Comparisons of the 2007 Biotic Ligand Model (BLM)-based and the 1984 hardness-based Copper criteria: update considerations

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Presentation to the IDEQ Negotiated Rulemaking Meeting
Boise,
October 28, 2015

Analyses may be provisional and subject to revision

U.S. Department of the Interior
U.S. Geological Survey

30-day old White sturgeon (Doug Hardesty)

Caveats

- **On behalf of NMFS and USFWS, I contributed to the "effects analysis" portions of their biological opinions ("BiOps") on EPA's approval of Idaho's water quality criteria for toxics.**
- **As such, I may be able to help explain some of science considerations behind the opinions, and how these BiOps relate to the proposed criteria changes;**

- **But I cannot specifically speak for either Service, or advocate particular positions or policies, beyond describing what's already in the BiOps.**

Copper's essentiality and selective toxicity has long been exploited

Unpopular with:

- Fouling organisms
- Molluscs
- Algae
- Rooted plants
- Crustaceans

Popular with:

- British Navy in 1700s
- Mariners
- Plumbers
- Aquaculturists
- Water deliverers
- USGS WQ staff

Chinook Salmon

Chris Mebane, USGS

Bull Trout

Chris Mebane, USGS

Steelhead

Chris Mebane, USGS

Bliss Rapids Snail

David Richards, Idaho Power

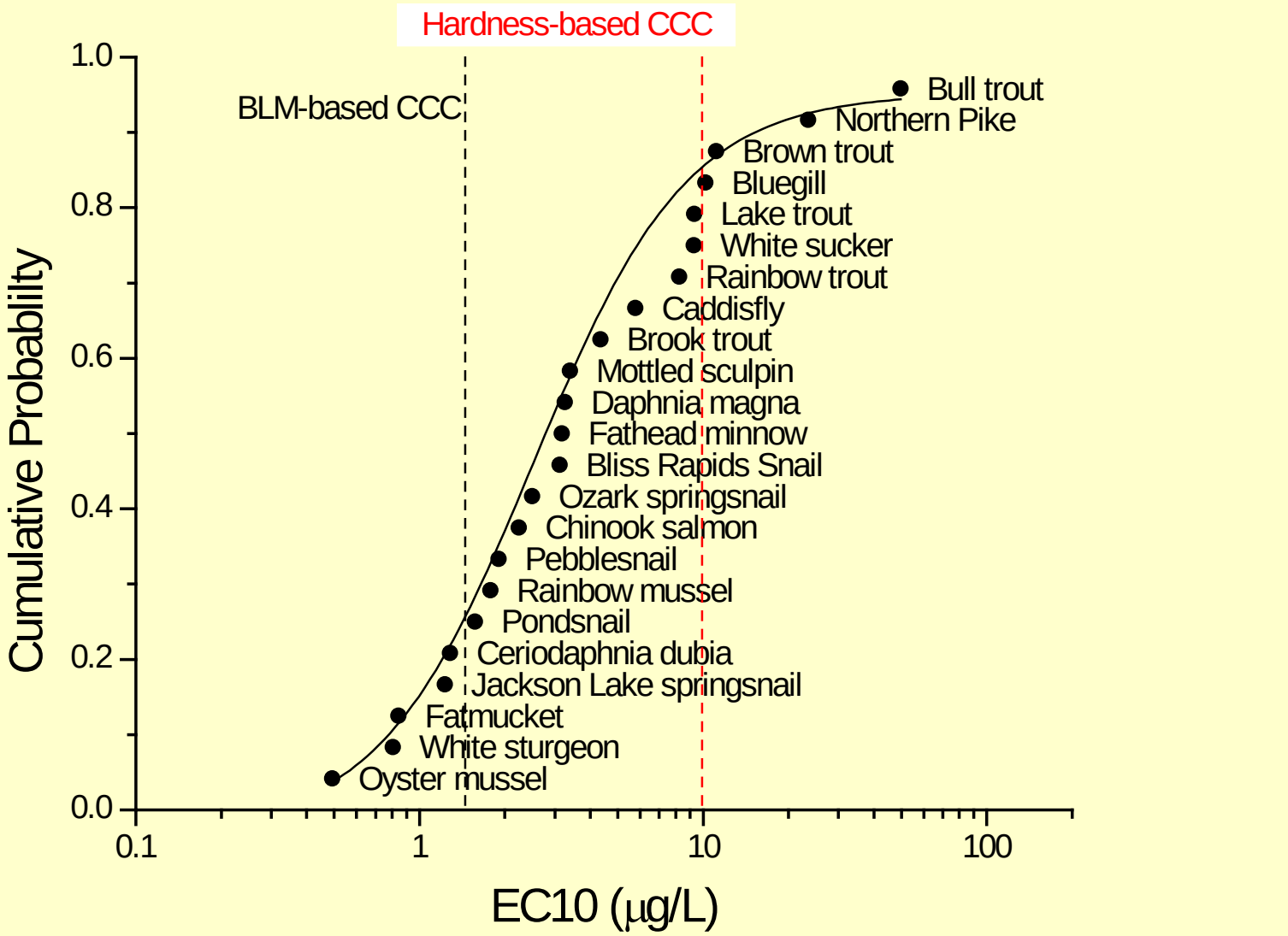
Banbury Springs Lanx
(Lymnaeidae)

