# YB TECHNOLOGIES, LLC

## AN™ TREATMENT of ACID MINE DRAINAGE:

LABORATORY, BENCH ENGINEERING & PILOT-SCALE TRIAL SUMMARIES

**Prepared by: YB Technologies, LLC**
**Locations:**

- **Bunker Hill Mining & Metallurgical Complex NPL Site, Kellogg, ID**
- **Bonita Peak Mining District NPL Site (BPMD), Silverton/Gladstone, CO**

YBT

*Technologies for a Cleaner Future*

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## Project Overview

The AN™ Treatment for Acid Mine Drainage (AMD) Project involves the development, testing, and field validation of an advanced chemical treatment process designed to remediate metal-laden, low-pH mine waters at priority hard-rock mining sites. Pilot testing has been conducted across multiple AMD sources within the Bunker Hill Mining & Metallurgical Complex in Idaho and the Bonita Peak Mining District in Colorado, allowing evaluation under diverse geochemical conditions. The technology has been deployed at laboratory, engineering, and field-pilot scales, with flow rates ranging from 2 to 12 gpm in both batch and continuous configurations. This work aims to characterize treatment performance, operational stability, and scalability to support future full-scale remediation decisions at National Priorities List (NPL) mining sites.

## Key Technology Features

| AN™ TECHNOLOGY HIGHLIGHTS FOR ACID MINE DRAINAGE (AMD) | |
|---|---|
| • Advanced Neutralization™ technology for AMD and other acidic aqueous fluids.<br>• Treats acidity/removes heavy metals from fluids, including RCRA metals and those under CERCLA umbrella to below acute and chronic aquatic toxicity levels.<br>• Disrupts emulsions and causes phase separation.<br>• Utilizes electricity, and other electro/mechanical inducements coupled with dimensionally stable and sacrificial electrode materials.<br>• Creates electron donating hydroxyl radicals that form water with acidic hydronium ions, oxidizes multivalent metals treatable forms (e.g., manganese, etc.) and destroys sulfides.<br>• Controllable to create reductive conditions.<br>• Treats acidity to within the operating pH range of 5.5 – 7.5 S.U.<br>• No conventional water treatment chemicals needed. | • No high pH metallic hydroxides formed.<br>• No calcium contribution to solids mass or density unless sourced from within AMD.<br>• Produced precipitates coagulate and mature to robust, dense and readily settleable solids of low-volume/low-mass suitable for dewatering by gravity, capillary drying, or conventional mechanical means.<br>• Filtration not needed to date for final treatment polishing to achieve low ug/L heavy metal concentrations.<br>• Settled solids are high in metals content, not diluted with calcium, polymer, bulking additives. No water hydration in highly alkaline pH conditions (e.g., <25-35% of the mass of conventional lime-polymer treatment solids).<br>• Solids are suitable for subsequent processing using the MBT™ treatment technology to mitigate heavy metal leachability.<br>• Uses 240V or 480V/3phase, 25 to 100-amp service for flows to 100gpm with minimal pump requirements<br>• AN treatment process effluent is suitable for discharge into a penstock and down gradient turbine for hydropower options to reduce/eliminate grid-supplied power. |

# SUCCESS MINE AMD, Wallace ID

## Bunker Hill Mining and Metallurgical Complex NPL Site

### Success Mine, Wallace ID

Bunker Hill Mining & Metallurgical Complex NPL Site
Legacy Site – Acid Mine Drainage
Issues: Heavy Metals
Technologies: AN™ Technology for AMD

| | | Untreated | AN Treated | | |
|---|---|---|---|---|---|
| ANALYTE | UNITS | RESULT | RESULT-3/1 | Result-3/8 | Result 8/1 |
| Aluminum | mg/L | 3.5 | 0.279 | 0.104 | 0.18 |
| Arsenic | mg/L | <0.0025 | <0.0025 | <0.0025 | <0.0025 |
| Cadmium | mg/L | 0.0554 | <0.005 | <0.005 | <0.005 |
| Copper | mg/L | 0.0187 | 0.026 | 0.179 | <0.005 |
| Iron | mg/L | 25.5 | 1.86 | 0.797 | 25.8 |
| Lead | mg/L | 0.251 | <0.0025 | <0.0025 | <0.0025 |
| Manganese | mg/L | 28.1 | 4.28 | 4.09 | 9.99 |
| Zinc | mg/L | 32.1 | 0.189 | 0.135 | 1.35 |
| pH | S.U. | 5.86 | 6.19 | 6.82 | 6.21 |

