June, 5th 2013
2:30 pm

Use of Spoil as a Low Permeable Barrier

Mariana da Rosa, Carmen T. Agouridis, and Richard C. Warner

Universidade Federal de Viçosa

Appalachian Mountains

Environmental Issues

- Break up of rocks at the top of the coal seams result in many smaller and readily dissolvable particles
  - Can have high sulfur and/or selenium content

- Appalachian Coal Belt emerging concern
  - Specific conductivity
  - Selenium

- U.S. Environmental Protection Agency (USEPA)
  - Specific conductance (2011): 300-500 $\mu S cm^{-1}$
  - Selenium: 5 $\mu g\ L^{-1}$

PETITION TO THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

- Petition for rulemaking to set water quality standards to protect Appalachian waters from mining waste and harmful levels of conductivity

- Submitted May 6, 2013 to the Administrator and Assistant Administrator of the Office of Water, U.S. Environmental Protection Agency

Low Permeable Barrier

- Reduce water from infiltrating into the spoil
- Isolate
  - High conductivity producing spoils
  - Selenium generating spoils
- Literature plentiful for clay barriers
  - Municipal solid waste
  - Hazardous waste
  - Low-level nuclear waste disposal site

Objective

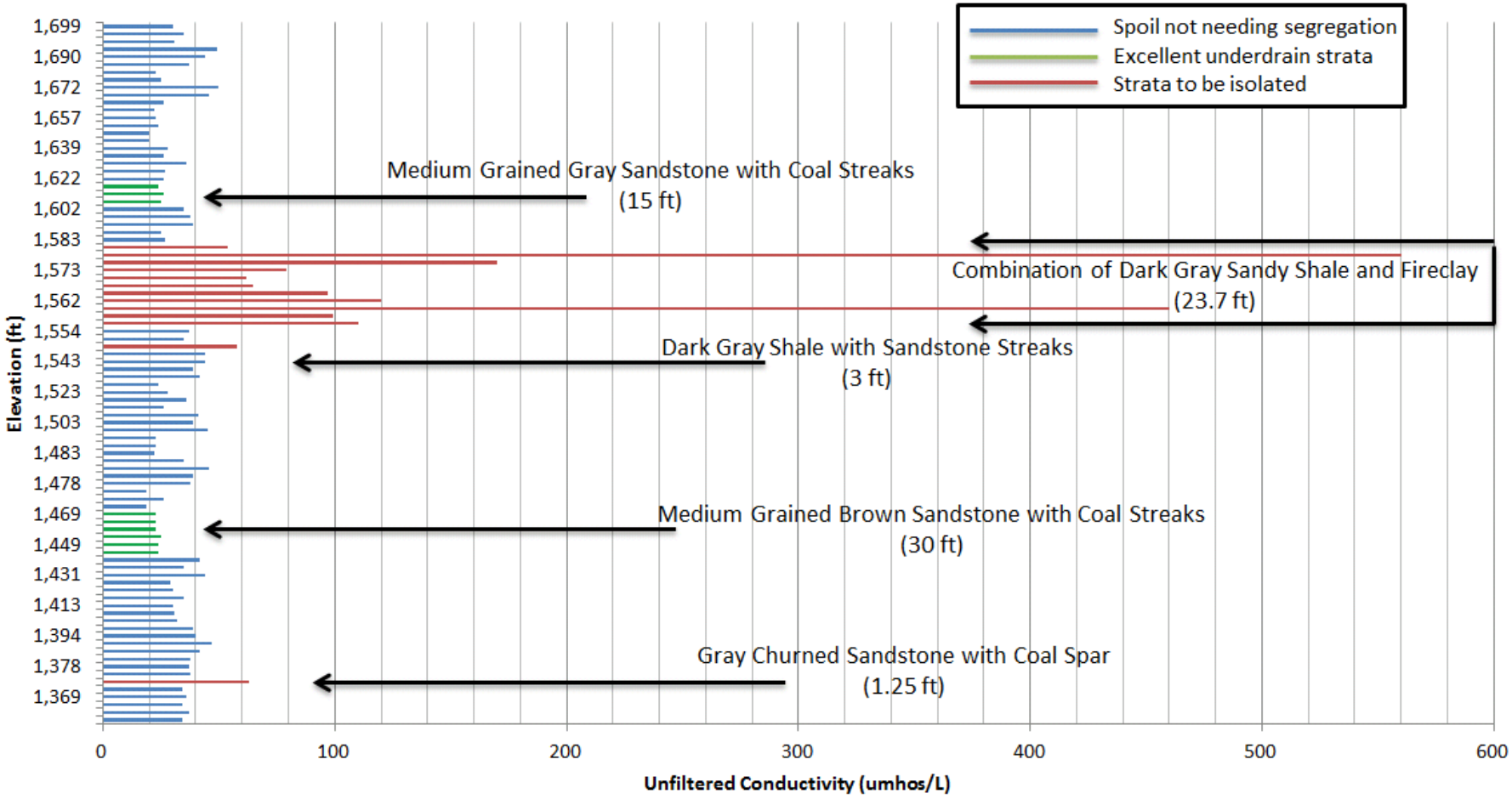
- Assess the potential of using weathered brown and/or gray sandstones to construct a low permeable barrier to isolate problematic spoils