Bill Mullins, USGS

Many freshwater mussel species
in central & eastern USA

Doug Hardesty, USGS

Chronic species-sensitivity distribution

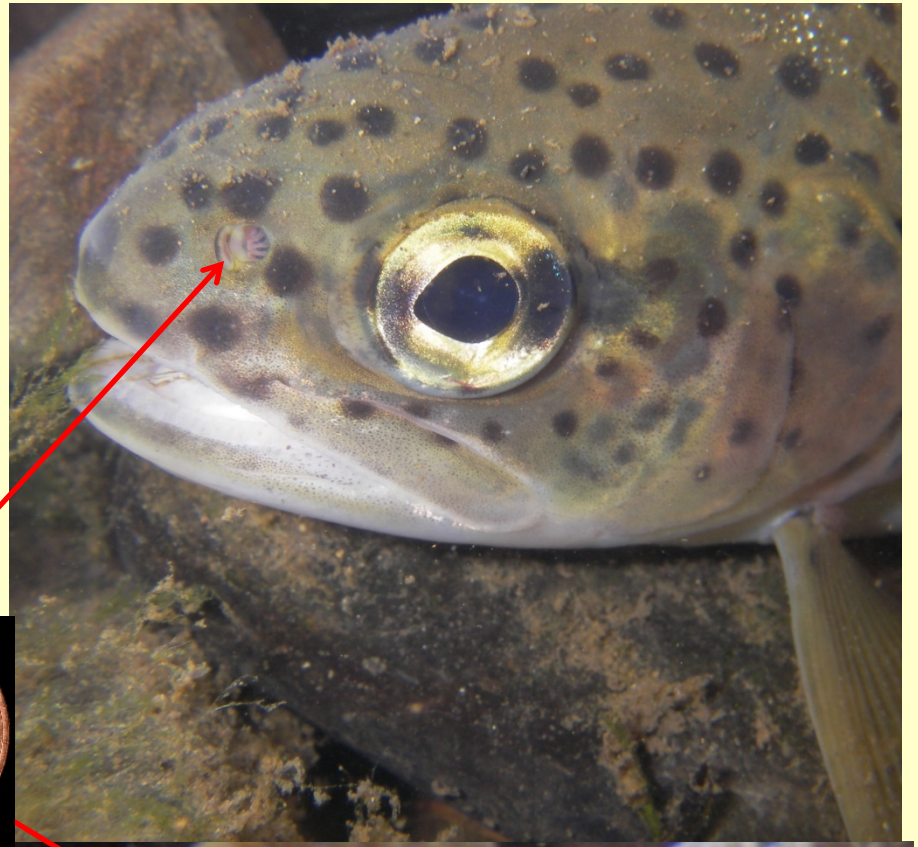


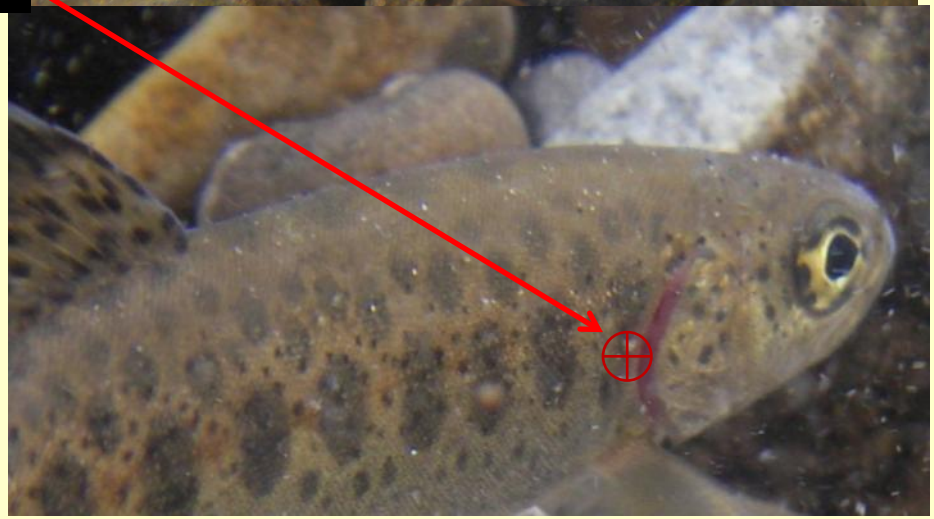
Chronic copper values, BLM-normalized to ASTM mod-hard water (hardness 84 mg/L)

Copper is sticky

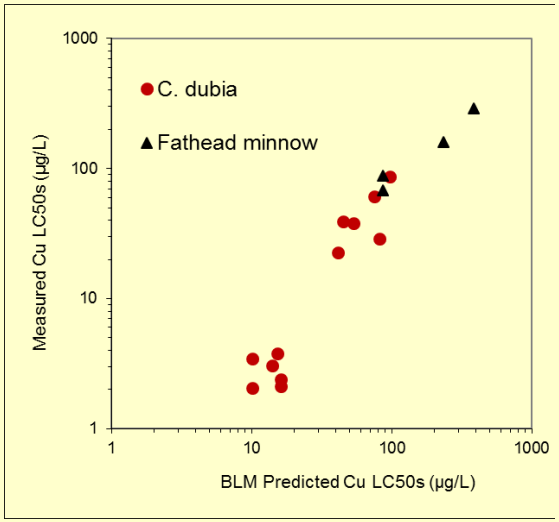
Binds strongly to organics, such as dissolved organic carbon in water (DOC) or gill surfaces

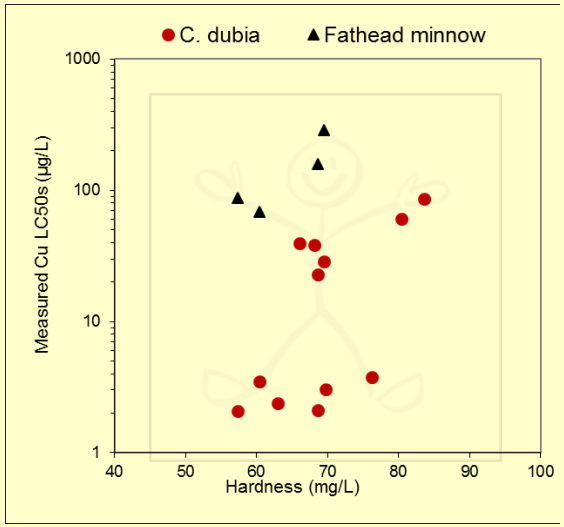
- The sites that bind:
  - Copper bound to DOC in water is less available to bind to the snout of a trout;
  - Or to the gill of a fish,
  - Or to any “biotic ligand”
  - If copper isn’t available to bind, it’s not toxic

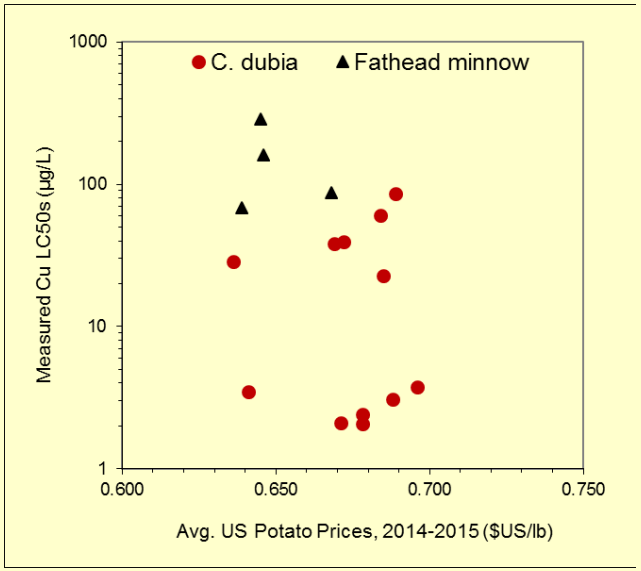




Performance of Cu BLM & hardness for predicting toxicity to fish and invertebrates in Boise River study