Comments:

1) Three (3) 5-gallon batch treatments performed using AN™ treatment technology for AMD
2) Optimization for manganese removal required.
3) 100-minute column setting time after AN treatment, without filtration.
4) Samples of settled clarification supernate collected for total metals analyses.

# Bunker Mine: Kellogg Tunnel AMD

## Bunker Hill Mining and Metallurgical Complex NPL Site

## Kellogg, ID

Bunker Mine/Kellogg Tunnel, Kellogg ID

Issues: pH, Heavy Metals

Technologies: AN™ for AMD

| Parameter | Units | Untreated | AN - Treated R-1 | AN - Treated R-2 |
|---|---|---|---|---|
| Aluminum, dissolved | mg/L | 1.23 | 0.476 | 0.05 |
| Aluminum, total | mg/L | 1.27 | 0.893 | 0.19 |
| Arsenic, dissolved | mg/L | <0.025 | <0.0030 | 0.0004 J |
| Arsenic, total | mg/L | 0.040 | <0.0030 | 0.0004 J |
| Cadmium, dissolved | mg/L | 0.0753 | 0.0500 | 0.020 |
| Cadmium, total | mg/L | 0.0750 | 0.0492 | 0.021 |
| Calcium, total | mg/L | 207 | NT | 197 |
| Copper, dissolved | mg/L | 0.059 | 0.00993 | 0.0018 J |
| Copper, total | mg/L | 0.0600 | 0.0107 | 0.0014 J |
| Iron, dissolved | mg/L | 18.8 | 36.8 | 1.98 |
| Iron, total | mg/L | 88.6 | 44.9 | 1.98 |
| Lead Dissolved | mg/L | 0.558 | <0.00300 | 0.00027 J |
| Lead, total | mg/L | 0.607 | 0.00539 | 0.00086 |
| Magnesium, total | mg/L | 113 | NT | 74.7 |
| Manganese, dissolved | mg/L | 68.2 | 61.0 | 46.66 |
| Manganese, total | mg/L | 68.8 | 60.5 | 48.04 |
| Nickel, dissolved | mg/L | 0.0615 | 0.162 | 0.024 |
| Nickel, total | mg/L | 0.059 | 0.165 | 0.025 |
| Sulfate | mg/L | 1430 | NT | 858 |
| Zinc, dissolved | mg/L | 40.3 | 14.5 | 2.197 |
| Zinc, total | mg/L | 50.2 | 15.1 | 2.296 |
| pH | S.U. | 2.34 | 6.74 | 7.54 |

Comments:

1) On-site AN™ treatment technology pilot study performed at 2 gpm continuous flow.
2) No conventional water treatment chemicals utilized.
3) Column settling for solids removal without filtration.
4) Effluent samples collected from supernate after 100-minute settling time

