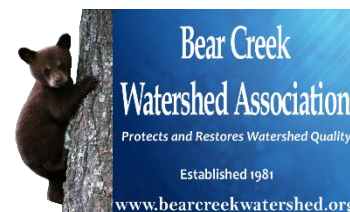


Technical Memorandum BCWA



Date: February 12, 2017
To: Bear Creek Watershed Association
From: Russell N. Clayshulte, Manager
Re: BCWA TM 2016.12 Copper Study

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In December 2015, The Colorado Water Quality Control Commission adopted a revised 303(d) list of priority pollutants causing impairment or those needing further monitoring and evaluation. The Colorado 303(d) List identifies those water bodies, where there are exceedances of water quality standards or non-attainment of uses. While the original proposal was to list the entire segment 1e for copper, the BCWA demonstrated successfully that the problem was only documented for a very limited portion of the segment within Morrison (See the Copper Database BCW Segment 1e spreadsheet). There were only four sample dates that exceeded the standard between 2008-2013. As such, the WQCC limited the listing to extend from the mouth of Mount Creek to the inlet of the Harriman Ditch.

Table 1 303(d) Listing for Copper

WBID	Segment Description	Portion	303(d) Impairment	303(d) Priority
COSPBE01e	Mainstem of Bear Creek from the outlet of Evergreen Lake to the Harriman Ditch.	Mount Vernon Creek to the Harriman Ditch	Cu	H

The Association is undertaking a copper specific monitoring program to better document the copper issue and potential identify a copper source(s) near Morrison. The Association will work with the Denver Water Department to obtain their entire water quality database for sites within the watershed and work to coordinate programs. Morrison will assist with the monitoring program. GEI is doing a low-level copper testing, which includes a hardness titration. Since this is a 303(d) listing, a 5-year monitoring program is necessary for delisting purposes. Three monitoring sites will be necessary for each sample date. The monitoring site locations maybe adjusted each year depending on annual data results. If a copper source(s) are found, then program may become limited.

Monitoring Program

- Three Sample Sites. Upstream of the Harriman Ditch diversion (BCWA Site P3 14c), BCWA sample site 87 or other upper segment sites on Mount Vernon Drainage, and at the USGS gaging station in Morrison Park West (BCWA Site 14b).

- Sample Frequency – Monthly (maybe limited during ice conditions). Generally, 12 sample sets per year.
- Sample Date - Linked with monthly P-1 sampling program.

- Samples collected as grab samples by Association Manager in sample container provided by contract lab (GEI). Field probe data and flow data is collected with samples.

- The hardness of the samples is measured by GEI (Standard Methods 2340C). The filtration for dissolved copper analysis is completed by GEI, the samples were then sent to *Accutest* for dissolved copper analysis.

- Copper Analytical Method EPA 200.8
 - All samples were digested and analyzed within the recommended method holding time.
 - All method blanks meet method specific criteria.
 - SAMS certifies that data reported for samples received, listed on the associated custody chain or analytical task order, were produced to specifications meeting AMS's Quality System precision, accuracy and completeness objectives except as noted.
 - Estimated non-standard method measurement uncertainty data is available on request, based on quality control bias and implicit for standard methods. Acceptable uncertainty requires tested parameter quality control data to meet method criteria.
 - SAMS is not responsible for data quality assumptions if partial reports are used and recommends that this report be used in its entirety. This report is authorized by SAMS indicated via signature on the report copy.