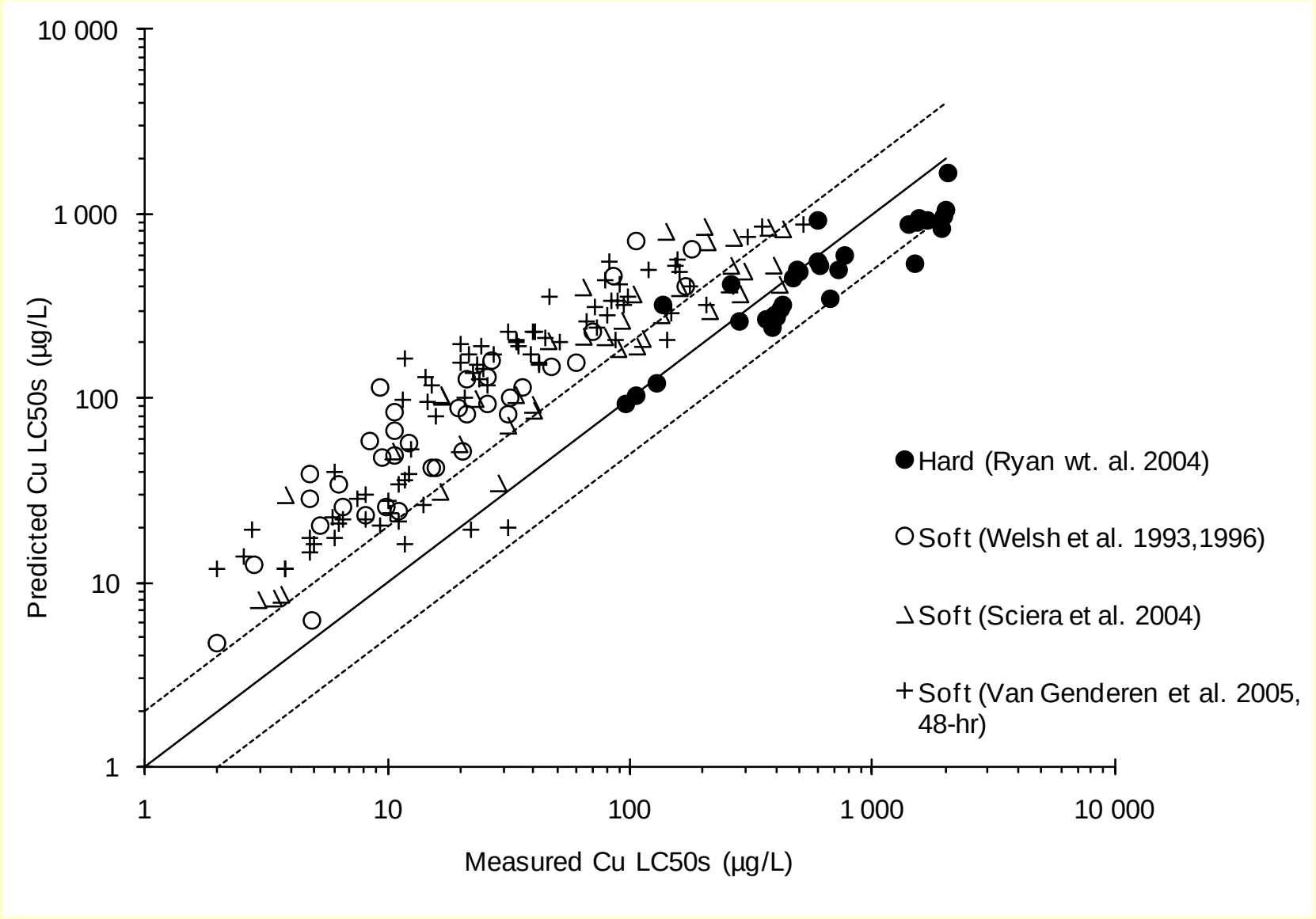
Ceriodaphnia dubia

Fathead Minnow

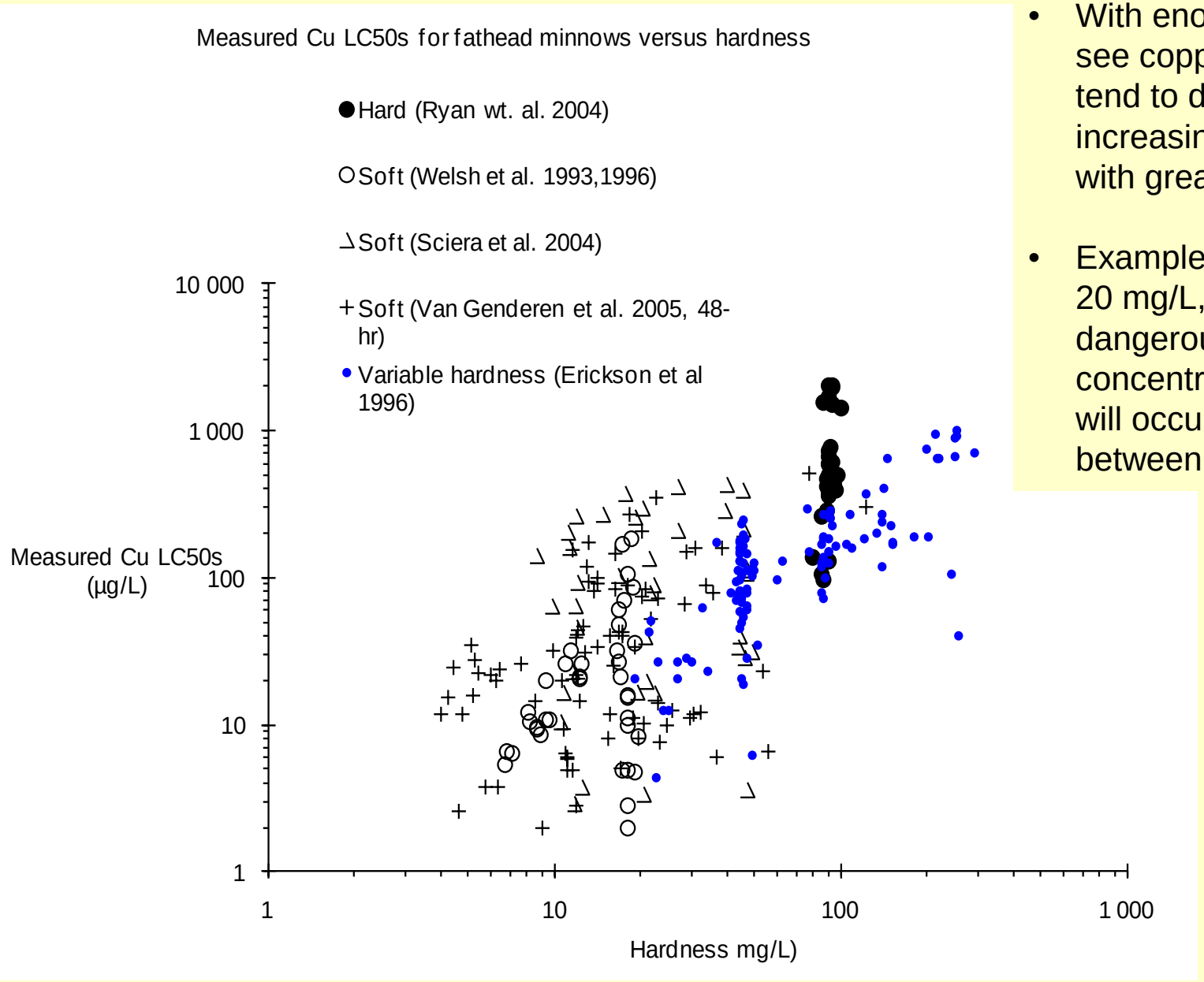
- BLM predicted actual results fairly well
- Hardness-predicted copper toxicity produced spurious patterns;
- Hardness little better than using a nonsense predictor variable

Data source: Boise River Water Effect Ratio Study, City of Boise, 2002

BLM performance with fathead minnow in diverse natural waters



Hardness performance with fathead minnow in diverse waters



- With enough data, we see copper toxicity does tend to decrease with increasing hardness, but with great uncertainty
- Example: At hardness of 20 mg/L, confidant that dangerous copper concentrations (LC50s) will occur somewhere between 2 and 400 µg/L

Hardness in streams is from weathering of rocks

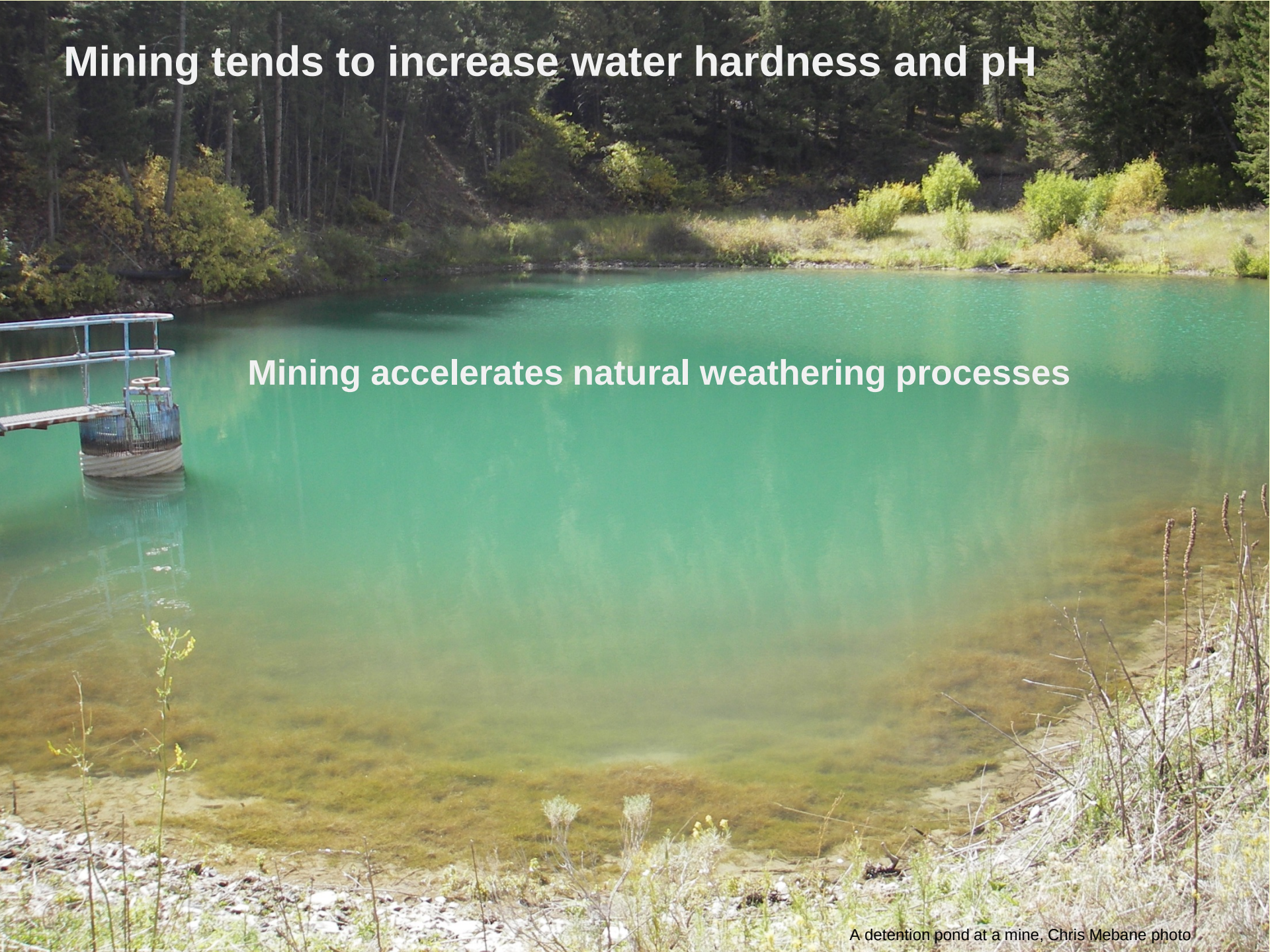
- Highest at baseflows
- Lowest during spring snowmelt runoff

