# Suboxic Waste Rock Management

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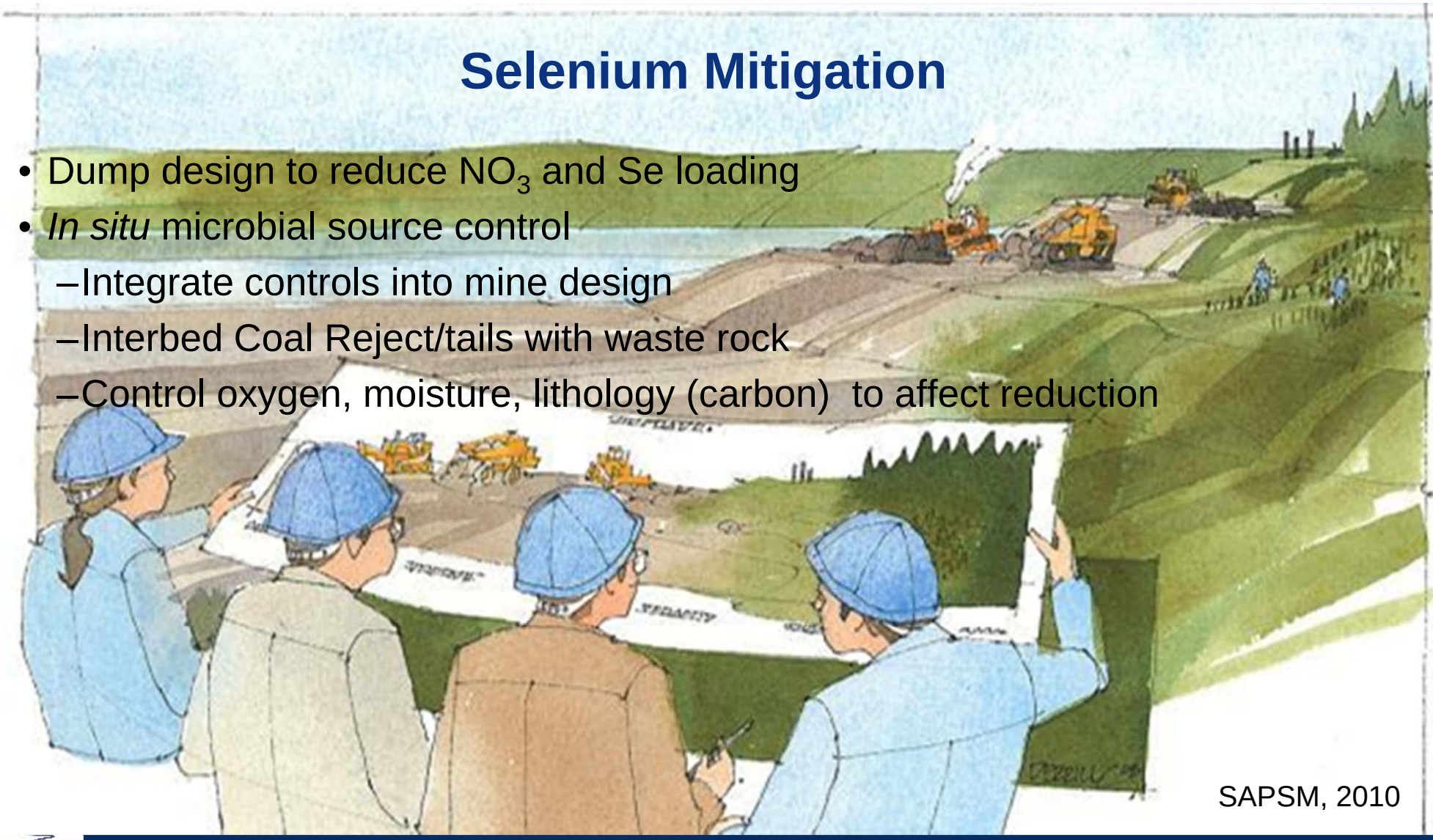
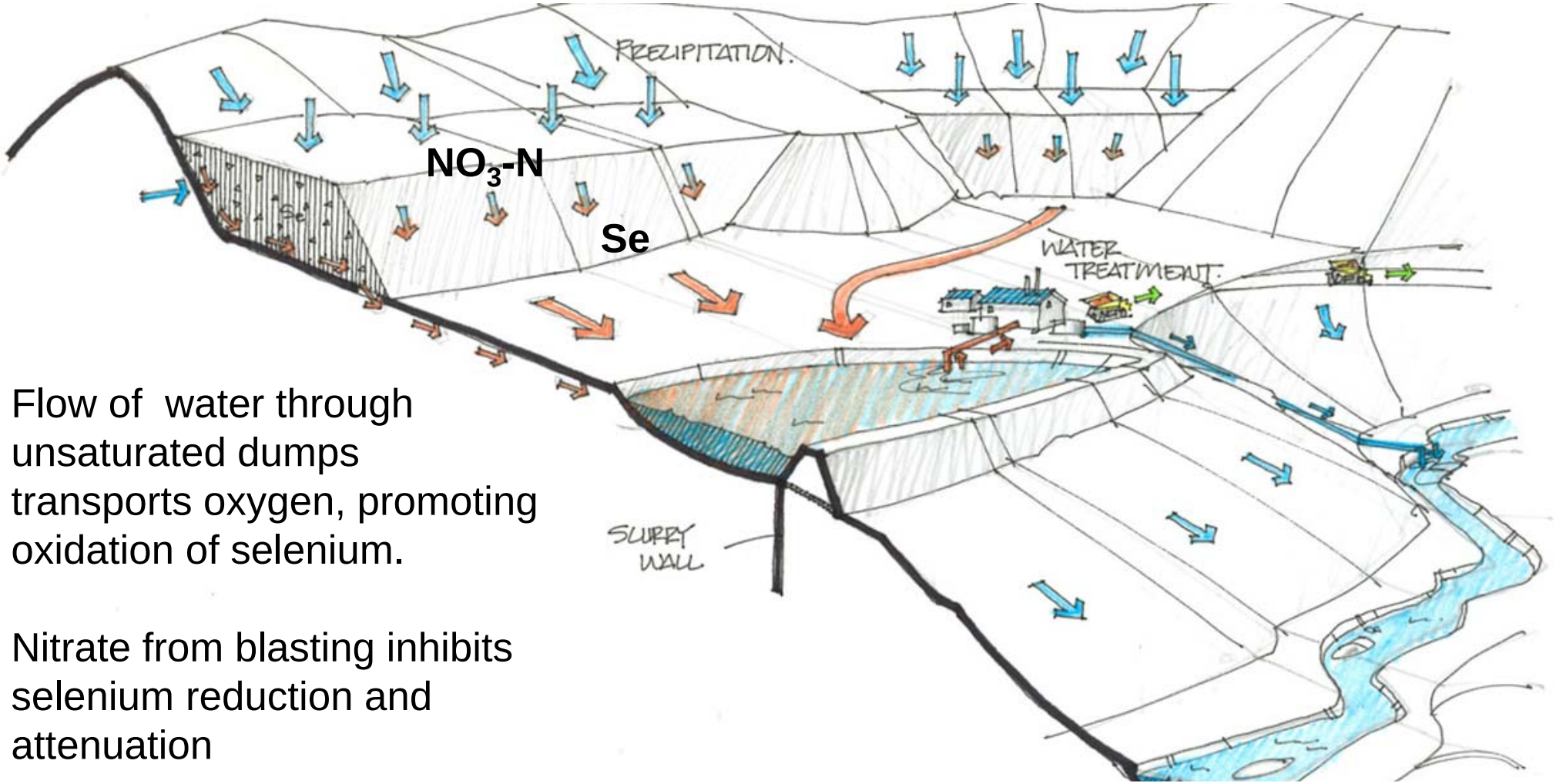
**Enviromin, Inc.**

