Recommended Methodology and Processes for Mine Water Treatment

Mine Design,
Operations & Closure Conference
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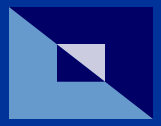

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Presentation Outline

- Steps in Selecting a Treatment Process
- Specific Contaminants
- Potential Treatment Technologies
- Mine Water Applications
- Recommendations
- Additional Resources

First Question

- **Usually Is:**
  - **What Does It Cost?**
- **Should Be:**
  - **What Are the Objectives?**

Steps in Selecting a Process

- Explore/confirm design criteria
- Review potential treatment technologies
- Develop process flow diagram
- Develop budgetary capital and operating costs
- Perform bench and/or pilot tests

Design Criteria

1. Flow
   - Maximum (design capacity)
   - Average (for determining operating costs)
2. Influent concentrations
   - Are they already known?
   - How well can they be estimated/modeled?
3. Effluent concentrations
   - Are permit limits already established?
   - If not, can they be estimated?

Keys

- Collect as much information as possible
- Good communication between client and water treatment consultant, and between consultants

Typical Contaminants of Concern in Mining Waters

- Suspended metals
- Dissolved metals
- Nitrate
- Ammonia
- Arsenic
- Sulfate

Potential Treatment Technologies

- Physical
- Chemical
- Biological

Physical Treatment Technologies

- Clarification
- Filtration
- Membranes

Clarifier at Kensington Mine

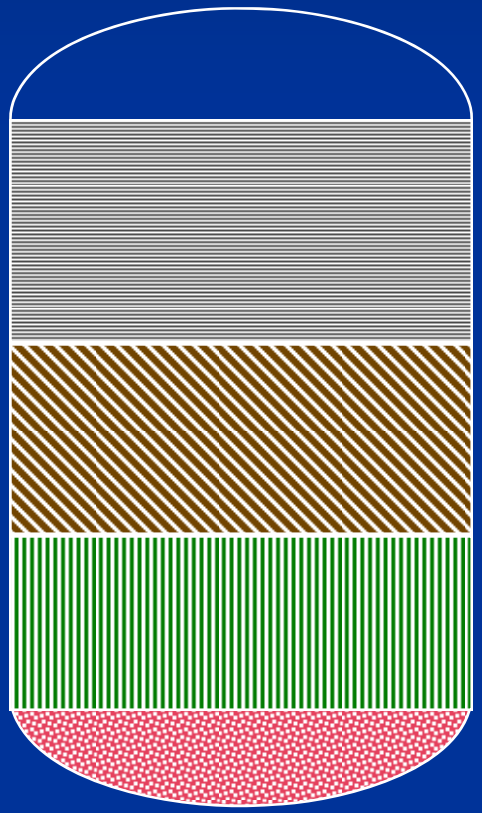
Clarifier centerwell at Central Treatment Plant (Kellogg, ID)

Clarifier overflow at Central Treatment Plant

Filtration

- Bag filters
- Cartridge filters
- Sand filters
- Multimedia filters

Typical Multimedia Filter



No. 1 Anthracite Coal

Silica Sand

Fine Garnet

Support Gravel

1000-gpm multimedia system at Lucky Friday Mine (Mullan, ID)

Membrane Processes

- Microfiltration (MF)
- Ultrafiltration (UF)
- Nanofiltration (NF)
- Reverse osmosis (RO)

500-gpm UF system at Montanore Mine
(Libby, MT)

RO Disadvantages

- Produces high-volume, continuous waste stream
- Can be energy-intensive
- Removal of monovalent ions such as nitrate may be limited
- Will not remove dissolved gases (e.g., ammonia)

Chemical Treatment Technologies

- Hydroxide precipitation
- Sulfide precipitation
- Oxidation/reduction
- Ion exchange
- Natural zeolites

