EarthTec:
Not all copper is created Equal

Paul Besenti- Midwest Region- MN,WI,IL,IN,MI,OH,MO,KS,IA,NE,KY,TN
Ed Shimer- East Region- GA, FL
Allan Goldschmidt-South Region- OK, AR
Tim Hartman- West Region

David Carrington- Business Manager

Earth Science Labs, Inc. Since 1991
EarthTec Technical Team

- David Nicholas- CEO- April 2013
  - 35 years in chemical/water treatment engineering
- Dave Carrington- EarthTec Business Manager- April 2014
  - 25 years in Water/Wastewater engineering
- David Hammond- Senior Scientist- May 2014
  - PhD over Zebra Mussels
- Reid Bowman- Chemist- January 2015
  - PhD – 40 years product formulation Dow Chemical
- Fred Singleton- Micro-Biologist- September 2015
  - PhD- 35 years pesticide research at Dow Chemical
- Allan Goldschmidt- Selling EarthTec since 2005
- Paul Besenti- March 2017
  - 20+ years water/wastewater experience.
- Case Studies- Customer supplied data for most applications
EarthTec- 2 for 1 Value

- In WTP Pipelines, Intakes and Reservoirs:
- Eliminate Zebra Mussels and Algae with a single low dose of EarthTec/EarthTecQZ
  - Eliminate zebra and quagga mussels
  - Eliminate algae from sed basins
  - Reduce taste and odor
  - Reduce TOC
  - Prevent and control cyanobacteria blooms
  - Increase filter run times
EarthTec Chemistry

- EPA Registered as an Algaecide/Bactericide/Molluscicide
- Registered in All 50 States as Algaecide/Bactericide and in several countries. 27 states as Molluscicide
- Certified to NSF Standard 60 for Drinking Water
- EarthTec Is the Easiest, Safest and Most Efficient Method to Deliver Copper
EarthTec Chemistry

EarthTec is:
- Liquid formulation containing 5% copper by volume
- Made from copper sulfate + proprietary carrier molecule (ET-3000)
- Unique features:
  - Copper is 99.99% cupric ion form (Cu^{++}) so it is readily bioavailable
  - Durational Control- prevents and controls for 14-30 days
  - Rapid-dispersing properties, so no need for mixing
  - Low pH- 0.2-0.3
  - Infinitely soluble in water, stays suspended, will not settle out
  - Low concentrations yield high performance: 30-120 ppb copper
    - 1 ppm EarthTec = 60 ppb copper
    - Most applications require 1-2 gallons/mgd depending on water quality
    - No immediate cell lysing
EarthTec Uses

EarthTec is a water pretreatment chemical:
- Used in WTP reservoirs, intakes and pipelines
- Control algae and blue-green algae (cyanobacteria/HAB’s)
- Reduce taste and odor compounds, especially geosmin
- Reduce TOC
- No production of DBPs, THMs or HAA5’s (regulatory issues)
- Reduce downstream consumption of:
  - activated carbon- ozone - coagulants
- Increase filter run times
- Reduce biofilm/slime on pipes (Improves pumping efficiency)
- Eliminate clogging in nozzles/sprinkler heads due to algae
- Control zebra mussels and quagga mussels: EarthTec QZ
- Reduce a wide range of Bacteria (non-public health)
- Wastewater filter/reuse
Reduces Carbon and Permanganate

• Reducing Carbon by 2 ppm will pay for the cost of EarthTec.
  – EarthTec reduces T&O and algae which can lead in a 5-10 ppm or more reduction in Carbon. This can save a customer $50-100/mgd per day.

• Reducing Permanganate by 2 ppm will pay for the cost of EarthTec.
  – Permanganate is often misapplied at the intake. Customers have to overcome the algae load in order to carry any oxidizing residual to the WTP.
Reservoir Treatment Methodologies

- Treat Entire Reservoir
- Spot-Treat Sections of Reservoir
- Treat Area around the WTP Intake, e.g., a 30-day supply
EarthTec Reservoir Treatment

- Copper Remains in Suspension
- No Restrictions After Application
- Low Dose Prevents Algae Blooms
- Better Water Quality at Plant Influent (maximize contact time where possible)

- Competition:
  - Copper Sulfate- Inefficient-Ineffective-Labor Intensive
  - PAK27- Expensive- Kills everything- Daily applications
PAK-27 and Peroxide Products