# Selenium Mitigation

- Dump design to reduce $NO_3$ and Se loading
- *In situ* microbial source control
  - Integrate controls into mine design
  - Interbed Coal Reject/tails with waste rock
  - Control oxygen, moisture, lithology (carbon) to affect reduction



SAPSM, 2010

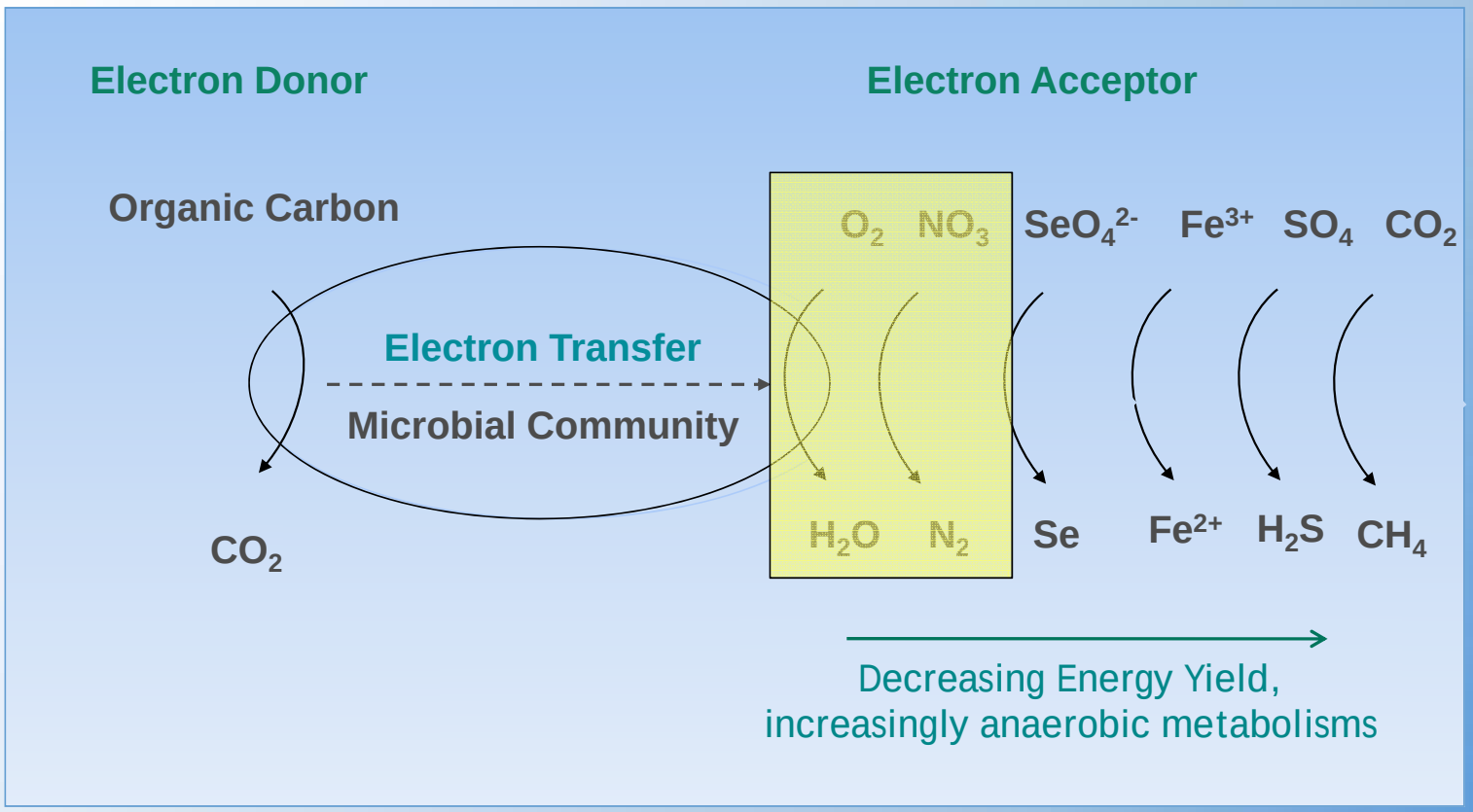



Flow of water through unsaturated dumps transports oxygen, promoting oxidation of selenium.