Weathered Spoil

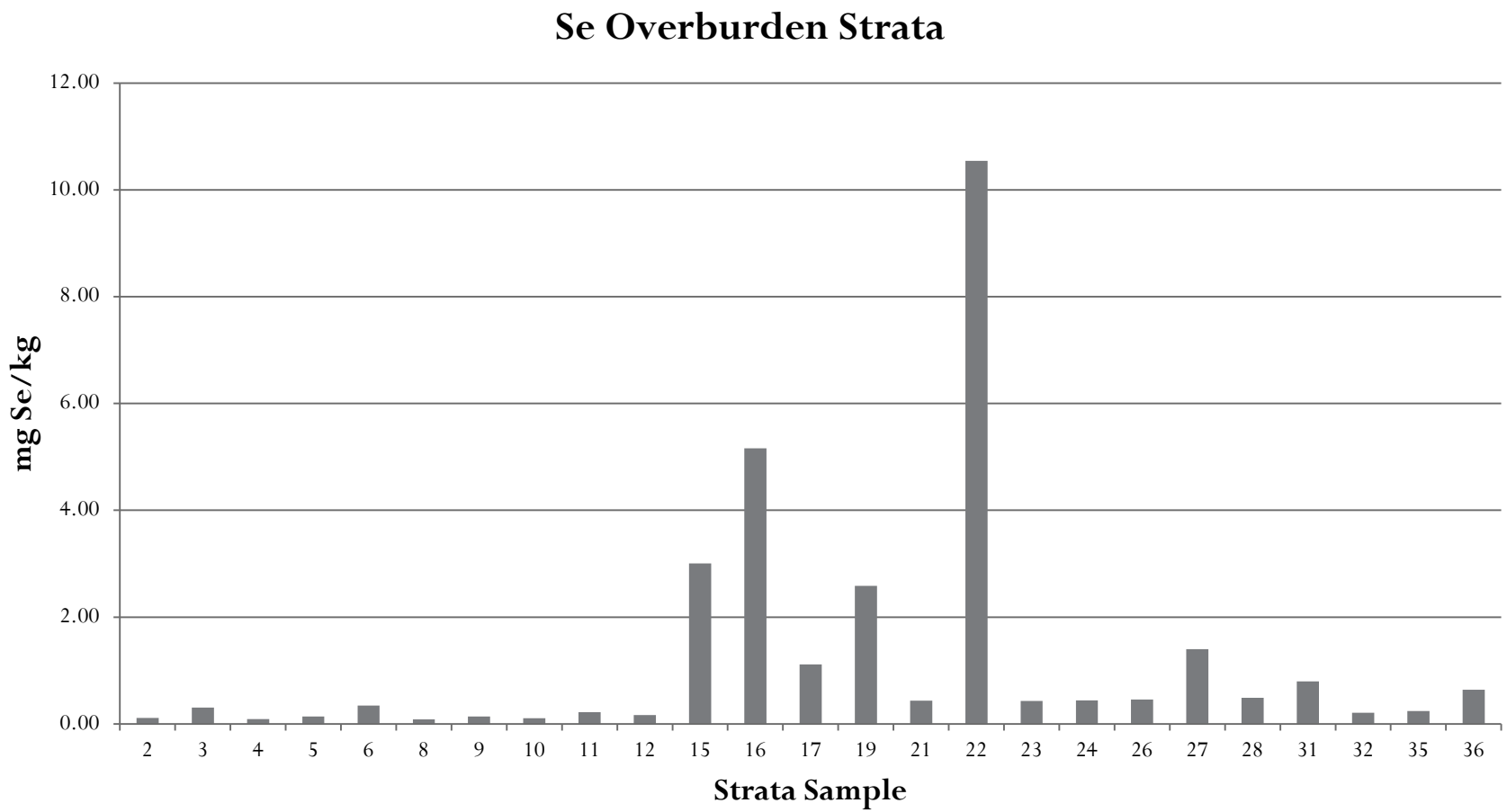
Spoil Characterization – SC & Se

- Specific conductivity
  - 1:3 mixture of spoil and deionized water
  - Multiparameter meter
    - HI991300; Hanna Instruments, Woonsocket, RI
- Selenium testing

Screening/classification Technique for Specific Conductivity (UK)



