DeWitt
Ross & Stevens s.c. Law Firm

Please respond to: Capitol Square Office
Direct line: 608-252-9319
Email: tps@dewittross.com

February 20, 2012

VIA EMAIL TO DNRImpairedWaters@wisconsin.gov
AND FIRST CLASS MAIL

Wisconsin Dept. of Natural Resources
Water Evaluation Section (WT/3)
P.O. Box 7921
Madison, WI 53707-7921

RE: Flambeau Mining Company Comments on WDNR's Proposed Decision to List Stream C South of Copper Park Lane on its 2012 Impaired Waters List

Dear Sir or Madam:

We represent Flambeau Mining Company ("FMC"). Pursuant to the Wisconsin Department of Natural Resources ("WDNR") Notice and Request for Comments dated December 20, 2011, FMC offers the following comments regarding WDNR's proposed decision to list Stream C (south of Copper Park Lane) on its 2012 Impaired Waters List.

I. BACKGROUND

Stream C is approximately .39 miles long and originates south of a road known as Copper Park Lane. The approximately .39-mile segment south of Copper Park Lane lies entirely on FMC property and was not altered by FMC to conduct mining operations. As noted by WDNR in its analysis of the data submitted by the Wisconsin Resource Protection Council, "[A]bove Copper Park Lane, Stream C becomes a headwater wetland complex…" The area above Copper Park Lane is a part of the FMC mine site. The area above Copper Park Lane has historically been altered on several occasions including ditching and installation of a culvert when it was in agricultural use, installation of Copper Park Lane and multiple culverts during active mining, and installation of a biofilter after active mining ceased. There is currently an ongoing permitted project to remove culverts and install infiltration basins in the area above Copper Park Lane.

There is no known background water quality data regarding Stream C before active mining began (See WDNR email attached as Exhibit A). There is very limited background flow data before active mining began. As noted in the Environmental Impact Statement for the mine and quoted in the attached DNR emails:

> "The Flambeau River harbors the only aquatic biological community which could be affected by the project. The other surface waters in the mine site vicinity (Stream A, B and C) are intermittent, and do not provide any significant support for biological communities."

After active mining ceased, WDNR characterized Stream C in 2004 as follows:

> Stream C is an intermittent stream of very limited aquatic life and the levels of copper and the rate of flow are such that the water quality of the Flambeau River is not substantially threatened.

(March 26, 2004 email from Larry Lynch attached as Exhibit B.)

> Although the Department determined it was not in a position to proceed with an enforcement action, the Department did react to the situation. An investigation verified that Stream C is an intermittent stream of limited aquatic life and the levels of copper and the rate of flow are such that the water quality of the Flambeau River was not substantially threatened.

(October 26, 2004 letter from Charles Hammer attached as Exhibit C.)

Finally, WDNR has recently completed a study of Stream C. The study concluded at several points that further investigation and analysis was needed (*see* pp. 13 and 16 of study).

II. STREAM C IS A LIMITED AQUATIC LIFE STREAM DUE TO ITS INTERMITTENT NATURE AND IS MEETING DESIGNATED USES.

As indicated above, WDNR has recognized that Stream C is a limited aquatic life stream due to its intermittent nature. Such a designation has been characterized by WDNR as follows:

- **Limited Aquatic Life (LAL) Community:** Stream capable of supporting macroinvertebrates and/or occasionally fish that can tolerate organic pollution. Typically this category includes small stream with very low-flow and very limited habitat. Certain marshy ditches, concrete line-drainage channels, and other intermittent streams. Representative aquatic life communities associated with these waters are tolerant of many extreme conditions, and require concentrations of DO that remain above 1 mg/L.

(2012 Wisconsin Consolidated Assessment and Listing Methodology Report at p. 40.)

WDNR's designation was confirmed by FMC's expert, Dr. G. Allen Burton:

> Stream C likely does not flow for extended periods of the year, based on its small drainage area, lack of visible channel or substrate suggesting flowing conditions, and

> steep gradient in the lower portion of the stream. It is well established that in intermittent streams there can only be limited aquatic life. Indeed there is a wealth of literature that shows flow is the most important stressor and factor organizing stream communities (1-3) and that is the situation for Stream C. The impacts of low-flow disturbance to aquatic communities are critically important (3). The "limited aquatic life" use designation as referenced by Larry Lynch in his March 26, 2004 letter, and Charles Hammer in his October 26, 2004 letter is appropriate.

(Dr. G. Allen Burton expert report, p. 5; a full cop of the expert report is attached as Exhibit D.)

As documented by WDNR's study and confirmed by FMC's experts, Stream C is meeting that designation:

> Stream C and its associated wetlands are enriched by copper and zinc, as are other similar streams in Rusk County. This may be due to naturally elevated metal concentrations in soils and sediments or it could be a result of human activity. **Regardless of the source, it is my opinion, that these elevated levels are not impacting the biota of Stream** C...The biological data show that the water in Stream C is not acutely toxic to fish as diversity and numbers are higher than in the reference stream, and also that the stream is not toxic to algae (based on personal observation). These conclusions are substantiated by the negative results from aquatic bioassays conducted with Stream C water. Impact of the metals on the stream's invertebrate community is difficult to interpret as the periods when the stream dries out also cause changes in the types of species that use the stream, and the resulting species assemblage looks similar to what might be seen with metal contamination. However, the negative bioassay results with *Ceriodaphnia* (an invertebrate known to be sensitive to copper) validate the conclusion that observed differences are a result of physical changes and not the amount of copper or zinc in the water...Therefore, in my opinion, the aquatic organisms in Stream C are not impacted by copper or zinc. Furthermore, because the total copper and zinc concentrations in the Flambeau River immediately below the confluence with Stream C are below the state's criteria values (based on dissolved concentrations), it is my opinion that the stream is not discharging enough of these metals to impact the river's biota. This is substantiated by the invertebrate community indices (IBI and HBI) calculated in 2010 that show no metal-related effects. (Emphasis supplied)

(Dr. Anne Fairbrother expert report, pp. 13, 14; a full copy of the expert report is attached as Exhibit E.)

III. WDNR'S 2012 WISCONSIN CONSOLIDATED ASSESSMENT AND LISTING METHODOLOGY REPORT ("WisCALM") DOES NOT SUPPORT LISTING STREAM C.

WDNR has developed an assessment and listing methodology for Clean Water Act reporting known as WisCALM. The proposed listing is based solely on water quality criteria exceedances of zinc and copper using the listing philosophy known as "independent applicability."

However, as noted in WisCALM, there are situations where the independent applicability philosophy should not be strictly adhered to:

> **7.1 Independent Applicability & Tools to Resolve Data Conflicts**
> Under Federal guidance, a water shall be listed on the Impaired Waters List if data is reflective of current conditions, data has met minimum data requirements, and the water does not meet water quality standards, including water quality criteria, designated uses, and/or antidegradation. This decision philosophy is referred to as *independent applicability*, consistent with the Clean Water Act that protects biological, chemical, and physical integrity of surface waters. However, EPA recognizes that there are certain situations in which factors beyond a strict interpretation of Independent Applicability should be considered to make the most appropriate listing decision. Accordingly, EPA allows states to formulate specific decision rules pertaining to circumstances under which one type of parameter should be given a greater 'weight' than others. Wisconsin has developed decision rules that use a hierarchy of indicators for certain parameters, which are described within the Lakes and Rivers & Streams chapters of this guidance document.
>
> If one of the water quality standards are not met, but multiple data sets produce conflicting results (some indicating impairment and some not), WDNR staff should review all available data to assist in making an attainment decision. There are several factors biologists may use to resolve these differences to arrive at a listing decision. A decision matrix is described in Figure 14 to describe the process for *not* making attainment decisions using independent application. Cases where this process is used will be rare and should be well documented for that water in the WATERS database. (Emphasis in original.)

Stream C is such a situation.

A. WDNR Should Use a Weight of Evidence Approach to Conclude that Stream C is Not Impaired.

WisCALM provides:

> **Weight of Evidence**
> In certain cases where two data sets conflict with one another, states may apply a "weight of evidence" approach. This approach helps define the extent of the problem based on how it impacts the Designated Use, and allows biologists to consider aspects of the data that might indicate whether one data set should be weighted more greatly than another.
>
> In all cases, Department staff will look for corroborating information, such as the various habitat and biological indices and water chemistry data. **If the suite of available data does not suggest an evident impairment, then the water will not be listed, but will be recommended for additional monitoring as resources allow.** WDNR will provide a rationale for those cases where data are available that show that a water quality criterion has been exceeded, but the water has not been recommended for the impaired waters list. In most cases, the indicator has not reached the magnitude, duration or frequency to warrant placing a waterbody on the list. (Emphasis supplied)

Here, as noted above, the suite of available biological data does not suggest an evident impairment. Accordingly, Stream C should not be listed. Rather, further monitoring should be conducted pursuant to the Mining Permit.

B. WDNR Should Use a Hierarchy of Indicators Approach, Utilizing Biological Indicators Such as Fish Survey and Macroinvertebrate IBI, Over the Chemical Monitoring Results, to Conclude that Stream C is Not Impaired.

WisCALM provides:

> **Hierarchy of Indicators**
> In some situations, a hierarchy of the indicators may be appropriate. For example, biological indicators (*e.g.*, fish or Macroinvertebrate IBI) for assessment of the fish & aquatic life use may have precedence over chemical indicators in the impairment decision process, because they are direct measures of health of aquatic life. However, this hierarchical approach should be used with caution, knowing that exceedance of chemical indicators may correspond to a more recent event that was not reflected in the biological community data due to differences in collection periods or delays in community response. In such a case, a decision to rely on a hierarchical approach would be inappropriate.

Here, as documented by the WDNR investigation, chemical exceedances have existed for some time and any biological impairment would be evident but, importantly, there is none. Accordingly, the use of a hierarchical approach is appropriate.

C. Alternatively, WDNR Should List Stream C as a Category 3 Water.

As noted at several points in the WDNR study of Stream C, further investigation and analysis is needed before definitive conclusions can be reached. While FMC asserts that the available biological data clearly establishes no impairment, WDNR could identify Stream C as a Category 3 water and conduct further studies.

A Category 3 water is described in Table 13 of WisCALM as follows:

> Category 3: There is insufficient available data and/or information to assess whether a specific designated use is being met or if the anti-degradation policy is supported.
>
> This category is also used for situations where the state has not yet had time or resources to analyze available data.

As an alternative to not listing, WDNR should use the results of its study to list Stream C as a Category 3 water. This is particularly the case given the changing nature of the Stream C watershed (*see* WisCALM Figure 14 Independent Application Matrix attached as Exhibit F).

IV. SUMMARY

The available biological evidence indicates that Stream C is not impaired. Further, the chemical monitoring data indicate declining metal concentrations in Stream C. Given the ongoing efforts, metal concentrations are expected to decline further. There is simply no technical or policy reason to list Stream C as impaired.

Very truly yours,

DeWitt Ross & Stevens s.c.

Timm P. Speerschneider
TPS:jav
Enclosures

Bruhn, Michael L - DNR

From: Johnson, Kenneth G - DNR
Sent: Friday, October 21, 2011 3:32 PM
To: Moroney, Matt S - DNR; Bruhn, Michael L - DNR
Subject: FW: Flambeau Mine Stream C Data

Looks like no other data is available

Kenneth G Johnson
Water Division Administrator
Wisconsin Department of Natural Resources
(☎) phone: (608) 264-6278
(☎) fax: (608) 266-6983
( ) e-mail: kenneth.johnson@wisconsin.gov

From: Jerow, Thomas S - DNR
Sent: Friday, October 21, 2011 1:02 PM
To: Rasmussen, Russell A - DNR; Johnson, Kenneth G - DNR
Subject: FW: Flambeau Mine Stream C Data

I suggest we take this as definitive - there is no pre-mine surface water data on stream C.

Tj

Tom Jerow
Northern Region Water Leader
Wisconsin Department of Natural Resources
107 Sutliff Ave.
Rhinelander, WI 54501
(☎) phone: (715) 365-8901
(☎) fax: (715) 365-8935
( ) e-mail: Thomas.Jerow@wisconsin.gov

From: Aartila, Tom P - DNR
Sent: Friday, October 21, 2011 11:31 AM
To: Jerow, Thomas S - DNR
Subject: Flambeau Mine Stream C Data

Hi Tom,

I looked through all of the files that I have in my office, including file folders from the time period of pre-start up at the mine, and found no information indicating that there was any pre-mine data collected on Unnamed Stream C or the other two Unnamed Streams. It would seem that all of the discussions surrounding monitoring was just in reference to the permitted wastewater discharge. In addition, the EIS for the site identified the three streams and named them Unnamed Stream A-C but did not indicate that any information had been gathered from them. The EIS did conclude something about flows:

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"Impacts to stream and river flows would be minor. One intermittent stream would be removed by the project, and the flows in two intermittent streams would be slightly reduced. No significant impacts to flows in the Flambeau River or in Meadowlark Creek would occur."

And about the biological communities:

"The Flambeau River harbors the only aquatic biological community which could be affected by the project. The other surface waters in the mine site vicinity (Streams A, B and C) are intermittent, and do not provide any significant support for biological communities."

This would lead me to believing that no data was collected on Stream C.

I also looked at our old Surface Water Resources of Rusk Co. publication and nothing there.

Phil Fauble - Phil also found no information pre-mine for Stream C. In 2004 when they found elevated levels of metals in the sediments of Stream C, the mine and DNR looked into the files to see if any water chemistry or sediment chemistry data was collected on Stream C and nothing was found. They also looked back at the EIS other information that was available.

Joe Ball - I talked to Joe and he did not recall any monitoring on the tributary streams just the Flambeau River. He was surprised that he or Water Resources would have missed or not looked at the tributaries but it seems they did not.

If you have any questions give me a call.

Tom

"Murphy, Jana (KMC)" <Jana.Murphy@riotinto.com>

03/26/2004 04:12 PM

To: "Fox, Fred (KMC)" <Fred.Fox@riotinto.com>, "Jim Hutchison (E-mail)" <jhutchison@foth.com>

cc:

Subject: FW: Stream C at the Flambeau Mine

GJB1

Following is Larry Lynches response to John Coleman's inquiries.

Jana

-----Original Message-----
From: Lynch, Lawrence J [mailto:Lawrence.Lynch@dnr.state.wi.us]
Sent: Friday, March 26, 2004 2:52 PM
To: John Coleman
Subject: RE: Stream C at the Flambeau Mine

John - After receiving your email, I checked with both our legal staff and our enforcement office to verify my understanding of how the Department addresses situations like the one experienced at the Flambeau mine site. I also put the information available to us before the water quality staff to get feedback on their level of concern.

You are correct that the water quality criteria that appear in NR 105 are the criteria that apply to Stream C. Specifically, the chronic standard for copper in Stream C would be on the order of 7ppb as you indicated. Further, the one time that water quality in Stream C was monitored, the results (22 and 30 ppb) exceeded the standards.

However, an exceedance of a water quality criteria is not, by itself, an enforceable action—there needs to be some other authority that requires an activity to comply with water quality standards. That is why point sources of pollution have long had to comply with water quality standards, including criteria, but non-point sources have historically not. (I'm told that its getting a bit better, these days, with respect to nonpoint sources).

While the Department, in conjunction with the Department of Justice, can usually find a defensible basis for undertaking an enforcement action, especially when the circumstance is a serious one, in this instance the authority to pursue an enforcement action is not all that obvious. However, more importantly, a focus on enforcement in a situation like this would be unusual for the Department.

Enforcement can and is used as a means of penalizing unacceptable behavior that causes harm to the environment. However, the principle use of enforcement is when it is the best tool to correct a problem. Usually, enforcement occurs when a known problem drags on, and an enforcement action of some sort appears to be the best method of correcting the problem and avoiding having the problem recur. Enforcement does not typically occur in circumstances in which 1) we have only one (or, even a few) exceedances of an enforceable requirement, and 2) corrective action is taken in a timely manner.

Stream C is an intermittent stream of very limited aquatic life and the levels of copper and the rate of flow are such that the water quality of the Flambeau River is not substantially threatened. The Department followed the typical regulatory response for such a situation by working with the owner/operator to address the problem on an informal basis to better characterize the problem and, if necessary, implement some type of corrective action to remedy the problem. Based on monitoring results from the 0.9-acre biofilter and Stream C and other observations at the site, a potential problem was identified and working through the authority of the mining program, we began discussions with Flambeau Mining Company to evaluate the problem. Subsequently, following completion of a soil sampling program last summer, in November 2003 the company removed the upper two feet of material in the railroad spur west of Highway 27, which is believed to be the main source of the elevated copper in the biofilter and Stream C. Monitoring of the 0.9-acre biofilter and Stream C will continue and additional action may be necessary in the future if conditions are not improved through removal of the rail spur material.

Finally, you requested copies of correspondence pertaining to this issue. Other than that related to the soil sampling program and subsequent rail bed removal activities conducted last year, the only correspondence that I am aware of are the separate letters transmitting the results of the biofilter sampling. I believe you already have copies of those letters. There are no formal responses to these letters from the department. Concerns regarding the results were discussed with representatives of Flambeau Mining Company through telephone conversations or in person during on-site inspections.

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B

Larry Lynch, P.G., Mining Team Leader
Bureau of Waste Management
Wisconsin Dept. of Natural Resources

(608-267-7553 Phone
(698)-267-2768 FAX
lawrence.lynch@dnr.state.wi.us

-----Original Message-----
From: John Coleman [mailto:colemanj@calshp.cals.wisc.edu]
Sent: Tuesday, March 02, 2004 4:18 PM
To: Lynch, Lawrence J
Subject: Stream C at the Flambeau Mine

Larry,

I was looking at the sampling results from the 0.9 acre wetland and Stream C. It looks like there has been elevated copper at the outlet where the 0.9 acre wetland discharges to Stream C in all samples since sampling began there in 1999 (25 - to 91 ug/L). The one time Stream C itself was sampled (2002) it also showed elevated copper (22 - 30 ug/L). Looking at the surface water standards in NR105 it looks to me like the Copper chronic standard for Stream C would be about 7 ug/L. Based on this, it looks to me like there was a documented exceedence of surface water standards in Stream C in 2002. In addition, based on the results from the 0.9 acre wetland and the elevated copper in soil samples from as far back as August 1998, one would suppose that standards in Stream C may very well have been exceeded frequently since 1999 and possibly earlier. I was wondering if there is any additional data for Stream C other than the two samples taken June 5, 2002?

Am I correct in my interpretation of the NR105 surface water standards and how they would apply to Stream C? If there was an exceedence of surface water standards in Stream C, was there some sort of citation or notice of violation? I assume that the problem is what stimulated the removal of the rail spur and contaminated ballast, but the Flambeau documents don't explicitly make the link. I was unable to find any reference to the exceedence in the 2002 or 2003 Annual Reports. I'd have thought it would show up in the Incident section if nowhere else. Is it discussed in other documents from 2002? If so, can I get them.

I assume there was correspondence back and forth between the company and the DNR concerning the elevated copper in the 0.9 ac wetland and in Stream C. Can I get a copy of that correspondence? And any insights into what's going on with Stream C would be appreciated. Thanks for helping me understand this issue.

Thanks,
john

WISCONSIN DEPT. OF NATURAL RESOURCES

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary

101 S. Webster St.
Box 7921
Madison, Wisconsin 53707-7921
Telephone 608-266-2621
FAX 608-267-3579
TTY Access via relay - 711

October 26, 2004

Mr. James H. Schlender, Executive Administrator
Great Lakes Indian Fish & Wildlife Commission
P. O. Box 9
Odanah, WI 54861

RECEIVED
OCT 27 2004
BUREAU OF
WASTE MANAGEMENT

Dear Mr. Schlender:

I am writing to you in response to your recent letter to Lawrence Lynch, the Department's Mining Team Leader, in which you suggest that the Department should take formal enforcement action against Flambeau Mining Company for violations of state water quality standards. Since the issue relates to environmental enforcement, Mr. Lynch asked that I respond on his behalf. I am the attorney on the Department's staff who has been assigned mining matters since the mid-1980s. However, my primary responsibility, for even longer, has been staffing the watershed program. Consequently, I am familiar with situations like that which occurred at the Flambeau Mine.

The issue at hand revolves around the question of whether elevated levels of copper in intermittent Stream C near the Flambeau Mine as a result of runoff from the mining site, constitutes an incident for which the Department should have pursued formal enforcement action. One aspect of water law often misunderstood is that an exceedance of a water quality standard is not, by itself, an enforceable action—there needs to be some other regulatory authority that requires an activity to comply with water quality standards. That is why point sources of pollution have long had to comply with water quality standards, but non-point sources have historically not. Perhaps a better example arises out of accidental spills of hazardous substances. When such spills are properly reported and remedied, they usually will not constitute a violation of any law, even when the spills have caused exceedances of water quality standards.

In the case of the Flambeau Mine situation, we have not been able to attribute the copper exceedances to a violation of a statute, administrative code, permit or plan approval. Thus we have no basis upon which we could allege a violation or seek penalties. In many ways, the Flambeau Mine situation is very similar to a spill case in which the responsible party properly informed the Department and proceeded to cooperate with the Department in a response to the spill. This conclusion has not been arrived at without careful consideration of the circumstances. Prior to Lawrence Lynch's earlier response to John Coleman's email on this issue, Mr. Lynch consulted with me as well as with Steven Sisbach, the Department's head of environmental enforcement. As a result of your follow-up letter to Mr. Lynch, I checked further with Mr. Sisbach as well as with several other attorneys on our staff who have experience on these and related matters. All concurred with the conclusions stated in this letter.

Although the Department determined it was not in a position to proceed with an enforcement action, the Department did react to the situation. An investigation verified that Stream C is an intermittent stream of

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C

limited aquatic life and the levels of copper and the rate of flow are such that the water quality of the Flambeau River was not substantially threatened. The Department followed the typical regulatory response for such a situation by working with the owner/operator to address the situation by characterizing the problem then, as in most instances, implementing corrective action to remedy it. Based on monitoring results from the 0.9-acre biofilter and Stream C and other observations at the site, a potential problem was identified. Subsequently, following completion of a soil sampling program, the company removed the upper two feet of material in the railroad spur west of Highway 27, which is believed to have been the source of the copper. The Company will continue regular monitoring of the site.

Department staff has asked that I assure you that they are treating this matter very seriously and will carefully evaluate the results of the follow-up monitoring. If the ongoing monitoring indicates water quality conditions have not been sufficiently improved through removal of the rail spur material, the Department will require that additional corrective measures be implemented.

Sincerely,

Charles R. Hammer
Staff Attorney

Cc: John Gozdzialski – NOR
Larry Lynch – WA/3
Steve Sisbach – LE/5

In the United States District Court for the Western District of Wisconsin, Case No. ll-cv-4S
Wisconsin Resources Protection Council, Center for Biological Diversity, and Laura Gauger v. Flambeau Mining Company

Prepared for

DeWitt Ross & Stevens
Two East Mifflin Street, Suite 600
Madison, WI 53703-2865

Prepared by

G. Allen Burton
211 W Summit
Ann Arbor, MI 48103

November 2011

Contents

Introduction

I have been asked by DeWitt Ross & Stevens to evaluate the impacts of the Flambeau Mine on the Flambeau River, as affected by Stream C. This work was preformed by me and the opinions are based on my professional qualifications, work experience, and knowledge and analyses of the Flambeau Mine. I reserve the right to supplement this report.

Qualifications and Experience

I have a B.S. degree in Biology and Chemistry from Ouachita Baptist University, an M.S. degree in Microbiology from Auburn University, and an M.S. degree in Environmental Sciences and a Ph.D. in Environmental Sciences with an aquatic toxicology emphasis from the University of Texas at Dallas. My Ph.D. was awarded in 1984. I received a Postdoctoral Fellowship at the Cooperative Institute for Research in Environmental Sciences at the University of Colorado from 1984 to 1985. I was a Life Scientist at the U.S. Environmental Protection Agency, Region VI, from 1980-1984. From 1985-2008 I held several faculty and administrative positions at Wright State University, ending as Professor and Chair of the Department of Earth & Environmental Sciences. While at WSU I was awarded the highest research honor in the university, the Brage Golding Distinguished Professor of Research.

Since 2008 I have been a Professor at the University of Michigan's School of Natural Resources & Environment and Director of the Cooperative Institute for Limnology & Ecosystems Research. I am leading the University of Michigan's new Sustainable Water Initiative, focused on solving challenging water issues regionally to internationally. I served as President of the Society of Environmental Toxicology & Chemistry and on several national and international committees, including for the USEPA Science Advisory Board (SAB) and National Research Council. I am Co-Editor-in-Chief of the journal *Environmental Toxicology & Chemistry* and have over 150 peer-reviewed publications dealing with ecotoxicology and the assessment of aquatic ecosystems. One of my books is a guide to assessing and managing stormwaters, prepared for the USEPA.

I have taught undergraduate and graduate level courses in Environmental Toxicology and Ecological Risk Assessment, among other courses dealing with water quality and the assessment of stressors on aquatic life, for several years. I have supervised over 30 graduate students and their externally funded thesis/dissertation research, with most recent projects dealing with metals in freshwater systems.

In addition, I have assisted the development of pollution management programs for the USEPA, Environment Canada and the State of Washington. I led and co-led development of standardized toxicity test methods and sampling approaches for the USEPA, ASTM and OECD.

I have had an active extramurally funded research program since 1985 focused primarily on stressors in aquatic ecosystems and assessing their ecological risk. In recent years I have helped develop sediment quality criteria for metals for two European Commission programs (Water Framework Directive and REACH). Some of my research projects, such as on the Clark Fork River, Montana, and the Des Plaines River, Illinois, addressed sites contaminated with elements common to those at the Flambeau Mine. In addition, I have been actively engaged in research and have published multiple articles on metal bioavailability and toxicity in aquatic ecosystems .

I am being compensated for my work on this case. Compensation since October 2011 through now has been at a rate of $300 per hour.

