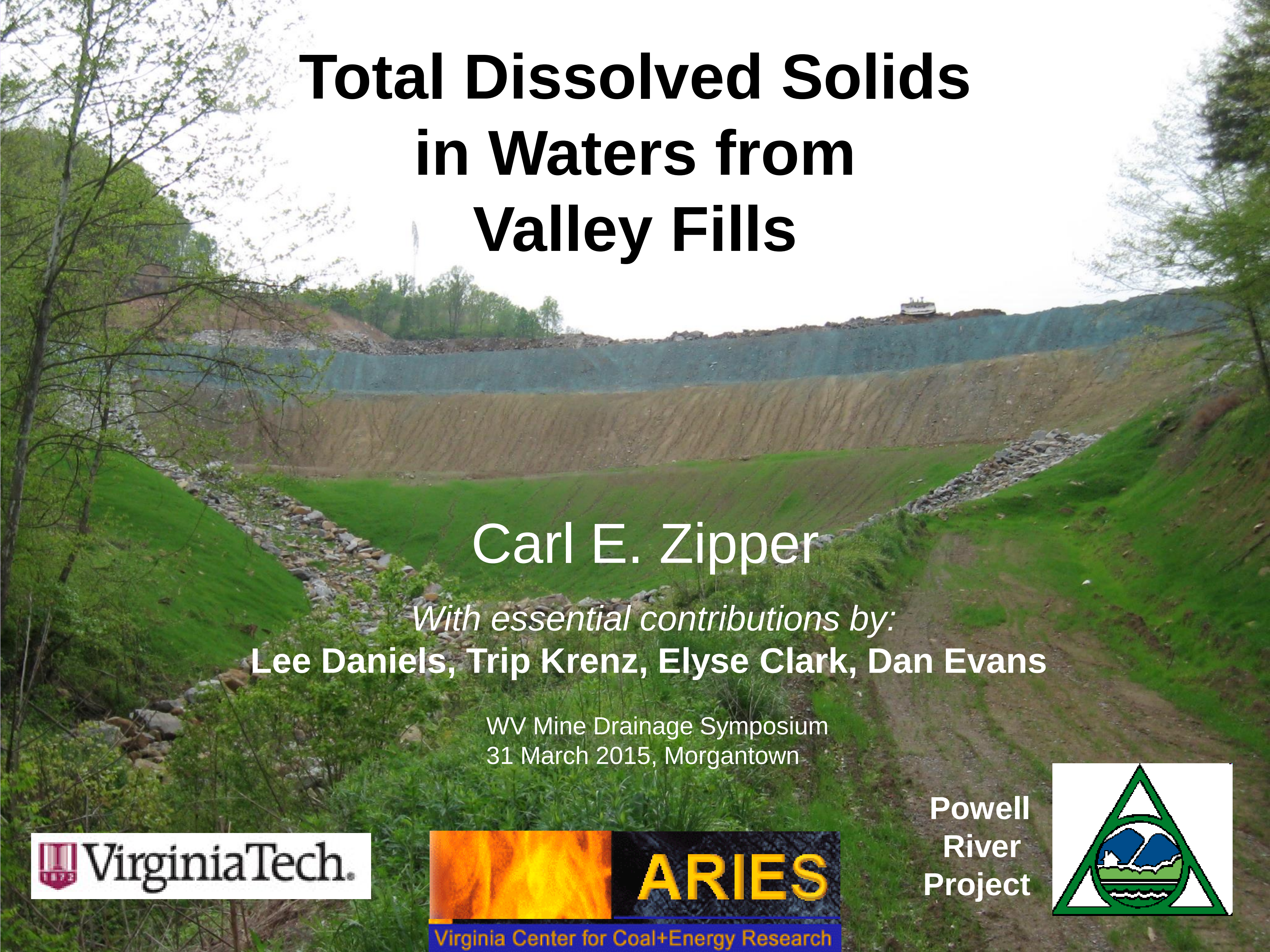


Total Dissolved Solids in Waters from Valley Fills

Carl E. Zipper

With essential contributions by:

Lee Daniels, Trip Krenz, Elyse Clark, Dan Evans

WV Mine Drainage Symposium
31 March 2015, Morgantown

VirginiaTech.

ARIES
Virginia Center for Coal+Energy Research

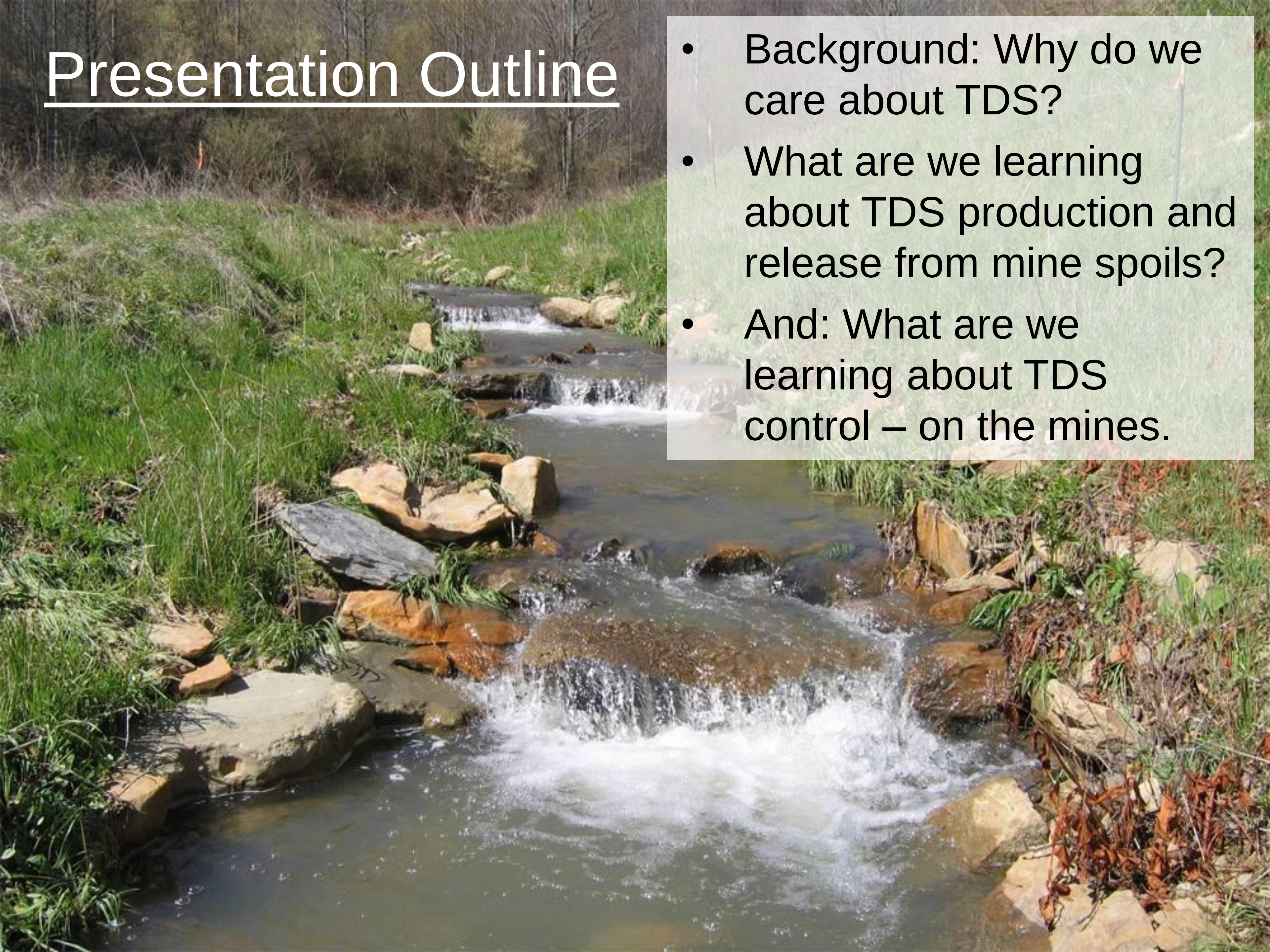
Powell River Project

Problem: Salts (measured as total dissolved solids, **TDS** and specific conductance, **SC** from coal mining operations area regulatory concern – and a concern to the coal industry.

What are we learning about TDS in mine water discharges?
What can industry do to address that problem?

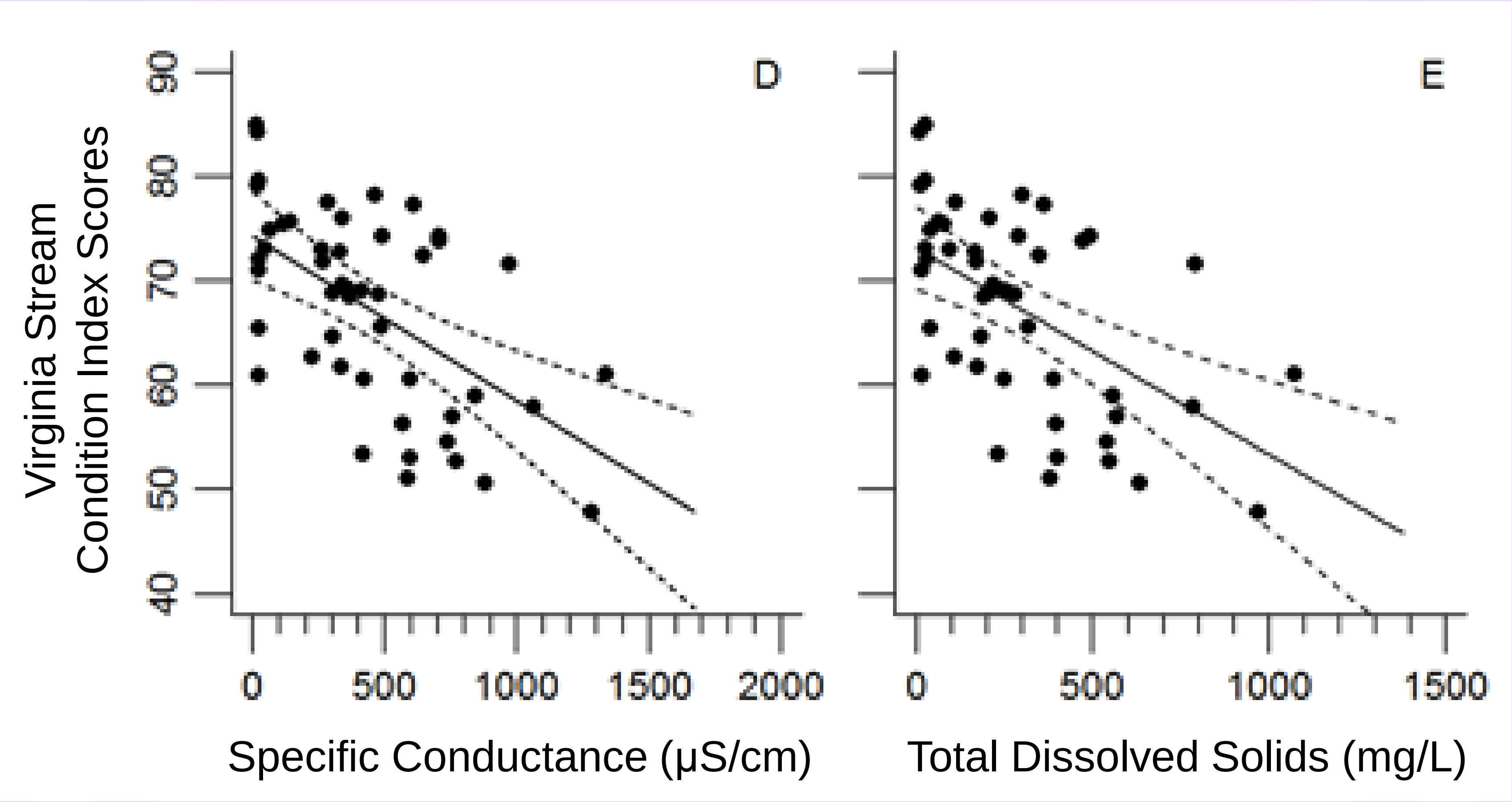
Presentation Outline

- Background: Why do we care about TDS?
- What are we learning about TDS production and release from mine spoils?
- And: What are we learning about TDS control – on the mines.