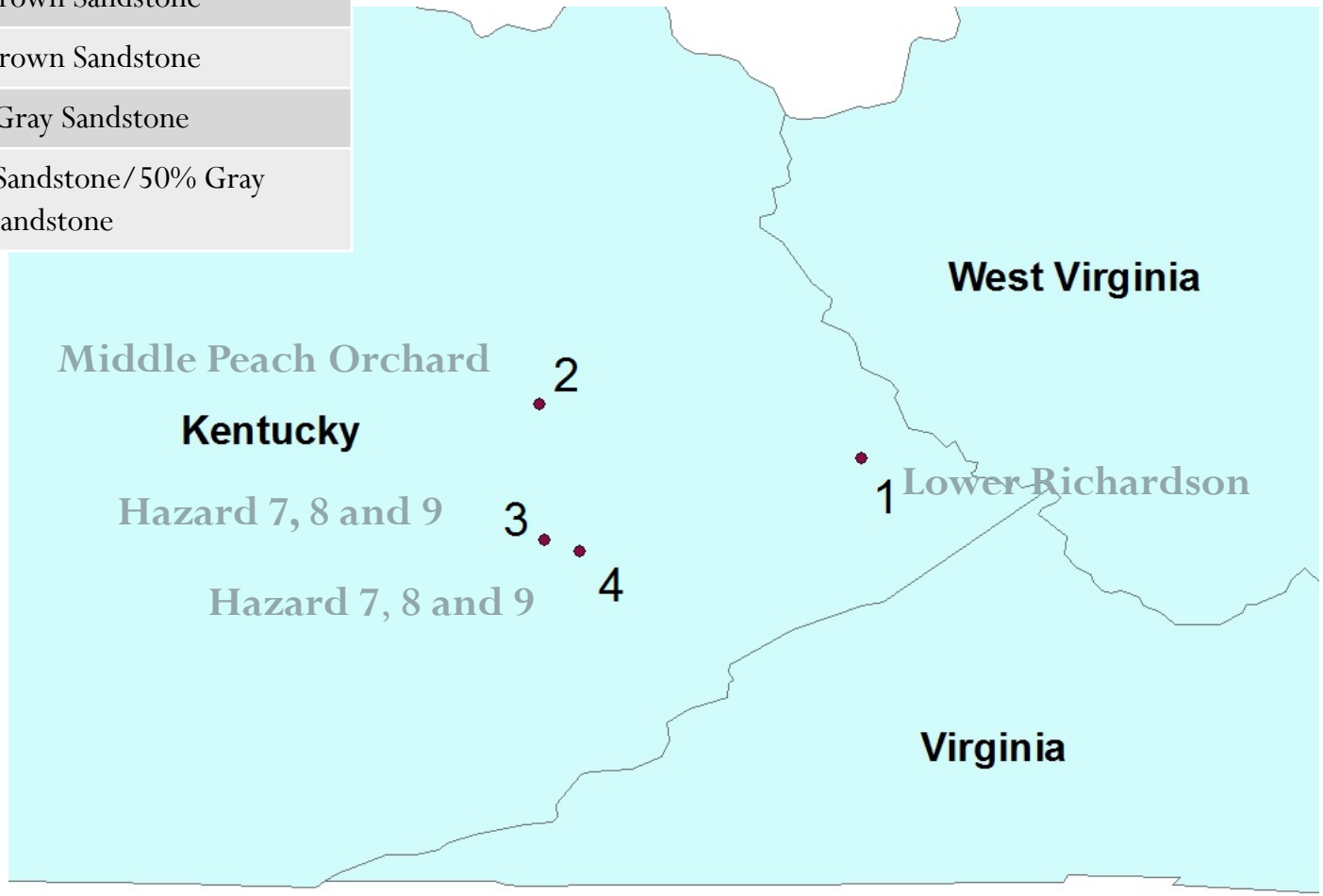
Drill Core Analysis of Se



Spoil to be Isolated

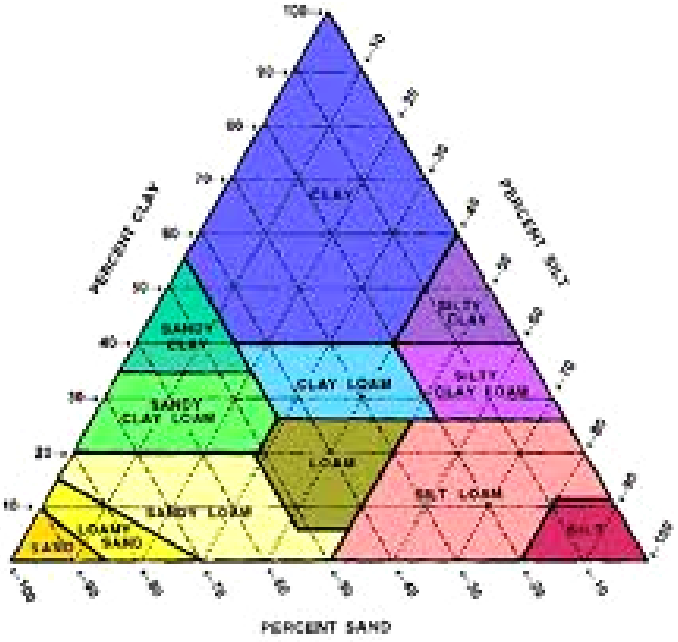
Study Sites & Coal Seams

Sample	Spoil Type
M1	100% Brown Sandstone
M2	100% Brown Sandstone
M3	100% Gray Sandstone
M4	50% Brown Sandstone/50% Gray Sandstone

