

Missouri Department of Natural Resources
Total Maximum Daily Load Information Sheet

Crooked Creek

Water Body Segment at a Glance:

County: Iron, Dent and Crawford
Nearby Cities: Viburnum
Length of impaired segment:
WBID 1928: 3.5 miles
Pollutants: Cadmium (S,W)¹ and Lead (S)
Length of impaired segment:
WBID 1928U-01: 5.2 miles
Pollutants: Cadmium (W)
Source: Buick smelter



State Map Showing Location of Watershed

Scheduled for TMDL development: 2012

Description of the Problem

Beneficial uses of Crooked Creek (WBID 1928)

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health (Fish Consumption)
- Whole Body Contact Recreation

Crooked Creek (WBID 1928U-01) is unclassified, so no uses are assigned

Uses that are impaired

- Protection of Warm Water Aquatic Life
- General Criteria

Standards that apply

- Missouri Water Quality Standards found in 10 CSR 20-7.031(4)(B)1 state:

Water contaminants shall not cause the criteria in Tables A and B to be exceeded. Concentrations of these substances in bottom sediments or waters shall not harm benthic organisms and shall not accumulate through the food chain in harmful concentrations, nor shall state and federal maximum fish tissue levels for fish consumption be exceeded.

¹ (S) = in sediment/soil; (W) = in water as dissolved metal

Table A of the Water Quality Standards contains dissolved metals criteria for the protection of aquatic life designated use. These criteria are hardness dependent and limits for cadmium are calculated from the formulas shown below:

Dissolved Cadmium (DCd)

$$\text{Acute} = e^{(1.0166 \cdot \ln(\text{hardness}) - 3.062490)} \cdot (1.136672 - (\ln(\text{hardness}) \cdot 0.041838)) = \mu\text{g/L, or} \\ \text{micrograms per liter}$$

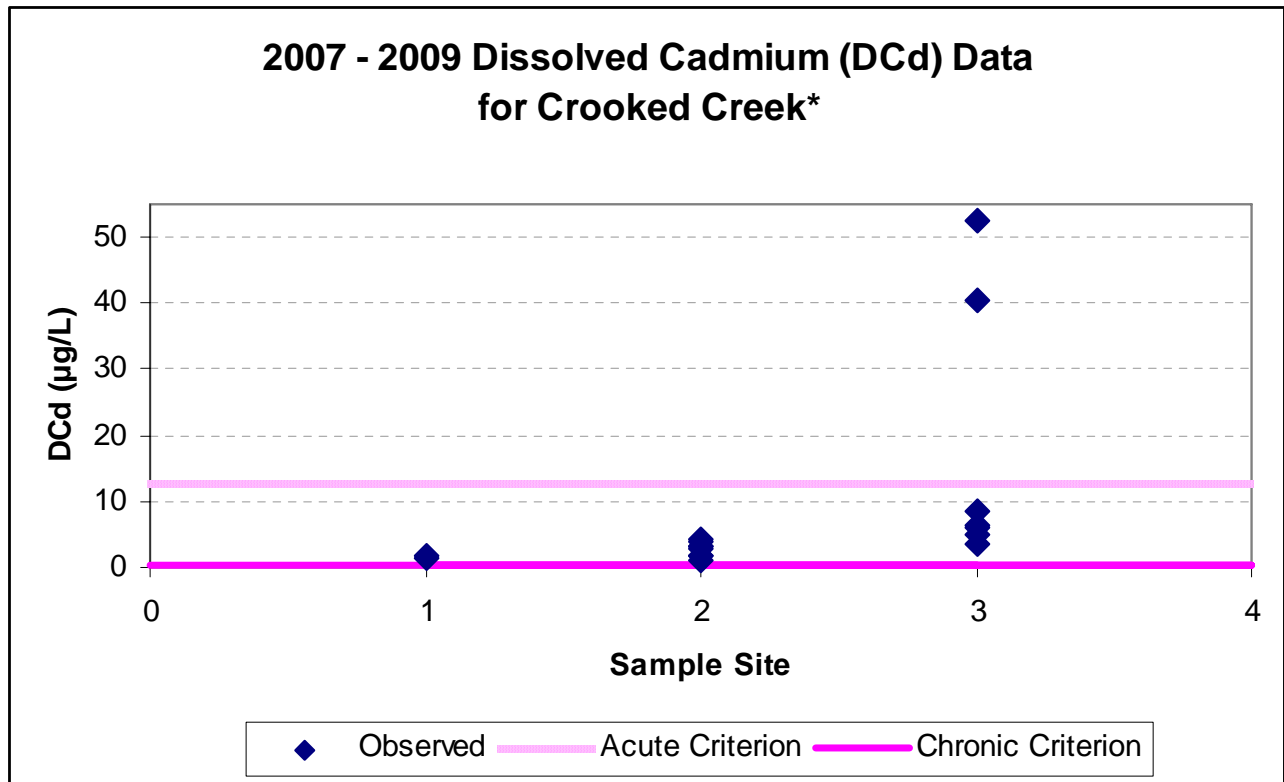
$$\text{Chronic} = e^{(0.7409 \cdot \ln(\text{hardness}) - 4.719948)} \cdot (1.101672 - (\ln(\text{hardness}) \cdot 0.041838)) = \mu\text{g/L}$$