- EarthTec will control existing algae and prevent new algae in reservoirs for 14-30 days. (Durational Control)
- EarthTec is 50-75% less cost.
- Peroxide products kill everything in the water (Biocide) and only last for 2-5 days before repeat applications are necessary.
- EarthTec will not rupture the algal cell or increase the cyanotoxin levels.
- Peroxide followed by EarthTec can be a great 1-2 punch
Reduces Algae
EarthTec use in WTPs

Before
EarthTec use in WTPs

After
Algae Kill Rates

- EarthTec starts killing immediately.
- Algae usually dies in 12-24 hours
- Heavy algal mats often take 3-7 days in order to kill all the way to the walls.
- 30 ppb EartHTec copper residual will prevent new algae growth.
EarthTec use in WTPs

Before
EarthTec use in WTPs

After
Texas, 50 MGD

QUALITATIVE ASSESSMENT

Before EarthTec:
- Algae Mats Floating in Clarifiers
- Algae on Steel (Needed Skin Divers to Clean Framework)
- Algae present in Outdoor Filters (Short Filter Runs)
- Feeding Copper Sulfate Crystals
- Feeding 12 ppm PAC

With EarthTec:
- Clarifiers Clear of Algae
- Algae No Longer Adhered to Structural Steel
- Outdoor Filters Free of Algae and more regular filter runs
- Discontinued Copper Sulfate
- Only Feeding PAC when needed, <3 ppm
Texas, 50 MGD

COST-BENEFIT ASSESSMENT

- **Before EarthTec:**
  - PAC at 12ppm, $1.00/lb x 5,000 lbs/d = $5,000/d
  - Copper sulfate at $1.50/lb x 100 lbs/d = $150/d
  - Total treatment for 50 MGD = **$5,150/d**

- **With EarthTec:**
  - PAC at <3ppm as needed, $1.00/lb x 1,250 lbs/d = $1,250/d
  - No copper sulfate
  - EarthTec = $400/d
  - Total for 50 MGD = **$1,650/d**

- EarthTec saving them **$3,500/d** during season

A 2 ppm reduction in consumption of PAC (Powdered Activated Carbon) offsets cost of 1 ppm EarthTec
### Texas, 50 MGD

#### Average TOC Removal Without and With EarthTec

<table>
<thead>
<tr>
<th>Month</th>
<th>2011 Raw</th>
<th>2011 Treated</th>
<th>% Removal</th>
<th>2012 Raw</th>
<th>2012 Treated</th>
<th>% Removal</th>
<th>Year-over-Yr Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>4.65</td>
<td>2.84</td>
<td>38.9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>5.08</td>
<td>2.44</td>
<td>52.0%</td>
<td>5.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>5.22</td>
<td>2.81</td>
<td>46.2%</td>
<td>5.56</td>
<td>2.95</td>
<td>46.9%</td>
<td>0.8%</td>
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<tr>
<td>April</td>
<td>4.93</td>
<td>3.16</td>
<td>35.9%</td>
<td>5.88</td>
<td>3.38</td>
<td>42.5%</td>
<td>6.6%</td>
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<tr>
<td>May</td>
<td>5.45</td>
<td>3.72</td>
<td>31.7%</td>
<td>5.14</td>
<td>3.11</td>
<td>39.5%</td>
<td>7.8%</td>
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<td>June</td>
<td>5.18</td>
<td>3.47</td>
<td>33.0%</td>
<td>4.78</td>
<td>2.95</td>
<td>38.3%</td>
<td>5.3%</td>
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<td>July</td>
<td>5.4</td>
<td>3.7</td>
<td>31.5%</td>
<td>4.47</td>
<td>2.59</td>
<td>42.1%</td>
<td>10.6%</td>
</tr>
<tr>
<td>August</td>
<td>5.46</td>
<td>3.69</td>
<td>32.4%</td>
<td>4.78</td>
<td>2.98</td>
<td>37.7%</td>
<td>5.2%</td>
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<tr>
<td>September</td>
<td>5.46</td>
<td>3.84</td>
<td>29.7%</td>
<td>4.41</td>
<td>2.92</td>
<td>33.8%</td>
<td>4.1%</td>
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<tr>
<td>October</td>
<td>4.29</td>
<td>2.97</td>
<td>30.8%</td>
<td>4.29</td>
<td>2.88</td>
<td>32.9%</td>
<td>2.1%</td>
</tr>
<tr>
<td>November</td>
<td>3.67</td>
<td>2.5</td>
<td>31.9%</td>
<td>4.64</td>
<td>2.78</td>
<td>40.1%</td>
<td>8.2%</td>
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<tr>
<td>December</td>
<td>3.82</td>
<td>2.64</td>
<td>30.9%</td>
<td>4.85</td>
<td>2.66</td>
<td>45.2%</td>
<td>14.3%</td>
</tr>
<tr>
<td>January</td>
<td>4.21</td>
<td>2.66</td>
<td>36.8%</td>
<td></td>
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<td></td>
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</tbody>
</table>