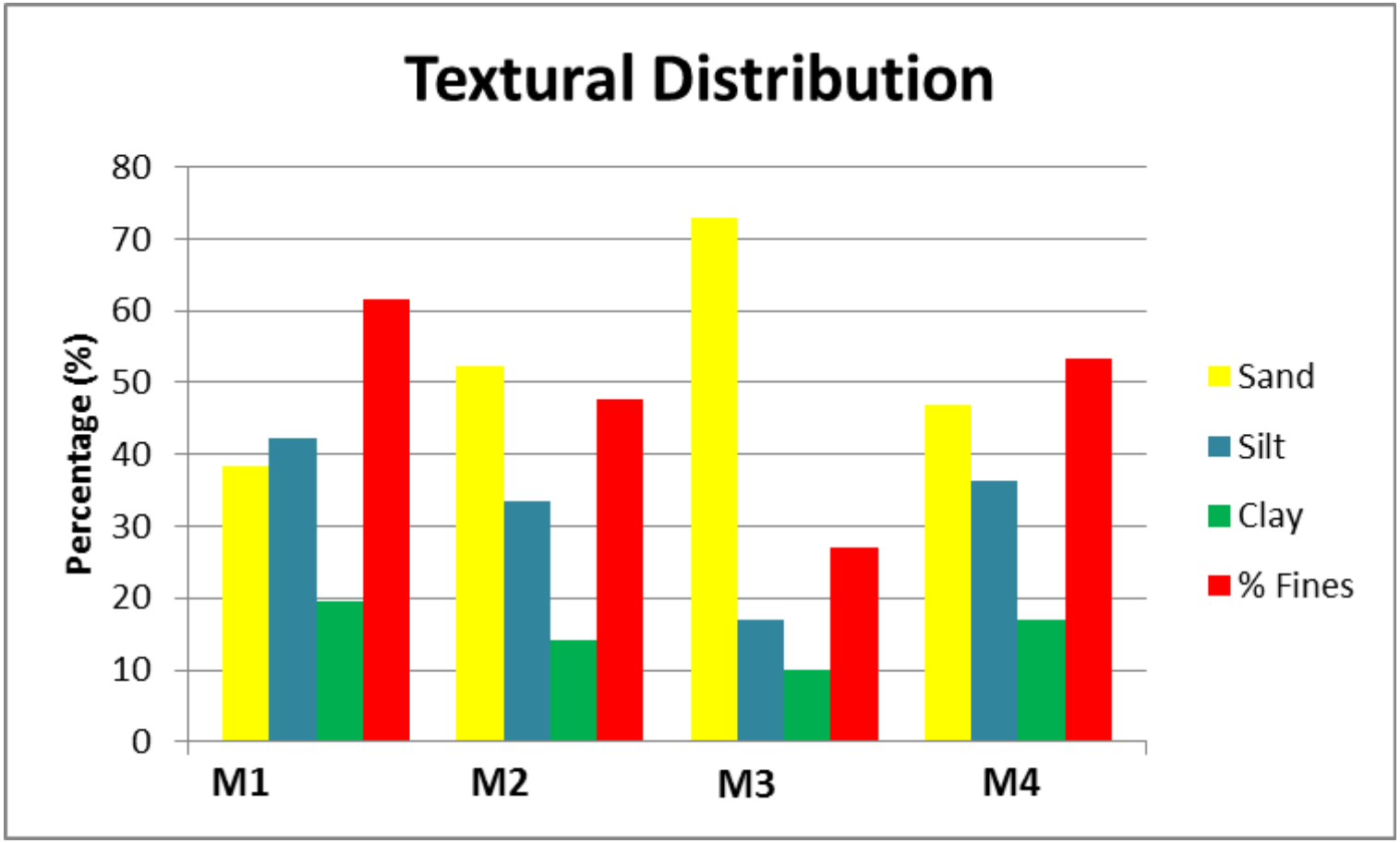


Weathered Spoil Characterization

- 3 subsamples
- UK Regulatory Service
  - Sand
  - Silt
  - Clay
- USDA textural triangle
  - USDA-NRCS, 2012
- One-way Analysis of Variance
- SigmaPlot 12.0



