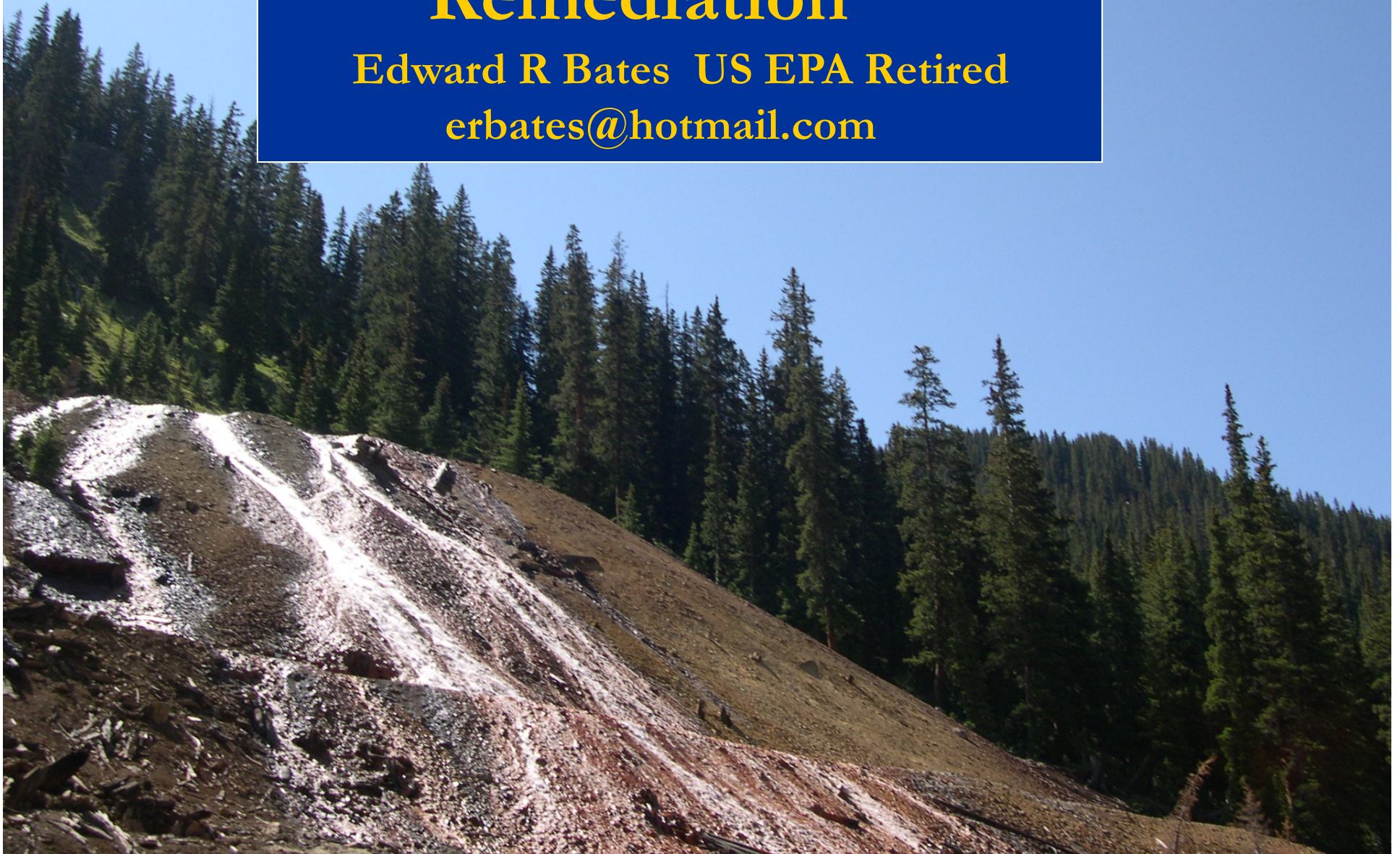


Legacy of Innovative Remediation

Edward R Bates US EPA Retired
erbates@hotmail.com



Presentation Overview

- Legacy of innovative projects
- Suggestions going forward

Legacy of Innovative Approaches

Keep Clean Water Clean

Leviathan



Bat Gate and Polymer Seal to Close Adits

US Forest Service



Pit Lake and Very Acid Rock

NEVADA
GOLDFIELDS
INC.

BARITE HILL PROJECT
MINE SITE

P.O. BOX 1510
McCORMICK, S.C. 29835
(803) 465-3321

**Barite Hill --Remediation of Hot Waste Rock via
Grading and Capping
Deep Quench(at 400 feet) of Hottest Material**



A photograph of Barite Hill Pit Lake, showing a large body of water with a reddish-brown shoreline. A man in a light blue shirt is standing in the foreground, looking towards the lake. A large pine tree is on the right side of the frame. The text is overlaid on the left side of the image.

**Barite Hill Pit Lake
After Remediation and
Establishing a viable
SRB culture**

**Waste Rock/Tailings USFS New Mexico Site
One Third leached Pb... treated with TSP
Rest only Contact/Ingestion Hazard... cover**



Tailings/Rock.....

