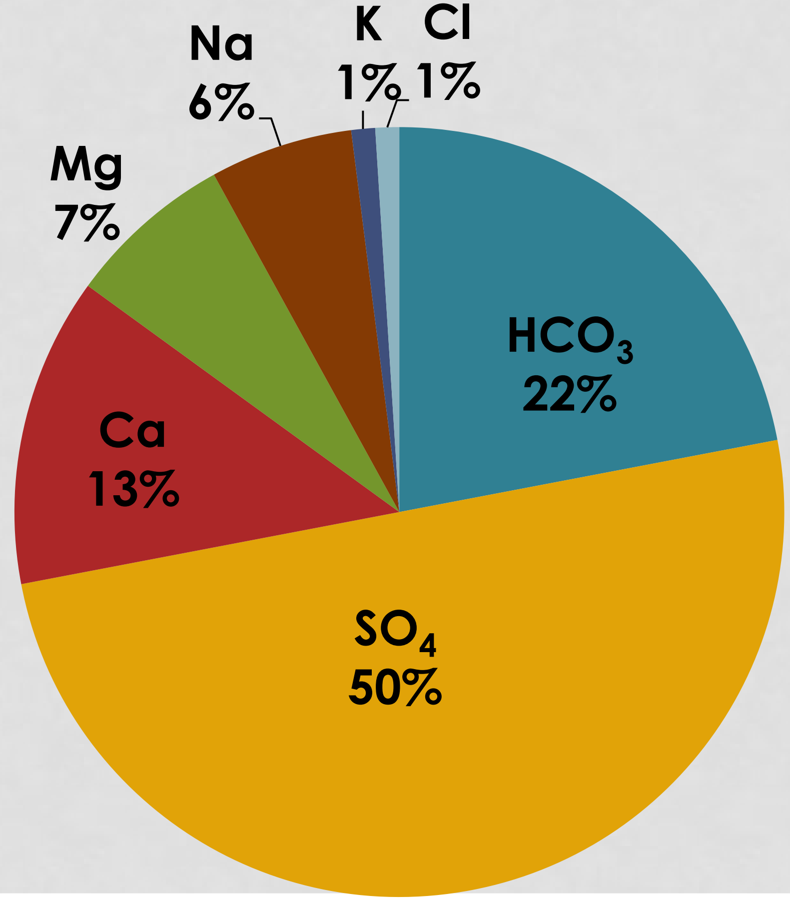
- Electrical Conductivity

- Gravimetrically:
  - Filter water sample
  - Evaporate at 180°C in a pre-weighed dish
  - The increase in weight (the dried residue) represents TDS measured in (mg $L^{-1}$)

# TDS Composition

## Down-Stream Coal Mine

**Mean TDS: 516 mg $L^{-1}$**



# Total Dissolved Solids (TDS)

## *Drinking water standards*

| Contaminant | Secondary MCL | Noticeable Effects above the Secondary MCL |
|---|---|---|
| Total Dissolved Solids (TDS) | 500 mg/L | hardness; deposits; colored water; staining; salty taste |

- USEPA guideline to assist public water systems in managing their drinking water for taste, color and odor, but not typically enforced.

# Total Dissolved Solids (TDS)

## *Aquatic Health*

- **EPT survival decreases as TDS increases**

# Objective

- **To develop a TDS release index from overburden material that could be used to predict and screen overburden materials that contribute to high TDS concentrations (> 500 mg/L)**
    - **Simulated weathering with dilute nitric acid ($HNO_3$)**
    - **Compared to ABA analysis**

# Materials & Methods

- **41 samples from WV, VA, and KY**
- **Emphasis on collecting a wide variety of rock types:**
  - **Black Shales, Mudstones, Brown Sandstone, Gray Sandstone**

# Overburden ABA Classification Scheme Based on Acid/Base

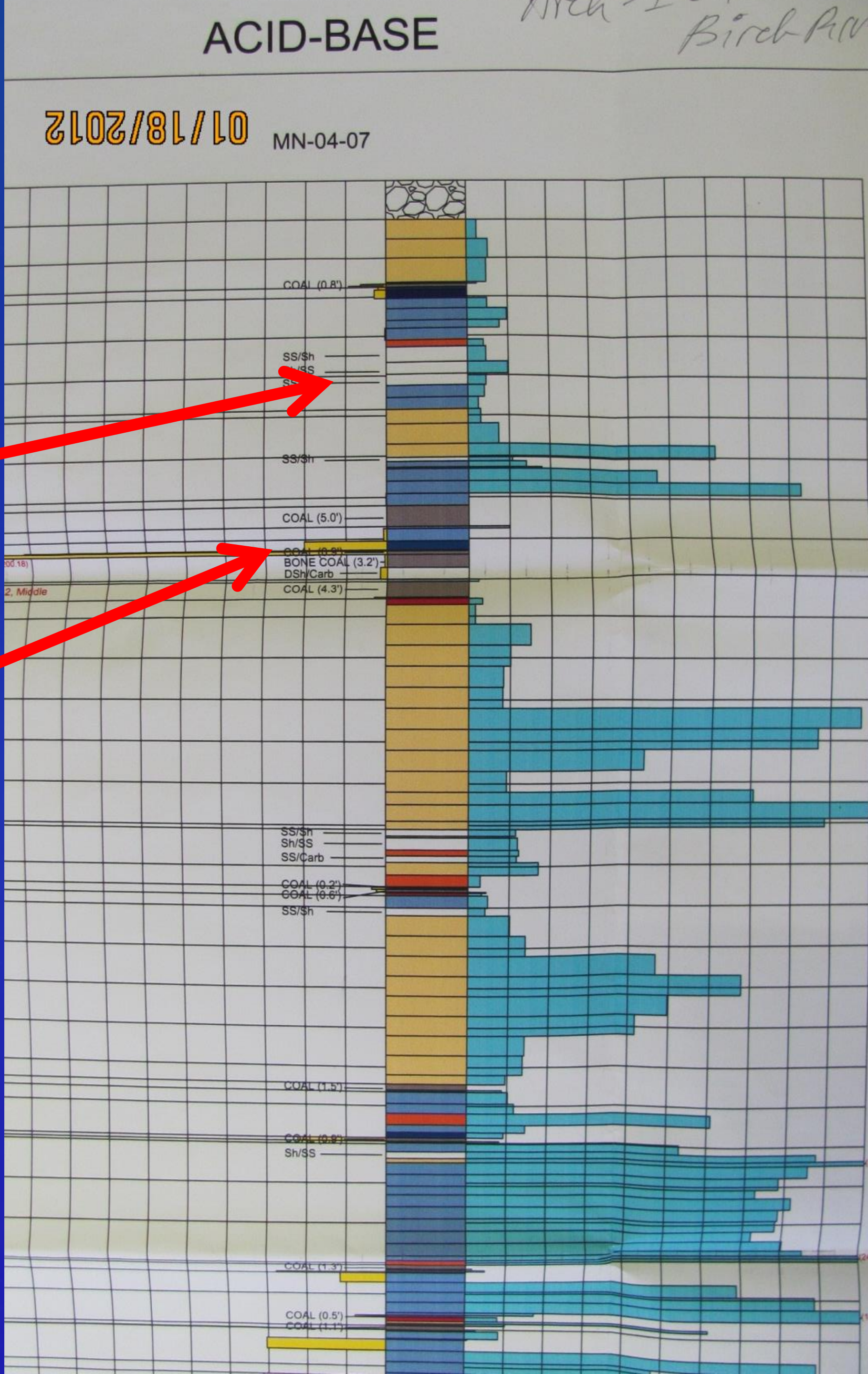
Low TDS (neutral)

