The Interstate Technology and Regulatory Council

Biochemical reactors for treating mining influenced water

Paul Eger, Global Minerals Engineering

Cherri Baysinger, Missouri Health and Senior Services

David Cates, Oklahoma DEQ

Steve Hill, RegTech

Overview

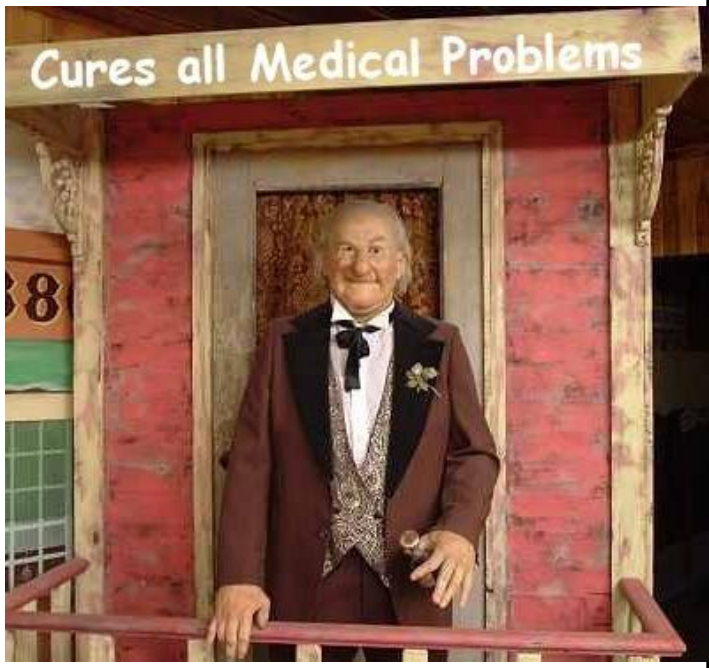
- Interstate Technology Regulatory Council (ITRC)
  - What is it?
  - Why does it exist?
  - What does it do?
- Mine waste team
  - History
  - Mine Waste Guidance
- Biochemical Reactor guidance

Vision

To be the market-recognized “go-to” provider of guidance and training on **innovative** solutions to protect human health and the environment

Innovative Technologies

Or



Innovative Technologies

The BIG Question?

Can I get a permit for this?

We're from the government and we'd like to help....

Addressing Regulatory Barriers and Technology Guidance

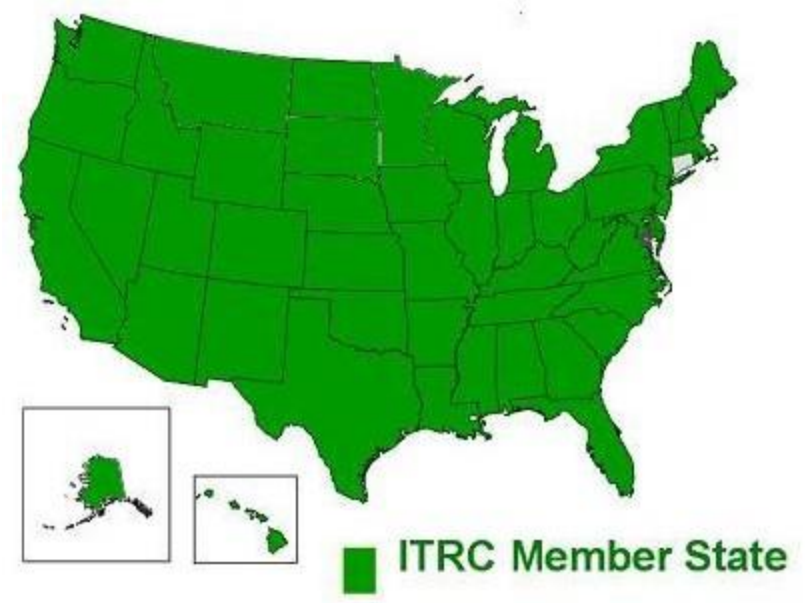
ITRC–Interstate Technology & Regulatory Council

State led organization

Host Organization

ECOS

ITRC State Members



Federal Partners

DOE EPA DOD

Industry, Academia, Consultants, Citizen Stakeholders

Why ITRC?