Background:

TDS: Why care?



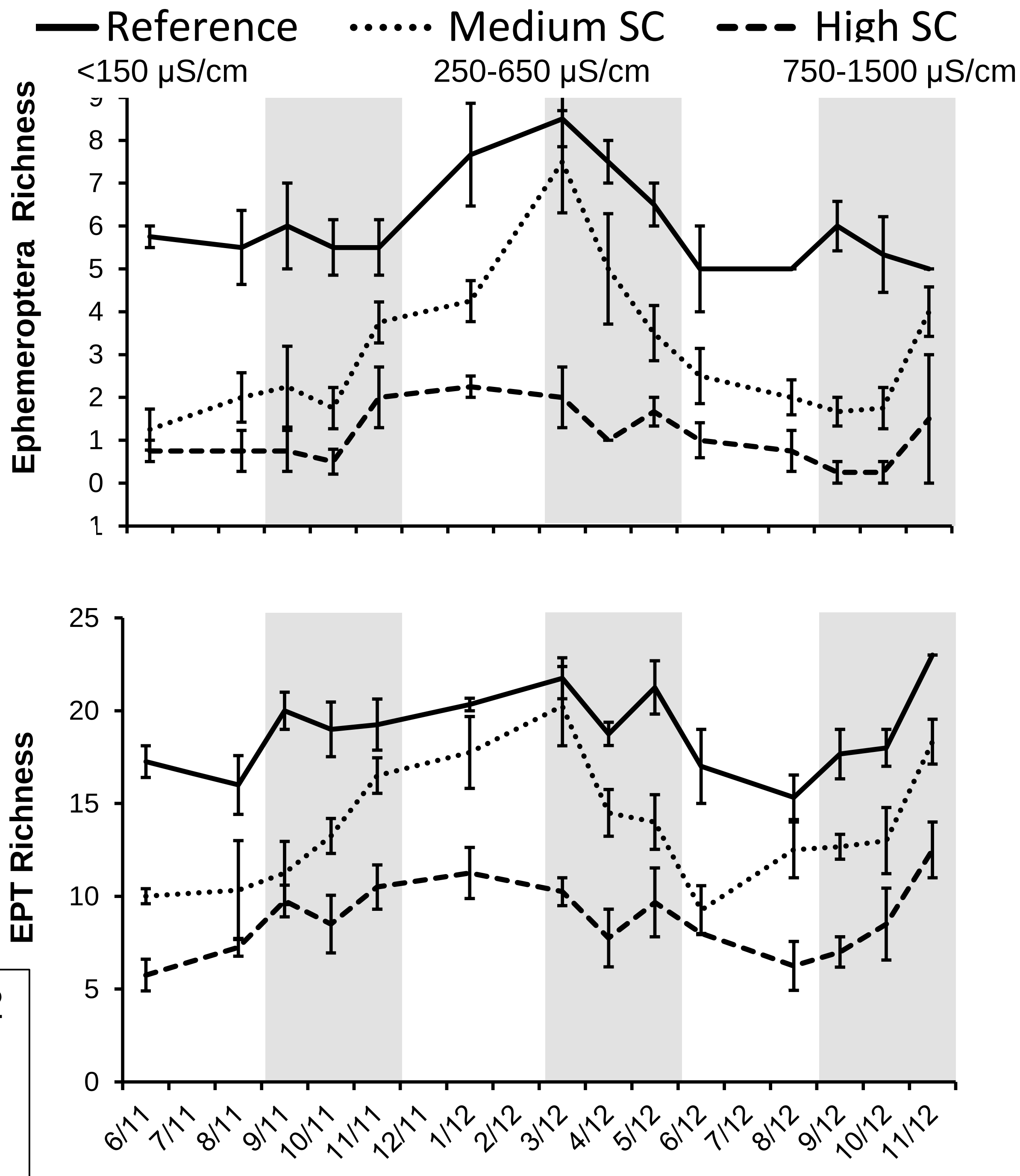
Timpano et al. 2015 JAWRA 51: 240-250.

Background:

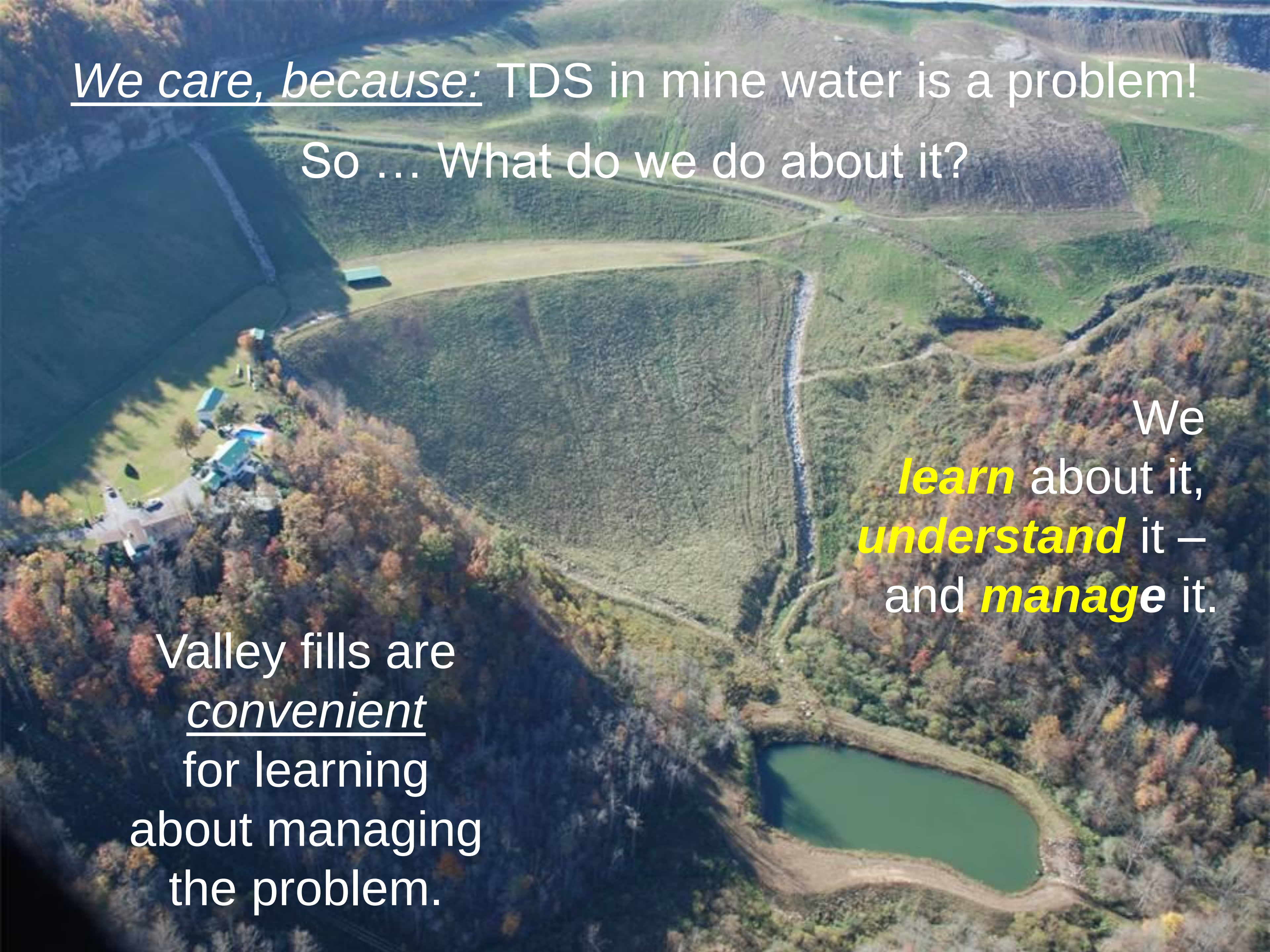
… and we have much to learn about the true nature of the TDS problem:

- Causes for taxa losses?
- Seasonal patterns?
- Impacts of taxa losses?
- How to gauge "*allowable*" impacts,
- etc.

Data: Community metrics in 12 streams of three water-quality types (4 streams per type), over 19 months.



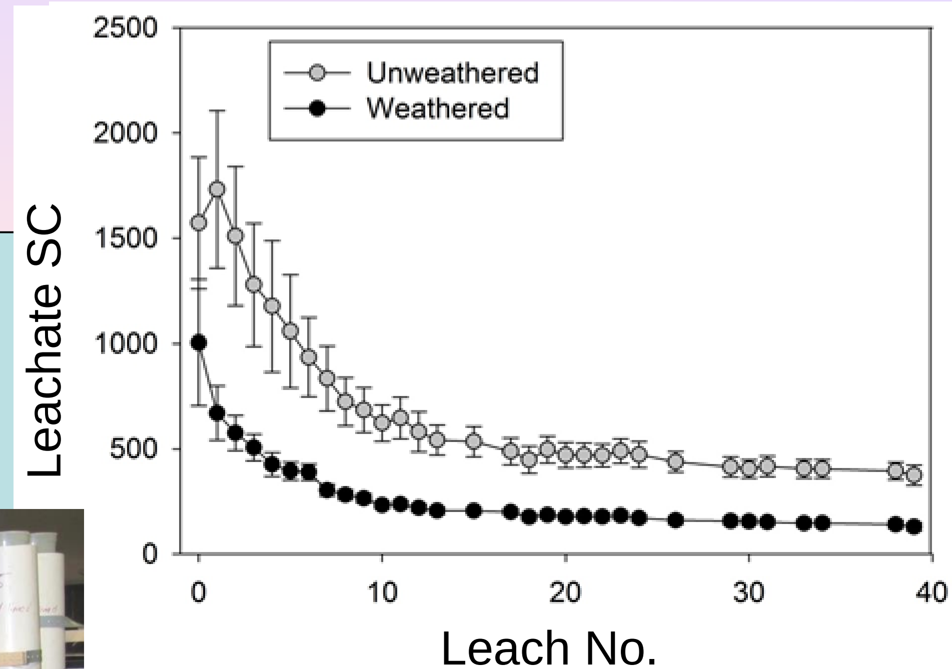
Boehme *et al.*, *Ecol. Applic.*, in review.


We care, because: TDS in mine water is a problem!
So … What do we do about it?
We
learn about it,
understand it –
and **manage** it.
Valley fills are
convenient
for learning
about managing
the problem.

Spoil Characterization Research - Lee Daniels, VT:

TDS release differs dramatically among spoils, but generally declines with time.