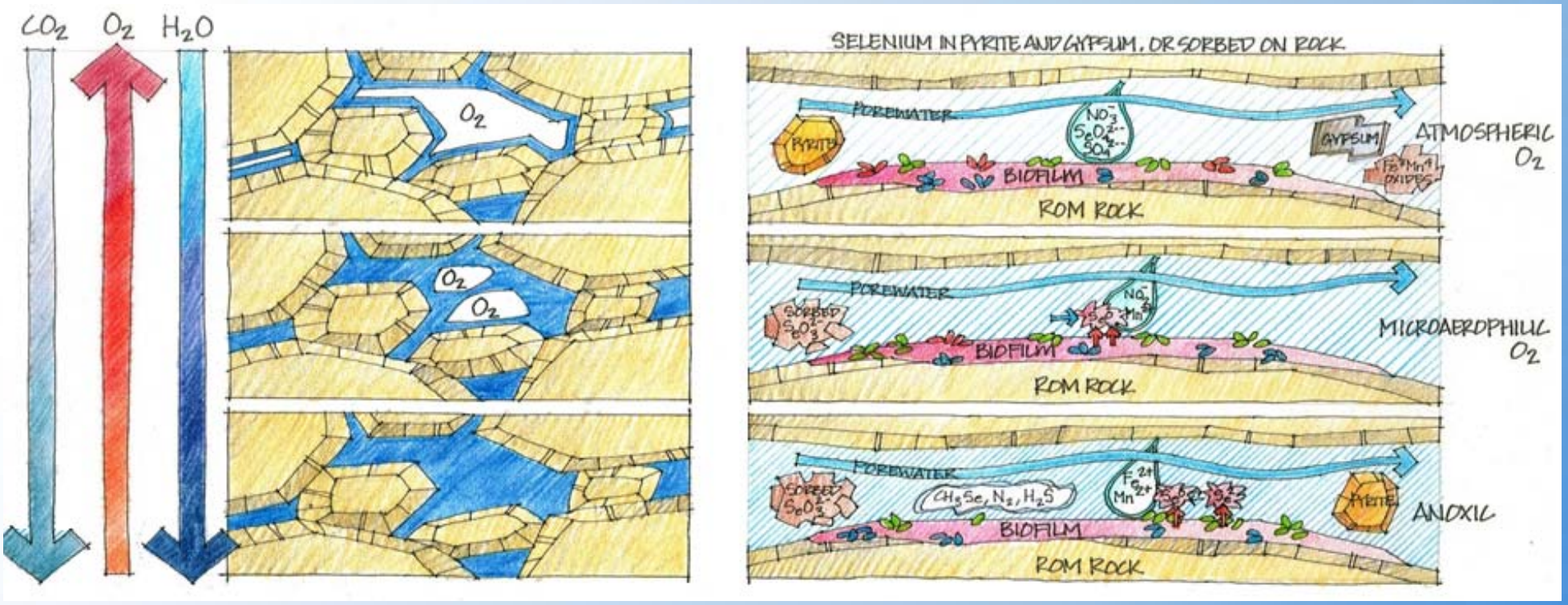
Nitrate from blasting inhibits selenium reduction and attenuation

SAPSM, 2010

# Microbial Metabolism



# Selenium Biogeochemical Model




- Soluble $SeO_4^{2-}$ is associated with $O_2$ , $NO_3^-$, & $SO_4^{2-}$
- Microbial community changes with $O_2$ availability
- $O_2$ & $NO_3^-$ consuming microbes also promote Se reduction

KIRK, 2015

# Project Objectives

- **Design a waste rock dump:**
  - achieve suboxic conditions
  - sufficient residence time for denitrification and selenium reduction
  - use carbon from coal reject
- **Create conditions needed to drive $O_2$ to suboxic levels required for nitrate and selenate reduction**
  - Material placement – built bottom up, layers, compaction
  - Support microbial community capacity to consume $O_2$ and reduce $NO_3$/Se
  - DOC availability – coal reject
- **Generate oxygen, nitrate, and selenium reduction rates for use in facility design**