- Large cleanups required at Department of Defense and Energy sites
- Conventional technologies were too expensive
- Innovative approaches were needed
- Common problems at sites throughout the country
- Once proven a method to streamline acceptance was needed
  - "Don't reinvent the wheel"
- ITRC started in 1995

Goals

- Increase state acceptance of innovative technologies
- Streamline state permitting processes

Goals

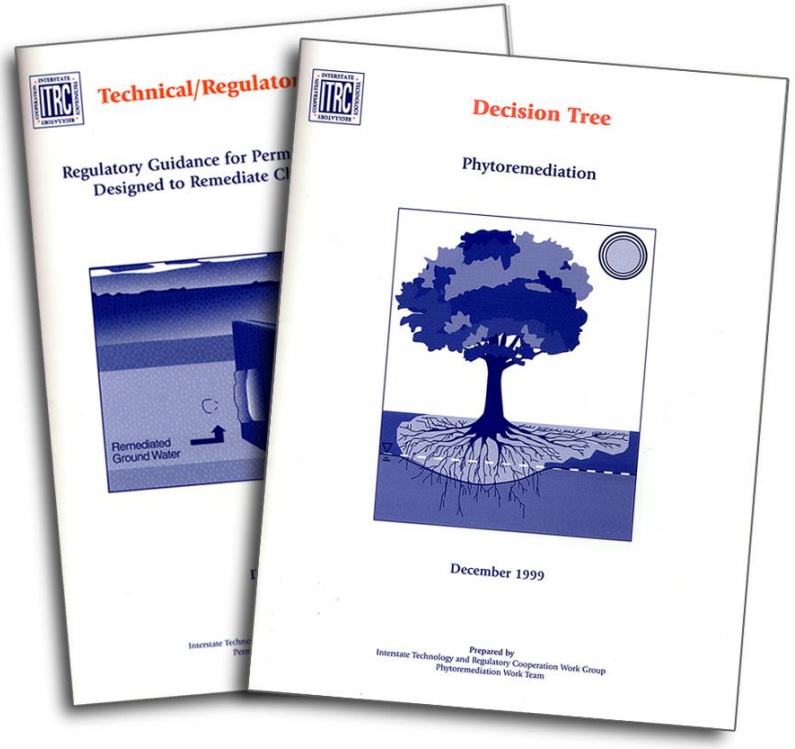
- Achieve better environmental protection through innovative technologies
- Identify and remove technical or regulatory barriers to the use of innovative technologies
- Build confidence about using innovative technologies

ITRC Process

- Proposals developed and ranked by states
- Teams are formed to solve the priority problems
  - State led
    - Minimum of 5 states
  - Industry
  - Federal agencies
  - Academia
  - Public stakeholders

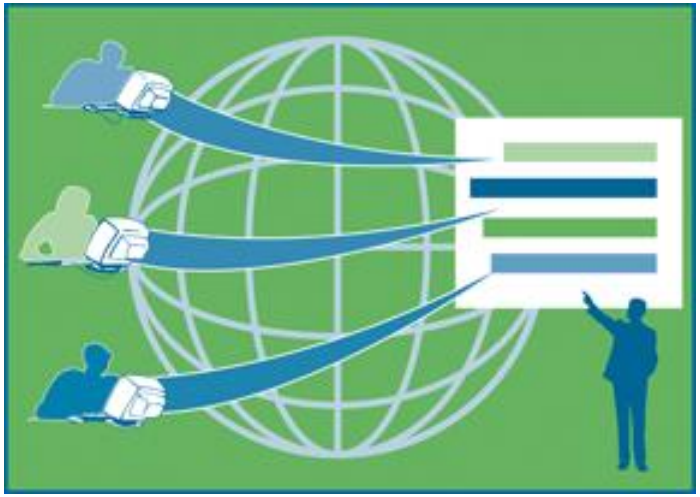
ITRC Process

- Products
  - Case studies
    - Applications
  - Technology overview
    - Team evaluation
  - Guidance document
    - Over 55 produced
    - Constructed Treatment Wetland
    - Phytotechnology
    - Permeable Reactive Barriers



ITRC Process

- Training
  - Free Internet
    - Over 90,000 participants
  - Classroom



Mine Waste

A BURNING ISSUE

History

- Mine waste team started 2007
  - White paper
  - State issues
- Problem based guidance
  - identify and evaluate innovative & cost effective technologies
  - Solid mine waste
  - Mining influenced water
- First web based guidance

Web Advantages

- Interactive
  - Easy to navigate
- Graphics
  - Color images, photos, etc can be used for illustration
- *Flexible*
  - Easier to update site as new information or case studies become available