I testified as an expert once in the last four years on behalf of Midwest Generation in the trial of Midwest Generation vs. Illinois EPA.

A copy of my *Curriculum Vitae*, which includes a list of my publications and research funding, is attached.

Information Reviewed

The following is a list of documents I reviewed in forming opinions for this report:

- Flambeau Mining Company. Figure 3: Copper Concentrations in Surface Water Monitoring 2006–2011. Dated November 2011. Prepared by Foth.
- Flambeau Mining Company. Figure 1: Surrogate Surface Water Sampling Locations and Analytical Results. Dated January 2011. Prepared by Foth.
- Peerenboom memorandum to file dated September 21, 2001. Copper Concentrations in Northern Region Public Water Supplies (PWSs).
- Peerenboom memorandum to Ken Markart dated May 10, 2006. Flambeau Mine Site–Copper Concentrations in Runoff.
- Fleming memorandum to Craig Roesler dated August 2, 2011. SLH Biomonitoring Results for the Flambeau Mine Intermittent Stream Near Ladysmith (Stream C).
- Exhibit 4–Roesler deposition. Complete surface water sample laboratory results plus calculated ATCs for copper, zinc, and field conductivity.
- Exhibit 5–Roesler deposition. Flambeau Mine Stream C and reference stream fish survey data, September 27, 2010.
- Exhibit 6–Roesler deposition. Flambeau Mine site stream macroinvertebrate indices.
- Exhibit 7–Roesler deposition. Flambeau Mine site 303(d) project. Macroinvertebrate sampling and analysis–Fall 2010. Jeffrey Dimick, University of Wisconsin, Stevens Point.
- Exhibit 11–Roesler deposition. Photograph of Stream C downstream of the culvert under Copper Park Lane.
- Exhibits 12, 13, and 14–Roesler deposition. Photographs of Mr. Roesler sampling fish in Stream C below Copper Park Lane.
- Chambers expert report. October 10, 2011.
- Lawrence Lynch, WDNR letter to John Coleman, March 26, 2004.
- Attorney Charles Hammer, WDNR letter to John Coleman, October 26, 2004.

- Wisconsin Resource Protection Council, Center for Biological Diversity and Laura Gauger v Flambeau Mining Company, Case No. 11-cv-45. Complaint.
- Foth 2008 Monitoring Results and Copper Park Lane Work Plan. October 14, 2008.
- Fleming K. SLH Biomonitoring results for the Flambeau Mine intermittent stream near Ladysmith (stream C). August 1, 2011.
- State of Wisconsin. Guidelines for Designating Fish & Aquatic Life Uses for Wisconsin Surface Waters. Publ-WT-807-04. December 2004. Madison WI.
- 2010. Wisconsin Department of Natural Resources. Wisconsin Consolidated Assessment and Listing Methodology (WisCALM). http://dnr.wi.gov/org/water/condition/wiscalm.htm.
- Foth October 10, 2005 memo—Stream C – 2005 Analysis of Collected Data

Opinion: Stream C is an Intermittent Stream that Supports Limited Aquatic Life and is Meeting that Designation

Stream C likely does not flow for extended periods of the year, based on its small drainage area, lack of a visible channel or substrate suggesting flowing conditions, and steep gradient in the lower portion of the stream. It is well established that in intermittent streams there can only be limited aquatic life. Indeed there is a wealth of literature that shows flow is the most important stressor and factor organizing stream communities (1-3) and that is the situation for Stream C. The impacts of low-flow disturbance to aquatic communities are critically important (3). The "limited aquatic life" use designation as referenced by Larry Lynch in his March 26, 2004 letter, and Charles Hammer in his October 26, 2004 letter is appropriate.

During a site visit on October 24, 2011, I observed that there was no surface water in the majority of the stream. A small pool of approximately 10 meters in length and 5 centimeters depth existed several meters downstream of Copper Park Lane. The Flambeau River extended into the lower 1 meter of the mouth of Stream C, where there was no flow. No fish or macroinvertebrates were apparent in the stream, since there was no water. It is likely the stream only flows following snow melt or extended periods of precipitation. Intermittent, ephemeral or low flow condition waters of this type are categorized by WDNR as being expected to have tolerant and very tolerant fish and aquatic life communities. State of Wisconsin. Guidelines for Designating Fish & Aquatic Life Uses for Wisconsin Surface Waters. Publ-WT-807-04. December 2004. Madison, WI.

The mere fact that Stream C may exceed water quality standards for zinc and copper (whatever the source) does not mean that there are toxicity impacts on the biota. There are a variety of other environmental factors that control the toxicity of copper and zinc. Indeed, based upon my site inspection and review of the available data, there is no evidence of biological toxicity impacts to the biota of Stream C from copper and zinc.

Opinion: There are no biologically significant metal effects on the Flambeau River from Stream C.

The benthic macroinvertebrate populations in the Flambeau River just below the mouth of Stream C are of exceptional high quality. This, in and of itself, shows unequivocally there are no ecologically significant metal effects.

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November 7, 2011

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Education:
University of Texas at Dallas, M.S. 1980, Ph.D. 1984
Major: Environmental Science (Aquatic Toxicology)
Auburn University, M.S. 1978
Major: Microbiology
Ouachita Baptist University, B.S. 1976
Majors: Biology and Chemistry

Experience:
University of Michigan, Ann Arbor.
Professor, School of Natural Resources & Environment, 2008-present
Professor, Department of Earth & Environmental Sciences, 2011-present
Director, Cooperative Institute for Limnology & Ecosystems Research, August 2008.

Wright State University, Department of Earth & Environmental Sciences, 2006- August 2008.
Department of Biological Sciences, 1987- 2006, Dayton, Ohio
Visiting Professor, Sept. 2008-2012.
Professor of Environmental Sciences, Sept.1996 – Aug. 2008.
Chair, Department of Earth & Environmental Sciences, 2006 - 2008.
Director, Institute for Environmental Quality, 1994 - 2006.
Interim Chair, Geological Sciences Department. October 2005 – June 2006.
Coordinator, Environmental Health Sciences B.S. Degree Program, 1985-2006.
Associate Director, Environmental Sciences Ph.D. Program. July 2003-2005.
Brage Golding Distinguished Professor of Research, 2000 – 2003.
Director, Environmental Sciences Ph.D. Program. July 2002- June 2003.
Associate Professor, Sept. 1990 - Aug.1996.
Associate Director of the Toxicant Contamination Research Program, 1987 - 1990.
Assistant Professor, Sept. 1985 - Aug. 1990.

Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder.
Visiting Fellow, Aug. 1984 - Aug. 1985.

U.S. Environmental Protection Agency, Dallas, Texas
Life Scientist, GS-11. Nov. 1980 - Aug. 1984.

University of Texas at Dallas, Richardson, Texas
Teaching and Research Assistant, Sept. 1979 - Sept. 1984.

U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi
Sept. 1978 - Sept. 1979
Microbiologist

Honors and Awards:

Editor-in-Chief. Environmental Toxicology & Chemistry. 2012.
Co-Editor-in-Chief. Environmental Toxicology & Chemistry. 2011.
Science Advisory Board, U.S. Environmental Protection Agency, Oil Spill Research Strategy Panel. 2011-2012.
Science Advisory Board, U.S. Environmental Protection Agency, Risk and Technology Review Assessments for Phase II Source Categories (RTR II) Panel. 2009-2010
Science Advisory Board, U.S. Environmental Protection Agency, Ecological Processes and Effects Committee. 2005-2011
Editor, Environmental Toxicology & Chemistry. 2009-2011.
University of Michigan Road Scholar. 2009.
Science Advisory Board, U.S. Environmental Protection Agency, Scientific and Technological Achievement Awards (STAA) Panel. 2006-2008.
National Research Council Committee on Sediment Dredging at Superfund Mega-sites. 2006-2007
Immediate Past-President, Society of Environmental Toxicology and Chemistry, 2008
President, Society of Environmental Toxicology and Chemistry, 2007
Vice-President, Society of Environmental Toxicology and Chemistry, 2006
World Council, Society of Environmental Toxicology and Chemistry, 2003-2008.
Brage Golding Distinguished Professor of Research, 2000-2003.
Editorial Board, J. Brazilian Society of Ecotoxicology. 2006-present.
Editorial Advisory Board, Aquatic Ecosystem Health & Management, 2001-2006.
Editorial Board, Chemosphere, 2003-2005.
Co-Editor, Ecotoxicology and Environmental Restoration, 1995-2003.
Editorial Board. Environmental Toxicology and Chemistry. 1990-1993.
Phi Kappa Phi National Honorary Society. 2000-present.
Phi Beta Delta International Honor Society. 2004-present.
Pi Epsilon National Honorary Society. 2004-present
Board of Directors, Society of Environmental Toxicology and Chemistry, 1993-1996.
Advisory Council, The Nature Conservancy of Ohio, 1994 - 1999.
NATO Senior Research Fellow, 1994, 1995, 1996.
Visiting Senior Scientist, Italian Institute for Hydrobiology. 1994, 2001, 2005.
Visiting Senior Scientist, New Zealand Institute of Water and Atmospheric Research. 1996.
Sigma Xi, Chapter President, 1991-1992, 2000.
First place award for oral presentation, 3rd International Symposium Toxicity Testing Using Microbial Systems, Valencia, Spain. 1987.
CIRES Visiting Fellow. 1984-1985.

Professional Societies (current):

Society of Environmental Toxicology and Chemistry
American Geophysical Union
Ecological Society of America
Society of Freshwater Science (formerly North American Benthological Society)
American Chemical Society
International Association of Great Lakes Research

Professional Training: Hazardous Waste Operation Emergency Response Certification (OSHA 24 Hr, 29 CFR 1910.120). 1999-2002.

Professional Service *(Chronological order; Academic service not included):*

Research Committee, Water Pollution Control Federation, 1981-1987.

Sediment Toxicology Subcommittee of ASTM E-47 Committee on Biological Effects and Environmental Fate. Task Group Chairman. 1987 - 1997.

American Society for Testing & Materials. Nominating Committee for E47 Main Committee. 1992-1995. Chair, 1995.

American Society for Testing & Materials, Co-Chair, Task Group on Sediment Toxicity Testing Using Bioluminescent Bacteria. American Society for Testing and Materials. E47.03. 1994-1997

Technical Advisory Committee. Stormwater Runoff Toxicity Program. Water and Hazardous Waste Treatment Division. Office of Research and Development. U.S. EPA. 1989-1992.

Ohio Nonpoint Source Monitoring Strategy Task Force. Ohio Environmental Protection Agency. 1989-1992.

City of Dayton Environmental Advisory Board, 1990-1992.

U.S. Environmental Protection Agency. Ecological Risk Assessment Guidelines. Case Study Workshop Leader. 1991-1992.

U.S. Environmental Protection Agency's Workgroup on Surface and Groundwater Fate, Exposure and Effects of Manganese/MMT. 1991.

U.S. Environmental Protection Agency. Toxicity/Chemistry Workgroup. Assessment and Remediation of Contaminated Sediments Program. 1991-1993.

External Review Committee. Arkansas U.S. EPA/EPSCoR (Experimental Program to Stimulate Competitive Research) Program. 1992.

Bioassay and Toxicity Test Working Group, Biomonitoring of Environmental Status and Trends (BEST) Program. U.S. Fish and Wildlife Service. 1992-1993.

Environment Canada. Review Committee. Standard Testing Protocols for Sediment Collection and Toxicity Testing. 1992-present.

External Review Committee. Alabama U.S. DOE/EPSCoR. 1992.

Standard Methods for Water and Wastewater, Joint Task Group on Method 8610,Toxicity Testing with Mollusks. American Public Health Association, American Water Works Association, and Water Environment Federation. 1992-1995.

Executive Board of Directors, Ohio Valley Regional Chapter, Society of Environmental Toxicology and Chemistry, 1989-1993.

President-elect, Ohio Valley Regional Chapter, SETAC, 1990-1991.

President, Ohio Valley Regional Chapter, SETAC, 1991-1992.

Past-President, Ohio Valley Regional Chapter, SETAC, 1992-1993.

Ad hoc Committee on Professional Opportunities. Society of Environmental Toxicology and Chemistry. 1991.

Membership Committee. Society of Environmental Toxicology and Chemistry. 1989-1991.

Editorial Board. Environmental Toxicology and Chemistry. 1990-1993.

Program Committee for 1992 Annual Meeting. Society of Environmental Toxicology and Chemistry. Chair, Poster Sessions.

Technical Committee, Society of Environmental Toxicology and Chemistry (SETAC). 1991-1994.

Short Course Committee, SETAC. 1992-1995.

Ad Hoc Committee on Scientific Initiatives, SETAC. 1992-1994.

Finance Committee, SETAC. 1992-1994.

Publications Committee, SETAC. 1992-1994.

Long-Range Planning Committee, SETAC. 1994-1996.

Meetings Committee, SETAC. 1994-1995.

Chair, Regional Chapters Committee, SETAC. 1994-1995.

Chair, SETAC *Ad hoc* International Programs Committee. 1995

Board of Directors, SETAC. 1993-1996.

National Environmental Health Association Accreditation Site Review Team. Eastern Kentucky University. 1993.

National Freshwater Sediment Toxicity Methods Committee, U.S. Environmental Protection Agency. 1992-2000.

External Review Panel. Environmental Biology Research Program. Exploratory Research. Office of Research and Development, U.S. Environmental Protection Agency. Washington, D.C. 1994, 1995.
Organizing Committee, 2nd International Symposium on Sediment Quality Assessment. Pallanza, Italy. 1996.
Chair, Scientific Initiatives Committee, SETAC. 1995.
Organizing Committee, Sediment Risk Assessment Workshop. A SETAC Pellston Workshop. 1994-1995.
Sediment Toxicology Editor, Quintessence Journal. 1995.
Ohio Advisory Council, The Nature Conservancy, Columbus, OH. 1994-1995.
Water Subcommittee, Chamber of Commerce, City of Dayton. 1995.
Review Panel, Chandler-Miesner Award, Journal of Great Lakes Research. 1995
Judging Panel, Tri-Service Toxicology Science Presentation. Armstrong Toxicology Laboratory, Wright Patterson Air Force Base, 1995.
Co-Editor, Ecotoxicology and Environmental Restoration. 1995-2000.
OECD (Organization for Economic Co-Operation and Development) Working Group on Aquatic Testing Method Guidelines. 1995 - 1999.
Organizing Committee, Sixth SETAC-Europe Annual Meeting, Taormina, Sicily, 1996.
Co-Chair, Sub-Committee, Public Awareness, Lower Great Miami Basin Watershed Enhancement Program. 1996-1999.
Scientific Committee, International Symposium on Integrated Ecotoxicology, Milan, Italy, 1997.
Whole Effluent Toxicity Expert Advisory Training Panel. SETAC Foundation for Environmental Education. 1996 - 2000.
Bald Eagle Die-Off Task Force. Arkansas Game & Fish Commission. 1996-1997.
U.S. Environmental Protection Agency Peer Review Panel. STAR Graduate Environmental Education Fellowship Program - Life Sciences - Ecology. April 1997.
U.S. Environmental Protection Agency Peer Review Panel. Aquatic Life Use Workshop Expert. Cadmus, August 1997.
U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development, Contaminated Sediments Proposals (invitation). 1997.
Environmental Management Advisory Committee, Greene County Career Center. 1997-1998.
Task Force, Upper Illinois Waterway. Commonwealth Edison, Chicago, IL. 1994-1998.
Miami Valley Tech Prep Committee on Environmental Programs. 1996-1997.
Co-editor, Chemosphere Special Issue, Proceedings of the International Symposium on Integrated Approaches to Ecotoxicology. 1998.
U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development, Ecological Indicators Program (invitation). 1998.
U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development, Environmental Engineering Program (invitation). 1998.
U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development Exploratory Research, Environmental Biology Program. June 1998.
National Environmental Health and Protection Accreditation Council Workgroup. Las Vegas, June 1998.
Ontario Ministry of the Environment, Canada. Sediment Advisory Panel. July 1998.
Visiting Scientist. University of Sao Paulo, Sao Carlos. (invitation). 1998.
U.S. Environmental Protection Agency Peer Review Panel. National Center for Environmental Research and Quality Assurance. Office of Research and Development. EMPACT Program. (invitation). 1998.
Lake Erie Commission, Task Group on Contaminated Sediments. 1998.
Dayton Metropolitan Area Network for Education Renewal 1999 Leadership Program. Associate Leader. 1999.
Whole Effluent Toxicity Expert Advisory Toxicity Identification Evaluation Panel. SETAC Foundation for Environmental Education. 1999 - 2001.
Greene County Combined Health District's Environment 2000 Project Committee. 1999.
U.S. Environmental Protection Agency Scientific Advisory Panel. Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs. Washington, D.C. Feb. 1999.
U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development, National

Center for Environmental Research and Quality Assurance. Zoology Graduate Fellowships. March 1999.

U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development, National Center for Environmental Research and Quality Assurance. STAR Research Grants Ecological Indicators Program. (invitation) May 1999.

Instituto de Ciencias Ambientales y Salud, International Committee. Buenos Aires, Argentina. 1999.

U.S. Environmental Protection Agency Peer Review Panel. Environmental Monitoring for Public Access and Community Tracking (EMPACT) Programs Metro Area Grants Peer Review. National Center for Environmental Research and Quality Assurance. (invitation). July 1999.

Environment Canada Scientific Advisory Group. Solid phase Reference Methods for Determining the Toxicity of Sediment Using Bioluminescent Bacteria (*Vibrio fischeri*). 1999-2000.

U.S. Environmental Protection Agency Federal Insecticide, Fungicide and Rodenticide Act Scientific Advisory Panel (SAP). June 1999 – 2000.

Co-Chair, Pellston Workshop on "Ecological Complexity: New Directions for Assessing Responses to Stress". Soc. Environ. Toxicol. Chem. Pellston, MI. Sept. 1999

Steering Committee, Pellston Workshop on Pore Water Toxicity Testing: biological, Chemical, and Ecological Considerations. Soc. Environ. Toxicol. Chem. Pensacola, March 2000.

National Association of State Universities and Land-Grant Colleges, Delegate to Section on Ecology. 1999-2000.

Ecotoxicity Technical Advisory Panel. Non-Ferrous Metal Industry. 1999-2005.

U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development, National Center for Environmental Research and Quality Assurance. Zoology Graduate Fellowships. (invitation) 2000.

U.S. Environmental Protection Agency Peer Review Panel. Office of Research and Development. EPA/NASA Environmental Indicators in the Estuarine Environment Research Program, Science to Achieve Results (STAR) Program. July 2000.

Beneficial Use Impairment Study Team. Black River NOACA. Cleveland, OH. 2000.

Steering Committee. 4th International Symposium on Sediment Quality Assessment. Otsu, Japan., Oct. 2000.

Metals Advisory Group. Society of Environmental Toxicology and Chemistry. 2000-present.

Meeting Chair. Weight-of-Evidence Workshop. Madrid, Spain. May 2000.

Meeting Chair. 5th International Symposium on Sediment Quality Assessment. Chicago, IL. 2002.

Editorial Board, Aquatic Ecosystem Health & Management, 2001-2004.

Sigma Xi Chapter President. 2001. Wright State University.

Review Panel. U.S. EPA EMPACT Metro Grants. (invite). 2001.

Review Panel. Illinois-Indiana Sea Grant Program. Chicago, IL. Aug. 2001.

Scientific Committee. 6th International Conference of the Aquatic Ecosystem Health and Management Society. Amsterdam, The Netherlands. Nov. 2001.

Review Panel. Sediment Decision Making Framework for the Great Lakes Areas of Concern. Environment Canada. Cambridge, Ontario. Nov. 2001.

Chair, Sediment- Water Interactions Group. Metals Industry. 2001-2002.

World Council, Society of Environmental Toxicology and Chemistry, 2003-2006

Editorial Board, Aquatic Ecosystem Health & Management, 2001-2004.

Editorial Board, Chemosphere, 2003-2005.

Workshop Panel. Decision Making Framework for Sediment Assessment. Environment Canada and National Water Research Institute. Cambridge, Ontario. November 2001.

Steering Committee. Pellston Workshop on Use of Sediment Quality Guidelines and Related Tools for the Assessment of Contaminated Sediments. Aug. 2002.

Council of Environmental Deans and Directors. National Council for Science and the Environment. 2001-2005.

Steering Committee and Session Chair. Approaches to Assessing and Managing Ecological Risks at Contaminated Sediment Sites Meeting. U.S. Environmental Protection Agency and American Chemical Council. April 2002.

Peer Review Panel. U.S. Environmental Protection Agency Region 2. Bioaccumulation Testing Evaluation

Framework for Dredged Materials. 2002.

IAPSO-IAHS Joint Commission on Groundwater-Seawater Interactions. 2003.

Scientific Committee, 6th International Symposium on Sediment Quality Assessment. 2004. Antwerp, Belgium.

Contaminated Sediments Committee, American Society of Civil Engineering. August 2003-present.

Review Panel. U.S. Environmental Protection Agency. Office of Research and Development. STAR Research Grants. Entomology. Feb. 2004.

Review Panel. U.S. Environmental Protection Agency. Office of Research and Development. STAR Research Grants. Ecological Risk Assessment. Feb. 2004.

Review Panel. U.S. Environmental Protection Agency Federal Insecticide, Fungicide and Rodenticide Act Scientific Advisory Panel (SAP). Aquatic Modeling. Feb. 2004. (Invited)

Peer Review Coordinator. Pellston Workshop Book "Toxicity of Dietary Metals to Aquatic Organisms". Society of Environmental Toxicology and Chemistry Press. May 2004.

Chair, Science Committee, World Council of the Society of Environmental Toxicology & Chemistry. 2003-2004.

Chair, International Programs Committee, World Council of the SETAC. 2004-2005.

Co-Chair, Technical Workshop on In Situ Effects Measures: Linking Responses to Ecological Consequences.

Society of Environmental Toxicology and Chemistry. Troutdale, Oregon. November 2004.

Wolf Creek Focus Group. Watershed Enhancement Program. Dayton, OH. November 2004-present.

Review Panel. European Union Metal Ecological Risk Assessment Guidance. Non-Ferrous Metals Industry. 2004-2005.

Great Miami River Watershed Enhancement Program Steering Committee. 2001-2005.

Advisory Board. Greene County Career Center and Bellbrook High School Environmental Program. 2004-2005.

Chair, Session on Environmental Education. Council of Environmental Deans & Directors, Washington DC, March 2005.

International Organizing Committee. SETAC Asia/Pacific meeting. Beijing, China. September 2006.

Peer Review Panel – Private Arbitration Appellate Proceedings. Houston, TX. 2005.

Science Advisory Board, U.S. Environmental Protection Agency. Ecosystem Processes and Ecology Committee (EPEC) 2005-2011.

Science Advisory Board. Scientific and Technological Achievement Awards Committee (STAA). 2005-2008

Vice-President, Society of Environmental Toxicology and Chemistry, 2006

World Council, Society of Environmental Toxicology and Chemistry, 2003-2008.

President, Society of Environmental Toxicology and Chemistry, 2007

Immediate Past-President. SETAC. 2008.

National Research Council, Committee on Evaluation of the Effectiveness of Dredging at Contaminated Sediment Sites. 2006-2007.

Chair, NIEHS Special Emphasis Panel, Innovative approaches to remediation of recalcitrant hazardous substances in sediments (R01). 2007.

Yellow Springs Instruments Foundation. Review Panel. 2007.

Chair. Metals Assessment Session. SETAC Europe Annual Meeting. Porto Portugal. May 2007.

Co-Chair. Metals Risk Assessment Session. SETAC North America Annual Meeting. Milwaukee, WI. Nov. 2007.

Co-Chair. Sediment Dredging Effectiveness Session. SETAC North America Annual Meeting. Milwaukee, WI. 2007.

Chair, Program Review Panel. Montclair University Dept. of Earth and Environmental Studies, New Jersey. 2008.

Review Panel. NIEHS Basic Superfund Research Program. 2008, 2009 (invited)

Science Advisory Board, U.S. Environmental Protection Agency, Risk and Technology Review Assessments for Phase II Source Categories (RTR II) Panel. 2009-2010

Expert Panel: ASTM E1924 as a Whole Effluent Toxicity Method. ReGenesis. Nov. 2010.

Editor, Environmental Toxicology & Chemistry. 2009-2011.
Co-Editor-in-Chief. Environmental Toxicology & Chemistry. 2011.
Great Lakes Threat Mapping Project Workgroup. The Joyce Foundation. 2009-2011.
State of Washington Department of Ecology. Freshwater Sediment Guidelines Proposed Regulation Review. 2010.
Risk Science Center Internal Advisory Panel. University of Michigan School of Public Health. 2010-2012.
Upper Midwest and Great Lakes Landscape Conservation (UMGL LCC) Technical Committee. 2010-2011.
Science Advisory Board, U.S. Environmental Protection Agency, Ballast Water Technology Panel. 2010-2011.
External Board of Reviewers. State of Washington Department of Ecology. Technology Assessment Protocol – Ecology (TAPE) for Stormwater. 2010-2012.
External Review Panel. Canadian Foundation of Innovation. University of Windsor. 2011.
Science Advisory Board, U.S. Environmental Protection Agency, Oil Spill Research Strategy Panel. 2011-2012.
Editor-in-Chief. Environmental Toxicology & Chemistry. 2012.
Use of Oil Spill Dispersants Research Strategy. NOAA. Mobile, AL 2011.
Trans-boundary Research University Network. UM representative. 2011-2012.
Executive Committee. University of Michigan Biological Station. 2011-2012.