Azure Pool, Yellowstone NP

Havasu Creek and the Colorado River, Grand Canyon NP

Blue Lakes near Twin Falls, unknown photographer

Mining tends to increase water hardness and pH



Mining accelerates natural weathering processes

A detention pond at a mine, Chris Mebane photo

Natural organic carbon in streams is mostly from decomposing vegetation

- Lowest during the low flow growing season
- Highest during spring snowmelt runoff

Tahquamenon Falls State Park, Michigan, Michigan DNR

Little Wood River in July, October, and March

Seattle Post-Intelligencer

piquenewsmagazine.com

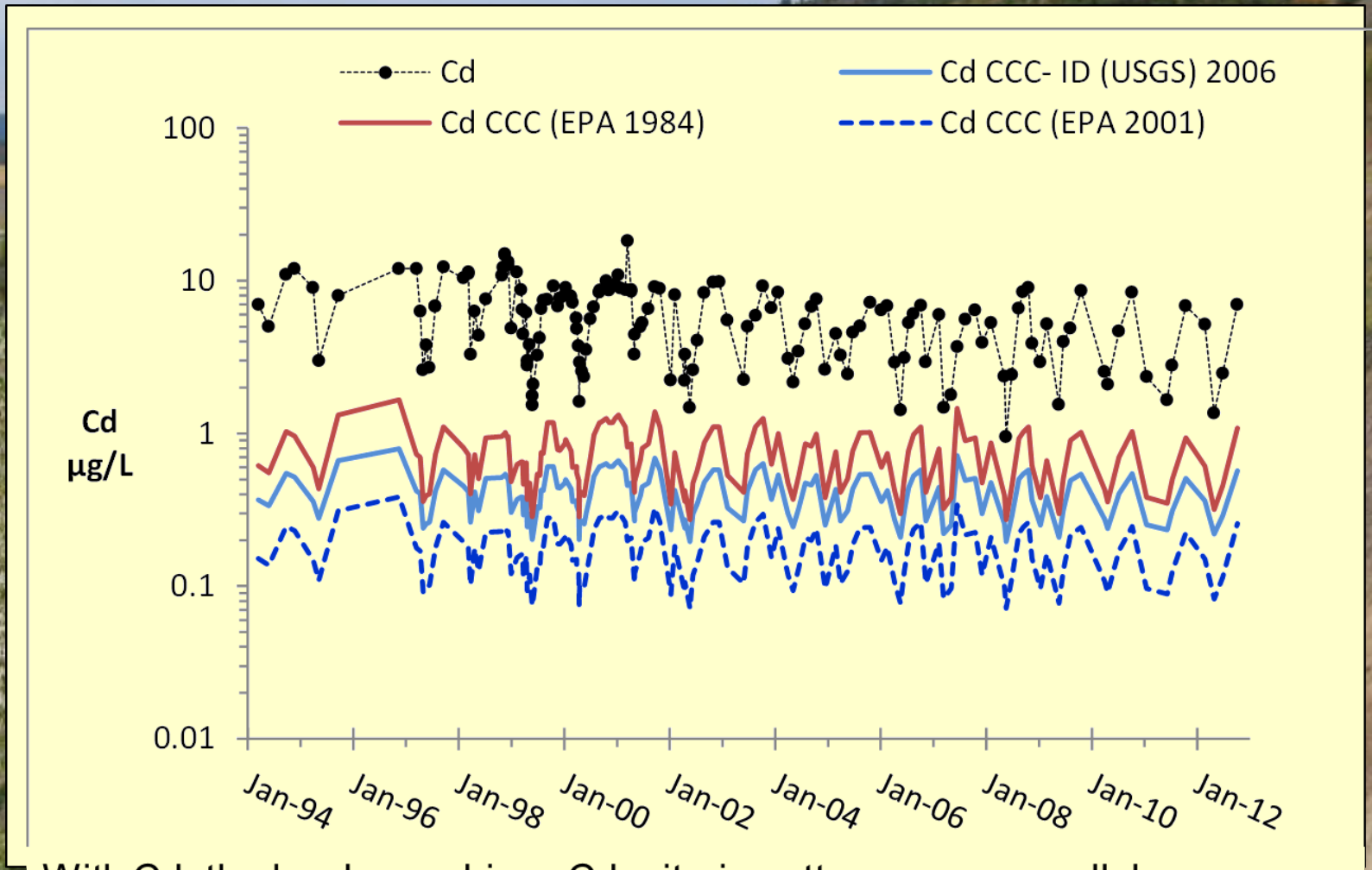
wsu.edu

Municipal wastewater or urban stormwater tends to increase hardness, pH, and DOC

City of Boulder

What's the big deal with BLM-Cu criteria revisions? Contrast with Cd criteria revisions: Cd is always in sync with Cd criteria

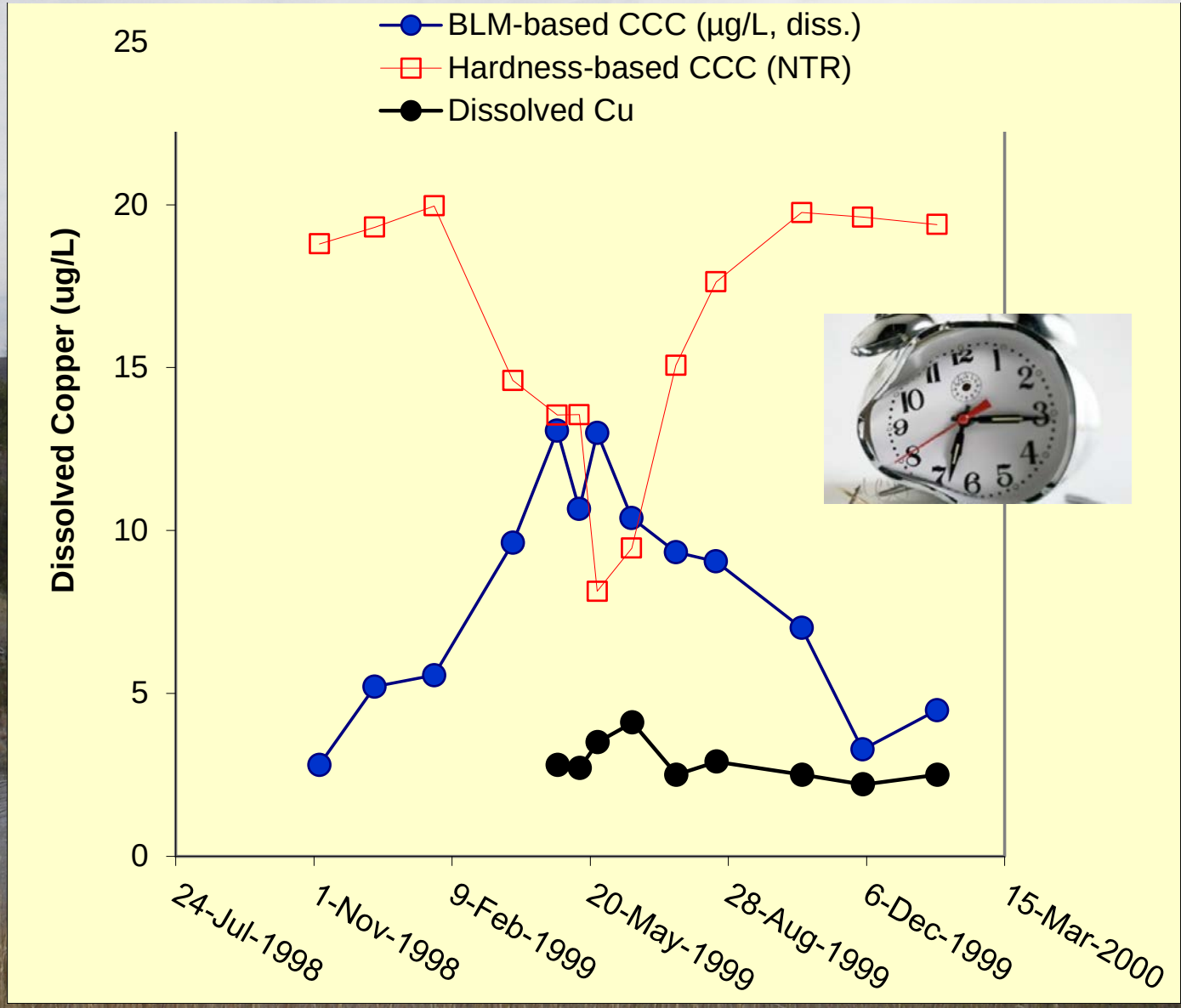
South Fork Coeur d'Alene River, near Pinehurst Idaho



With Cd, the hardness-driven Cd criteria patterns were parallel across versions; the concentrations differ but not the patterns.

