Source Identification Studies Copper and Dissolved Oxygen East San Joaquin WATER QUALITY COALITION

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Source Identification Requirements

"If field studies are not proposed, the thirdparty must demonstrate how the alternative source identification method will produce data or information that will enable the determination of contributions from irrigated agricultural operations to the water quality problem."

Appendix MRP-1; MRP Order R5-2012-0116-R4



Historical perspective

- Had numerous exceedances of copper that triggered management plans
- Other pesticide exceedances triggered management plans at the same locations
- Focused outreach occurred for copper and pesticides (e.g., chlorpyrifos)
- The Coalition was successful in completing management plans for organic pesticides but not copper
- Coalition undertook an examination of the potential sources of copper to understand the agricultural contribution





*ATSDR 2004; OEHHA Public Health Goals for Copper 2008

Hardness correction – calculation of the Water Quality Objective

 $CuWQO = exp^{((0.8545*\ln(hardness)-1.702)*0.96)}$





Results

- Median concentrations at sites range from about .5 $\mu g/L$ to 5 $\mu g/L$
 - Exception is Mustang Creek with median concentration of about 13 µg/L
- With a few exceptions, relatively narrow range of concentrations within each site
 - Exceptions are very large watersheds
- No temporal trends across years or within years
- No seasonal trend in exceedances
- Hardness ranges from about 20 to 450 mg/L and exceedance concentrations of copper range from 2.3 µg/L to about 29 µg/L respectively



Copper concentrations (data through 2014)







Hardness

ML

ENVIRONMENTAL





Agricultural Applications

- Major uses are on almonds, walnuts, and grapes
- Exceedances occur weeks to months after last applications
 - Applications are most common during winter/spring
 - Exceedances occur in every month
- No relationship between pounds applied and concentration in the water
- No relationship between acres receiving applications and concentration in the water





Copper and pesticide applications

- Copper concentrations in surface water are independent of any measure of copper application
 - Total pounds applied each year (p = 1.0)
 - Total number of acres receiving applications (p = 1.0)
 - Pounds per acre per year (p = 0.80)
 - Percent of acres in the watershed receiving applications (p = 0.17)

Copper applications



■ 2014 ■ 2015 ■ 2016 ■ 2017 ■ 2018 ■ 2019





Irrigation District Canal Maintenance

- Only a few districts used copper
- Timing of exceedances did not correspond to maintenance periods
 - Summer applications winter exceedances
- Different sites in same district experienced different patterns of exceedances
- As many exceedances in "non-copper use" districts as in "copper use" districts





Mines

- Dozens of inactive mines in Sierra foothills and higher elevations
- Expectation is rainfall events may mobilize mine drainage







Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet Projection: property=Lambert Conformal Conic Units: Foot US





Service Lawer Credits: Shaded Reter, Copyright © 2009 ESR Hydrology - NHD Hydroddia, 124 (000 scale, Mp. White upge gen Mean - Mean Barrisona Social States, 19755

Effect of mines on concentration at monitoring locations

Upstream condition	Average copper concentration (µg/L)
At least one upstream copper mine	1.0
No upstream copper mines	3.4
At least one upstream mine	1.5
No mines upstream	4.2



Groundwater

- Groundwater used for irrigation and is a potential source of copper
- Examined dissolved copper concentrations from wells in GeoTracker





Copper in groundwater and surface water

• Surface and groundwater copper concentration are correlated

But

- Groundwater pumping is seasonal, but exceedances occur throughout the year
- Watersheds with elevated groundwater concentrations and irrigation with groundwater have no exceedances



Hardness and copper

- Exceedances are determined as much by hardness as by the concentration of copper
 - Elevated concentrations are not exceedances at elevated hardness
 - Low concentrations are exceedances at low hardness





Hardness and exceedances



Log Hardness





Variation in hardness

- Source of water varies within a single year and across years
 - Water from the Sierra Nevada is rainfall and snowmelt derived and is soft
 - Groundwater is hard
- Irrigation water
 - All surface water
 - All groundwater
 - Blend of surface and groundwater
- Generates a range of hardness across the year

Conclusions copper

- No relationship between concentration of copper and any aspect of mines, irrigation districts, or agricultural applications
- Indication that site-specific factors determine copper concentrations
 - Naturally occurring
 - Groundwater
- Only factor associated with exceedances is hardness





Dissolved Oxygen



Every monitoring site is in a management plan for DO

Objective is based on beneficial uses (5 mg/L, 7mg/L)

Objectives may not apply to drains and laterals (constructed conveyances)

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A field measurement recorded every sampling event

Physical factors impact DO



Agricultural discharges could decrease DO Nutrients stimulating algal growth



Data

- Data from 2003 2014
- 1200 sampling events from 25 stations in ESJWQC region





DO – Variables



DO – Variables



Developed 7/2007 by Kate Schofield & Suzanne Marcy; modified 6/2010 ENVIRONN.

DO – Variables





Analyses

- Guided by US EPA Causal Analysis/Diagnosis Information System (CADDIS Volume 2) example for DO
- Coded DO concentrations as being below or above the objective (exceedance = 1, acceptable = 0)
 - Performed logistic regression analyses separately for both objectives (5mg/L, 7 mg/L)
- Random sampling of data to obtain 200 data points (jackknife)
 - Performed 1000 sampling events and ran logistic regression analyses on each of the 1000 samples of 200





Nothing is strongly correlated with DO exceedances

- Flow
- TOC
- NO₃
- PO₄
- NH₄
- Temperature
- Specific Conductance
- Explain 19% of the variation in exceedances
- Complex interaction of factors as CADDIS diagram depicted



Results

Feedback to Management Plan Process

- Likely source of copper is naturally occurring copper
 - Focused Outreach is still conducted although additional practices are unlikely to prevent copper from being found in the water
- Grower discharges of nutrients unlikely to be responsible for DO exceedances
 - Explain only 11% of variation in DO exceedances
- Flow continues to decrease due to improved water use efficiency and reduced tailwater discharge
 - No Focused Outreach for DO
 - Field measurements are collected