Reviewer

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Air Force Office of Scientific Research, Basic Research Program. 1991, 1993, 1994.
Air Force Office of Scientific Research, New Investigator Award. Society of Toxicology.(5), 1993.
American Chemical Society, Book. 1994.
American Society for Testing and Materials. 1991, 1992, 1993, 1994, May 1996.
American Society of Microbiology, Book. 1994.
Ann Arbor Press. Book outlines. 1995 (1), 1996 (3), 1997 (2).
Aquatic Ecosystem Health and Management. 1998 (3), 1999, 2000 (6), 2001 (3), 2002 (3), 2003 (2), 2004 (4), 2005, 2007(2), 2008.
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Archives of Environmental Contamination and Toxicology. 1987-1989, 1996, 1997 (5), 2000. 2005
Association of Environmental Health Academic Program Proposals. 2002 (5).
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Bulletin of Environmental Contamination and Toxicology. 1988-1989, 1994, 1997, 1998 (4), 2003, 2005 (2).
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Canadian J. Fisheries and Aquatic Sciences. 1995, 1998, 2002.
Canadian Natural Sciences & Engineering Research Council. 1997.
Canadian Social Sciences and Humanities Research Council Proposal. 2003.
CETESB manuscript, Sao Paulo, 1995.
Chapman & Hall, Book Proposal, Aug. 1995.
Chemosphere, 1998, 2001, 2003 (3), 2004, 2005 (2), 2006, 2007, 2008 (3). 2010.
Chilean Comision Nacional de Investigacion Cientifica Y Tecnologica. Proposal. 2009
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CNR Italian Institute for the Study of Ecosystems. Manuscripts. 2004 (2). 2006 (2)
Comparative Biochemistry and Physiology. 1997, 1998.
Conservation Biology. 2001.
Continental Shelf Research. 2003.
CRC Lewis Publ., Book Chapters. 1994, 1996 (2), 2001.
CRC Press Book Review. Science and Policy: Managing Metal Contamination in Aquatic Environments. 2005

Critical Reviews in Environmental Science and Technology. 1994.
Ecotoxicology. 2000, 2009.
Ecotoxicology and Environmental Restoration. 1996 (2), 1997 (5), 1998 (5), 2000 (7)
Ecotoxicology and Environmental Safety. 2004 (2), 2005. 2008. 2010.
Ecovision World Monograph Series, 1995, 2002, 2003 (3), 2005
Electrical Power Research Institute. 1989.
England Dept. of Environmental Transport and the Region report. 2000
Environment Canada, Environmental Protection Division. Biomonitoring Program Review. 1998.
Environment Canada Guidance Manuals. 1993, 1994, 1995, 1996, 2000.
Environment International. 2006. 2011.
Environmental Management 2003.
Environmental Monitoring and Assessment. 2004, 2005.
Environmental Pollution. 1998, 2001, 2004 (3), 2005, 2006, 2008, 2009.
Environmental Science and Technology. 1990, 1993, 1994, 1998, 2000, 2001, 2005 (2), 2006 (2), 2007, 2009 (3). 2011(2)
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Environmental Toxicology. 2005
Environmental Toxicology and Chemistry. 1988-1994, 1995, 1996 (2),1997 (8), 1998 (3), 1999, 2000 (4), 2001 (2), 2002 (2), 2003 (2), 2004 (3), 2006 (2), 2007 (2), 2008 (2), 2009 (3). 2010-present began as Editor so no longer tracking numbers.
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Journal of Great Lakes Research. 1992, 1993, 1995 (2), 1997, 1998 (2), 2000, 2005, 2006.
Journal of the Water Pollution Control Federation. 1991.
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Kuwait Institute for Scientific Research, Proposal and Final Report. Kuwait Foundation for the Advancement of Sciences. KISR 6879. 2004. 2007
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National Research Council, Cooperation in Applied Science & Technology Program with Newly Independent States. 1993, 2000.
National Research Council. 1996, 2000. 2006-2007.
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New Zealand Foundation for Research, Science and Technology Antarctic Research Funding Program. 1997, 1998 (2).
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NIH Minority Biomedical Research Support Program. 1995
NOAA Climate Change Program. SARP. Proposal. 2008
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2001 Funding: $800,754

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2009 Funding: $1,688,988

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2010 Funding: ~$283,180

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Total Funding through 2010 ~$10,000,000

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Use of toxicity assays in situ (plenary). Latin-American Symposium on Aquatic Ecosystem Health and the Ecological Significance of Bioassays. Sao Carlos, Brasil. October, 1994. Approx. $3,500.
Chemistry and ecotoxicology: current issues (plenary). Annual Meeting of the Brasilian Society of Chemistry. Caxumba, Brazil, May 1995. Approx. $3,500.
Evaluating toxicity: test response issues (keynote). Workshop on Toxicity Testing Applied to Soil Ecotoxicology. Canada National Research Council, Montreal, Canada, Nov. 1995. Approx. $1,000.
Assessing ecosystem contamination. Refinaria Gabriel Passos (REGAP) Belo Horizonte, Minas Gerais, Brazil, Dec. 1995. Approx. $1,000.
Linking stressors with causality: sediment's dubious uncertainties (plenary). International Symposium of Environmental Contamination and Toxicology ' 96. Sydney, Australia. July 1996. Approx. $1,500.
Assessment of contaminated sediments (keynote). Third Finnish Conference on Environmental Sciences, University of Jyvaskyla, Jyvaskyla, Finland. May, 1997. Approx. $1,500.
Assessing aquatic ecosystem contamination with *in situ* approaches. University of Joensuu, Joensuu, Finland. May, 1997. Approx. $500.
The challenge of assessing multiple stressors in ecosystems. (keynote). Congreso Mexicano De Toxicologia. Mexico City. Mexico. May 1997. Approx. $1,000.
Ecological relevance of ecotoxicology: critiques of traditional and novel approaches (keynote). International Symposium on Integrated Ecotoxicology: From Molecules/Organisms to Ecosystems. Milan, Italy. June, 1997. Approx. $2,500.
Realistic Assessments of Water Quality: Matching Exposure with Effects. International Conference on Ecology of Cities. Rhodes, Greece. June 1998. Approx. $1,000.
Assessment of Ecological Impairment Associated with Sediments: Issues and Approaches. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. October 2003. ~$2,300.
Sediment Quality Assessments: Integrated Approaches with Case Examples. Asociacion Mesoamericana de Ecotoxicologia y Quimica Ambiental. Jiutepec, Morelos, Mexico. March 2004.

~$1,800.
Stressor Identification in Freshwater Ecosystems, and The Society of Environmental Toxicology & Chemistry: An Overview. VIII Brazilian Congress of Ecotoxicology. Florianopolis, SC, Brazil. October. 2004. ~2,200.
Integrated Approaches for Assessing Stormwater and Sediments and Their Role in Ecosystem Stress. Australasian Society of Ecotoxicology, Annual Meeting. Melborne, Australia. September 2005. (cost below)
Stressor Identification in Sediments. Contaminants and Ecological Risk Assessment Symposium. CSIRO. University of Adelaide, Australia. September 2005. (cost below)
Evaluation of Nickel Effects in Sediments Using Field Based Approaches. CSIRO. Sydney, Australia. September 2005. (cost below)
Ecotoxicology and its Paradigms: A Critical Overview. Keynote Lecture. Ecotox 2006, SETAC Brasilian Society of Ecotoxicology Biannual Meeting. Sao Paulo, Brazil, July 2006. ~2,500.

International Short Course Instruction:
Evaluating Biological Effects of Contaminants in Freshwater Sediments. Contaminated Sediments Workshop. University of Coimbra, Coimbra, Portugal. March, 1993. Approx. $2,000.
Water and Sediment Ecotoxicology - Theory and Practice. University of Coimbra, Portugal. May, 1994. $3,000.
Assessment of Sediment Contamination in Aquatic Ecosystems Short Course and Workshop. Companhia De Tecnologic De Saneamento Ambiental (CETESB). Sao Paulo, Brazil. August, 1993. Approx. $3,500.
Sediment Toxicity Assessment. Centro de Recursos Hidricos e Ecologia Aplicada da Escola de Engenharia de Sao Carlos and the Aquatic Ecosystem Health and Monitoring Society. Univerity of Sao Paulo at Sao Carlos, Brasil. October, 1994. Approx. $3,500.
Sediment Ecotoxicology. University of Coimbra, Portugal, May 1995. Approx. $2,000.
Assessing Sediment Contamination. XXVI International Congress of the Society of International Limnology. Sao Paulo, Brasil, July 1995. Approx. $3,000.
Aquatic Ecosystem Quality Assesment. PETROBRAS. Rio de Janeiro, Brazil. Dec. 1995. Approx. $7,000.
Sediment Ecotoxicology. University of Coimbra, Portugal, April 1996. Approx. $2,500
Sediment Ecotoxicology. University of Coimbra, Portugal. May, 1997. Approx. $2,500.
Ecotoxicology of Boreal Lakes. Field and laboratory methods for measuring stress. University of Joensuu, Joensuu, Finland. June 1999. Approx. $2,500.
Short Course: Field Methods in Water and Sediment Ecotoxicology: Theory and Practice. Mazatlan, Mexico. Feb. 2001. Sponsored by CIAD and ICMyL-UNAM. Approx. $1,700
Short Course. Ecological Risk Assessment: Theory and Practice. CIAD. Mazatlan, Mexico. July 2006. ~$2,000

International Conference or Workshop Participation:
Workshop on Sediment Toxicity Assessment (WOSTA). Society of Environmental Toxicology and Chemistry - Europe. Renesse, The Netherlands. November, 1993. $1,600.
Sediment Advisory Panel. Ontario Ministry of Environment. July 1998. $800.
Environment Canada. Water and Sediment Subgroup, Aquatic Effects Technology Evaluation Program. Assessing aquatic ecosystems using pore waters and sediment chemistry. 1998. $2,350.
Chair. Platform Session on Urban Toxicology. Australasian Society of Ecotoxicology. Melbourne, Australia. September 2005. $3,500

International Visiting Scientist:
NATO Senior Fellow. Research collaboration on mine drainage assessments. Depart. of Zoology, University of Coimbra, Portugal. 1994. ~$3,000

NATO Senior Fellow. Faculty lecturer. University of Coimbra, Portugal. 1995, 1996, 1997. ~$6,000
Visiting Senior Scientist. Italian Institute of Hydrobiology, National Research Council. Pallanza, Italy. June 16 - July 17, 1994. Approx. $3,500.
Visiting Senior Scientist. National Institute of Water and Air, Hamilton, New Zealand. June - August, 1996. Approx. $10,000.
Visiting Scientist. Environmental Research Institute of the Supervising Scientist. Jabiru, Northern Territory, Australia. July, 1996. Approx. $1,000.
Visiting Senior Scientist. Italian Institute of Hydrobiology, National Research Council. Pallanza, Italy. July 1 - July 31, 2001. Approx. $2,500.
Visiting Senior Scientist. Italian Institute of Hydrobiology, National Research Council. Pallanza, Italy. June 18-July 2, 2005. Approx. $1,000.

International Consulting and Research:
Water Research Centre. Evaluation of stormwater toxicity assessment methods. 1996. $5,000.
Water Research Centre. Toxicity based criteria for assessing receiving water quality in England. 1996. $3,025.
Natural Resources Canada, Canada Centre for Mineral and Energy Technology. 1997-1998. $7,500.
Antarctica New Zealand. Evaluation of *in situ* toxicity from polycyclic aromatic hydrocarbons: Scott Base, Ross Sea. 1997. Approx. $80,000.
Environment Canada. CANMET - Aquatic Effects Technology Evaluation Program. Technical Evaluation on assessing aquatic ecosystems using pore waters and sediment chemistry. 1998. $7,000.
U.S. AID, University Linkages Project, Phase II, Alexandria University, Egypt. Restoration and Development of Lake Maryut. 1999-2001. $50,000 (Co-PI AB – $20,000).
Lake Biwa Research Institute. Comparison of Sediment Criterions Around the World. 2000. $10,000
Workshop Panel. Decision Making Framework for Sediment Assessment. National Water Research Institute and Environment Canada. 2001. $2,000.
Copper Development Association, RioTinto, and International Copper Association. An Assessment of Copper Effects on Benthic Invertebrates in Freshwater Ecosystems. 2005-2007. $80,884.
Metal Risk Assessment Guidance Review. International Council of Metals and Mining. London. May 2005. $5,923
RIVM, the Netherlands. Weight-of-Evidence based GIS System for Stressor Detection. QERAS Project. $10,000. 2006.
European Copper Association. 2006. An Assessment of Copper Effects on Benthic Invertebrates in Freshwater Ecosystems, Project Amendment. $36,575.
International Copper Association, Dissolved Organic Carbon Dynamics in Brandenberg Pond, Ohio. $2,700. 2007.
International Zinc Association. Zinc and Sediments: Defining the State-of-the-Science and Key Data Gaps. $12,000. 2007.
International Copper Association and Copper Development Association. An Assessment of Copper Effects on Benthic Invertebrates in Freshwater Ecosystems, Project Amendment. $19,278.
Environment Agency – United Kingdom. A Quantitative Approach for Scientifically-Based Decision Making: Linking Physical and Chemical Factors with Ecosystem Responses. $20,900. 2007-2008.

Total international funding (pre-2008): $416,285

University Courses Taught:
Water Quality and Treatment
Environmental Toxicology
Hazardous Waste Management
Introduction to Environmental Health Sciences

Limnology
Risk Assessment I and II
Assessment of Sediment Contamination
Ecotoxicology
Problems in Environmental Health Sciences
Watershed Processes
Environmental Stressor Identification
Stream Hydrology and Ecological Interactions
Environmental Problem Solving
Sediment Quality Assessment
Aquatic Ecosystems
Aquatic Ecosystem Quality Assessment
Water and Sediment Quality Assessment
Ecological Risk Assessment
Great Lakes Stressors
Stressor Dynamics in Aquatic Ecosystems

Graduate Students Supervised:

1. B.L. Stemmer. M.S. 1988. Thesis: An Evaluation of Various Effluent and Sediment Toxicity Tests.
2. K.L. Winks. M.S. 1990. Thesis: Effects of Metal Mixtures on *Pimephales promelas* Larval Growth in Water and Sediment Exposures.
3. S.D. Leibfritz-Frederick. M.S. 1990. Thesis: Toxicity of Metals to *Daphnia magna* and *Hyalella azteca* in Sediment Assays and Methodological Variables Within the Test.
4. G.N. Noel-Sasson. M.S. 1990. Thesis: Sediment Toxicity Evaluations Using *Ceriodaphnia dubia*.
5. C. Skalski. M.S. 1991. Thesis: Laboratory and *In Situ* Sediment Toxicity Evaluations Using Early Life Stages of *Pimephales promelas*.
6. R. Fisher. M.S. 1991. Thesis: Sediment Interstitial Water Toxicity Evaluations Using *Daphnia magna*.
7. J. Rawlings. M.S. 1994. Thesis: Pesticide Toxicity Alteration in Constructed Wetlands.
8. S. Ireland. M.S. 1995. Thesis: Evaluation of In Situ Testing in Stormwater Assessments.
9. N. Sarda. M.S. 1994. Thesis: Spatial and Temporal Heterogeneity in Sediments with Respect to Pore Water Ammonia and Toxicity of Ammonia to *Ceriodaphnia dubia* and *Hyalella azteca*.
10. K. Jacher. M.S. 1994. Thesis: *In Situ* Testing of Stormwater and Sediment Contamination with *Hyalella azteca*.
11. K. Yu. Ph.D. 1995. Dissertation: An In Vivo/In Vitro Comparison of the Pharmacodynamics of Selected Polychlorinated Compounds.
12. R. Collier. 1996. Thesis: Effect of Suspended Sediments on *Pimephales promelas* larvae.
13. D. Chappie. 1996. Thesis: Use of *In Situ* Toxicity Assays in Lake Systems.
14. A. C. Hatch. 1997. Thesis: Multiple Species Responses to Photoinduced Toxicity and Bioaccumulation of Polycyclic Aromatic Hydrocarbons.
15. D. Lavoie. 1999. Thesis: Use of Hydra and Bryozoans as In situ Toxicity Indicators
16. J. Brooker. 1999. Thesis: Use of the Asian Clam and Mayflies as In situ Toxicity Indicators
17. L. Moore. 2001. Thesis: *In situ* Determination of Urban Runoff Toxicity.
18. K. Kroeger. 2000. Thesis: Comparison of Artificial Streams with In situ and Laboratory Exposures.
19. C. Rowland. 2002. Thesis: Optimization of *Lumbriculus variegatus* and *Hyalella azteca In situ* Test Methods.
20. M. Greenberg. 2002. Ph.D. Dissertation: Factors Affecting Nonpolar Chemical Partitioning in Sediments and Organisms.
21. C. A. Irvine. 2003. Thesis: The influence of colloids on the toxicity of cadmium and fluoranthene to freshwater invertebrates.
22. K. Custer. 2004. Thesis: Development of a benthic macroinvertebrate in situ toxicity identification evaluation (BiTIE) chamber.
23. J. Nordstrom. 2005. Thesis: Stressor Identification Evaluation in Streams.
24. S. Fowler Geyer. 2007. Thesis: In Situ Stressor Identification

25. J. Johnson. 2007. Thesis: Separating Stormwater Stressors.
27. Katherine Kapo. 2004 PhD Candidate
28. Kevin Custer. 2006 PhD Candidate
29. Christina Cloran, 2008. MS. Nickel flux and toxicity in clay sediments.
30. Anthony Honick. MS candidate. 2008
31. Michael Eggleston. MS candidate. 2008.
32. Miling Li. MS candidate. 2009.
33. Michele Sawyer. MS candidate. 2009
34. Stephanie Tubbs. MS candidate. 2009.
35. Kyle Fetter. MS candidate. 2010.
36. Megan Witala. MS Candidate. 2011

Publications:

1. Burton, G.A., Jr. 1978. Isolation, Frequency of Occurrence, and Survival of *Yersinia enterocolitica* in Aqueous Environments. Thesis. 88 pp. Auburn University, Auburn, Alabama.
2. Gunnison, D., J.M. Brannon, I. Smith, Jr., and G.A. Burton, Jr. 1980. Changes in respiration and anaerobic nutrient regeneration during the transition phase of reservoir development. Proceedings of the Workshop on Hypereutrophic Ecosystems, Vaxjo, Sweden, 10-14 September, 1979.
3. Gunnison, D., J.M. Brannon, I. Smith, Jr., G.A. Burton, Jr. and K.M. Preston. 1980. A reaction chamber for study of interactions between sediments and water under conditions of static or continuous flow. Water Res. 14: 1520-1532.
4. Burton, G.A., Jr. and J.M. Lazorchak. 1982. Substrate associated microfauna. (Review article). J. Water Pollut. Contr. Fed. 54: 922-931.
5. Burton, G.A., Jr. and J.M. Lazorchak. 1983. Substrate associated microfauna. (Review article). J. Water Pollut. Contr. Fed. 55: 863-869.
6. Lazorchak, J.M. and G.A. Burton, Jr. 1984. Substrate associated microfauna. (Review article). J. Water Pollut. Contr. Fed. 56: 787-791.
7. Burton, G.A., Jr. 1984. Microbial Activity Tests: Factors Affecting Their Potential Use in Sediments. Ph.D. dissertation, 304 pp. University of Texas at Dallas, Richardson.
8. Lazorchak, J.M. and G.A. Burton, Jr. 1985. Substrate associated microfauna. (Review article). J. Water Pollut. Contr. Fed. 57: 724-728.
9. Burton, G.A., Jr. 1985. Microbiological water quality, In: Microbial Processes in Reservoirs. D. Gunnison (ed.), Junk Publishers, pp. 79-97.
10. Burton, G.A., Jr. and G.R. Lanza. 1985. Microbial enzyme activity tests: factors affecting their use to detect toxicant impacts on sediment microbiota, pp. 214-228, In: R.D. Cardwell, R. Purdy, and R.C. Bahner (eds.), Aquatic Toxicology and Hazard Assessment, STP 854. American Society for Testing and Materials, Philadelphia, PA.
11. Lazorchak, J. and G.A. Burton, Jr. 1986. Substrate associated microfauna. J. Water Pollut. Contr. Fed. 58: 699-703.
12. Burton, G.A., Jr. and G.R. Lanza. 1986. Variables affecting two electron transport system assays. Appl. Environ. Microbiol. 51: 931-937.
13. Burton, G.A., Jr., T. Giddings, P. DeBrine, and R. Fall. 1987. A high incidence of selenite-resistant bacteria from a site polluted with selenium. Appl. Environ. Microbiol. 53: 185-188.
14. Burton, G.A., Jr., J. Lazorchak, W. Waller and G. Lanza. 1987. Arsenic toxicity changes in the presence of sediments. Bull. Environ. Contam. Toxicol. 38: 491-499.
15. Burton, G.A., Jr., D. Gunnison and G.R. Lanza. 1987. Survival of enteric pathogens in freshwater sediments. Appl. Environ. Microbiol. 53: 633-638.
16. Burton, G.A., Jr. and G.R. Lanza. 1987. *Aeromonas hydrophila* densities in thermally-altered reservoir water and sediments. Water, Air, Soil Pollut. 34: 199-206.
17. Burton, G.A., Jr., D. Nimmo, F. Payne and D. Murphey. 1987. Microbial activity and *Ceriodaphnia* stream impact survey. Environ. Toxicol. Chem. 6: 505-513.
18. Burton, G.A., Jr., A. Drotar, J. Lazorchak and L. Bahls. 1987. Relationship of microbial activity and *Ceriodaphnia* responses to mining impacts on the Clark Fork River, MT. Arch. Environ. Contam. Toxicol. 16: 523-530.
19. Drotar, A., G.A. Burton, Jr., J.E. Tavernier and R. Fall. 1987. Widespread occurrence of bacterial thiol methyl-transferases and the biogenic emission of methylated sulfur gases. Appl. Environ. Microbiol. 53: 1626-1631.
20. Burton, G.A., Jr. and G.R. Lanza. 1987. Aquatic microbial activity and macrofaunal profiles of an Oklahoma stream. Water Res. 21: 1173-1182.
21. Burton, G.A., Jr. 1988. Occurrence of bacterial resistance to arsenite, copper, and selenite in diverse habitats. Bull. Environ. Contam. Toxicol. 39: 990-997.
23. Burton, G.A., Jr. and B.L. Stemmer. 1988. Evaluation of surrogate tests in toxicant impact assessments. Toxicity Assess. 3: 255-269.
24. Burton, G.A., Jr. 1988. Sediment impact assessments using microbial activity tests, In: J. Lichtenberg, J. Winter, C. Weber, and L. Fradkin (eds.), Chemical and Biological Characterization of Municipal Sludges,

Sediments, Dredge Spoils and Drilling Muds, STP 976, American Society for Testing and Materials. Philadelphia, PA, pp. 300-310.
25. Burton, G.A., Jr. 1989. Health effect assessments at hazardous waste sites: increasing your expertise. Ohio J. Environ. Health. 39: 22-23.
26. Lanza, G.R., G.A. Burton, Jr. and J.M. Doughtery. 1989. Microbial enzyme activities: potential use for monitoring decomposition processes, In: J. Cairns, Jr. and J.R. Pratt (eds.), Functional Testing of Aquatic Biota for Estimating Hazards of Chemicals, ASTM STP 988. American Society for Testing and Materials, Philadelphia, PA. pp. 41-54.
27. Burton, G.A., Jr. 1989. Evaluation of seven sediment toxicity tests and their relationships to stream parameters. Toxicity Assess. 4: 149-159.
28. Burton, G.A., Jr., B.L. Stemmer, K.L. Winks, P.E. Ross, and L.C. Burnett. 1989. A multitrophic level evaluation of sediment toxicity in Waukegan and Indiana harbors. Environ. Toxicol. Chem. 8: 1057-1066.
29. Burton, G.A., Jr., B.L. Stemmer, P.E. Ross, and L.C. Burnett. 1989. Discrimination of sediment toxicity in freshwater harbors using a multitrophic level test battery. In, W.S. Davis and T.P. Simon (eds.), Proceedings of the 1989 Midwest Pollution Control Biologists Meeting. U.S. Environmental Protection Agency, Region V, Instream Biocriteria and Ecological Assessment Committee. Chicago, IL. EPA 905/9-89-007. pp. 71-84.
30. Burton, G.A., Jr., 1990. Ecotoxicology: The Study of the Effects of Chemicals on Natural Systems (a four part feature series--Special Editor). Environ. Sci. Technol. 24: 9.
31. Stemmer, B.L., G.A. Burton, Jr., and S. Leibfritz-Frederick. 1990. Effect of sediment test variables on selenium toxicity to Daphnia magna. Environ. Toxicol. Chem. 9: 381-389.
32. Stemmer, B.L., G.A. Burton, Jr., and G. Sasson-Brickson. 1990. Effect of sediment spatial variance and collection method on cladoceran toxicity and indigenous microbial activity determinations. Environ. Toxicol. Chem. 9: 1035-1044.
33. Burton, G.A., Jr. and P.F. Landrum. 1990. New Standard Guide for Sediment Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing. ASTM Standard E1391. American Soc. Testing and Materials. Philadelphia, PA.
34. Sasson-Brickson, G. and G.A. Burton, Jr. 1991. In situ and laboratory toxicity testing with *Ceriodaphnia dubia*. Environ. Toxicol. Chem. 10: 201-207.
35. Hieber, P., L. Bedel, and G.A. Burton, Jr. 1991. A noise survey of groundskeepers and highway workers. Ohio J. Environ. Health. 41: 26-29.
36. Kenoyer, G., J. Seaberg, J. Reese, G. Hess, and G.A. Burton, Jr. 1991. Simulation of aquifer remediation with laboratory and field tests of sorption of chlorinated VOCs. Proceedings, National Waterwell Association Outdoor Action Conference, May, 1990, Las Vegas. NWWA, Columbus, OH.
37. Burton, G.A., Jr. 1991. Assessing freshwater sediment toxicity. Environ. Toxicol. Chem. 10: 1585-1627.
38. Burton, G.A., Jr. 1991. Impacts of sediment contaminants on sediment macrofacuna. L. 'Ecotoxicologie Des Sediments, Rapport et communications du congres international de La Rochelle. Societe D'Ecotoxicologie Fondamentale et Appliquee. Paris, France.
39. Burton, G.A., Jr. 1992. Sediment Toxicity Assessment. Editor. Lewis Publishers. Boca Raton, FL. 457 p
40. Burton, G.A., Jr. 1992. Sediment collection and processing: factors affecting realism. In, Sediment Toxicity Assessment. Lewis Publishers. Boca Raton, FL. pp. 37-66.
41. Burton, G.A., Jr. 1992. Plankton, macrophyte, fish and amphibian toxicity testing of contaminated freshwater sediments. In, Sediment Toxicity Assessment. Lewis Publishers, Boca Raton, FL. pp.167-182.
42. Burton, G.A.,Jr., M.K. Nelson, and C. Ingersoll. 1992. Freshwater benthic toxicity assays. In, Sediment Toxicity Assessments. Lewis Publishers, Boca Raton, FL. pp. 213-240.
43. Chapman, P., E. Power, and G.A. Burton, Jr. 1992. Integrative assessments in aquatic ecosystems. In, Sediment Toxicity Assessment. Lewis Publishers. Boca Raton, FL. pp. 313-340.
44. Burton, G.A., Jr. 1992. Annex X4. *Daphnia* and *Ceriodaphnia* sp. In ASTM Standard Guide E1383. New Standard Guide for Conducting Sediment Toxicity Tests with Freshwater Invertebrates. Amer. Soc. Testing and Materials. Philadelphia, PA.
45. Ross, P.E., G.A. Burton, E.A. Crecelius, J.C. Filkins, J.P. Giesy, Jr., C.G. Ingersoll, M.J. Mac, T.J. Murphy, J.E. Rathbun, V.E. Smith, H.E. Tatem, & R.W. Taylor. 1992. Assessment of sediment contamination at Great Lakes Areas of Concern: the ARCS Program Toxicity-Chemistry Work Group strategy. J. Aquatic Ecosystem Health 1:193-200.