Medium TDS

High TDS

High Alkalinity

High Acidity



# Materials & Methods

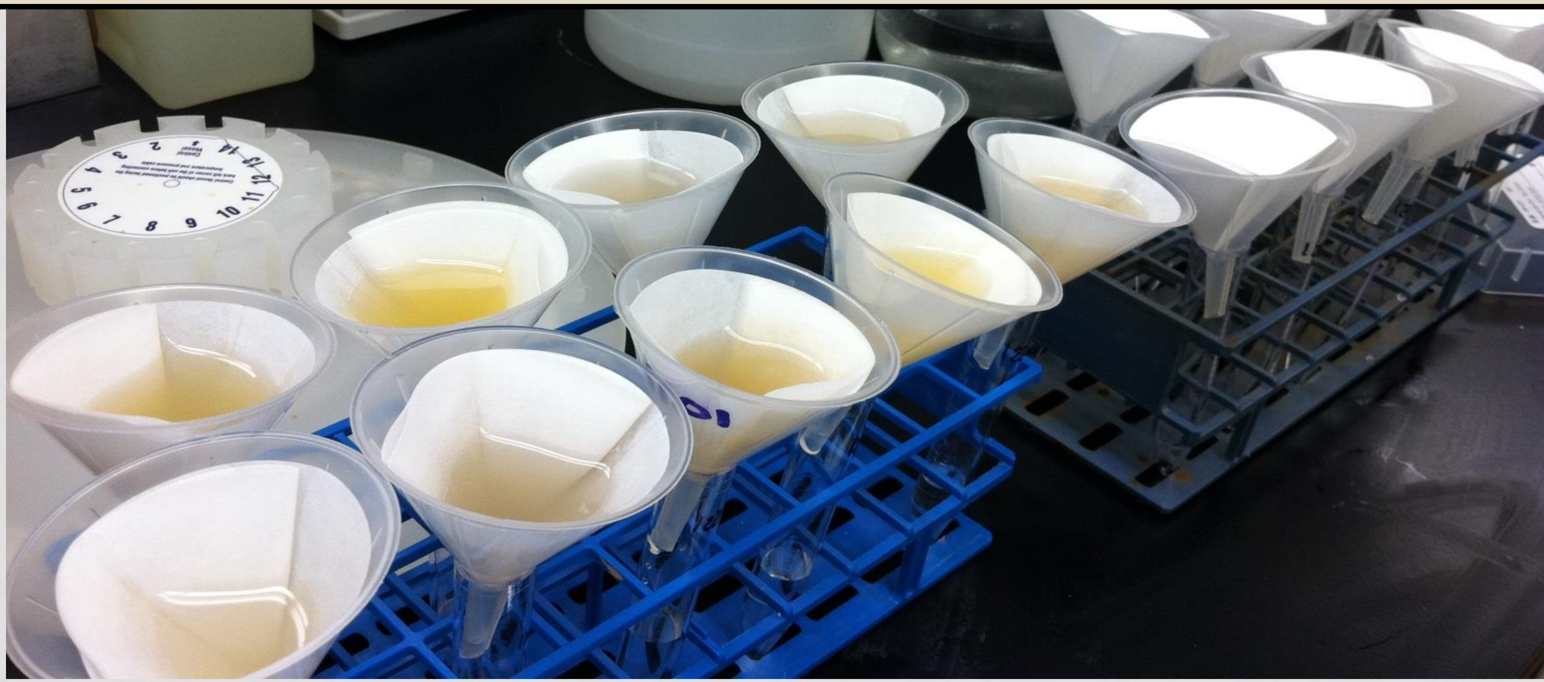
# Simulated Weathering via Shaking

1g overburden + 200mL dilute $HNO_3$

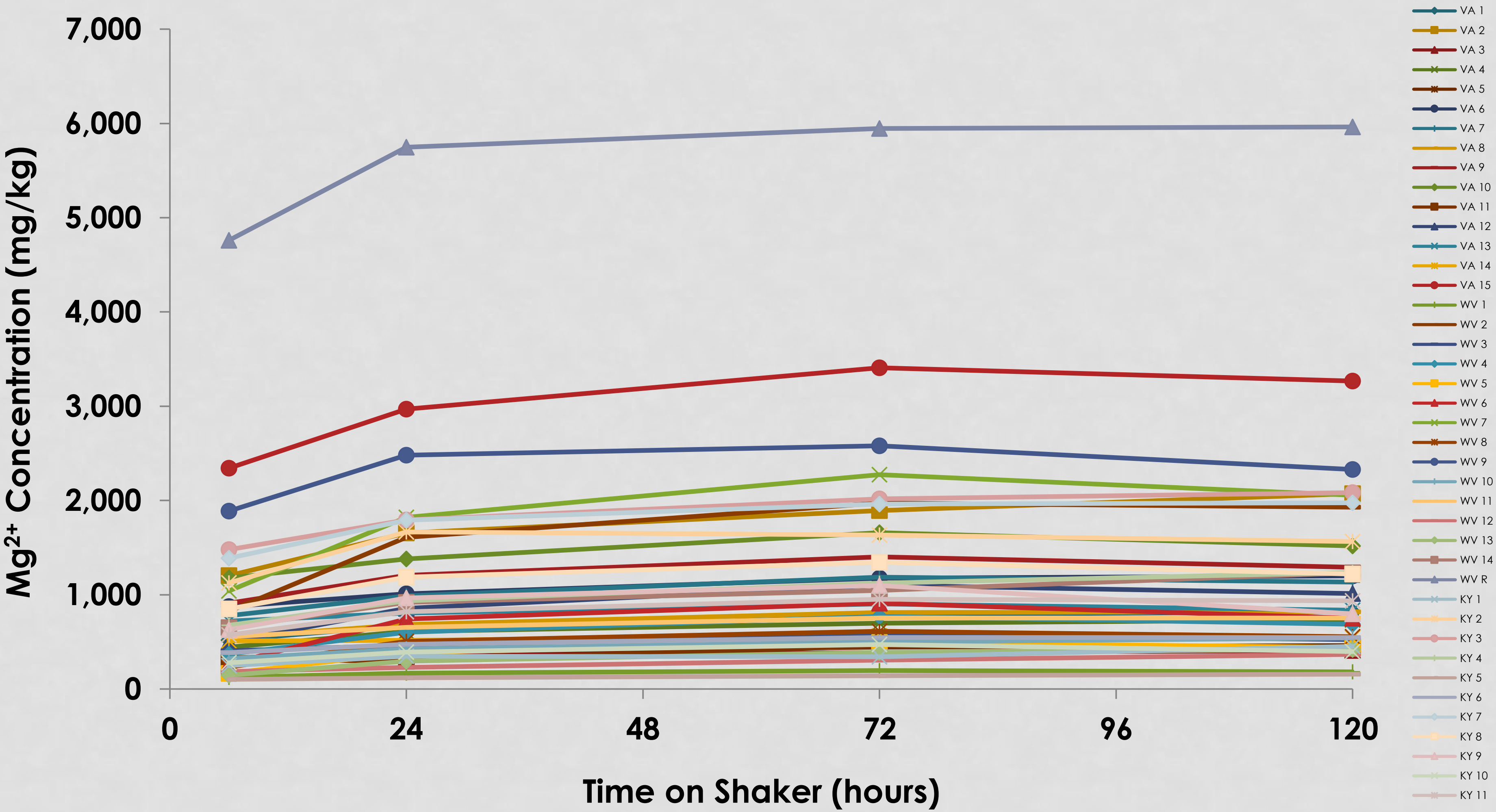
# Simulated Weathering via Shaking

**6, 24, 72, 120, 168 hours, until concentrations of ions released stabilized.**

**Al, Fe, Mg, Mn, Ca, P, K, Na, $SO^4$, pH, EC**

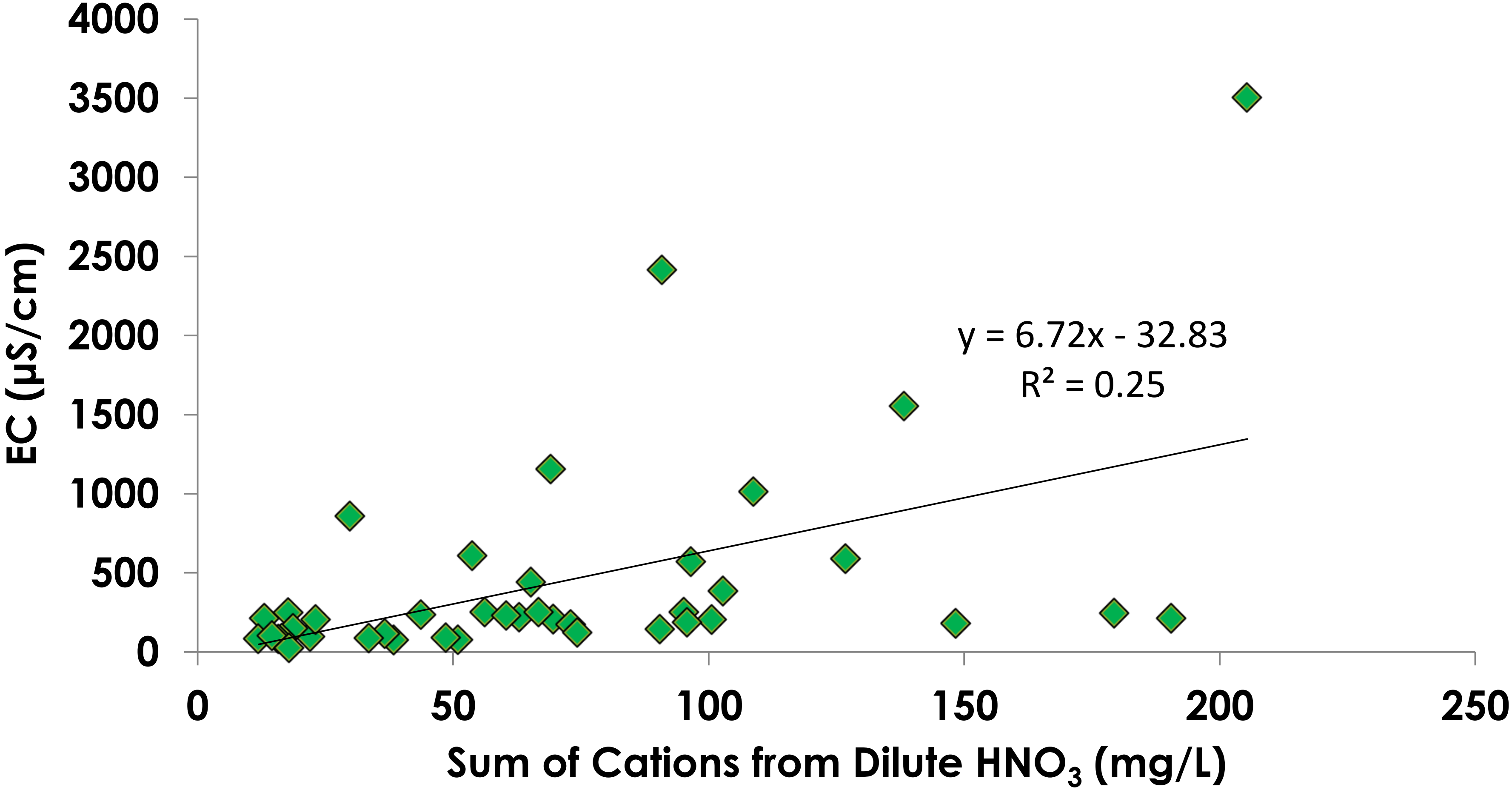


# Magnesium Released From all 41 Samples Shaken In Dilute $HNO_3$



# Can we use the concentration of ions released from these overburden samples to predict TDS release?

# EC versus Sum Of Cations Released From Dilute $HNO_3$



# Calculated TDS

- TDS was calculated from paste EC using equations (1) and (2) (Evangelou, 1998):

1. **EC < 1 dS $m^{-1}$**

   **TDS = 640 * EC (dS $m^{-1}$)**

2. **EC > 1dS $m^{-1}$,**

   **TDS = 640 * [EC (dS $m^{-1}$)] $^{1.087}$**

**(64 = average equivalent weight of salts in natural waters)**

# The Acid-Base Account

| | | | | | | $CaCO_3$ equivalent - tons/1000 tons of material | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Number | Bottom depth (feet) | Rock type | Fizz | Color | %S | Max. from %S | Amount present (NP) | Max. needed (pH7) | Excess | Paste pH |
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# Maximum Potential Acidity

- MPA represents the acid potential of an overburden sample due to sulfide materials.