Spoil Characterization – Grain Size

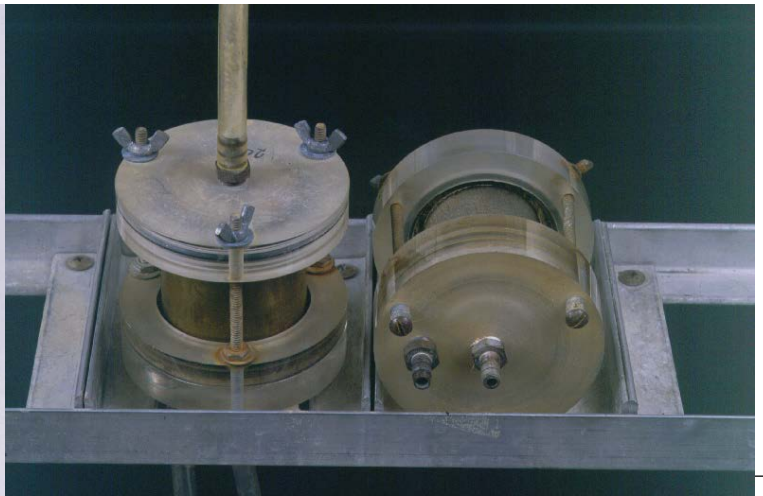


Spoil Characterization – Specific Conductivity

Spoil Sample	Specific Conductivity ($\mu S\ cm^{-1}$)
M1	24
M2	46
M3	23
M4	24

Spoil Compaction and Permeability

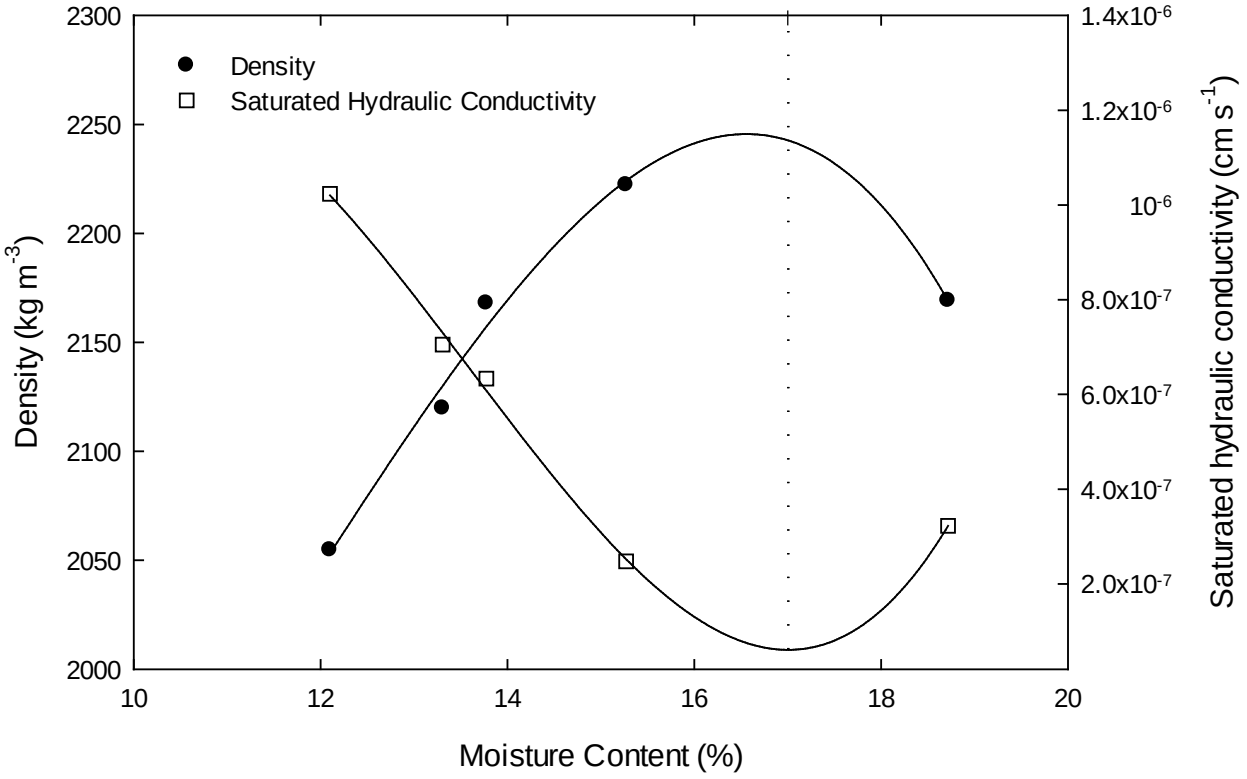
- Air dried and ground (Thomas Wiley Laboratory Mill Model 4)
- Standard Proctor test (ASTM D698)
  - maximum achievable level of compaction (ρ_{max})
  - optimum moisture content (MC)
- Rigid wall double-ring permeameter
  - saturated hydraulic conductivity (h_{sat})