46. Burton, G.A., Jr. 1992. Assessing contaminated aquatic sediments (a two part feature series - Special Editor). Environ. Sci. Technol. Vol. 26:1862-1863.
47. Burton, G.A., Jr. 1993. Assessing the quality of life for aquatic biota. In, Proceedings 1992 International Symposium on Environmental Dredging, A Solution to Contaminated Sediments?. Erie County Environmental Education Institute, Inc.. Buffalo, NY.
48. Burton, G.A., Jr. and K.J. Scott. 1992. Sediment toxicity evaluations: Their niche in ecological assessments. Environ. Sci. Technol. Vol. 26:2068-2075.
49. Burton, G.A., Jr., T. La Point, and C. Zarba. 1993. Contamination assessment of sediments in freshwater ecosystems, In, J. Saxena, ed., Hazard Assessment of Chemicals - Current Developments, Vol. 8: 171-205. Taylor and Francis Publ. Corp., Washington, DC.
50. Burton, G.A., Jr. 1993. Sediment quality assessments, Proceedings of the Conf. on Assessment and Treatment of Contaminated Sediments in the North Branch Chicago River. Northeast Illinois Planning Commission, Chicago, IL. pp. 23-30.
51. Nelson, M.K., P.F. Landrum, G.A. Burton, Jr., S.J. Klaine, E.A. Crecelius, T.D. Byl, D.C. Gossiaux, V.N. Tsymbal, L. Cleveland, C.G. Ingersoll, G. Sasson-Brickson. 1993. Toxicity of contaminated sediments in dilution series with control sediments. Chemosphere 27:1789-1812.
52. Burton, G.A., Jr. 1994. Assessing stormwater impacts. In, G. V. Cotroneo and R.R. Rumer (eds.), Hydraulic Engineering '94, Proceedings of the 1994 Conference. Amer. Soc. Civil Engineers Publ. pp. 1198-1202.
53. Burton, G.A., Jr. and C.G. Ingersoll. 1994. Evaluation of sediment toxicity, In Assessment Guidance Document. Assessment and Remediation of Contaminated Sediments (ARCS) Program, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL. pp. 86-130.
54. Hoffman, D.J, B.A. Rattner, G.A. Burton, Jr., and J. Cairns, Jr. (eds.) 1995. Handbook of Ecotoxicology. Lewis Publishers, Boca Raton, FL.
55. Burton, G.A., Jr. and C. MacPherson. 1995. Test methods for measuring sediment toxicity, In Hoffman, D., et al. (eds.), Handbook of Ecotoxicology. Lewis Publishers, Boca Raton, FL. pp.70-103.
56. Burton, G.A., Jr. 1995. Quality assurance issues in assessing receiving waters. In E.E. Herricks, ed., in Stormwater Runoff and Receiving Systems: Impact, Monitoring, and Assessment. Lewis Publishers, Boca Raton, FL.pp. 275-284.
57. Sarda, N. and G.A. Burton, Jr., 1995. Ammonia variation in sediments: Spatial, temporal and method-related effects. Environ. Toxicol. Chem. 14:1499-1506.
58. Ingersoll, C.G., G.T. Ankley, D.A. Benoit, E.L. Brunson, G.A. Burton, F.J. Dwyer, R.A. Hoke, P.F. Landrum, T.J. Norberg-King, and P.V. Winger. 1995. Toxicity and bioaccumulation of sediment-associated contaminants using freshwater invertebrates: a review of methods and applications. Environ. Toxicol. Chem. 14:1885-1894.
59. Burton, G.A., Jr. 1995. Critical issues in sediment bioassays and toxicity testing. J. Aquatic Ecosystem Health 4: 151-156.
60. Ireland, D.S., G.A. Burton, Jr., and G.G. Hess. 1996. *In Situ* toxicity evaluations of turbidity and photoinduction of polycyclic aromatic hydrocarbons. Environ. Toxicol. Chem. 15:574-581.
61. Burton, G.A., Jr., T.J. Norberg-King, C.G. Ingersoll, D.A. Benoit, G.T. Ankley, P.V. Winger, J. Kubitz, J.M. Lazorchak, M.E. Smith, E.Greer, F.J. Dwyer, D.J. Call, K.E. Day, P. Kennedy, and M.Stinson. 1996. Interlaboratory study of precision: *Hyalella azteca* and *Chironomus tentans* freshwater sediment toxicity tests. Environ. Toxicol. Chem. 15:1335-1343
62. Burton, G.A., Jr. W.R. Arnold, L.W. Ausley, J.A. Black, G.M. DeGraeve, F. Fulk, J. Heltshe, W.H. Peltier, J. Pletl, and J.H. Rodgers, Jr. 1996. Discussion synopsis: effluent toxicity testing variability, in D. Grothe, K. Dickson, and D. Reed-Judkins (eds.) Whole Effluent Toxicity Testing: An Evaluation of Methods and Prediction of Receiving System Impacts. SETAC Press, Pensacola, FL, pp. 131-156.
63. Burton, G.A., Jr., C. Ingersoll, L. Burnett, M. Henry, M. Hinman, S. Klaine, P. Landrum, P. Ross, and M. Tuchman. 1996. A comparison of sediment toxicity test methods at three Great Lakes Areas of Concern. J. Great Lakes Res. 22:495-511.
64. Yu, K. O., D.E. Tillitt, J.Z. Byczkowski, G.A. Burton, Jr., S.R. Channel, J.M. Drerup, C.D. Flemming, and J.W. Fisher. 1996. *In vivo/in vitro* comparison of the pharmacokinetics and pharmacodynamics of 3,3',4,4'-tetrachlorobiphenyl (PCB77). Toxicol. Appl. Pharm. 141:434-438.

65. Canfield, T.J., F.J. Dwyer, J.F. Fairchild, P.S. Haverland, C.G. Ingersoll, N.E. Kemble, D.R. Mount,T.W. LaPoint, G.A. Burton, M.C. Swift. 1996. Assessing contamination in Great Lakes sediments using benthic invertebrate communities and the sediment quality triad approach. J. Great Lakes Res. 22:565-583.
66. Burton, G.A., Jr., C. Hickey, T. DeWitt, D. Morrison, D. Roper, and M. Nipper. 1996. *In situ* toxicity testing: Teasing out the environmental stressors. SETAC NEWS 16(5):20-22.
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Burton, G.A., C. Rowland, D. R. Lavoie, Nita Nordstrom, M. Greenberg. Nov. 2001. Assessment of sediment toxicity and bioaccumulation using macroinvertebrates in the Lower Housatonic River, Massachusetts. Annu. Meet. Soc. Environ. Toxicol. Chem., Baltimore, Maryland. (invited)

Rowland, C.D., G.A. Burton, M. Leppanen. Nov. 2001. *In situ* bioaccumulation of sediment associated PCBs in the freshwater oligochaete *Lumbriculus variegatus.* Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem., Baltimore, Maryland. (invited)

Greenberg, M., G. Allen Burton, M. Leppanen. Nov. 2001. Accumulation and toxicokinetics of fluoranthene and trifluralin in sediment bioassays with *Hyalella azteca* and *Lumbriculus variegatus.* . Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem., Baltimore, Maryland.

Burton, G.A., C. Irvine, J. Johnson, R. McWilliam, J. Gallagher, B. Schwab, M. Greenberg, M. Leppanen. May 2002. Biological concern values: a simplistic and realistic assessment tool for weight-of-evidence approaches. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Europe., Vienna, Austria.

McWilliam, R.A., G.A. Burton, C. Irvine, J. Johnson, B. Schwab. May 2002. Separating natural and anthropogenic stressors using in situ and laboratory approaches. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Europe., Vienna, Austria.

Leppanen, MT, Greenberg, MS, G.A. Burton. May 2002. Assessing the use of *Lumbriculus variegaturs* (Oligochaete) in sediment toxicity testing. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Europe., Vienna, Austria.

Ristola, T., MT Leppanen, J. Johnson, and G.A. Burton. May 2002. Comparing two midge species (*Chironomus*) in sediment toxicity tests using *in situ* and laboratory exposures. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Europe., Vienna, Austria.

Leppanen, MT, PF Landrum, JVK Kukkonen, MS Greenberg, GA Burton, S. Robinson, DC Gossiaux. May 2002. Bioavailability of sediment-associated tetrachlorobiphenyl to benthic invertebrates. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Europe., Vienna, Austria.

Greenberg, M.S. and G.A. Burton. 2002. Modeling bioaccumulation in systems where hydrologic conditions affect the bioavailability of sediment-associated contaminants. Abstr. Annu. Meet. North Amer. Benthol. Soc., Pittsburgh, PA.

Irvine, CA, Burton GA, Greenberg MS, Johnson JP. 2002. Effects of aqueous colloids on feeding and bioconcentration in Hyalella azteca and Daphnia magna exposed to fluoranthene and cadmium. 5th International Symposium on Sediment Quality Assessment. Aquatic Ecosystem Health Management Society. Chicago, IL.

Burton, GA, Irvine, CA, Johnson, JP, McWilliam RA, Greenberg MS. 2002. Using multiple lines of evidence to assess sediment quality. 5th International Symposium on Sediment Quality Assessment. Aquatic Ecosystem Health Management Society. Chicago, IL.

Burton, GA. 2002. Summary of Pellston workshop on use of sediment quality guidelines (SQGs) and related tools for the assessment of contaminated sediments. 5th International Symposium on Sediment Quality Assessment. Aquatic Ecosystem Health Management Society. Chicago, IL.

Johnson, JP, Burton, GA, Irvine, CA. 2002. The impacts of aircraft deicing fluid on Lytle Creek (Wilmington, OH) using in situ and laboratory approaches. 5th International Symposium on Sediment Quality Assessment. Aquatic Ecosystem Health Management Society. Chicago, IL.

Greenberg MS and Burton GA. 2002. A model of bioaccumulation in stream systems where groundwater-surface water interactions affect the bioavailability of sediment-associated contaminants. 5th International Symposium on Sediment Quality Assessment. Aquatic Ecosystem Health Management Society. Chicago, IL.

Irvine CA, Burton GA, Greenberg, MS. 2002. The influence of colloids on the toxicity of cadmium and fluoranthene to freshwater invertebrates. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Salt Lake City, UT.

Greenberg, MS, Burton GA, Leppanen MT, Schwab, BA. 2002. Bioconcentration and toxicokinetics of waterborne fluoranthene and trifluralin in Lumbriculus variegates and Hyalella azteca. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Salt Lake City, UT.

Greenberg, MS, Burton GA. 2002. Modeling bioaccumulation in stream systems where groundwater-surface water interactions affect the bioavailability of sediment-associated contaminants. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Salt Lake City, UT.

Burton, GA, Batley, GE, Chapman, PM, Forbes VE, Smith EP, Reynoldson T, Schlekat, CE, den Besten, PJ, Bailer AJ, Green AS. 2002. Weight of evidence framework: Improving certainty in the decision-making process. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Salt Lake City, UT.

Burton, GA, Irvine, CA, Johnson, JP, McWilliam RA, Greenberg MS, Schwab, BA. 2002. Weight of evidence sediment quality assessment: Don't expect concordance... Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Salt Lake City, UT.

Burton, G.A. Jr. 2003. Field Evaluation of Sediment Zinc Risk Assessment. University of Ghent. Technical Management Committee. European Union Zinc Risk Assessment. Ghent, Belgium (invited)

Burton, G.A. Jr. 2003. Measuring Toxicity and Bioaccumulation: Linking Exposure and Effects. Sediment Chemical Stability Workshop. San Diego, CA. http://www.sediments.org (invited)

Burton, G.A. Jr. 2003. Field Evaluation of Sediment Zinc Risk Assessment. Zinc International Lead Zinc Research Organization. Bologna, Italy (invited)

Irvine, CA and Burton GA. 2003. Colloid influence on *D. magna* feeding and tissue residues following contaminant exposure. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Austin, TX.

Burton GA, LT Nguyen, C Janssen, R McWilliam, B Bossuyt, M Beltrami, R Baudo, A Green. 2003. Field validation of zinc effects and the SEM-AVS model: Benthic colonization and in situ toxicity. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Austin, TX.

Greenberg MS, Burton GA Jr, Landrum PF, Leppanen MT, Kukkonen JVK. 2003. Concentration-dependent desorption of fluoranthene and trifluralin from Great Lakes sediments. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Austin, TX.

Burton, G. Allen. 2003. Assessment of Ecological Impairment Associated with Sediments: Issues and Approaches. Abstr. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. (Keynote)

Burton, GA Jr., LT Nguyen, C Janssen, R McWilliam, B Bossuyt, M Beltrami, R Baudo, A Green. 2003. Sediment Quality Assessments: Strategically Integrating Multiple Lines-of-Evidence to Improve Decision Making. Abstr. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. (Invited)

Burton, GA Jr. 2003. Developing realistic assessment guidelines for sediment using benthic colonization and short term *in situ* responses. Abstr. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. (Invited)

Burton, GA Jr. 2003. Environmental Sciences Curricula: Balancing Depth with Breadth. Abstr. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. (Invited)

Sterner TR; PJ Robinson, DR Mattie, GA Burton. 2004. Preliminary analysis of algorithms predicting blood:air and tissue:blood partition coefficients from solvent partition coefficients. Abstr. Annu Meeting Soc of Toxicology.

Burton GA, K. Custer, S Geyer, LT Nguyen, C Janssen, R McWilliam, B Bossuyt, M Beltrami, R Baudo, A Green. 2004. Identification of stressor effects using *in situ* exposures of species, populations and communities. Abstr. Annu. Meet. Soc. Environ. Toxicol. Chem. Prague, Czechoslovakia. (invited)

Custer, K.W., G. Allen Burton. 2004. Use of indigenous species in field toxicity identification evaluation (TIE) chambers. Abstr. Annu. Meet. North American Benthological Society, Louisville, KY.

Rosiu, CJ, MS Greenberg, J Coles, FP Lyford, GA Burton Jr. 2004. Evaluation of impacts from discharge of contaminated ground water to the Sudbury River, Nyanza Chemical Waste Dump Superfund Site, Ashland, Massachusetts. Abstr. Joint Meeting of the AGU, CGU, SEG, EEGS. Montreal, May 2004.

Custer, K.W., G. Allen Burton. 2004. Use of indigenous species in field toxicity identification evaluation (TIE) chambers. Abstr. Annu. Meet. World Congress, Soc. Environ. Toxicol. Chem. Portland, OR.

Geyer, S. G. A. Burton. 2004. Optimization of an in situ Toxicity Identification Evaluation device. Abstr. Annu. Meet. World Congress, Soc. Environ. Toxicol. Chem. Portland, OR

Roberts AP, Oris JT, Clements WH, Burton GA. 2004. Development and field application of a molecular biomarker approach for exposure assessment. Abstr. Annu. Meet. World Congress, Soc. Environ. Toxicol. Chem. Portland, OR.

Roberts AP, Oris JT, Clements WH, Burton GA. 2005. Development and field application of a molecular biomarker approach for exposure assessment. Abstr. Annu. Meet. European Soc. Environ. Toxicol. Chem. Lille, France.

Nguyen THL, Burton GA, Janssen CR, Schlekat C. Response of benthic invertebrate community to sediment nickel toxicity. Abstr. Annu. Meet. European Soc. Environ. Toxicol. Chem. Lille France. (invited)

Burton, GA, Nguyen LTH, Roman YP, Zoetardt H, Janssen CR, Schlekat CE. Evaluation of nickel effect levels in freshwater sediments. Abstr. Annu. Meet. European Soc. Environ. Toxicol. Chem. Lille France. (invited)

Wendelyn, KL, Watters GT, Burton GA, Runkle JR. 2005. A survey of freshwater mussels (unionidae) in Twin Creek, Southwest Ohio. Freshwater Mollusk Conservation Society Symposium.

Burton, GA. 2005. Field assessment of benthic invertebrate community to sediment nickel toxicity. Nickel Environmental Risk Assessment Panel. Ghent, Belgium.

Custer KW, Burton GA. 2005. Macroinvertebrate community responses in streams using the benthic in situ Toxicity Identification Evaluation (BiTIE) chamber. Abstr. Annu. Meeting North American Benthological Society. New Orleans, LA.

Ren, J-J, Burton GA. 2006. Characterizing and predicting flux of PBT compounds between sediments and overlying waters in streams. SERDP Annual Meeting. Washington DC.

K.E. Kapo and G. A. Burton, Jr. Application of GIS-Based Weights of Evidence and Weighted Logistic Regression in a Multi-scale Watershed Assessment. Poster presentation, SETAC Europe meeting, The Hague, May 2006.

K.E. Kapo and G. Allen Burton, Jr. Eco-epidemiological analysis of Ohio (USA) rivers using GIS-based weights-of-evidence and weighted logistic regression. Poster presentation, SETAC Asia-Pacific meeting, Beijing, September 2006.

K.E. Kapo and G. Allen Burton, Jr. Eco-epidemiological analysis of Ohio (USA) rivers using Bayesian spatial analysis: comparison of biological endpoint selection in risk assessment. Poster presentation, SETAC North America meeting, Montreal, November 2006.

K.E. Kapo and G. Allen Burton, Jr. Application of GIS-Based Weights of Evidence and Weighted Logistic Regression in Eco-epidemiological analysis of monitoring data. Platform presentation, SETAC North America meeting, Montreal, November 2006.

L. Posthuma, K.E. Kapo, D. DeZwart, G. A. Burton, Jr. Cross-validation of two methods for eco-epidemiological analyses of monitoring data that show local magnitudes of impact and likely local causes of impact. Poster presentation, SETAC North America meeting, Montreal, November 2006.

Ren J, Burton GA. Defining and Predicting PCB Fluxes and Their Ecological Effects in Stream and River Systems for Risk Characterizations U.S. EPA STAR Nanotechnology Environmental Applications and GRO Progress Review Workshop. Washington DC, November 2006. (invited)

Kapo, K.E. and Burton, G.A., Jr. 2007. Application of GIS-based Weights of Evidence Approach in an Eco-epidemiological Assessment of Ohio Rivers. Poster Presentation, Fourth International Conference on Remediation of Contaminated Sedments (January 2007) Savannah, Georgia,USA. (invited)

Burton, G.A., Jr., and Custer, K. 2007. Separating Natural and Chemical Stressors in a Sediment and Stormwater Assessment of Wolf Creek, Dayton, OH. Poster Presentation, Fourth International Conference on Remediation of Contaminated Sedments (January 2007) Savannah, Georgia, USA. (invited)

Kapo KE and G. A. Burton, Jr. Complexity in Ohio land use patterns and effects on diagnostic assessment: a Tier 1 database evaluation applying the GIS-based WOE/WLR method. SETAC Europe Annual Meeting Abstracts. Porto, Portugal. Mary 2007 (invited).

Kapo KE and Burton GA Jr. 2007. Complexity in Ohio land use patterns and effects on diagnostic assessment; a Tier-1 database evalutation applying the GIS-based WOE/WLR method. Platform Session, SETAC Europe, Porto Portugal, May 20-24 2007.

Kapo KE and Burton GA Jr. 2007. Diagnosing land use patterns and effects applying the GIS-based WOE/WLR method. Abstr. Annual Meeting SETAC North America, Milwaukee, Nov. 2007.

Kevin W. Custer,[1] G.A. Burton, Jr.,[1] P. Anderson,[1] and C. Schlekat *Ceriodaphnia dubia* field and laboratory population responses to nickel concentrations in chronic toxicity tests. Abstr. Annual Meeting SETAC North America, Milwaukee, Nov. 2007.

Chadwick B, Guerrero J, Rosen G, Groves J, Smith C, Paulsen R, Burton A, Greenberg M. The Trident Probe Capabilities and Applications for Identifying and Mapping Groundwater Discharge Zones. Abstr. Annual Meeting SETAC North America, Milwaukee, Nov. 2007.

Muir, D, Burton GA and Mozur M. The Society of Environmental Toxicology and Chemistry: a forum for discussion of global chemical pollution issues. Dioxin 2007. Japan. 2007.

Burton GA, Chadwick B, Rosen G, Greenberg M. 2007. The Sediment Environmental Assessment Protocol (SEAP). SERDP Annual Meeting. Washington DC.

Camarena C, Otero D, Ren J, Burton GA, Packman A. 2007. Esxperimental study and modeling of the stream-subsurface exchange of p,p'-DDE in the presence of naturally occurring fine particles. American Geophysical Union Abstr. Annu. Meeting. San Francisco.

Burton, G.A. 2008. Assessing Environmental Risk in Aquatic Systems: Realistic and Efficient Approaches for Effective Decision Making. Jeddah Environmental Forum and Exhibition. Jeddah, Saudi Arabia.

Custer, K, Taulbee K, Burton A, Anderson P, Bessom S, Cloran C, Ellis K, Kochersberger J, Schlekat C. 2008. Nickel effects on indigenous and surrogate organisms in sediment: species growth, survival, and community responses. Abstr Annu Meeting SETAC Europe. Warsaw Poland.

Taulbee K, Burton A, Custer, K., Smith P, Anderson P, Bessom S, Cloran C, Ellis K, Kochersberger J, Delbeke K. 2008. Copper flux exposure and effects in freshwater sediments. Abstr Annu Meeting SETAC Europe. Warsaw Poland.

Slye, J, Smith, PS , Burton A, Kennedy J, LaPoint T, Ortego L.. 2008. Sediment Recolonization Study to Examine Potential Fipronil Effects on Benthic Macroinvertebrates in Freshwater Ecosystems in the Southern United States. Abstr Annu Meeting SETAC Europe. Warsaw Poland.

Custer KW, Taulbee K, Burton GA, Anderson P, Bessom S, Cloran C, Ellis K, Kochersberger J, Schlekat, C. 2008 Indigenous and surrogate organism responses to nickel in sediment and water exposures. Abstr Annu Meeting North American Benthological Society. Salt Lake City, NV.

Kocheresberger JP, Burton GA, Custer K, Taulbee K, Anderson P, Cloran C, Simpson K. 2008. Linking embeddedness and macroinvertebrate health in two southwest Ohio streams. Abstr Annu Meeting North American Benthological Society. Salt Lake City, NV.

Kapo KK, Burton AG, Pemberton E, Wells C, Whitehouse P. 2008. A multi-stressor regional risk assessment for aquatic macrofauna in England and Wales applying GIS-based WOE/WLR methodology. Abstr. Annu Meeting Soc. Environ Toxicol Chem. Sydney Australia.

Custer, K, Taulbee K, Burton A, Anderson P, Bessom S, Cloran C, Ellis K, Kochersberger J, Schlekat C. 2008. Nickel spiked sediments and other bioavailability factors changing over time in situ in Southwest Ohio. Abstr. Annu Meeting Soc. Environ Toxicol Chem. Sydney Australia.

Custer KW, Burton GA, Cloran C, Anderson P, Taulbee K, Hammerschmidt C, Schlekat C. 2008. Nickel effects examining bioavailability factors in sediments and water-only tests. Abstr Annu Meeting Soc Environ Toxicol Chem. Tampa, FL.

Rosen G, Chadwick DB, Greenberg M, Burton GA. 2008. Linkage of exposure with biological effects using in situ-based monitoring tools in marine and estuarine systems. Abstr Annu Meeting Soc Environ Toxicol Chem. Tampa, FL.

Cloran CE, Burton GA, Taulbee K, Custer K, Hammerschmidt C, Schlekat. 2008. Investigating Nickel Flux and Toxicity in Clay Sediments with Batch and Stream Recirculating Flume Experiments. Abstr Annu Meeting Soc Environ Toxicol Chem. Tampa, FL.

Hammerschmidt CR, Burton GA. 2008. Inter-laboratory Comparison of Acid-Volatile Sulfide and Simultaneously Extracted Metals in Freshwater Sediments. Abstr Annu Meeting Soc Environ Toxicol Chem. Tampa, FL.

Bessom SM, Hammerschmidt CR, Burton GA. 2008. Nickel uptake and toxicity to lotic periphyton communities. Abstr Annu Meeting Soc Environ Toxicol Chem. Tampa, FL.

Slye JL, Smith P, Holes CM, Ortego LS, La Point TW, Burton GA. 2008. Sediment recolonization study to examine potential fipronil effects on benthic macroinvertebrates in freshwater ecosystems in the southern United States. Abstr Annu Meeting Soc Environ Toxicol Chem. Tampa, FL.