- MPA is calculated by multiplying % S by 31.25

# Maximum Potential Acidity (MPA)

* 31.25

| | | | | | | CaCO$_3$ equivalent - tons/1000 tons of material | | | | |
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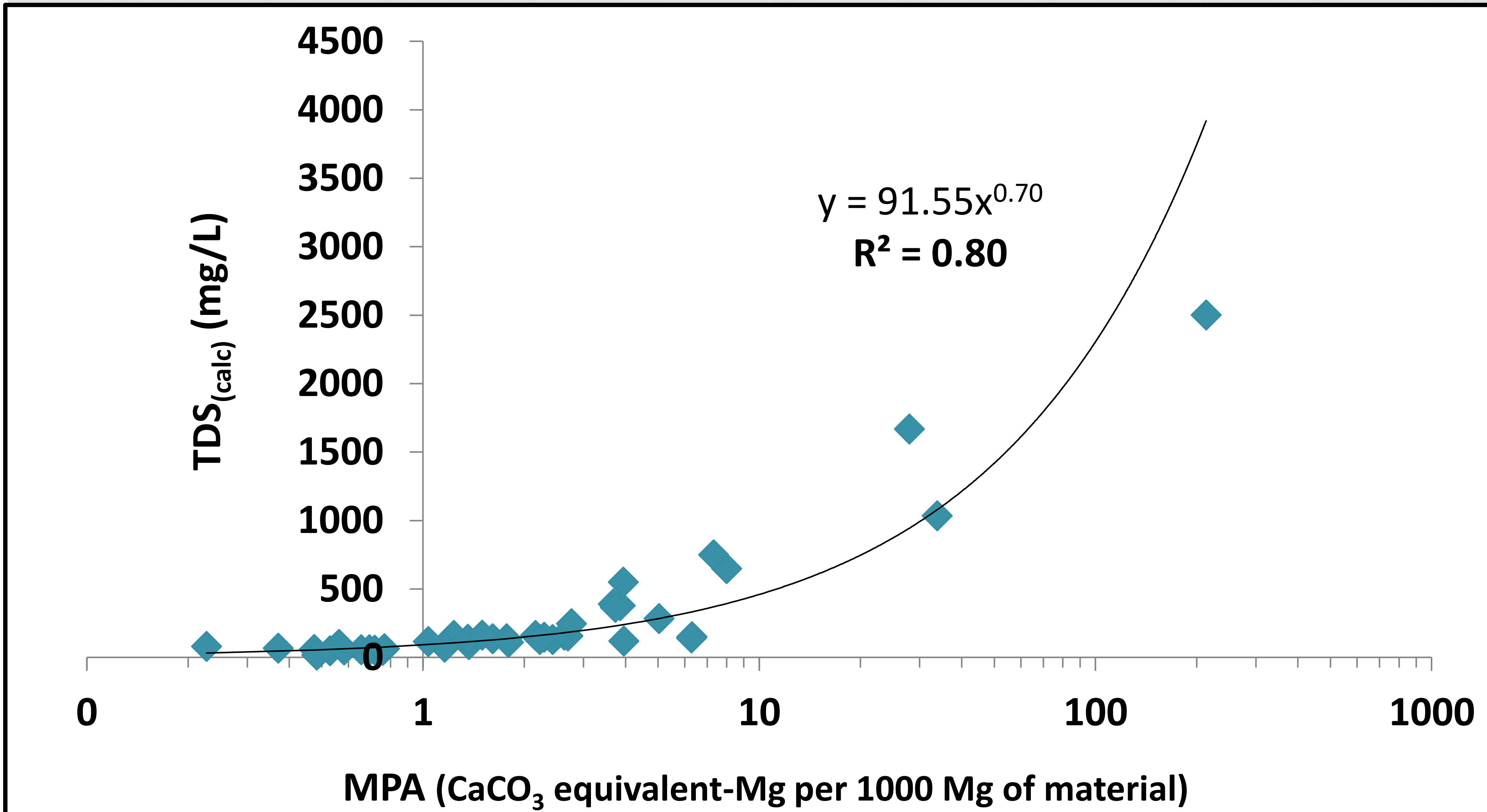
Material containing 1% S (assuming all as pyrite) would yield an amount of sulfuric acid which would require 31.25 Mg of calcium carbonate to neutralize 1000 Mg of the material

# Calculated TDS versus Maximum Potential Acidity



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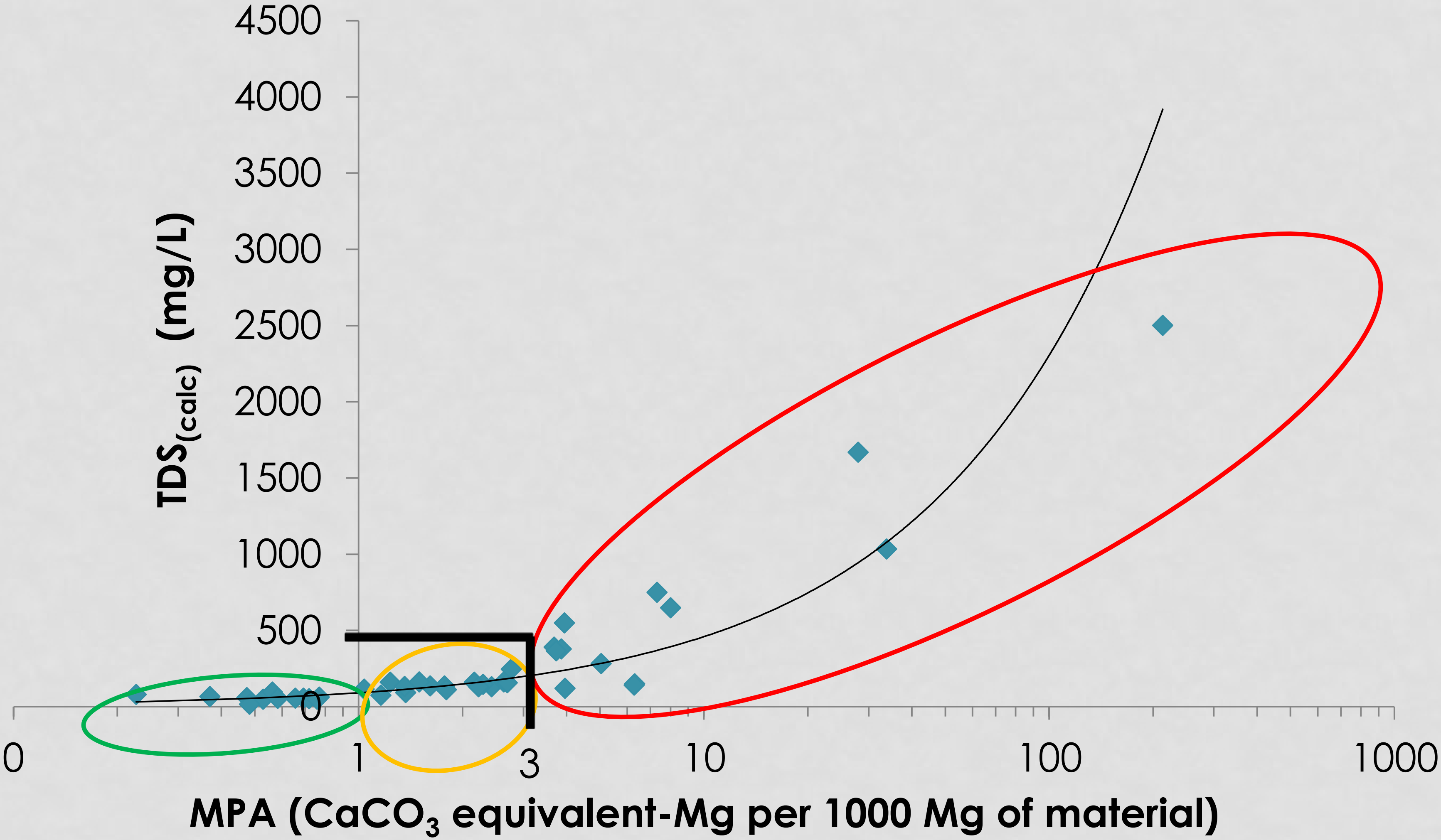
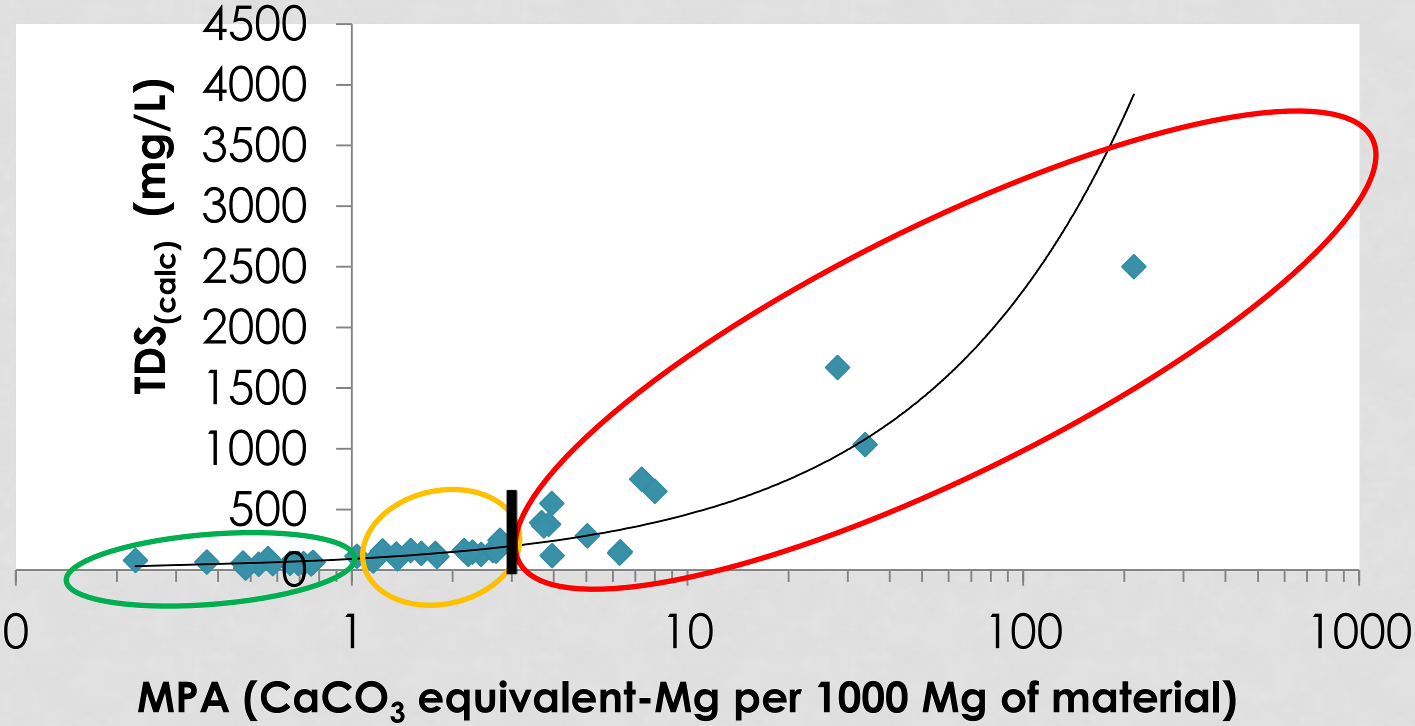