SC in mine-spoil leachate:

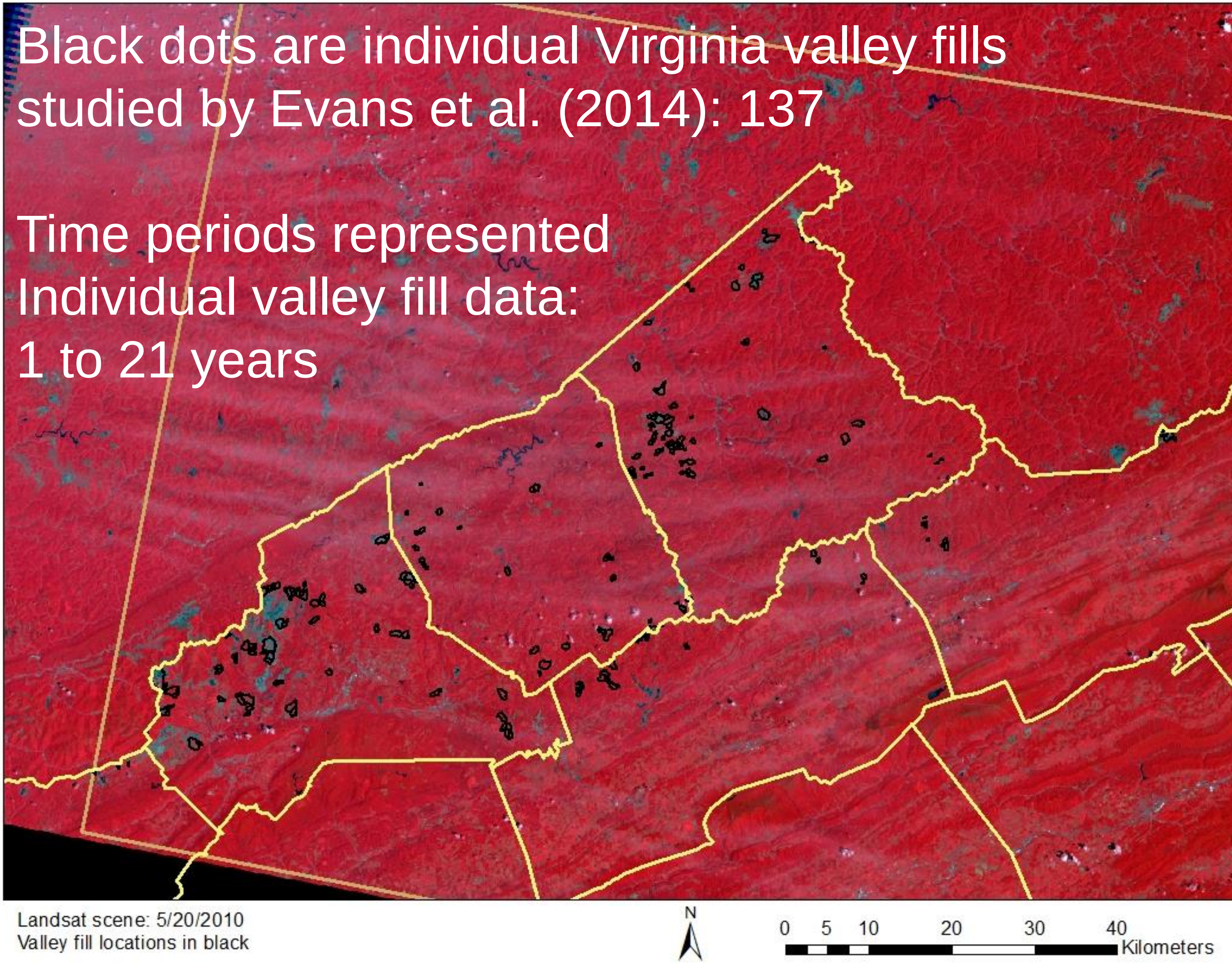


Data from Lee's student, Clay Ross, shows spoil placed in large vessels, leached with rainwater, behave similar to the columns – but with higher concentrations emerging after extended dry periods.

L.Clay Ross. 2015. M.S. thesis, VT.

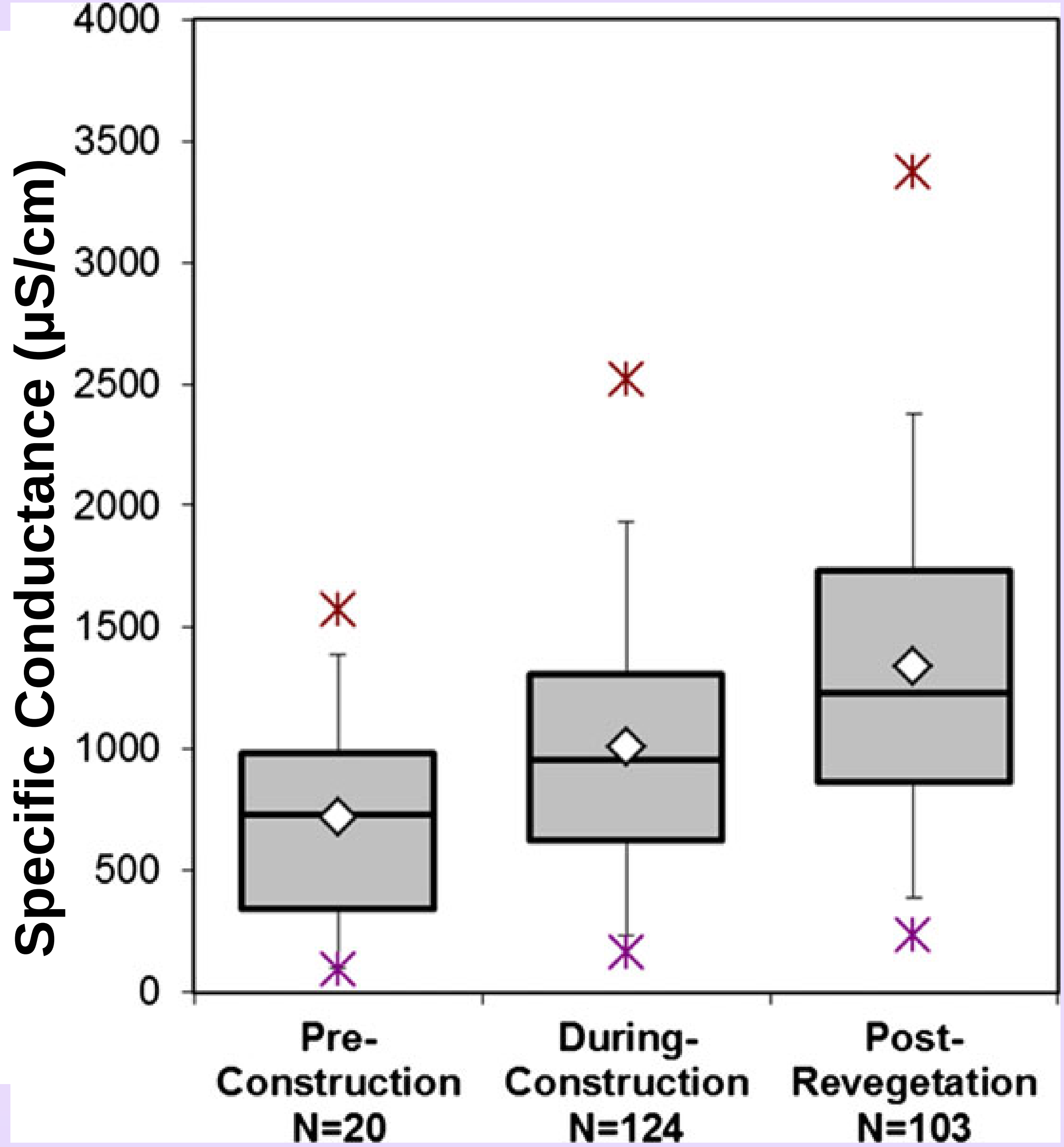

Water quality data from UKy plots are also consistent with the column data
Bent Mtn. KY plots; field data from UKy
Field plots: each ~1 acre in size, 4 feet in depth. Each with its own water collection drains.
Data in: Daniels, Barton, Skousen et al. 2015. in prep.

Research (Evans et al. 2014): 137 Virginia valley fills, agency data: SC of water discharge over periods extending from ~1 to >20 years.


Black dots are individual Virginia valley fills studied by Evans et al. (2014): 137
Time periods represented
Individual valley fill data:
1 to 21 years
Landsat scene: 5/20/2010
Valley fill locations in black
N
0
5
10
20
30
40
Kilometers

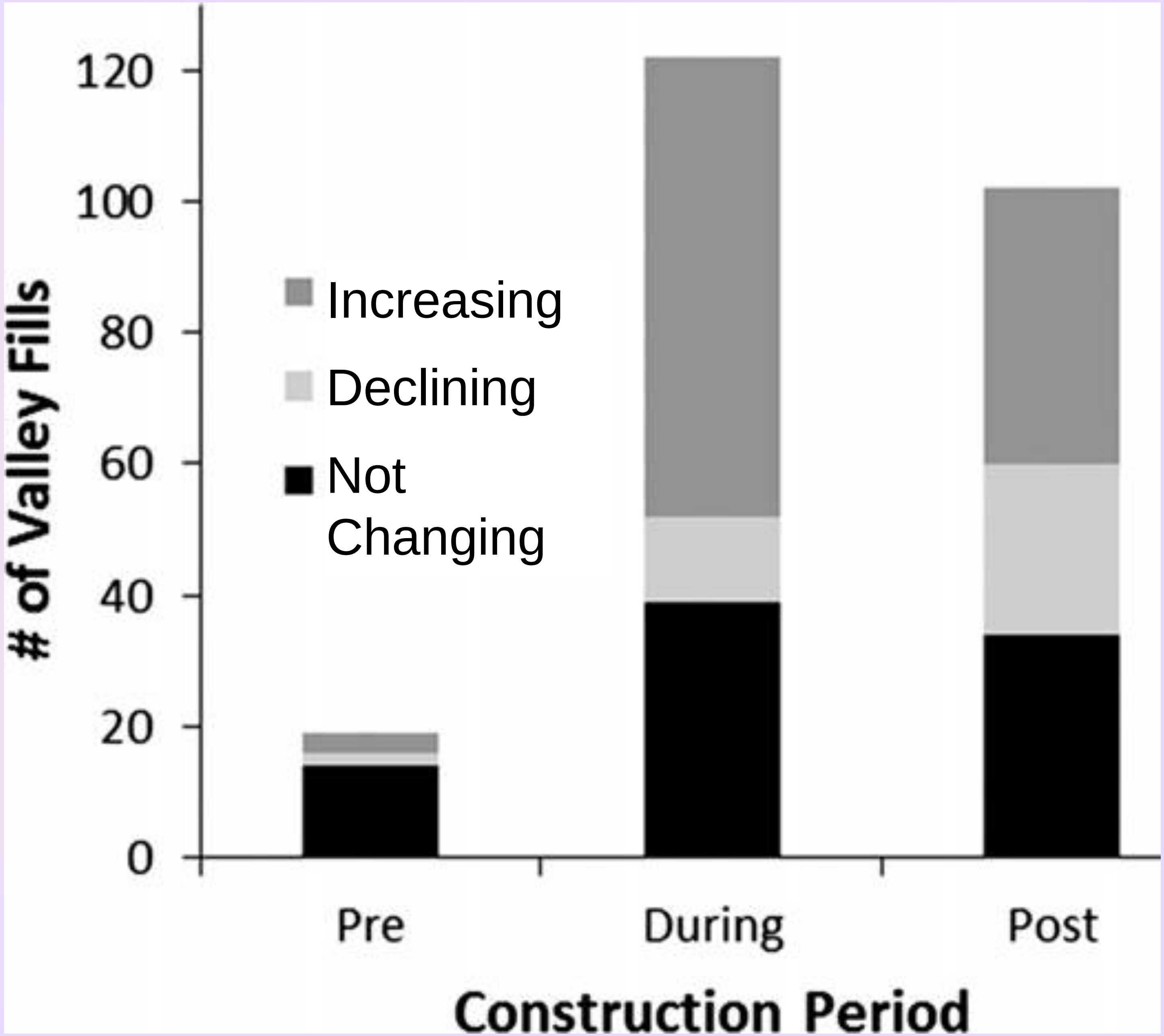
Quality of Waters emerging from Virginia valley fills:

Highly variable.