Custer KW, Burton GA, Anderson P, Fetters K, Hummel S, Kochersberger J, Taulbee K, Schlekat C. 2009. Single species growth and benthic macroinvertebrate community responses to nickel. North Am Benthol Soc. Grand Rapids, MI.

Custer KW, Burton GA, Taulbee K, Fetters K, Hummel S, Schlekat C. 2009. Aquatic insect responses to nickel spiked sediments: in situ and laboratory exposures. Intern Assoc Great Lakes Res. Toledo OH.

Kapo K, Burton GA. 2009. Delineation of stressor response associations using regional spatial analysis of archival Ohio watershed data. Intern Assoc Great Lakes Res. Toledo OH.

Posthuma L, deZwart D, Mulder C, Kapo K, Burton A, Whitehouse P, Dyer S, Murray J. June 2009. Ecoepidemiology: A comparison of methods. Ann Meeting Europe Soc Env Toxicol Chem. Goteborg Sweden.

Custer, K.W., G.A. Burton, Jr., K. Taulbee, K. Fetters, S. Hummel, C. Schlekat. 2009. Sediment nickel effects with field collected aquatic insects during *in situ* and laboratory exposures. The Society of Environmental Toxicology and Chemistry, Europe Meeting, Goteborg, Sweden.

Kapo K, Burton GA, Rosen G, Chadwick DG, Greenberg M. 2009. Integrated approach for assessing ecological risk and recovery of contaminated sediment sites: a case study for the San Diego Harbor Naval Station. Ann Meeting Soc Environ Toxicol Chem. New Orleans LA.

Custer, K.W., G.A. Burton, Jr., P. Anderson, K. Fetters, S. Hummel, J. Kochersberger, K. Taulbee. 2009. Single species growth and benthic macroinvertebrate community responses to nickel. The North American Benthological Society's Annual Meeting, Grand Rapids, MI, USA.

Custer KW, Burton GA. 2010. Dissolved organic carbon affects nickel toxicity to *Lymnaea stagnalis* and *Daphnia magna*. Abstr. Annu. Meeting Society of Environmental Toxicology and Chemistry, Seville, Spain.

Custer KW, Burton GA, Fetters K, Hummel S, Weller R. 2010. Effects of sediment characteristics on nickel bioavailability and benthic communities. Abstr. Annu. Meeting North American Benthological Society and American Society of Limnology & Oceanography. Sante Fe, NM.

Costello DM, Burton GA, Hammerschmidt CR, Honick AS, Custer KW, Rogevich EC, Schlekat CE. 2010. Field testing of nickel contaminated sediments: Contaminant flux, chemical speciation and toxicity to aquatic invertebrates. Abstr. Annu. Meeting North American Benthological Society and American Society of Limnology & Oceanography. Sante Fe, NM.

Allan JD, McIntyre PB, Halpern B, Boyer G, Buchsbaum A, Burton A, et al. 2010. The Great Lakes Threat Mapping Project: A new tool to aid in prioritization. Abstr. Annu. Meeting International Assoc Great Lakes Research. Toronto, Canada.

Eggleston M, Costello D, A. Burton. 2010. Impact of sediment resuspension events on the availability of heavy metals in freshwater sediments. Abstr. Annu. Meeting Society of Environmental Toxicology and Chemistry, Portland, OR.

Costello D., B. Burton. C. Hammerschmidt. 2010. Field-testing of nickel contaminated sediments: nickel flux, chemical speciation, and toxicity to aquatic invertebrates. Abstr. Annu. Meeting Society of Environmental Toxicology and Chemistry, Portland, OR.

Rosen, G., Chadwick B., Burton, G., Greenberg M. 2010. Evaluation of an integrated exposure and effects assessment approach involving in situ and laboratory tools along three contamination gradients. Abstr. Annu. Meeting Society of Environmental Toxicology and Chemistry, Portland, OR.

Taulbee K, Burton G., Custer K. 2010. Bioavailability of copper and nickel in sulfidic and non-sulfidic freshwater sediments. Abstr. Annu. Meeting Society of Environmental Toxicology and Chemistry, Portland, OR.

Custer K., Burton G., Hammerschmidt C. 2010. Nickel toxicity to Lymnaea stagnalis and Hyalella azteca in sediment, water and food exposures. Abstr. Annu. Meeting Society of Environmental Toxicology and Chemistry, Portland, OR.

Costello D, Burton G, Taulbee K, Custer K. 2011. Bioavailability of nickel and copper in sulfidic and non-sulfidic freshwater sediments. Abstr. Ann Meeting American Soc Limnology & Oceanography. San Juan, Puerto Rico.

Allan JD, McIntyre PB, Halpern B, Boyeer G, Buschsbaum A, Burton A et al. Prioritizing restoration and conservation opportunities in the Great Lakes. Abstr. Coastal Zone 2011 Conference. July 2011 Chicago.

Costello D, Burton G, CR Hammerschmidt, Taulbee K. 2011. Evaluating the performance of passive sampling devices (DGTs) for predicting Ni sediment toxicity. Abstr. Ann Meeting European Soc Environmental Toxicology & Chemistry. Milan, Italy.

Vangheluwe M, I. Vercaigne, J Besser, W Brumbaugh, C Ingersoll, GA Burton, E Rogevich, C. Schlekat. 2011. An integrated effects assessment of Nickel in freshwater sediments. Abstr. Ann Meeting European Soc Environmental Toxicology & Chemistry. Milan, Italy.

Costello D, Burton G, CR Hammerschmidt, Taulbee K. 2011. Evaluating the performance of passive sampling devices (DGTs) for predicting Ni sediment toxicity. Abstr. Biannual Meeting ICOBTE. Florence Italy.

Costello DM, Burton GA. 2011. Biofilm response to metal-contaminated sediments is stream dependent. North American Benthological Society. Providence RI.

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Invited Lectures:

Microbiological water quality. Annu. Meet. Am. Soc. Microbiol. St. Louis, MO. 1984.

Evaluation of short-term tests in hazard assessments. Environmental Monitoring and Support Lab. U.S. Environmental Protection Agency. Cincinnati, OH. 1986.

Environmental health and ecotoxicity testing. Annu. Meet. Southwest District Ohio Environ. Health Assoc. Dayton, Ohio. 1986.

Environmental health: academics and research. Annu. Meet. Ohio Environ. Health Assoc. Columbus, Ohio. 1987.

Effects of sediments on bacterial survival and response to metals. U.S. Environmental Protection Agency. Cincinnati, Ohio. 1987.

Field validation of *Ceriodaphnia* and microbial toxicity tests. University of Illinois, Champaign, Illinois. 1987.

Field validation of *Ceriodaphnia* and microbial toxicity tests. University of Dayton. Dayton, OH. 1988.

Assessment of aquatic toxicity: current approaches and issues. Regional Chapter, Society of Toxicology, Dayton, OH. 1988.

Methodological effects on sediment toxicity. Center for Environ. Toxicol. Michigan State Univ. East Lansing, MI. 1989.

Identifying contaminated sites. Hazardous Waste Symposium, Ohio Environmental Health Association. Reynoldsburg, OH. 1989.

Multitrophic level assessments of sediment quality. National Symposium on Water Quality Assessment. U.S. Environmental Protection Agency. Colorado State University, Ft. Collins. 1989.

Methods for determining acute and chronic sediment toxicity. Bioassay Toxicity Testing Workshop. University of Wisconsin, Milwaukee. 1990.

An overview of sediment toxicity standards and assessments in the ASTM and ARCS programs. U.S. Environmental Protection Agency Sediment Oversight Technical Committee. USACOE Waterways Experiment Station, Vicksburg, MS. 1990.

Validation of sediment toxicity with surrogate species. Dept. of Zoology, Miami University. Oxford, OH. 1990.

Multitrophic level assessment of aquatic ecosystem impairment. Biological Sciences Department, Indiana-Purdue University. Ft. Wayne, IN. 1990.

Solid phase toxicity testing. Third Annual National Superfund Environmental Evaluation Workshop. San Diego, CA. 1991.

Evaluating aquatic toxicity with multiple bioindicators and endpoints. U.S. Environmental Protection Agency. Environmental Monitoring and Systems Laboratory, Cincinnati, OH. 1991.

Impact of polluted sediments on freshwater macrofauna. Intern. Symposium on Ecotoxicology of Coastal, Estuarian, and Freshwater Sediments. Société d'Ecotoxicologie Fundamentale et Appliquée. La Rochelle, France. 1991.

Assessing impacts on aquatic ecosystems. Society for Risk Analysis Annual Meeting, Ohio Chapter. Dayton, OH. 1991.

Quality assurance issues. Effects of urban runoff on receiving systems: an interdisciplinary analysis of impact, monitoring, and management. Engineering Foundation Conference. Mt. Crested Butte, CO. 1991.

Sampling design. Whole Sediment Toxicity Testing. Continuing Education course on Assessing and Treating Contaminated Sediment. University of Wisconsin. Madison. 1991.

Comparative sensitivity and efficacy of sediment toxicity tests using freshwater organisms. Strengths and Weaknesses. U.S. Environmental Protection Agency Contaminated Sediment Management Strategy Tiered Testing Workgroup. Washington, DC. 1991.

Sediment toxicity testing: current issues and research directions. U.S. Environmental Protection Agency Environmental Monitoring and Support Laboratory, Cincinnati, OH. 1992.

Intercomparison of bioassays. Field assessments. Quality assurance/quality control (3 presentations). U.S. Environmental Protection Agency, Great Lakes National Program Office, ARCS All Work Group Meeting and RAP Workshop, Chicago, IL, 1992.

Evaluating sediment contamination in dredging areas. 1992 National/International Environmental Dredging Symposium. Buffalo, NY.

Options and Considerations in Assessing Sediment Contamination. How Can We Assess Sediment Quality? Assessment and Treatment of Contaminated Sediments in the North Branch Chicago River - A Model Approach for an Urban Waterway Conference. Bureau of Mines. Chicago, IL. 1992.

Freshwater Sediment Toxicity Assays; Necessary and Desirable Attributes. U.S. Environmental Protection Agency Tiered Testing Issues for Marine and Freshwater Sediments, Workshop. Washington, D.C. 1992.

Assessing Contamination in Freshwater Ecosystems. Department of Environmental Health. East Tennessee State University, Johnson City. 1992.

Questions and Issues in Determining Sediment Contamination. Proctor and Gamble, Inc., Cincinnati, OH. Feb.1993.

Assessment of Sediment Contamination in Freshwater Ecosystems. Institute of Applied Sciences, University of North Texas, Denton, TX. Mar. 1993

Evaluating Biological Effects of Contaminants in Freshwater Sediments. Contaminated Sediments Workshop. University of Coimbra, Coimbra, Portugal. Mar. 1993.

Toxicity Testing Procedures and Demonstrations. Managing Contaminated Sediment Course. Sponsored by U.S. Environmental Protection Agency. Univ. of Wisconsin, Madison, WI. April 1993.

Monitoring the Effects off Urban Runoff: The Coyote Creek Project. R. Pitt and G.A. Burton, Jr., National Conf. on Urban Runoff Management., Chicago, IL. April 1993.

Methods and Regulatory Issues for Assessing Sediment Contamination. Workshop on Contaminated Sediments. Companhia De Tecnologia De Saneamento Ambiental (CETESB). Sao Paulo, Brazil. Aug. 1993

Current Issues in Assessments of Sediment Contamination. Instituto de Radioprotecao e Dosimetria, Comissao Nacional de Energia Nuclear. Rio de Janeiro, Brazil. Aug. 1993.

The Environmental Sciences Program at Wright State University. Air Force Institute of Technology. Wright Patterson Air Force Base. Dayton, OH. Sept. 1993.

Environmental Sciences: Current Status and Future Developments. Environmental Science Advisory Board. WSU, Dayton, OH. Sept. 1993.

The Future of Biological Monitoring. Safety, Health, Environmental & Nursing Conference. Mead Corp. Dayton, OH. Sept. 1993.

Sediment Ecotoxicology: The U.S. Approach. Centre des Sciences de l'Environnement, Universite de Metz, France. Nov. 1993.

Toxicity and Bioaccumulation Testing. Short Course on "Assessment of Contaminated Sediment". Annu. Meet. Soc. Environ. Toxicol. Chem., Houston, TX. Nov. 1993.

Toxicity Testing Battery. Final ARCS (Assessment and Remediation of Contaminated Sediments Program) All-Hands Meeting. Great Lakes National Program Office, U.S. Environmental Protection Agency. Chicago, IL. Nov. 1993.

Beneficial Applications of In Situ Toxicity Testing in Ecosystem Assessment. Zoology Dept. University of Coimbra, Coimbra, Portugal. June 1994.

Approaches to Sediment Toxicity Assessment: Multi-Species Comparisons and In Situ Testing. Italian Institute of Hydrobiology, Verbania-Pallanza, Italy. July 1994.

Keynote Address: Critical Issues in Sediment Bioassays and Toxicity Testing. First International Symposium on Sediment Quality Assessment: Rationale, Challenges and Strategies. Goteborg, Sweden. August 1994.

Plenary Lecture: The Use of In Situ Toxicity Testing in Assessments of Aquatic Ecosystem Health. I Latin-American Symposium on Aquatic Ecosystem Health and the Ecological Significance of Bioassays. SECAO Latino-Americana (Aquatic Ecosystem Health and Management Society). Sao Carlos, Brasil. August 1994.

Health and Safety, Quality Assurance, and Variability in Freshwater Sediment Toxicity Testing. Short course on "Assessment of Contaminated Sediment". Annu. Meet. Soc. Environ. Toxicol. Chem. Denver, CO. Oct. 1994.

Commentary on Case Study - United Heckathorn Site, Richmond Harbor. Case Studies in Ecotoxicological Risk Assessments. Irvine, CA. June 1995.

Plenary Lecture: Ecotoxicology: Has It Improved the Quality of Life?. Annu. Meet. Brasilian Society of Chemistry. Caxumba, Brasil. June, 1995.

Chemistry's Complex Role in Aquatic Toxicology. Annu. Meet. Brasilian Soc. Chem., Caxumba, Brasil. June, 1995.

Managing Contaminated Sediment. University of Wisconsin Professional Development Course. Madison, WI. Oct., 1995.

Keynote Address: Evaluating Toxicity: Test Response Issues. Workshop on Toxicity Testing Applied to Soil Ecotoxicology. Canada National Research Council. Montreal, Canada. November, 1995.

Assessing Ecosystem Contamination. Refinaria Gabriel Passos (REGAP) Belo Horizonte, Minas Gerais, Brazil. Dec. 1995.

Ecosystem Contamination and the Environmental Programs at WSU. Faculty Research Colloquium. Wright State University, Dayton, OH. Feb. 1996
Assessment of Sediment Contamination: Characterization Issues. U.S. EPA, Region IV, Atlanta, GA, Mar. 1996.

Standardized Methods and Toxicity and Bioaccumulation Assay Selection. Short Course on "Understanding Sediment Analysis and Interpretation". University of Wisconsin - Madison. Sept. 1996.

Keynote address: Assessment of contaminated sediments. Third Finnish Conference of Environmental Sciences. Jyvaskyla, Finland, May 1997.

Assessing aquatic ecosystem contamination with *in situ* approaches. University of Joensuu, Joensuu, Finland. May, 1997.

Keynote address: The challenge of assessing multiple stressors in ecosystems. Congreso Mexicano De

Toxicologia. Mexico City. Mexico. May 1997.

Keynote address: Ecological relevance of ecotoxicology: critiques of traditional and novel approaches International Symposium on Integrated Ecotoxicology: From Molecules/Organisms to Ecosystems. Milan, Italy. June, 1997.

Current environmental research and issues in aquatic toxicology. Great Lakes Environmental Research Consortium. Wright State University. April 1997.

Standardized Methods and Toxicity and Bioaccumulation Assay Selection. Short Course on "Understanding Sediment Analysis and Interpretation". University of Wisconsin Course at University of Washington, Seattle, WA, July 1997.

Assessing Metal Bioavailability in Sediments. Short Course on "Ecologist Risk Assessment: Strategies for an Emerging Discipline". International Business Communications, Boston, MA, July 1997.

Toxicity of Oils and Chemical Countermeasures: Reality Issues. Freshwater Spills Conference. U.S: Environmental Protection Agency. St. Louis, MO. March 1998.

Watching our Food Chain. Round Table Speaker at Rotary Club, Dayton Daily News, and Kettering Medical Center Earth Day Town Meeting. Kettering, OH, April 1998.

Use of In situ Testing in Assessments of Bioavailability in Sediments. U.S. Dept. of Defense and National Environmental Policy Institute. Base Reorganization and Closure Conference. St. Louis, MO. April 1998.

Whole Effluent Toxicity Testing. Short Course Instructor. Annu. Meeting Ohio Valley Regional Chapter, Soc. Environ. Toxicol. Chem., Dayton, OH. June 1998.

Use of In situ Testing in Assessments of Bioavailability in Sediments. U.S. Dept. of Defense and National Environmental Policy Institute. Base Reorganization and Closure Conference. San Diego, CA. June 1998.

Realistic Assessments of Water Quality: Matching Exposure with Effects. International Conference on Ecology of Cities. Rhodes, Greece. June 1998.

Contaminated Sediment Toxicity in the Black River. Ohio EPA Black River Symposium. Cleveland, OH. 1998.

Standardized Methods and Toxicity and Bioaccumulation Assay Selection. Short Course on "Understanding Sediment Analysis and Interpretation". University of Wisconsin Course. Albany, NY. Oct. 1998.

Environment Canada. Water and Sediment Subgroup, Aquatic Effects Technology Evaluation Program. Assessing aquatic ecosystems using pore waters and sediment chemistry. Ottawa, Ontario, August, 1998.

Assessment Approaches and Issues in Ecological Characterizations. Ground-Water/Surface Water Interaction Workshop. U.S. EPA. Denver, CO. Jan. 1999.

Standardized Methods and Toxicity and Bioaccumulation Assay Selection. Short Course on "Understanding Sediment Analysis and Interpretation". University of Wisconsin Course. Portland, OR. Mar. 1999.

Field and laboratory methods for measuring stress. Short Course on "Ecotoxicology of Boreal Lakes".

University of Joensuu, Joensuu, Finland. June 1999.

Assessing ecological effects in surface/ground water transition zones. The Conference on Remediation of Subsurface Contaminants: The Meaning and Measures of Success. National Ground Water Association Conference. Keynote invitation. November 1999.

Novel methods for assessing aquatic contamination. University of Dayton. Dayton, OH. September 1999.

Urban Sprawl from Every Angle. The Garden Club of Dayton. Dayton, OH. November 1999.

Strengths and Weaknesses of Various Approaches for Determining Sediment Background, Benchmark and Standards Values. Ohio Environmental Protection Agency. Columbus, OH. November 1999.

Teasing Out Primary Stressors in Aquatic Systems Using Stressor Identification Chambers. U.S. Environmental Protection Agency Region 10. Regional Science Council Speaker. Seattle, WA. January 2000.

Strengths and Weaknesses of Sediment Bioassay/Toxicity Evaluations. Ohio Environmental Protection Agency. Columbus, OH. February 2000.

Sediments: Sink or Source of Metals. Ecotoxicity Technical Advisory Panel Meeting. Verona, Italy. February 2000.

Nickel in Sediments: Bioavailability Issues. Nickel Ecotoxicity Workshop. Verona, Italy. February 2000.

Confounding Factors in the use of Pore Waters for Toxicity Assessments. Plenary Presentation. Pore Water Pellston Workshop, Pensacola, FL. March 2000.

Realistic Assessments of Urban Sediments and Nonpoint Source Runoff. Contaminated Sediments 2000. Legal Institute of the Great Lakes. University of Toledo, OH. April 2000.

Realistic Assessments of Cause and Effects. 7th FECS Conference on Chemistry and the Environment. Porto, Portugal. August 2000. Keynote Address (invited).

Comparisons of Sediment Assessment Methods. ECOTOX Conference. Sao Carlos, Brazil. September 2000 (invited).

Comparisons of Sediment Quality Criterions in Use Around the World. Keynote Presentation. 4th International Symposium on Sediment Quality Assessment: Approaches, Insights and Technology for the 21st Century. Otsu, Japan. October 2000.

Effective Approaches for Site Characterization. U.S. EPA's Forum on Managing Contaminated Sediments at Hazardous Waste Sites. Alexandria, VA. May 2001.

Ecological Risk Assessment and *In Situ* Approaches. National Sediment Dialogue Conference. Hall of States, Washington, D.C. August 2001.

Traditional and Novel Assessment Methods for Determining Aquatic Ecosystem Contamination. Graduate Research Institute, Alexandria University, Cairo, Egypt. October 2001.

Critical Issues Affecting Ecological Risk Assessments: Effective Resolution. National Sediments Conference. National Environmental Policy Institute. National Press Club, Washington, DC. November 2001.

Improved Approaches for Assessing Sediment Toxicity. Blasland, Bouck & Lee, Inc. Sediment Management Seminar. Orlando, FL. Feb. 2002.

Linking Exposure and Effects in Dynamic Sediment Environments. RTDF Sediment Action Team. Silver Springs MD. Mar. 2002

Weight-of-Evidence in Sediment Quality Assessments. Keynote. Pellston Workshop on Sediment Guidelines. Fairmont Springs, Montana. Aug. 2002.

The Critical Role of Permeable Sediments in Risk Assessments of Streams. Gordon Conference. Bates College, Lewiston Maine. June 2003

Keynote address: Assessment of Ecological Impairment Associated with Sediments: Issues and Approaches. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. October 2003.

Water Quality Assessments: Weight of Evidence Approaches. Wright State University, Biological Sciences Dept. October 2003.

Sediment Quality Assessments: Integrating Multiple Lines of Evidence. Northwestern University, Department of Civil and Environmental Engineering. January, 2004.

Assessing Stormwater Quality in Wolf Creek. Montgomery County Soil Conservation Service. Trotwood, OH. Feb. 2004.

Assessing Municipal Separate Storm Sewer System (MS4) Effects in Wolf Creek. Ohio Environmental Protection Agency. Dayton, OH. Feb. 2004.

Keynote address: Sediment Quality Assessments: Integrated Approaches with Case Examples. Asociacion Mesoamericana de Ecotoxicologia y Quimica Ambiental. Jiutepec, Morelos, Mexico. March 2004.

Integrating Multiple Lines-of-Evidence to Improve Sediment Quality Risk Assessments. Second Iowa Workshop on Contaminated Sediments. Fairport, Iowa. October, 2004.

Stressor Identification in Freshwater Ecosystems, and The Society of Environmental Toxicology & Chemistry: An Overview. VIII Brazilian Congress of Ecotoxicology. Florianopolis, SC, Brazil. October. 2004.

Short Course on Field-Based Exposure & Effects Measures. Freshwater In situ methods. World Congress of the Society of Environmental Toxicology & Chemistry. Portland, OR. November 2004.

Improving In Situ Methods and Approaches. SETAC Technical Workshop on In Situ-Based Effects Measures: Linking Responses to Ecological Consequences in Aquatic Ecosystems. Plenary Presentation. Clements and Burton. Portland OR. November 2004.

Phi Beta Delta International Forum. International Business Travel Overview. Wright State University. January 2005.

Stressor identification in freshwater ecosystems. Institute of Applied Sciences. University of North Texas. Denton, TX. February 2005.

Kapo, K and Burton GA. A Weight-of-Evidence Based GIS System for Ecosystem Assessment. Proctor & Gamble. Cincinnati, OH. March 2005.

Kapo, K and Burton GA. A Weight-of-Evidence Based GIS System for Ecosystem Assessment. U.S.

Environmental Protection Agency, Office of Research & Development. Washington DC. April 2005.

Kapo, K and Burton GA. A Weight-of-Evidence Based GIS System for Ecosystem Assessment. Ohio Environmental Protection Agency. Columbus, OH. April 2005.

Pleanary address: Integrated Approaches for Assessing Stormwater and Sediments and Their Role in Ecosystem Stress. Australasian Society of Ecotoxicology, Annual Meeting. Melbourne, Australia. September 2005.

Café Scientifique. Water Quality: What does it mean and what are the issues? Five Rivers MetroParks. Dayton, OH. July 2005.

Stressor Identification in Sediments. Contaminants and Ecological Risk Assessment Symposium. CSIRO. University of Adelaide, Australia. September 2005.

Evaluation of Nickel Effects in Sediments Using Field Based Approaches. CSIRO. Sydney, Australia. September 2005.

Science and Mentoring: A Tale of Two Superstars. University of North Texas Institute of Applied Sciences. October. 2005.

U.S. House of Representatives, Science Committee Hearing on Environmental Impacts of Emerging Contaminants. Regulating Emerging Contaminants. May 1, 2006

Ecotoxicology and its Paradigms: A Critical Overview. Keynote Lecture. Ecotox 2006, SETAC Brasilian Society of Ecotoxicology Biannual Meeting. Sao Paulo, Brazil, July 2006.

Stressor Identification in Aquatic Ecosystems. Wright State University Department of Earth & Environmental Sciences. September 2006.

Stressor Identification in Aquatic Ecosystems. Proctor & Gamble Co. Cincinnati, OH. September 2007.

Assessing Aquatic Ecosystem Impairment: Issues and Approaches. School of Natural Resources and Environment. University of Michigan. November 2007.

Assessing Aquatic Ecosystems: Issues and Approaches. Honor Society of Metropolitan Dayton. Wright State University. January 2008.

Assessing Environmental Risk in Aquatic Systems: Realistic and Efficient Approaches for Effective Decision Making. Jeddah Environmental Forum and Exhibition. Jeddah, Saudi Arabia. April 2008. (invited, but cancelled)

Sustaining Human Health and the Environment. Special Programs & Continuing Education. University of Dayton. June 2008.

Assessing Aquatic Ecosystem Impairment: Issues an Approaches. University of Gothenburg, Sweden. October 2008.

Assessing Aquatic Ecosystem Impairment: Issues and Approaches. Western Michigan University. October 2008.