Hydroxide Precipitation

- Typically use lime to increase pH
- Can be hydrated lime or pebble lime (slaker)
- Can also use caustic soda (liquid), soda ash or magnesium hydroxide
- pH target depends upon contaminants of concern
- Co-precipitation can increase removal

Central Treatment Plant
in Kellogg, Idaho

Aeration Basin at Central Treatment Plant

Sulfide Precipitation

- Typically used as “polishing” step for low metals concentrations
- Will achieve lower levels than hydroxide ppt.
- Can use sodium sulfide or hydrosulfide (NaHS)
- Need little reagent and low retention time
- Perform at neutral-to-alkaline pH to avoid H_2S

Oxidation/Reduction

- May be required to transform contaminants into less-soluble form
- Arsenic: Add oxidizing agents such as chlorine, hydrogen peroxide, ozone, permanganate
- Chromium, selenium: Add reducing agents such as sodium bisulfite or metabisulfite
- Reaction is quite rapid
- Will add TDS

Ion Exchange (IX)

- Specific resins available for dissolved metals, arsenic, nitrate
- Sodium or chloride are exchanged for contaminants removed
- Several resin manufacturers available
- Resin is expensive but can be regenerated (on-site or off-site)
- Waste stream is typically much less than RO

IX vessels at Buckhorn Mountain

Natural Zeolites

- Can be used for ammonia removal
- Also have a high selectivity for thallium
- Much less expensive than IX resin
- Regenerate with salt

Biological Treatment

- Can be used for the following contaminants:
  - Organics
  - Ammonia
  - Nitrate
  - Selenium
  - Sulfate