| MPA Range | TDS Concentration | TDS Release Index |
|---|---|---|
| ----- g kg -1 ---- | ---- mg L-1 ---- | |
| 0.0 to <1.0 | < 150 | Low |
| 1.0 to <3.0 | < 300 | Medium |
| 3.0 + | > 500 | High |



# MPA Summary

- Maximum Potential Acidity may be a practical parameter for predicting TDS release

| MPA Range | TDS Concentration | TDS Release Index |
| --- | --- | --- |
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# MPA Summary

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# Net Neutralization Potential

**Neutralization Potential (NP)**

**− Maximum Potential Acidity (MPA)**

---

**Net Neutralization Potential (NNP)**

+ Potentially acid-neutralizing

− Potentially acid forming

# Net Neutralization Potential

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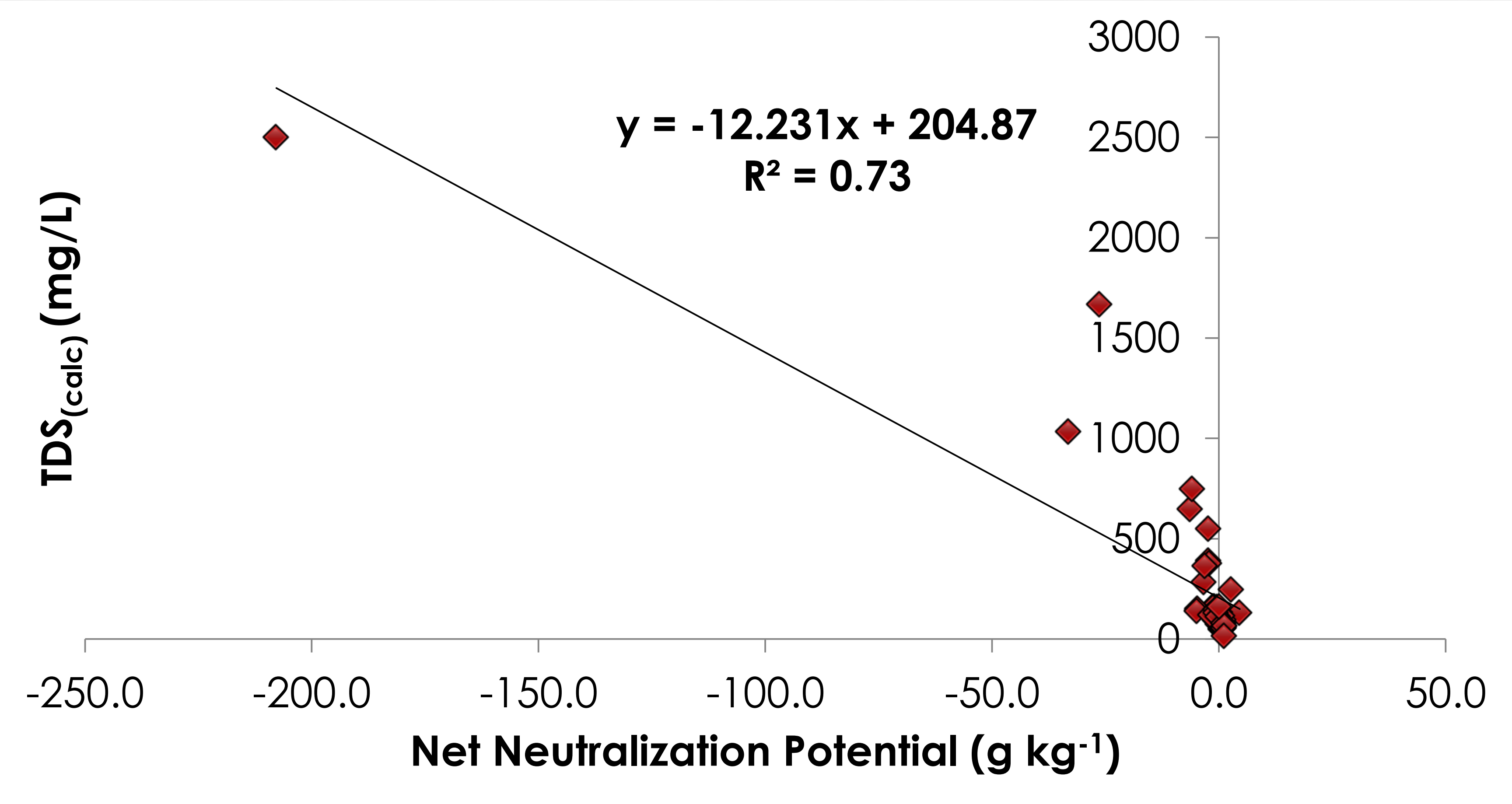
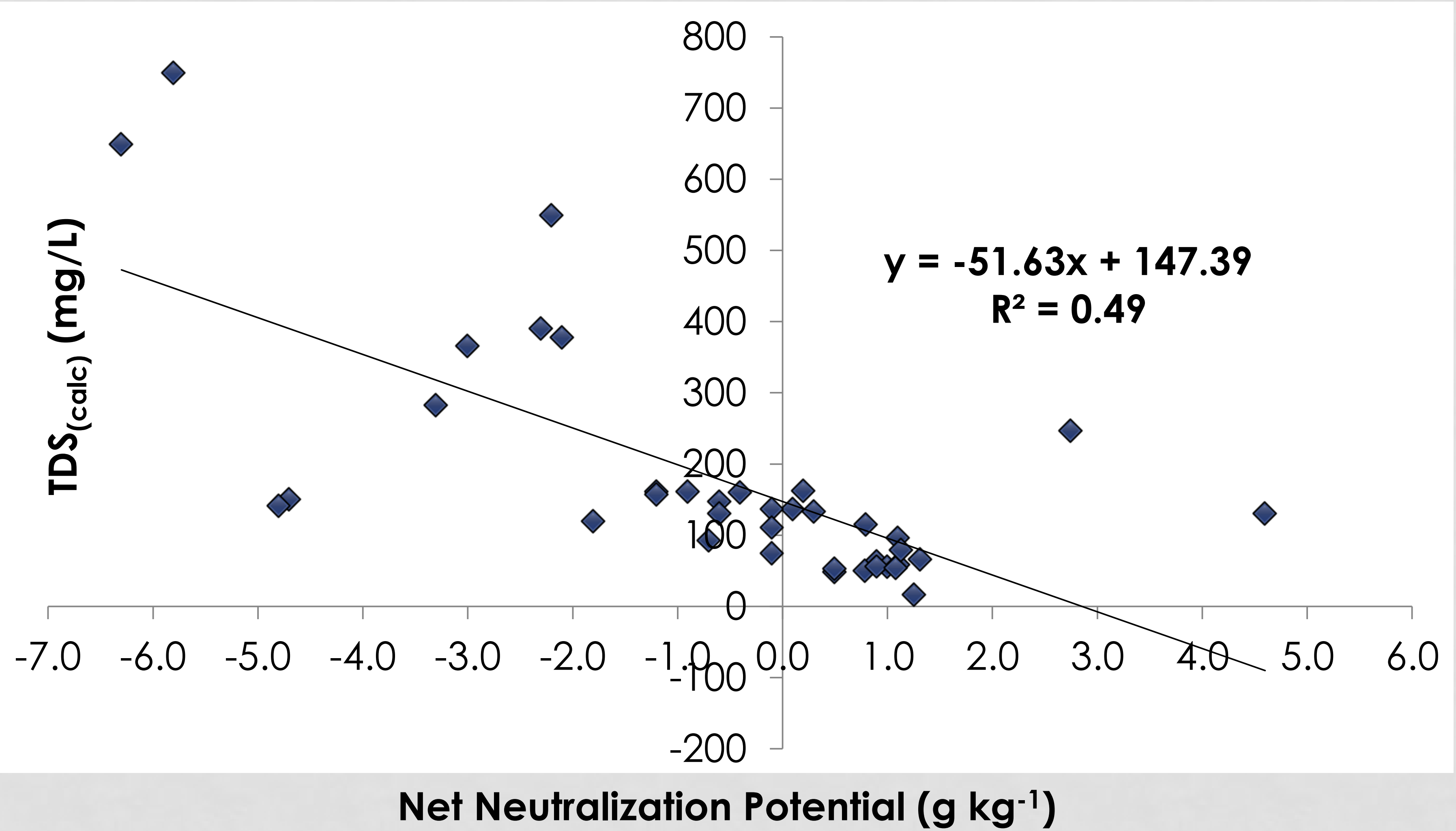
# Relationship Between Net Neutralization Potential (NNP) and $TDS_{(Calc)}$ for 41 Overburden Samples