- Copper Standard
 - Chronic = $e^{(0.819(\ln(\text{hardness}))-1.7428)}$
 - Acute = $e^{(0.9422[\ln(\text{hardness})]-1.7408)}$
 - *Hardness values to be used in equations are in mg/l as calcium carbonate and shall be no greater than 400 mg/L. The hardness values used in calculating the appropriate metal standard should be based on the lower 95 per cent confidence limit of the mean hardness value at the periodic low flow criteria as determined from a regression analysis of site-specific data. Where insufficient site-specific data exists to define the mean hardness value at the periodic low flow criteria, representative regional data shall be used to perform the regression analysis. Where a regression analysis is not appropriate, a site-specific method should be used. In calculating a hardness value, regression analyses should not be extrapolated past the point that data exist.*
 - *Both acute and chronic numbers adopted as stream standards are levels not to be exceeded more than once every three years on the average.*
 - *For acute conditions the default assumption is that salmonids could be present in cold water segments and should be protected. For chronic conditions, the default assumptions are that early life stages could be present all year in cold water segments and should be protected.*



Figure 1 Copper Monitoring Sites

Table 2 Copper and Hardness Data Summary

Seg ment	Site ID	Site Location by Stream Segment	Dissolved Copper, ug/l								Aver age	Standard Deviation
			5/16/2016	6/10/2016	7/7/2016	8/13/2016	9/20/2016	10/18/2016	11/17/2016	12/5/2016		
1e	Site 14a	Mainstem Bear Creek, Morrison Park west	1.4	1.3	2.6	1.6	1.6	1.7	1.6	1.6	1.7	0.4
4a	Site 87	Mt Vernon Drainage, Morrison	1.6	2.9	2.4	1.1	2.4	1.8	2.0	1.8	2.0	0.6
1e	Site 14c	Mainstem Bear Creek, Morrison at Harriman	1.2	4.7	1.1	1.2	2.4	1.4	1.4	1.7	1.9	1.2
			Hardness as CaCO3, mg/l									
1e	Site 14a	Mainstem Bear Creek, Morrison Park west	58	40	46	62	56	72	70	76	60	13
4a	Site 87	Mt Vernon Drainage, Morrison	378	440	456	482	470	510	510	476	465	43
1e	Site 14c	Mainstem Bear Creek, Morrison at Harriman	76	50	60	76	74	96	104	102	80	20