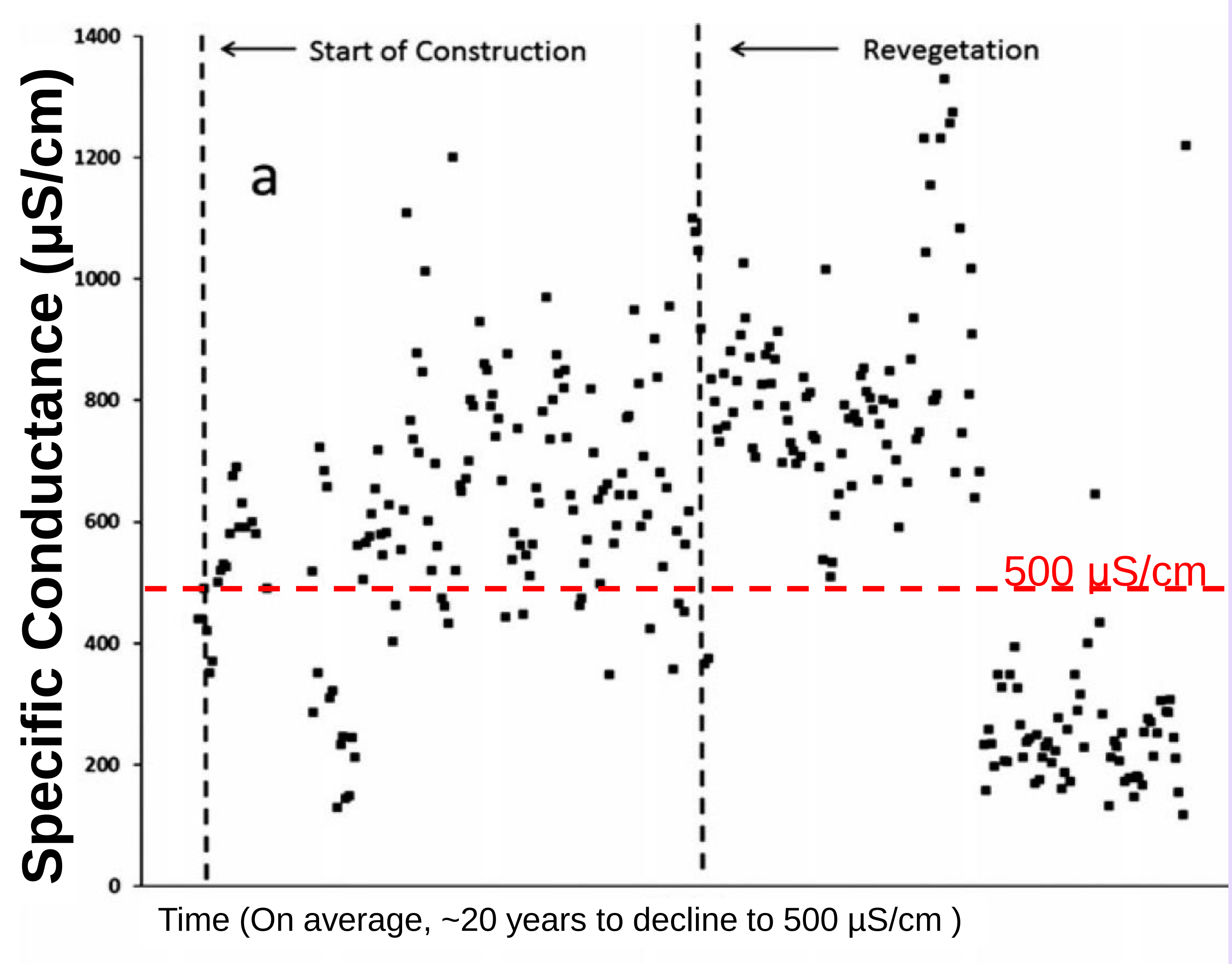


Evans et al. 2014. JAWRA 50: 1449-1460

Quality of water emerging from many valley fills is changing with time.



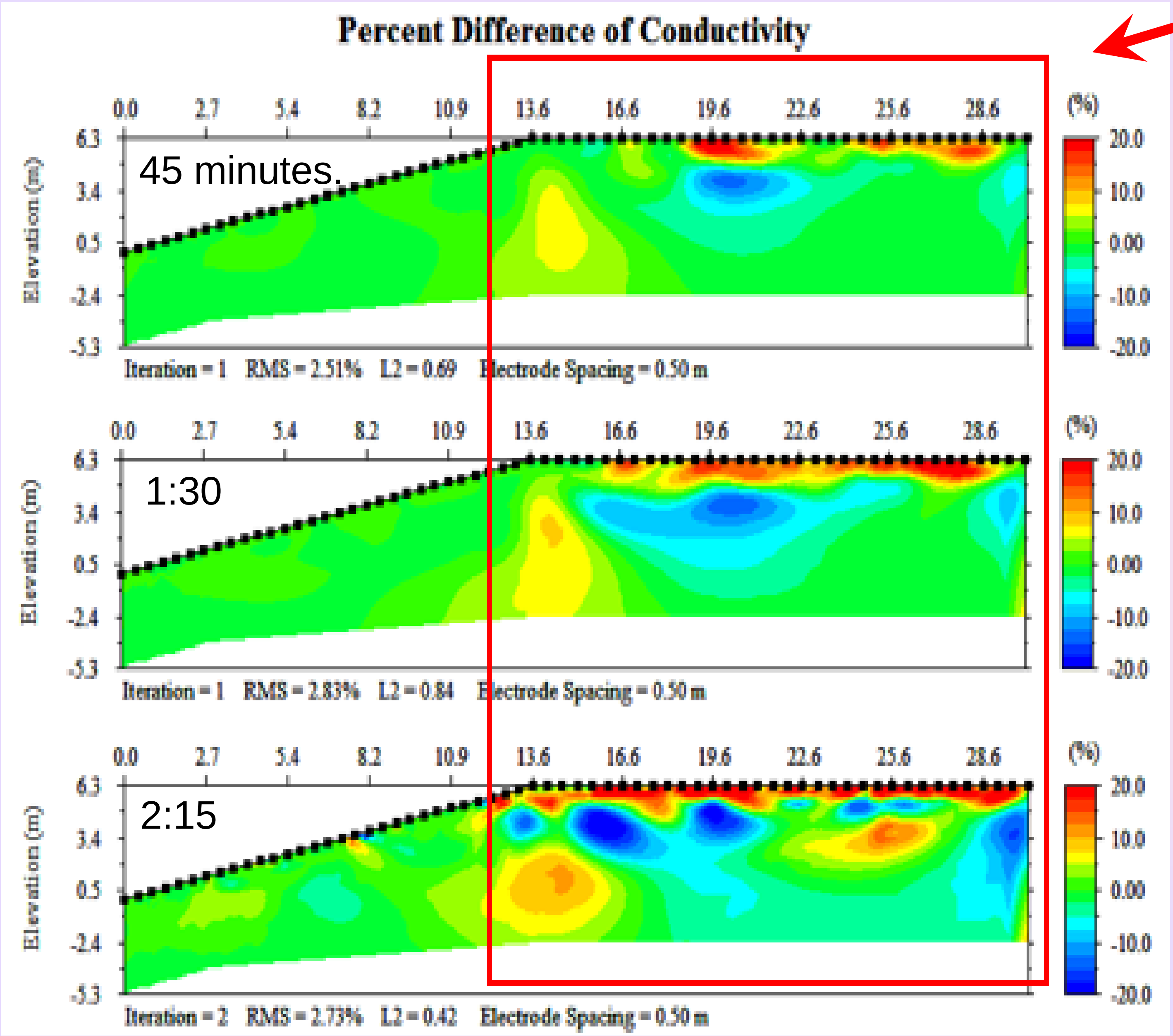
Example: SC of waters discharged by one valley fill over 20+ years (Virginia DMME database)



The older the valley fill, the more like it is to exhibit declining SC. On average: the older Virginia fills required ~ 20 years to reach 500 µS/cm

Electrical Resistivity Imaging: Water within a valley fill,

Response to Artificial Rainfall Application



Red Box: Area of artificial rainfall (pond water, 1.5 to 2 inches total) on a valley-fill cross section

Red & Yellow: moisture has increased.

Green: No detectable change.

Blue: Strong moisture contrast to adjacent red-yellow (no detectable change).

Source: B. Greer, M.S. thesis (E. Hester), VT

What have we learned?

- ✓ Spoil characterization procedures can predict relative differences between materials in the field - although under some circumstances, columns underpredict actual SC levels.

- ✓ Management of both spoil placement and water movement is essential to SC/TDS control.

- ✓ Known differences between spoils and valley fills – and known high-TDS practices* that can be changed -- suggest opportunities for improved TDS management– *if we try.*

* Known high-TDS practices:
  - ➢ alkaline/acid spoil blending;
  - ➢ lack of attention to high-TDS spoil placement;
  - ➢ lack of control over water movement into the fill.

Questions:

How to apply what is being learned?

How to build mine-spoil fills for reduced TDS in mine water discharge –

on the job?

Two experimental fills are being constructed.

1. Alpha / Paramont, 88 Strip near Duty: Under construction for approx. 3 years.
2. Teco / Clintwood Elkhorn, Spring Branch near Hurley: Drain construction began December 2014.