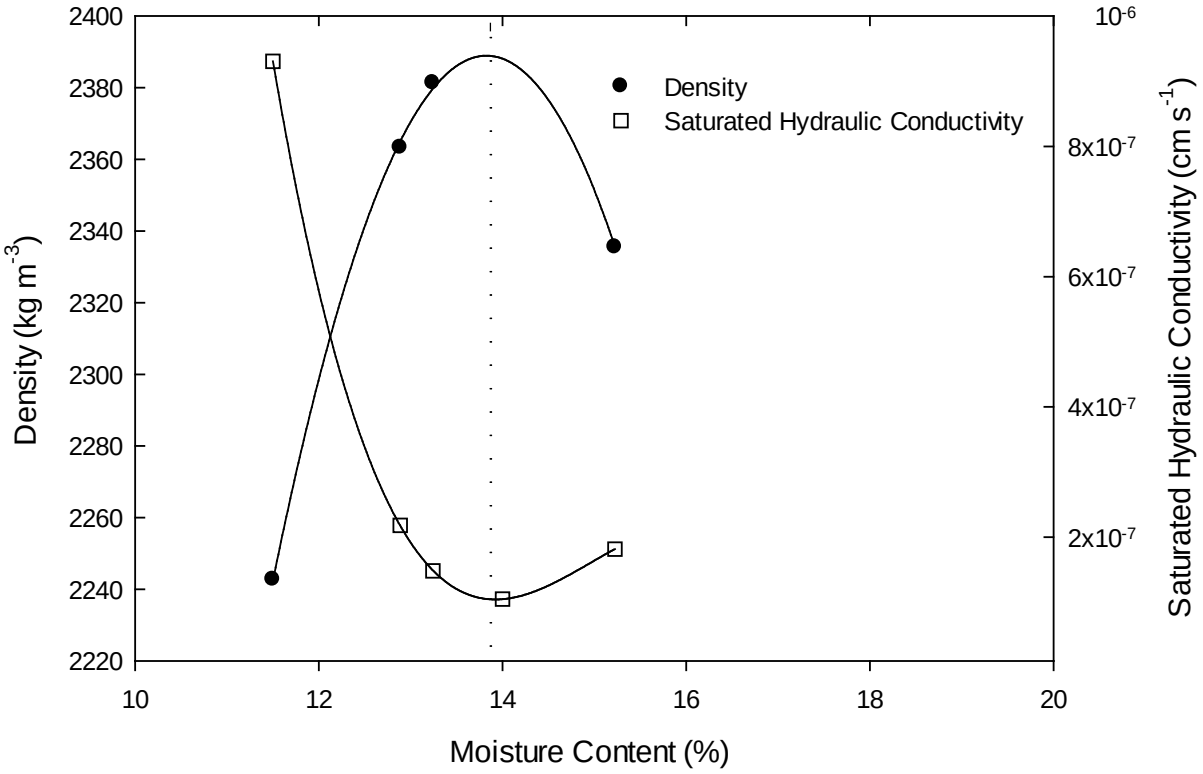
Spoil Compaction and Permeability

Spoil Sample	ρ_{max} - kg m^{-3} (lb ft $^{-3}$)	Moisture Content (%)	h_{sat} (cm s^{-1})	Moisture Content (%)
M1	2,250 (140.5)	16.6	5.94x10^{-8}	17.0
M2	2,360 (147.3)	13.8	1.28x10^{-7}	13.9
M3	2,490 (155.4)	11.6	3.08x10^{-7}	11.4
M4	2,450 (152.9)	12.6	2.74x10^{-7}	13.2

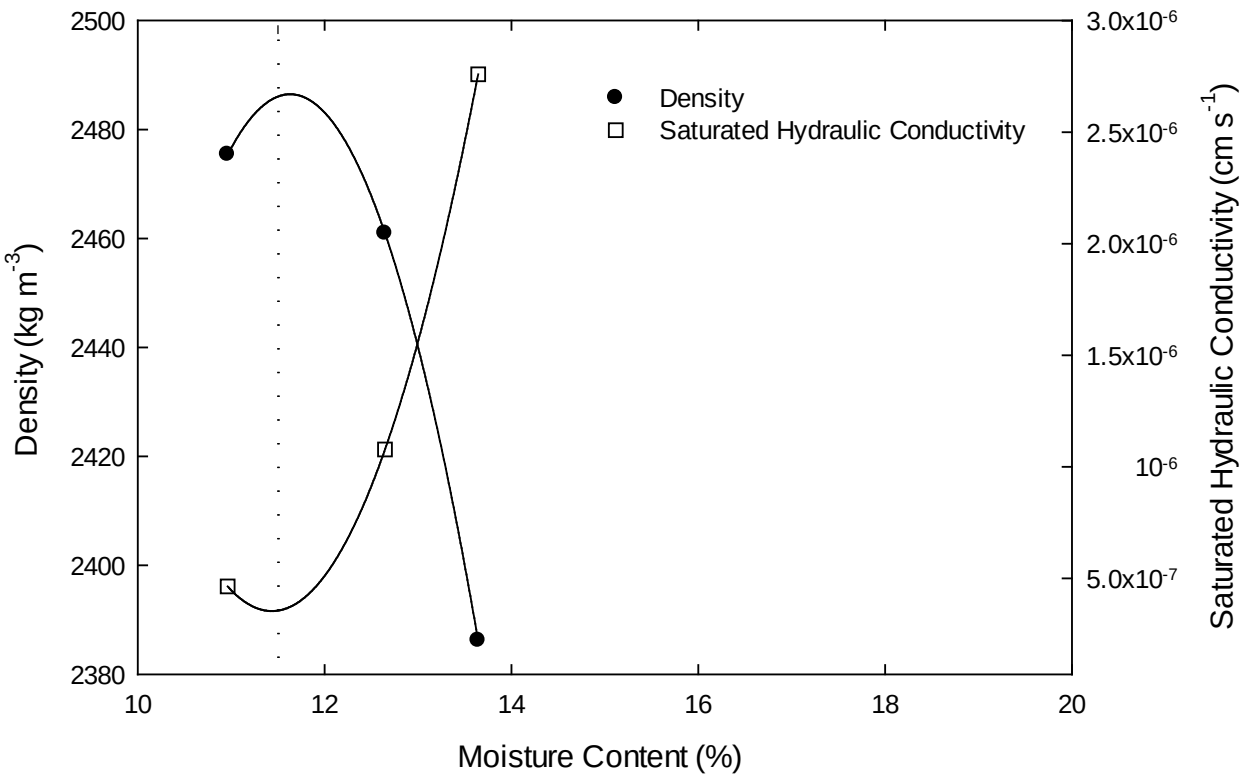
M1 – Proctor & Sat. Hydraulic Cond.