**Average without EarthTec** 35.1%

**Average with EarthTec** 41.0%  6.4%
Treatment Example

Texas, 50 MGD

Average TOC Removal Without (2011) and With (2012) EarthTec

Average TOC Removal in 2012 is 6.4% lower than in 2011
Copper Comparison

- EarthTec starts working immediately with results usually with 24 hours.
- EarthTec outperforms other copper products containing 2x-5x the amount of copper.
- EarthTec is much more efficient at delivering copper to algae/bacteria.
- EarthTec does not waste any copper as it will stay in suspension until consumed by algae, bacteria or organics.
Dispersion Video
## Copper Sulfates vs. EarthTec

<table>
<thead>
<tr>
<th></th>
<th>Copper Sulfate</th>
<th>Chelated Copper</th>
<th>EarthTec</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Copper</td>
<td>25%</td>
<td>9-10%</td>
<td>5%</td>
</tr>
<tr>
<td>BioAvailable CU++</td>
<td>2.5%</td>
<td>20-50%</td>
<td>100%</td>
</tr>
<tr>
<td>Self Mixing</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Distribution</td>
<td>Bottom</td>
<td>Slow</td>
<td>Immediate</td>
</tr>
<tr>
<td>pH</td>
<td>2-3</td>
<td>2-3</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Tulsa, OK

- Source water: Lake Spavinaw and Eucha
- Geosmin at intake often >1,000 ng/L
- Apply 1 ppm EarthTec at 50 mile pipeline intake
- Geosmin at pipeline outfall <30 ng/L
Tulsa, Dec 2013

Geosmin levels (ng/L) in raw water at Spavinaw Lake (two sample locations)

Start EarthTec, 1 mg/L

Avg 98% geosmin removal

Geosmin levels (ng/L) in water arriving at WTP, avg 12 ng/L
Proposed Mechanism for Destruction of Geosmin

Acidic Dehydration

trans-1,10-dimethyl-trans-9-decalol
182 g/mol.
Boiling point: 270 °C

1, 10-dimethyl-l(9)-octalin
182 g/mol.
Boiling point: 230 °C

Geosmin

Argosmin C

Prof. Linda Schweitzer, Ph.D., Oakland University, Michigan
Tampa

- Source water: Slow-moving river
- Geosmin at time of dose 900 ng/L
- Applied 1 ppm EarthTec at water surface
- Geosmin at 24 h <30 ng/L
Tampa, Feb 2015

Graph 1: Copper vs. Algae Count
- Copper (mg/L)
- Days since application
- Algae Count

Graph 2: Copper vs. Geosmin
- Copper (mg/L)
- Days since application
- Geosmin (ppt)
Cyanobacteria

- EarthTec does not rupture algal cells at our low dose of 1-3 ppm.
- EarthTec selectively goes after cyanobacteria at these doses allowing good bacteria to consume intracellular contents.
Effect of 120 ppb Cu⁺⁺ (in EarthTec) on morphology of *Microcystis* sp. In marina water (Mag. = 400X)

- Cell morphology changed -- spherical to flat
- 3-D morphology of cell cluster lost – globular to single layer of cells
Change in Relative Concentrations of Dissolved Organics in Marina Water (*Microcystis* Bloom) Treated with Selected Concentrations of Cu (EarthTec). Wavelengths = 260 and 235 nm as indices of Nucleic Acids and Carbohydrates, respectively.
Lake Management

- Easy to apply, no spraying necessary
- If sprayed, batches well with herbicides
- Preventative, long term durational control
- Irrigate immediately
- Irrigation lines – keep clean
- Bacteria control – condo lakes etc.
LABEL
SURVEY FORM

Date: ________________________   PRE-TREATMENT PROCESS SURVEY

Facility: ________________________________________________________________

Address: ______________________________________________________________________

Phone: _______________________________   Fax: _________________________________

Contact Person: ________________________________________________________________

Raw Water Source: River___ Lake___ Reservoir ___ size in acres ___ total gallons ______

Distance from Raw Source to Influent of Plant: _______________________________________

Number of Gallons Treated per Day:   Winter ________________     Summer _______________

T and O:  ___ Yes    ___ No    ___ Geosmin  ___ MIB   Time of Year: ____________________