Mine Waste Guidance

- Web-address: www.itrcweb.org/miningwaste-guidance
- Quick tool to identify appropriate technologies
  - Flow charts
  - Technology overview
  - Advantages/ limitations

Why Biochemical Reactors

- Promising technology
  - More information needed
- Case studies
- Technology guidance

Biochemical Reactors

- ***Engineered treatment system that uses an organic substrate to drive microbial and chemical reactions to reduce concentration of metals, acidity, and sulfate in MIW (mining influenced water).***

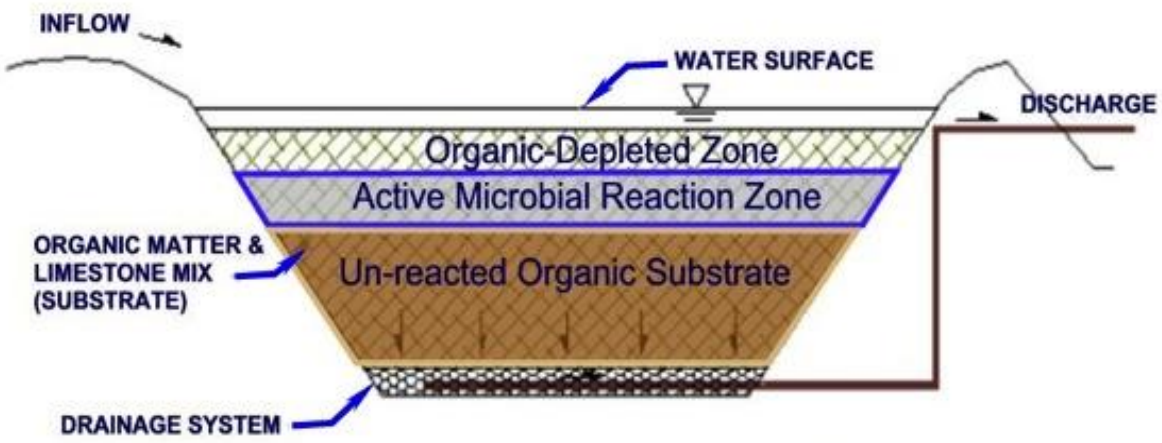


Table of Contents

How does a BCR work?

Guido Sarducci's
5 Minute University

INTRO TO BCRS

What Does a BCR Do?

- Precipitate metals and metalloids
- Produce circumneutral waters

Iron precipitate in a BCR

Golinsky BCR, Lake Shasta, CA

How Does a BCR Do That?

- Sulfate reducing bacteria
  - Common bacteria
  - Present in soil
  - High concentrations in manure
- Remove sulfate by reducing it to sulfide
- Need oxygen free environment, sulfate, and an electron donor
  - Usually organic compound

Photo of sulfate reducing bacteria

Chemistry 101

- Sulfate reacts with organic carbon
  - Produce hydrogen sulfide and bicarbonate
  - Hydrogen sulfide reacts with metals
  - Produce metal sulfide and hydrogen