Greg Clark

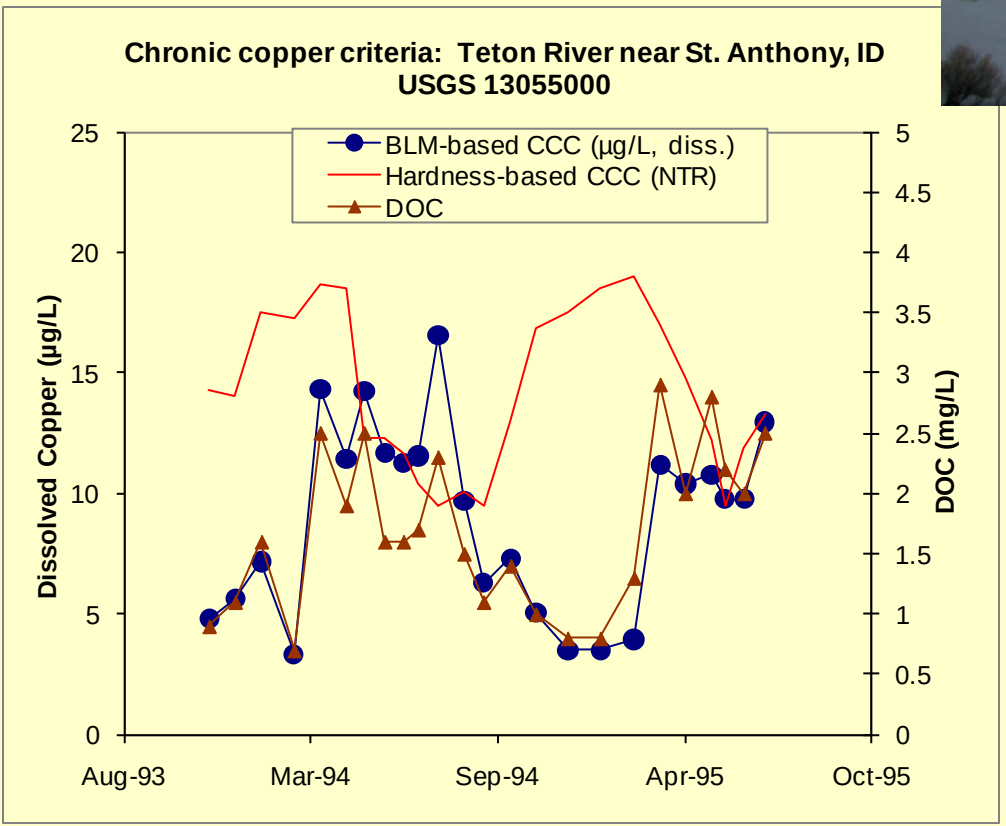
Not so with Copper.



Hardwater stream with low DOC

Teton River near St Anthony

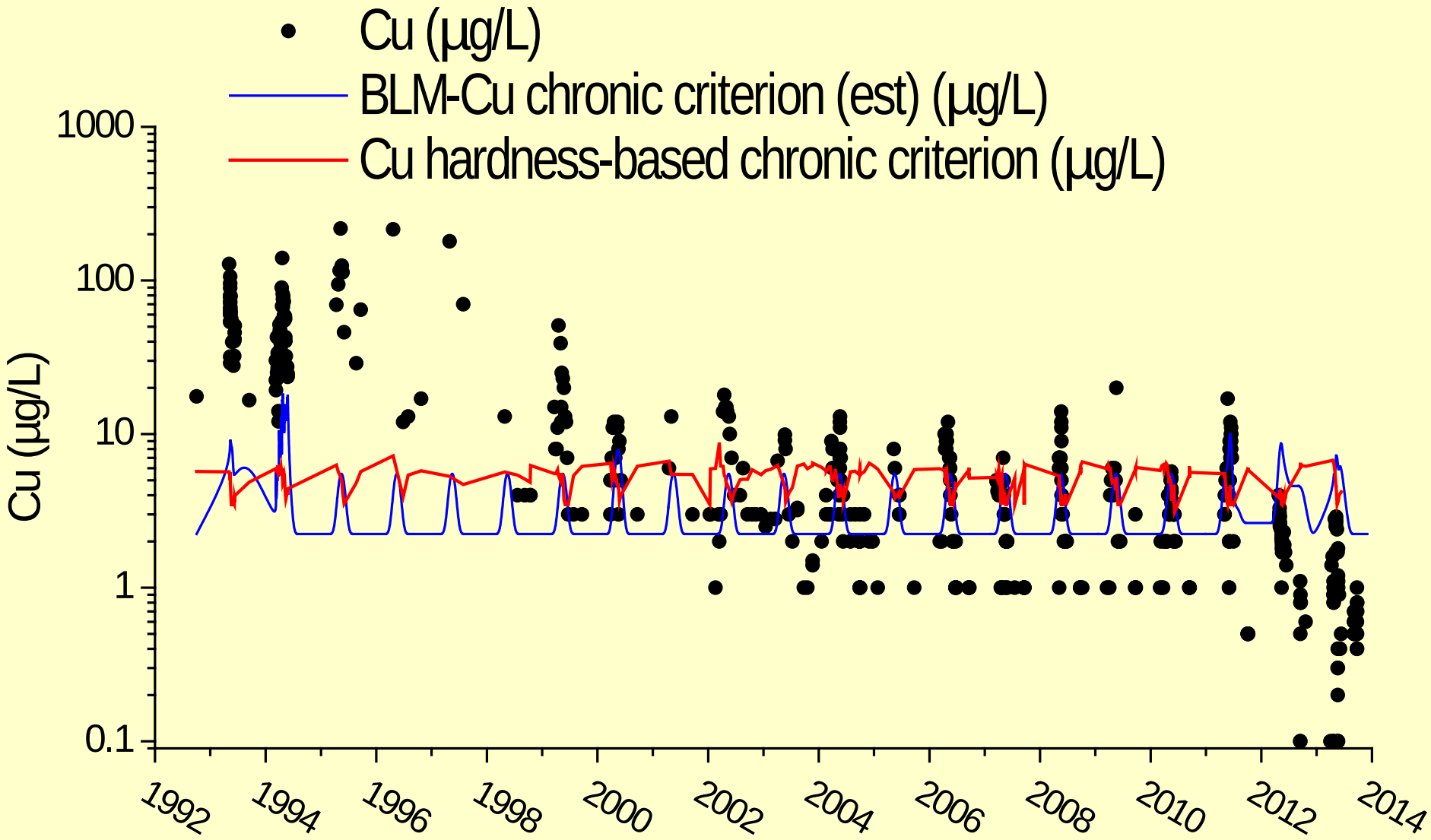
Probably relevant to hardwater streams such as Pahsimeroi R, Lemhi R, Mid-Salmon R. downstream the Lemhi