# Mogul Mine AMD

## Conita Peak Mining District NPL Site
## Silverton/Gladstone, CO

## Mogul Mine AMD: AN™ Technology vs. Lime Treatment

**August 17, 2015 Sample Collection**
**Dissolved Metals**

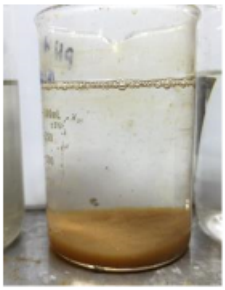
| Parameter | Units | Untreated | Lime Treated pH 7.86 S.U. | Lime Treated pH 10.34 S.U. | AN Treated |
|---|---|---|---|---|---|
| **Aluminum** | **mg/L** | **3.5** | 0.05 | **0.17** | **0.06** |
| Arsenic | mg/L | <0.0025 | 0.0004 J | 0.0003 J | **0.0002 J** |
| **Cadmium** | **mg/L** | **0.054** | **0.031** | <0.00025 | **0.000125 J** |
| Chromium | mg/L | N/A | <0.001 | <0.001 | **N/A** |
| **Copper** | **mg/L** | **0.0187** | 0.002 | 0.0007 J | **0.0013 J** |
| Iron | mg/L | 25.5 | <0.050 | <0.050 | **0.03 J** |
| Lead | mg/L | 0.251 | 0.00016 J | <0.0005 | **0.00016 J** |
| **Manganese** | **mg/L** | **28.1** | **22.10** | **6.80** | **0.30** |
| **Nickel** | **mg/L** | **0.016** | **0.017** | 0.007 | **0.009** |
| Silver | mg/L | 0.00006 J | <0.0002 | <0.0002 | **<0.00001** |
| **Zinc** | **mg/L** | **32.1** | **8.740** | 0.022 | **0.019** |
| **pH** | **S.U.** | **3.46** | 7.86 | **10.34** | **6.48/7.52** |

**NOTES:**
1) Lime treated samples w/calcium hydroxide to pH indicated.
2) pH measured in field/treatabilty laboratory
3) No filtration in treatment. Samples settled 2 hrs.
4) Untreated sample data by Green Analytical Laboratory, Durango, CO
5) Treated sample data by Edge Analytical, Inc., Burlington, WA

Yost Brothers, LLC -- BlueQ Labs, LLC

Lime Treated

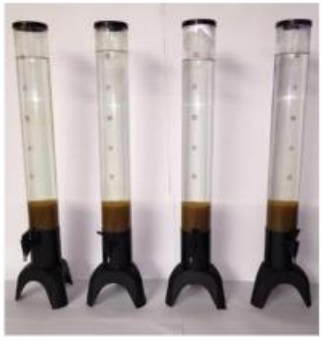
AN Treated



# AN Solids Settling Times

Left to Right:

2 minutes
5 minutes
7 minutes
10 minutes

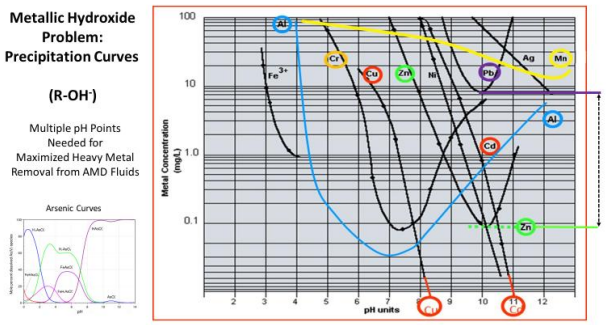


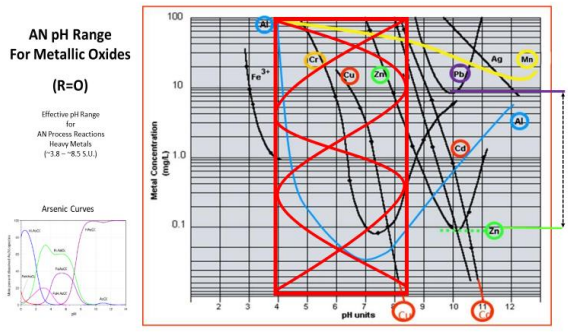
30 minutes

9.86 gallons of Mogul Mine AMD → 86.7 g of AN solids (air dried to damp paste)

## COMMENTS:

1) Treatability performed on 5-gallon bucket quantities of Mogul Mine AMD
2) AN generated solids at ~30% of Lime generated solids
3) pH monitoring for lime treatment AMD was continuous during lime addition and mixing to achieve pH end-point where lime addition was halted. pH at T=120 mins after last lime addition and settling is reported. pH for AN treated AMD measured at T=0 minutes, and at T=120 mins through settling from end of treatment when sample was collected for analyses.