# Relationship Between Net Neutralization Potential and TDS for 38 Overburden Samples



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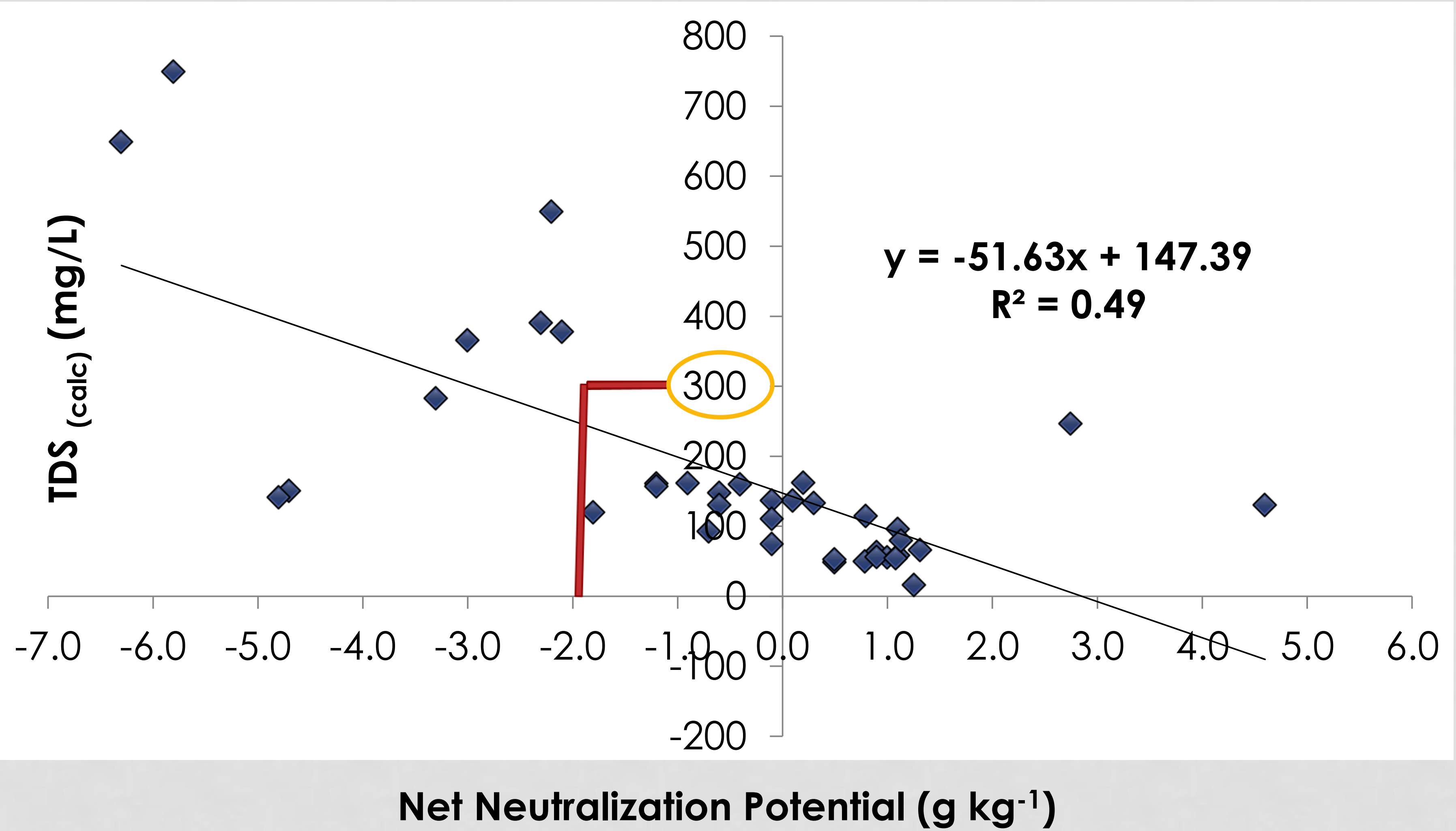
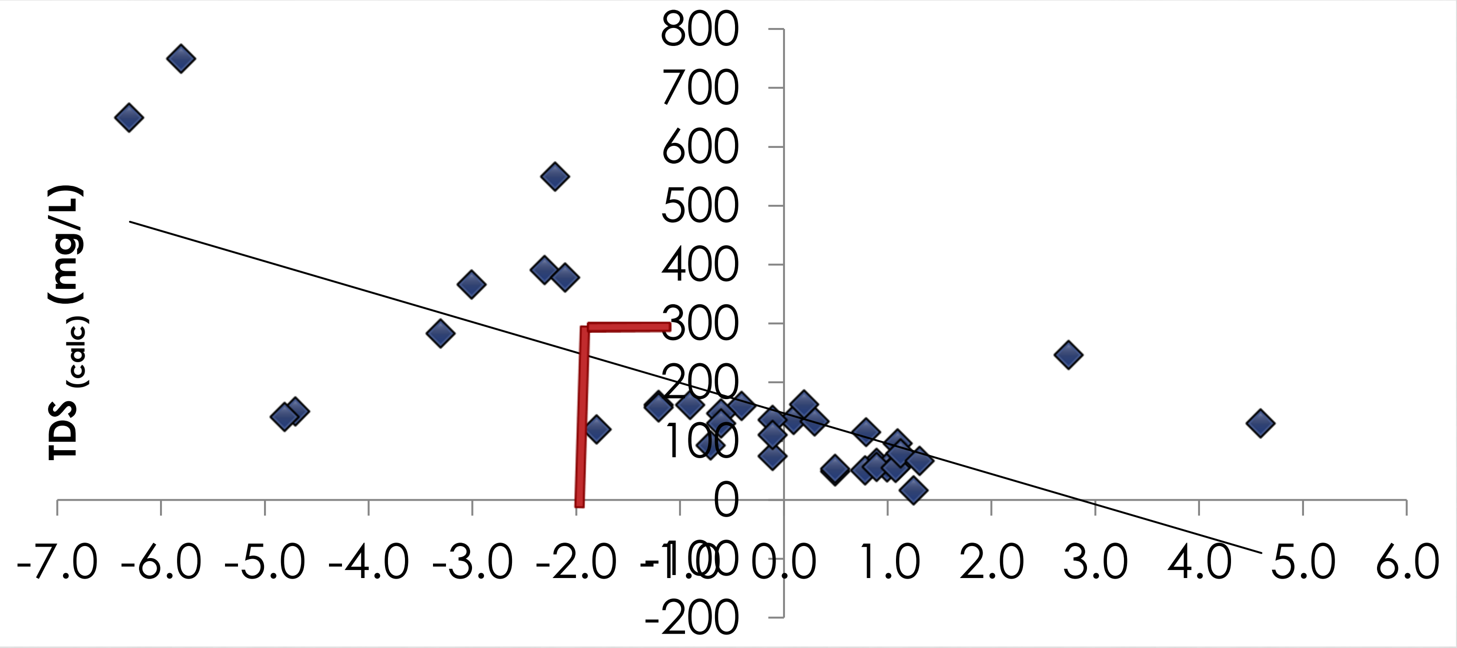


| NNP Range | TDS Concentration | TDS Release Index |
|---|---|---|
| ---- g kg $^{-1}$ ---- | ------- mg $L^{-1}$ ------ | |
| ≥ -2.0 | < 300 | Low |
| < -2.0 | ≥ 300 | High |




Net Neutralization Potential (g kg$^{-1}$)

# Net Neutralization Potential Summary

- NNP may be a practical parameter for predicting TDS release

| NNP Range | TDS Concentration | TDS Release Index |
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| ---- $g\ kg^{-1}$ ---- | ------- $mg\ L^{-1}$ ------ | |
| ≥ -2.0 | < 300 | Low |
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# Net Neutralization Potential Summary

Deficiency in $CaCO_3$

| Sample Number | Bottom depth (feet) | Rock type | Fizz | Color | %S | CaCO3 equivalent - tons/1000 tons of material: Max. from %S | Amount present (NP) | Max. needed (pH7) | Excess | Paste pH |
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# Summary

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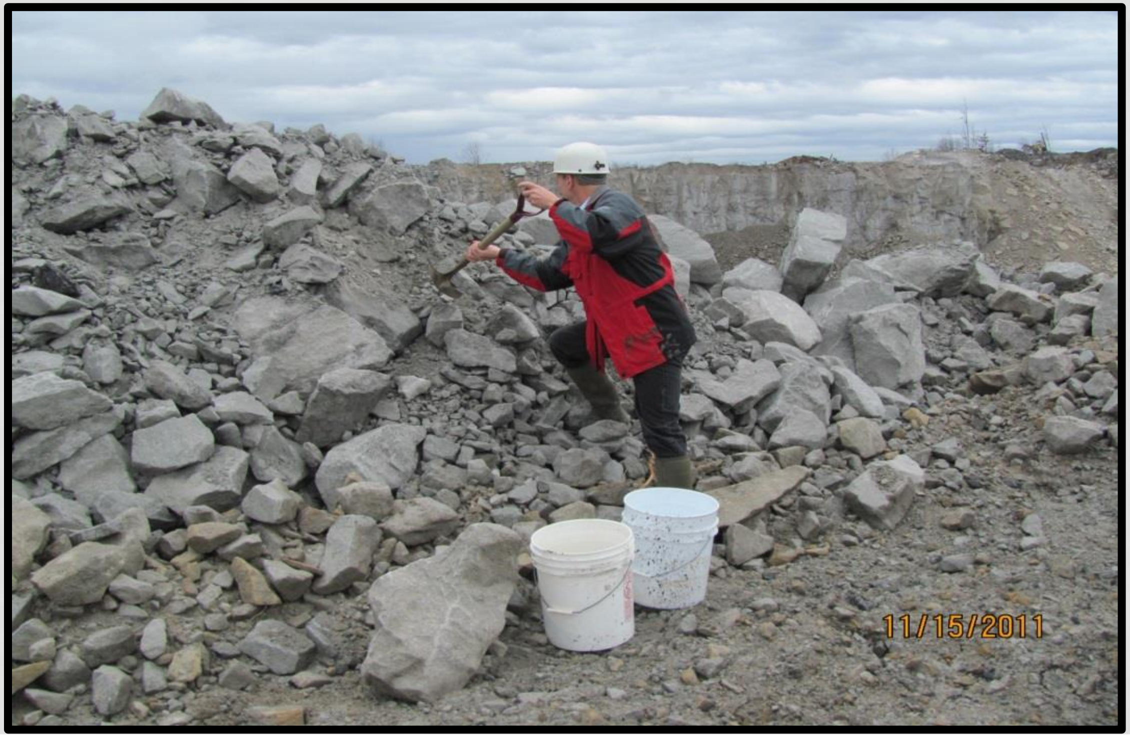
# Summary