- When a Missouri stream is unclassified, it is protected by the general criteria found at 10 CSR 20-7.031(3). The particular general criteria that apply to Crooked Creek WBID 1928U-01 include:
 - (D) Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life.
 - (G) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.
 - (I) Waters in mixing zones and unclassified waters which support aquatic life on an intermittent basis shall be subject to the following requirements:
 1. The acute toxicity criteria of Tables A and B and the requirements of subsection (4)(B) [quoted in the first bullet].
- Missouri has no standards for metals in sediment. Likewise, the U.S. Environmental Protection Agency has not yet established federal guidelines for toxic chemicals in stream or lake sediments. In lieu of such criteria, Probable Effect Levels, or PELs, suggested by McDonald, et al.², are used. PELs are the concentrations at which some toxic effect on aquatic life is likely

Background information and water quality data

The department conducted water quality monitoring on Crooked Creek from 2002 to 2009 and found the water column in both segments of Crooked Creek contaminated by cadmium. A water body is judged to be impaired by metals if chronic or acute numeric criteria are exceeded on more than one occasion during the last three years for which data is available. These criteria are dependant on the hardness of the water. The chronic criterion applies to classified waters and the acute criterion applies to unclassified waters. For the classified portion of Crooked Creek, the 25th percentile hardness value is estimated at 256 mg/L, or milligrams per liter (which is the same as parts per million). Using this hardness, the chronic criterion was calculated as 0.47 µg/L. On this segment of Crooked Creek (sites 1 and 2), all ten dissolved cadmium measurements exceeded the chronic criterion (see graph below). For the unclassified portion of Crooked Creek, the 25th percentile hardness value is estimated as 274 mg/L and the acute criterion calculated as 12.69 µg/L. On the unclassified segment of Crooked Creek (site 3), two of the seven dissolved cadmium measurements from the last three years of data exceeded the acute criterion. Thus, both segments of the stream are judged to be impaired by dissolved cadmium.

² *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems*, D. MacDonald, et al., 2000. USGS



*The acute criterion of 12.69 µg/L is based on the unclassified segment's hardness of 274 mg/L. The chronic criterion of 0.47 µg/L is based on the classified segment's hardness of 256 mg/L.

The sediment in the classified segment of Crooked Creek is contaminated by lead and cadmium. The relationship between the amount of a toxicant in sediment and the strength of the toxicity it exerts is not simple or straightforward. While neither Missouri nor EPA has standards or guidelines for sediment toxicity, the U.S. Geological Survey has reviewed a large number of research papers on the subject. Based on this review, the USGS suggests numeric guidelines that could be used to judge the potential for toxicity to aquatic life. These are the PELs mentioned in the bullet above.

The department conducted sediment monitoring in 2004-2007. The mean, or average, level of cadmium in the sediments for Crooked Creek is 32.7 mg/kg, or milligrams per kilogram, which is the same as parts per million. This is six times the PEL, the concentration at which some toxic effect on aquatic life is likely. The mean level of lead in the sediments for Crooked Creek is 236 mg/kg (see table below). This is more than one and a half times the PEL. Based on the location of sediment sampling sites and known or suspected sources of metals, 3.5 miles of the creek were judged to be impaired by cadmium and lead in the sediment. The levels of several metals in the sediments for the unclassified portion of Crooked Creek are also more than the PEL. However, the small size of the data set (one sample) is inadequate for making a scientifically defensible decision regarding impairment. It is recommended that this segment receive additional monitoring.

Cadmium and Lead in Sediment Data -- Highlighted Values Show Exceedance of PEL

Site	Sample Date	Cd	Pb
2	5/2/2007	51.7	1670
3	10/19/2004	47.1	206
3	2/27/2006	18.2	266
Mean		32.7	236
PEL		4.98	128