Assessing Aquatic Ecosystem Impairment. Environment Canada. Burlington, Ontario. October 2008.

Mining in Michigan. Panelist for discussion. School of Natural Resources & Environment. Univ. of Michigan. Ann Arbor. November 2008.

Management of Contaminated Sediments: The Path to Risk-Based Remedial Action Decisions - Linking exposure with effects in sediment assessments. SERDP Annual Meeting. Washington DC. December 2008.

Assessing ecosystem quality. Michigan American Fisheries Society. Dundee MI. Mar 2009.

Assessing ecosystem quality: from small streams to lakes and harbors. Grand Valley State University, Annis Water Resources Institute. Muskegon, MI. Oct. 2009

Assessing ecosystem quality: from small streams to lakes and harbors. University of Melbourne. Melbourne, AU. Sept. 2009.

Linking sediment contamination with ecologically relevant impacts. Keynote address. Australasian Soc Ecotoxicology. University of Adelaide, Adelaide, AU. Sept 2009.

Predicting the fate and effects of resuspended metal contaminated sediments. SERDP Science Advisory Board. Arlington VA. Sept. 2009

Coupling between pore water fluxes, structural heterogeneity, and biogeochemical processes controls contaminant mobility, bioavailability, and toxicity in sediments. SERDP Science Advisory Board. Arlington VA. Oct. 2009.

Assessing ecosystem quality: from small streams to lakes and harbors. Dept of Civil and Environmental Engineering. University of Texas. Austin TX. Oct 2009

Great Lakes Water Quality and Resources. A Green Midwest, A Blue Midwest, 2nd annual Global Midwest Conference. Chicago, IL. November 2009.

Water quality issues in the Great Lakes. University of Michigan Alumni Chapter. Lansing, MI. October 2009.

Field research experiences. SNRE PhD Student seminar series. Feb. 2010.

Great Lakes and Water Resources. Panel speaker. Sustainability Teach-In. 40 Earth Day. University of Michigan. March 2010.

When are sediments important stressors of aquatic ecosystems? Putting assessment back into ecological risk assessments. Death Valley Environmental Assessment Summit. Ryan Camp, Death Valley. March 2010.

Assessing ecosystem quality: from small streams to lakes and harbors. University of Roskilde, Denmark. April 2010.

My love affair with mud, and other complex issues. SNRE. May 2010.

Advances in Sediment Risk Assessment. Chemical stress and remediation in the aquatic environment. ERAC Edu seminar series. Kuopio, Finland. November 2010.

Water water everywhere, so why all the fuss? OSHER Lifelong Learning Program. Ann Arbor MI. January 2011.

Invited Lectures = 144

Symposia, Session and Short Course Leader:

Chairman, "Volatile Organic Compounds: Environmental and Human Health Significance." Annual Biomedical Sciences Program Symposium. Wright State University. May, 1989.

Co-Chairman, "Waste Water Analytical Methods and Instrumentation," Center for Groundwater Management and Environmental Health Sciences Program. Wright State University. October, 1989.

Session Chair, "Sediment Toxicity," 1990 Midwest Pollution Control Biologists Meeting. Chicago, IL. April, 1990.

Workshop Chairman, "Hazardous Waste Operations and Emergency Response." NCR World Headquarters. Dayton, OH. March, 1990.

Session Co-Chair, "The Scientific Basis Behind Environmental Quality Criteria," Annual Meeting, Society of Environmental Toxicology and Chemistry. Arlington, VA. November, 1990.

Workshop Co-Leader, "Freshwater Sediment Toxicity Testing." 1991 Midwest Pollution Control Biologists Meeting. Chicago, IL. March, 1991.

Session Chair, "Assessment of Contaminated Sediments." Annual Meeting, Society of Environmental Toxicology and Chemistry. Seattle, WA. November, 1991.

Poster Session Chair, Annual Meeting, Society of Environmental Toxicology and Chemistry, Cincinnati, OH. November, 1992.

Session Chair, "Sediment Toxicity Testing", 1st SETAC World Congress, Ecotoxicology and Environmental Chemistry - A Global Perspective. Lisbon, Portugal, March, 1993.

Session Chair, "Sediment Quality Assessments," 6th Intern. Symp. The Interactions Between Sediments and Waters. Santa Barbara, CA. December, 1993.

Session Chair, "Stormwater Runoff Effects," Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, TX. November, 1993.

Session Chair, "Irrigation and Stormwater Runoff," Annual Meeting, Society of Environmental Toxicology and Chemistry, Denver, TX. October, 1994.

Session Chair, "Effluent Variability" Pellston Workshop on Wastewater Effluent Variability, Pellston, MI, September, 1995.

Short Course Co-Chair, " Use of In situ Toxicity Testing" Annual Meeting, Society of Environmental Toxicology and Chemistry, Vancouver, BC, Canada. November, 1995.

Session Co-Chair, "Use of In situ Toxicity Testing," Annual Meeting, Society of Environmental Toxicology and Chemistry, Vancouver, BC, Canada. November, 1995.
Organizing Committee, Sediment Risk Assessment Workshop. A SETAC Pellston Workshop. 1994-1995.

Session Co-Chair, "Critical Issues in the Characterization of Sediment Contamination" Annual Meeting, Society of Environmental Toxicology and Chemistry, Washington, DC. November, 1996.

Scientific Committee, Sixth SETAC - Europe Annual Meeting, 1996. Taormina, Italy.

Scientific Committee, International Symposium on Integrated Ecotoxicology: From Molecules/Organisms to Ecosystems. 1997. Milan, Italy.

Instructor. Sediment Ecotoxicology. University of Coimbra, Portugal. May, 1997.

Short Course Co-Chair. *In situ* Field Exposures Using Transplanted Indigenous and Cultured Populations. Annu. Meet. Soc. Environ. Toxicol. Chem., 1997. San Francisco, CA.

Session Chair. U.S. Environmental Protection Agency's Ground Water Forum. Jan. 1999. Chemistry Session. Denver, CO.

Workshop Co-Chair. Assessing the Effects of Complex Stressors in Ecosystems. Soc. Environmental Toxicology and Chemistry, Pellston Workshop. Sept. 1999.

Workshop Steering Committee. Pore Water Toxicity. Soc. Environmental Toxicology and Chemistry, Pellston Workshop. March, 2000.

Steering Committee. 4th International Symposium on Sediment Quality Assessment. Otsu, Japan., Oct. 2000.

Session Chair 4th International Symposium on Sediment Quality Assessment. Otsu, Japan., Oct. 2000.

Short Course: Evaluation of Ecological Effects in Surface Water-Ground Water Transition Zones. Annu. Meeting Soc. Environ. Toxicol. Chem., Nashville, TN., Nov. 2000

Short Course: Field Methods in Water and Sediment Ecotoxicology: Theory and Practice. Mazatlan, Mexico. Feb. 2001. Sponsored by CIAD and ICMyL-UNAM.

Short Course: *In Situ* Approaches for Assessing Groundwater-Surface Water Interactions. U.S. Environmental Protection Agency RCRA National Meeting. Jan. 17, Washington, DC. 2002.

Short Course: In Situ Field Testing Using Caged Organisms: Approaches and Applications. ASTM Symposium on "Multiple Stressor Effects in Relation to Declining Amphibian Populations". Pittsburgh, PA April 16-17, 2002.

Short Course: *In Situ* Approaches for Assessing Groundwater-Surface Water Interactions. U.S. Environmental Protection Agency. National Association of Remediation Project Managers. Orlando, FL, May, 2002.

Meeting Chair. 5th International Symposium on Sediment Quality Assessment. Chicago, IL. 2002.

Steering Committee: Sediment Chemical Stability Workshop. San Diego. 2003.

Co-Chair. SETAC Technical Workshop on *In Situ*-Based Effects Measures: Linking Responses to Ecological Consequences in Aquatic Ecosystems. Portland, OR. 2004.

Co-Chair. Symposium on *In Situ*-Based Effects Measures: Linking Responses to Ecological Consequences in Aquatic Ecosystems. SETAC Annual Meeting. Portland, OR. 2004.

Chair. Platform Session on Urban Toxicology. Australasian Society of Ecotoxicology. Melbourne, Australia. September 2005.

Short Course. Ecological Risk Assessment: Theory and Practice. CIAD. Mazatlan, Mexico. July 2006.

Chair, NIEHS Special Emphasis Panel, Innovative approaches to remediation of recalcitrant hazardous substances in sediments (R01). 2007.

Chair. Metals Assessment Session. SETAC Europe Annual Meeting. Porto Portugal. May 2007.

Co-Chair. Metals Risk Assessment Session. SETAC North America Annual Meeting. Milwaukee, WI. Nov. 2007.

Co-Chair. Sediment Dredging Effectiveness Session. SETAC North America Annual Meeting. Milwaukee, WI. Nov. 2007.

Chair, Session. Innovative Approaches and Methods in Aquatic Toxicology. Australasian Society of Ecotoxicology. Adelaide AU. Sept. 2009

Co-Chair, Session. Sediment in situ assessments and passive sampling devices. Soc Environ Toxicol Chem. New Orleans. Nov. 2009.

Co-Chair, Session. When are sediments important stressors? Soc Environ Toxicol Chem. Portland, OR. Nov. 2010.

Chair and Short Courses= 44

IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF WISCONSIN

Case No. ll-cv-4S

WISCONSIN RESOURCES PROTECTION COUNCIL,
CENTER FOR BIOLOGICAL DIVERSITY, AND
LAURA GAUGER

v.

FLAMBEAU MINING COMPANY

Expert Report of Anne Fairbrother, D.V.M., Ph.D.

Anne Fairbrother

On behalf of Flambeau Mining Company
November 6, 2011

EXHIBIT
E

1 Introduction

Pursuant to Federal Rule of civil Procedure 26(a)(2)(B), this report contains:

1. A complete statement of my opinions and the basis and reasons for them;
2. The facts or data considered by me in forming them;
3. Any exhibits that will be used to summarize or support them;
4. My qualifications, including a list of all publications authored in the previous 10 years;
5. A list of all other cases in which, during the previous 4 years, I have testified as an expert at trial or by deposition; and
6. A statement of the compensation to be paid for the study and testimony in the case.

Pursuant to Federal rule of Civil Procedure 26(a)(2)(E), I reserve the right to supplement this report.

Finally, all of my opinions are to a reasonable degree of scientific certainty.

2 Qualifications, Case List and Compensation

Attached to this report is a copy of my resume, which contains a list of all the papers and book chapters I have published in the past 10 years. I am a Principal Scientist in Exponent's Ecological and Biological Sciences practice, with more than 30 years of experience in ecotoxicology, wildlife toxicology, contaminated site assessment, and regulatory science for existing and emerging chemicals in the United States and Europe.

I have conducted risk assessments at mines in the tropics, deserts, mountains, and many other ecosystems, determining risk thresholds for plants, wildlife, and aquatic life. I have provided consultation on future development of mine pit lakes, assessed the risk to livestock from use of wastewater on irrigated pasture during mine closure operations, and conducted assessments of risk to terrestrial and aquatic organisms from abandoned mines. I have conducted assessments of the potential ecological risks to aquatic life in San Francisco Bay and coastal southern California posed by use of copper pipes. I have also assessed risks to ecosystems at sites contaminated with organic chemicals, including DDT, polychlorinated biphenyls, dioxins, and petroleum hydrocarbons in Delaware, Texas, Oregon, and California, integrating ecological risks with human health risk assessments.

I have participated in and led the development of guidance documents for ecological risk assessments. For example, I was a primary author of the U.S. Environmental Protection Agency's (EPA), *Framework for Metals Risk Assessment* and for the BC Ministry of Environment's guidance for implementing Tier 1 ecological risk assessments of contaminated sites and for setting soil clean-up values. I also participated in the development of ecological soil screening levels for EPA.

While a scientist at EPA, I led research into the ecological risks of bioengineered crops, methods for assessing risks of nanomaterials, and some of the early guidance for field assessments of Superfund sites and effects of pesticides on birds. I researched and developed methods for assessment of chemical effects on bird immune and endocrine systems.

I have published more than 80 peer-reviewed articles, books, and book chapters that reflect my expertise in wildlife toxicology, immunotoxicology, endocrine-disrupting chemicals, and ecological risk assessment. I serve on numerous scientific boards, expert panels, and editorial boards in support of scientific and regulatory issues.

I am a veterinarian and Certified Wildlife Biologist, and am HAZWOPR certified. I have served as President of the Society of Environmental Toxicology and Chemistry, the American Association of Wildlife Veterinarians, and the Wildlife Disease Association (WDA). I am the recipient of the WDA Distinguished Service Award (2002), and a gold medal for Commendable Service from EPA. I hold an adjunct professorship at Oregon State University, Department of Environmental and Molecular Toxicology.

In the past 4 years, I have testified by deposition in the following case:

- *Teck Metals Ltd. v. Certain Underwriters at Lloyd's, et al.*, U.S. District Court, Eastern District of Washington at Spokane, No. CV 05-0411-LRS.

I have not testified at trial in any case in the past 4 years.

Exponent is compensated at my current rate of $295 per hour for my services in preparation of expert testimony, and testifying by deposition or at trial.

3 Information Reviewed and Considered

The following is a list of documents I reviewed and considered in forming the opinions that I express herein, in addition to my education, experience, training, and general technical knowledge of the scientific literature pertaining to the effects of copper and other metals on aquatic life. I visited the site on one occasion. I reserve the right to utilize any or all of these sources as exhibits if called upon to testify.

- Expert report of Dr. David M. Chambers, on behalf of Plaintiffs Wisconsin Resources Protection Council, Center for Biological Diversity, and Laura Gauger. October 10, 2011.
- Expert report of Robert J. Nauta, P.G., on behalf of Plaintiffs Wisconsin Resources Protection Council, Center for Biological Diversity, and Laura Gauger. October 10, 2011.
- Flambeau Mining Company. Figure 3: Copper Concentrations in Surface Water Monitoring 2006–2011. Dated November 2011. Prepared by Foth.

- Flambeau Mining Company. Figure 1: Surrogate Surface Water Sampling Locations and Analytical Results. Dated January 2011. Prepared by Foth.
- Peerenboom memorandum to file dated September 21, 2001. Copper Concentrations in Northern Region Public Water Supplies (PWSs).
- Peerenboom memorandum to Ken Markart dated May 10, 2006. Flambeau Mine Site–Copper Concentrations in Runoff.
- Fleming memorandum to Craig Roesler dated August 2, 2011. SLH Biomonitoring Results for the Flambeau Mine Intermittent Stream Near Ladysmith (Stream C).
- Exhibit 4–Roesler deposition. Complete surface water sample laboratory results plus calculated ATCs for copper, zinc, and field conductivity.
- Exhibit 5–Roesler deposition. Flambeau Mine Stream C and reference stream fish survey data, September 27, 2010.
- Exhibit 6–Roesler deposition. Flambeau Mine site stream macroinvertebrate indices.
- Exhibit 7–Roesler deposition. Flambeau Mine site 303(d) project. Macroinvertebrate sampling and analysis–Fall 2010. Jeffrey Dimick, University of Wisconsin, Stevens Point.
- Exhibit 11–Roesler deposition. Photograph of Stream C south of the culvert under Copper Park Lane.
- Exhibits 12, 13, and 14–Roesler deposition. Photographs of Mr. Roesler sampling fish in Stream C below Copper Park Lane.

4 Copper and Zinc in the Environment

Copper and zinc are naturally occurring elements in soil, water, and sediment, and both have been mined for hundreds of years from areas of localized enrichment. In fact, copper has been used by people for nearly 15,000 years; longer than any other metal.[1] Both copper and zinc are essential micronutrients for all plants and animals.[2,3] Copper is required for proper production of various cells in the blood and for utilization of iron in the formation of hemoglobin (the oxygen carrying pigment in humans and other mammals). In invertebrates, copper substitutes for iron in hemoglobin. Both copper and zinc play important roles in many cellular enzymes, including those that reduce free radical formation and provide protection against some forms of

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1 International Programme on Chemical Safety. 1996. ICPS News. Copper: Essentiality and Toxicity. Issue 10.

2 International Programme on Chemical Safety. 1998. Environmental Health Criteria No. 200: Copper. www.inchem.org/documents.

3 International Programme on Chemical Safety. 2001. Environmental Health Criteria No. 221: Zinc. www.inchem.org/documents.

cancer. They are also an important part of gene regulation (turning genes on and off at the proper times). Copper and zinc, as well as iron, may interact with each other, such that some of the signs of zinc toxicity may be more properly ascribed to zinc-induced copper or iron deficiency. Consequently, animals may tolerate higher levels of all three metals as long as they all increase in the proper ratios.

Too much copper or zinc will result in toxicity. Most organisms have a fairly wide tolerance for zinc, but copper is more toxic particularly to algae and some aquatic invertebrates. Cladocerans, such as the invertebrate water flea (*Ceriodaphnia* sp.) are very sensitive to copper; showing mortality after only 2–3 days of exposure to as little as 5 µg/L (ppb) copper[4]. Some species of fish, most notably cold water species such as salmon and trout, are also sensitive to copper, although not as much as the invertebrates (acute toxicity thresholds are at about 40 µg/L). On the other hand, some species are very tolerant of copper, even those that are closely related to other very sensitive species. For example, cladocerans other than *Ceriodaphnia* and some mayflies can tolerate five times as much copper as the waterflea (25–35 µg/L), while midges (*Chironomus* spp.) can tolerate short exposures at over 800 µg/L[4] and some caddisfly species (*Tricoptera* sp.) can tolerate similar exposures at over 10,000 µg/L[5]. As with many substances, long-term tolerances are much lower, as these are based on concentrations that affect sublethal endpoints such as growth or reproduction.

Copper is used as an algaecide and as an herbicide to control nuisance aquatic weeds. It inhibits photosynthesis and, therefore, plant growth. Effective concentrations can be as low as 1–5 µg/L for some algae and 24 µg/L for duckweed, but generally range from 30 to 8,000 µg/L for most plant and algae species.[6]

Zinc, on the other hand, is much less toxic to aquatic organisms than is copper[7]. It is most toxic to cladocerans but at concentrations well above those of copper (50 µg/L for *Ceriodaphnia* to greater than 250 µg/L for *Daphnia*). Most aquatic invertebrates are not acutely affected until zinc concentrations exceed 1,000 µg/L. Fish are even less sensitive, with acute toxicity levels ranging up to 13,000 µg/L depending on species.[5] Algae and most nuisance water plants such as duckweed and Eurasian water milfoil are not affected by zinc, even at concentrations well over 2% zinc.

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4 Brix, K.F., D.K. DeForest, and W.J. Adams. 2001. Assessing acute and chronic copper risks to freshwater aquatic life using species sensitivity distributions for different taxonomic groups. Environ. Toxicol. Chem. 20:1846–1856. All values in this paper were adjusted to 50 mg/L hardness for comparative purposes.

5 Brix, K.F., D.K. DeForest, and W.J. Adams. 2011. The sensitivity of aquatic insects to divalent metals: A comparative analysis of laboratory and field data. Sci. Total Environ. 409:4187–4197.

6 U.S. EPA. 2007. Aquatic life ambient freshwater quality criteria–copper. 2007 Revision. EPA-822-R-07-001. U.S. Environmental Protection Agency, Office of Water, Washington DC.

7 U.S. EPA. 2007. Aquatic life ambient freshwater quality criteria for zinc -1987. EPA-440/5-87-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Therefore, it is reasonable to assume that any detrimental effects on an aquatic ecosystem following enrichment by copper and zinc will be due to the presence of elevated copper, with little to no consequence from the zinc until it reaches very high levels.

5 Bioavailability of Metals in Aquatic Systems

Opinion 1. Not all of the copper or zinc that is measured in a water sample is bioavailable.

Copper and zinc are known as "divalent cationic metals" because the free form of the ion is positively charged and has two binding sites. In nature, positively charged ions like copper and zinc molecules bind with negatively charged ions, such as chlorides or sulfides. Different ions have different binding strengths, so there is an established hierarchy of preference to which negatively charged ions copper or zinc will bind. The gills of aquatic invertebrates and fish are also negatively charged, primarily to attract calcium ions that are important in cell functioning and osmoregulation, but copper and zinc will also bind to the cell membrane at these sites. If there are a lot of copper or zinc ions, they will fill up all the calcium binding sites and result in a toxic response by the organism. However, the negative charge on the gill cells is very weak compared to the chloride or sulfide ions in the water. Organic matter also has negatively charged binding sites that will strongly attract and bind copper and, to a lesser extent zinc. Particulate matter in the water, such as suspended soil or sediment particles will have copper and zinc bound tightly into the crystal lattice matrix of the particle. The metal ions that are bound to soil or sediment particles, organic matter, or other strongly negatively charged ions are not available for binding to fish or invertebrate gills. Thus, not all of the copper or zinc that is measured in a water sample is *bioavailable*. It is only the bioavailable copper or zinc that causes toxicity.

Opinion 2. It is necessary to measure dissolved metals, rather than the total recoverable amount, when determining whether a stream or river is likely to be impacted.

When a laboratory measures the *total recoverable* amount of copper or zinc in a water sample, they are measuring all the metal that is present which, in most natural waters, is more than the bioavailable (or toxic) amount. The laboratory treats the water with a strong acid to pull all the metals into solution, including those that are bound up in suspended particles or are attached to other ions.[8] In natural waters, aquatic organisms do not have access to all these bound metals, so this results in an overestimate of toxicity. A standard approach that is used is to measure the bioavailable metal is to first filter the water sample through a very fine filter (0.45-μm). This removes the suspended particles and their associated metals, leaving behind the metal that is

[8] U.S. EPA. 2001. Determination of metals and trace elements in water and wastes by inductively coupled plasma- atomic emission spectrometry, EPA Method 200.7, Version 5.0. USEPA Office of Research and Development, Cincinnati, OH. EPA-821-R-01-010 .

dissolved in the water; this is referred to as the *dissolved* metal. The laboratory does not treat this sample with a strong acid, so some of the metal will remain bound up by the organic matter or other ions that are small enough to pass through the filter. However, the measured concentration of metals in the filtered sample is much closer to the bioavailable fraction (the amount that actually causes toxicity). It also is more similar to the water that is used in laboratory tests that form the basis of the water quality criteria. Therefore, it is necessary to measure dissolved metals, rather than the total recoverable amount, when determining whether a stream or river is likely to be impacted. This was not done at the Flambeau Mine site where only total recoverable metal concentrations have been reported.

6 Water Quality Standards for Metals

Opinion 3. Comparing the copper or zinc concentration in an unfiltered sample to the water quality criteria will provide a conservative approach for *protection* of waters but will not be *predictive* of metal-related impacts.

Because the relative percent of the total metal that is bioavailable varies from site-to-site, simply measuring the total amount of metal present does not provide an adequate measure of its potential toxicity. EPA recognized this many years ago in the development of aquatic life water quality criteria and has since developed guidance for how to account for the influence of bioavailability differences when predicting effects of metals on aquatic biota.[9] First, EPA changed their aquatic life water quality criteria to be based on the concentration of dissolved metal, not on the amount of total recoverable metal. Because many of the toxicity tests that EPA relied on in the development of the criteria only reported information about total metals, the Agency developed conversion factors to change the criteria values to the dissolved form.[10] However, because most laboratory toxicity studies use very pure water spiked with a metal salt, the majority of the metal is already in the dissolved form so the difference in the toxicity threshold in these tests between total or dissolved metal is very small. For example, the copper criteria based on dissolved copper is 96% of the criteria based on total copper and the zinc dissolved criteria is 98% of the total zinc. Many states, such as Wisconsin, have retained their metal criteria as the original total recoverable values promulgated by EPA, and provide the conversion factors for calculating criteria for dissolved metal.[11] To compare field-collected samples to the dissolved criteria, the samples need to be filtered through 0.45-μm filters prior to

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[9] U.S. EPA. 2007. Framework for metals risk assessment. EPA 120/R-07/001. U.S. Environmental Protection Agency, Office of the Science Advisor, Risk Assessment Forum, Washington DC. See page 1-6.

[10] U.S. EPA. 1996. The metals translator: Guidance for calculating a total recoverable permit limit from a dissolved criterion. EPA 823-B-96-007. Available at: http://www.dep.wv.gov/WWE/permit/individual/Documents/365_dissmetals.pdf. U.S. Environmental Protection Agency, Office of Water, Washington, DC. Also found in Appendix A of the Aquatic Life Water Quality Criteria: Conversion Factors for Dissolved Metals. http://water.epa.gov/scitech/swguidance/standards/current/index.cfm#appendxa

[11] Procedures for calculation of criteria on a dissolved basis are in WDNR 105. Surface Water Quality Criteria and Secondary Values for Toxic Substances, Sections 105.05 and 105.08.

measuring the metal concentrations, while unfiltered samples can be compared directly to the total recoverable metal criteria. The latter approach was taken at the Flambeau Mine, so there is no site-specific information regarding the percent of the metal in a sample that is in the dissolved phase. Comparing the copper or zinc concentration in an unfiltered sample to the total recoverable criteria will provide a conservative approach as these criteria were derived from laboratory studies using very clean water,[9] so it is likely that field-collected samples have a much lower amount of dissolved metals. Therefore, such comparisons are useful for *protection* of waters but will not be *predictive* of metal-related impacts. If the total amount of metal measured in a sample is below the criterion, then there is no doubt that the water body is not being affected by the metal. However, if the total amount of metal is greater than the criterion, no conclusion about the impact of the metals can be drawn as the percentage of the metal that is in the dissolved form is not known.

Furthermore, not all of the dissolved metal is bioavailable, as discussed above. The effect of water hardness (the calcium and magnesium concentrations) and pH on the bioavailability of metals has been known for nearly two decades, resulting in equations for adjusting the dissolved metal criteria concentration to the site-specific water hardness.[12] More recently, EPA has adopted a fully mechanistic approach known as the Biotic Ligand Model (BLM)[13] to quantify the amount of metal ion at any specific site that is available for binding to the gill cell membrane, taking into account physical and chemical factors affecting metal speciation, complexation, and competition. The 2007 revision of the national aquatic life water quality criteria for copper is based on the BLM approach.[6] The copper BLM is particularly sensitive to pH, temperature, and the organic matter concentration in the water.