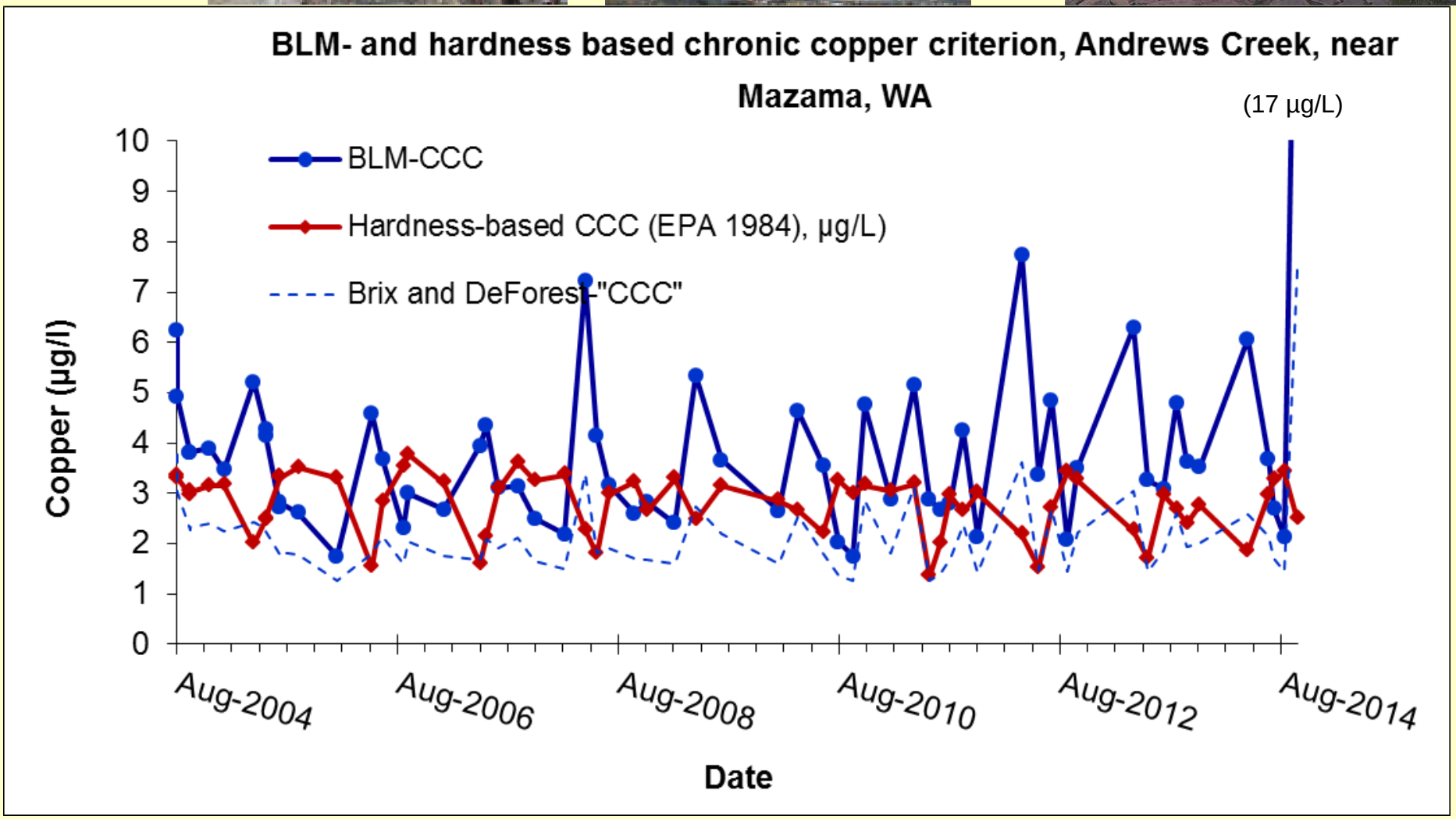


(Hardness 65-175 mg/L, pH 7.7-8.6, DOC 0.9 to 3 mg/L)

BLM-Cu criteria in sync with instream Cu, not so with hardness

Panther Creek, near Salmon, Idaho




BLM- and hardness based chronic copper criterion, Andrews Creek, near Mazama, WA
(17 µg/L)
BLM-CCC
Hardness-based CCC (EPA 1984), µg/L)
Brix and DeForest-"CCC"
Copper (µg/l)
0
1
2
3
4
5
6
7
8
9
10
Aug-2004
Aug-2006
Aug-2008
Aug-2010
Aug-2012
Aug-2014
Date