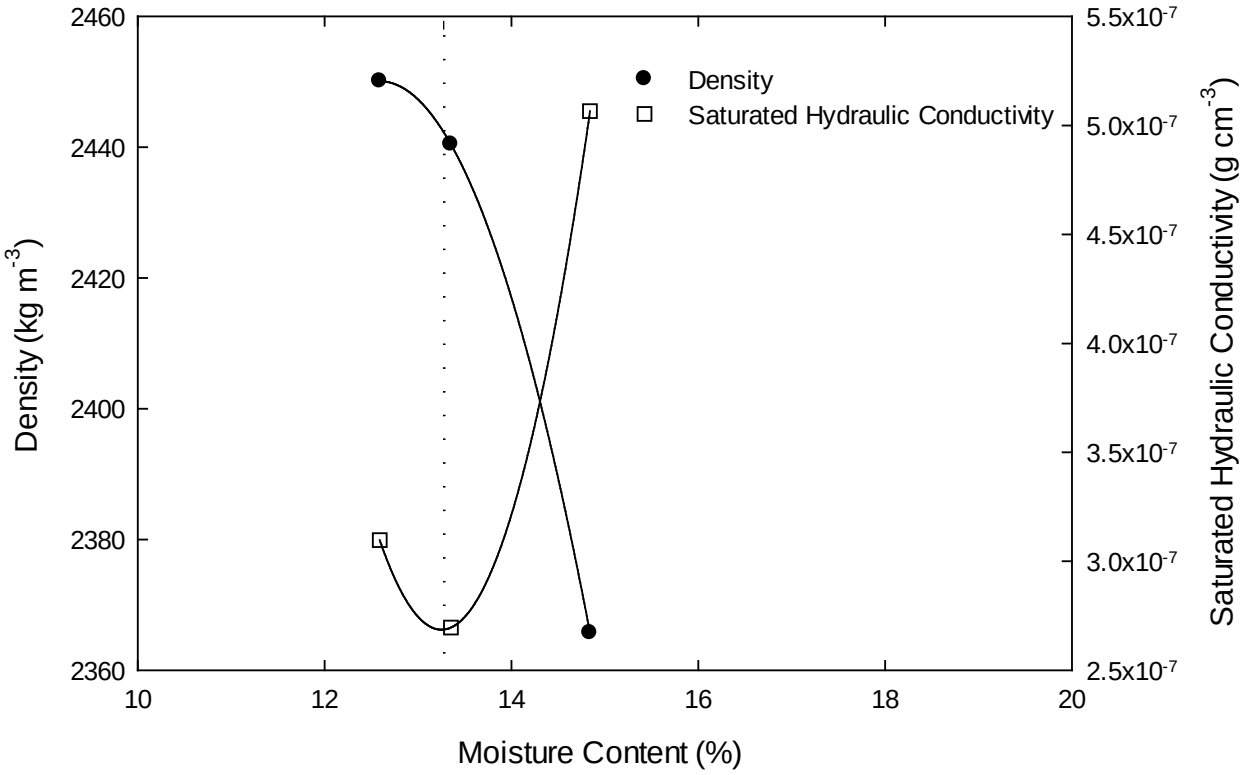
M2 – Proctor & Sat. Hydraulic Cond.