# American Tunnel AMD

## Bonita Peak Mining District NPL Site
## Silverton/Gladstone, CO

American Tunnel Mine

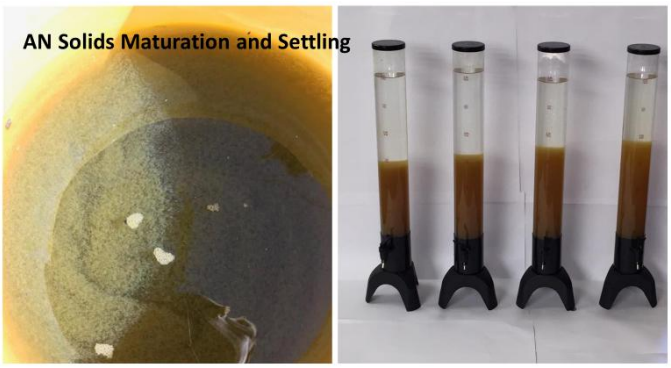
SITE: BPMD NPL Site, Gladstone, CO
Legacy Site – Mine Drainage
Issues: pH, Heavy Metals
Technologies: AN™ Technology for AMD

**AN Treatability Results**
**American Tunnel**
**April 12-15, 2016**

| Parameter | Units | Untreated | AN Treated |
|---|---|---|---|
| Aluminum, total | mg/L | 5.15 | 1.39 |
| Aluminum, dissolved | mg/L | 4.35 | <0.500 |
| Cadmium, total | mg/L | 0.0019 | 0.0015 |
| Cadmium, dissolved | mg/L | 0.0022 | 0.0017 |
| Calcium, total | mg/L | 421 | 514 |
| Calcium, dissolved | mg/L | 424 | 391 |
| Copper, total | mg/L | 0.0160 | <0.0100 |
| Copper, dissolved | mg/L | 0.0136 | 0.0018 |
| Iron, total | mg/L | 129 | 102 |
| Iron, dissolved | mg/L | 126 | 75.2 |
| Magnesium, total | mg/L | 30.1 | 29.6 |
| Magnesium, dissolved | mg/L | 29.9 | 23.1 |
| Manganese, total | mg/L | 44.2 | 33.5 |
| Manganese, dissolved | mg/L | 42.5 | 36.3 |
| Lead, total | mg/L | <0.0050 | <0.0050 |
| Lead Dissolved | mg/L | <0.0050 | <0.0050 |
| Zinc, total | mg/L | 14.1 | 4.10 |
| Zinc, dissolved | mg/L | 14.4 | 4.09 |
| pH | S.U. | 3.82 | 7.66 |

Comments:

1) 5-gallon batch treatment using AN™ technology for acidic fluids and AMD
2) No water treatment chemicals utilized. No filtration processing step



# Gold King Mine AMD

## Bonita Peak Mining District NPL Site
## Silverton/Gladstone, CO

BPMD NPL Site, Gold King Mine, Gladstone CO

GKM - AN™ Solids Maturation

GKM – AN™ Clarified Effluent

## 5-Gallon Batch Testing Results (April 2016)

Gold King Mine
BPMD NPL Site, Gladstone, CO
Legacy Site – Mine Drainage
Issues: pH, Heavy Metals
Technologies: AN™ Technology for AMD