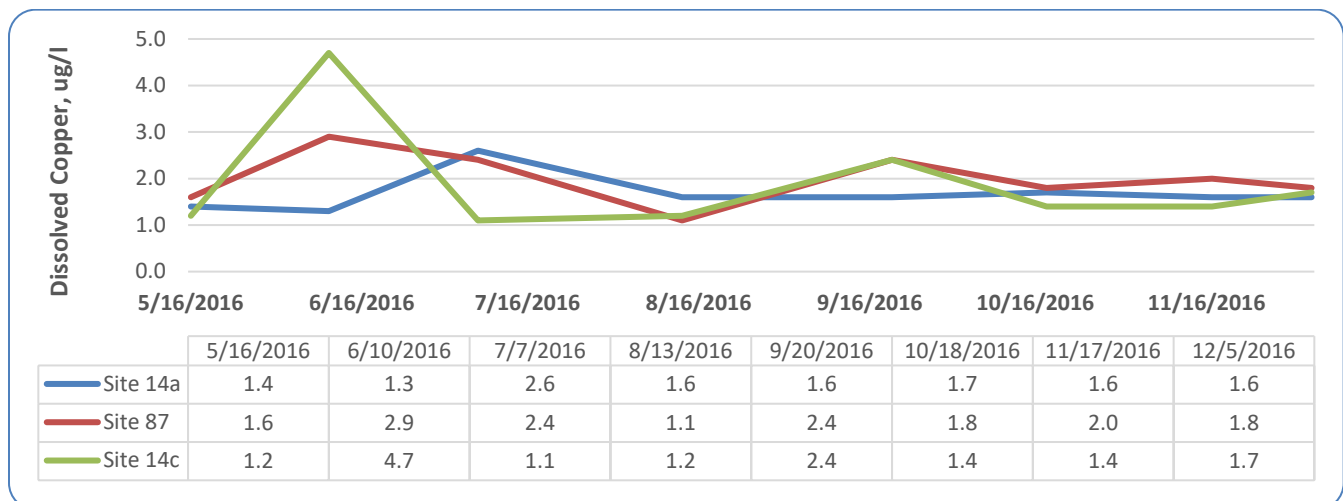


Figure 2 Dissolved Copper Data

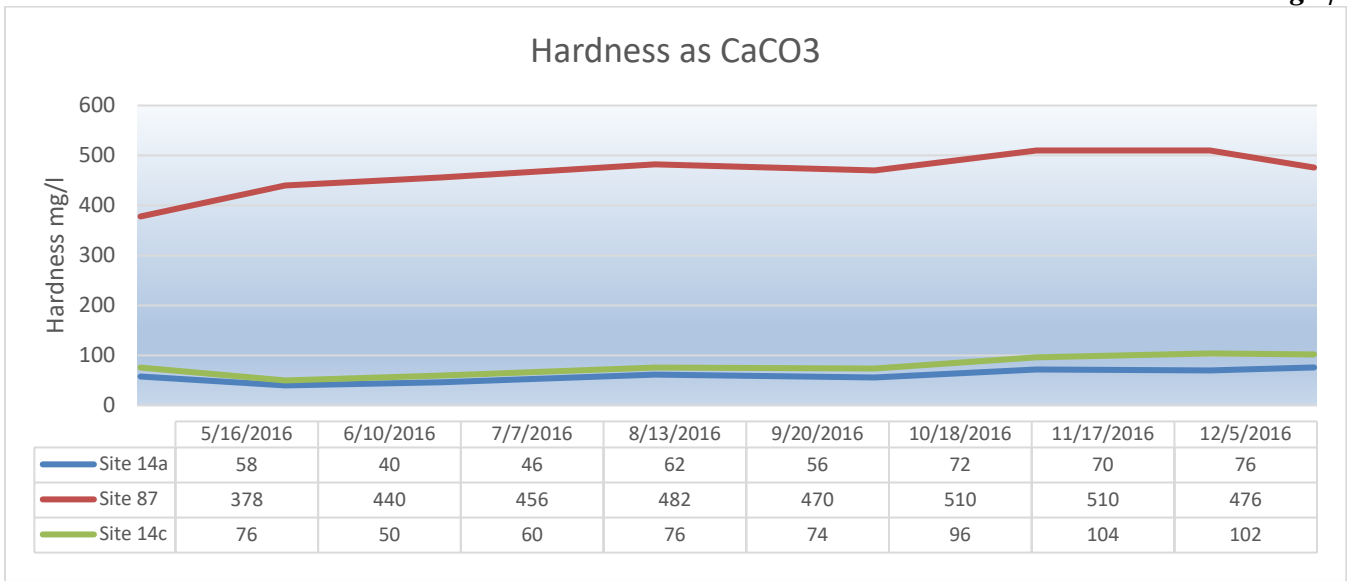


Figure 3 Measured Hardness Summary

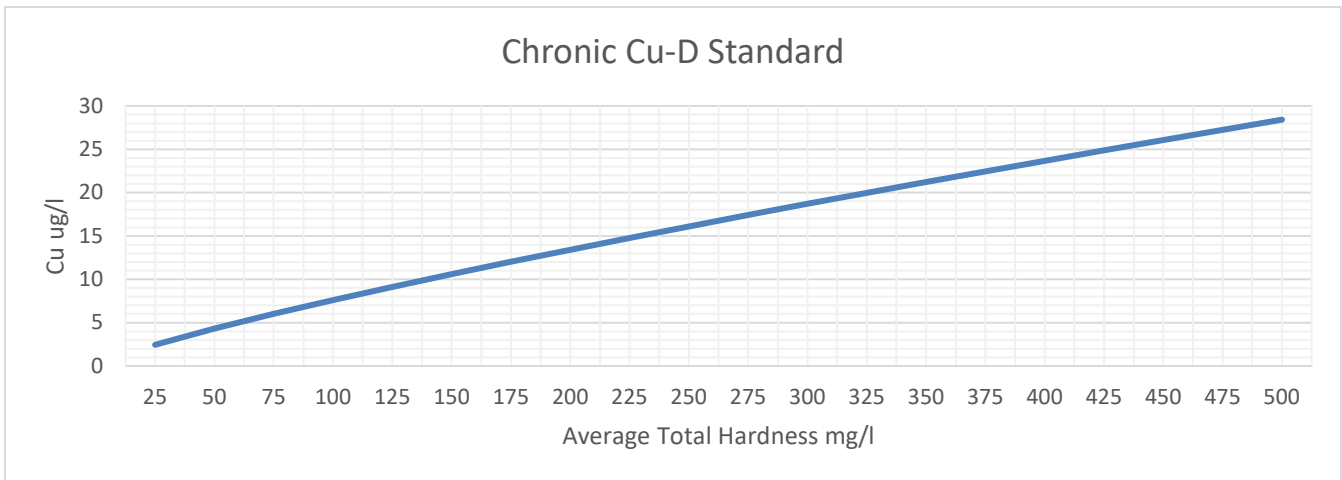


Figure 4 Chronic Cu-D Standard versus Hardness

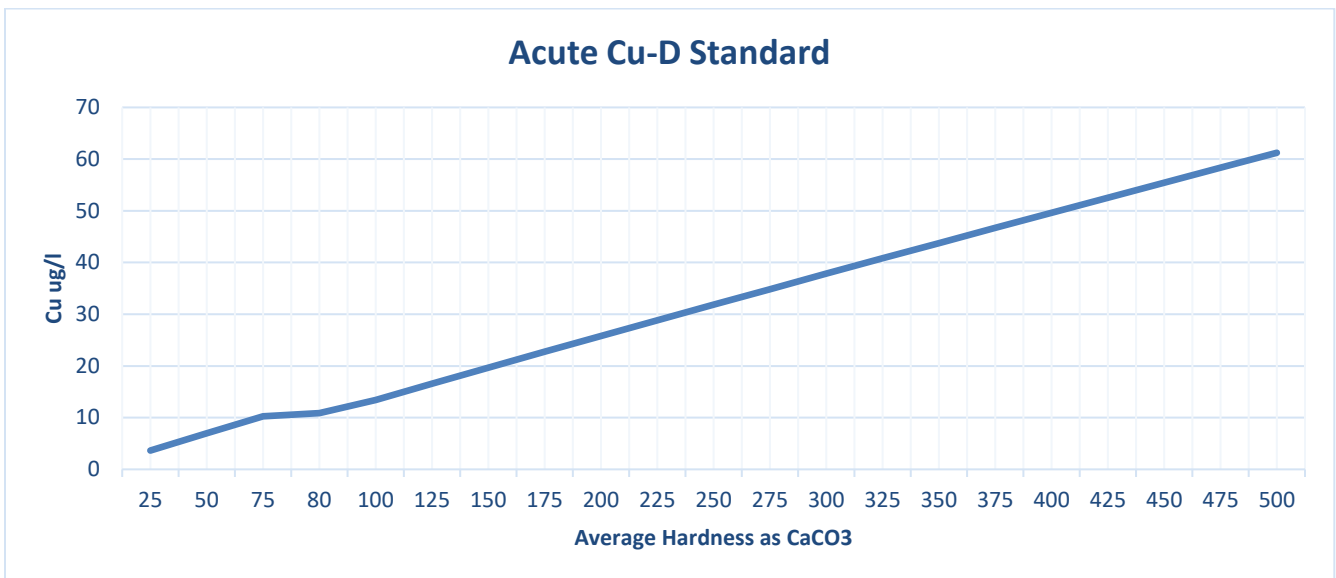


Figure 5 Acute Cu-D Standards versus Hardness

Table 3 **Copper Standards (Hardness Based), There was one chronic standard exceedance at site 14c.**

Site	Average Hardness	Chronic Cu-D Standard	Acute Cu-D Standard	95th Percentile	Chronic Cu-D Standard	Acute Cu-D Standard
Site 14a	60	5.01	8.31	42	3.74	5.93
Site 87	465	26.78	57.18	400	23.66	49.62
Site 14c	80	6.33	10.89	54	4.56	7.26