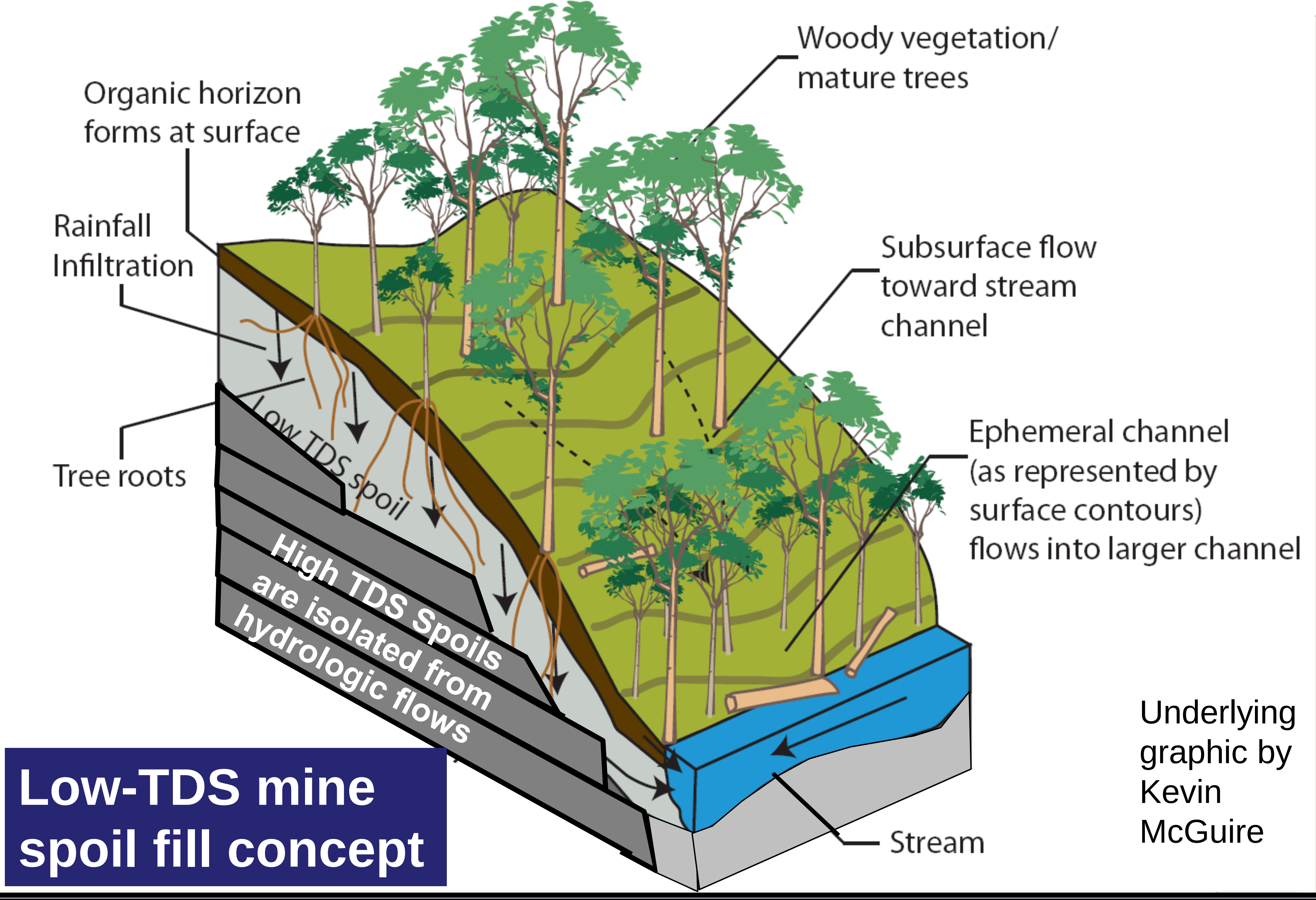
Similar strategies are being employed for the 2 fills – but with some differences

Waters emerging from experimental fills are monitored.

Conventional fills constructed in similar strata are also monitored for comparison.

Project Goals:

- ✓ ***Reduce TDS*** levels coming out of the fill, relative to TDS produced by fills constructed using conventional techniques.
- ✓ Produce surface-water flows that more closely approximate ***pre-mining hydrology*** than current fills.
- ✓ Establish a forest cover that will develop into a ***forested ecosystem*** resembling those which occur on nearby non-mined areas.
- ✓ ***Control costs*** to extent possible, as needed for profitable mining.



Low-TDS mine spoil fill concept

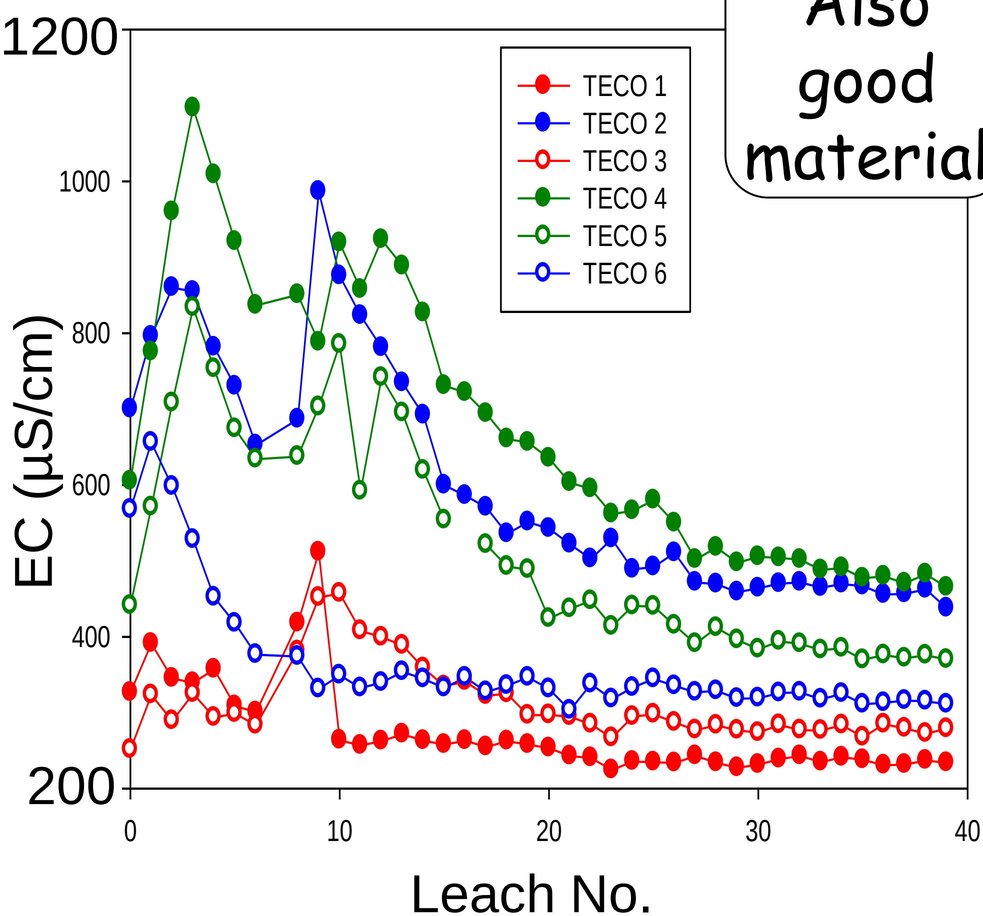
Mined Land, as envisioned: Forest and Hydrologic Restoration, Water Quality Protection. Operational prototypes being developed by industry.

Basic Strategies

Test spoils for TDS, segregate/handle accordingly.

Select for drains

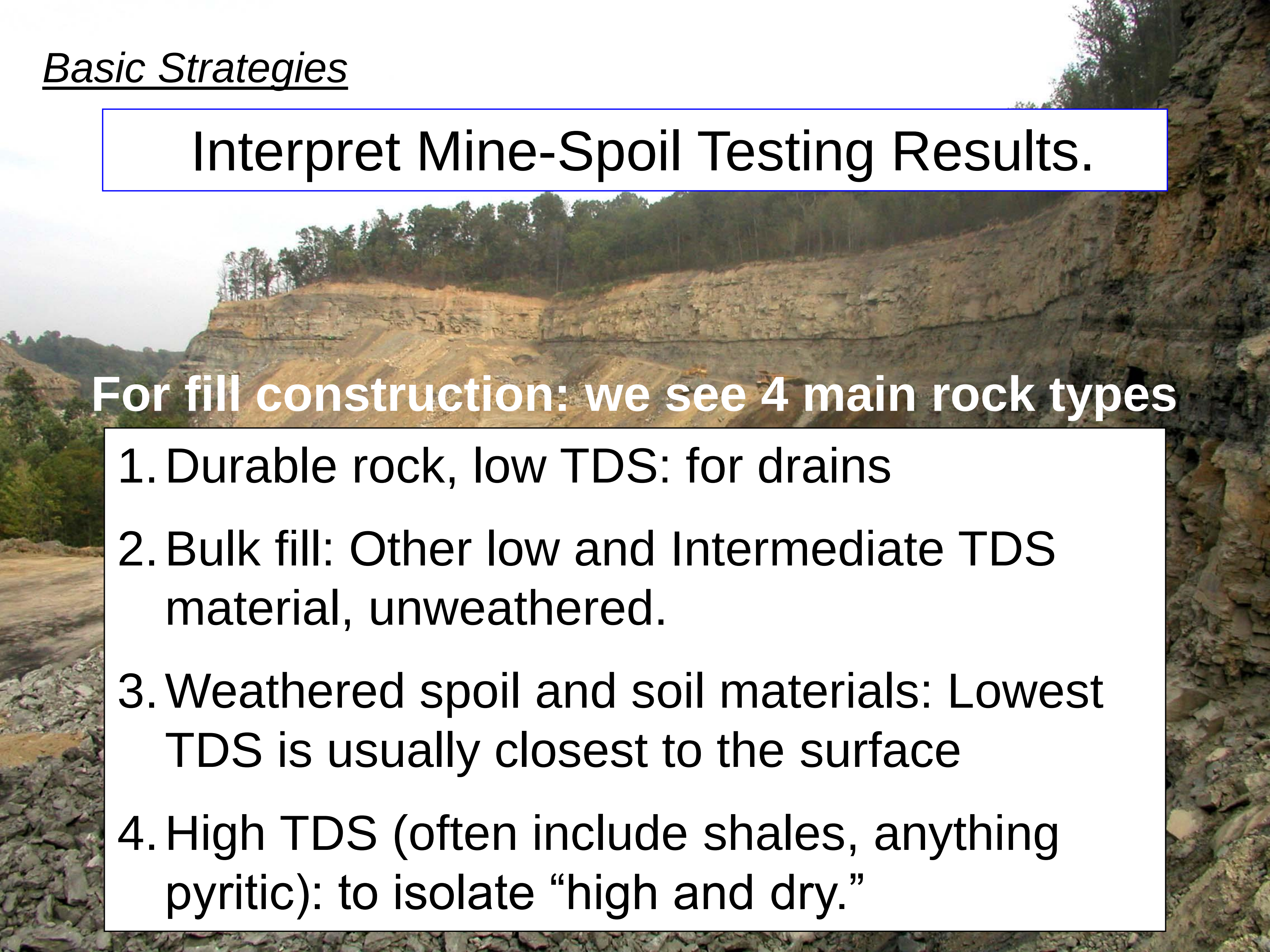
Also good material



TECO	DEPTH (ft)	ROCK TYPE COMPOSITION	(%)
1	462-520	gray sandstone	100
2	415-460	gray sandstone	37
		gray shale	31
		gray sandy shale	31
3	376-408	gray sandstone	66
		gray sandy shale	23
		gray shale	10
4	290-375	gray shale	83
		gray sandy shale	15
		minor sandstone	2
5	211-290	gray shale	50
		gray sandstone	26
		gray sandy shale	24
6	160-211	sandy shale	54
		gray sandstone	43
		brown sandstone	3

Basic Strategies

Interpret Mine-Spoil Testing Results.