PEL = Probable Effect Level; Cd = Cadmium; Pb = Lead

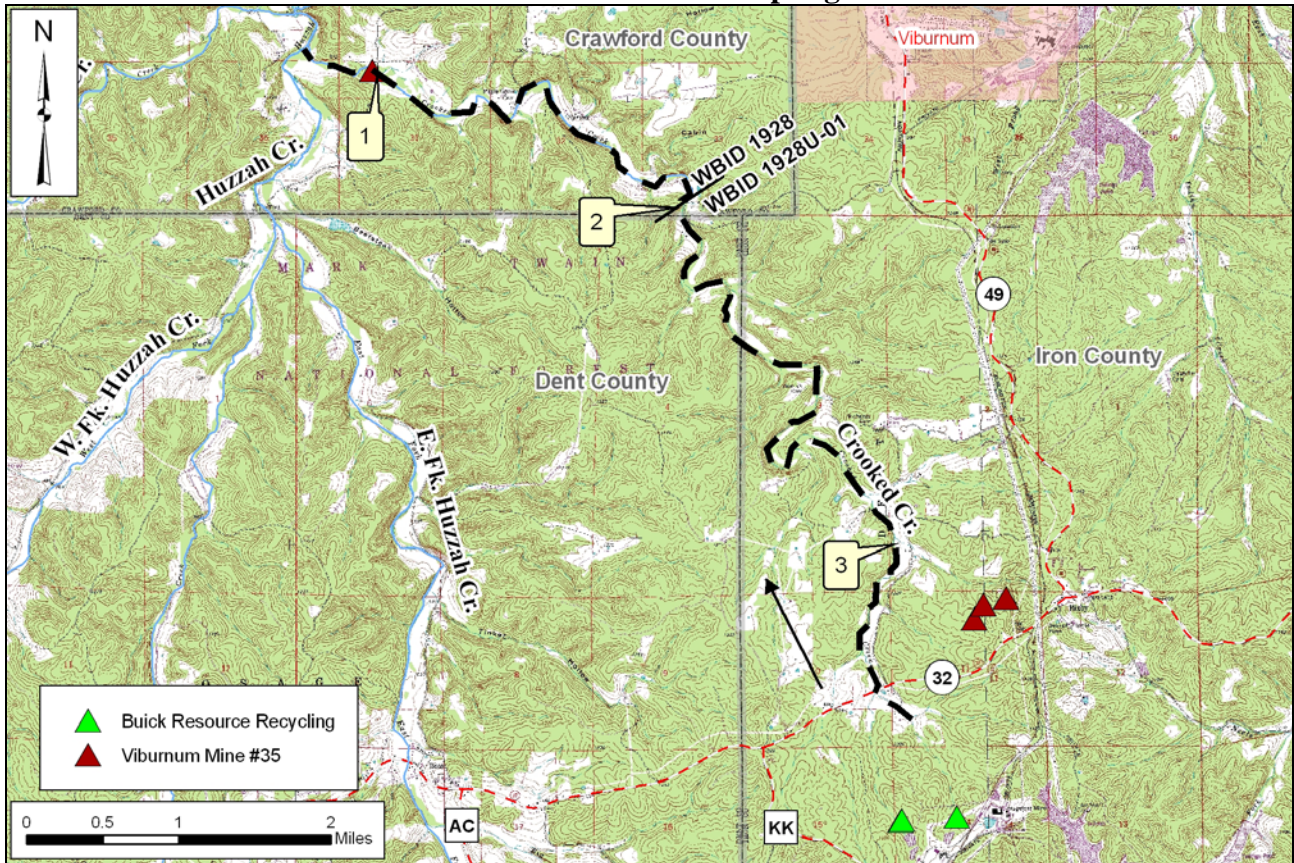
Contamination of stream sediments has led to the contamination of fish and other aquatic life. New studies are showing that the lead and other metals in these tailings are toxic to mussels, crayfish and other small invertebrates that inhabit the bottom of the river. It is already known that lead bioaccumulates in the bodies of aquatic creatures, which has been documented in the levels of lead in fish in Big River.

Cadmium is a minor component in most lead ores and therefore is a by-product of lead production. With the exception of its use in nickel-cadmium batteries, the use of cadmium is generally decreasing in all other applications, such as pigments and corrosion resistant plating. This decrease is due to the high toxicity and carcinogenicity of cadmium.

The facility that affects Crooked Creek is the Buick Resource Recycling Facility, a secondary lead smelter. This facility receives used batteries (like car batteries) and other lead bearing materials, breaks them open, recovers the lead and re-smelts it into ingots. Their discharge permit has limits for lead, cadmium, zinc, arsenic, antimony and copper.

A map of Crooked Creek showing the sampling sites may be found on the next page.

**Map Showing Crooked Creek in Iron, Dent and Crawford Counties, Mo,
and the Location of the Sampling Sites**



Impaired Segment
 Direction of flow

Sample Sites

1 – Crooked Creek 3 miles west of Viburnum, Mo. (classified)
 2 – Crooked Cr. at Chandler Road (classified)
 3 – Crooked Cr. just above tributary from Casteel Mine (unclassified)

For more information call or write:
 Missouri Department of Natural Resources
 Water Protection Program
 P.O. Box 176, Jefferson City, MO 65102-0176
 1-800-361-4827 or 573-751-1300 office
 573-522-9920 fax
 Program Home Page: www.dnr.mo.gov/env/wpp/index.html