Chemical Immobilization

- Many Metals... Add Alkali...acid base accounting
- Pb...Add Phosphates
- As...Add iron or iron compounds
- Hg...Polysulfides, ZVI

Leviathan Lime Lagoon ..needs lots of space



Active and Semi-Passive Lime Treatment of Acid Mine Drainage at Leviathan Mine, California EPA/540/R-05/015) 2006

RCTS Technology

Lime Rotating Cylinders

Treated 9 million gallons in 2011
Tim Tsukamoto, Ionic Water Technologies, Leviathan



ZVI PRB for Arsenic—East Helena, MT

Rick Wilken - EPA



Bioreactors

More Appropriately Called

Bio-Chemical Reactors

Big 5 Portal –Const Wetland/Bioreactor 1987-1990.....CDM, CSM, EPA

Handbook for Constructed Wetlands Receiving Acid Mine
Drainage (EPA/540/R-93/523) 1993



Burleigh Tunnel Compost Bioreactors

1994-1997....EPA, State of Colorado

Anaerobic Compost-Constructed Wetlands System (CWS)

Technology (EPA/540/R-02/506) 2002



BLM and Karl Ford have constructed several bioreactors--this one near Silverton in operation over 7 years when photo taken in 2007



Luttrell Bioreactor Ten Mile Range, MT

Jim Gusek and David Reisman, built 2002



Luttrell Bioreactor Proved

- **Bioreactor can be built for very cold climate**
- **May become a frozen poop-sickle in winter**
- **Will thaw and still work well**

*So Where Are We Going To Build
This Bioreactor ? Golinski Mine, CA*



No flat area ? Pipe the water to a flat area photos Jim Gusek, Golinski Mine



Leviathan Bioreactor System



Slope Stability Analysis Preceded Const.



Leviathan Uses Cobbles Not Organic Substrate

Microbes Fed Ethanol

Gravity Flow or Recycle

Designed in 2001-2002 by Tim Tsukamoto, Glenn Miller, Ed Bates



Innovative Use of Standpipes, In Place of Valves, to Control Flows



In Recycle Mode, Metals are Precipitated Outside the Bioreactor in a Settling Lagoon (black plume)



Leviathan Rock Substrate Bioreactor

- In continuous successful operation since 2004
- Has survived several upset conditions
- Has been successfully flushed following an upset
- Treated 7 million gallons in 2011
- Unplanned down time 0.4% in 2011
- Remote monitoring/operation

Compost-Free Bioreactor Treatment of Acid Rock Drainage
Leviathan Mine, California EPA/540/R-06/009 2006

www.epa.gov/region9/leviathanmine

Nacimientito Mine Bioreactor

Design by Tim Tsukamoto, Ed Bates

- Forest Service New Mexico
- Treating groundwater plume (pumped)
- Rock substrate, recycle, bioreactor
- Constructed Fall 2008, start-up Spring 2009
- Treated 18 million gallons thru 2011
- Turned off for 1 year, restart with success

Nacimiento Mine

USFS- New Mexico-Treatment of Groundwater



Nacimiento Bioreactor Under Construction



Nacimiento System- 2011



Suggestions Future Directions

- Better define eng. properties of rock reactors
- Expanded use of both organic and rock reactors
- Better partnering between regulators & mining
- View impacts/remediation on watershed basis

Better Define Eng Properties of Rock Reactors

- Optimum size of rock
- Treatment capacity per unit of volume
- Define microbe culture
- Investigate use of wastes as food
- Reduce/increase food with loading
- Reduce hydrogen sulfide emissions

Expand Use of Both Organic and Rock Reactors

- Improved designs available
- Both gravity and recycle modes
- Remote monitoring feasible
- In mine use of bioreactors

Better Partnering Between Regulators & Mining

- Increased R&D cooperation
- View re-mining as a solution to pollution
- Ease discharge requirements for re-mining existing sources
- Consider alternative legacy cleanup to full compliance on some point discharges

View Impact/Remediation on Watershed Basis

- Allocate \$ to achieve a clean stream, not just on basis of total load removed
- Relax discharge requirements for innovative cleanup of legacy sites
- Encourage good Samaritan cleanups
- Think broadly--remediating 90% of 5 sources may be better than 99% of 1 source

Some Final Advice

Think Outside the Box



What food can you feed to Rock Substrate bioreactors ???



Can you feed ethanol to
organic substrate bioreactors ???

Yes !!!