Because of the inherent difficulties in predicting metal toxicity solely from measured water or sediment concentrations (even when making adjustments for dissolved fraction, hardness, and pH), some states,[14] including Wisconsin, use the water quality criteria to screen out water bodies that are obviously not at risk, and then rely on biological indices such as the IBI as part of their final determination of whether to put a water body on the state's "Impaired Waters List" under Section 303(d) of the Clean Water Act[15].

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[12] WDNR 105. Surface Water Quality Criteria and Secondary Values for Toxic Substances. Table 2 (acute criteria) and Table 6 (chronic criteria). Wisconsin Department of Natural Resources.

[13] Di Toro, D.M., H.E Allen, H.L. Bergman, J.S. Meyer, P.R. Paquin, and R.C. Santore. 2001. Biotic ligand model of the acute toxicity of metals. 1. Technical Basis. Environ. Toxicol. Chem. 20:2383–2396.

[14] Michigan, Minnesota, North Carolina, Ohio, Oklahoma, Pennsylvania, and Washington.

[15] WDNR. 2009. Wisconsin 2010 consolidated assessment and listing methodology (WisCALM): Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting. Wisconsin Department of Natural Resources, Revised November 30, 2009.

7 Impacts of Copper and Zinc Discharge on the Flambeau River

Opinion 4. There is no influence on aquatic organisms from the discharge of copper or zinc from Stream C on the Flambeau River.

I reached this conclusion based on reported total recoverable copper concentrations in the river below the mouth of Stream C[16] and the description of the invertebrate communities above and below the confluence of the river and Stream C reported by Mr. Jeffrey Dimick of the University of Wisconsin, Stevens Point, in Exhibits 6 and 7 of the Roesler deposition.

Although the average total recoverable copper concentration measured in the Flambeau River at the mouth of Stream C (1.9 µg/L total copper[17]) for the years 2007–2011 was higher than that of the upstream average (1.2 µg/L total copper), all concentrations were below values that are toxic to aquatic organisms and below the state acute and chronic toxicity criteria for total recoverable copper of 8 µg/L and 5 µg/L, respectively (at 50 mg/L hardness).[12] Furthermore, copper concentrations measured in 2010 and 2011 at the mouth of Stream C were below the level of detection for the analytical method used), which is the same as the measurements in the Flambeau River upstream of the confluence with Stream C at those sampling dates.

Zinc concentrations in the Flambeau River measured October 26, 2010, were very low at all stations, reported as 8 µg/L total zinc above Stream C and 7.6 µg/L total zinc below Stream C. Measurements taken in April and June 2011 ranged from < 2 µg/L (i.e., below level of detection) to 4 µg/L total zinc in both locations. These values are well below concentrations expected to cause toxicity to aquatic organisms and are below the state acute and chronic toxicity criteria for total recoverable zinc of 66 µg/L.[12]

Comparison of total recoverable metal concentrations to aquatic life criteria is a very conservative estimate of potential impact; if total recoverable metal concentrations are below the criteria values, there is no question that the dissolved concentrations are below toxic levels.

The description of the Flambeau River invertebrate community provided in Mr. Dimick's report, and the accompanying biotic indices that he calculated, support my conclusion that the measured copper concentrations were below toxic levels. Although mayflies and early-instar caddisflies are relatively sensitive to copper, both organisms were present above and below the mouth of Stream C, although the mayfly species differed between the two locations. Mr. Dimick suggested that the reason why the two samples had different species is because of a

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[16] As reported by Flambeau Mining Company. Figure 3: Copper Concentrations in Surface Water Monitoring 2006–2011. Dated November, 2011. Prepared by Foth. Data also in Exhibit 4–Roesler deposition.

[17] Averages were calculated using one-half the reported value for those samples identified as either "less than" or with a "j" qualifier, indicating those measurements were at the method detection limit.

change in the periphyton[18] communities at these locations results in species with different feeding habits. The heavy organic matter enrichment from Stream C could be the cause of periphyton growth at the downstream location. Furthermore, Mr. Dimick calculated species diversity and estimated similar densities and diversities of invertebrates above and below Stream C.

Mr. Dimick calculated two macroinvertebrate indices (see Exhibit 6–Roesler deposition): the Index of Biotic Integrity (IBI) and the Hilsenhoff Index (HBI). The IBI was first developed by Dr. James Karr of the University of Washington to assess the integrity of fish populations in Midwestern warmwater streams, and was later expanded by EPA to include a larger assemblage of species, including aquatic invertebrates.[19] It is used as a general measure of environmental degradation. The HBI was developed by Dr. William Hilsenhoff, a professor at University of Wisconsin, Madison, to assess the impacts of low dissolved oxygen caused by the loading of organic matter into streams.[20] It is widely used by Wisconsin DNR for this purpose.

The IBI values calculated from invertebrate sampling conducted on October 13, 2010, in the Flambeau River downstream of the mouth of Stream C were all in the "good" to "excellent" categories. Samples collected from upstream of the mouth of Stream C were categorized as "fair" to "good." From this, I conclude that the discharge from Stream C is not causing the degradation of the invertebrate community in the Flambeau River, which would be an expected consequence of copper toxicity. Additionally, taxa in the Ephemeroptera, Plecoptera, and Trichoptera orders (EPT taxa) that are generally considered sensitive to metals[21] were described by Mr. Dimick as "fantastic" both above and below the confluence of Stream C, primarily because of the large numbers of Ephemeroptera (mayflies), which are the most sensitive to copper. The HBI downriver of the mouth of Stream C was described as "very good," while the upriver HBI was "excellent" near Stream C and "fairly poor" farther upriver. Because the HBI primarily responds to the amount of dissolved oxygen in the river as a function of the amount of organic matter, depth and location of samples can be particularly important in a river the size of the Flambeau. I agree with Mr. Dimick's conclusion that "Ultimately, it may be that the level of known copper and zinc contamination was too low to be the primary driving stressor to the Flambeau River benthic macroinvertebrate community." This is concordant with the measured total recoverable concentrations for both of these metals.

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[18] Periphyton is the slimy material found on rocks and other submerged surfaces, and is made up of algae, bacteria, and decaying organic matter.

[19] Index of Biotic Integrity (IBI) http://www.epa.gov/bioiweb1/html/ibi_history.html.

[20] Hilsenhoff Biotic Index (HBI) http://www4.uwsp.edu/cnr/research/gshepard/History/History.htm. Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entimolog. 31–39.

[21] Hickey, C.W., and L.A. Golding. 2002. Response of macroinvertebrates to copper and zinc in a stream mesocosm. Environ. Toxicol. Chem. 21:1854–1863.

8 Impacts of Copper and Zinc Discharge on Stream C

Opinion 5. There are no impacts of copper or zinc on aquatic organisms in Stream C.

There were no acute or chronic effects seen in bioassays with the water flea (*Ceriodaphnia dubia*), fathead minnow (*Pimephales promelas*), or algae (*Selenastrum capricornutum*) using water collected from Stream C. Biological data from Stream C are confounded by the added stress of the intermittent nature of water flow in the stream and the chemical monitoring data are missing key parameters required to reach conclusions based on water chemistry only. I based my opinions on the results of the aquatic bioassays and sampling of fish from Stream C and a nearby reference stream conducted by Mr. Craig Roesler of Wisconsin DNR, as reported in the stream fish survey dated September 27, 2010 (Exhibit 5–Roesler deposition), Mr. Jeffery Dimick's report of invertebrate biodiversity in both streams (Exhibit 7–Roesler deposition), and on a memorandum from Ms. Keri Fleming at the State Laboratory of Health dated August 2, 2011. I also relied on my personal observations of the site during a visit on October 18, 2011, and photographs from Mr. Roesler's visit during his fish survey. Data on total recoverable copper and zinc concentrations in Stream C[22] were inconclusive, as described below. However, comparisons with concentrations in similar streams in the area that are not associated with the mine[23] support my conclusion that natural enrichment of metals occurs in area streams as a result of elevated soil and subsurface background concentrations of these metals.

Opinion 6. Laboratory bioassays confirm lack of toxicity in water from Stream C.

Laboratory bioassays were conducted on water samples collected from Stream C and the unnamed reference stream by Mr. Craig Roesler in June 2011.[24] The bioassays used an invertebrate known to be sensitive to metals (the water flea), a representative fish species (fathead minnow), and a common algae (*Selenastrum capricornutum*). These bioassays are standard tests used to determine whether water is toxic to aquatic organisms. All tests results were negative, indicating that the water in Stream C is not toxic to aquatic organisms even though total recoverable copper and zinc concentrations exceed the Wisconsin DNR water quality criteria values.

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22 Water quality data are in Exhibit 4–Roesler deposition and on a map (Flambeau Mining Company. Figure 3: Copper Concentrations in Surface Water Monitoring 2006–Fall 2011. Dated November, 2011. Prepared by Foth.

23 As reported on a map produced by Foth for the Flambeau Mining Company titled "Figure 1: Surrogate Surface Water Sampling Locations and Analytical Results," dated January 2011, and in a memorandum from D. Peerenboom to file dated September 21, 2001, regarding copper concentrations in Northern Region Public Water Supplies (PWSs).

24 Memorandum from Kari Fleming to Craig Roesler dated August 2, 2011, regarding State Laboratory of Health (SLH) biomonitoring results for the Flambeau Mine intermittent stream near Ladysmith (stream C).

Opinion 7. Observed differences in invertebrate species assemblages between Stream C and the unnamed reference stream are a result of physical differences and not the amount of copper or zinc in the water.

Invertebrate biodiversity in streams can be impacted by metals, generally resulting in taxonomic shifts due to the loss of sensitive taxa. EPT species are sensitive to metals, and their absence is often interpreted as an indicator of unacceptably high metal concentrations.[21] However, they are also sensitive to drought conditions and generally are not found in intermittent streams such as Stream C.[25] Conversely, chironomids are very opportunistic and quickly recolonize streams following the onset of water flow. Mr. Roesler collected one invertebrate sample from Stream C in the spring of 2011 and another sample from a nearby unnamed reference stream. Although the reference stream was selected to be as similar to Stream C as possible, Mr. Roesler noted "distinct physical differences in seasonality of streamflow," which likely affected the invertebrate community.[26] Mr. Dimick analyzed these samples and noted in his report the predominance of chironomids in Stream C; he commented that their short lifecycle "facilitates their existence in a pertubated environment subject to changing conditions." He also noted that multiple stages of invertebrates in the unnamed reference stream suggest a more stable environment (i.e., year-round stream flow, as opposed to the intermittent flow in Stream C). Therefore, it is my opinion that it is not possible to conclude, based only on the field observations, that the difference in the invertebrate communities between the two streams is a result of copper or zinc toxicity. The lack of toxicity to a sensitive aquatic organism (*Ceriodaphnia*) in the aquatic bioassays[24] leads me to conclude that observed differences are due to physical changes and not the amount of copper or zinc in the water.

Opinion 8. The data on fish biodiversity collected by Mr. Roesler in September 2011 show that the water in Stream C is not acutely toxic to fish or the aquatic invertebrates and periphyton that they depend on for food.

Mr. Roesler identified 57 individual fish belonging to six species in Stream C and 46 individual fish belonging to three species in the unnamed reference stream. He did not describe where in the stream the fish were collected, but from the photographs provided (Exhibits 12, 13, and 14–Roesler deposition), it appears to be the section of the stream below Copper Park Lane. The presence of fish in the stream indicates that the water is not acutely toxic to fish (i.e., does not kill them within 1–2 days) or to the invertebrates and periphyton that they eat. This is in agreement with the results of the bioassay tests.

Opinion 9. Bioavailability of the copper and zinc is relatively low in this area.

Copper concentrations in Stream C vary with time and location. The wetland area north of Copper Park Lane and east of the biofilter had total recoverable copper concentrations of

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25 Lake, P.S. 2003. Ecological effects of perturbation by drought in flowing waters. Freshwat. Biol. 48:1161–1172.

26 Quoted as personal communication in Mr. Jeffrey Dimick's written report; Exhibit 7–Roesler deposition.

74 µg/L in August 2006, although concentrations have declined steadily since that time to 9.4 µg/L in September 2011.[27] Below Copper Park Lane, total copper concentrations in the water declined from 47 µg/L in September 2007 to a low of 11 µg/L in April 2011 (range of 11 – 25 µg/L for 2009 = 2011);[31] Wisconsin DNR measured 9–24 µg/L total copper in this region of Stream C in April–October 2010 (Exhibit 4–Roesler deposition). Zinc concentrations measured by Wisconsin DNR in the reach of Stream C below Copper Park Lane ranged from 28 to 41 µg/L total recoverable zinc during this same time interval. Both the copper and zinc concentrations exceed Wisconsin's acute toxicity criteria, adjusted for hardness, at all times. Copper concentration in the unnamed reference stream and a tributary to Stream C south of Copper Park Lane also exceeded the state's acute toxicity criteria for copper on one or more occasions. However, as previously discussed, criteria based on total recoverable metals are very conservative estimates of the potential for adverse effects. Because aquatic organisms respond only to the dissolved form, measurements of total recoverable metals overestimate the toxicity of a sample. Therefore, the only conclusion that can be made is that if total concentrations are *less* than criteria, then no toxicity will occur. However, if total concentrations are *above* the criteria values, it is not possible to reach a conclusion about whether or not the water sample would be toxic to aquatic life because the amount in the dissolved fraction is not known. In a memorandum to Ken Markart dated May 10, 2006 (as amended), Dan Peerenboom, a water resources engineer with the State of Wisconsin, noted that dissolved copper accounts for 55% of the copper present in surface waters in northern Wisconsin. Applying this percentage to the water measurements in Stream C reduces the measured exceedances to little more than twice the criteria values in most cases (adjusted for hardness and dissolved fraction[28]).

Moreover, high amounts of decaying organic matter and other ions strongly bind to copper, further reducing the amount available to cause toxicity to aquatic organisms. These types of environments are found in shallow wetlands and slow moving streams, like Stream C. I observed a strong smell of decay during my visit at the site on October 18, 2011, suggesting this might be occurring in the wetland portion of Stream C north of Copper Park Lane, and in the southern reach of the stream during times of low flow. The portion of Stream C south of Copper Park Lane had shallow water and was full of leaves with obvious signs of decay (e.g., dark color, a sheen of tannins on the water surface). I also observed a significant amount of algae present in the water around the wetland area, and photographs from Mr. Roesler's sampling earlier in the year (Exhibit 11–Roesler deposition) showed significant algal growth. Given the relative sensitivity of algae to copper, and the negative results from the algal bioassay, it is my opinion that this is further evidence that bioavailability of the metal is relatively low in this area.

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[27] Flambeau Mining Company. Figure 3: Copper Concentrations in Surface Water Monitoring 2006–Fall 2011. Dated November, 2011. Prepared by Foth.

[28] Procedures for calculation of criteria on a dissolved basis are in WDNR 105. Surface Water Quality Criteria and Secondary Values for Toxic Substances, Sections 105.05 and 105.08.

Opinion 10. Streams in northern Wisconsin have naturally high copper and aquatic organisms may become tolerant to these higher concentrations.

It is also possible that metal enrichment in Stream C may be a naturally occurring event that could result in increased metal tolerance of the local aquatic species.[29] Samples collected from similar streams in Rusk County had total copper concentrations in the same range (i.e., 2.1–42 µg/L; average 12 µg/L) and even higher total zinc concentrations (i.e., 18–100 µg/L; average 34 µg/L).[30] Drinking water in Northern Region public water supplies is even higher, with a median value of 370 µg /L and some values as high as 1,570 µg/L.[31] Samples taken from the ditches on both sides of State Highway 27 upstream of the wetland portion of Stream C (i.e., to the east of the biofilter) also had higher copper concentrations (i.e., 8.9–34 µg/L; average 25.1 µg/L) and an intermittent tributary to Stream C south of Copper Park Lane had concentrations up to 15 µg/L total recoverable copper.

9 Summary and Conclusions

Stream C and its associated wetlands are enriched by copper and zinc, as are other similar streams in Rusk County. This may be due to naturally elevated metal concentrations in soils and sediments or it could be a result of human activity. Regardless of the source, it is my opinion, that these elevated levels are not impacting the biota of Stream C. It is not possible to reach definitive conclusions of impact based solely on measurements of total recoverable copper or zinc because site-specific water chemistry has a large influence on the percentage of the metals that are biologically available. Therefore, I relied on the biological and toxicological data to reach my conclusions of no impact. The biological data show that the water in Stream C is not acutely toxic to fish as diversity and numbers are higher than in the reference stream, and also that the stream is not toxic to algae (based on personal observation). These conclusions are substantiated by the negative results from aquatic bioassays conducted with Stream C water. Impact of the metals on the stream's invertebrate community is difficult to interpret as the periods when the stream dries out also cause changes in the types of species that use the stream, and the resulting species assemblage looks similar to what might be seen with metal contamination. However, the negative bioassay results with *Ceriodaphnia* (an invertebrate known to be sensitive to copper) validate the conclusion that observed differences are a result of physical changes and not the amount of copper or zinc in the water. Water chemistry data are lacking the information that is required to make predictions of toxic effects, such as pH, temperature, percent dissolved metal, amount of organic carbon, and concentrations of sulfate,

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[29] Morgan, A.J., P. Kille, and S.R. Stürzenbaum. 2007. Microevolution and ecotoxicology of metals in invertebrates. Environ. Sci. Technol. 41:1085–1096.

[30] Flambeau Mining Company. Figure 1: Surrogate Surface Water Sampling Locations and Analytical Results. Dated January 2011. Prepared by Foth.

[31] Peerenboom, D. 2001. Memorandum to file dated September 21, 2001, regarding copper concentrations in Northern Region public water supplies (PWSs).

chlorine, and other materials that bind to the copper or zinc and make them unavailable to the invertebrates. However, chemistry data from other locations in the north central region of the state indicate a low bioavailability of copper. Therefore, in my opinion, the aquatic organisms in Stream C are not impacted by copper or zinc. Furthermore, because the total copper and zinc concentrations in the Flambeau River immediately below the confluence with Stream C are below the state's criteria values (based on dissolved concentrations), it is my opinion that the stream is not discharging enough of these metals to impact the river's biota. This is substantiated by the invertebrate community indices (IBI and HBI) calculated in 2010 that show no metal-related effects.

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Professional Profile

Dr. Anne Fairbrother is a Principal Scientist in Exponent's EcoSciences practice, with more than 30 years of experience in ecotoxicology, wildlife toxicology, contaminated site assessment, and regulatory science for existing and emerging chemicals in the U.S. and Europe. She has conducted large-area (>100 sq mile) risk assessments at mines in tropical, desert, and mountain ecosystems, determining risk thresholds for plants and wildlife. She provided consultation on future development of mine pit lakes, assessed the risk to livestock from use of wastewater on irrigated pasture during mine closure operations, and conducted an assessment of risk to terrestrial and aquatic organisms from mercury. She also assessed risks to wildlife at sites contaminated with organic chemicals, including DDT, PCBs, dioxins, and petroleum hydrocarbons in Delaware, Texas, Oregon, Washington, and California, integrating ecological risks with human health risk assessments.

As a consultant, Dr. Fairbrother has supported various chemical industry groups in compiling and reviewing data from the literature in support of both U.S. and European regulatory processes. Historically, this included preparation of screening information data sets (SIDs) for submission through EPA to the OECD's High Production Volume (HPV) data call-in program. More recently, she also has input the data into the IUCLID database for Europe-wide risk assessments and the REACH chemical registration program. She has provided expertise and consultation for setting water and soil criteria or standards in the U.S., Canada, and Europe.

Dr. Fairbrother has participated in or led the development of guidance documents for ecological risk assessments. For example, she was co-author of the EPA's *Framework for Metals Risk Assessment* and for BC Ministry of Environment guidance for implementing Tier 1 ecological risk assessments of contaminated sites, incorporating weight of evidence practices into ecological risk assessments, and for setting soil clean-up values; she participated in the development of Ecological Soil Screening Levels (Eco-SSLs) for EPA.

While a scientist at the EPA, Dr. Fairbrother led research into the ecological risks of bioengineered crops, methods for assessing risks of nanomaterials, and some of the early guidance for field assessments of Superfund sites and effects of pesticides on birds. She researched and developed methods for assessment of chemical effects on bird immune and endocrine systems.

Dr. Fairbrother has published more than 80 peer-reviewed articles and book chapters that reflect her expertise in wildlife toxicology, immunotoxicology, endocrine-disrupting chemicals, and ecological risk assessment. She serves on numerous scientific boards, expert panels, and editorial boards in support of scientific and regulator y issues. A veterinarian and Certified Wildlife Biologist, Dr. Fairbrother served as President of the Society of Environmental

Toxicology and Chemistry, American Association of Wildlife Veterinarians, and Wildlife Disease Association (WDA). She is the recipient of the WDA Distinguished Service Award (2002), and a gold medal for Commendable Service from EPA. Dr. Fairbrother holds an adjunct professorship at Oregon State University, Department of Environmental and Molecular Toxicology.

Academic Credentials and Professional Honors

Ph.D., Veterinary Science, University of Wisconsin, Madison, 1985
M.S., Veterinary Science, University of Wisconsin, Madison, 1982
D.V.M., Veterinary Medicine, University of California, Davis, 1980
B.S., Wildlife and Fisheries Biology, University of California, Davis, 1976

Distinguished Service Award, Wildlife Disease Association, 2002
Gold Medal for Commendable Service, EPA, 2005
Bronze Medal for Commendable Service, EPA, 2006, 2008

Licenses and Certifications

Certified Wildlife Biologist, The Wildlife Society, 1995
40-hour Hazwoper Training and Certification

Publications

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Books Edited

Fairbrother A (ed). Test Methods for Hazard Determination of Metals and Sparingly Soluble Metal Compounds in Soils. SETAC Press: Pensacola, FL, 2002.

Fairbrother A, Locke L, Hoff, GL (eds). Non-Infectious Diseases of Wildlife, Second Edition. Iowa State University Press: Ames, IA, 1996.

Selected Published Abstracts

International

Fairbrother A, Wentsel R, Wood W, Sappington K, Noyes P. Framework for inorganic metals risk assessment. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Montreal, Canada, November 2006.

Gallagher K, Morris J Willis, J., Alwood A, Bauer D, Boethling R, Brody M, Burgin D, Chow F, Dreher K, Fairbrother A, Henry T, Karn B, Libelo L, Lingle S, Nabholz J, Prothero S, Savage N, Sayre P, Scalera J, Schoepf W, Street A, Utterback D, Williamson T, Zepp R. Nanotechnology: environmental opportunities and challenges. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Montreal, Canada, November 2006; and Society for Risk Analysis Meeting, Baltimore, MD, December 2006.

Schumaker N, Nagy L, Fairbrother A. PATCH: A spatically explicit wildlife population model for assessing risks of pesticides to songbirds. Presented at the Wildlife Disease Association World Congress, Cairns, Australia, June 2005.

Fairbrother A, Wentsel R. Framework for inorganic metals risk assessment. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Lille, France, May 2005.

Fairbrother A. Communicating probabilistic risk outcomes to risk managers. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Hamburg, Germany, April 2003.

Clark J, Fairbrother A, Brewer L, Bennett RS. Effects of exogenous estrogen on mate selection of house finches. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Vienna, Austria, May 2002.

Blanton ML, Driver CJ, Fairbrother A, Touart L. Detailed review paper for an avian two-generation and partial life-cycle reproductive and developmental toxicity test. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Vienna, Austria, May 2002.

Trust KA, Fairbrother A, Hooper MJ. Effects of 7,12-dimethylbenz[a]anthracene on immune function and mixed-function oxygenase activity in the European starling. Society of Toxicology Annual Meeting, New Orleans, LA, March 1993; and Wildlife Disease Association Annual Meeting, Guelph, Canada, August 1993.

Fairbrother A. Biomarkers in wildlife. Society of Environmental Toxicology and Chemistry Annual Meeting, Toronto, Canada, November, 1989.

Fairbrother A. Immunotoxicology of wild and laboratory birds. Wildlife Disease Association 6th International Meeting, East Berlin, GDR, August, 1990.

Yuill TM, Hinsdill RD, Porter WJ, Fairbrother A. The hidden challenge: determining sublethal effects of wildlife diseases. Wildlife Disease Association 6th International Meeting, East Berlin, GDR, August, 1990.

National

Edwards M, Fairbrother A. Surface water quality in the upper Columbia River, Washington. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Portland, OR, November 2010.

Fairbrother A, Edwards M, Mayfield D. Contaminant analysis of fish in the upper Columbia River, Washington. Presented at the Society of Environmental Toxicology and Chemistry Annual.Conference, Portland, OR, November 2010.

Fairbrother A, Menzie C. Integrated exposure analysis for human health and ecological risks at contaminated site. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Portland, OR, November 2010.

Palmquist K, Fairbrother A, Salatas J, Guiney P. Environmental fate of pyrethroids in urban stream sediments and the appropriateness of *Hyalella azteca* model in determining ecological risk. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Portland, OR, November 2010.

Fairbrother A. The art and practice of weighing evidence for environmental assessment. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, New Orleans, LA, November 2009.

Fairbrother A, Dohmen P, Marchand M, McCarty LS, Solomon K. Use of (Eco) toxicity data as screening criteria for the identification and classification of PBT / POP compounds. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Tampa, FL, November 2008.

DeForest D, Fairbrother A, Adams BA. Selenium hormesis in birds—Implications for developing dietary and egg-based toxicity thresholds. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Tampa, FL, November 2008.

Fairbrother A, Dohmen P, Marchand M, McCarty LS, Solomon K. Use of (Eco) toxicity data as screening criteria for the identification and classification of PBT / POP compounds. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Tampa, FL, November 2007.

DeForest D, Fairbrother A, Adams BA. Selenium hormesis in birds—Implications for developing dietary and egg-based toxicity thresholds. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Tampa, FL, November 2007.