**AN Treatability Results**
Gold King Mine AMD
**April 12-15, 2016**

| AMD | | | AN Treated | | | |
|---|---|---|---|---|---|---|
| Parameter | Units | Untreated | R-1 | R-1A | R-2 | R-3 |
| Aluminum, total | mg/L | 13.9 | 1.43 | 1.39 | DGap | DGap |
| Aluminum, dissolved | mg/L | 8.94 | <0.500 | <0.500 | DGap | DGap |
| Arsenic, total | mg/L | 53* | NT | NT | 0.0004 J | 0.00035 J |
| Arsenic, dissolved | mg/L | 62* | NT | NT | 0.0005 | 0.00036 J |
| Calcium, total | mg/L | 367 | 342 | 340 | 143.8 | 102.2 |
| Calcium, dissolved | mg/L | 371 | 335 | 302 | 151.2 | 90.8 |
| Cadmium, total | mg/L | 0.0379 | 0.0285 | 0.0017 | 0.0012 | <0.00025 |
| Cadmium, dissolved | mg/L | 0.0384 | 0.0302 | 0.0014 | 0.0009 | <0.00025 |
| Copper, total | mg/L | 2.96 | 0.114 | <0.0100 | 0.008 | 0.002 |
| Copper, dissolved | mg/L | 2.69 | 0.109 | <0.0100 | 0.0016 J | 0.0013 J |
| Iron, total | mg/L | 58.5 | 5.58 | <0.500 | 23.54 | 2.05 |
| Iron, dissolved | mg/L | 43.8 | 4.28 | <0.500 | 0.03 J | 0.007 J |
| Lead, total | mg/L | 0.0193 | <0.0050 | <0.0050 | 0.00017 J | 0.0017 |
| Lead Dissolved | mg/L | 0.0086 | <0.0050 | <0.0050 | <0.0005 | <0.0005 |
| Magnesium, total | mg/L | 17.7 | 16.4 | 13.4 | 7.4 | 2.8 |
| Magnesium, dissolved | mg/L | 17.4 | 16.3 | 12.1 | 7.7 | 2.5 |
| Manganese, total | mg/L | 21.5 | 18.2 | 5.53 | 7.762 | 0.303 |
| Manganese, dissolved | mg/L | 20.0 | 18.6 | 5.44 | 4.631 | 0.012 |
| Sulfate | mg/L | 1685* | 983 | 811 | NT | NT |
| Sulfide, total | mg/L | NT | NT | NT | <0.05 | NT |
| Sulfur, total | mg/L | NT | NT | NT | 157 | 153 |
| Sulfur, dissolved | mg/L | NT | NT | NT | 167 | 166 |
| Zinc, total | mg/L | 21.5 | 5.54 | <0.100 | 0.038 | 0.019 |
| Zinc, dissolved | mg/L | 10.1 | 5.69 | <0.100 | 0.0074 | 0.001 J |
| pH | S.U. | 5.2 | 5.75 | 7.66 | 6.62 | 7.24 |
| pH | S.U. | 3.28* | | | | |

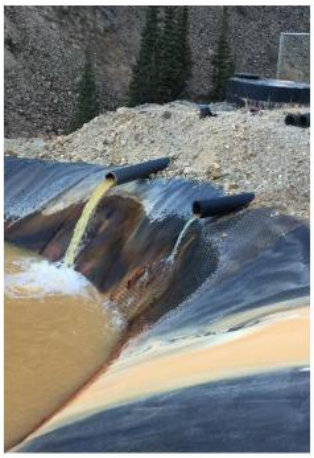
* Historic average

Comments:

1) 50 gallons of Gold King Mine AMD collected in 5-gallon buckets for AN treatability study using laboratory bench-scale treatment system in Lebanon, OR
2) No conventional water treatment reagent additives utilized
3) No filtration after AN treatment. 100-minute floc maturation time and settling prior to sampling.

# 20 gpm On-site Pilot-Scale Treatment Results

## Gold King Mine Field Trial (October 2017)



**Gold King Mine AMD, Gladstone, Colorado**
**Yost Brothers, LLC Field Trials - October 24-30, 2017**
**Advanced Neutralization Treatment Technology**
**Water Treatment Analytical Data Summary**