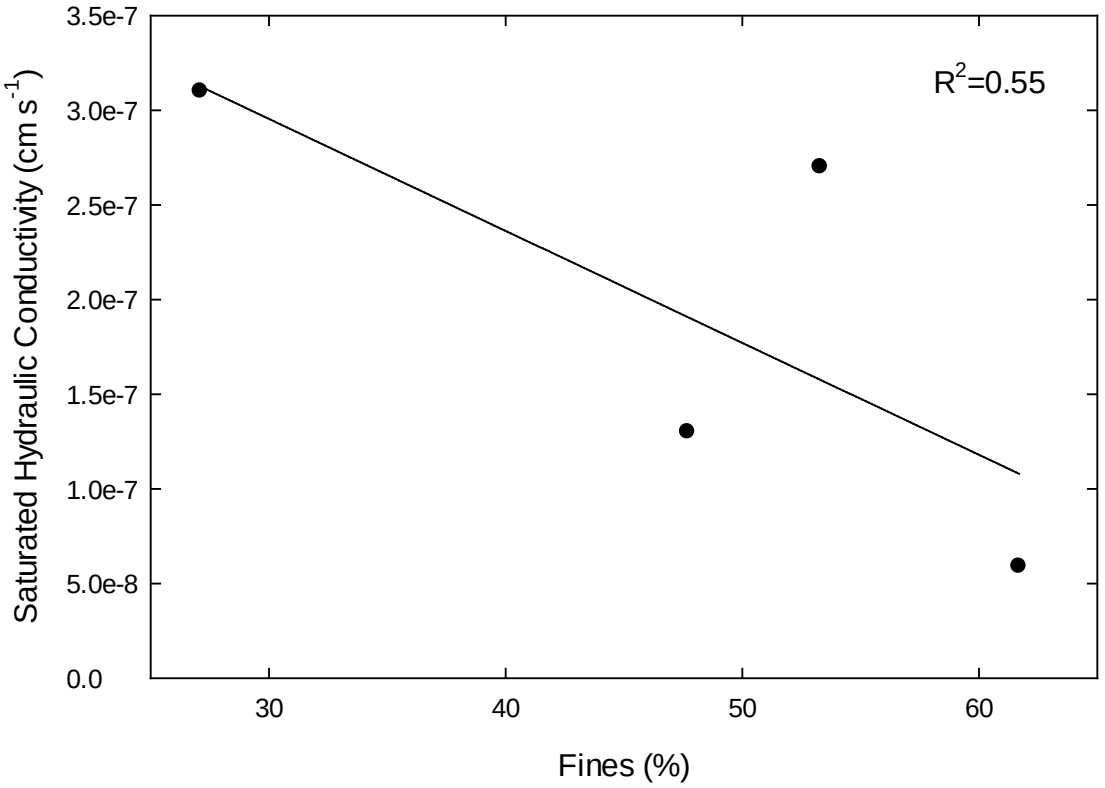
M3 – Proctor & Sat. Hydraulic Cond.



M4 – Proctor & Sat. Hydraulic Cond.



Influence of Fines on Sat. Hyd. Cond.



Conclusions

- Weathered sandstones
  - Abundant in the Appalachian Coal Belt region
  - Low specific conductance and selenium levels

- Weathered brown sandstones
  - A promising spoil in construction of a low permeable barrier to isolate problematic spoils

Conclusions (cont.)

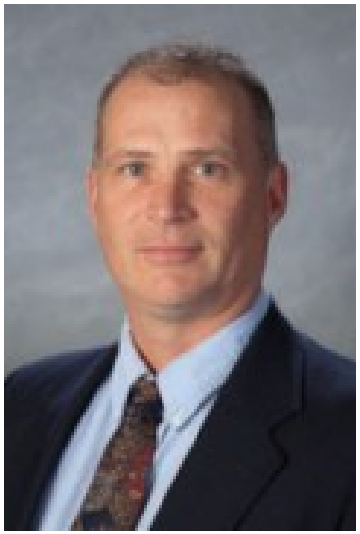
- Two weathered brown sandstones tested
  - ~ 1 x 10^{-7} cm s^{-1} saturated hydraulic conductivity
  - Gray weathered sandstone was slightly more permeable

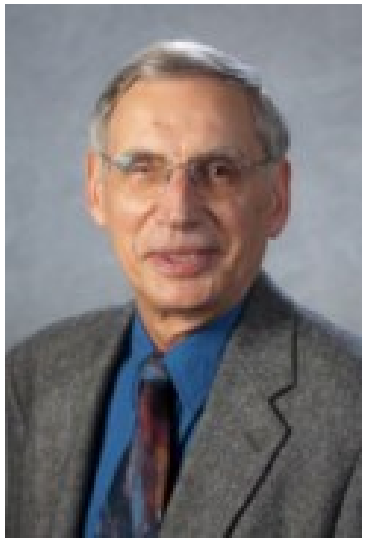
- Low permeable barrier with saturated hydraulic conductivity value > 1 x 10^{-7} cm s^{-1} may be acceptable when isolating problematic spoils
  - a higher value may provide the needed water quality protection

Future Work

- Mine site low permeable barrier construction and evaluate performance
- Capillary barrier
  - Low permeable weather spoil barrier above
  - Spoil with larger size aggregate
- Subvert capillary forces, which dominate under conditions of low flow and small pores

Acknowledgements






TIME FOR QUESTIONS


thank you