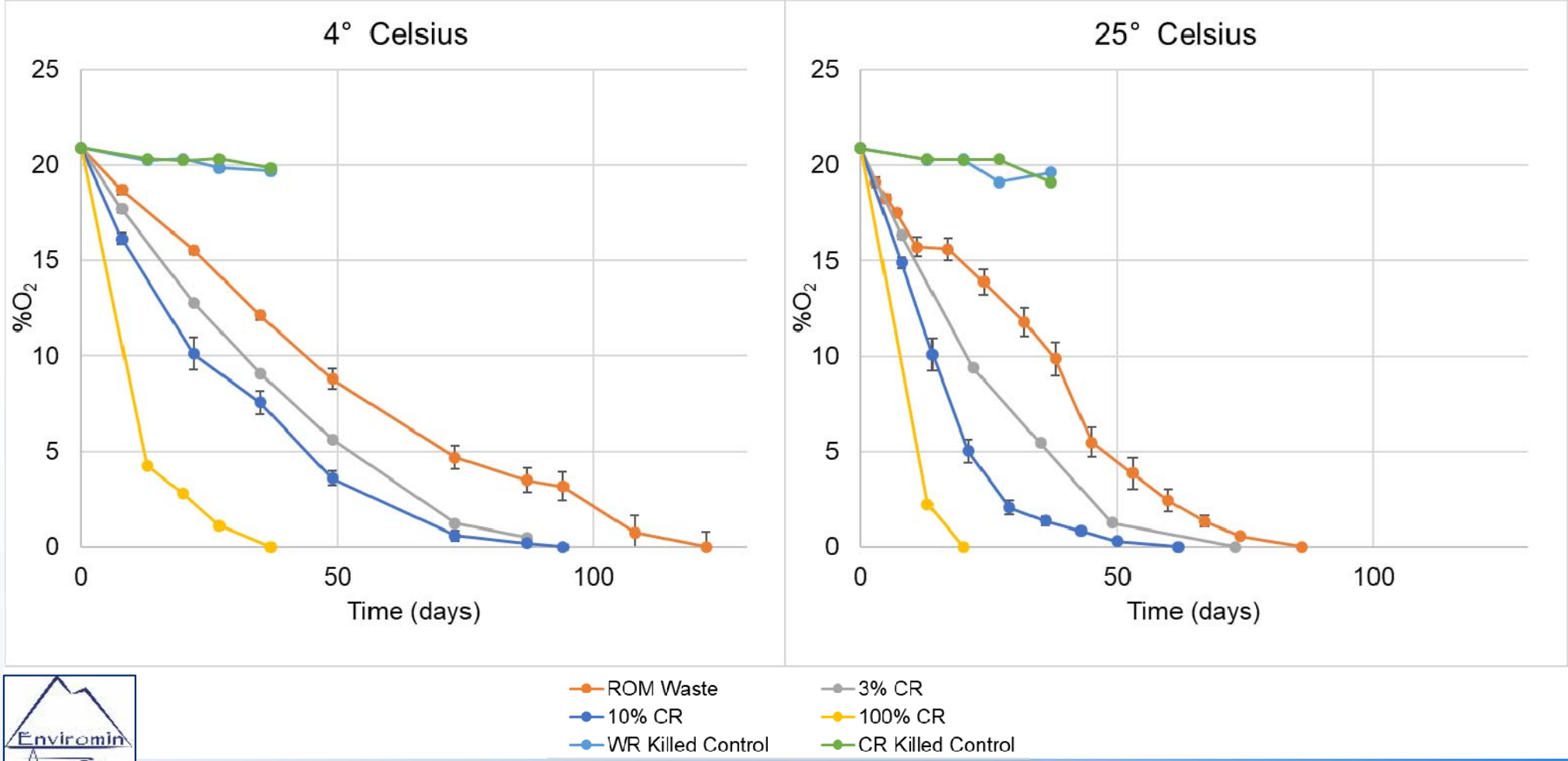
# Respirometry Testing

**Objective:**

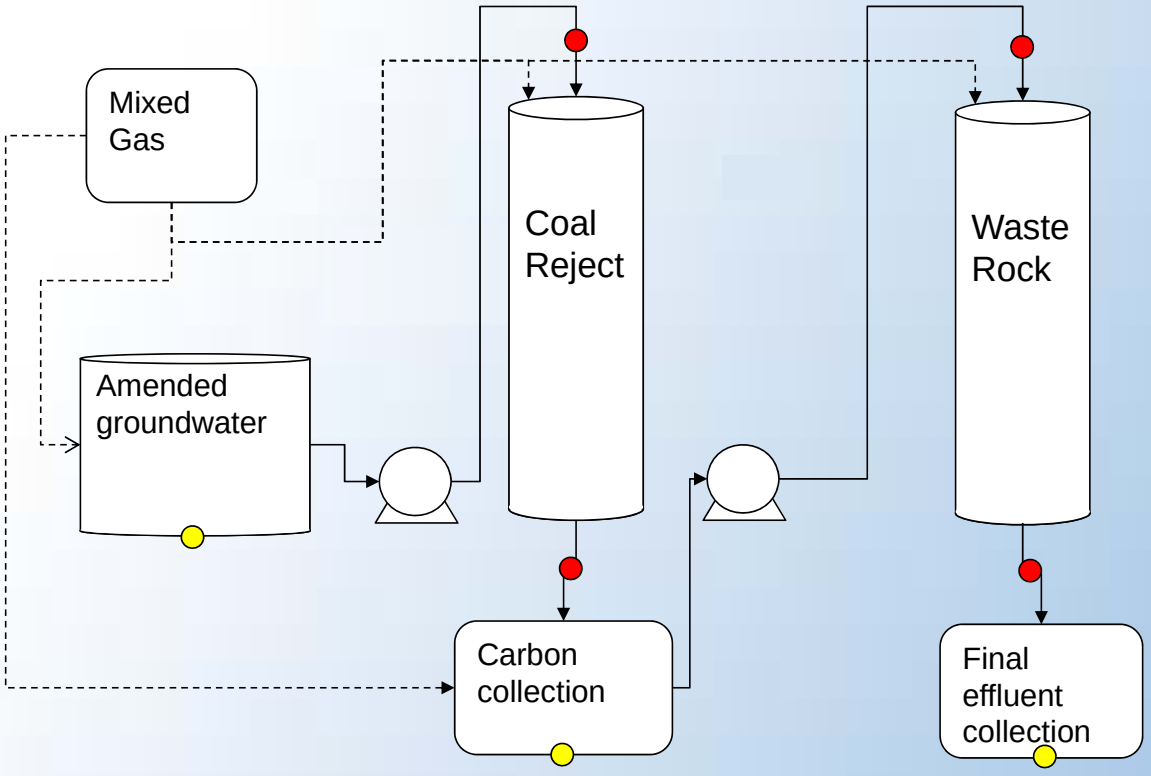
- Characterize progressive consumption of oxygen by biotic and abiotic activity
- Create suboxic conditions needed for nitrate and selenium reduction