“Beats the heck out of eating
crap and sawdust”, actual quote
from a microbe

Don't Let Your Thinking Get Locked Up In A Knot





Get the Best Help You Can Find
Regardless of Species

If Desperate : Hire Consultants



END



Comparison Gravity-Recirculation

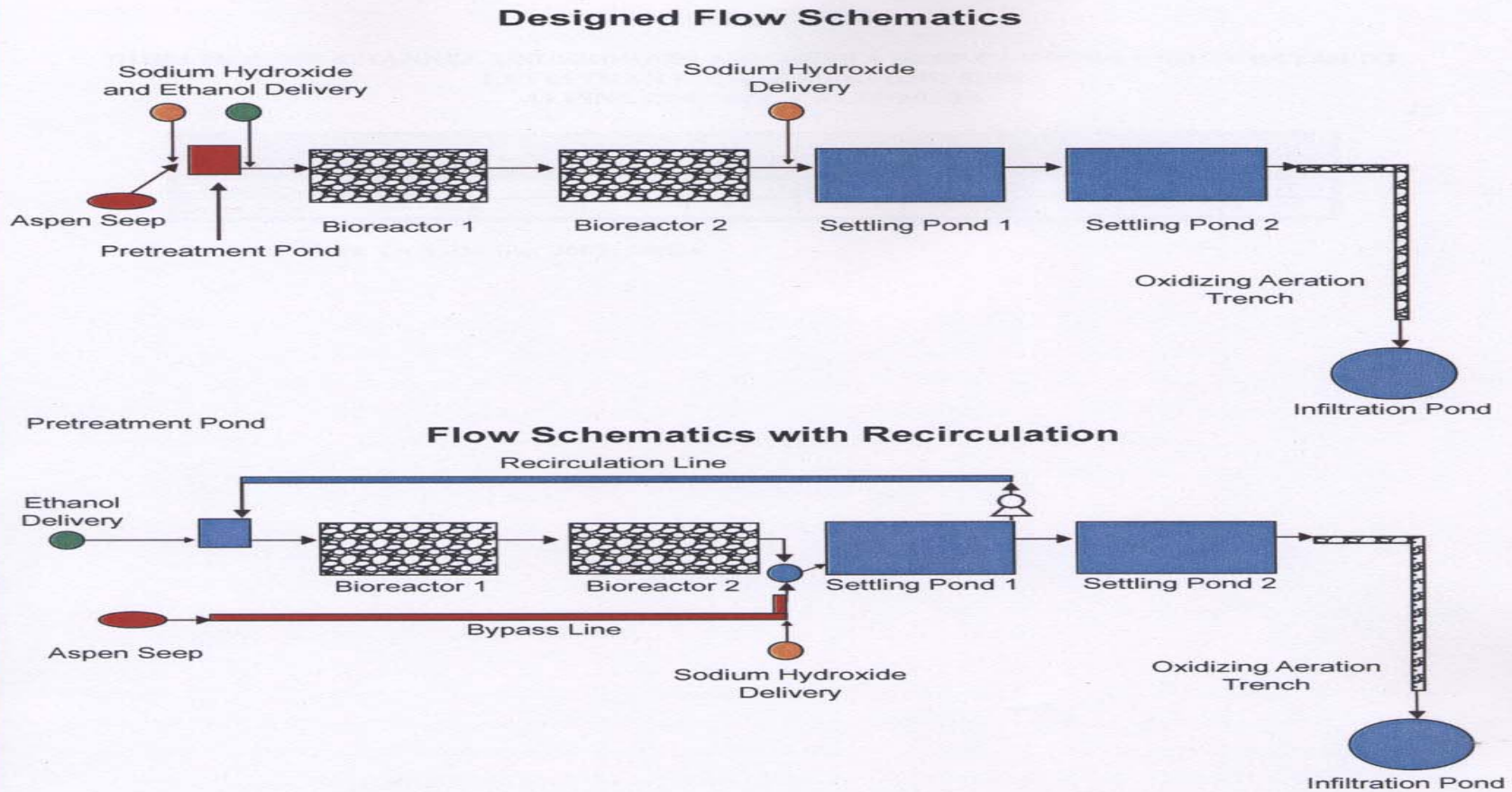


FIGURE 2-6
COMPARISON OF ASPEN SEEP
BIOREACTOR OPERATION WITH AND
WITHOUT RECIRCULATION
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

To Rock or Not to Rock ???



Bioreactors: Rock vs. Organic Substrate

<u>Parameter</u>	<u>Rock</u>	<u>Organic</u>
Food Source Built in	No	Yes
External Food Supply	Yes	Optional
Flushable	Optional	No
Gravity Mode	Yes	Yes
Recycle Mode	Yes	Yes
Substrate Needs Replacement	No	Yes

Bioreactors: Rock vs. Organic Substrate

Parameter	<u>Rock</u>	<u>Organic</u>
■ Bed Depth Limited	No	Yes
■ Prone To Short Circuits	No	Yes
■ Requires Rebuilding	No	Yes
■ Complex Microbial Culture	No	Yes
■ Easy Start Up	?	Yes
■ Quick Response to Controls	Yes	No
■ Requires constant food addition	Yes	No

Black Cloud of Sulfide Precipitation



Leviathan Aspen Seep Mine Tails



This Mine has a Hydraulic Seal



Hydraulic Mine Seals

- Like a dam
- Where does the water come from ?
- Where will the water go ??
- How will the water be treated ?
- Will the rock hold water or leak ?
- Blowout risk ?
- Will there be a release valve ?