$$SO_4^{-2} + 2\,CH_2O = H_2S + 2\,HCO_3^-$$

$$H_2S + M^{+2} = MS\,(solid) + 2H^+$$

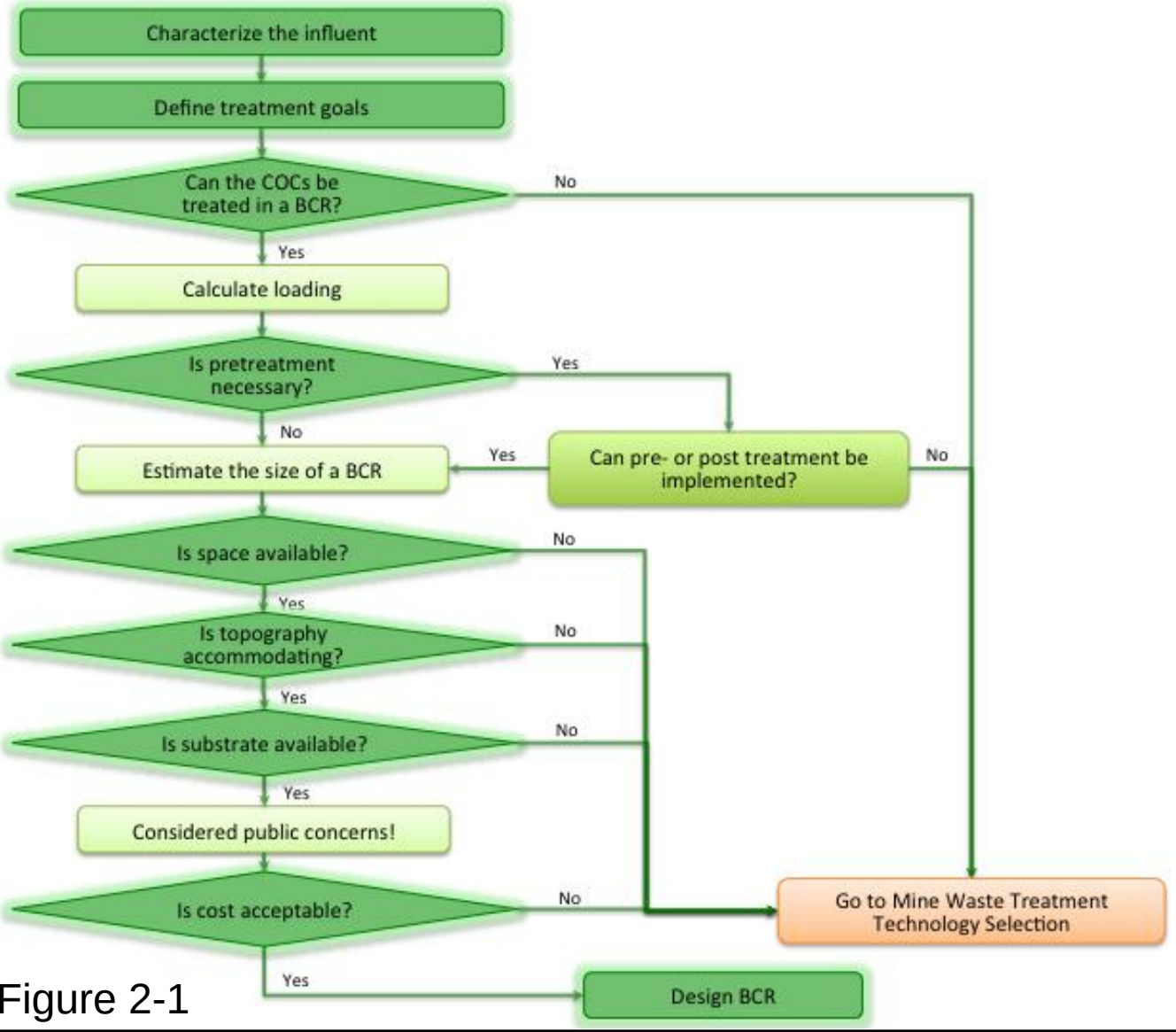
- Limestone is often necessary
  - Increase the alkalinity
  - Consume hydrogen
  - Thus raise the pH

$$2H^+ + 2HCO_3^{-1} = 2\,H_2CO_3$$

$$2H^+ + CaCO_3(solid) = Ca^{+2} + 2HCO_3^{-1}$$

- If there is not enough M^{+2}
  - H_2S will be lost as a gas

Determining Applicability of BCR



ITRC BCR-1, 2013: Figure 2-1

Is My Water BCR-Worthy

Periodic Table of Treatable Elements

Elements in Blue can be treated in a BCR

1 H	2											13	14	15	16	17	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac~	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 ---	111 ---	112 ---		114 ---		116 ---		118 ---