| **Sample ID** | BLM/EPA Provided Data | BLM/EPA Provided Data | GKM 08152017 | GKM 103017-1000 | GKM 102617-1523 | GKM 102617-1512 | GKM 102617-1455 | GKM 102617-1546 | GKM 102617-1555 | GKM 102717-2015 | GKM 103017-1730 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field Trial No.** | NA | NA | NA | INF-A | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Date:** | 10/19/15 - 9/21/16 | 10/19/15 - 9/21/16 | 8/15/2017 | 10/30/2017 | 10/26/2017 | 10/26/2017 | 10/26/2017 | 10/26/2017 | 10/26/2017 | 10/27/2017 | N/A |
| **Water Type** | Raw Influent | EPA Lime Treated Effluent | Raw Influent | Raw Influent | AN Treated | AN Treated | AN Treated | AN Treated | AN Treated | AN Treated | QA/QC Blind Field Blank |
| **Flow Rate (gpm)** | NA | NA | NA | NA | 5 | 5 | 6 | 10 | 12 | 12 | Distilled Water Bottle Blank |
| **Parameters* (mg/L)** | | | | | | | | | | | |
| Aluminum | 18.7 | 4.3 | 45.5 | 4.65 | 26.1 | 6.4 | 12.8 | 1.59 | 1.30 | <0.046 | <0.046 |
| Arsenic | 0.033 | 0.005 | NR | <0.0050 | <0.0250 | <0.0250 | <0.0250 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| Calcium | 362.5 | 362.5 | 377 | 441 | 364 | 356 | 347 | 337 | 350 | 344 | <0.152 |
| Iron | 84.8 | 13.1 | 174 | 114 | 61.7 | 41.8 | 28.5 | 58 | 63 | 10.3 | <0.102 |
| Cadmium | 0.049 | 0.014 | 0.113 | 0.0025 | 0.074 | 0.071 | 0.073 | 0.069 | 0.067 | <0.0025 | <0.0025 |
| Cobalt | 0.07 | 0.02 | 0.121 | 0.148 | 0.0882 | 0.0766 | 0.0788 | 0.075 | 0.071 | 0.0395 | <0.0025 |
| Copper | 4.07 | 0.78 | 10.5 | 0.0441 | 5.84 | 2.00 | 2.97 | 0.349 | 0.240 | <0.025 | <0.0025 |
| Lead | 0.028 | 0.006 | 0.055 | 0.0157 | 0.024 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.0025 |
| Manganese | 19.1 | 16.3 | 30.6 | 48.2 | 30.1 | 30.6 | 29.3 | 28.6 | 29.2 | <0.01 | <0.0025 |
| Nickel | 0.043 | 0.018 | NR | 0.0884 | 0.0884 | 0.193 | 0.18 | 0.191 | 0.16 | <0.0050 | <0.0050 |
| Zinc | 17.2 | 3.62 | 22.7 | 18.4 | 22.22 | 18.8 | 20.2 | 15.1 | 14.4 | 0.064 | <0.0050 |
| pH (S.U.) | NR | NR | 2.81 | 3.62/2.95 | 4.32 | 3.33 | 4.51 | 4.29 | 4.95 | 6.12 | 6.71 |

Comments:

1) Final AN treatment runs #6 processed continuously for after optimization on 5-10gpm production treatments (#'s 1-5).
2) AN™ Treatment Run #6 included enhanced electrochemical oxidation not used in other runs.
3) No conventional water treatment reagents utilized. No process filtration. 1.5-2 hr. settling.
4) Metals analyzed as totals.
5) Pilot-project ended prematurely. Winter storm prediction caused EPA to shut-down site.

## Conclusion:

The AN™ Treatment technology offers a fundamentally different and highly effective approach to managing Acid Mine Drainage, addressing core limitations of traditional chemical-based systems. Its electrochemically driven Advanced Neutralization™ process eliminates the need for lime, caustic, polymers, and other conventional reagents, reducing secondary impacts, operational complexity, and long-term residuals management. By generating reactive hydroxyl radicals and enabling controlled oxidative or reductive environments, AN™ Treatment consistently achieves substantial acidity reduction and metals removal—including RCRA and CERCLA-listed contaminants—to levels protective of aquatic life.

These advantages demonstrate that AN™ Treatment provides a reliable, scalable, and environmentally superior solution for AMD remediation. Its performance across diverse geochemical conditions, minimal chemical footprint, reduced solids generation, and potential for energy integration make it an ideal choice for long-term management of legacy mine water impacts at complex, high-priority sites.

No Filtration