Grim KC, Fairbrother A, Monfort S, Tan S, Rattner B, Gerould S, Beasley V, Aguirre A, Rowles T. Results of a wildlife toxicology workshop held by the Smithsonian Institution—Identification and prioritization of problem statements. National Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Hope B, Allard P, Fairbrother A, Hull R, Johnson MS, Kapustka LA, McDonald B, Sample BE. Representation and consequences of uncertainty in the toxicity reference value. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Allard P, Hill R, Mann G, Mackintosh C, Hull R, Kapustka LA, Mcdonald B, Hope B, Sample BE, Fairbrother A, Johnson MS. Using dose-response relationships for wildlife TRVs. Presented at the Society for Risk Analysis Annual Conference, Milwaukee, WI, November 2007.

Kapustka L, Fairbrother A, Sample BE. Linking assessment endpoints and wildlife TRVs. Presented at the Society for Risk Analysis Annual Conference, Milwaukee, WI, November 2007.

Hull RN, Allard P, Fairbrother A, Hope B, Johnson MS, Kapustka LA, McDonald B, Sample BE. Summary of recommendations for wildlife TRV development and use. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Fairbrother A. Environmental immunotoxicants: Human-wildlife relationships. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Fairbrother A, Sappington K, Wentsel R, Menzie C, Bottimore D, Downey P, Haber L, Harding-Barlow I, Nelson M, Thornton K. Principles for Metals Risk Assessment USEPA Framework. Presented at the Society for Risk Analysis Annual Conference, Baltimore, MD, December 2006.

Fairbrother A, Wentsel R, Sappington K, Wood W, P. Noyes. Framework for inorganic metals risk assessment. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Montreal, Canada, November 2006.

Morzillo AT, Fairbrother A. Effects of human activities on resident mammals within urban ecosystems. Presented at the 86th Annual Meeting of the American Society of Mammalogists meeting, Amherst, MA, June 2006.

Smith C, Stubblefield W, Clark J, Fairbrother A, Allen H, Schoeters I, Dwyer R. Distribution of soil bioavailability parameters throughout Europe and development of metalloregions. Major Scientific/Technical Contributions. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Wentsel R, Fairbrother A. Overview of the development of the Framework for Metals Risk Assessment. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Fairbrother A. Comparison of European and United States approaches to new and existing substances regulation. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Adams W, Brix K, DeForest D, Toll J, Fairbrother A, Kapustka L. Ecological risk assessment at a copper smelter. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Suter II GW, Fairbrother A, Munns Jr WR, Norton SB, Wentsel R, Kravitz MJ. Individuals versus organisms versus populations in the definition of ecological assessment endpoints. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Smolders E, Fairbrother A, Hale B, Lombi E, McGrath S, McLaughlin M, Rutgers M, Van der Vliet L. Hazard assessment of metals and metal compounds in terrestrial systems. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Austin, TX, November 2003.

Adams WJ, Tear LM, Edwards M, Fairbrother A, Brix KV. Re-analysis of field data used to derive selenium toxicity thresholds for birds. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

Fairbrother A. Values of constructed and natural ecosystems: Are they equivalent? Presented at Society for Risk Analysis Annual Meeting, Arlington, VA, December 2000.

Fairbrother A, Tear L, Toll J. Probabilistic risk assessment of methiocarb in terrestrial agroecosystems. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

McQuillen H, Brewer L, Fairbrother A, Clark J, Bennett RS, Fry DM. Field deployable techniques to monitor exposure to environmental estrogens throughout the reproductive cycle of wild birds. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

Fairbrother A. A critical review of avian test methods for endocrine disrupting activity of environmental chemicals. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA, November 1999.

Fairbrother A, Bennett RS. Environmental risk assessment and the precautionary principle. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Charlotte, NC, November 1998.

Fairbrother A, Bennett RS. Ecological risk assessment at the Mother Lode mercury mine, Ochoco National Forest. The 47th Annual Meeting of the Wildlife Disease Association, Madison, WI, August 1998.

O'Hara T, Franson C, Fairbrother A. Forensic investigations of wildlife: contaminants. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA, November 1997.

Clark J, Fairbrother A, Brewer L, McQuillen H, Bennett RS. Effects of exogenous estrogen on mate selection of house finches. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

Invited Presentations

International

Fairbrother A. Environmental effects of manufactured nanomaterials. Invited plenary presentation at SETAC World Conference, Sydney, Australia August 2008.

Fairbrother A. Ecological risk assessment and wildlife toxicology. 1st International Conference on Environmental Issues, Hanoi, Vietnam, March 2004.

Fairbrother A. Genetically modified foods: Technological breakthrough or ecological nightmare? Keynote address at SETAC Asia Pacific conference, Christchurch, New Zealand, September 2003.

Fairbrother A, Turnley JG. Communication of probabilistic risk assessments. Invited presentation in special symposium on Probabilistic Risk Assessment at SETAC Europe 13th annual conference, Hamburg, Germany, April 2003.

Clark J, Fairbrother A, Brewer L, Bennett RS. Effect of exogenous estrogen exposure on mate selection by the female house finch. Invited presentation at SETAC Europe 12th Annual Conference, Vienna, Austria, May 2002.

Robinson S, Fairbrother A. Human health risks from organotins in household products. Proceedings of the Organotin Environmental Programme Association Meeting, Sardinia, Italy, October 2000.

Fairbrother A, Brix KV, DeForest DK, Adams WJ. Critical review of tissue-based selenium toxicity thresholds for fish and birds. Presented at Mine Reclamation Symposium, Williams Lake, British Columbia, June 2000.

Fairbrother A. Fellow of the Crown Research Institute, Wellington, New Zealand. Invited lectures to scientific staff, regulators and academics (University of NZ, Christchurch), October 2000.

Fairbrother A. Keynote speaker and invited lecturer, Zoo and Wildlife Veterinary Medicine, Continuing Education. Western Plains Zoo, Dubbo, Australia. September 1999.

Fairbrother A. Tier 1 (Screening Level) risk assessments in British Columbia. Workshop sponsored by the Ministry of the Environment, Vancouver, BC, November 1998.

National

Seminar: Introduction to Ecological Risk Assessment. Environmental and Molecular Toxicology Department, Oregon State University, Corvallis, OR April 2011.

Plenary: Federal environmental legislation in the U.S. for protection of wildlife and regulation of environmental contaminants. Smithsonian Wildlife Toxicology Symposium, Washington DC March 2007.

Keynote: History of development and use of bioindicators and biomarkers in the U.S. 14th International Conference on Bioindicators. Baltimore, MD April 2006.

Lecture: RCRA and CERCLA: Environmental containment, contamination, and clean up. School of Veterinary Medicine, University of Illinois, March 2005.

Co-instructor: Introduction to Ecological Risk Assessment. Dept. of Fisheries and Wildlife *and* Dept. of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR, Winter 2003–2007.

Lectures: Risk assessment overview and introduction to TSCA and FIFRA. Presented in an upper division graduate level course on environmental studies. Department of Environmental Science, Oregon State University, Corvallis, OR, Fall 2002, Winter 2003, 2004.

Ecological Risk Assessment Guidelines in Oregon -- Case Study. Presentation at the Environmental Law Education Center, 2nd Annual Meeting on Contaminated Sites Issues, Portland, OR, March 1998.

Selenium toxicity in wetland birds. Selenium Symposium, Salt Lake City, UT, March, 1997.

Toxicity Extrapolations in Terrestrial Systems. Lead Instructor. A short-course workshop at the Society of Environmental Toxicology and Chemistry 17th Annual Meeting, Washington, DC, November, 1996.

Environmental Risk Assessment for Sustainable Development. Nevada Environmental Conference, Reno, NV, September–October, 1996.

Ecological risk assessment benefits, environmental management. Invited presentation at Ecological Risk Assessment Symposium, Corvallis, OR, November, 1994.

The biomedical paradigm applied to ecosystems. Ecosystem Health Meeting sponsored by University of California, Davis, Sacramento, CA, October, 1993.

Ecological aspects of land spreading of sewage sludge. Land Application of Sewage Sludge Symposium, Minneapolis, MN, August, 1993.

Seminar: Ecological risk assessment: from biomarkers to landscapes. Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR, February 2003.

Lectures: Ecological Risk Assessment. Team-taught upper division/graduate level course at Oregon State University, Corvallis, OR, Winter Quarter 2003.

Lectures: Wildlife Toxicology. Presented in an upper division graduate level course on wildlife diseases. Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, March 1998 and 1999.

Lectures: Situational Ethics – the use of science in policy making. Oregon Junior Science and Humanities Symposium, Oregon State University, Corvallis, OR, March 1996–1999.

Invited Weisse Lecturer: Ecological Risk Assessment and Wildlife Toxicology. Department of Zoology, University of Oklahoma, Norman, OK, January 1998.

Seminar: Toxicity extrapolations in terrestrial systems. University of Nevada, Reno, NV, April 1997.

Lecture: Introduction to ecotoxicology. University of Nevada, Reno, NV, April 1997.

Lecture: Ecotoxicology and veterinary medicine. School of Veterinary Medicine, Oregon State University, Corvallis, OR, August, 1995 and 1996.

Lecture: Ecological risk assessment practices. Envirovet Program, Duluth, MN, August, 1994.

Lecture: Current and future ecological risk assessment approaches in the EPA. Envirovet Program, Duluth, MN, July, 1993.

Lecture: Environmental science and policy in the 21st century. Oregon Junior Science and Humanities Symposium, Corvallis, OR, March, 1993.

Lecture: Wildlife veterinary medicine and conservation biology. School of Veterinary Medicine, University of California, Davis, CA, February, 1992.

Seminar: Environmental toxicology: a growing concern? College of Veterinary Medicine, Oregon State University, Corvallis, OR, November, 1990.

Lecture: Career opportunities in wildlife medicine. Keynote speaker at Phi Beta chapter Annual Meeting, Oregon State University, Corvallis, OR, May, 1990.

Lecture: Wildlife immunotoxicology. Oregon State University, spring term of even years, Corvallis, OR.

Lecture: The role of the USEPA in environmental toxicology. Institute of Wildlife Toxicology and Chemistry, Western Washington University, Bellingham, WA, April, 1990.

Lecture: The Wildlife Toxicology Research Team at the USEPA Environmental Research Laboratory in Corvallis. Institute of Wildlife Toxicology and Chemistry, Western Washington University, Bellingham, WA, 1987.

Prior Experience

Sr. Consultant and Lead for Environmental Risk Assessment and Toxicology, Parametrix, Inc., 2007–2008

Associate Director for Science, U.S. EPA, National Health and Environmental Effects Research Laboratory, Western Ecology Division, 2006–2007

Chief, Risk Characterization Branch, (Supervisory Life Scientist, hired at the GS-15 level [science promotion to Grade 15, 9/02]); U.S. EPA, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, 2002–2006

Director and Senior Ecotoxicologist, Terrestrial Ecotoxicology; Parametrix, Inc., 1999–2002

Sr. Wildlife Ecotoxicologist; Ecological Planning and Toxicology, Inc.,1994–1999

Chief, Ecotoxicology Branch, (Supervisory Ecologist, detailed at the GM-15 level), USEPA Environmental Research Laboratory, 1992–1994

Research Ecologist USEPA Environmental Research Laboratory (GS12 – GS14), 1986–1992

Courtesy Associate Professor, College of Veterinary Medicine, Oregon State University, 1987–2003

Courtesy Professor, Department of Environmental and Molecular Toxicology, Oregon State University, 2003–present

Selected Project Experience

Conducting an RI/FS for 150 miles of the upper Columbia River (Canadian border to the Grand Coulee Dam) and surrounding uplands to assess potential ecological risks of smelter emissions to aquatic life, plants, and wildlife. Studying contaminated sediments to ascertain bioavailable metals, conducting food-chain analyses for fish and wildlife, and evaluating soil and uplands in depositional areas to assess risks to plants and wildlife. Work is being conducted under agreement with EPA and participating parties.

Conducted a Detailed Ecological Risk Assessment of the tailings management system of the Gratzburg mine, Irian Jaya, Indonesia. This included assessing risks to plants and wildlife in jungles and estuarine mangrove ecosystems through food-chain analyses, ecological function studies, and floristic composition analyses. Performed extensive plant phytotoxicity and metal uptake studies to determine risk thresholds for tropical species. A detailed report was written estimating current and future (until mine closure in 2034) risks.

Served as an Expert Advisor to Cominco and its contractors for design and conduct of a terrestrial wide-area assessment under the Contaminated Site Regulations of British Columbia. This included development of appropriate assessment endpoints, conceptual site models, sampling and analysis plans, and final risk estimates. The area encompassed the upper Columbia River Valley and associated side valleys that had been subject to past deposition from the zinc-lead smelter plume.

Conducted an Ecological Risk Assessment for 165 square miles of property surrounding the Bingham Canyon, Utah, gold mine. Work included a survey of plants and wildlife on the site, food-chain analysis of potential metal contamination, field measurements of small-mammal populations, nesting surveys of shorebirds, and development of management options for various portions of the site. Included a probabilistic risk assessment of effects of selenium on the local populations of wading birds.

Conducted an assessment of risk to terrestrial and aquatic organisms from an abandoned mercury mine in the Ochoco Mountains, Oregon, and determined risk-based cleanup levels. This was the first risk assessment to follow the newly published Oregon Department of Environmental Quality guidelines.

Assessed the potential for risk to livestock from use of wastewater on irrigated pasture during mine closure. Selenium and thallium were identified as contaminants of concern. Plant uptake studies were conducted to refine risk estimates for thallium, both in laboratory and field situations.

Provided expert consultations on review comments relating to potential future development of pit lakes at gold mines in Nevada. Included interpretation of information on contaminants of concern, potential for bioaccumulation, and wildlife food-chain contamination.

Conducted an assessment of the potential ecological risks posed by use of copper pipes in housing in California. Specific emphasis was on amount of copper discharged to San Francisco Bay. Other areas, such as the Southern California Bight and San Diego Bay, also were assessed. Endpoints included protection of aquatic life, achievement of water quality criteria, and methods for establishing water effect ratios for specific locations.

Reviewed literature and available toxicity tests for various pesticides to develop Other Scientifically Relevant Information (OSRI) in response to EPA's request for endocrine disruptor Tier 1 screening.

Conducted a screening-level and Level II ecological risk assessment as part of a cleanup of stormwater runoff from the bus yard of the Tri-Met transportation authority in Portland, Oregon. Runoff into a bioswale had contaminated a small wetland and possibly a nearby creek. Endangered species of concern included the red-legged frog. Human health risks also were assessed for final cleanup.

Developed a probabilistic risk assessment model for determining risk of pesticides to birds using agricultural fields, including both flowable and granular pesticides. The model was developed using the Analytica® decision-based software system. The model was developed for industry as part of the ECOFRAM process sponsored by the EPA. The basic model is applicable to exposure to any contaminant, and contains a fate module that allows input of degradation rates over time.

Provided technical and managerial support to the organotin industry for submission of a screening information data set (SID) of information on 27 chemicals to the OECD's High Production Volume (HPV) data call-in program. Reviewed the available literature on physical/chemical properties, environmental fate, ecotoxicity, and human health effects for all the chemicals, and entered appropriate data into the IUCLID database system. Tests were placed with contract laboratories to fill data gaps. Structure-activity relationships and chemical categories were developed to reduce the need for testing. Developed rest plans, SIARs, and dossiers for submission to the regulatory authorities.

Collated all existing toxicity reference values for wildlife, plants, and soil invertebrates into a user-friendly database. Information was accessible via an interface with Microsoft Access. Included in the database were the endpoint, species tested, method of determining TRV/ benchmark, and jurisdiction. All values were rated on 20 criteria, and a desirability rating was provided to guide the selection of an endpoint when multiple values (i.e., jurisdictions) were available. The database is to be integrated into the Tri-Services web-based screening-level risk assessment model.

Built a database of nickel toxicity and essentiality and mechanisms for maintaining homeostasis. Retrieved and collated all available information on essentiality and toxicity of nickel to terrestrial and aquatic receptors (other than humans). Reviewed papers for data quality and entered information into a Microsoft Access database for easy retrieval (subsequently migrated to IUCLID). Literature citations were entered into ProCite.

Reviewed entire literature for effects of zinc and phthalate esters on terrestrial organisms (plants, wildlife, soil organisms). Qualified all studies for data quality and summarized the extent of the database. Provided all information in written report and electronic database of endpoints and data quality. Zinc data were used in the continent-wide ecological risk assessment conducted by the European Union (EU) and subsequently were migrated to IUCLID for use in REACH.

Wrote a Tier I assessment and supervised the conduct of toxicity and exposure studies for registration with the U.S. Fish and Wildlife Service of a new non-toxic shot for waterfowl hunting. Successfully completed the registration process under the new regulations, which allow selected testing rather than a complete battery of tests. Information also was submitted to Environment Canada for review. Shot has been registered and successfully marketed in the U.S. for several years.

Co-author of the EPA's *Framework for Metals Risk Assessment*. This guidance document provides the basic concepts for conducting human health and ecological risk assessments on inorganic metals, primarily at contaminated sites. It includes definitions and guidance for major areas, including background, bioavailability, bioaccumulation, and environmental chemistry of metals.

Wrote and produced the guidance document and checklist manual for British Columbia Ministry of Environment, Land, and Parks for implementing Tier 1 ecological risk assessments of contaminated sites. Presented the materials at training workshops in Vancouver. Updated the Detailed Ecological Risk Assessment guidance to include weight-of-evidence approaches.

Directed studies in a fully compliant GLP laboratory following FIFRA pesticide registration guideline for mallard and bobwhite quail. Included acute, subchronic, and reproduction studies with novel chemical and biological pesticides, conducted for most of the large agrichemical companies. Additional studies included tests specifically tailored to address questions of contaminant uptake from soil, potential food aversion from chemical-treated feed, and other studies to address specific aspects of exposure of wildlife to pesticides.

Conducted and published laboratory studies with the rat as a model of the pica child to determine the uptake efficiency of petroleum hydrocarbons from soils. Soil types included aged soils, treated soils, and lampblack. Information from the study can be used in exposure equations in place of default values when estimating total uptake of PAHs from different soil types during either human or ecological risk assessments of contaminated sites.

Researched effects of estrogen supplementation in house finch breeding behavior, including mate selection, changes in plumage coloration, and reproductive output. Animals were implanted with time-release devices for continual elevation of estrogen levels, and an ELISA method for measurement of fecal/urate estrogens was adapted to the house finch to monitor changes in hormones during the breeding cycle. Used videography to assess effects on nest behaviors.

Academic Appointments

- Associate Professor (Adjunct), Department of Environmental and Molecular Toxicology, Oregon State University, 2003 - present
- Associate Professor (Adjunct), College of Veterinary Medicine, Oregon State University, 1987–2003

Advisory Appointments

- European Research Council Expert Panel Reviewer, 2009–2011
- The Institute of Environmental and Human Health, Texas Tech University, Science Advisory Board, 2005–present
- British Columbia Science Advisory Board for Contaminated Sites, 2003–present
- International Metals Consortium Ecological Technical Advisory Panel, 1995–present
- USPEA, Endocrine Disruptor Methods Validation Committee, 2004–2006
- Utah Division of Water Quality, selenium standard development, Science Advisory Panel, 2004–2008
- Novel Methods for Integrated Risk Assessment of Cumulative Stressors in the Environment (NOMIRACLE), Expert Advisory Panel, 2005–2007
- USEPA Risk Assessment Forum member, 2004–2007
- USGS BRD National Wildlife Health Center (NWHC) and Forest and Rangeland Ecology Science Center (FRESC), Peer Review Science Panel, 2005
- USEPA Office of Research and Development, Board of Scientific Counselors, 2001
- USEPA Science Advisory Panel (Pesticides), 2001
- Contaminated Soils Advisory Group, Society of Environment Toxicology and Chemistry, 1996–present
- Science Advisory Committee, US Environmental Protection Agency, Center of Excellence in Ecotoxicology, University of California, Davis, 1992–1998
- Science Advisory Panel for Soil Toxicity Criteria, British Columbia Ministry of Environment, 1996

- Peer Review Panel for Ecotoxicity Threshold Values, Superfund Program, US Environmental Protection Agency, 1995
- US Environmental Protection Agency Peer Review Panel, Ecological Risk Assessment Guidelines, 1995
- Blue Ribbon Peer Review Panel, US Fish and Wildlife Service, Patuxent Wildlife Research Center, 1990–1991
- National Research Council Committee Member, Use of Animals as Indicators of Environmental Health Hazards, 1988–1991

Editorships and Editorial Review Boards

Editorial Boards

- *Environmental Toxicology and Chemistry*, 1995–1997
- *Human and Ecological Risk Assessment*, 2004–present
- *Journal of Wildlife Diseases*, 1998–present
- *Risk Analysis*, 2001–present
- *Ecotoxicology,* 2009–present

Associate Editor

- *Journal of Wildlife Diseases*, 1986–1991
- *Journal of Wildlife Management*, 1995–1996
- *Chemosphere* (Risk Assessment section), 2003–2005
- *Ecotoxicology*, 1995–present

Guest Editor

- Seminars in Avian and Exotic Pet Medicine *Toxicology* Vol 8, Jan 1999
- Fact Sheets on Environmental Risk Assessment, www.icmm.org, 2001–2002
- *Ecological Applications* special issue on mercury in Clear Lake, CA, 2006–2007

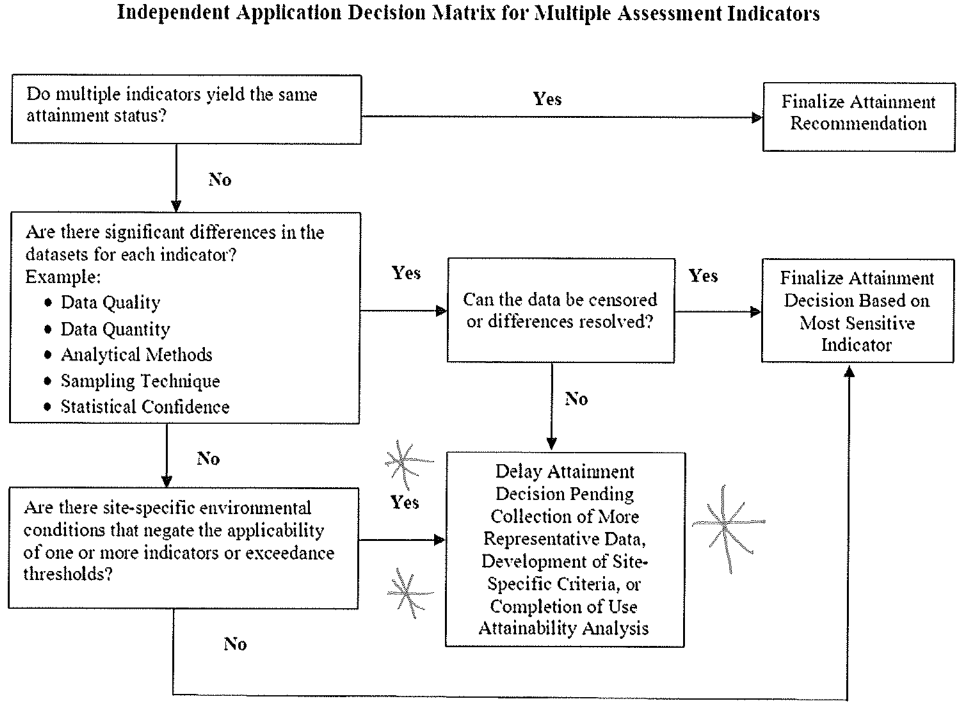
Peer Reviewer

- *Archives of Environmental Contamination and Toxicology*
- *Bulletin of Environmental Contamination and Toxicology*
- *Comparative Physiology*
- *Ecological Applications*
- *Ecological Modelling*
- *Environmental Toxicology and Chemistry*
- *Human and Ecological Risk Assessment*
- *Integrated Environmental Assessment and Management*
- *Journal of Wildlife Diseases*
- *Journal of Wildlife Management*
- *Risk Analysis*

Professional Affiliations

- American Veterinary Medical Association—AVMA
  – Committee on Environmental Issues, 2001-2003 (Chair, 2002–2003)
- American Association of Wildlife Veterinarians—AAWV
  – President, 1991–1993
- Society of Environmental Toxicology and Chemistry—SETAC
  – President SETAC North America, 2002–2003
- Society for Risk Analysis—SRA
- Wildlife Disease Association—WDA
  – President, 1995–1997

Figure 14. Independent Application Matrix



Data quality differences
If one parameter indicates impairment but another does not, differences between the two data sets in data quality, data quantity, analytical methods, sampling technique or statistical confidence may provide reason to weight one set of data more heavily than another.

Site-specific factors
Natural background levels of a pollutant may be higher than impairment thresholds or uncontrollable factors may cause an exceedance of water quality standards. In these circumstances, WDNR will determine whether criteria exceedance are reasonably expected to be due to natural or uncontrollable causes, as defined in the "Six Factors" of Use Attainability Analysis (40 CFR 131.10(g)). If assessment documentation supports that impairment is due to natural or uncontrollable factors, a Use Attainability Analysis (UAA) should be pursued to modify the Designated Use and/or associated criteria. However, a water with suspected naturally occurring pollutant levels that exceed applicable water quality criteria should be placed on the Impaired Waters List under Category 5C, until the appropriate designated use and/or site-specific water quality criteria have been approved by WDNR and EPA. Category 5C waters are those that are identified as impaired, but the cause of the impairment may be attributed to natural or uncontrollable source(s) (see Table 13).

Weight of Evidence
In certain cases where two data sets conflict with one another, states may apply a "weight of evidence" approach. This approach helps define the extent of the problem based on how it impacts the Designated Use, and allows biologists to consider aspects of the data that might indicate whether one data set should be weighted more greatly than another.

In all cases, Department staff will look for corroborating information, such as the various habitat and biological indices and water chemistry data. If the suite of available data does not suggest an evident

EXHIBIT
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