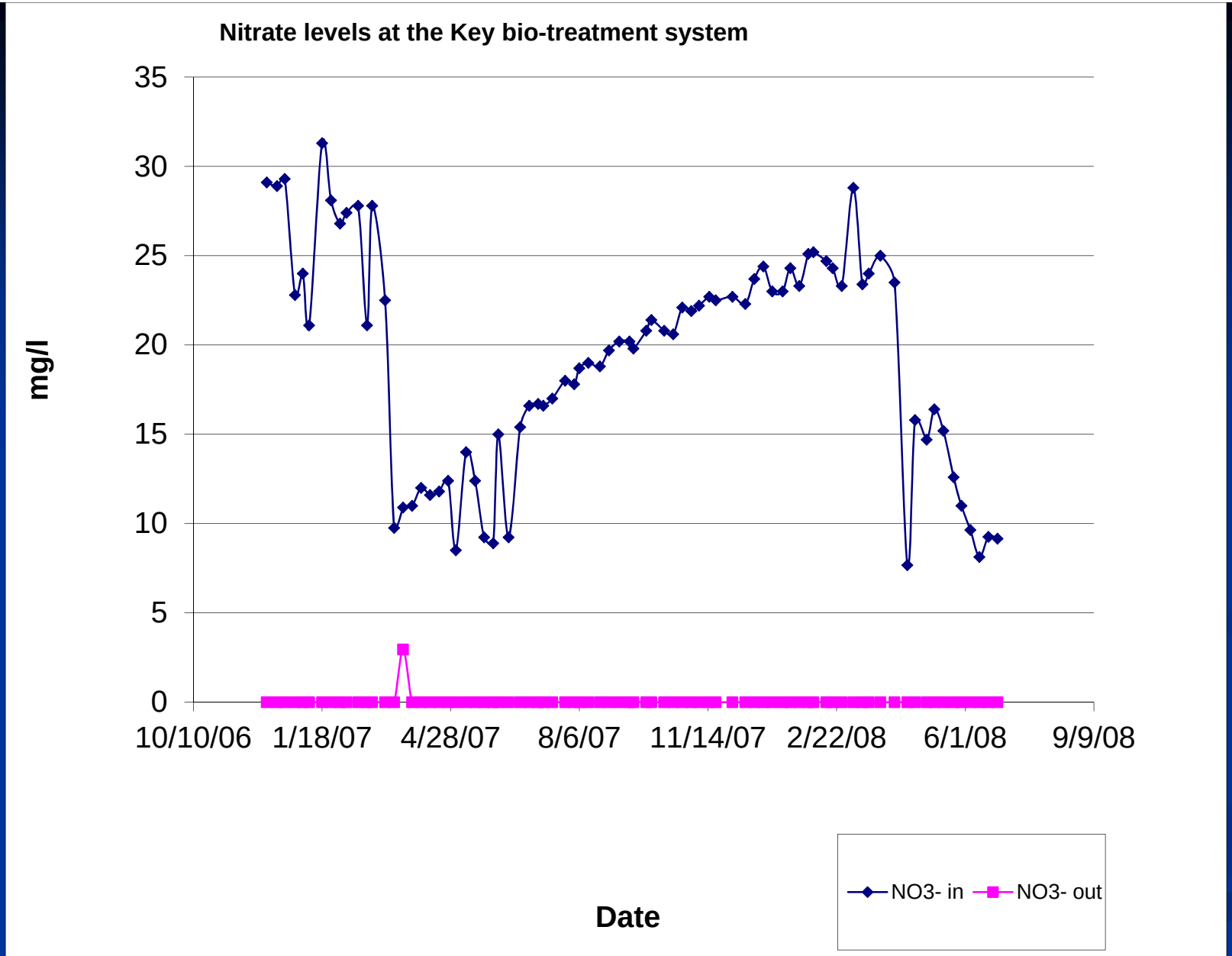
Biological Treatment Technologies

- Attached growth systems
- Suspended growth systems
- Membrane bioreactors

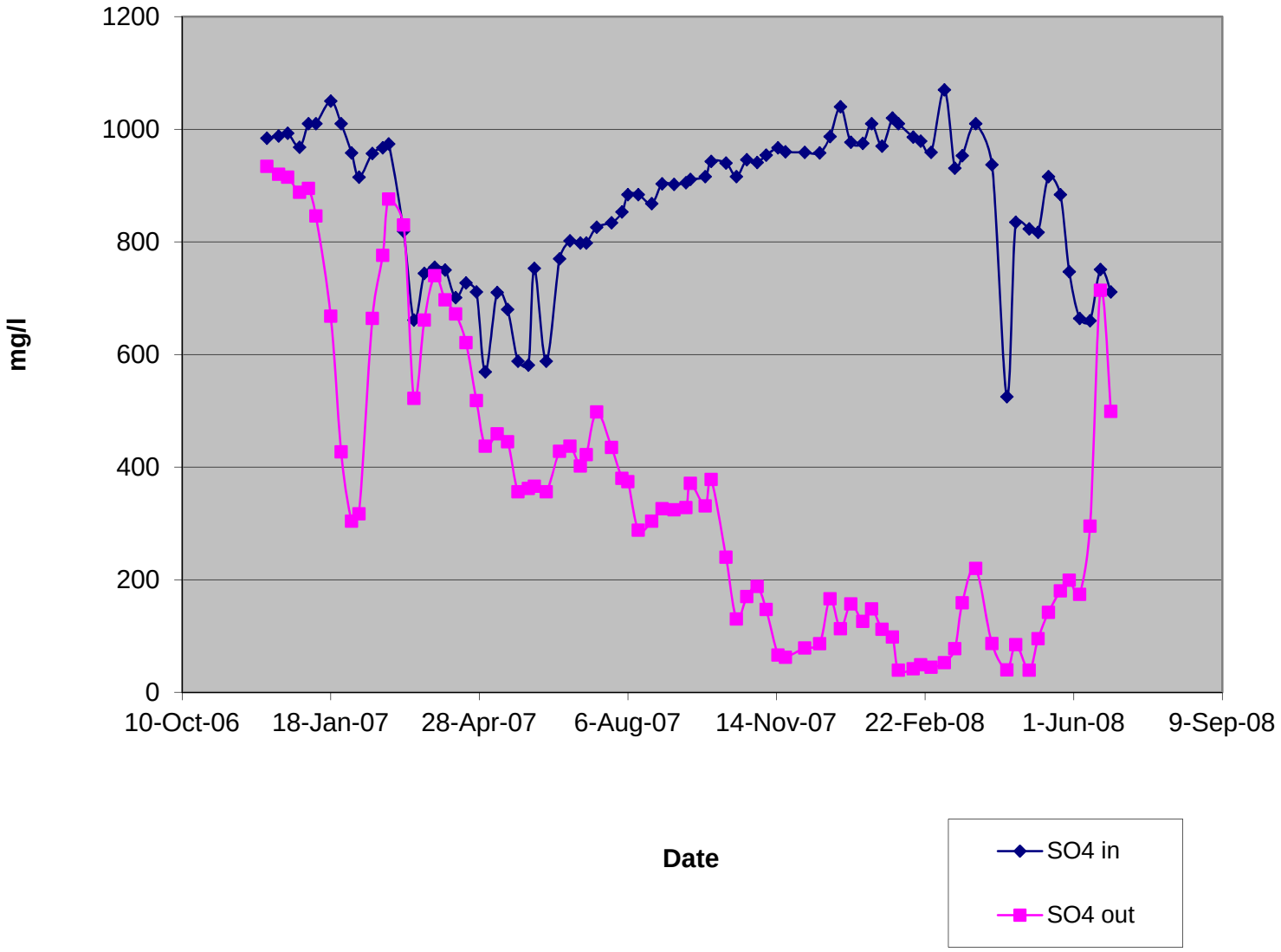
Attached Growth Systems

- Bacteria are attached to a surface or media
- Biofilm provides a very robust process
- Very resilient to changes in flow, pH, concentrations, etc.
- Best choice for high concentrations

Biological treatment system at Key Mine (Republic, WA)


Nitrate levels at the Key bio-treatment system
mg/l
35
30
25
20
15
10
5
0
10/10/06
1/18/07
4/28/07
8/6/07
11/14/07
2/22/08
6/1/08
9/9/08
Date
NO3- in
NO3- out

Sulfate levels at the Key bio-treatment system



Biological nitrate removal system
at Stillwater Mine (Nye, MT)

Bench/Pilot Testing

- Will determine whether selected technology can meet discharge limits
- Can provide valuable information for full-scale capital and operating costs
- May be required by agencies
- Bench testing is simpler, shorter and less expensive than pilot testing
- Jar tests or column tests?

Possible Jar Tests

- Chemical precipitation
- Oxidation
- Coagulation/flocculation
- IX/zeolites

Possible Column Tests

- Leach testing for nitrate/ammonia
- IX
- Biological

Recommendations

- Organics
  - Biological treatment or activated carbon
- Dissolved metals
  - Hydroxide ppt. or sulfide ppt. or IX
- Nitrate
  - Denitrification (attached growth) in almost all cases
- Ammonia
  - Nitrification or zeolites or breakpoint chlorination
- Arsenic
  - Iron coagulation/filtration or adsorptive media or IX
- Sulfate
  - Biological (attached growth) or chemical ppt. or NF

Additional Resources

- Reference Guide to Treatment Technologies for Mining-Influenced Water
  - EPA, March 2014
  - Passive and active treatment
  - www.clu-in.org/download/issues/mining/reference_guide_to_treatment_technologies_for_miw.pdf
  - Cost table at end of document
- Mining Waste Treatment Selection technology
  - More on active treatment
  - www.itrcweb.org/miningwaste-guidance/technology_overviews.htm
- NAP Global Acid Rock Drainage (GARD) Guide
  - www.gardguide.com/index.php/Chapter_7

Questions?

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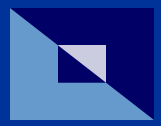

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