| Parameters Tested | |
|---|---|
| ROM Waste | At 4°C, 10°C, 25°C |
| 3% Coal Reject | |
| 10% Coal Reject | |
| 100% Coal Reject | |
| CR Control | |
| WR Control | |

# Respirometry Results




# Column Experiments




## Objective:

- Determine residence times
- Determine oxygen, nitrate, and selenium removal rates
- Verify hydraulic parameters

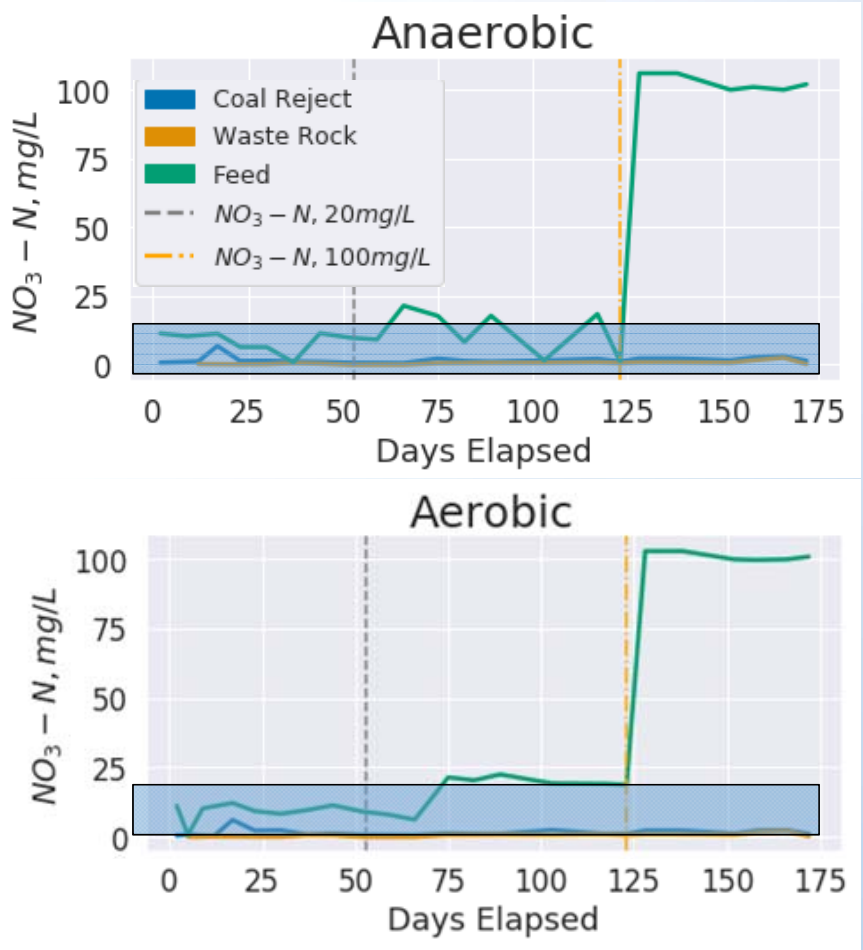
Key

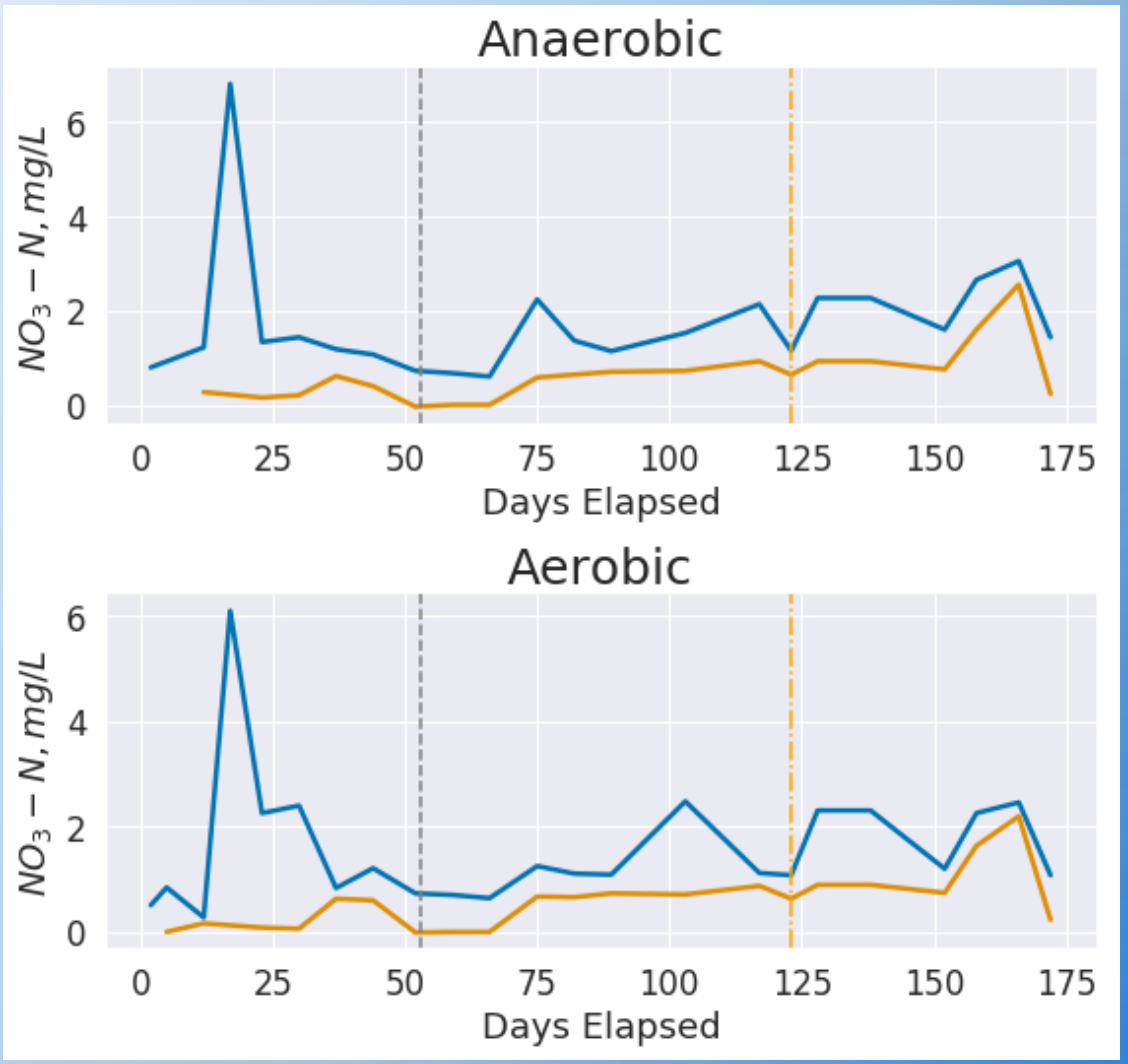
Peristaltic pump

$NO_3$/Se sampling location