- **Goal:** “Quick Test”
- **Findings:** MPA + NNP provide insight on whether overburden will release high TDS
- **Progress:** Compare these results to field experiments



# ARIES Statement

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# Acknowledgements

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To Louis McDonald, Dorothy Vesper, Lee Daniels, and Zenah Orndorff

To Marianne Mannix, and Joan Wright

&

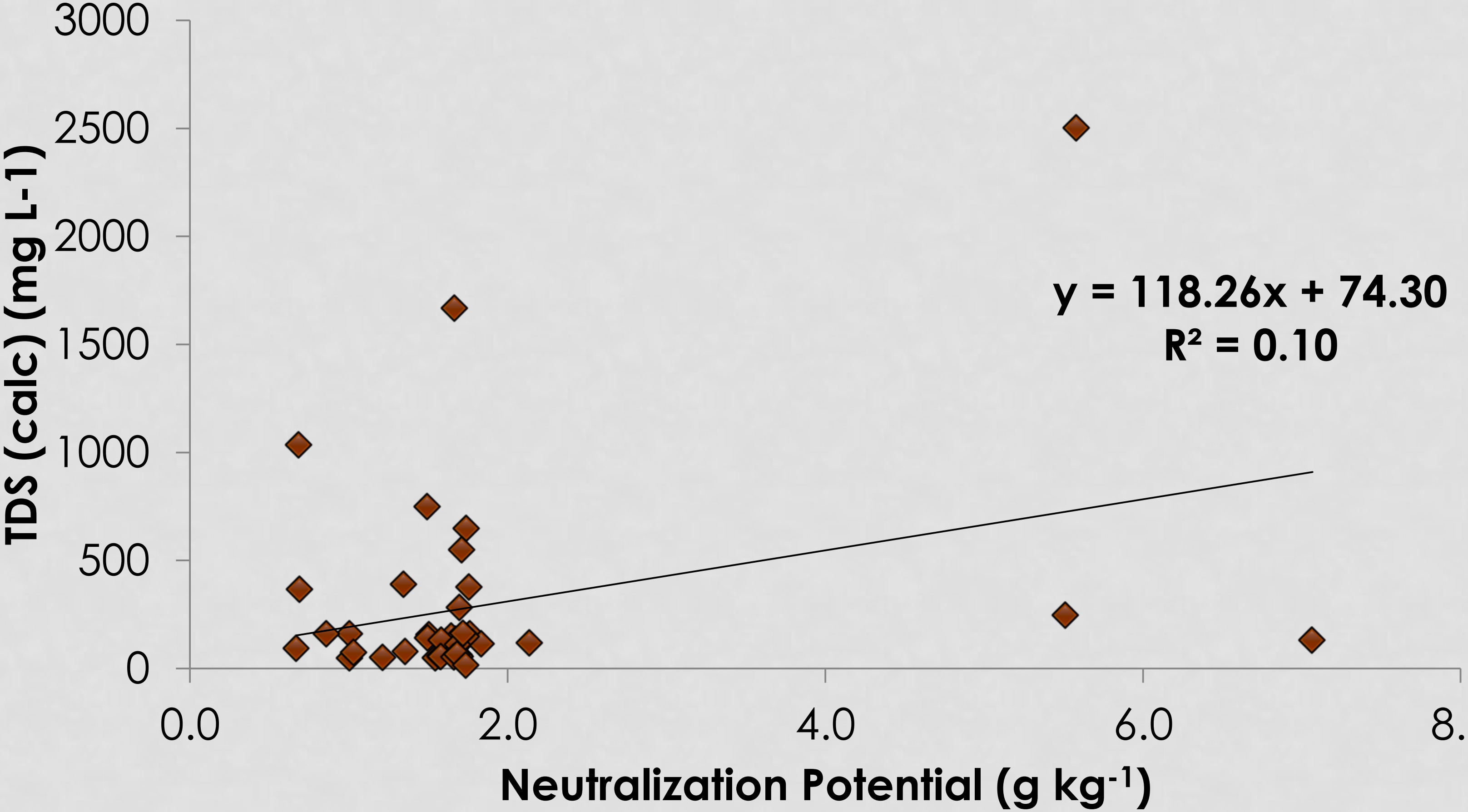
To Moody & Associates, Inc.

Moody
and Associates, Inc.