Northwestern soft water salmon stream, Big Soos Creek, near Auburn, WA

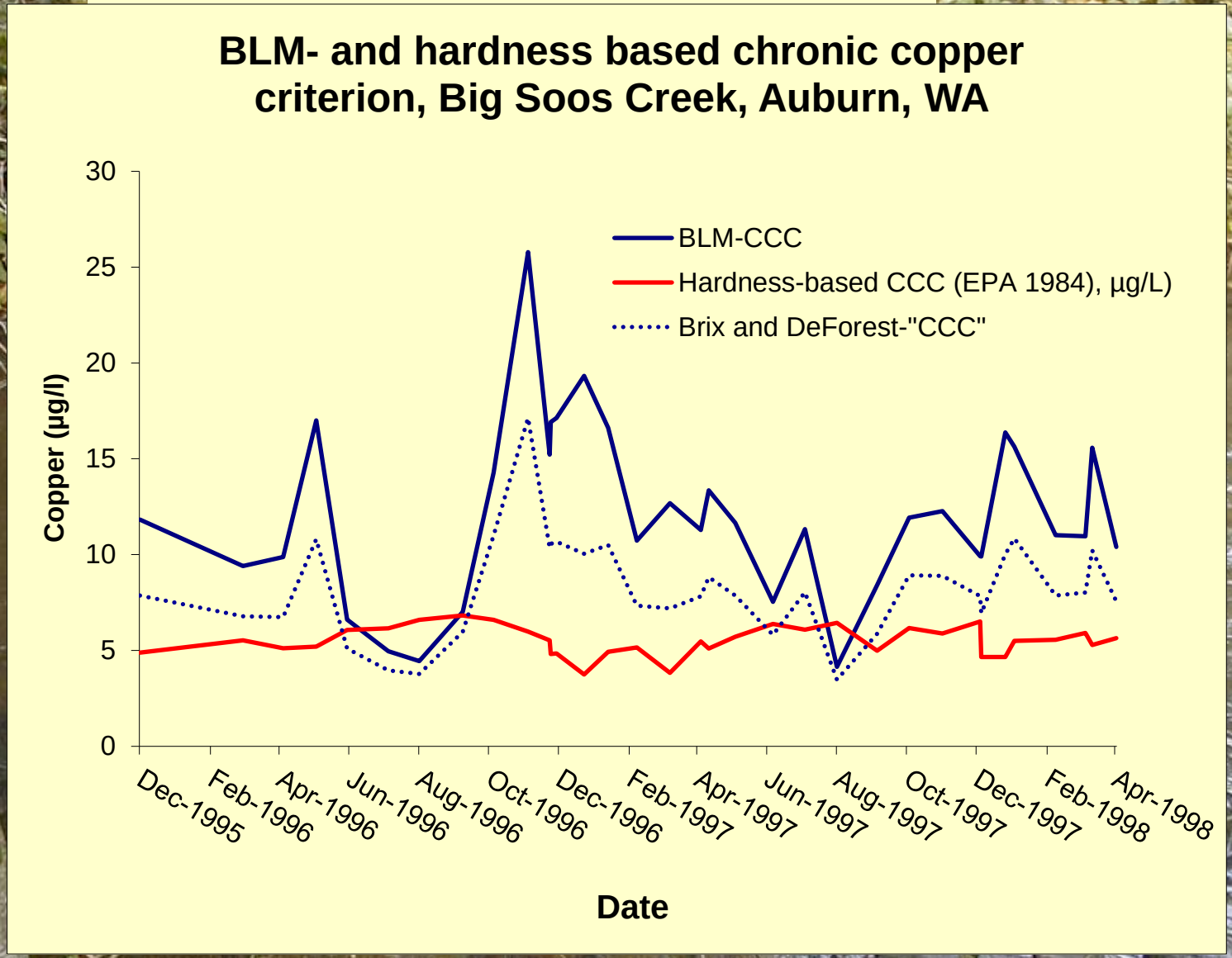
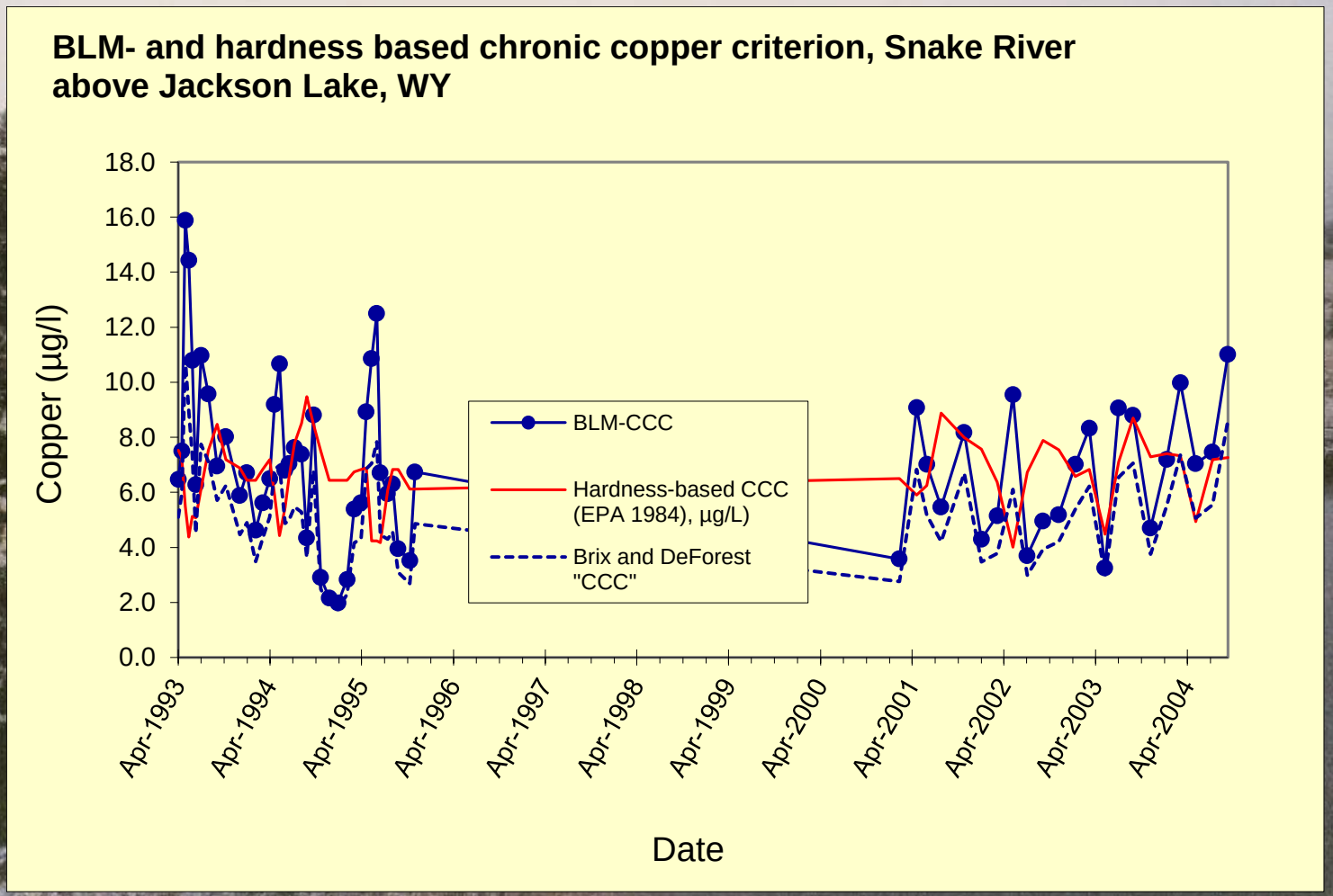
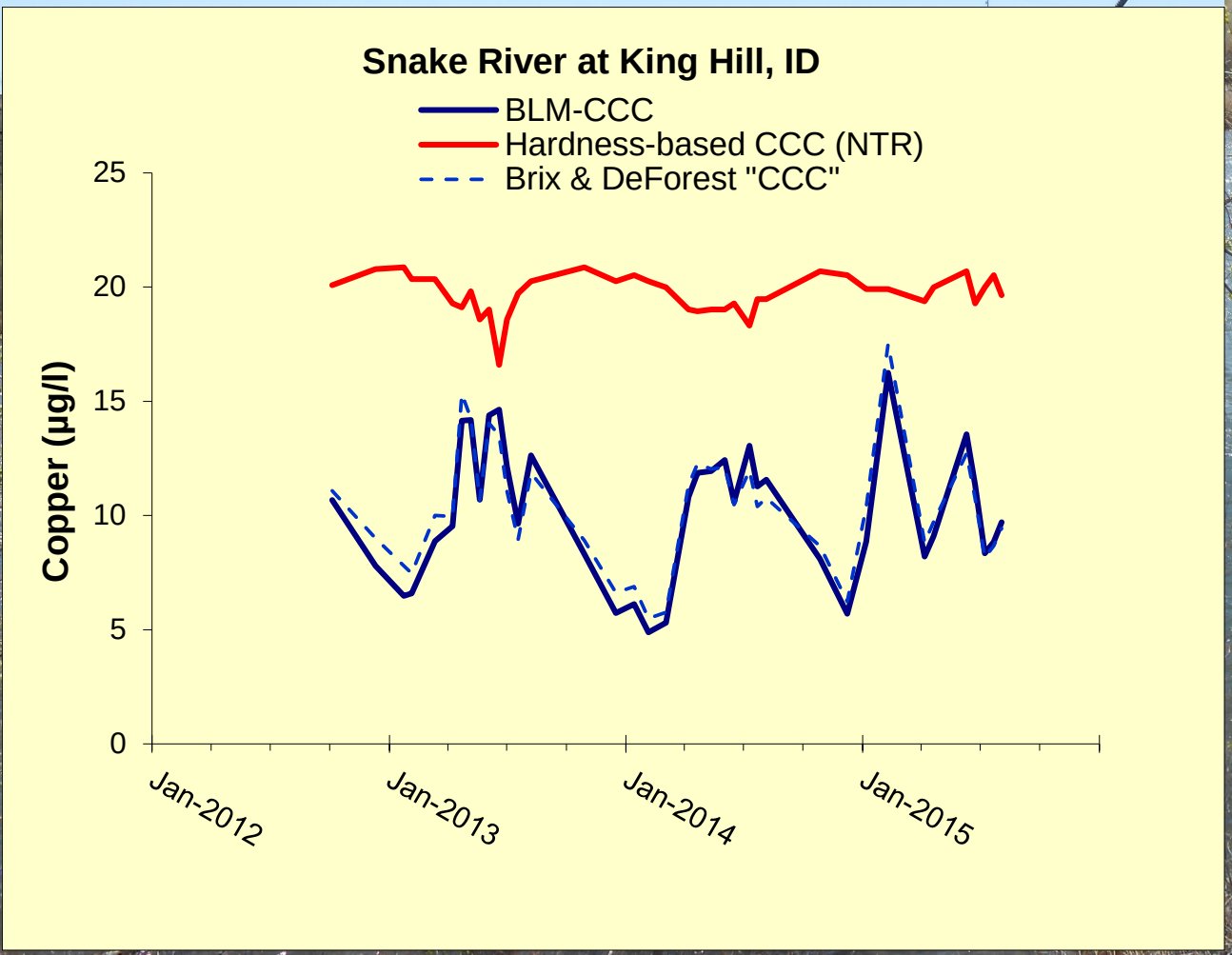


Photo King County Department of Parks and Natural Resources

Snake River above Jackson Lake, Wyoming (hardness 25-60 mg/L, pH 7 to 8.5, DOC 0.9 to 4.5 mg/L)



Snake River at King Hill, ID (hardness 170-205 mg/L, pH 8 to 8.8, DOC 0.9 to 2.8 mg/L)



2.8.3.2. New Acute and Chronic Aquatic Life Criteria for Copper

" The EPA shall ensure, either through EPA promulgation of criteria or EPA approval of a state-promulgated criteria, that new acute and chronic criteria for copper are in effect in Idaho within 3 years of the date of this Opinion. The new criteria shall be no less stringent than the Clean Water Act section 304(a) 2007 national recommended aquatic life criteria (i.e. the BLM Model) for copper. The NMFS does not anticipate that additional consultation will be required if the 2007 national recommended aquatic life criteria for copper are adopted."