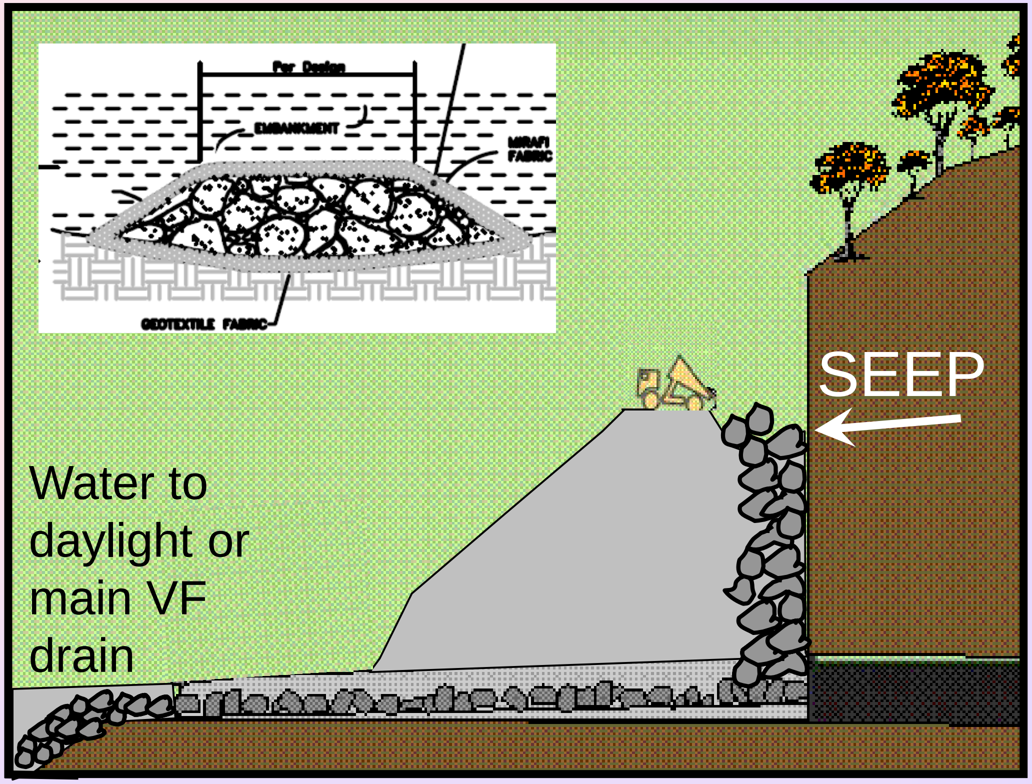


For fill construction: we see 4 main rock types

1. Durable rock, low TDS: for drains
2. Bulk fill: Other low and Intermediate TDS material, unweathered.
3. Weathered spoil and soil materials: Lowest TDS is usually closest to the surface
4. High TDS (often include shales, anything pyritic): to isolate “high and dry.”

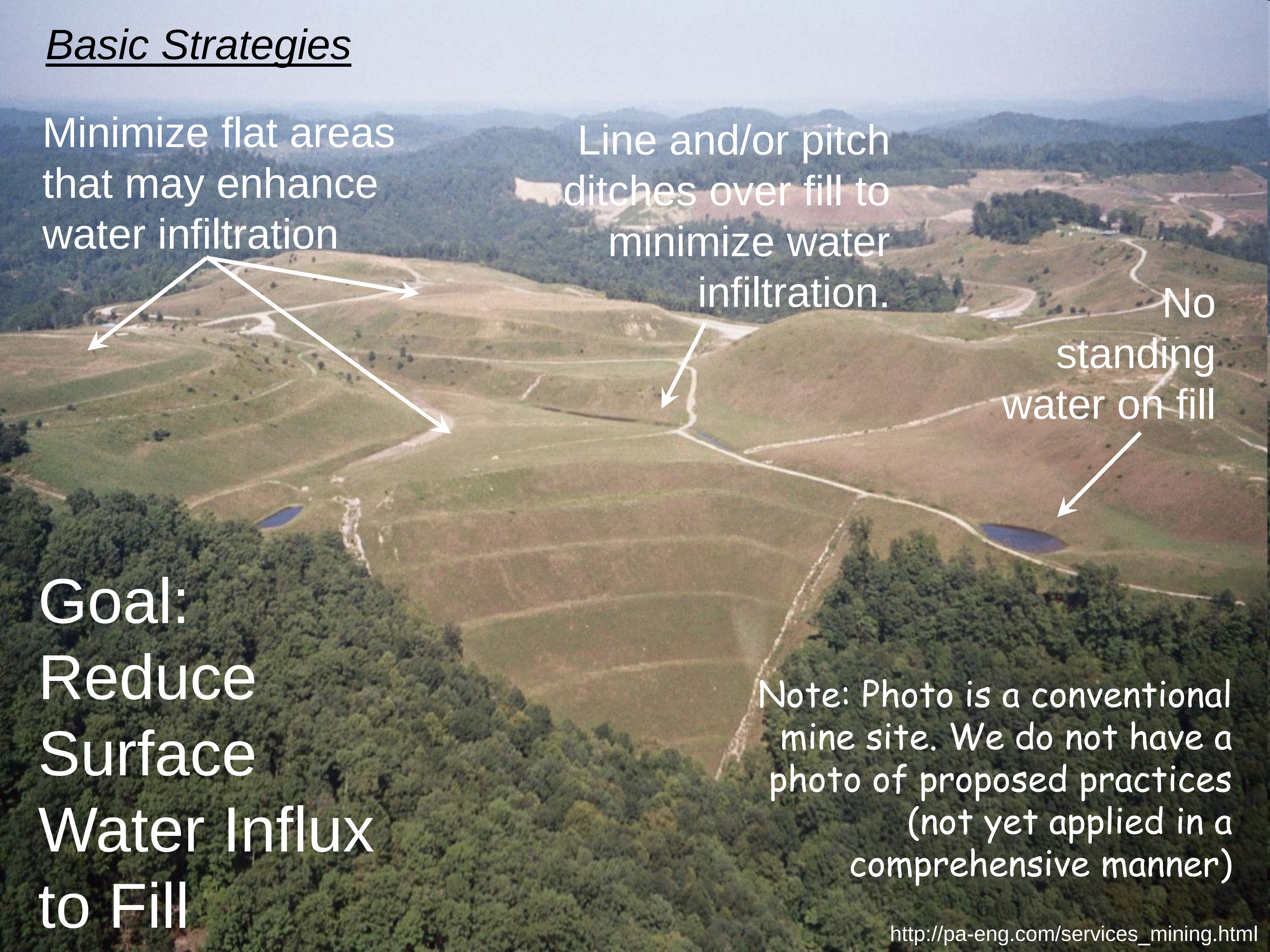
__Basic Strategies__

- Install drains to intercept known groundwater entries, direct waters to daylight along low TDS pathways.



Underdrain construction using selected low-TDS sandstone Paramont fill

Basic Strategies



Minimize flat areas that may enhance water infiltration

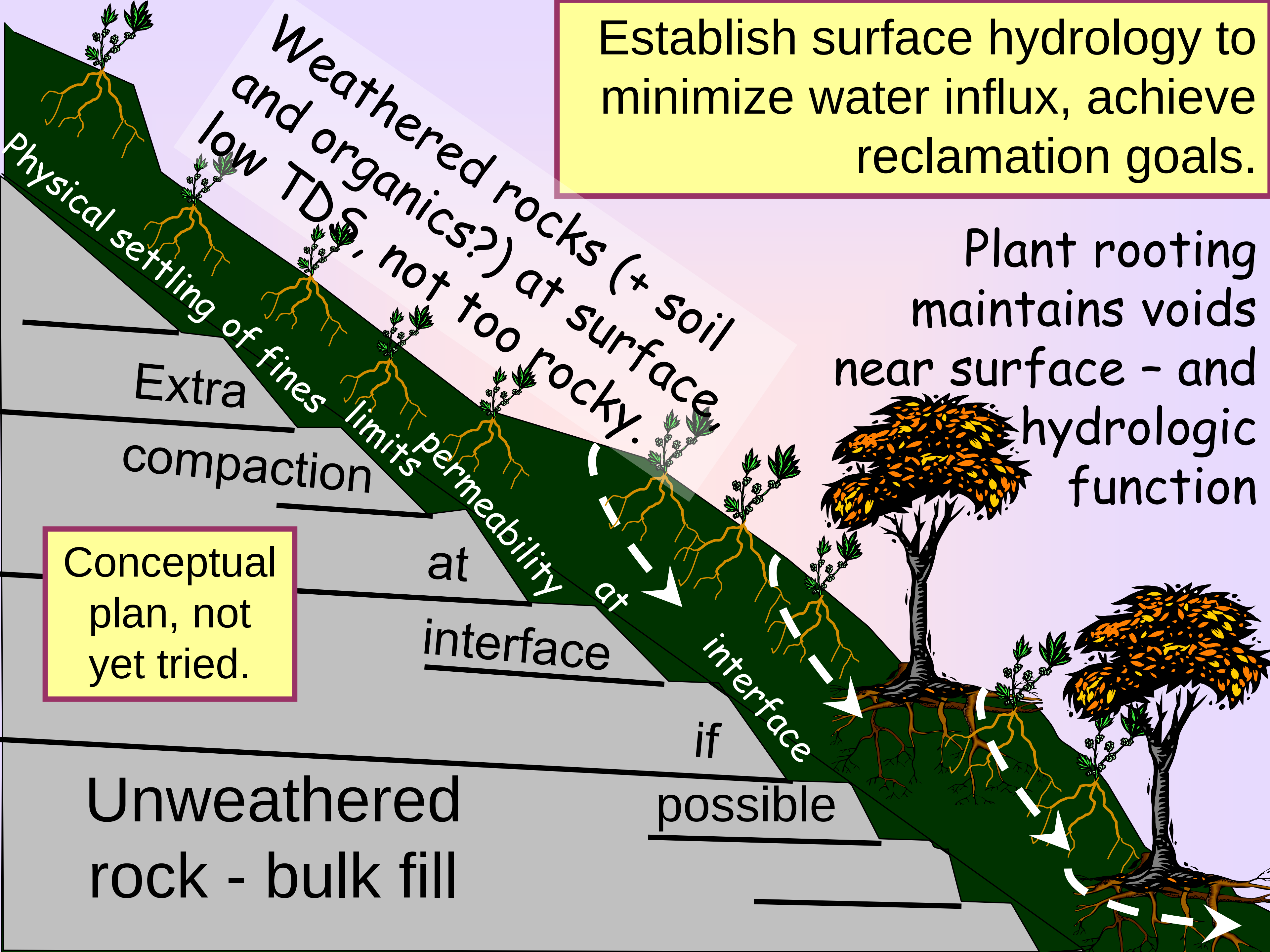
Line and/or pitch ditches over fill to minimize water infiltration.

No standing water on fill

Goal: Reduce Surface Water Influx to Fill

Note: Photo is a conventional mine site. We do not have a photo of proposed practices (not yet applied in a comprehensive manner)

http://pa-eng.com/services_mining.html


Establish surface hydrology to minimize water influx, achieve reclamation goals.
Weathered rocks (+ soil and organics?) at surface, low TDS, not too rocky.
Plant rooting maintains voids near surface - and hydrologic function
Physical settling of fines limits permeability at interface
Extra compaction at interface if possible
Conceptual plan, not yet tried.
Unweathered rock - bulk fill