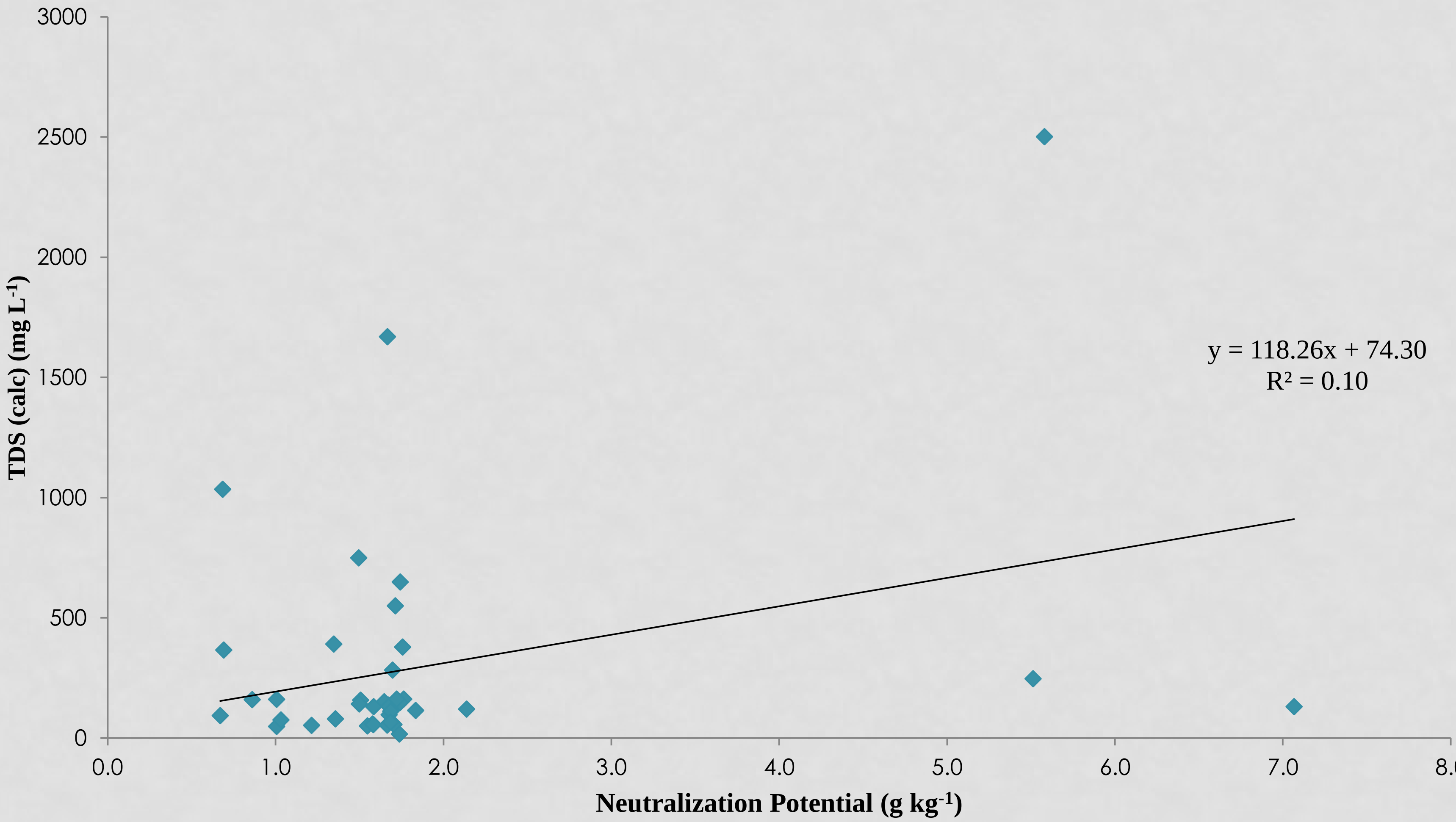
West Virginia University

# Questions?

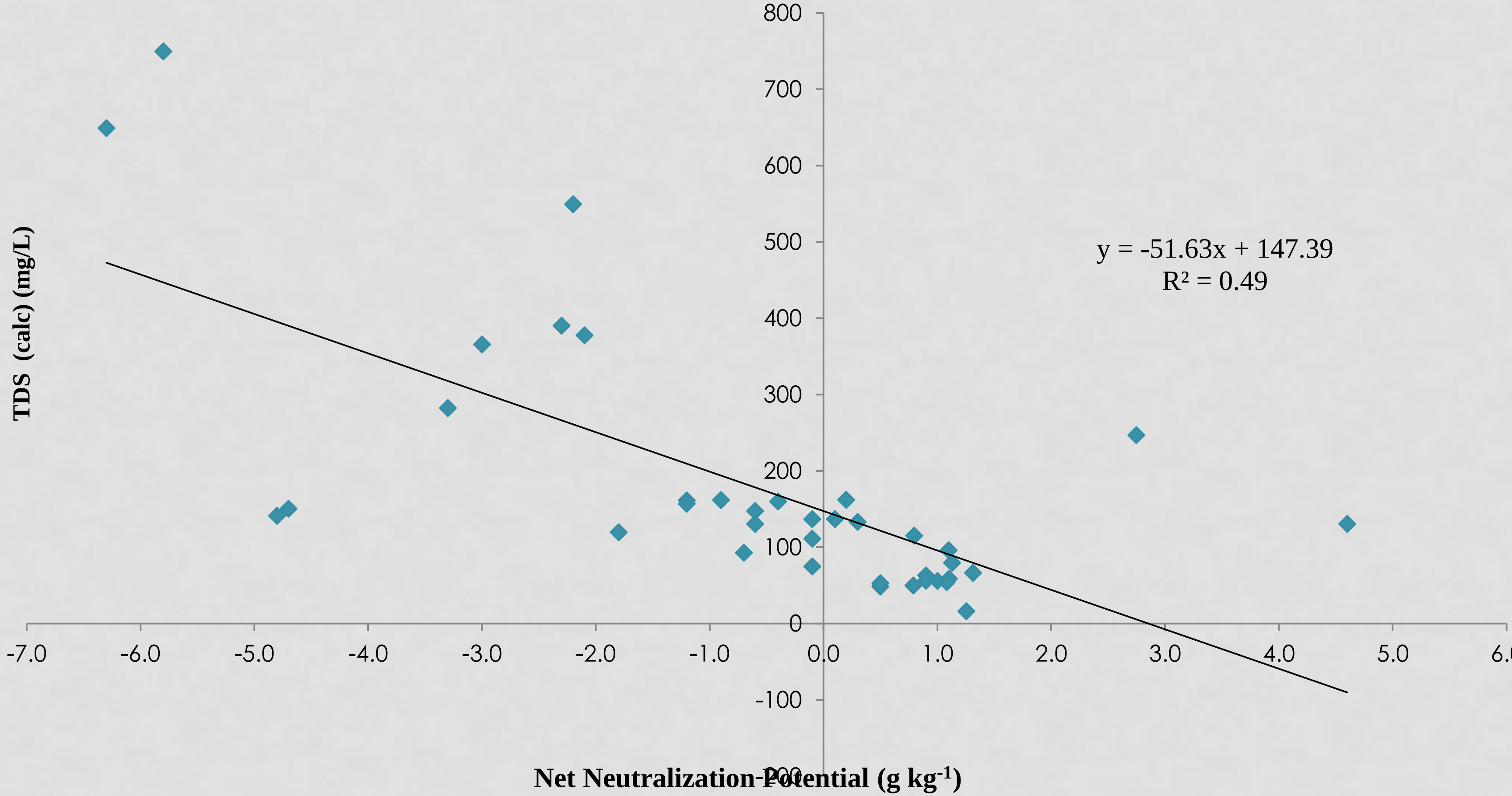
# Relationship Between Neutralization Potential (NP) and $TDS_{(Calc)}$ for 41 Overburden Samples



# RELATIONSHIP BETWEEN NEUTRALIZATION POTENTIAL (NP) AND TDS (CALC) FOR 41 OVERBURDEN SAMPLES.



# RELATIONSHIP BETWEEN NET NEUTRALIZATION POTENTIAL AND TDS (WITHOUT THREE OUTLIERS) FOR 38 OVERBURDEN SAMPLES.



# NET NEUTRALIZATION POTENTIAL (NPP) AND ITS POTENTIAL RELEASE OF TOTAL DISSOLVED SOLIDS

| TDS Release Index | TDS Concentration | NNP Range |
| --- | --- | --- |
| | -------- mg $L^{-1}$ ------- | ---- g $kg^{-1}$ ---- |
| **Low** | < 300 | ≥ -2.0 |
| **High** | ≥ 300 | < -2.0 |

# The Acid-Base Account

**Acidity**

| | | | | | | CaCO$_3$ equivalent - tons/1000 tons of material | | | | |
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**A number greater than 5.0 in the Excess Acidity Column is considered TOXIC**

# Acknowledgements

Thank you to Dr. Skousen for your mentorship and pushing me to be a better scientist.

To Dr. McDonald for your patience and insight.

To Dr. Vesper for being a wonderful and inspiring teacher.

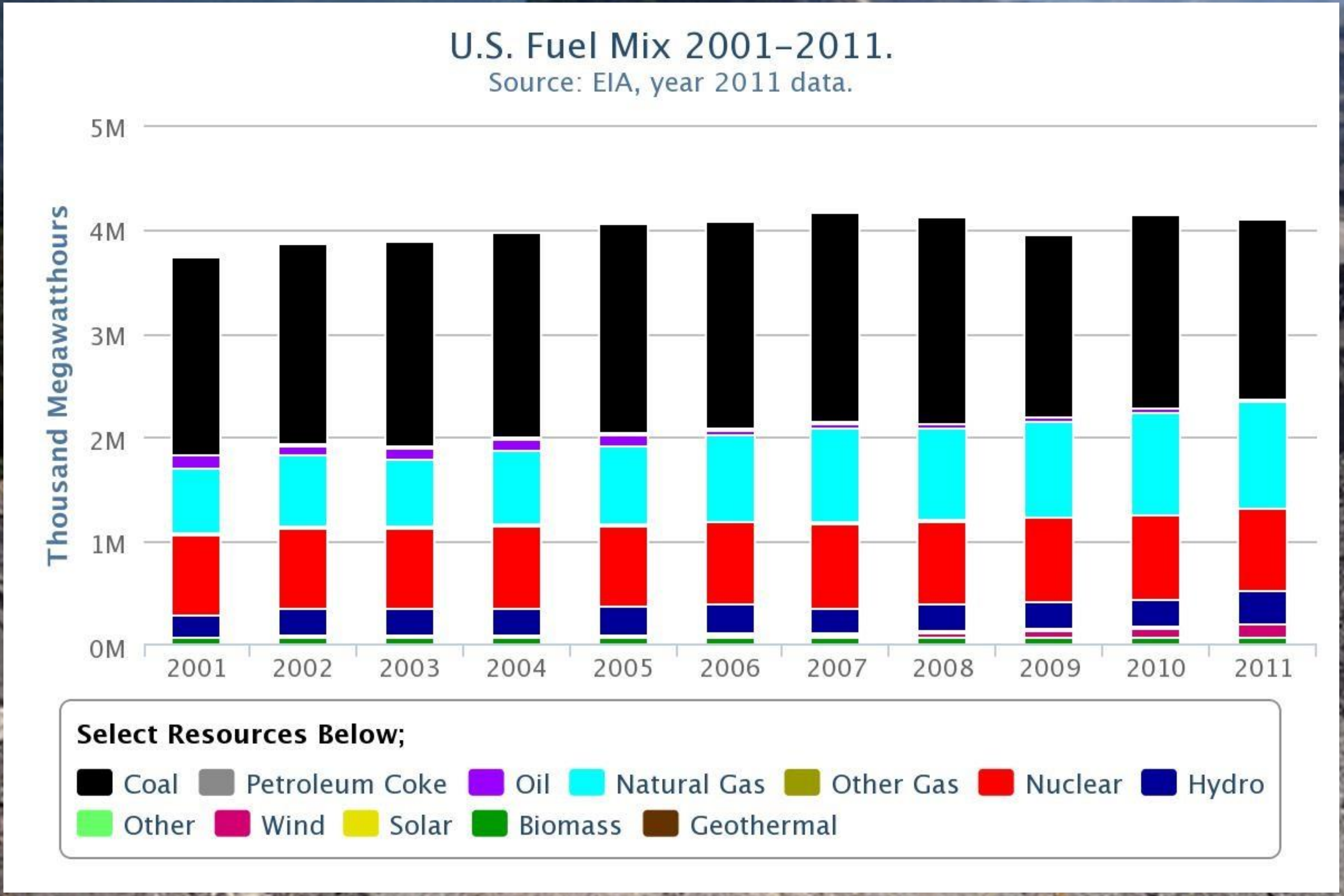
Thank you to Dr. Daniels and Zenah Orndorff for sharing their data.

A special thanks to Marianne Mannix for the sulfur analysis, and Joan Wright for operating the ICP.

Thank you to my friends for support and making these past two years incredible.

Thank you Alex Joyce and my family for their endless encouragement!