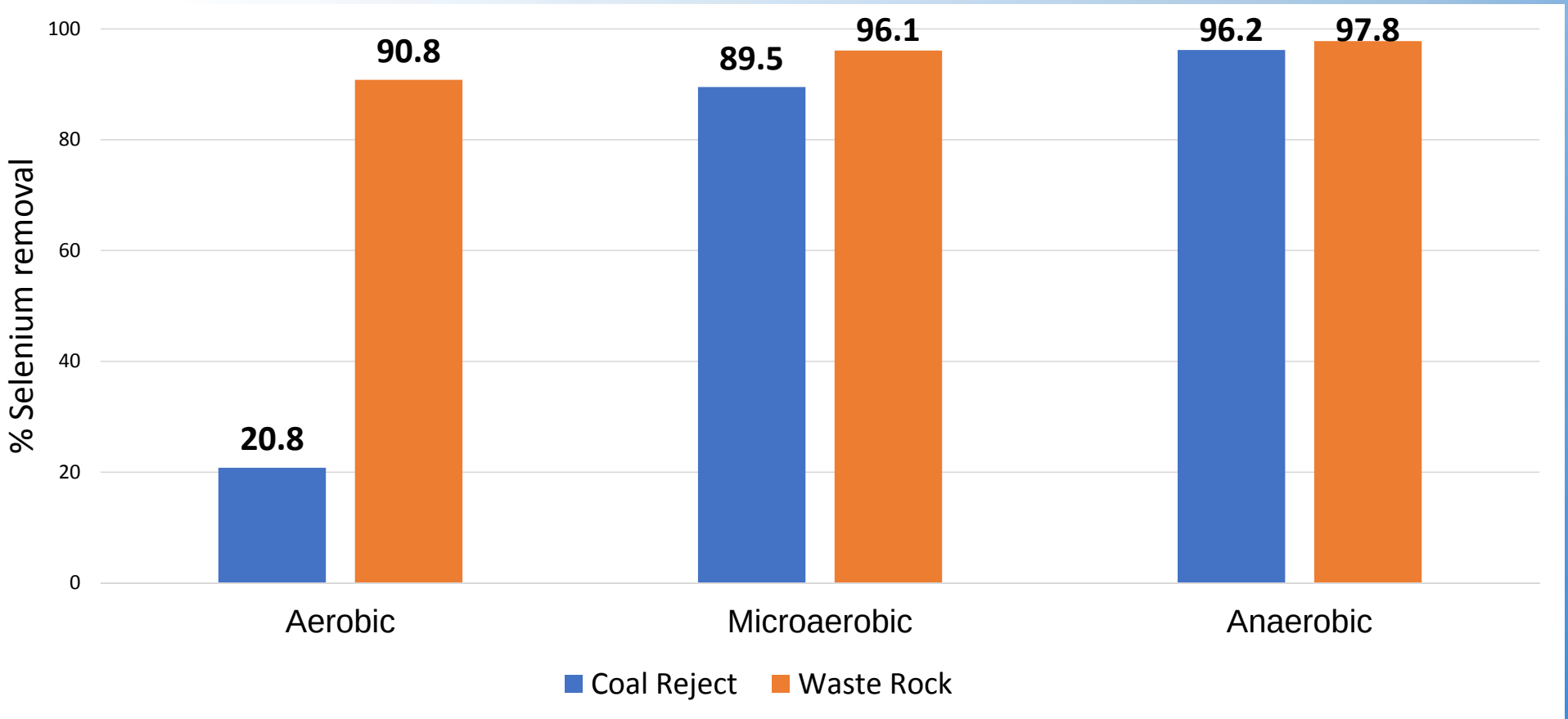
DO sampling port

# Nitrate


Anaerobic
Coal Reject
Waste Rock
Feed
$NO_3 - N$, 20mg/L
$NO_3 - N$, 100mg/L
$NO_3 - N$, mg/L
Days Elapsed
Aerobic
$NO_3 - N$, mg/L
Days Elapsed


Anaerobic
$NO_3 - N$, mg/L
Days Elapsed
Aerobic
$NO_3 - N$, mg/L
Days Elapsed

# Selenium


% Selenium removal
100
80
60
40
20
0
20.8
90.8
89.5
96.1
96.2
97.8
Aerobic
Microaerobic
Anaerobic
Coal Reject
Waste Rock

# Conclusions

- Microbes in coal reject and waste material are capable of nitrate and selenium removal
- Oxygen concentration affects rates and extent of denitrification and selenium reduction.
- Oxygen consumption rates are much higher than previously reported, based on abiotic sulfide oxidation
- $O_2$, nitrate, and selenium reduction rates can be applied to pilot and full-scale dump design for full-scale testing.

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# Thank you.

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# Questions?