Raw pH            Low _________    High _________

Raw Alkalinity    Low _________    High _________

Raw Ca Hardness   Low _________    High _________

Raw TOCs         Low _________    High _________

TOCs % Removal Required ________________________________

TOCs % Removal Achieved ________________________________

THM Counts _______________________________________________

HAA Counts _______________________________________________

Other Chemicals (with Dosages) Being Fed Between Source Water and Plant: _____________

Notes: ______________________________________________________________________

_____________________________________________________________________________

* Draw map on reverse side indicating flow diagram from source to plant with application points of other chemicals.
EarthTec QZ successfully controls zebra mussels at the intake of a major municipal water treatment plant

David Hammond, PhD,
Senior Scientist, Earth Science Laboratories, Inc.
EarthTecQZ

• Eliminate Quagga and Zebra Mussels with EarthTecQZ
  – 20-30 Installations and growing quickly
  – Low dose of 1-4 ppm as QZ achieves 100% mortality
  – WTP intakes and pipelines
  – Fish hatcheries
  – Pond and reservoir eradication
  – Emergency response at lakes
  – Requires additional service and monitoring
Zebra mussels have historically infested the intake structure of a major municipal WTP in the Midwest 2015-16

Raw Water Intake Structure for a 60 MGD Municipal WTP
Overview of Vadnais Lake Intake and proposed Trial of EarthTec QZ Water Intake Structure

Raw water enters here

Water then travels 4.5 miles to WTP
Design of an intake that allows dosing to protect intake screens
2015-16

Raw water enters through openings large enough that they can’t clog

Chemical dosing occurs within the intake structure itself, so you protect screens but don’t need to dose in the lake or river
This is what the clean screens look like
Zebra mussels fouled the intake screens of the WTP
2015

Screen fouled with zebra mussels, 2015
Zebra Mussels Infesting the 92” Raw Water Pipeline

2015
Zebra Mussels Infesting the 92” Raw Water Pipeline
2015
Zebra mussels being removed from the raw water pipeline
2015

Manual cleaning represents a worker safety hazard, requiring Tyvek suits and respirators.
Zebra mussels removed from the pipeline and screens

Mussels are removed by the dumpster load
Zebra Mussel Control
Summer, 2016

Bulk storage tank for EarthTec QZ -- 5,500 gallons
Treatment with 1ppm QZ ensured intake screens are free of zebra mussels

September, 2016
EarthTec QZ successfully prevented biofouling in Summer-Fall of 2016

September, 2016
Treatment with 1 ppm QZ ensured pipeline remained free of zebra mussels

September, 2016

EarthTec QZ successfully prevented biofouling in Summer-Fall of 2016

1 ppm dose as QZ = 60 ug/L as copper sufficient to achieve complete control
Treatment with 1ppm QZ ensured intake gates remained free of zebra mussels

September, 2016

1 ppm dose as QZ = 60 ug/L as copper sufficient to achieve complete control

6 ft x 4 ft intake gate

EarthTec QZ successfully prevented biofouling in Summer-Fall of 2016
Treatment with 1 ppm QZ ensured intake gates remained free of zebra mussels

September, 2016

Note that mussels were only able to colonize a few spots within eddies of unmixed water, such as the feed line itself.
Copper concentration (ug/L = ppb) in treated water reaching the municipal WTP, summer of 2016

<table>
<thead>
<tr>
<th>Date</th>
<th>WTP</th>
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<tbody>
<tr>
<td>6/14/2016</td>
<td>0</td>
</tr>
<tr>
<td>6/23/2016</td>
<td>2</td>
</tr>
<tr>
<td>6/30/2016</td>
<td>0</td>
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<tr>
<td>7/7/2016</td>
<td>3</td>
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<td>7/14/2016</td>
<td>4</td>
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<tr>
<td>7/21/2016</td>
<td>1</td>
</tr>
<tr>
<td>7/28/2016</td>
<td>0</td>
</tr>
<tr>
<td>8/11/2016</td>
<td>0</td>
</tr>
<tr>
<td>8/18/2016</td>
<td>1</td>
</tr>
<tr>
<td>8/25/2016</td>
<td>0</td>
</tr>
<tr>
<td>8/31/2016</td>
<td>0</td>
</tr>
<tr>
<td>9/15/2016</td>
<td>0</td>
</tr>
<tr>
<td>Average:</td>
<td>0.92</td>
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</tbody>
</table>

Dose applied at pipeline intake = 1 ppm as QZ = 60 ug/L as copper, yet copper residual in water reaching the WTP averages < 1 ug/L.

Copper is consumed by biological background demand in the pipeline.
Questions?