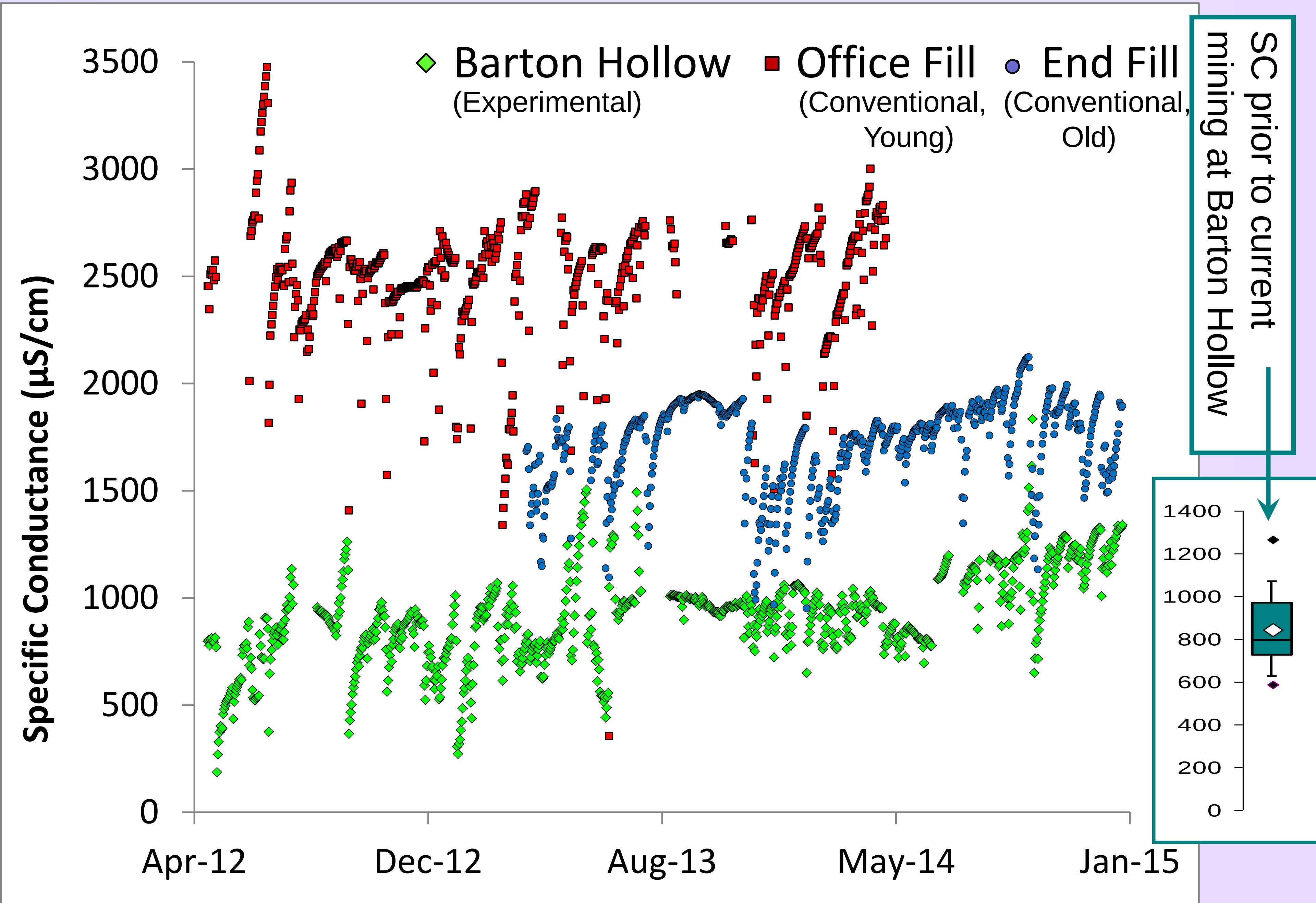
FRA: Operational Reclamation with VT Oversight, Age 6

Paramont / 88 Strip Fill Design:

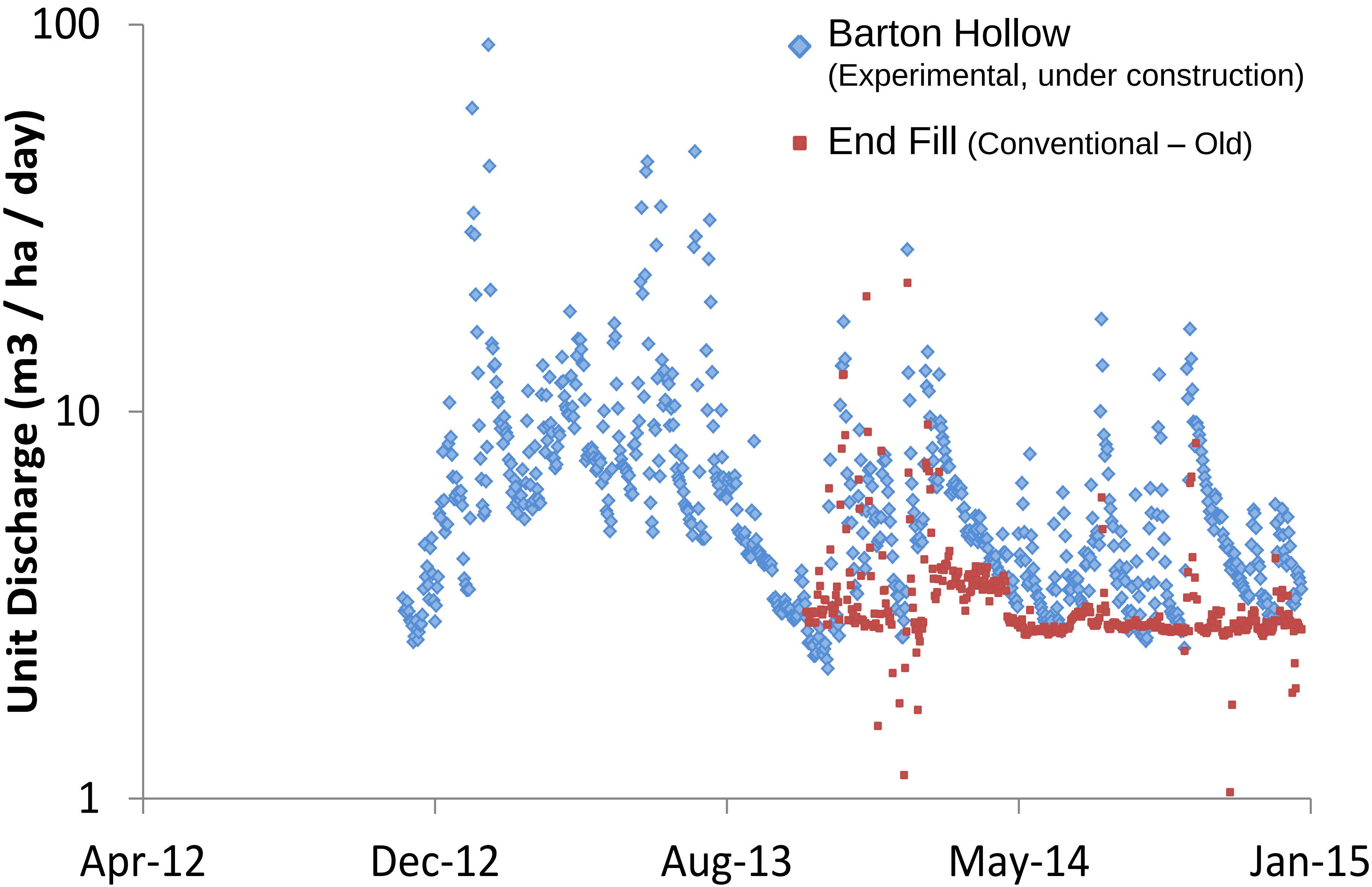
- Build low-TDS rock drains to collect groundwater from abandoned deep-mine seep and old valley fill being covered with new, larger fill.
- Use low-TDS spoils (including weathered material) to build fill.
- Build road down into fill, with weathered spoil base.
- Construct fill as compacted lifts, 25 foot, crowned.
- Contour surface with steep slopes, in effort to prevent seepage into fill.
- Cover with soil/weathered spoil where possible, reclaim with Forest Reclamation Approach.

At Paramont 88 Strip

Paramont 88 Strip Valley Fills: SC, Mean Daily Values



Paramont 88 Strip Valley Fills: Unit Discharge, Mean Daily Values



Teco, Spring Branch Fill Design:

- ❖ Build low-TDS rock drains to collect *<u>all</u>* ground-water (including highwall seeps) for gravity discharge.
- ❖ Isolate high TDS spoils "high and dry".
- ❖ Loose dump bulk spoil over drains.
- ❖ Contour surface with steep slopes, in effort to prevent seepage into fill.
- ❖ Build all channels to prevent seepage into fill.
- ❖ Cover with soil/weathered spoil where possible, reclaim with Forest Reclamation Approach.
- ❖ Minimize open-spoil areas, to extent possible.

Teco (at Hurley)

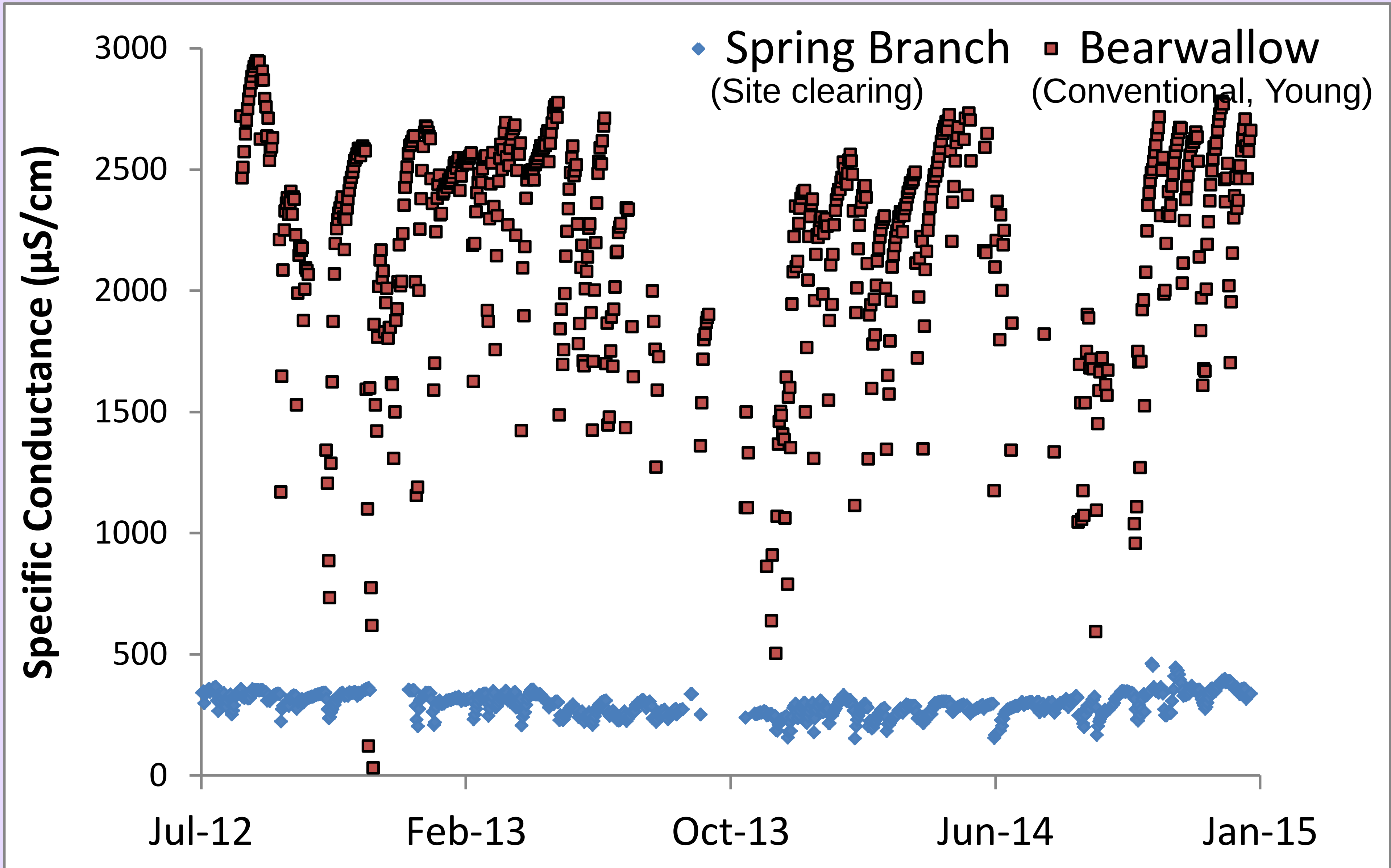
Bearwallow (conventional)