# Introduction

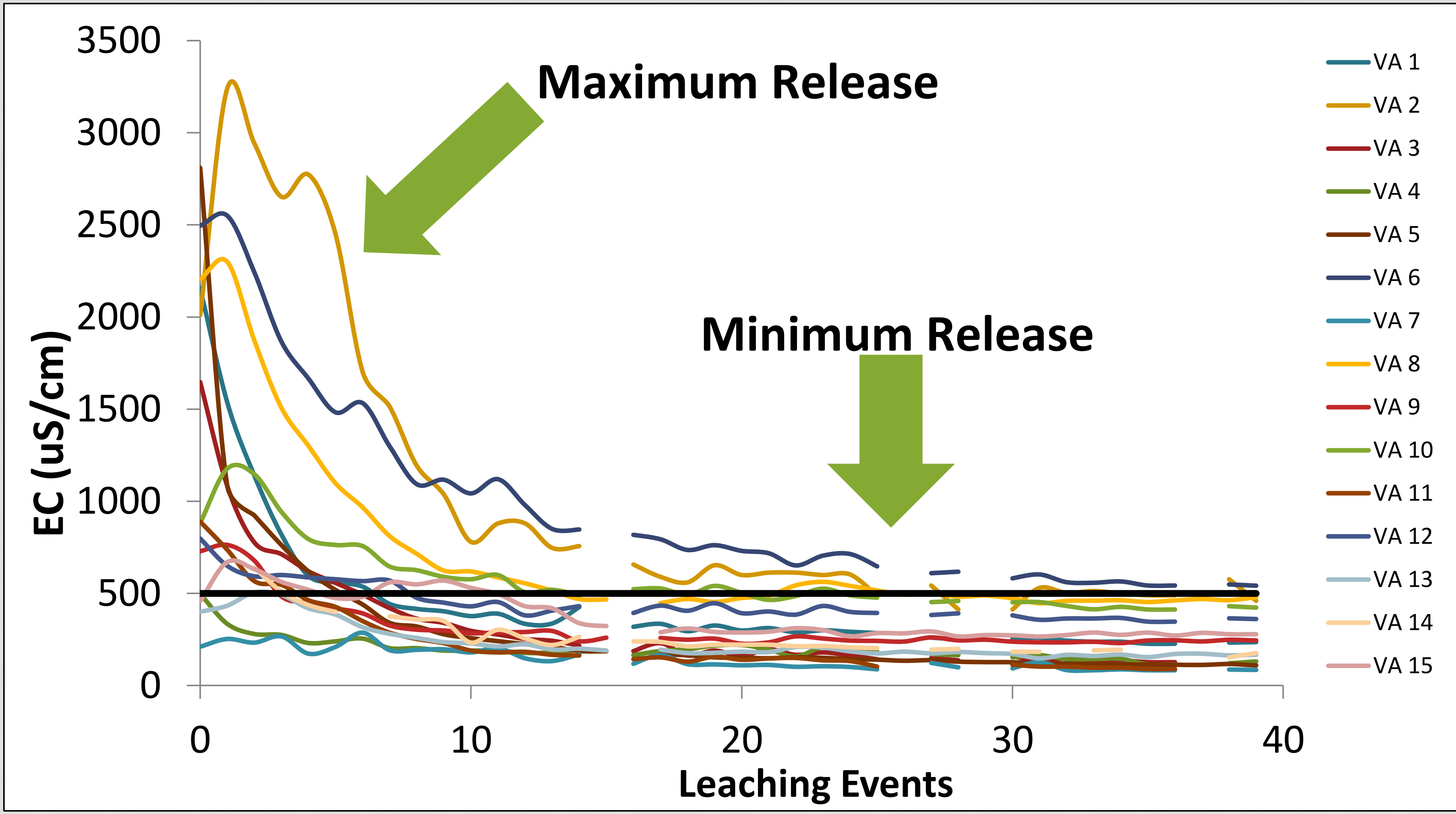


# Introduction

## Environmental Impacts:

- Deforestati
- Landscape
- Acid mine
- Erosion
- Acid rain

# Virginia Tech Leaching Columns



# Purpose

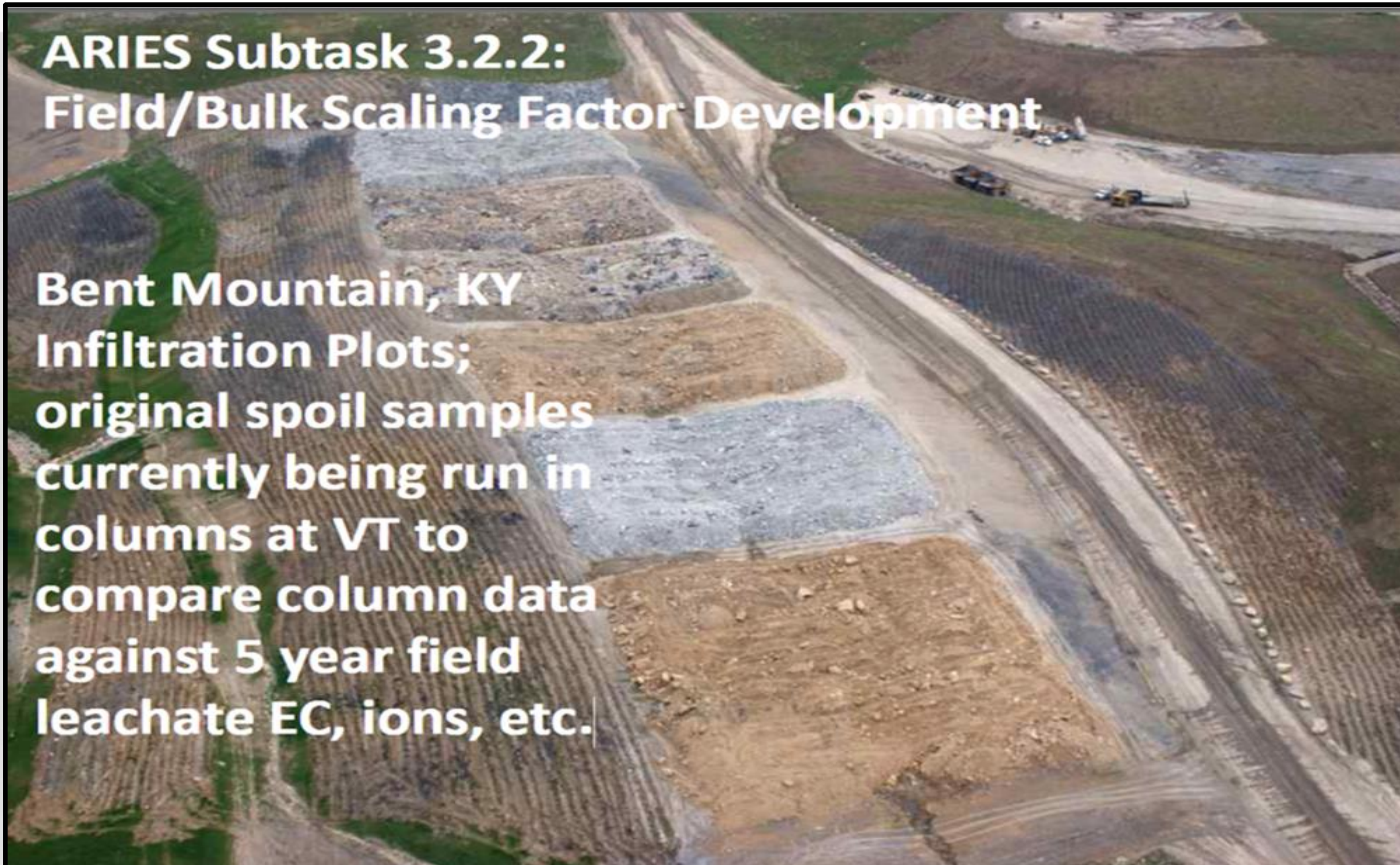
**To determine at Total Dissolved Release Index:**

**High, Moderate, or Low**

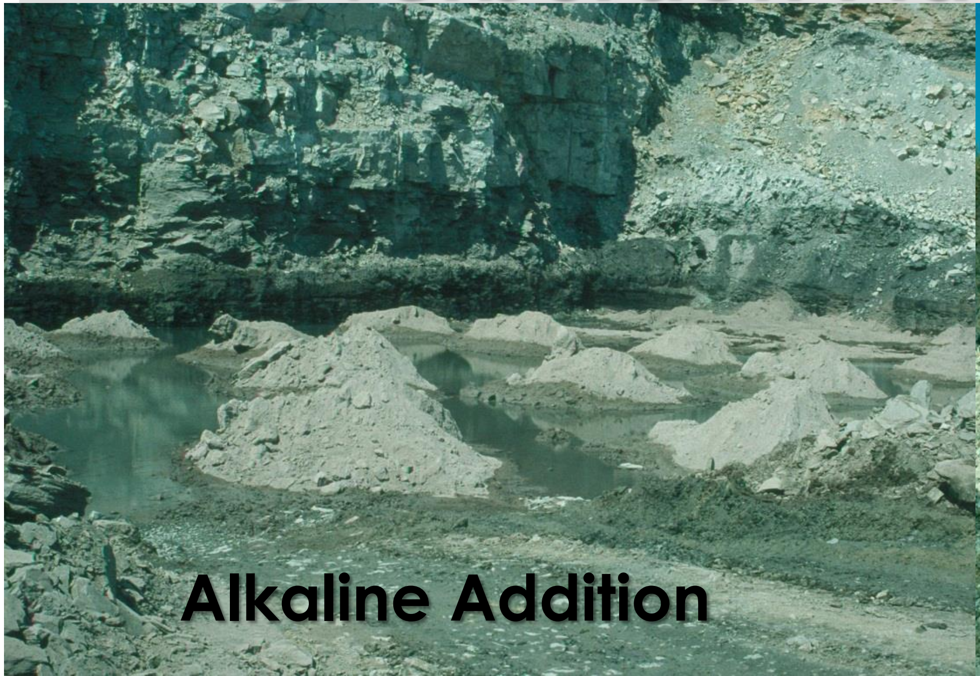
**so that operators can properly treat, isolate, and/or handle their overburden in a manner that will decrease TDS runoff from their site.**

# Collaborative Effort: Virginia Tech

# Collaborative Effort: University of Kentucky




# Overburden Placement Plans

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| | | | | | | $CaCO_3$ equivalent - tons/1000 tons of material | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Number | Bottom depth (feet) | Rock type | Fizz | Color | %S | Max. from %S | Amount present (NP) | Max. needed (pH7) | Excess | Paste pH |
| 1 | 3 | Soil | 0 | 7/3 | .035 | 1.09 | 3.52 | | 2.53 | 4.4 |
| 2 | 6 | SS | 0 | 8/6 | .029 | 0.91 | -1.51 | 2.42 | | 4.3 |
| 3 | 6 | SS | 0 | 8/2 | .023 | 0.72 | -1.59 | 2.31 | | 4.6 |
| 4 | 14 | SH | 0 | 7/4 | .009 | 0.28 | -0.60 | 0.88 | | 4.6 |
| 5 | 17 | SS | 0 | 7/4 | .009 | 0.28 | -0.09 | 0.37 | | 4.7 |
| 6 | 20 | SH | 0 | 8/3 | .011 | 0.34 | -0.17 | 0.51 | | 4.5 |
| 7 | 24 | MS | 0 | 7/1 | .263 | 8.22 | -0.94 | 9.16 | | 4.8 |
| 8 | 28 | MS | 1 | 7/1 | .179 | 5.59 | 78.33 | | 72.74 | 7.8 |

# The Acid-Base Account

- **Each geologic layer is identified by:**
  1. Rock color
  2. Rock hardness
  3. Rock fizz

- **Toxic, potentially toxic, and alkaline-producing overburden are determined by:**
  1. pH
  2. Total S
  3. NP – basic carbonates, exchangeable bases, basic silicates