Complementary steps (address uncertainty, potential additive mixture toxicity)

- **Limit mixing zone to 25% of volume, unless site-specific analysis**
- **Whole effluent toxicity testing**
- **Instream biomonitoring**

An approach on implementation

1. Simple, conservative, default screening values by major river basin

Integrated list, RPTE for monitoring requirements. Could use straight up or have data collection triggers.

2. Where warranted, use MLR-based spreadsheet "criteria" values or BLM-criteria values to estimate critical conditions

Data needs? 6X per year 3/years?

3. Use critical condition concentrations in NPDES/IPDES in permit waste load allocations in the usual way

1. Default screening values example – no monitoring needed

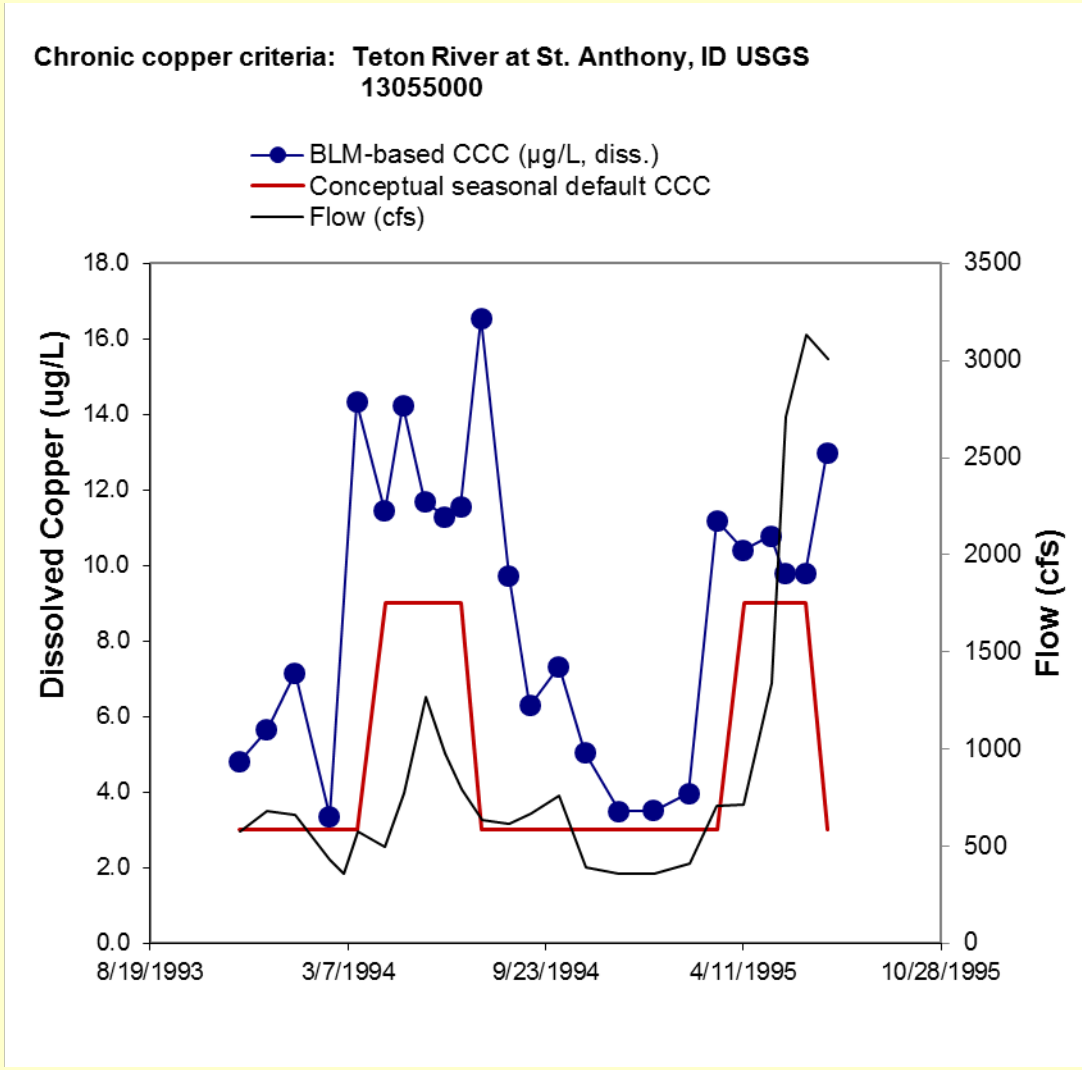
Appendix C: Evaluation of EPA's 2007 biotic ligand model (BLM) based copper criteria

Table 3. Ranges of chronic copper criterion concentrations estimated for critical late summer/fall baseflow conditions in subbasins within the range of anadromous salmonids in the Snake River basin, Idaho.

Subbasin	Common subbasin geologic characteristics	Critical late-summer Cu benchmark concentration (µg/L)	Based upon EPA's 2007 Cu chronic criterion (CCC) using data collected or estimated using:
Selway, Lochsa, MF Clearwater R	Granitic or intrusive rocks from Idaho Batholith or Precambrian metamorphic rocks	0.6	St Joe River at Red Ives, 9/14/2007; SF Coeur d'Alene R at Pinehurst, 9/10/2007; NFCDA Fig 25
SF Clearwater River	Idaho Batholith	1	SF Clearwater at Stites
MF and SF Salmon and tributaries	Idaho Batholith	1	Extrapolated using low conductivity measured in undisturbed streams in the Salmon R basin (Ott and Maret 2003), ~30 µs/cm, pH 6.9, using DOC of 1 mg/L and then estimating major ions with regression equations from streams in Coeur d'Alene R with similarly low conductivity
Upper Salmon R	Idaho Batholith and Challis volcanics	3	Snake River (Fig. 24); Johnson Creek at Yellow Pine, 10/10/2007
Upper Salmon R tributaries	Challis volcanics	3	Assumed similar to Panther Creek
Panther Creek	Challis volcanics and Idaho Batholith	3	Minimum BLM=CCC calculated for low-flow, low DOC conditions from a 1994 dataset (Maest *et al.* 1995)
Lemhi and Pahsimeroi Rivers	Tertiary sediments from ancient lake bottoms	6	Pahsimeroi at Ellis, 9/18/2007
Lower Salmon (downstream of SF Salmon)	Diverse	3	Salmon River at White Bird, 9/27/2007
Snake River	Diverse	6	Minimum BLM calculated for Snake River at mouth (Burbank, WA)

Data collected in 2007 were for a single data collection. It seemed reasonable to assume that late summer baseflow conditions were probably close the critical condition (i.e., annual minimum) CCC calculated using the BLM-based Cu criteria. However, because the BLM-based criteria is sensitive to pH and these mid-day collected samples probably

2. A hypothetical two-stage high flow/low flow critical conditions scheme



3. Consider the spreadsheet equation developed by Brix and DeForest in lieu of the 2007 HydroQual Windows software

A streamlined alternative that draws on the science behind BLM

Cu "CMC" =EXP(-14.23+6.8067*LN(**pH**)+0.8947*LN(**DOC**)+0.4418*LN(**Hardness**))

Similar in complexity to existing ammonia equations:

d. Ammonia. The following criteria are not to be exceeded dependent upon the temperature, T (degrees C), and pH of the water body: (3-15-02)

i. Acute Criterion (Criterion Maximum Concentration (CMC)). The one (1) hour average concentration of total ammonia nitrogen (in mg N/L) is not to exceed, more than once every three (3) years, the value calculated using the following equation:

$$CMC = \frac{0.275}{1 + 10^{7.204 - pH}} + \frac{39.0}{1 + 10^{pH - 7.204}}$$

(3-15-02)

ii. Chronic Criterion (Criterion Continuous Concentration (CCC)). (3-15-02)

(1) The thirty (30) day average concentration of total ammonia nitrogen (in mg N/L) is not to exceed, more than once every three (3) years, the value calculated using the following equations: (3-15-02)

(a) When fish early life stages are likely present:

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \bullet MIN(2.85, 1.45 \cdot 10^{0.028(25-T)})$$

(3-15-02)

(b) When fish early life stages are likely absent:

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \bullet 1.45 \cdot 10^{0.028(25-T)})$$

(3-15-02)