Actinide Series: 92 U

Figure courtesy of Jim J. Gusek, 2009

Treatability Testing

- What is needed for treatability testing?
  - Site MIW
  - Substrates

Hay

Wood Chips

Limestone

Testing

- Proof of Principle
- Bench
- Pilot

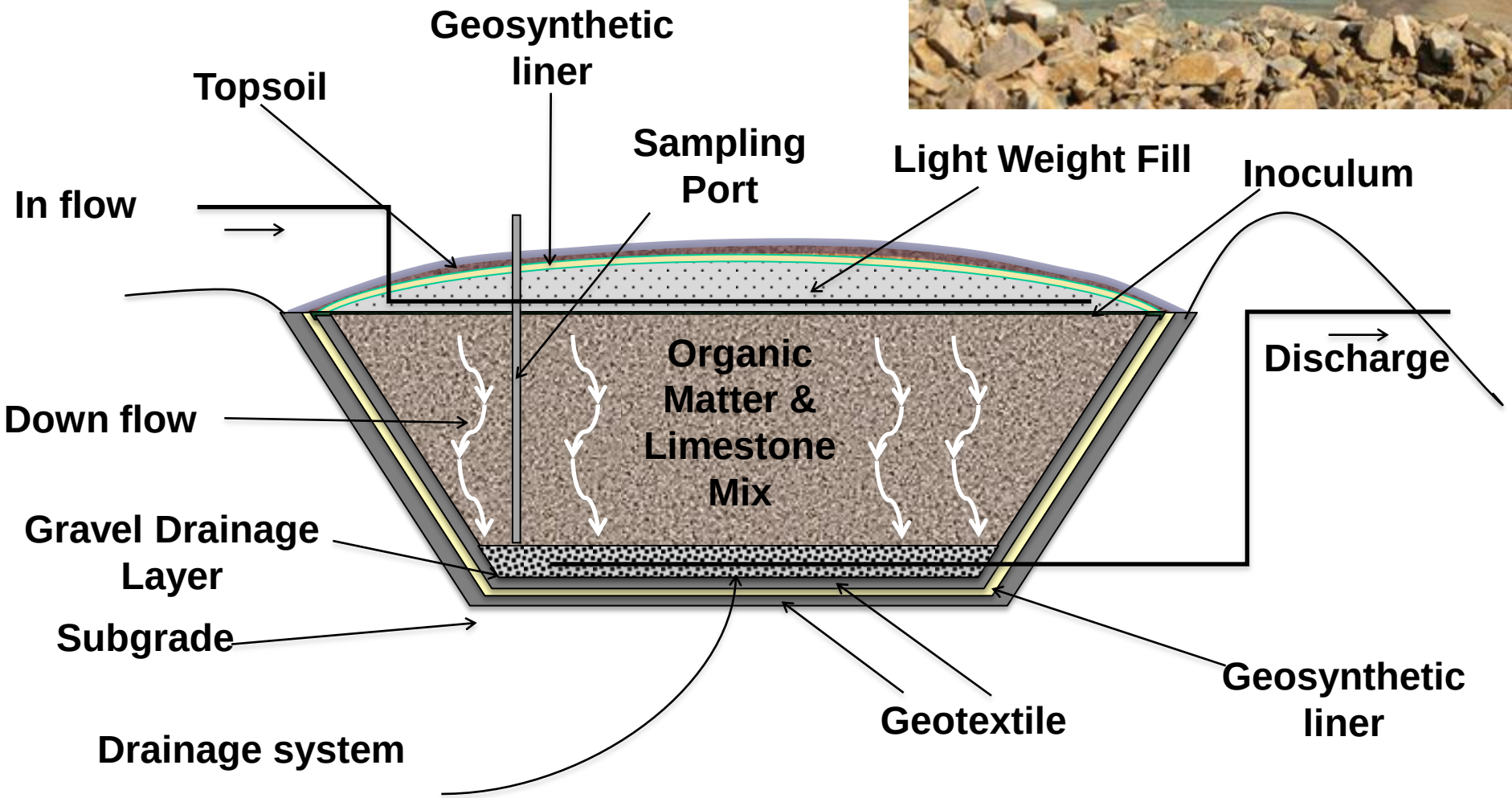
Design Inputs

- Detailed design inputs
- Characterization
  - MIW flow and quality
    - Average and extremes
  - Site
    - Workable area available
    - Detailed site map
    - Climate
      - Average
      - Extremes
  - Treatment goals
  - Pre-and post-treatment?

Performance Data

- Seasonal variability
- Loading range
- Residence time
- Substrate mixture
  - Thickness
  - Degradation rate
  - Metal removal efficiency

Construction



Does It Have To Be So Complex?

- Goals
  - Best Management Practices or National Pollution Discharge Elimination System
- Size
- Setting

Operation, Monitoring, Maintenance

- 6. System Start-up, Operation, and Maintenance
  - 6.1 System Start-up
  - 6.2 Monitoring and Maintenance Activities
  - 6.3 Maintenance
    - 6.3.1 Substrate Nutrient Change Out
    - 6.3.2 Troubleshooting
  - 6.4 Sampling Protocol
  - 6.5 Contents of an Operation and Maintenance Plan

Issues

- Technical
- Regulatory
  - Permitting
  - Water Quality Standards
  - Disposal of Residual Materials
  - Wetlands
- Stakeholder
  - Community, tribal concerns
  - Liability
  - Use of MIW as a Resource

Key Messages

1. BCRs are *viable alternatives* for treating MIW, even in remote areas
2. BCRs are *site-specific*
3. BCRs are not *walk away* systems

What does this guidance do for me?