Spring Branch (experimental)
Photo: 1/15

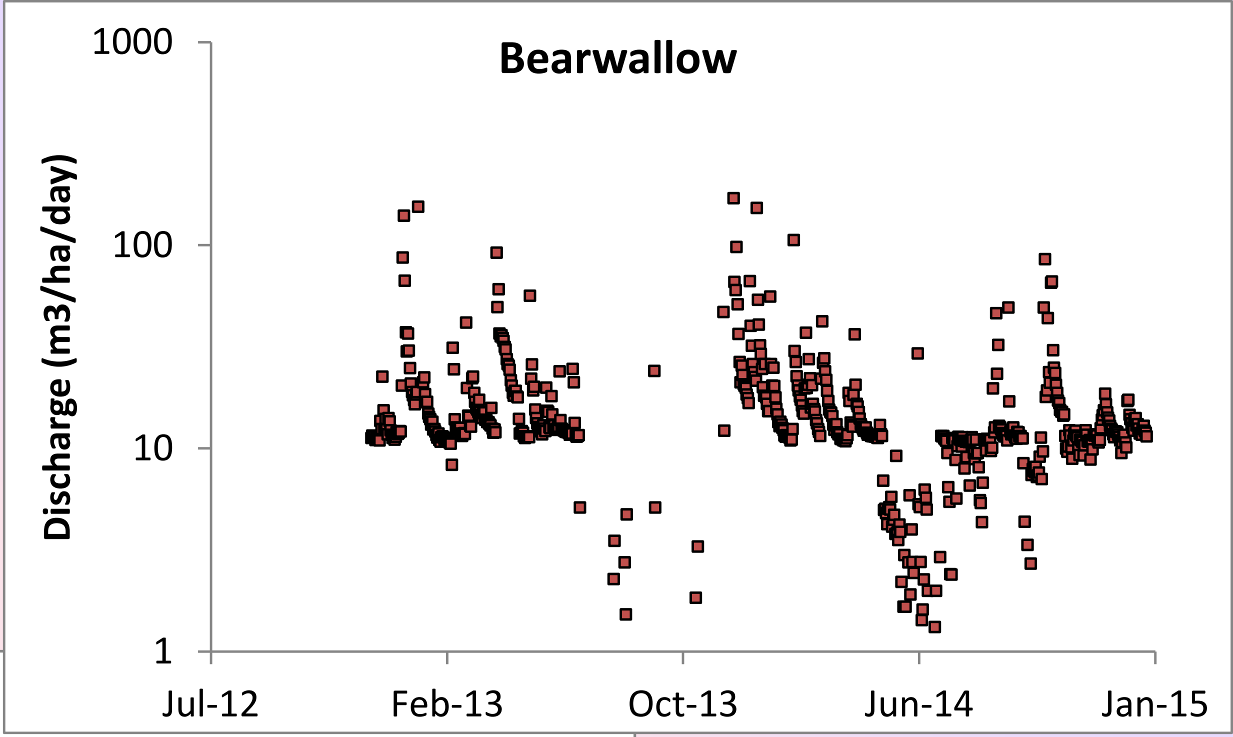
Flume at Bearwallow

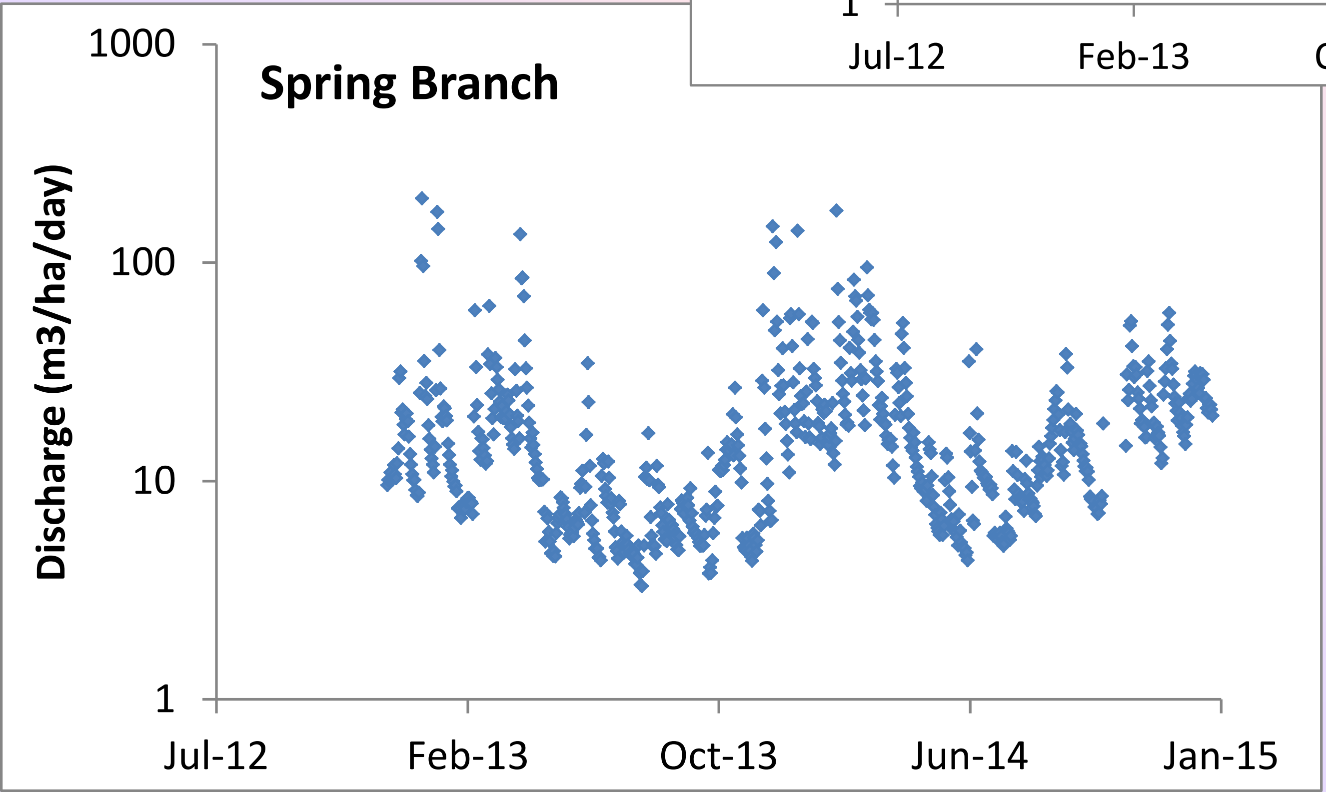
Spring Branch below flume

Valley Fills at Teco Hurley: SC, Mean Daily Values

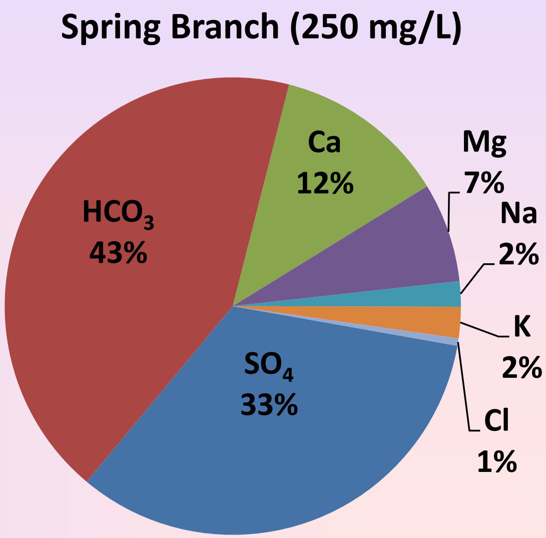


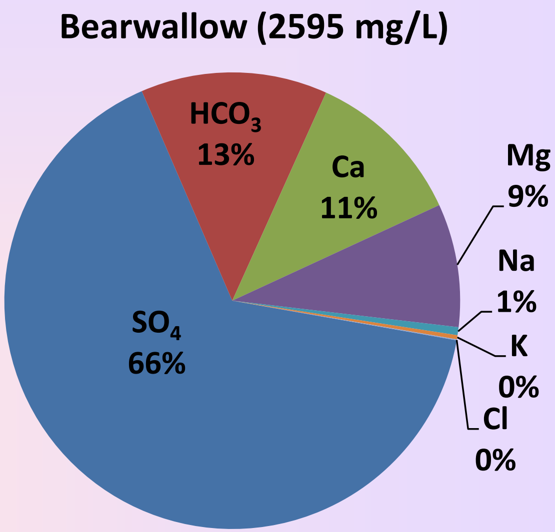
Valley Fills at Teco Hurley: Unit Discharge, Mean Daily Values

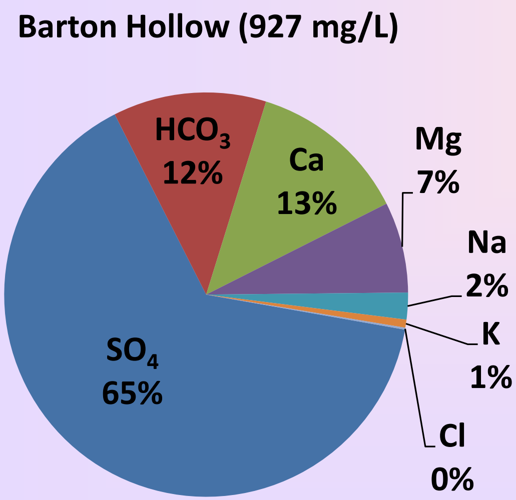


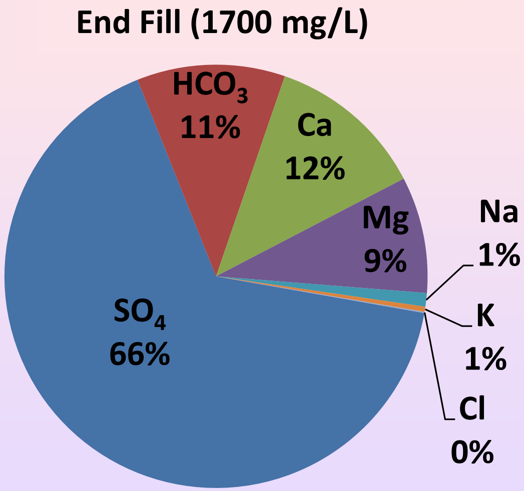


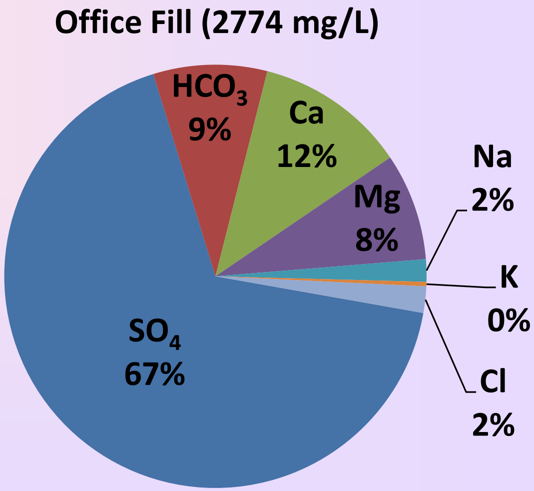
Water chemistry: Means of all samples to date.











Conclusions

Spoil testing and characterization can differentiate mine spoils based on TDS generation potentials.

Valley fills exhibit significant variation in SC discharge, suggesting opportunities for SC management in mine spoil fill construction.

Two Virginia valley fills are designed to test different SC management strategies; construction of both are underway.

This study 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."

Thank You!

ARIES: Current and major funding

Powell River Project: For startup

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Chris Stanley, Dale Harrell, Gene Boyd, and others, Teco

Roman Lawson, D&H Engineering

Lance DeBord, David Allen, Tim Browning

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