- Convenient *resource* when considering a BCR
- Overview
- Audience
  - Practitioners
  - Regulators
  - Clients

http://itrcweb.org/bcr-1/

Next training: September 23, 2014 2:00 PM - 4:15 PM EST

Biochemical Reactors

The perfect should not be the enemy of the good

Advantages

- Low energy requirements
- May be low maintenance if designed properly
- Can be used in remote situations
- Removes metals
- Flexible and versatile
- Treats wide variety of MIW
- Will improve ecological function of receiving stream

Cautions

- BCRs may not consistently meet strict water quality standards
- BCRs are not *walk away* systems
- Monitoring is required
- Maintenance may be needed periodically

Operation/Maintenance/Monitoring

- Troubleshooting

Regulatory – Residuals and Wetlands

- Disposition of residual materials (for example, spent substrate)
- Wetlands
  - Mitigation
  - Attractive nuisance
  - Decreased BCR performance
- ITRC's Wetlands documents
  - Constructed Treatment Wetlands (WTLND-1, 2003)
  - Characterization, Design, Construction, and Monitoring of Mitigation Wetlands (WTLND-2, 2005)

Stakeholder Concerns

- Community concerns
  - Noise
  - Attractive nuisance and safety
  - Hydrogen sulfide odor
  - Public outreach

BCR in Central City, PA.
Note the houses in the background

Stakeholder Concerns (cont.)

- Tribal concerns
  - Clean Water Act Authority
- Volunteer groups
  - Watershed groups
  - Abandoned mine sites

Fran Coal Mine MIW

Liability Concerns

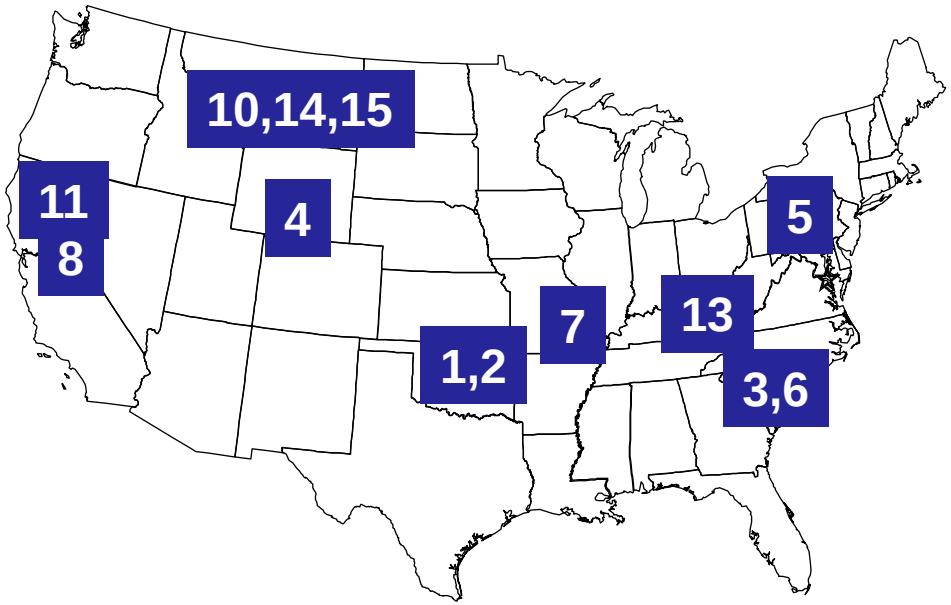
- Liability of Good Samaritans
- Disposal of spent substrate
- Effluent compliance
  - NPDES versus Infiltration or Recharge

The perfect should not be the enemy of the good

What does this do for me?

BCR Case Studies

1. Beaver Creek, OK
2. Mayer Ranch, OK
3. Haile Mine, SC
4. Ferris Haggerty, WY
5. Fran Coal Mine, PA
6. Brewer Mine, SC
7. West Fork, MO
8. Leviathan, CA
9. Wheal Jane, UK
10. Peerless Jenny, MT
11. Golinsky Mine, CA
12. Dankritz Mine, Germany
13. Copper Basin Mine, TN
14. Lady Leith Mine, MT
15. Luttrell, MT



Not on map:
9 Cornwall, England
12 Sachsen, Germany

ITRC BCR-1, 2013: Appendix B

Approach

- Problem based technology/regulatory guidance
  - Multiple technologies solve problems
  - Select appropriate technologies
- Optimize your approach
  - Clean up the source
  - Clean up the media